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Book of Abstracts

6th International Conference on "Earth Sciences Pakistan 2022"

June 25-27, 2022
Baragali Summer Campus, Abbottabad

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

BOOK OF ABSTRACTS

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'Earth Sciences Pakistan'

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PREFACE

Established in 1974, the National Centre of Excellence in Geology (NCEG) is a leading institute in Pakistan for higher studies and research in geosciences. Besides education and research, NCEG also plays a major role in organizing conferences, seminars and workshops on topics related to geosciences. One of the successful events of NCEG is the "Earth Sciences Pakistan (ESP)" international conference organized biennially. The first event of this series was held in 2010, followed by events in 2012, 2014, 2016 and 2018. The 6th conference of the series is scheduled in June 2022.

This international event is providing an opportunity to the geoscientists to exchange and share their research and innovative work among the scholars. A wide-ranging and interdisciplinary approach is required to address the Earth Sciences related global challenges. This international conference "ESP 2022" aims to bring together scientists and policy makers from academia and industry from all over the country and abroad to present their research on various aspects of earth sciences.

Besides the traditional conference themes, this conference also offers sponsored sessions to all the government and non-government organizations who need a better platform to showcase their research and professional activities to share with the community. In this regard, the "ESP 2022" provides all conference facilities for the sponsored sessions. The sponsored session is dedicated to the organization concerned, who leads/chairs the whole session. Furthermore, the ESP 2022 provides an opportunity for corporate sector to showcase their products/services and connect with 300+ researchers, stakeholders and policy makers from all over the country and abroad. They can network with attendees and access to all educational sessions.

In response to the call for papers for ESP 2022, we have received 183 abstracts from academics, graduate students and professionals from academia and industry on different themes of earth sciences. All submitted abstracts have been reviewed by a minimum of two referees. After the meticulous process, 84 abstracts are accepted for oral presentations and 67 for poster presentations. All accepted abstracts are included in Abstract Volume of Journal of Himalayan Earth Sciences.

The Organizers of ESP 2022 would like to thank all the authors and peer reviewers for their valuable contributions. We also appreciate the dedicated efforts of the members of the committees formalized for ESP 2022. Finally, we gratefully acknowledge the chief guests, guests of honor, foreign and national keynote speakers, session chairs/co-chairs and participants for accepting our invitation to attend ESP 2022 and share their ideas in the field of earth sciences. We wish your expertise enhance the conference in the best possible way and looking forward to establishing a long-lasting relationship for the benefits and growth of the industry in particular and the field of science in general.

Dr. Liaqat Ali (Convener)

Dr. Seema Anjum Khattak (Chief Organizer)

Dr. Khalid Latif (Conference Secretary)

ABOUT PASTIC

Pakistan Scientific & Technological Information Centre (PASTIC) is a subsidiary organization of Pakistan Science Foundation (PSF), under the umbrella of Ministry of Science and Technology (MoST). PASTIC is a specialized premier organization in the field of S&T information handling and dissemination responsible for catering to information needs of R&D and industrial community across the country. The PASTIC National Centre is housed at Quaid-e-Azam University Campus, Islamabad having a network of 6 Sub-Centres at Karachi, Lahore, Peshawar, Quetta, Faisalabad and Muzaffarabad.

To begin with PASTIC supported research community across the country when S&T research infrastructure in Pakistan was at a nascent stageand provided facilities including supply of scientific and technical documents, abstracts and indexes, bibliographies, translations, patent information and patent indexes, science reference library service, technological information transfer service, dissemination of computer-based information services, reprographic and publication services.

PASTIC Objectives

- National S&T/R&D Information Repository of indigenous information resources (databases)
- S&T/R&D information dissemination through contemporary reference information tools
- Strengthen National Science Reference Library for resource sharing & Inter-library collaborations (consortium) and empowerment of information professionals.
- Promotion of R&D based industrial development
- Facilitate printing of S&T/R&D Publications
- Capacity/skill development of researchers & entrepreneurs
- Develop collaborations with national and international information networks

PASTIC Activities/Functions

PASTIC Online databases

Pakistan Science Abstracts (PSA): National research published in Pakistani S & T Journals & Conference Proceedings etc.

PakCat: Union online Public Access Catalogue (OPAC) of Books available in Science and technology Libraries of Pakistan.

DSpace full text digital repository of indigenous S&T literature.

Database of R & D Projects executed in Pakistan.
Industy related databases.

S&T Publications

- *Pakistan Journal of Computer & Information Systems (PJCIS):*A biannual Open Access primary Journal meant for researchers from Computer Science & Engineering, Information & Communication Technologies (ICTs), Information Systems, Library and Information Science.
- *Technology Roundup:* Publish bi-monthly bulletin by repackaging of latest global Trade and Technology information.
- *Union Catalogue:* Provide information on research materials (books/journals/conference proceedings/reports, etc) available in different S&T libraries of Pakistan.
- *Scientific Periodicals of Pakistan***:** A handy guide of scientific periodicals published in Pakistan.
- *Abstract Books of Conferences:* PASTIC support publication/printing of Abstract Books organized by various S&T universities (on request).

Promotion of Commercializable Technologies & Industrial Products

Organize STEM and IT Expoto promote local Research and Development, SMEs, technologies/products/services/industrial R&D challenges/issues as well as empowering youth and general public on new and faster ways of delivering and accessing information.

National Science Reference Library Facility

A state-of-the-art Traditional Library facilitating the researcher through following services: Reference & Referral Services; Reader Service; Internet Service, Journal Listings; Photocopying & Scanning Services.

Human Resource Development (Capacity Building)

Organize Seminars/Workshops /Trainings/ for capacity building of:

- Young Researchers on Data Analysis and bibliographic citation Tools (SPSS, EndNote, Mendeley)
- Women Entrepreneurs on e-marketing and e business skills
- Library Professionals on Library Information Management Tools & techniques (Koha, D-space etc)
- Researchers and entrepreneurs on Intellectual Property Rights, Media Information Literacy

CONFERENCE PROGRAM

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Climate change and Glaciers	Mineral Deposits of Pakistan
Conference Session 5 (Hall A)	**Workshop Session 2 (Hall B)**
Environmental Geosciences	Mineral Deposits of Pakistan
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INVITED TALKS

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2. Khyber Pakhtunkhwa oil & gas potential and future resources.
   Nasir Khan(CEO KPOGCL)

3. Evaluating, mapping, modelling of hydrocarbon kitchen and its importance in guiding oil & gas exploration.
   Abrar Ahmad (Saudi Aramco)

4. Oil & Gas services perspective on the future of E&P Industry.
   Said Rehman (CEO Vizdom Solution)

5. Determination of selected heavy metals in soil and *Trifolium alexandrinum* irrigated with Rohi Drain wastewater.
   Sajid Rashid Ahmad, Sana Ashraf (College of Earth and Environmental Sciences, University of the Punjab)

6. Emerging applications of CubeSats in geological exploration.
   Rehan Mahmood
   (IST, Lab Director, SSTRL, NCGSA)

7. Cryosphere changes and its impacts in the Upper Indus Basin.
   Sher Muhammad (International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal)

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   Shaukat Ali
   (Ministry of Climate Change, Islamabad, Pakistan)

9. Global warming is the harbinger of climate change which, in turn, is a major threat to food security and sustainable development.
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10. Petrography, geochemistry & petrology of the Wadhrai ganite stock, Nagar Parkar igneous complex, southeast Sindh.
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11. Systematic Geomechanical Cave Stability Assessment: Malaysian case studies.
Goh Thian Lai, Abdul Ghani Rafek, Ailie S. Serasa
(Department of Earth Sciences and Environment, Universiti Kebangsaan Malaysia)

12. Future mineral prospects: Challenges and Way forward in Mineral Sector Development of Pakistan
M. Tahir Shah (NCE in Geology, UoP)

13. Liquefaction potential evaluation of Mangla Dam Reservoir Sediments
Sohail Kibria (Research & Development NESPAK)

14. Continent-continent collision, deep subduction, and Ultrahigh -Pressure metamorphism in the Himalayan orogen: solved issues and future problems.
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15. Public Sector spending on disaster risk reduction and Climate Change in Khyber Pakhtunkhwa.
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(Institute of GIS, NUST Islamabad Pakistan)

17. GIS & Remote Sensing in Geosciences, from theory to practice
Muhammad Shafique (GSAG, NCE in Geology, UoP)

ABSTRACTS

Facies and diagenetic analysis of Khewra Formation within the Potwar subbasin, Pakistan

Atif Iqbal Abbasi*, Imran Khan, Asad Ali and Muhammad Ajaz Abbasi

COMSATS University Islamabad, Abbottabad Campus, University Road, Tobe Camp, Abbottabad
**atif_Iqbal100@hotmail.com*

Khewra Formation/Sandstone is one of the most important hydrocarbon reservoirs within the eastern part of Potwar subbasin. Several authors have worked on the petrography and reservoir nature of Khewra Sandstone before but significantly less data is presented for these reservoir rock units especially on regional level. The current study is aimed to provide a regional facies correlation of the Khewra Sandstone. The study also aims to address the depositional and diagenetic controls on the reservoir nature of these sandstones. Exposure of the Khewra Formation has been studied in detail in five sections located within eastern and central part of the Salt Ranges. Five lithofacies including Parallel Laminated Sandstone Facies, Cross Bedded Sandstone Facies, Channelized Sandstone Facies, Amalgamated Sandstone Facies, and Shale/Clay Facies, has been identified in various outcrops. These facies are generally grouped into the three facies associations i.e., Delta Front Facies Association, Pro-Delta Facies Association, and Delta Plain Facies Association, demonstrating ancient deltaic deposited within western passive margin of the Indian Plate. Quartz is dominating in the Khewra Sandstone which tells about the well mature nature of the sandstone and categorized the sandstone to be of quartz Arenite classification. There is a dearth of feldspar which is caused by extreme chemical weathering of the source region, extensive transportation, diagenetic dissolution, alteration, and replacement. SEM analysis of researched samples indicate that the dissolution of unstable framework grains and volcanic lithics produces various clay minerals. The primary porosity is disturbed by the formation of clay minerals and cementation in pore spaces. The overburden pressure of the overlying formation and the chemistry of the clay minerals depicting the intermediate depth of burial of the Khewra Sandstone. Overall, the reservoir nature of these sandstones is appreciable not only in the eastern part of the basin but also in the central part and can be a potential target for the HC exploration in future activities.

Hydrocarbon source rock potential of the Patala Formation within the Upper Indus Basin, Pakistan: An Organ-geochemical insights

Muhammad Ajaz Abbasi[1*], Imran Khan[1], Asad Ali[1], Atif Iqbal Abbasi[1] and Adil Khan[2]

[1]COMSATS University Islamabad, Abbottabad Campus, University Road, Tobe Camp, Abbottabad
[2]Pakistan Petroleum Limited, Pakistan
**jazziabbasi154@gmail.com*

Patala Formation is considered a source of the generated hydrocarbons within Kohat and western Potwar. Previous work shows that detailed research work has been done on sequence stratigraphy, facies association, depositional environment, and biostratigraphy. The source rock characterization of the Patala Formation has been carried out on the outcrop samples pertaining only to the western part of the basin (Nammal Gorge). The available information on the source rock characterization of the Patala Formation on the regional level is scarce and insufficient to determine the separate petroleum system within various parts of the basin. The outcrop study of the Patala Formation shows the formation is 16-20 meters thick. Based on outcrop data, the Patala Formation is divided into five lithofacies, i.e., Coaly shales and coal, mudstone, limestone, grey shales, and a mixture of sandstone and shale facies. Coal and shales are analyzed for orangofacies analysis based on saturated hydrocarbon data acquired using Saturate-Gas Chromatogram suggest multiple organic matter inputs for the Patala Formation suggestion nearshore environment. Various geochemical parameters like Pristane/Phytane, Isoprenoid/n-Alkanes, Carbon Preference Index (CPI), and Odd/Even Carbon Preference (OEP), all suggest low to early mature source rock deposited with oxic to sub-oxic depositional settings. The source rock characterization based on Total Organic Carbon (TOC, Wt%) suggests that coal and coaly shale from the eastern, and central part of the basin with TOC ranging between 3.5 and 77.4 % can have a good source rock upon attaining the required maturity. The hydrocarbon yield (S_2) determined using rock-eval pyrolysis also suggests a good to excellent petroleum potential for these samples in the central and eastern part of the basin. TOC values and rock eval pyrolysis show that the shales from the Patala Formation have Type-II and Type-III kerogen suggesting an obvious organic matter mixing of different sources. The T_{max} average value is 445.4 ^{o}C in the studied sections which showed the late Paleocene Patala Formation is thermally mature and can/have produced hydrocarbon.

Determination of residual pesticides in vegetables from market and home garden and soil sample from home garden

Muhammad Abdullah*, Shazma Muzammal, Nida Rasool, Rahib Hussain and Sajid Rashid Ahmad

College of Earth and Environmental Sciences, University of the Punjab, Lahore, Pakistan
**m.abdullahqayyum99@gmail.com*

An effort has been made in this study to determine the residual pesticides in the vegetable sample and soil samples. This research was conducted during the winter season that's why the vegetables available were Cauliflower, Radish, Spinach, etc. The results show that Mancozeb pesticides was 10 %, Diazinon 4%, methamidophos 9.6, Fenvalerate 4.6%, monocrotophos 8.7%, Dimethoate 6.6 %, chlorpyrifos 7 %, and Trichlorfon 7% in soil. Pesticides have become an important tool for the management of insects, weeds, and fungi and have positive effects on the agricultural economy. Vegetables play a significant role in the maintenance of health and prevention of diseases. All vegetable contains an appreciable amount of essential nutrients. Pesticides help to increase the production of agricultural products, it affects both environmental and socio substances. In this research, different vegetables were collected from the market and the concentration of different residual pesticides was determined followed by the calculation of Hazard Quotient, which was 0.87 and 0.3 for soil and vegetable, respectively. On the other side, vegetables were grown in the kitchen garden and pesticides were sprayed on them after different intervals. The concentration of different residual pesticides was determined and then their hazard quotient was calculated. The pesticides which were used to detect in samples were Deltamethrin, Cypermethrin, Chlorpyrifos, Malathion, and Bifenthrin. The technique that was used for the detection of pesticides was GC. The experimental results showed the variation in concentration of different residual pesticides in the market and home-based samples. Similarly, soil samples from the home garden were also analyzed. In soil samples, only Bifenthrin and Chlorpyrifos were detected while in vegetable samples, all pesticides were detected.

Mineralogical studies of shales and possible occurrence of bauxite from Manchar Formation, Laki Range, Sindh, Pakistan

Muhammad Hassan Agheem*, Sarfraz Hussain Solangi, Aijaz Ali Halipoto, Jamshed Ali Rahomoon and Abdul Karim Bhangar

Centre for Pure & Applied Geology, University of Sindh, Jamshoro
**mhagheem@usindh.edu.pk*

In sedimentary successions, the commercial bauxite is usually found in shale units of any formation. Bauxite is the aggregate of gibbsite, boehmite, diaspore, laterite and goethite etc. Bauxite has vast metallurgical applications along with other industrial uses. A few commercial deposits of the bauxite are reported from the Salt Range, Kalachitta Range and Muzaffarabad-Kotli region of the Azad Kashmir. Some showings of aluminum rich rocks in the form of variegated shales/clays are seen in the Manchar Formation of Miocne-Pliocene age in Laki Range. This formation is also famous for the occurrence of wood and mammal fossils along with the occurrence of uranium. It is nicely exposed in the northern part of Laki Range and the studied sections are some 8-15 Km away from Sehwan Sharif, District Jamshoro. For present studies, total seventy-eight variegated shale/clay samples were collected from different units of various sections for mineralogical characterization. Five techniques such as the SEM, EDS, ZSM, XRD and XRF are used to determine the whole rock geochemistry, mineral chemistry, mineral characterization and textural analysis etc to assess the occurrence of bauxite. Among all the analyzed samples; only thirty-three samples having the higher percentage of alumina than average % found in shales. The samples having higher percentage of alumina when observed through SEM, it appears that the grain size is roughly less than five um and it is very difficult to distinguish various minerals. When all the samples having higher concentration of alumina analyzed through XRD then it became evident that only one bauxite mineral in the form of gibbsite is present with maximum of 8.70 %. On the basis of semi-quantitative XRD analysis; the other minerals are quartz, kaolinite, clinochlore, illite, vermiculite, dickite, siderite, calcite etc. The results indicate that only in ten samples, the anomalous alumina is observed and it ranges from 23 wt.% to 40 wt.%. On the basis of current analytical data, it is concluded that the bauxite within the Manchar Formation is of very low grade and out of three bauxite minerals; only gibbsite is identified within the analyzed samples. It has also been noticed that though in certain samples, the alumina contents are as high as 40 % but the percentage of bauxite does not exceed 8.0 wt.%. It indicates that instead of formation of bauxite, the alumina has been accommodated within the crystal structures of certain other clay and phyllo-silicate minerals as is evident by XRD analysis.

Evaluating, mapping and modelling of hydrocarbon kitchen and its importance in guiding oil & gas exploration

Abrar Ahmad

Saudi Aramco
abrar296@yahoo.com

Petroleum source rock is an essential and fundamental element of any petroleum system. Hydrocarbon Kitchens are the areas where organic rich rock facies undergo thermal stress which resulted in cracking of kerogens and generation of hydrocarbon (HC). In hydrocarbon exploration, source rock characterization, especially the mapping of the kitchens was one of the most neglected areas, till the exploitation of oil and gas from shale oil and shale gas pays at commercial scale. In this article we will discuss the geochemical techniques of source rock characterization, their limitation and common error in its use. In E&P industry generally the source rock richness, quality, and maturity as generally taken as individual entities. The quantity and quality of organic matter changes with increase in maturity, therefore, total organic content and its proneness as oil and gas source must be interpreted in the light of its level of maturity. Further, the thickness and areal extent of the source rock is required for mapping of source rock. The area where measured geochemical data is not available or sparely present, depositional model of source rock may be used for reasonable extend of the potential rock. It is, therefore, important to understand the deposition environment of source rock facies. Additionally, the application of petroleum system modelling will help in reconstruction of burial history and simulation of kerogen cracking, generation, and expulsion of hydrocarbons. It will provide the volume of HC generated, its timing and migrated from the kitchen. On the top it will provide the migration pathways and reasonable understanding about the areal extent of a petroleum system. The time of petroleum generation is important in relation to the formation of structures, stratigraphic traps, and faults as migration pathway or act as seal. The mapping of kitchens will also be helpful in exploration of unconventional shale oil and shale gas resources. Demarcation of kitchen boundary and limits of a working petroleum system will guide DGPC in creation of exploration blocks. It will reduce the exploration risk and will increase confidence regarding perceptivity of certain area.

Potential of zeolite-based urea formulations to reduce N losses from soil and enhance crop yield

Ayaz Ahmad[1], Shahzada Sohail Ijaz[1*], Khalid Saifullah Khan[1] and Muhammad Ansar[2]

[1]Institute of Soil & Environmental Sciences, PMAS-Arid Agriculture University Rawalpindi, Pakistan
[2]Department of Agronomy, PMAS-Arid Agriculture University Rawalpindi, Pakistan
**shahzadasohail@uaar.edu.pk*

Zeolites have the capability of holding ammonia (NH_4+), thus reducing nitrogen (N) losses when applied as a soil amendment. There is very little information on the characterization of zeolite found in Pakistan and its performance as zeolitic-urea formulation on soil N losses. Zeolitic-urea formulations 1:3, 1:2, 1:1, 2:1, and 3:1 were prepared and evaluated against sole urea fertilizer for delayed release and reduced leaching and volatilization. Nitrogen release was studied in an incubation experiment while leaching was studied in plexiglass columns. The results of XRD, FTIR and EDX confirmed the presence of zeolite in the samples. The SEM images showed the clinoptilolite structure and morphology of zeolitic formulations. Results of the incubation experiment revealed that zeolitic urea formulations delayed the peaks of NH4-N and NO3-N concentrations in the soil as compared with urea under flooded and non-flooded moisture conditions. Zeolitic-urea 1:1 retained 10.15% higher mineral N in the soil as compared with urea. Further, zeolitic-urea 1:1 reduced NH_3 loss by 34.5% and 32.87% under flooded and non-flooded conditions respectively. Similarly, zeolitic-urea 1:1 significantly decreased NH_4-N losses by 28% for light textured soil and 13% for medium textured soil in the column leaching experiment. Under field experiment conditions, zeolitic-urea retained the highest NO_3 in 0-30 cm soil depth while these were highest at depth 60-90 cm with sole urea in both wheat and rice crops. Grain yield of wheat and rice crops with N100%U was similar to that of with N75% ZU where 25% less N was applied. Zeolitic-urea enhanced the nitrogen use efficiency by 25.82% in wheat crop and 34.80% in rice crop.

Multiple diagenetic alterations and its impact on the porosity evolution of Late Triassic Kingriali Formation, Kohat sub-basin, Pakistan

Imran Ahmad[1,2*], Mumtaz M. Shah[1], Juan Diego Martin-Martin[3], Irene Cantarero[3], Anna Trave[3] and Muhammad Ibrar[4]

[1]*Department of Earth Sciences, Quaid-i-Azam University, 45320 Islamabad (Pakistan)*
[2]*Department of Geology, University of Malakand, 18800 Chakdara (Pakistan)*
[3]*Department of Mineralogy, Petrology and Applied Geology, Faculty of Earth Sciences, University of Barcelona (UB), 08028 Barcelona (Spain)*
[4]*Centre for Earth & Space Sciences, University of Swat, 19200 Swat (Pakistan)*
**imran_geo@uom.edu.pk*

Late Triassic Kingriali Formation is well exposed along the northern and southern deformed zones of the Upper Indus Basin, Pakistan. Present study focuses on the diagenetic alterations as well as its impact on the reservoir heterogeneities of the Kingriali Formation exposed in Surghar Range, Kohat sub-basin, Pakistan. Detail field observations and logged section suggest that 80% carbonate successions of the studied formation have been dolomitized, while few beds are still unaltered. Petrographic study reveals that the host limestone is diagenetically modified by micritization and early marine cementation (C-I) followed by selective replacement dolomitization (Dol-I & Dol-II). Matrix and allochemical components of the host rock were preferentially replaced by the early phase of selective replacement and exhibits retention of the depositional texture. The fine-medium crystalline Dol-I were observed as matrix replacive dolomites, while medium-crystalline Dol-II has completely replaced the allochemical constituents. The stable isotopic (δ18O & δ13C) composition and radiogenic strontium (86Sr/87Sr) ratio of the micritized grains as well as the early replacive dolomites occurred in the limit of Late Triassic marine signatures. Stylolization, sutured grain contacts and distortion of ooids evidently describes burial compaction in the investigated formation. Crystallization of Dol-I along the amplitude of stylolite illustrates as conduit for the circulation of reactant bearing fluids. Dol-III were observed as precipitation of medium-coarsely crystalline dolomites in the dissolution induced vugs/cavities. Reservoir character of the studied dolostones has pronouncedly increased by the crystallization of Dol-I and Dol-II and occluded by the precipitation of Dol-III in most of the inherited cavities. Subsequent crystallization of high temperature saddle dolomites (Dol-IV) in open spaces demarcates the diagenetic alteration of Kingriali Formation at greater burial depth. Highly depleted δ18O, less depleted δ13C and more radiogenic 86Sr/87Sr values of Dol-IV apparently designates dolomitization at greater burial depth. Corrosion of the dolomite crystals signify its interaction with geothermally heated fluids, also suggest its burial to greater depth. Almost all the diagenetic phases of the studied formation have been cross-cutted by multiple calcite-filled veins (C-II) indicates the last stage of diagenetic alterations. It has been concluded

that porosity of the examined dolostones has increased by the early phase replacive dolomites (Dol-I & II) and greatly reduced by Dol-III & IV and C-II.

Evaluating the landslides characterization and deformation using Multi-Temporal UAVs imageries in Northern Pakistan

Naseem Ahmad*, Muhammad Shafique and Mian Luqman Hussain

National Centre of Excellence in Geology, University of Peshawar
GIS and Space Application in Geosciences Laboratory (GSAG-L)
**naseemkhattak02@gmail.com*

The UAVs (Unmanned Aerial Vehicles) have emerged as the most cost-effective tool for mapping the landslide dynamics. The structure from motion (SfM) algorithm provides an inexpensive way to create orthomosaic and digital surface models (DSMs) from the UAV acquired imageries. This study is focused on mapping of the Nara, Nokot and Mayun landslides in the rugged terrain of north Pakistan, to acquire high resolution imageries using Pix4D capture software. The aerial survey was carried in April and August 2019 for Nara and Nokot landslides while for the Mayun landslides, the survey was carried out in September 2018 and August 2019. The images were processed in the Pix4D mapper to create the orthomosaic and digital surface models (DSMs). The ground control points (GCPs) collected in a geodetic survey with the GNSS/PPK were used to co-registered and orthorectify the UAV imageries. The dense point cloud was generated with an average density of 7.7 for the Nara and Nokot landslide and that of the Mayun landside with 2.36m3. The DSM changes were analyzed by subtracting the DSMs from each other and showed that there are volumetric changes in the lateral depositional areas of the Nara. The NS and NW scarp of the Nokot landslide shows volumetric changes. The scarp and lateral portions of the Mayun landslides show the volumetric changes. The shaded relief single band was used to correlate the temporal images for the Nara, Nokot and Mayun landslide using COSI-Corr algorithm. The statistical and frequential correlator was used. It was found that only statistical correlator works on the UAV images and frequential correlator is sensitive and does not work on the UAV imageries. The results developed show that the Nara landside a surface movement ranging from 1 to 29m in the NE scarp and lateral areas. The Nokot landslide has active NS, NE and NW scarps with a surface movement ranging from 1 to 25.5m. The Mayun landslide shows a slow movement in the scarp drainage channels and in the lateral parts above the central toe region ranging from 1 to 12m. The accuracy assessment was carried out to analyze the vertical accuracy of DSMs generated. The RMSE calculated for the Nara landslide is 0.853, for the Nokot 0.87696 and for the Mayun 0.8775m. This shows that the use of UAVs with the DGPS geodetic survey is strongly recommendable for mapping landslide dynamics.

Remote sensing approaches and related techniques to map and monitor landslides in District Chitral, NW Pakistan

Said Mukhtar Ahmad[1*], Mona Lisa[1] and Saad Khan[2,3]

[1]*Department of Earth Sciences, Quaid-i-Azam University, Islamabad 45320, Pakistan*
[2]*Department of Geology, Bacha Khan University Charsadda, Charsadda 24420, Pakistan*
[3]*National Centre of Excellence in Geology, University of Peshawar, Peshawar 25130, Pakistan*
**mukhtargeo44@gmail.com*

Northern Pakistan is regarded as the hotspot of various natural hazards and is comprised of the rugged mountainous terrains, high gradient, active seismicity, complex lithology, and snow-covered peaks. District Chitral lies in the northwest of Pakistan, which hosts a variety of natural hazards like earthquakes, landslides, flash floods, and glaciers lake outburst floods and debris flow. Among all these natural hazards, landslides are a frequent phenomenon and usually occurs frequently in Chitral which leads to a severe threat to the local community and economic loss. This study was carried out in Chitral Reshun to construct a landslide inventory map and develop a susceptibility map. Various causative factors were considered in this study like slope, aspect, geology, streams distance, fault distance, landcover, earthquake and rainfall. Two approaches (Frequency ratio and Analytical Hierarchy process) were adopted to know the influence of causative factors over mass movement. Results of both the approaches were compared and validated using area under curve that yielded 78% of AHP and FR with 84%. Persistent Scatterer Interferometry (PSI) Interferometric Synthetic Aperture Radar (InSAR) technique was applied to know the deformation style of the slowly moving landslide in the target area. Results of remote sensing InSAR analysis revealed that Line of Sight (LOS) deformation velocity and signatures also mark the high susceptible zones of both models.

Efficiency assessment of agricultural water resources in Rachna Doab, Punjab, Pakistan, using Geospatial Techniques

Sajid Rashid Ahmad, Muhammad Arshad Javed, Muhammad Asif Javed* and Waqas Karim Awan

College of Earth and Environmental Sciences, University of the Punjab, Lahore, Pakistan
**m.asifjaved13@gmail.com*

Climate change is the drastic long-term changes in the climate, i.e., weather patterns and temperature, due to anthropogenic and natural activities. Climate change is the primary concern of the twenty-first century. The emission of greenhouse gases, mainly from anthropogenic activities, causes a 1.0℃ rise in Earth's temperature. It is estimated that this increment will rise to 1.5℃ by 2030

– 2050 if the rate of emission of greenhouse gases remains constant. Major natural environmental incidents occurred due to climate change in 2018. About 68.5 million people were affected, and the economy lost $131.7 billion worldwide, of which floods, wildfires, and droughts accounted for 93% loss. California wildfires were the fatal wildfires that damaged the economy and took so many lives. Other resources under attack by climate change are water, food, health, habitat, infrastructure, and ecosystem. Paris agreement was signed in 2015, according to which only a 2℃ rise in temperature is acceptable till 2100, and every country is making efforts to lessen its greenhouse emissions. Few strategies to reduce climate change, such as negative emissions technologies, conventional mitigation technologies, and radiative forcing geoengineering, are discussed in this article. The aim of negative emissions technologies (also known as Greenhouse Gas Removal (GGR)) is to remove carbon dioxide from the atmosphere. Conventional mitigation strategies aim at lessening the fossil fuel-based carbon dioxide from the ecosystem. Lastly, radiative forcing geoengineering focuses on the alteration of Earth's radiative energy to reduce the temperature of Earth. Conventional mitigation technologies are not enough to reduce greenhouse gas emissions to meet the Paris agreement's goal of temperature. Combining different strategies can help, but as mentioned earlier, these technologies are not mature enough, so biogenic-based sequestration techniques can be installed as these are mature to a certain extent.

Determination of selected heavy metals in soil and *trifolium alexandrinum* irrigated with Rohi Drain Wastewater

Sajid Rashid Ahmad* and Sana Ashraf

College of Earth and Environmental Sciences, Quaid-e-Azam Campus, University of the Punjab, Lahore-Pakistan
**sajidpu@yahoo.com*

Heavy metals are the toxic environmental pollutants and persist in the environment for long time. They have potential of bioaccumulation and bioaugmentation in living beings of the environment. The fodder crops like Trifolium alexandrinum are being harvested in soil by irrigating Rohi drain wastewater in Lahore, Pakistan. In this study, the soil and Trifolium alexandrinum plant samples being irrigated with Rohi drain wastewater were collected and analyzed to determine heavy metals (Pb, Cd and Cr) and other physiochemical parameters by following standard procedures. The results have revealed that concentration of Pb and Cd in soil and Trifolium alexandrinum samples was higher than permissible limit of National Environmental Quality Standards (NEQS). However, the concentration of Cr was found within permissible limit of NEQS. Hence, soil in vicinity of Rohi drain is polluted with heavy metals (Pb and Cd) and not suitable for agricultural purposes.

A new durability based classification for argillaceous rocks

Luqman Ahmed* and Mian Sohail Akram

Institute of Geology, University of the Punjab, Quaid-e-Azam Campus, Lahore 54590, Pakistan
**luqman.phd.geo@pu.edu.pk*

The present research proposes a new durability-based classification for argillaceous rocks, which is based on the slaking nature of rocks. A number of slake durability tests were carried out on different units of Murree Formation. The samples were collected along the Islamabad Muzaffarabad Dual Carriageway, Pakistan. A testing program was followed around the year that involved periodic (month-wise) testing on the samples that were exposed to atmosphere and weathering. In the light of various levels of disintegration corresponding to the degrees of weathering, and the outcome of the laboratory test, a new disintegration ratio and durability-based classification is proposed. According to this classification, the studied rocks were grouped into four classes: low, medium, medium-high, and high, whereby low durability reflected weak rock having very low durability against weathering, whereas very high durability represented very resistant rock against weathering and disintegration. This classification can be well-used in the dimension stone industry and in assessing the requirement of surface treatment along the cut and natural slopes in the argillaceous rocks such as those found in the study area.

GIS and remote sensing-based seismicity analysis in and around Azad Kashmir, Pakistan

Tanveer Ahmed[1,2]*, Khaista Rehman[1], Muhammad Shafique[1], Wajid Ali[1] and Waqar Ahmad[1]

[1]National Centre of Excellence in Geology, University of Peshawar, Pakistan
[2] GIS and Space Applications in Geosciences (GSAG), National Centre of GIS and Space Applications (NCGSA), Institute of Space Technology, Islamabad, Pakistan
**tanveergeologist13@gmail.com*

The current study focuses on identifying earthquake potential areas in the study region using an integrated remote sensing and Geographical Information System (GIS) technique. Sentinel-2 and Shuttle Radar Topography Mission (SRTM) satellite data, past earthquake data, and fault data are utilized in this approach. Significant earthquake-related parameters were identified, and relative input thematic data layers (digital elevation model, slope, magnitude of earthquake, epicenter location, lineaments, faults, and distance to active faults and epicenter) were constructed. A numerical ranking scheme was used to assign a rank value to each factor for the appraisal of the earthquake potential index (EPI) map for the study region using data integration in GIS. The study region is divided into four potential classes in the final earthquake potential index map: high (Epi=6.5-8.1),

moderate (Epi=5-6.5), low (Epi=3-5), and extremely low (Epi=1.2-3). The earthquake potential map created for the region was compared to earlier seismic hazards maps created using standard earthquake-based approaches. In comparison to previous methodologies, the application of numerous parameters and implementation of the recommended method in the research region elucidates its good and detailed estimation of earthquake potential areas.

Heat induced structural changes in palygorskite, sepiolite and smectite for aflatoxin B1 adsorption

Saba Akbar[1]*, Mohammad Saleem Akhtar[1], Ahmad Khan[1] and Youjun Deng[2]

[1] Institute of Soil and Environmental Sciences, PMAS-Arid Agriculture University, Rawalpindi, Pakistan

[2]Department of Soil and Crop Sciences, Texas A&M University, College Station, Texas, USA

**syedasaba101@gmail.com*

Smectites are an effective binder for aflatoxin in aqueous suspensions but are suspected to adsorb essential nutrients, vitamins and proteins in the gut non-selectively. Palygorskite and sepiolite act as a molecular sieve and may serve as alternatives or compliments to smectites. The specific objective was to determine the heat treatment's effect on structural characteristics of palygorskite (Pal_PK, Pal_CN), sepiolite (Sep) and smectite (Sm-37GR) and the consequent effect on aflatoxin B1 adsorption and selectivity. The selected clay minerals were heat treated at 200, 400, 500 and 600°C and characterized for any phase and structural changes by X-ray diffraction and IR. Comparative aflatoxin B1 adsorption was determined in aqueous and simulated gastric fluid as the equilibrium solutions. The clay structures irreversibly collapsed in all the clays with heating at 400°C and above with zeolitic and coordinated water disappearing progressively in the fibrous clays. The smectite had the greatest maximum aflatoxin B1 adsorption of all the clays. The estimated adsorption capacity of the clays for aflatoxin B1 followed the trend: Sm-37GR > Pal_PK > Sep > Pal_CN. Sepiolite had greater binding strength for aflatoxin B1 than all the other clays. With intact clay structure heating induced negligible effect on aflatoxin B1 adsorption by the fibrous clays while in the smectite Sm-37GR adsorption increased with heating at up to 250°C. Heat induced folding and structural collapse that had occurred at 400°C caused an abrupt decline in aflatoxin B1 adsorption irrespective of the clay type. In the simulated gastric fluid, the decline in aflatoxin B1 adsorption due to pepsin competition was 25-30% in the sepiolite and 52-60% in the smectite while it remained unaffected in the palygorskite. Palygorskite and sepiolite though have had lower maximum adsorption capacity for aflatoxin B1 than the smectite but also have had lower adsorption for pepsin therefore, may both prove effective as feed additives.

Synthesis and application of egg shell biochar for As (V) removal from aqueous solutions

Asma Akram*, Nida Zafar, Muhammad Bilal Shakoor and Sajid Rashid Ahmad

College of Earth and Environmental Sciences, University of the Punjab, Lahore 54000, Pakistan
**asmakhanasmakhan230@gmail.com*

Water is the most fundamental natural resource without which there will be no life on earth. Water quality and quantity have been declining during the last few decades particularly due to several natural climatic changes. Events such as weathering, windstorms, flooding, etc along with different anthropogenic activities keep on worsening the water quality by adding numerous pollutants including toxic heavy metals. Arsenic, which has been classified as a carcinogen is continuously becoming a part of groundwater, which is a major source of drinking water in most parts of the world. Moreover, arsenic in water bodies has increased to toxic levels and become a major issue worldwide. Among various treatment methods, the removal of As from polluted water with low-cost and environmental-friendly sorbents such as biochar is considered a very promising technique nowadays. In an experiment, the treatment of As-contaminated water using eggshell biochar was studied. Various parameters affecting the sorption, such as pH, contact time, sorbent dose, As (V) concentration, and the effects of anions, were also examined. The results revealed that at a pH of 4.5, maximum sorption of 6.3 mg g−1 was observed, and the As (V) removal was 96% with an As concentration of 0.6 mg L−1 and a sorbent dose of 0.9 g L−1. At a contact time of 2 h (120 min), maximum sorption of 6.3 mg g−1 was noted with a removal percentage of 96%. The sorption of As (V) was obtained at an optimal sorbent dose of 0.9 g L−1. The SEM-EDS data illustrated that biochar consisted of a large number of active sites for As (V) adsorption, and As appeared on the biochar surface after the sorption experiments. Moreover, XPS analyses also confirmed the presence of As (V) on the biochar surface after treatment with As-contaminated water. In a nutshell, the results of this study demonstrate that eggshell biochar has notable efficiency in the removal of As (V) from aqueous solution and that eggshell biochar could be a cost-effective and environmental-friendly sorbent for the treatment of As(V)-contaminated water, specifically in developing countries. On the contrary, other Physico-chemical methods for the removal of arsenic are proved to be very less efficient and non-eco-friendly as compared to the usage of biochar or organic biosorbents.

Hydro-geochemical implication of Siwaliks Horizon of Bhimber and adjoining areas of Azad Jammu and Kashmir

Iftikhar Alam[1], Huma Shakoor[2]* and Sajjad Ahmad[3]

[1]AEMC, REO Peshawar, Pakistan
[2]International University of London LGS, Pakistan
[3]Geological Survey of Pakistan (GSP), Quetta, Baluchistan, Pakistan
**humashakoor85@gmail.com*

The Southeastern Kashmir is an integral part of the Himalayan foreland basin and mainly composed of late Cenozoic sediments of the continental origin. Tectonic and sedimentary evolution of the study area reveals that the basin's architecture was constructed during the lower middle Tertiary of the early Neogene by frontal off scrapping of coarse to medium-grained sediments derived from the northern Indian plate and Island arcs as interactions deposits. These clastic deposits mainly composed of Siwalik Group sequence. The outcropping clastic sequence discloses the composite continental fluvial environments of the region. Rapid uplift and compressional tectonics brought the substrate over the Siwaliks compensation depth soon after the basin was formed. The sediment delivery system to the basin was probably re-routed subsequent to instigation of subduction of the Indian plate beneath the intraoceanic Island arcs. Hydro-geochemical equilibrium evaluation of the area has been established by analyses of 71No of water samples collected from different sources. All these samples have been analyzed for physicochemical properties such as pH (acidity and alkalinity), Eh (oxidation reduction potential), TDS (salinity) and Temperature at the sampling site. Detailed chemical analyses have been done in the lab. The samples have been treated for their mean, Median and Standard deviation by means of SPSS program. The pH values of water samples of the study area are somewhat acidic to slightly alkaline and are ranging from 6.80 to 8.84. The Mode (most common value) of pH is 7.08 and Median is 7.45 that is weakly alkaline. The pH distribution and TDS concentration in the ground water is normal. The mean TDS concentration is 333.80mg/l. The water quality of area is complex and observed the concentration of NaHCO3, CaHCO3, NaCaHCO3 and CaMgHCO3.

Geochemical investigation and up-gradation of coal deposits from Khyber Pakhtunkhwa, Pakistan

Liaqat Ali, Mohibullah Khan* and Sarfraz Khan

National Centre of Excellence in Geology, 25130, KP, Pakistan
**mohibgeo86@yahoo.com*

The current research provides an excellent case study for geochemical composition and up-gradation of coal from Akkakhel, Akhorwal and Shiekhan areas in order to improve its quality. Data was generated using advanced techniques such as Atomic Absorption, Elemental Analyzer and Froth Floatation etc. Results of geochemical analysis indicated major (Fe, K, Na, Mg, Ca and Mn) and trace (Ag, Co, Ni, Cd, Cr, Cu, Zn and Pb) elements and Sulphur with relatively high values, when compared with known coal deposits of the world. The presence of these elements has severely affected the quality of coal. However, the problem can be overcome by using Froth Floatation technique, wherby the ash and sulfur contents were reduced to a greater extent. The optimum process parameters established were at -140 mesh (105 μm) particle size, 20 % solids in floation pulp and pH value of 9. Under these conditions ash was reduced from 40.6% to 13.8% (66 % reduction) and sulfur from 3.97 to 1.57% (60.45 % reduction), while the calorific value was enhanced from 7070 kcal/kg to 7963 kcal/ kg (13% enhancement) in the coal samples of Akkakhel area. In the coal samples of Akhorwal area, ash was reduced from 35% to 18.16% (48.11 % reduction) and sulfur from 6.31 to 3.51% (44.37 % reduction) while the gross calrific value was enhanced from 5500 kcal/kg to 6308 kcal/ kg (14.69% enhancement). Similarly, in the coal samples of Shiekhan area, ash was reduced from 41.6% to 20.1% (51.68% reduction) and sulfur from 3.1% to 1.5% (51.61% reduction) while the calorific value was enhanced from 3795 kcal/kg to 4941 kcal/ kg (30.19% enhancement). It is concluded that the processing techniques applied to the coal samples during the current sudy have prmoising results for up-gradation of the coals of Khyber Pakhtunkhwa and can also be very useful for the industries such as energy, power and cement manufacturing. Moreover, upgradation of coal will result in reduction of sulfur to considerable level that will contribute in reduction of SOX emission to environment and a significant reduction in ash as combustion residue.

Rock mass characterization and recommendations for slope stability of rocks exposed along the Khyber Pass Highway, Khyber Ranges, Pakistan

Mazhar Ali[1*], Ihtisham Noor[1] and Nowrad Ali[2]

[1]National Centre of Excellence in Geology, University of Peshawar
[2]Department of Geology, University of Peshawar
**mazhar.ali939@yahoo.com*

Rocks exposed along the Khyber Pass Highway, District Khyber, Pakistan have been studied in details to investigate their rock mass characterization and other geological parameters. The study area dominantly consists of meta-sediments and sedimentary rocks of Proterozoic and Early Phanerozoic ages and has been divided into four formations i.e., Landikotal Formation, Shagai Formation, Ali Masjid Formation and Khyber Limestone. Discontinuity data survey along the road cut was conducted by following the standard norms of International Society for Rock Mechanics (ISRM-1978) in order to determine the engineering characteristics of the rock mass/rock packages. Each discontinuity including bedding planes, joints, shear zones and faults encountered during the survey has been measured and recorded their persistence, aperture, spacing, roughness, alteration, field Rock Quality Designation (RQD) and Uniaxial Compressive Stress (UCS) and orientation of discontinuities. After establishing the input parameters for the different rock units based on field discontinuity survey and laboratory testing, these rocks have been classified empirically in detail by applying the norms of the well-established rock mass classification systems like Rock Mass Rating (RMR). The rocks of Landikotal Formation and Ali Masjid Formation fall in very poor and poor rock categories, respectively, whereas the rocks of Shagai Formation and Khyber Limestone fall in fair rock category. Finally, with respect to the slope conditions of each formation, the thickness of shotcrete, and length and spacing of systematic bolts, are recommended to prevent slope failure.

Evaluating the impact of prime minster agriculture emergency program for food security and sustainable agriculture in southern Khyber Pakhtunkhwa, Pakistan

Muhammad Ali[1,3]*, Abid Sarwar[1,2], Shazia Gulzar[2], Jabir Nazir[1,3]

[1]National Centre of Excellence in Geology, University of Peshawar
[2]Directorate General, Soil and Water Conservation Khyber Pakhtunkhwa
[3]GIS and Space Application in Geosciences Lab (GSAG), National Centre for GIS and Space Applications (NCGSA)
**aliumarzai@uop.edu.pk*

Agricultural production systems are intricate and interconnected, and they play a significant role in ensuring global food security. Agriculture generates 18.5 percent of the Gross Domestic Product (GDP) of the country, and employs 38.5 percent of the labor force. Despite the fact that high performing agriculture has a significant role in the economic growth and poverty alleviation, it still ranks backward. The agricultural sector's performance has fallen short of expectations over the last decade, owing to stagnant productivity of major crops. The major crops (wheat, sugarcane, rice, maize, and lentils) have largely remained unchanged in terms of cropped area. Climate change is also posing a serious threat to the agriculture sector of Pakistan, threatening the water supply and food security. Because of its importance in achieving food security and sustainable farming livelihoods, groundwater usage is a key policy domain in developing countries. Pakistan agriculture is relying on the Indus River basin, which is experiencing severe water scarcity as a result of changing climate. Water and food security in the country are threatened by poor irrigation techniques and a lack of policy reforms are major threats to Pakistan's water and food security. The government's goal is to boost agricultural production, therefore, the Prime Minister's Agriculture Emergency Program (PMAEP) was launched in 2018. The key objectives of the project are; to bring maximum non-cultivable land to best agriculture land, to conserve rainwater and to recharge aquifer. Water Conservation in rainfed areas of the province is a huge project under the PMAEP, where Soil and Water Conservation department constructed 1000 different structures to harvest rainwater. The purpose of this study is to find out the impact of water conservation structures in the region after the PMAEP, and to find out how much non-agriculture land was transformed to agriculture land. Bannu and DI Khan Divisions were taken into consideration where the ground water potentiality was checked using multi-influencing factor (MIF) approach in GIS environment and supervised classification algorithm were used to determine the agriculture land use changes in the proposed study regions. Around 560 water recharge facilities were constructed in Southern Khyber-Pakhtunkhwa including; check dams, gullies, water ponds, water reservoirs and earthen ponds that can conserve rainwater, and quickly recharge the aquifer. In DI khan and Kohat regions, 5 Watershed were constructed. The PMAEP have a positive role in groundwater recharge, future water availability and food security. Aa a result of

this program, a total of 220 hectare scrub land were converted to agriculture land in different micro watersheds, while different slope areas were converted to terrace farming for best agriculture production.

Estimation of annual groundwater changes from InSAR-derived land subsidence

Muhammad Zeeshan Ali

Department of Civil Engineering, International Islamic University, Islamabad, Pakistan
**zeeshanaliktk1992@yahoo.com*

Groundwater is a highly valuable resource that represents almost 99% of all the fresh water on earth and is a vital resource for domestic water supply and agriculture in many regions of the world. The unmanaged exploitation of groundwater has a highly significant impact on society and the economy which has led to deleterious land subsidence, reservoir depletion, and saline intrusion. Understanding the extent and quantity of groundwater drawdown is critical for developing a mitigation strategy for water management. It has become common practice for using of spatial and temporal water-level data in groundwater and subsidence modeling studies to estimate the total compaction (subsidence) caused by the observed water-level changes, which are dependent on the hydrologic and poromechanical properties of the aquifer system. In this study, interferometric synthetic aperture radar (InSAR) derived from Sentinel-1 imaging is used to estimate surface deformations in the Choshui river alluvial fan, Taiwan, between 2016 and 2018. This study illustrates that the model can be used for the spatial estimation of groundwater drawdown using InSAR-based deformation data. Spatial regression (SR) is applied to estimate the annual groundwater drawdown with the R-square: 0.96 (low model residuals: -1.3 to +0.8 m), which is shown to be superior to a traditional one. Moreover, the SR model is shown to catch the trend of annual predicted drawdown, i.e., the R-square is 0.75 (predication residuals: -1.2 to +2.8 m). Furthermore, this study demonstrates the potential of the satellite-based groundwater drawdown map prediction without requiring detailed groundwater-level observations.

Effects of biochar on the bio-accessible fractions and uptake of organochlorine pesticides (OCPs) and microbial community in contaminated soil

Neelum Ali[1,2,3], Sardar Khan[1,2,3*], Huaiying Yao[1,2,4] and Juan Wang[1,2]

[1]Key Laboratory of Urban Environmental Processes and Pollution Control, Ningbo Urban Environment Observation and Research Station-NUEORS, Chinese Academy of Sciences, Ningbo, 315800, People's Republic of China
[2]Key Laboratory of Urban Environment and Health, Institute of Urban Environment, Chinese Academy of Sciences, Xiamen, 361021, People's Republic of China
[3]Department of Environmental Sciences, University of Peshawar, Peshawar 25120, Pakistan
[4]Research Center for Environmental Ecology and Engineering, School of Environmental Ecology and Biological Engineering, Wuhan Institute of Technology, Wuhan 430073, People's Republic of China
**sardar.khan2008@yahoo.com*

Biochar has been widely studied as a soil amendment but its effects on organochlorine pesticides (OCPs) and soil microbial community remain unclear. This study investigates the effects of selected biochars such as soybean straw biochar (SBBC), sewage sludge biochar (SSBC), peanut shells biochar (PNBC), rice straw biochar (RSBC) on the bioaccessibility of OCPs in contaminated soil and their consequent accumulation into vegetables. The impact of these soil amendments on the soil microbial community was also evaluated with Illumina next generation sequencing technique. The results indicated that the application of SSBC (52%), PNBC (51%), RSBC (60%), and SBBC (47%), markedly reduced the bioaccessibility of ΣOCPs in soil and uptake in vegetables. Health risk assessment revealed that biochar addition significantly reduced cancer and non-cancer risks for OCPs related to vegetable consumption. Moreover, the results of high throughput sequencing indicated considerable differences in soil microbial community structure between the treatments that were determined by differences in the relative abundance of microbes. The relative abundances of Chloroflexi, Acidobacteria, Verrucomicrobia and Nitrospirae decreased with the addition of biochar. However, biochar application increased the relative abundance of Proteobacteria, Actinobacteria, Bacteroidetes, Planctomycetes, Gemmatimonadetes, and Firmicutes, though the increase of these phyla was strongly dependent on the type of feedstock/biochar applied.

What controls the deadliest rockfalls along the Jaglot-Skardu Road: Lithology, Seismicity or Climate?

Sajid Ali* and Tanveer Ul Haq

COMSATS University Islamabad, Abbottabad Campus, University Road, Tobe Camp, Abbottabad
**sajidsikander@cuiatd.edu.pk*

The Jaglot-Skardu Road (JSR) connects Skardu with other parts of the region and country through the Karakoram Highway. This 170 km long road passes through deeply incised Indus Valley and rugged topography. Geology along the road is characterized by mostly metamorphics (quartzites, phyllite, schists and gneisses), quaternary deposits (pre-historical landslide deposits) and active faults. These faults are responsible for frequent moderate shallow earthquakes in the area. The area lies in the arid climatic zones with flimsy precipitation. However, the slopes along the road at numerous locations are unstable and resulted into frequent landslide activity. This study reports multiple susceptibility mapping techniques through GIS, SPSS and FlowR software to determine the control of these rockfalls. The performance of different models was compared. The FlowR was found useful in terms of finding the potential failure sites. Seismicity was found main triggering factor with locations mainly controlled by lithological variations. In the Rondu area, differential erosion in old landslide deposit has left large boulders highly susceptible to failure. Furthermore, for road expansion, slope was excavated without proper design.

Cross valley barriers in the Kaghan-Naran valley, NW Himalaya, Pakistan: control, stability and landscape evolution

Shah Zeb Ali and Sajid Ali*

COMSATS University Islamabad, Abbottabad Campus, University Road, Tobe Camp, Abbottabad
**sajidsikander@cuiatd.edu.pk*

The Himalayan region is one of the global landslide hotspots. We studied natural barriers on the Kunhar River, situated in Kaghan-Naran valley, Northwest Himalaya, Pakistan. The area lies in the active Indus-Kohistan Seismic Zone, characterized by recent major earthquakes (2005 Kashmir; M = 7.6). The Muzaffarabad Fault and Hazara Kashmir Syntaxis controls the seismicity in the area. Both climate and seismicity are considered responsible for the landslide activity in the area. Furthermore, these slope failures act as a barrier in the narrow gullies and also have impact on the landscape and sediment flow rate. Our research has discussed these landslide barriers and different impacts on landscape evolution. We found some interesting features and evidences related to natural damming in area. These features were not been studied before. Their

interpretation by field work, data and remote sensing has explained landscape development in the study area. The methodology of our research work involves the interpretation of satellite imagery to locate possible landslide barriers on the basis of geomorphology. After locating barriers, a tentative inventory of these barriers (landslides, fans and moraines) was prepared. Afterwards, their presence was validated through knick points and river thalweg. A Comprehensive inventory of these barriers for detailed analysis. i.e., barriers effect on landscape and valley sedimentation, stability indicators through morphometric analysis, and geological and structural control of the area, was completed. The stability indices proposed in the literature are based on the morphometric data, which is quite easy and fast to collect. The stability indices of the studied cross valley dams explained the reasons behind the stability of the Lulusar, Burawai, and Saif ul Maluk. However, the Domel is uncertain and Kawai is unstable dam. So, according to research and calculations, three dams are stable, one dam is uncertain and one dams is unstable in our research area.

Facies, sedimentary stuctures in Sharaban Formation, Neoproterozoic Kirana Complex, Sargodha, Punjab, Pakistan

Syed Haroon Ali[1*], Bilal Ahmad[1], Muhammad Hamza[1], Ali Wahid[2], Noureen Shoukat[3] and Yasir Bashir[4]

[1]Department of Earth Sciences, University of Sargodha, Sargodha, Pakistan.
[2]Institute of Geology, University of Azad Jammu and Kashmir, Muzaffarabad, AJK, Pakistan
[3]Department of Geosciences, Universiti Teknologi PETRONAS, 32610 Tronoh, Perak, Malaysia
[4]School of Physics, Universiti Sains Malaysia, Penang, Malaysia
**haroon.ali@uos.edu.pk*

The Sharaban Formation lies in north-eastern part of Kirana hills in Sargodha, Punjab Pakistan. Here, metasedimentary rocks were documented, with minor volcaniclastics interbedded. There are four dominant facies found in the studied area which are meta-sand stone, meta-conglomeratic sandstone, limestone and some quartz veins. Differences in the slumping behavior in terms of sedimentary examples are described and modelled. Various types of sedimentary structure are found like graded bedding, cross bedding, convolute structure, flame structure, syn-sedimentary deformation structure, folds and faults, chevron-type folding, ball and pillow structure, chaotic bedding, imbrication etc. Their depositional environment is from low energy coastal environment to possibly braided river system, while limestone could have deposited in lagoonal setting. The sedimentary structures might show a paleo-landslide in Neoproterozoic rocks of Indian Shield elements.

Efficacy of plant growth-promoting rhizobacteria and acidified organic amendment to remediate Cd contaminated soil by *Brassica juncea* L.

Sana Ashraf* and Sajid Rashid Ahmad

College of Earth and Environmental Sciences, Quaid-e-Azam Campus, University of the Punjab, Lahore-Pakistan
**sana.cees@pu.edu.pk*

Heavy metal contamination of soil is an alarming environmental dilemma all over the world. With increasing industrialization, it is the need of time to develop low-cost and eco-friendly remedial techniques for heavy metal contaminated soil. Phytoremediation is an emerging technique to remove heavy metals from contaminated soil for environmental sustainability. In the present study, Brassica juncea L. was used for phytoextraction of cadmium (Cd) form contaminated soil. The Cd resistant plant growth-promoting rhizobacteria (PGPR) were isolated and best strain (CTB5) was selected for seed coating to be used in pot experiment. To enhance the bioavailability of Cd, cow dung (CD) was acidified by mixing with elemental sulfur (S°) and molasses and also bioaugmented with sulfur oxidizing bacteria (SOB). Pot experiment was conducted for 60 days under Cd spiked and normal soil for Brassica juncea L. with six treatments (T1: Control; T2: 0.5% acidified organic amendment; T3: 1% acidified organic amendment; T4: PGPR coated seeds of B. juncea; T5: 0.5% acidified organic amendment + PGPR coated seeds of B. juncea; T6: 1% acidified organic amendment + PGPR coated seeds of B. juncea). The results have shown that T6 treatment caused maximum increase in shoot and root Cd concentration of Brassica juncea (164% and 102%, respectively) as compared to respective untreated control. Similar trend was observed in bioconcentration and translocation factors. The results suggest that combine application of plant growth-promoting rhizobacteria and acidified organic amendment improved the antioxidative defense mechanism of Brassica juncea L. and could be effective for phytoremediation of Cd contaminated soil.

Effects of heat treatment on the granitic rocks from North Pakistan

Abdul Rahim Asif[1]*, Muhammad Sajid[2] and Waqas Ahmed[1]

[1]National Centre of Excellence in Geology, University of Peshawar
[2]Department of Geology, University of Peshawar
**abdulrahimasif@yahoo.com*

In the recent years, high-temperature rock mechanics have received a lot of attention, notably in projects like geothermal development, nuclear waste disposal, oil and gas storage, and coal mining. Because of the intricacies of constituent minerals of granite and their varied thermal coefficients, mineral expansion at high temperatures causes considerable levels of thermal stress

between minerals, resulting in crack formation within rock and adversely impacting rock mechanical properties. This study is proposed to identify the physical and mechanical properties of texturally and mineralogically distinct granitic rocks from north Pakistan, before and after high-temperature treatment (i.e., 25, 100, 200, 400, 600, 800, and 1000 °C). Subsequently, the influence of high temperatures on its textural behavior, intrinsic connections, appearance, mineral stability, Ultrasonic pulse velocity, and strength characteristics of studied granites have been determined. The results reveal that the thermal treatment reduces the strength of granitic rocks while increasing their porosity. The physical and mechanical properties including Ultrasonic pulse velocities, Schmidt rebound values, and uniaxial compressive strength decrease with increasing temperature. With increasing temperature, the frequency and magnitude of thermal cracks in granites increases, directly altering the physical and mechanical properties of these rocks.

Investigation of shape and size effect on the mechanical properties of the Granitic rocks from North Pakistan

Abdul Rahim Asif[1]*, Muhammad Sajid[2] and Waqas Ahmed[1]

[1]National Centre of Excellence in Geology, University of Peshawar
[2]Department of Geology, University of Peshawar
**abdulrahimasif@yahoo.com*

The behavior of a rock in terms of its physical and strength attributes has an impact on any design or construction built on it. In large-scale structures and engineering groundworks, accurate assessments of rock strength are critical. The present study aimed to investigate the dependency of shape and size on the strength parameters of Granitic rocks. Eight different varieties of felsic intrusive igneous rock from North Pakistan were tested. For the preparation of different shapes and sizes of specimens, four bulk samples from each rock were selected. The shape effect was studied using six different r-values: 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0. Specimens with diameters of 42 mm, 54 mm, 64 mm, 84, and 100 mm were used to study the size effect. Physical and mechanical properties including specific gravity, porosity, water absorption, dry density, ultrasonic pulse velocity, Schmidt rebound, and uniaxial compressive strength were determined. Young's modulus and Poisson ratios were also derived from the results. Data analysis reveals the maximum strength at a limit value of shape ratio i.e., 2.5, and afterward, the strength becomes nearly equal or decreases for higher shape ratios. Similarly, the lower diameter/width gives maximum strength in comparison to the greater values of diameter/width.

Future impacts of exacerbating disasters of volcanic eruptions under climatic influence, their models and hazard assessment

Anam Aslam

College of Earth and environmental sciences, University of the Punjab, Pakistan
iman07518@gmail.com

The rapid increase in climate change tends to arise numerous hazards which occurs naturally in the environment, one of them is the volcanic eruption while other hazards include wildfires, floods, landslides and drought that occurs simultaneously. This chain of events in a system has negative impact on related systems and for this reason, the future indication of the exacerbating disasters are much intense than eruptions alone. Different volcanologists and other disaster management professionals, provides the successful feedback by collecting the information of past patterns and describe the current volcanic events by using that information. It permits the plan of action which involves four steps that is preparation, monitoring, evacuation, and recovery. These combined hazards will be very difficult to predict in the future because of the complications in the familiar patterns of events in past. The social science outlook into disaster planning and management should be integrated more intentionally by the volcanologists and also expand the information about non-volcanic hazards for the acknowledgement of future events. During the volcanic eruption, several gasses releases, one of which is the sulfur dioxide that is basically the secondary pollutants and form different products such as sulfate aerosols, acid rain and particulate matter. These sulfate aerosols are basically the extremely small solid or liquid particles or droplets that are suspended in the atmosphere. In this way, the energy radiations reaches from the sun to the surface of Earth become scattered causes the reduction in the arrival of energy on the earth which will impact the major net production of solar energy. A model is used named as energy-balance-based climate model for the confirmation of the prime data of paleoclimatic and paleovolcanic data and it is also used for the calculation of quantitative effects in this model. The remarkable advancement in the paleovolcanic records helps us to understand the role of volcanic activities in the climate change during the current decade. These improvements includes: 1) in the climatic system, the preferable understanding of the feedback mechanism in order to respond to the volcanic disruptions.2) the radiative impact of volcanic eruptions up to a couple of years and the investigation and relationship between super-eruptions and climate variations for a long period of time.3) Due to the emission of greenhouse gases by anthropogenic activities, global warming happens while the role of volcanic eruption in this matter is limited. Moreover, there is need for further research or investigation for introducing the sulfur dioxide into the stratosphere and evaluation of this system by the geoengineering theory while this system is based on the cooling effects of stratospheric volcanic eruption and also pose severe irreversible results.

Nature based solutions: A sustainable approach to climate change

Sarfa Aslam* and Sania Nawaz

University of the Punjab, Pakistan
**sarfaaslam@gmail.com*

To support sustainable development and address the challenges of society, nature based solutions (Nbs) that are capable to address the loss of biodiversity and climatic change are becoming popular in modern era. Nature based solutions include the management of land, ecosystem conservation and restoration activities and providing health facilities to human. Despite the fact that nature based solutions can benefit humans and nature as well but recently more attention is on the plantation of trees for carbon sequestration which is sidetracking the idea of eliminating the use of fossil fuel and also the plantation of forests on one hand as a mitigation measure of climate change can form carbon rich ecosystem. We need researchers, policymakers and practitioners to collaborate and trade-offs regarding Nbs and urge them to follow four major rules so that Nbs can provide sustainable benefits to society.1. The fast elimination of fossil fuels cannot be replaced by Nbs. 2. Nbs not only cover forests but also a wide range of other ecosystems in oceans and on the land surface.3. The implementation of Nbs needs the participation of local and indigenous communities 4. Nbs should be designed clearly for the benefits of the biodiversity. These rules help in the development of an efficient and resilient Nbs that will help us describe the challenges of climate change, loss of biodiversity and thus lead towards a sustainable nature and future.

Lithofacies, petrography Hydrogeochemistry of drinking water resources and their relationship to the surrounding geology along Chat-Pat and Gujjar Abad villages, District Lower Dir, Khyber Pakhtunkhwa

Sana Azhar[1]*, M. Naveed Anjum[1], Saba Shaheen[2], Waqas Ahmad[2], Rizwanullah[2] and Muhammad Qasim[2]

[1]NCE in Geology, University of Peshawar
[2]Department of Geology, University of Peshawar
**sayeda.sana95@gmail.com*

This study investigates drinking water quality and health risk at Chat Pat and Gujjar Abad villages, Lower Dir, Khyber Pakhtunkhwa, Pakistan. For this purpose, physiochemical characteristics were determined using water samples (n=20), collected from wells, springs and tanks whereas geochemical and petrographic analyses were carried out for assessing the impact of Geology on water quality of the study area. This study revealed that physical parameters such as pH (7.4 to 7.8), Turbidity (0.28 to 1.23 NTU) and Total dissolved solid (124 to 595 mg/L) lie within the permissible limits as recommended by World Health

Organization (WHO) except the electric conductivity (830 µS/cm). Similarly, the chemical parameters such as Sulphate (7 mg/L to 60 mg/L), Chloride (7.5 mg/L to 75 mg/L), Sodium (13 mg/L to 95 mg/L) and Potassium (3.1 mg/L to 9.9 mg/L) concentrations also fall within the permissible limits as suggested by WHO whereas the fluoride (1.69 mg/L to 2.22 mg/L) and nitrates contents (0.8 mg/L to 12.6 mg/L) exceeds the permissible limits. Among heavy metals the lead, chloride, iron, zinc, magnesium, nickel and copper concentrations lie within permissible limit except chromium and lead (i.e., 0.153 mg/L and 0.08 mg/L respectively). The anomalous values of fluoride are attributed to contamination from Chakdara Granitic Gneiss whereas nitrates contamination is because seepages of dissolved fertilizers from the surrounding fields. The detrimental concentrations of chromium and lead added could be because of the surrounding calcareous-marble and gneissose rocks. Water borne diseases such as dental fluorosis, skeletal fluorosis, gastroenteritis, dysentery, diarrhea and viral hepatitis are reported among the inhabitants of the study area. There is dire need for spreading awareness among local population to stop the drinking groundwater from the existing sources. Farmers should be properly trained to avoid the overuse of agrochemicals so as to avoid water contamination. It is, further, recommended that government in collaboration with private sector, should install water filtration plants at different accessible locations for providing clean treated water for public.

Spatio-temporal landslide inventory and susceptibility assessment using Sentinel-2 images in the Himalaya Mountainous region of Pakistan

Alam Sher Bacha[1]*, Muhammad Shafique[1,3], Harald van der Werff[2], Mark van der Meijde[2], Mian Luqman Hussain[1] and Sohail Wahid[1,3]

[1]National Centre of Excellence in Geology, University of Peshawar, Peshawar, Pakistan
[2]Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente, The Netherlands
[3]GIS and Space Applications in Geosciences (GSAG) Laboratory, National Centre of GIS and Space Applications in Geosciences, Institute of Space Technology, Islamabad, Pakistan
**mian.alamsher@gmail.com*

The 2005 Kashmir earthquake has triggered widespread landslides in the Himalayas Mountains in northern Pakistan specifically in the Muzaffarabad and surrounding areas, some of these landslides are still active and are posing a significant risk. Landslides triggered by the 2005 Kashmir earthquake are broadly studied, nevertheless, no one has observed their spatio-temporal landslide susceptibility. This is partially a result of the limited availability of high temporal resolution remote sensing data. We present a semi-automated technique to use the Sentinel-2 MSI data for co-seismic landslide detection, landslide activities monitoring, spatio-temporal change detection and spatio-temporal susceptibility mapping. Time series of the Sentinel-2 MSI images for the period of 2016-2021

and ALOS PALSAR DEM are used for semi-automated landslide inventory map development and temporal change analysis. Spectral information combined with topographical, contextual, textural and morphological characteristics of the landslide in Sentinel-2 images are applied for landslide detection using object-based image analysis. Subsequently, a spatio-temporal landslide susceptibility maps are developed utilizing the weight of evidence statistical modeling with seven causative factors, i.e., elevation, slope, geology, aspect, distance to fault, distance to roads and distance to streams. Geology, road and slope are observed most influential factors for landslide occurrences with the highest weight calculated from the weight of evidence modeling. The results reveal that landslide numbers increased from 432 to 468 in 2016 and 2021 respectively. The coverage of areas of relatively high susceptibility class has increased from 18.72 km^2 to 28.55 km^2 in the study area.

Origin of ruby and spinel in marble from Karakoram metamorphic complex, Gilgit-Baltistan, Pakistan: Constraints from geochemical and C-O isotopic systematics

Sher Sultan Baig[1,2]*, Chuandong Xue[2], M. Qasim Jan[3], Hawas Khan[1], Amjad Hussain[4] and Masroor Alam[1]

[1]Karakoram International University, Gilgit-Baltistan 15100, Pakistan
[2]Department of Earth Sciences, Kunming University of Science and Technology, Kunming 650093, China
[3]National Centre of Excellence in Geology, University of Peshawar, Peshawar, KP, Pakistan
[4]China University of Geosciences Wuhan, 430074, PR China
**sher.sultan@kiu.edu.pk*

The Karakoram Metamorphic Complex (KMC) in Hunza largely comprises pelitic schists and gneisses with marble layers, and sheets of amphibolite and granitic rocks. The pelitic assemblages range from chlorite grade near the Shyok suture in the south to sillimanite grade near the Karakoram batholith in the north. The marbles have been investigated through field work, microscopic studies, geochemistry, C-O isotopes, and EPMA analysis. Based on petrography, texture, color and occurrence of particular gem, the marble units have been divided into five main types which display similar metamorphic textures. The marble beds range from 0.1 to 300 m and mineralization is confined to <10m thick impure dolomite layers. Gem quality ruby occurs in 0.1– 5 cm thick pelite-mixed layes and shear-bands that are parallel and sub-parallel to the main rock deformation trend. Paragenesis observed in the ruby marbles comprise ruby+phlogopite±biotite±muscovite±spinel±pargasite±apatite and ruby and/or spinel+phlogopite± pargasite±diopside±anorthite±sulphide±chlorite±margarite, and siliceous dolomite is represented by forsterite+diopside+calcite+dolomite. Mineral parageneses in the associated metapelites suggest that the marbles developed during Barrovian-type metamorphism. The Hunza area pelites

underwent maximum PT conditions of 670oC, 5.5 kbar [1], but 600-650oC, 5.5-6.5 kbar conditions were suggested for the formation for the ruby. These PT conditions, along with the general characteristics of ruby mineralization, are similar to those of Neelum valley and Kaghan ruby. The marbles from Hunza display restricted ranges in δ18O (from 23.4 to 28.4‰ relative to SMOW) and δ13C (from 1.5 to 4.8‰ relative to PDB) that reflects marine carbonate affinity.

Effect of sepiolite on the growth of spinach in cadmium contaminated soil

Saqib Bashir[1*], Safdar Bashir[1], Sanaullah Yasin[1], Allah Bakhsh Gulshan[2] and Javaid Iqbal[3]

[1]Department of Soil and Environmental Sciences, Ghazi University, Dera Ghazi Khan, Pakistan
[2]Department of Botany, Ghazi University, Dera Ghazi Khan, Pakistan
[3]Department of Agronomy, Ghazi University, Dera Ghazi Khan, Pakistan
**saqibbashir416@yahoo.com*

Soil pollution because of cadmium (Cd) presence is recognized a serious problem which is affecting sustainable environment around the globe. Thus, solubility of Cd in polluted ecosystem can be curtailed using the soil amendments which will eventually lessen its translocation from soil to plants. For this purpose, a pot experiment was executed to assess the influence of sepiolite from 1% to 3% on Cd mobility and its uptake in spinach shoot root parts. Soil chemical properties (pH and EC), soil Cd bioavailable pool, Cd buildup in plants tissue and Cd sorption mechanism were estimated. Results were observed that soil pH was improved from 0.4 to 0.8 units when sepiolite dose was increased from 1% to 3%. Likewise, Cd concentration in bioavailable pool was reduced by 34.3% at 3% rate over control. Furthermore, the substantial decrease in Cd uptake by spinach shoots and roots was estimated by 43.7% and 28.3% at 3% dose level correspondingly. Additionally, the maximum Cd sorption capacity was estimated by 56.3 mg g-1 when sepiolite was incorporated at 3% rate over control. This study suggested that sepiolite has potential to improve Cd stabilization and thereby, decreases its phytoavailable pool in contaminated soil to lessen food security challenge.

Seasonal evaluation of glaciers dynamics and risk analysis using remote sensing technique in Booni Zom valley of Chitral river basin, north Pakistan

Sidra Bibi[1]*, Muhammad Shafique[2] and Neelum Ali[1]

[1]*Department of Environmental Sciences, University of Peshawar, Peshawar 25120, Pakistan*

[2]*National Centre of Excellence in Geology, University of Peshawar, Peshawar 25200, Pakistan*

**sidrasiddique23@gmail.com*

The Hindukush range of northern Pakistan contains large to medium size valley glaciers outside the polar region. These glaciers are continuously subjected to shrinking and retreat due to climate change affecting the water discharge and rise potential risk to the downstream area. The seasonal variation (ablation and accumulation), snout area changes and the associated hazards are posing risks to the population in the Chitral valley in the Hindu Kush range of north Pakistan. The study reported the seasonal status of the glaciers area loss and retreat over 28 years (1990-2018) in the Booni Zom Valley of the Chitral River basin of the Hindu Kush range of north Pakistan. Three glaciers (Khorabhor, Phargam and Gordoghan) from the Hindu Kush range of district Chitral were mapped by using time-series Landsat data (1990-2018) to determine the glacier dynamics and the seasonal changes. The annual climate trend has been estimated by using the non-parametric Mann Kendall test for the mean temperature and total precipitation for the Chitral Met Station. A large variation been has recorded during the ablation and accumulation season with the seasonal average of temperature (15°C) and precipitation (24mm). The results revealed that the glacier area has reduced from 17.67% in 1990 to 15.88% in 2018 showing a recession of 4.72% during the period of accumulation season (winter). The glacier area has drastically decreased from 2015 to 2018, the highest rate (1.69 km²±0.82) has been observed for the Khorabhor, followed by the Phargam and Gordoghan glacier (1.11 km²±0.55 and 0.93 km² ±0.36, respectively). The glacier snout area receded more at an elevation from 3000 to 4000 m asl (above sea level) compared to the high elevation of more than 5000 m and other factors, i.e., aspect, slope, climate, sun-facing angle. The Phargam glaciers with an area <=10 km² have receded significantly (4.59%) than the larger glaciers Gordoghan <17 km² (0.09%), followed by Khorabhor <=15 km² (0.66%). The result of the Risk Probability Model showed that the settlement of Phargam valley situated 9.7 km away from the snout position of the studied glaciers is 62.5% at risk, due to the high rate of the glacier's recessions resulting in the glacial outburst, water storage in the fragile moraine at the terminal area and increasing the water flow in the Chitral River through the environmental effects.

Estimation of amplitude characteristics to identify gas hydrates saturated zones

Muhammad Irfan Ehsan*, Perveiz Khalid, Irfan Raza and Muhammad Yasin Shafique

Institute of Geology, University of the Punjab, Pakistan
**irfan.geo@pu.edu.pk*

As conventional energy resources are depleting and unconventional energy resources are gaining immense intention to overcome energy needs. Gas hydrates is a prominent unconventional energy resources which is gaining intention to overcome energy needs of modern world. In order to identify gas hydrates properly their true seismic signature identification is essential. Numbers of researchers tried to identify gas hydrates by different attributes with their amplitude character. As gas hydrates have different formation pattern they exist as part of grains and as part of fluid and each formation pattern have its own amplitude character. We have tried to estimate seismic signature and amplitude character of gas hydrates when temperature and pressure conditions are varied and methane is leaked from gas hydrates saturated zone. It is observed that computation of amplitude character with AVO provides true understanding to estimate methane leakage from gas hydrates zone. These findings will provide accuracy to identify gas hydrates zone properly.

Short- and long-term volcano–climate interactions

Maryam Ejaz* and Masooma Zahra

CEES, University of the Punjab, Lahore
**maryammejaz@gmail.com*

As global average temperatures rise, understanding the interactions between the atmosphere and the geosphere becomes increasingly essential. The prospect of more frequent volcanic eruptions and thus more frequent volcanic ash clouds cause worries among the general public and the aviation industry. With an emphasis on Iceland and northern Europe, this paper examines the significant mechanisms involved in short- and long-term volcano–climate interactions, revealing a complex interwoven system in which volcanoes directly affect the climate and climate change may indirectly affect volcanic systems. The effect of volcanic inputs into the atmosphere on climate conditions and the converse relationship – that is, how global temperature changes may influence the occurrence of volcanic eruptions – are investigated in this work. Explosive volcanic eruptions can produce surface cooling on regional and global scales by injecting aerosols and tiny ash particles into the stratosphere, as seen in many previous eruptions like the 1991 Pinatubo eruption. Because of more excellent aerosol dispersion and impacts on the meridional temperature differential, the atmospheric effects of large-magnitude explosive eruptions are more noticeable

when they occur in the tropics. Furthermore, due to global warming, deglaciation may alter the frequency of large-magnitude eruptions on a multi-centennial scale. Many conceptual models use Iceland as an example to argue that post-glacial isostatic rebound will dramatically exacerbate decompression melting and that this is now happening beneath Vatnajökull and other smaller Icelandic glaciers. Cryptotephra records from peat and lake sediments across northern Europe show that such a link existed in the past. Such recordings are currently incomplete, with spatial gaps. Because a rise in volcanic activity in Iceland would result in more frequent ash clouds over Europe, affecting aviation and transportation, a better understanding of the relationship between global climate and volcanism will considerably improve our ability to foresee and prepare for future disasters.

Evaluating the applicability of ALEXI model to map spatio-temporal trends of evapotranspiration using remotely sensed Energy Balance approach in Peshawar Basin, Northwest Pakistan

Beena Fahim[1, 2]*, Mohammad Sufyan Qazi[1], Samiullah[3] and Muhammad Ali[1, 2]

[1]National Centre of Excellence in Geology, University of Peshawar
[2]GIS and Space Application in Geosciences Lab (G-SAG), National Centre for GIS and Space Applications (NCGSA)
[3]Department of Geography, University of Peshawar
**pinkyali1988@gmail.com*

Being the major component of the water cycle and energy budget, Evapotranspiration (ET) has profound impacts on hydro-meteorological systems, water management, vegetation, crop growth, soil moisture, droughts and rainfall patterns. ET is also considered the second-largest component of the water balance. It is a dynamic phenomenon with very marked spatio-temporal variations on even a very small temporal scale. Temporally, there might be variation in ET trends even on less than an hour scale. Therefore, spatio-temporal trends and patterns of ET should be evaluated with state-of-the-art techniques and datasets. Customarily, ET is measured by various techniques including; lysimeter, atmometer, scintillometer, evaporation pan, Eddy Covariance, and Bowen ratio. All the aforementioned customary methods have a very small footprint and hence can represent the small area around the point of measurement. Therefore, these methods are not recommended for regional-scale mapping over heterogeneous surfaces, especially in areas with very limited ground-based observatories. With the advent of technological advancement in remote sensing sensors and techniques, these are extensively employed to monitor and map the spatio-temporal trends for vast areas. Satellite products with spectral bands in shortwave, longwave and thermal infrared (TIR) regions are best for designing energy balance algorithms. In this study, the energy balance model, namely ALEXI (Atmospheric Land Exchange Inverse) model was applied to the Landsat 8 data over a large

heterogeneous area of Peshawar Basin, in northwest Pakistan. The modeled results were compared with the data from the evaporation pan installed by the National Agromet Centre Islamabad, Pakistan at the Regional Meteorological Centre Peshawar. Modeled ET has a good correlation with pan evaporation in terms of r (correlation coefficient), RMSD (root mean squared difference) and MBE (mean biased error). For a study period of four years from 2013 to 2016, the model showed a correlation coefficient of 0.81. The model will be further extended to different agroecosystems across Pakistan, in order to check its robustness for areas with different hydro-meteorological conditions.

Pre- and post-collisional sandstone assemblages of the Sulaiman Fold-Thrust Belt, Pakistan: Implications for tectonic evolution

Shazia Fareed[1], Aimal Khan Kasi[2*], Akhtar Muhammad Kassi[1] and Namik Aysal[3]

[1]Department of Geology, University of Balochistian, Sariab Road, Quetta, Pakistan
[2]Centre of Excellence in Mineralogy, University of Balochistan, Sariab Road, Quetta, Pakistan
[3]Department of Geological Engineering, Istanbul University-Cerrahpasa, Istanbul, Turkey
**aimal_kasi@yahoo.co.uk*

Sandstones of the Mesozoic and Cenozoic successions of the western Sulaiman Fold-Thrust Belt (SFTB), Pakistan, were petrologically studied to determine the variations in their compositional and detrital modes. They are categorized into pre-collisional and post-collisional sandstone assemblages. The pre-collisional assemblage was deposited before the collision of Indian Plate with Eurasian Plate. The pre-collisional assemblage is categorized into Wulgai-Mughal Kot, Bibai and Pab sub-assemblages. The post-collisional assemblages were deposited after the initiation of collision and categorized as Ghazij and Urak sub-assemblages. The Wulgai-Mughal Kot sub-assemblage mainly consists of highly quartzose sandstones of the Triassic Wulgai and Upper Cretaceous Mughal Kot formations. The Pab sub-assemblage (Upper Cretaceous Pab Formation) consists of quartzose sandstone with addition of limestone and calcareous fossil fragments. Their detrital mode is craton interior, which is most probably the basement complex of the Indian Sheild rocks. The Bibai sub-assemblage comprises lithic arenite of the Middle-Upper Cretaceous Bibai Formation (Bibai Group), which is predominantly composed of mafic volcanic fragments, having detrital mode of the magmatic arc. The Ghazij sub-assemblage, of the post-collisional assemblage, comprises lithic arenite of the Eocene Ghazij Formation, derived mostly from a recycled orogen, indicating the initial uplift and sedimentation of the older volcano-sedimentary successions of the SFTB. The Urak sub-assemblage comprises lithic arenite of the Miocene Uzda Pusha and Pliocene Shin Matai formations. It is composed of a variety of sedimentary lithic fragments with ample

quantities of quartz and feldspar. It indicates detrital mode of recycled orogen derived from the collision orogen of the SFTB. The shift, in composition, provenance and detrital modes, from the pre-collisional to the post-collisional assemblages indicate initiation of the uplift and sedimentation of the older successions, including the hot spot volcanics of the Bibai Group. The study supports the notion that India-Eurasia collision initiated soon after the Late Cretaceous, resulting in the emergence of the older successions of the SFTB, reaching its culmination in Pliocene.

Work process for pore pressure and fracture gradient forecast from seismic velocities, Balkassar Oil Field, Potwar Sub-Basin, Punjab, Pakistan

Muhammad Fawad[1*], Muhammad Hanif[1] and Khalid Amin Khan[2]

[1]National Centre of Excellence in Geology, UOP, KP, Pakistan
[2]OGDCL, Islamabad, Pakistan
[*]muhammadfawad@uop.edu.pk

The Balkassar field is located in southern Potwar Basin which is a sub basin of Upper Indus Basin, onshore, Pakistan. Tectonically, the study area lies in a compressional regime where reverse faults are observed which make pop up structures. To reduce the risk and problems during drilling a well, the evaluation of underground pore pressure is very important. Estimating pore pressure before drilling is valuable at all levels of exploration and development. Previously extrapolation of pore pressure has been done in one dimension through compilation of logs of closely spaced wells. Now the prediction of pore pressure is carried out in two-dimension and three-dimension cubes by utilizing seismic velocities. For all intents and purposes to arrange, predrill estimation of pore pressure gradient and fracture gradients are important (e.g., for selection of right mud weight). The pore pressure gradient and fracture gradients delineate the lower and upper parameters of mud weight respectively. 2D seismic lines were interpreted by correlating with well data of BLK-OXY-01. Three horizons on seismic lines were studied and marked. Three prominent faults were identified and interpreted on the seismic sections and one normal fault was observed in the basement. The contours of the horizons (Chorgali, Patala and Khewra formations) are trending north-east to south-west. The contours around the faults show reverse faults forming pop-up structure i.e. north-west and south-east dips and north-east and south-west strike. Velocity modeling is used to convert time section into depth section. Low velocity values in the central part of the average velocity contour maps indicates shallow portion of the formations which is a good structural lead, while faults are bounded in between low and high average velocities. 2D and 3D depth surface models indicates that the main structure which is shallower extends in the direction of north-east to south-west with dipping along south-east and north-west directions. The target reservoirs in Balkassar oil field are Chorgali, Sakessar and Khewra formations in well BLK-OXY-01. The overall depth range

of the reservoirs zone are in between 2420m to 3100m. In reservoirs zone, the pore pressure gradient values lie in between 1.31 psi/m to 2.23 psi/m while the fracture gradient values lie in between 1.77 psi/m to 2.36 psi/m. Major abrupt changes in pore pressure gradient and fracture gradient values are perceived on the basis of colour variations in the model (2600m- 3100m and CDP of 200-325).

A comparative analysis of climatic variability in Potwar plateau and Peshawar Basin, Pakistan

Shazia Gulzar[1]*, Atta-ur-Rahman[2], Muhammad Ali[3,4] and Abid Sarwar[1,3]

[1]Directorate General, Soil and Water Conservation Khyber Pakhtunkhwa
[2]Department of Geography, University of Peshawar
[3]National Centre of Excellence in Geology, University of Peshawar
[4]GIS and Space Application in Geosciences Lab (GSAG), National Centre for GIS and Space Applications (NCGSA)
**shaziaguzar70@gmail.com*

This study examines the spatiotemporal variability in temperature and rainfall (climatic parameters) in the Potwar Plateau and the Peshawar Basin, with a particular emphasis on the highland and lowland parts of these regions. Seven meteorological stations were chosen for this study: Peshawar, Cherat, Risalpur and Tarbela in the Peshawar valley, while Rawalpindi, Islamabad and Jhelum in the Potwar plateau, all of which have large time series data. The meteorological data were obtained from Pakistan's Meteorological Department over a period of forty-seven years (1970-2017). Standard statistical approaches were used to achieve the study's goals. The average data values were carefully analyzed on a monthly, seasonal, and annual basis in order to determine a pattern and trend (spatiotemporal) for the period 1970 to 2017. The results of the analysis show that the averages of maximum and minimum temperatures in both regions have been increasing since 1970. The total precipitation of the Potwar plateau (Rawalpindi, Jhelum, and Islamabad) at the Rawalpindi met station, on the other hand, shows a rising trend in rainfall in all seasons except winter, which shows a decrease in rainfall. Except for the summer monsoon period, when rainfall increases, there is a decrease in rainfall at Jhelum Met Station. Similarly, rainfall at the Islamabad Met Station has decreased in all seasons except the monsoon season, which has increased. The same is true in the Peshawar valley, where rainfall is increasing in Peshawar and Cherat while decreasing in Risalpur during the monsoon and reducing in the winter.

Lithofacies, petrography and reservoir properties of Cretaceous Lower Goru Formation, a case study of Bobi 7 well, Dhamrakhi field, southern Indus Basin, Pakistan

Syed Waqas Haider*, Mumtaz Ali Bukhari and Mujahid Ahmed Khan

Hydrocarbon Development Institute of Pakistan, Islamabad
**waqashaider@hdip.com.pk*

The present work portrays the reservoir properties of the Lower Goru Formation by highlighting its lithofacies and petrography. The Formation comprises nine different lithofacies such as massive sandstone; bioturbated sandstone; parallel laminated sandstone; cross laminated sandstone; massive mudstone; intercalations of sandstone and mudstone; laminated mudstone; brecciated sandstone; and pebbly sandstone. These lithofacies are grouped into three facies association i.e., foreshore facies association, shoreface facies association and offshore facies association. This study suggests fluvial to tidal dominated delta front to shallow marine depositional environment. Further the petrographic studies classified the sandstone into subfeldsarinite to sublithicarinite that deposited in transitional recycled orogeny. Apart from this, porosity and permeability in the Lower Goru Formation make it important for exploration industry. High porosity and low permeability are observed in bioturbated and laminated sandstone lithofacies. The fine-grained sandstone and mudstone intervals show the lowest values of porosity and permeability whereas massive sandstone has high porosity and permeability that clarify the basal sand of the Lower Goru Formation has good reservoir as compared to massive sandstone.

Evaluation of radon concentration in drinking water and associated health risks of Mulazai and adjacent areas, District Peshawar

Haseeb Haroon*, Zeeshan Ullah, Syed Samran Ali Shah and Abdul Rahim

National Centre of Excellence in Geology, University of Peshawar, Pakistan
**awanhaseeb13@gmail.com*

Radon (222Rn), a readily water-soluble natural gas, is carcinogenic posing serious threats to humans' health. A study was conducted in Mulazai and adjacent areas of district Peshawar by collecting groundwater samples (n=30) from hand pumps and wells and analyzed in order to find out the concentration of radon with the help of RAD7 instrument (Durridge Company, USA) following the international standards. The results revealed that radon concentration in the analyzed water samples is greater than the proposed level by the United States Environmental Protection Agency (USEPA). i.e., 11.1 Bq/liter. However, the mean annual effective dose was found to be lesser than 0.1 mSv per annum recommended by WHO and European Union Council. In order to avoid the harmful effects of such

excessive radon level on the humans' health, proper ventilation and storage of water in storage reservoirs for long time before use is recommended to decrease the radon level in water. Similarly, boiling of water is also beneficial before its use for drinking purposes in the study area.

Integrating depositional facies and sequence stratigraphy in characterizing the reservoir potential of the Cretaceous sediments, Upper Indus Basin, Pakistan

Syed Irfanullah Hashmi[1], Irfan U. Jan[1], Suleman Khan[2], Nowrad Ali[2], Khalid Latif[1], Muhammad Hanif[1] and Sajjad Ahmad[2]

[1]National Centre of Excellence in Geology, University of Peshawar
[2]Department of Geology, University of Peshawar
**irfanhashmi@uop.edu.pk*

The Cretaceous successions in the Upper Indus Basin, Pakistan, i.e., Chichali, Lumshiwal and Kawagarh formations have been investigated to link the reservoir quality with stratal deposition, diagenetic modifications and sequence stratigraphy. The lowermost Chichali Formation revealed the presence of laterite, glauconitic sandstone and carbonaceous shale facies, representing middle to outer ramp depositional setting. The presence of bioclastic sandy limestone, quartz arenite and glauconitic sandstone lithofacies within the overlying Lumshiwal Formation represented deltaic to inner ramp depositional setting. The pelagic-rich limestone within the overlying Kawagarh Formation revealed an outer ramp to open marine depositional setting. The sequence stratigraphic analysis revealed that Chichali Formation is deposited during transgressive system tract of 2nd order depositional cycle. The transgression-associated glauconitic sandstone facies of the Chichali Formation are overlain by carbonaceous green shale facies, associated with maximum flooding surface. The mixed- carbonates and -silisiclastic succession of the overlying Lumshiwal Formation is deposited in the series of transgressive and regressive depositional cycles. The texturally and mineralogically mature sandstone deposited in the deltaic depositional settings represents the reservoir potential zone within the Lumshiwal Formation. The overlying Kawagarh Formation showed deposition during transgressive system tract of 2nd order depositional cycle.

Source rock potential of the Jurassic, Cretaceous and Early Eocene succession in the South Waziristan, Middle Indus Basin, Pakistan: Implication for the new oil and gas avenue

Syed Irfanullah Hashmi[1, 2*], Azhar Mahboob[1], Waseem Ahmad[1] and Mehmood Ahmad Khan[1]

[1] Oil & Gas Facilitation Unit Energy & Power Department, Government of Khyber Pakhtunkhwa.
[2]National Centre of Excellence in Geology, University of Peshawar
**irfanhashmigeo@gmail.com*

The Chiltan (Jurassic), Sember and Parh (Cretaceous), and Ghazij Formation (Eocene) outcrop samples along Gomal Zam road in the South Waziristan District were collected and analyzed for source rock evaluation. Total 29 rock samples obtained from these formations were subjected to geochemical and organic petrographic analyses. The Total Organic Carbon (TOC) of all the studied formations indicates poor to fair source rock potential except the Ghazij Formation which shows poor to good potentiality in terms of source. Geochemical and organic petrographical analyses indicate Type IV/III kerogen for Chiltan, Type III for Sember and Ghazij formations, while Parh Formation contains Type III & Type II of kerogens. The vitrinite reflectance (R_o %) measurements showed that all the studied formations are mature with respect to source rock characterization and mainly lie within wet gas generating window. However, on the basis of Tmax Ghazij and Chiltan formations lie in the dry gas window, Parh Formation in wet and oil windows, and Sember Formation in dry gas zone with oil window tendencies in few samples.

Global climate change and human health impacts

Rahib Hussain, Amna Arshad* and Nisha Lal Din

CEES, University of Punjab, Pakistan
**hafizaamnaarshad@gmail.com*

The Earth's climate is quickly changing, owing primarily to human activity. Increasing temperatures, sea-level increases, altering precipitation patterns, and more frequent and severe extreme events are expected to have a significant negative impact on human health, including access to clean water and food, as well as suitable shelter. Social factors, such as gender affect the consequences of climate change on human society and our ability to reduce and adapt to them. There are gender differences in many of the health risks that are predicted to be impacted by continued climate change. Natural catastrophes such as droughts, floods, and hurricanes kill more women than males worldwide, and women are killed at a younger age. These impacts are also influenced by the event's nature and social position. Gender disparities in life expectancy are more pronounced in more severe disasters and in areas where women's socioeconomic standing is

particularly low. Other climate-related health effects, such as malnutrition and malaria, have significant gender differences. Health risks that are directly linked to meteorological hazards have gender inequalities. These disparities are the result of a complex interaction of physiological, behavioral, and social factors. Other research has found that unmarried males are more at risk than unmarried women, and that social isolation, particularly among senior men, is a risk factor. Differences are also seen in vulnerability to climate-related hazards' indirect and longer-term effects. The cardiovascular and gastrointestinal systems are especially vulnerable to the negative consequences of global warming. Furthermore, climate change affects some infectious diseases and their animal vectors, increasing the risk of typhus, cholera, malaria, dengue fever, and West Nile virus infection. Effective mitigation and adaptation methods to lessen the impact of global warming on human health must be implemented at the global level.

Geochemical investigation and rehabilitation of coal waste contaminated soil in Dara Adam Khel, Khyber Pakhtunkhwa, Pakistan

Rahib Hussain*, Sajid Rashid Ahmad and Fatima Nadeem

College of Earth and Environmental Sciences, University of the Punjab, Lahore 54590, Pakistan
**rahib.cees@pu.edu.pk*

The study was carried out to explore the extent of contamination in coal-contaminated soil and its rehabilitation through pyrolyzed biochar in Dara Adam Khel areas, Khyber Pakhtunkhwa, Pakistan. For these purposes, the coal contaminated soil samples (n=16) were collected from Dara Adam Khel and treated through pyrolyzed biochar and then analyzed through atomic absorption spectroscopy. The results showed that before treatment the average concentration (mg/kg) of Pb, Cr and Cd was 252 mg Kg-1, 280 mg Kg-1, 3.3 mg Kg-1, respectively. While after treatment, the average concentration of Pb, Cr, and Cd was reduced to 98, Cr 110, and Cd 1.7 mg Kg-1, respectively. Further, the average variation in the minimization of toxic trace elements (TTEs), namely Pb 61%, Cr 63%, and Cd 46% occurred effectively. The reduction of the TTEs through biochar application was attributed to the high surface area, porosity and functional groups of pyrolyzed biochar, which adsorbed the TTEs and limit the mobilization of elements from soil to food crops. The ~55 % minimization in TTEs revealed that the biochar prepared from the garden wastes has low surface areas and microporosity, which adsorbed the TTEs up to some extent. However, garden waste biochar is cost-effective and can be prepared in a short time using less energy. The study concluded that the biochar prepared from the garden waste is effective for the sorption and immobilization of TTEs in coal-contaminated soil. However, the present suggested using woody biochar which has high microporosity and surface area and can adsorb the TTEs up to maximum level.

Natural causes of twentieth century temperature change

Asma Idrees*, Aqsa Rauf and Rahib Hussain

CEES, Punjab University, Lahore, Pakistan
**asmaidrees97@gmail.com*

We want to analyze spatio-temporal patterns of near-surface temperature change to provide an attribution of twentieth century climate change. We apply an "optimal detection" methodology to seasonal and annual data averaged over a range of spatial and temporal scales by using GIS and remote sensing. Over the years, the temperature near the surface increased sharply between 1910 and 1940, and then flattened off up until the late 1960s before rising rapidly again. 1998 was the warmest year in the instrumental record, almost 0.6K warmer than the 1961-1990 average. We find the major natural reasons for the sharp rise in the temperature. We analyze those natural causes, most important of them include changes in stratospheric volcanic aerosols and changes in total solar irradiance may have contributed significantly to the global warming in the first half of the century, although this result is dependent on the reconstruction of total solar irradiance that is used. Another way to refer to climate forcings is to call them climate drivers. Natural climate drivers include changes in the sun's energy output, regular changes in Earth's orbital cycle, and large volcanic eruptions that put light-reflecting particles into the upper atmosphere. This study keenly observes the mentioned parameters and the potential drivers.

Mesozoic and Cenozoic vertebrate Paleozoological fauna of Koh Sulaiman Range, Barkhan, Kohlu and Dera Bugti districts of Balochistan, and Taunsa, Dera Ghazi Khan and Rajanpur districts of South Punjab, Pakistan

Muhammad Ilyas[1, 2, 3*,] M. Sadiq Malkani[4], Ghulam Akbar[5], Khizar Samiullah[6], Inayatullah Malik[6], Syed Sibt E Hassan[6] and Aqsa Noor[6]

[1]Department of Paleomammalogy, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing 100044, China
[2]University of Chinese Academy of Sciences, Beijing, China
[3]CAS Centre for Excellence in Life and Paleoenvironment, Beijing 100044, China
[4]Geological Survey of Pakistan, Muzaffarabad, Azad Kashmir, Pakistan
[5]Geological Survey of Pakistan, Quetta, Pakistan
[6]Department of Zoology, Ghazi University, Dera Ghazi Khan, South Punjab, Pakistan
**hafizilyasgcuf@gmail.com*

Latest Cretaceous (Late Maastrichtian) Vitakri Formation yielded bone fossils of titanosaurian (mostly poripuchian) sauropods (*Gspsaurus pakistani*, *Saraikimasoom vitakri* and *Nicksaurus razashahi* Gspsauridae, *Balochisaurus malkani* and *Marisaurus jeffi* Balochisauridae and *Pakisaurus balochistani*, *Sulaimanisaurus gingerichi* and *Khetranisaurus barkhani* Pakisauridae),

abelisaurian theropods (*Vitakridrinda sulaimani* and *Vitakrisaurus saraiki* Vitakrisauridae), mesoeucrocodiles (*Induszalim bala* and *Pabwehshi pakistanensis* Induszalimidae, *Mithasaraikistan ikniazi* Mithasaraikistanidae and *Sulaimanisuchus kinwai* Sulaimanisuchidae), pterosaur-the flying reptiles (*Saraikisaurus minhui* Saraikisauridae), paleobird (*Wasaibpanchi damani* Wasaibpanchidae), large paleosnake (*Wadanaang kohsulaimani*) and paleotree (*Baradarakht goeswangai*) (recently described by one of us MSM). The Maastrichtian Pab sandstone yielded ichnotaxa Ornithopaonia *Pashtosauroperus zhobi* titanosaurian sauropod or ornithischian dinosaurs, Pteropaonia *Anmolpakhiperus alleni* pterosaur and Sauropaonia *Dgkhansauroperus maarri* titanosaurian sauropod. The Cenozoic strata yielded many vertebrates since a long time. But recently the Eocene strata yielded walking whale (*Artiocetus clavis*, *Rodhocetus Kasrani* and *Rodhocetus balochistanensis*) and swimming whales (*Basilosaurus drazindai*, *Basiloterus hussaini* and *Sulaimanitherium dhanotri*) and horses/cyonid (*Bolanicyon shahani*), the Oligocene Chitarwata Formation yielded largest land rhinoceros (*Buzdartherium gulkirao*) and large eucrocodile (*Asifcroco retrai*), and the Miocene Litra sandstone yielded the large proboscidean (*Gomphotherium buzdari*). Besides vertebrates, the Mesozoic and Cenozoic strata yielded many invertebrates. Recently reported invertebrates are arthropods (*Nisaukankoil beakeri* and *Phailawaghkankoil derabugti*) from Early Paleocene Rakhi Gaj sandstone and nautiloid (*Pakiwheel vitakri*) from Early Paleocene Sangiali green shale and sandstone.

Application of SEBAL model and landsat data for mapping evapotranspiration and estimating surface energy fluxes in the northern Pakistan

Benazeer Iqbal[1, 2] and Muhammad Ali[1,2*]

[1]National Centre of Excellence in Geology, University of Peshawar, 25130-Peshawar, Pakistan
[2]GIS and Space Application in Geosciences Lab (G-SAG), National Centre for GIS and Space Applications (NCGSA)
**aliumarzai@uop.edu.pk*

Evapotranspiration (ET) is a major component of the water cycle. ET is closely linked with temperature, precipitation, relative humidity, vegetation, crop growth, crop water requirement, water use of various land uses and water resource management. It can be measured by direct methods i.e., Eddy Covariance, Bowen ration, Atmometer, and Evaporation Pan, however, this data is unable to represent the surrounding large geographical areas owing to its low spatial footprint. Therefore, mapping evapotranspiration using remotely sensed satellite imagery can provide ET for large spatio-temporal scales. In areas like Pakistan, very limited station-based ET data is available. These sparse station-based data are unable to appropriately represent the vast heterogeneous surfaces. This study aims to evaluate the applicability of the remotely sensed energy balance approach based

on the SEBAL (Surface Energy Balance Algorithm for Land) model in a region characterized by a cold snowy dry and hot summer-like climate in northern Pakistan. Six Landsat 8 OLI images of June month for the years 2013, 2014, 2015, 2016, 2017 and 2018 were processed to estimate the ET using SEBAL model. SEBAL based ET results were correlated with ground-based ET provided by the National Agromet Centre Islamabad, Pakistan. ET estimated via SEBAL and measured at ground-based station exhibited strong correlation in terms of r (Pearson correlation coefficient) with value equal to 0.88. It was found that open water and green vegetation have high evapotranspiration rate than the dry soil and barren land. The modelled ET was further evaluated with absolute accuracy parameters like RMSD (Root Mean Squared Difference) and MBE (Mean Bias Error) showing a value of 0.01 and 0.03, respectively. This research demonstrates a considerable potential of SEBAL model to estimate spatial scale ET with limited ground-based data over large heterogenous surfaces.

Variations in the optical properties of aerosols in Pakistan

Hadia Iqbal*, Azhar Ali and Sajid Rashid Ahmad

College of Earth and Environmental Sciences, University of the Punjab, Lahore 54590, Pakistan
**hadiaiqbal1248@gmail.com*

It is well established that aerosols affect the climate in a variety of ways. In order to understand these effects, we require an insight into the properties of aerosols. In this research we present a study of optical aerosol properties all-over Pakistan and around 5 major cities of Pakistan i.e., Islamabad, Karachi, Lahore, Peshawar and Quetta. The data from satellite model MERRA-2 provided by NASA's official website Giovanni have been used over the period 1st January 2016 to 31st December 2016.The optical properties of aerosols like Black Carbon, Organic Carbon, Dust and Sulfate are studied which shows the reflection and absorption of solar radiations by these particles. 2016 was the year in which there was high concentration of aerosols in atmosphere of Pakistan. The optical properties of aerosols present in Pakistan in their respective concentrations in 2016 resulted in change in amount of solar radiations reaching the Earth and also reflecting amount of radiation varied greatly. The increase in radiation absorbing aerosols caused increase in temperature which is above than normal. This change resulted in change in weather pattern and season durations in Pakistan. In Pakistan, the winters in 2016 were warmer than previous years due to increase in aerosol concentration in atmosphere. The atmospheric parameters like temperature, pressure, relative humidity, aerosol optical depth, total aerosol extinction, etc. varies with the concentration of aerosols in atmosphere according to the emission level.

Source rock geochemistry, age constraints and causes of organic richness of Patala Formation, Kohat sub-basin, Pakistan

Muhammad Ishaq[1]*, Afrasiab[1,2] and Muhammad Hanif[1]

[1]National Centre of Excellence in Geology, University of Peshawar, Pakistan
[2]Khushal Khan Khattak University, Karak, Pakistan
**geoishaq88@gmail.com*

The Patala Formation in the Kohat Sub-basin is mostly comprised of basal argillaceous limestones, calcareous and fissile shales with subordinate coal. The formation was evaluated for its source rock potential, nature and origin of organic matter, age elucidation and identification of various types of clay minerals from Tarkhobi and Panoba sections, Kohat Sub-basin. The geochemical analyses include; Total organic Carbon (TOC), Rock-Eval pyrolysis, biomarker analysis and vitrinite reflectance. TOC and generative potential reveal poor to fair source rock potential. The rock eval pyrolysis results exhibited mainly type III-II kerogen in Patala Formation. Tmax vs. Hydrogen Index (HI) and Tmax vs. Production Index (PI) indicated that the shale intervals are thermally mature and are mainly oil prone and gas prone while the present hydrocarbons show indigenous nature. The biomarker analysis includes; Pristane/nC17 to phytane/nC18 revealed immature to post mature mixed terrestrial/marine organic matter. Hopanes C31R/C30 vs. pristane/phytane indicated shales and carbonates are deposited in marine conditions. The kerogen macerals are dominated by vitrinite, finely bituminite, converted vitrinite and minor inertinite. The formation's biostratigraphy (i.e., planktonic foraminiferal and calcareous nannofossils) was performed in order to re-evaluate the age of the formation from the Tarkhobi and Panoba sections. The age diagnostic species like *Globanomalina pseudomenardii*, *Acarinina saldadoensis*, *Morozovella valascoensis* and *Pseudohistagerina wilcoxensis* were identified among others and their respective zones i.e., P4, P5+E1 and E2 were marked representing late Paleocene age and Thanetian to early Ypresian stage at Tarkhobi section. The calcareous nannofossils from Panoba Section with age diagnostic species of *Tribrachiatus orthostylus* and *Discoaster lodoensis* were identified with respective zones including NP10, NP11 and NP12 and on the basis of these zones early Eocene age and Ypresian stage is assigned to formation in Panoba section. The examined sections demonstrate that the Tarkhobi and Panoba sections are segmented parts of the Patala Formation in the eastern Kohat sub-basin and preserve their age as evidenced in the Potwar sub-basin. The presence of smectite-illite-kaolinite-montmorillonite confirmed the deep marine deposition of Patala Formation under anoxic conditions which is further evidenced by presence of ore minerals i.e. magnetite, barite and hematite. The organic richness of the Patala Formation can be closely associated with the early Paleogene hyperthermal events (i.e., PETM and EECO).

Landslide hazard vulnerability and risk assessment of a part of eastern Hindu Kush ranges, Pakistan

Muhammad Ishfaq[1,2*], Muhammad Shafique[1,2], Nisar Ali Shah[1,2] and Yasin Ullah[1]

[1]National Centre of Excellence in Geology, University of Peshawar
[2]GIS and Space Applications in Geosciences (G-SAG), National Center of GIS and Space Applications (NCGSA), Institute of Space Technology, Islamabad, Pakistan
**ishfqm@uop.edu.pk*

Landslides are devastating natural hazards in mountain areas with significant impacts on the society and economy. District Chitral is part of the eastern Hindu Kush ranges and is frequently prone to widespread and damaging landslides, debris flow, and floods. Therefore, it is important to depict the landslide hazard zones and their impacts on society, physical infrastructure, and the environment, which can be utilized for disaster risk reduction. The premier objectives of this research work are 1). To analyze and portray the landslide hazard zones in area 2). To determine the social, physical, and environmental vulnerability of the landslide-prone area 3). To evaluate the risks of these landslide-prone areas. An extensive field has been conducted in the area to verify the landslides and their distribution into different classes. Moreover, building topology data has been acquired for 19,000 buildings in the area. The causative parameters (geological, topographical and anthropogenic) are compared with the landslides inventory using a bivariate statistical model, and a landslide susceptibility map has been generated. The accuracy of the model has been checked by making the area under the curve (AUC), which showed 89% accuracy. Furthermore, multi-criteria evaluation techniques have been used to determine the landslide's vulnerability and risk. The results were analyzed per administrative unit at village levels, which shows that most of the villages located on tributary junction fans in upper Chitral are in a very high-risk zone.

Replacement of crushed stone aggregate: A case study of Panjkora river bed material use as a coarse aggregate in concrete, Dir Lower, Pakistan

Izazullah, Shakeel Ahmad*, Asad Muhammad, Suliman Khan, Jamal Shah, Syed M Wasim Sajjad and Syed Mamoon Siyar

Department of Geology, University of Malakand, Chakdara 18800, KP, Pakistan
**shakeelgeo25@gmail.com*

The current study envisages the potential use of Panjkora River bed material as replacement of crushed stone aggregate in concrete. Due to increase in construction activities, coarse aggregate is under depletion, so an alternate aggregate with the required strength can be used as construction aggregate. Field investigations reveals that the catchment area is a braided river with high gradient

and size of bed load are cobbles and pebbles of the granitic, gabbroic and amphibolitic composition. The physical properties were determined as per international standards (ASTM). It includes specific gravity (2.88), water absorption (0.79%), soundness (7.70 %), Los Angeles Abrasion (19.40 %), Flakiness & Elongation (27.70 %) and crushing value (13.85 %). The examined values range within the specified limits. The easily accessible and vast material based on the above mentioned results can be a potential replacement aggregate in concrete and other construction works.

Earthquakes hazard and awareness in Pakistan

Haider Zaman Khan Jadoon[1] and Ishtiaq A. K. Jadoon[2]*

[1]Modern Age Public School and College, Abbottabad,
[2]COMSATS University Islamabad, Abbottabad Campus, University Road, Tobe Camp, Abbottabad
**jadooniak@gmail.com*

Pakistan is seismically most active in the World with earthquake hazards all across the region. This contribution is aimed at creating awareness about the earthquake occurrence, causes, and hazard across the World in general and Pakistan in particular. The earthquakes occur due to breakage (slip) along a fault in the earth's crust with propagation of seismic waves as Primary (fastest), Secondary (slower) and Surface (slowest) waves with back-and-forth, sidewise, and circular motion, respectively. These shocks are received with variable ground motion one after the other, creating panic in public. They are caused by the movement of tectonic plates comprised of hard (brittle) part of the earth crust and upper mantle over the soft (molten) part of the inner mantle. The brittle lithospheric plates to 80 km depth move toward, away, and side-wise along a convergent (colliding), divergent (expending), and transform (strike-slip) plate boundary causing earthquakes to 700, <30, and 7-29 km depth, respectively. This is why earthquakes occur linearly and predictively with variable depths and strength along the plate boundaries with thrust, normal, and strike-slip focal-mechanism solutions. The shallow (0-70 km) earthquakes occur along all types of plate boundaries. Whereas, the intermediate (71-300 km) and deep (301-700 km) earthquakes occur along convergent plate margins and mountain belts such as the Himalayas and the Andes. The depth of earthquakes in the Himalayas is presently restricted to ~20-40 km) with exception of Hindukush, with 300 km, due to advance stages of continental collision. All kind of destructive earthquakes are expected to occur in north Pakistan and Makran due to colliding and laterally sliding Indian and Eurasian, and Arabian and Eurasian plates, respectively. Mw 7.5, 6 June 1819 Run of Kutch Sindh with 3200 casualties, Mw 7.8, 24 September 1827 Lahore with ~1000 casualties, Mw 7.7, 31 May 1935 Quetta with 40,000-60,000 casualties, Mw 8.1, 28 November 1945 Pasni with ~4000 casualties, Mw 7.6, 08 October 2005 Kashmir with ~86,000 casualties, and Mw 7.7, 24 September 2013 Awaran Baluchistan with ~1000 casualties are examples of some

great earthquakes in Pakistan. Based on seismicity, 04 zones of severe earthquake hazards are located as Balakot-Bagh Fault Zone (BBFZ) along the Himalayas in north Pakistan, Quetta-Harnai-Kohlu Fault Zone in the Sulaiman fold belt, Thatha east of Karachi in Thar Desert along the Indus Onshore, and Makran Convergence Zone between Gawadar and Pasni. The threat of great future earthquakes occurs along these zones with most vulnerable being the BBFZ due to over-population along the active fault. The public awareness drills with "drop, cover, and hold-on" during the earthquake inside and staying away from buildings and poles outside are recommended. Locating active faults, declaring them as State Parks, relocating population by discouraging development in red zones are some of the measures to be adopted by the government to mitigate earthquakes. Whereas, public cooperation for relocation and construction of earthquake resistant buildings are some of the measures to be adopted to avert the hazard with sustainable development.

Balanced cross-section across the eastern Sulaiman foreland and hydrocarbon exploration

Saif-Ur-Rehman K. Jadoon[1, 2*], Lin Ding[1, 2] and Ishtiaq A. K. Jadoon[3]

[1]Key Laboratory of Continental Collision and Plateau Uplift, Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing, China
[2]Centre of Excellence in Tibetan Plateau Research, Beijing, China
[3]COMSATS University Islamabad, Abbottabad Campus, University Road, Tobe Camp, Abbottabad
**saif_jadoon@itpcas.ac.cn*

Seismic and well data-sets were analyzed to understand the geometry and development along the eastern Sulaiman fold-and-thrust belt (SFTB) located at the western passive margin of the Indian Plate. About 350 km NS oriented monoclinal feature located at the eastern Sulaiman deformation front is interpreted to have a thin-skinned passive roof duplex style of deformation. The floor thrust consisting of multiples duplexes above it stacked between a floor and a roof thrust, is inferred to be located at a depth of ~ 9 km in the Paleozoic pelitic/calcareous strata rather than Eocambrian evaporates near the deformation front. The hinterland propagating passive-roof thrust is located in the thick Cretaceous strata with the presence of pop-ups in the roof sequence. Hydrocarbon prospects are recognized both in the roof i.e., pop-ups and duplex sequences as duplexes (Zindapir Anticlinorium), and anticlinal stacks (Fort-Munro). A 60 km deformed section was restored to an original length of 172 km, giving an overall shortening of 112 km (65%). This 65% shortening in the cover strata from the eastern SFTB is higher than the 50% observed in the SFTB and the Salt Range-Potwar Plateau, but is compatible with the observed stacked duplexes and high structural relief over a narrow zone along the eastern edge of the Sulaiman lobe.

The organic geochemistry of oil seeps from the H-13 Islamabad and comparison with biomarkers of Golra oil seep, Upper Indus Basin, Pakistan

Samina Jahandad* and Saba Nazir

Hydrocarbon Development Institute of Pakistan, Islamabad
**gm.io@hdip.com.pk*

The present research work deals with the organic geochemical analysis of 03 samples collected from 02 oil seepages of H-13 Islamabad and their comparison with Golra oil seep in Islamabad Upper Indus Basin, Pakistan. Biomarkers (triterpanes, hopanes, steranes, n-alkanes and acyclic isoprenoids) were analyzed using gas chromatography mass spectrometry (GCMS). These hydrocarbon rich fluids have undergone biodegradation (2–6 on the Peters and Moldowan scale), showing both the loss of n-alkanes and the microbial degradation of isoprenoids, hopanes and to some extent of steranes. These oil seeps were generated from a mature source rock that is appeared to have mixed organic matter input with dominating terrestrial paleoenvironment. Moreover, these seeps are likely derived from the Upper Palaeozoic - Lower Jurassic Formation that reached a level of maturity near the peak of oil generation in the study area. Golra oil seep is also showing the almost same results which indicates that both the oil seeps might be generating from the identical source rock. H-13 oil seep fluid is heavy in nature due to evaporation and biodegradation of oil during upward migration and seep out in the H-13 area in the upper Indus Basin, but it can be evidence for the presence of light oil trapped in the study area should prompt re-exploration in the northwestern area of this Basin in shallow reservoirs. Biomarkers data of both oil seep is leading towards the same source of Golra and H-13 oil seeps that might be Datta Formation as per biomarkers data/fingerprints have been studied.

Phytoremediation a cost effective technique in air pollution control

Tahira Jameel* and Samia Farooq

University of the Punjab, Pakistan
**tahirarana96@gmail.com*

Air pollution originates from both anthropogenic and natural sources. Pollutants can travel through and down the food chain. Different strategies can be used to treat these pollutants and contaminants. Particulate matter, volatile organic compounds, inorganic air pollutants, heavy metals, and black carbon are examples of airborne pollutants. Airborne pollutants can cause a variety of ailments, including circulatory, heart and lung disease, asthma, breathing problems, cancer, carcinogen, impaired pregnancy outcomes, and photosynthesis inhibition. These airborne infections are treated using a variety of methods. Phytoextraction is a process for extracting pollutants from soil and absorption by plants. When plants

are harvested, incineration is used to clean up the mess. Plants take up toxins during phytovolatilization, although they may eventually be released into the atmosphere. Perhaps the toxicity of contaminants is reduced in the atmosphere. Plants are able to help with phytodegradation, in which pollutants concentrate in plants and plant enzymes strive to change them into less polluted forms. Plants use rhizofiltration to absorb and then precipitate contaminants from aqueous solutions. Rhizodegradation is the process of contamination degradation, in which microbes degrade the contaminants which are present in rhizosphere. In this research, Phytoremediation is focused more to treat these pollutants such as particulate matter, inorganic air pollutants, volatile organic compound, persistent organic compound. In comparison to soil and water, air pollution poses a greater challenge. Phytoremediation has been shown to be an effective and efficient method of combating air pollution. This includes environmental influences, plant specific features, air pollutant composition, plant and microbial selection, and plant tolerance to pollutant exposure. These are challenging factors which are needed to be treated properly to practice best phytoremediation for air borne particles. This is a low-cost approach that requires little management.

Petrography, geochemistry and petrology of the Wadhrai ganite stock, Nagar Parkar igneous complex, southeast Sindh

M. Qasim Jan[1]*, M. Hassan Agheem[2], Tahseenullah Khan[3] and Hafiz U. Rehman[4]

[1]National Centre of Excellence in Geology, University of Peshawar, Peshawar, Pakistan
[2]Centre for Pure & Applied Geology, University of Sindh, Jamshoro, Pakistan
[3]Department of Earth and Environmental Sciences, Bahria University, Islamabad, Pakistan
[4]Graduate School of Science and Engineering, Kagoshima University, Kagoshima 890-0065, Japan
**mqjan@yahoo.com*

The Wadhrai granite body is the second largest pluton of the Nagar Parkar Igneous Complex--an extension of the Neoproterozoic Malani Large Igneous Province (LIP) of western Rajasthan. It consists essentially of a petrographically uniform and fresh granite composed of perthite, sodic plagioclase, quartz, small quantities of biotite, opaque oxide, titanite, and secondary chlorite, epidote and leucoxene. The rocks are sparingly porphyritic and locally display granophyric and myrmakitic rextures. There are dykes and veins of dolerite, microgranite, aplite, quartz, and rare pegmatite. In the south-central part, the granite is invaded by parallel sheets and swarms of many mafic dykes, and in the western part by sodic rhyolite sheets. Fourteen major-, trace-, and rare-earth element analyses suggest that the granites are alkaline, A2-type and metaluminous to peraluminous. The analyses are characterized by high SiO2, alkalis, and FeO*/ (Feo*+MgO) ratios. Mantle-normalized trace elements show enrichment in LILE, pronounced Ti, P, Sr, and minor Nb negative anomalies, and chondrite-normalized REE diagram

shows enrichment of LREE over HREE and minor negative Eu anomaly. The analyses were plotted on a variety of chemical discrimination diagrams used for deciphering the tectonic settings of magmatic rocks. In most of the here used diagrams, they plot in the fields of granites of anorogenic and extensional (within plate) settings, but on a few diagrams, they share the chemical characteristics of those of subduction/syn-collisional settings. From these, and by analogy with the granitoids of the Malani LIP, we consider that the Wadhrai granite mamga originated in continental extension set up, but was possibly derived from source rocks which may be arc-related. The magma may have been the product of partial melting of a source of dominantly tonalitic composition with some contribution from associated greywackes and a little from pelites. Alternatively, tonalite-derived magma may have been contaminated by greywackes and pelites during upward migration. Pressure-Temperature estimates (4-6 kbar and 840oC) suggest about 15 km depth. Negative Eu anomaly and Rb/Sr vs. Sr relations suggest some plagioclase fractionation, and Sc/Th vs. SiO2/Al2O3 relations suggest a little biotite fractionation.

Global warming is the harbinger of climate change which, in turn, is a major threat to food security and sustainable development

M. Qasim Jan[1]* and Muhammad Zaffar Hashmi[2]

[1]National Centre of Excellence in Geology, University of Peshawar. Peshawar
[2]COMSATS University Islamabad, Abbottabad Campus, University Road, Tobe Camp, Abbottabad
**mqjan@yahoo.com*

Instrumental and paleo-proxy records suggest that global warming is on the rise, with estimates of 0.8–1.0 °C since 1880. The accumulation of greenhouse gases (GHGs) in the atmosphere is commonly considered the cause of present-day global warming. GHGs result from agriculture emissions, and burning of hydrocarbons in industry, power generation, vehicles and domestic use – all related to anthropogenic activities. However, many also argue that the rise in global temperature may, instead, be due to natural causes, such as variability in solar flares, astronomical periodicities, volcanic eruption, wildfires, meteorite falls, storms, floods, and plate tectonics. We here present a summary of the evidence, causes and impact of climate change, and some mitigation measures for food security and sustainable development. The greatest challenges of the 21st century comprise the nexus of climate change, food security, human health, water and energy. Climate change poses imminent threat to life, human well-being and is significantly impacting sustainable development and agriculture all over the world. Poor and developing countries, including Pakistan, will be the most adversely affected and least able to cope with the anticipated shocks to their social, economic and natural systems. Since climate change is a worldwide threat, global and regional efforts are required to redress its impact, both through adaptation and

mitigation to ensure sustainable development. Agro-ecological management strategies in combination with traditional system may be a viable and robust path for resilience, sustainability and increased productivity in changing climate scenarios.

Water availability and its consumption feasibility in twenty-one major cities of Pakistan

Mariam Javed*, Sajid Rashid Ahmad, Rahib Hussain, Seemal Basit, Maryam Asghar and Mehreen Ali

College of Earth and Environmental Sciences, Quaid-e-Azam Campus, University of the Punjab, Lahore-Pakistan
**mariamjaved685@gmail.com*

Rapid population growth in Pakistan is a responsible contributor for reduction in per capita water resource availability. Hence, water availability has been reduced as a result of water shortages and increased competition for various uses. This paper reviews and highlights drinking water availability and its feasibility for consumption in twenty-one cities of Pakistan. In this study chemical, physical and bacteriological contaminants were investigated in the water samples. Water samples were collected from, Tap, dug wells, tube wells, and hand pumps. Microbial contamination was detected in at least 45% of the samples collected from various districts. The results show that the samples taken from the district Kasur were 100% contaminated and unsafe for drinking purposes. Similarly, arsenic (As) contamination exposure was found in the water samples i.e., Gujranwala (64% samples), Bahawalpur (88%), Kasur (100%), Multan (94%), Lahore (100%), and Sheikhupura (73%), posing a high risk to the consuming population. The concentration of total dissolved solids (TDS) and sodium in Kasur, Faisalabad, Sargodha, and Sheikhupura was higher than the permissible levels, while water samples collected from Sargodha and Rawalpindi were contaminated by elevated amounts of Nitrates (NO_3) and were subsequently declared unsuitable for consumption. Water quality parameters collected from four different cities of Khyber Pakhtunkhwa (KP) revealed that at least 55 % of the samples were microbiologically polluted, in particular, 83% of samples in Mardan were found unsafe. Iron (Fe) contamination in water was identified in cities, namely Peshawar and Mardan, where the contamination ratio was 67 % and 38 %, respectively. The study concluded that As prevalence was found in cities of Punjab, presence of iron in water samples of cities of KP and nitrate in Balochistan (Loralai, Ziarat, Khuzdar and Quetta) and greater turbidity was found in Sindh. Microbiological and As contamination was the principal contaminants discovered in 12 cities of Punjab districts. However, majority of the samples were microbiologically contaminated in all four provinces.

Structural geometric analysis with reference of balanced cross sections, southern Kohat Sub Basin, Pakistan

Salik Javed[1,2*] and Sohail Wahid[1,2]

[1]GIS and Space Application in Geosciences Lab (G-SAG)
[2]National Centre of Excellence in Geology, University of Peshawar, Pakistan
**salikjaved16@gmail.com*

Kohat Fold and Thrust Belt (KFTB) marks western terminations of the sub-Himalaya. Kohat Plateau exhibits distinctive thrust sheet geometry and forms the northwest element of the Himalayan ranges. It mostly consists of broader synclines, narrow evaporite-cored anticlines and Pop-up structures, having great displacement along upper-level detachment that is provided by Eocene evaporites. A lower decollement is interpreted at the base of the Paleozoic section. Upper-level detachment is restricted to the Kohat area whereas the lower detachment is common to both the Kohat and Salt Range/ Potwar Plateau. The Karak trough covers the southern part of Kohat Plateau, having complex folded and faulted structural geometries with its complicated geological aspects e.g., asymmetrical structures and moderate-steeper dips which may have been formed by a larger number of thrust/normal faults. Bordering the foothills of Himalaya Pakistan, Kohat Plateau is located at the northwestern apex of the southern deformed fold and thrust belt. Present study paid more attention on recognizing major structures, revising and modifying the tectono-stratigraphic map and constructing structural cross-sections across Karak area located in the southern Kohat Plateau, Kohat Basin. It has been interpreted that study area is primarily composed of high angle reverse faults and their trajectory is flattened near the surface while steepened with depth, having general trend in East-West direction. Generally E-W trend, Narrow hinged Anticlinal and broadened synclinal folds are mapped in the area. The area has undergone an early North-South compressional phase of deformation which is responsible for East-West oriented structures overprinted by a North-West oriented plio-pliestocene phase of transpersonal deformation responsible for F-2 structures related to a less prominent D-2 phase.

Spatio–temporal characteristics of hydro–metrological drought in Baluchistan, Pakistan

Fozia Khan Kakar[1], Muhammad Ali[1,2*], Rahat Ullah[3] and Mukhtiar Ghani[3]

[1]*National Centre of Excellence in Geology (NCEG), University of Peshawar*
[2]*GIS and Space Application in Geosciences Laboratory (GSAG-L)*
[3]*Geological Survey of Pakistan (GSP), Quetta, Baluchistan*
**aliumarzai@uop.edu.pk*

Drought is a recurrent hydro–metrological phenomenon in Pakistan; especially in Balochistan Province, drought is the most complicated and least recognized of all-natural disasters, posing a threat to humans and agriculture productivity. The most severe drought in the region is recorded in 1998 and extended up to 2002 in certain areas and happened due to low and irregular rainfall. This research aims to analyze the drought conditions in the arid, semi-arid, and hyper-arid regions of the Balochistan province by using the standard precipitation index (SPI) based on the annual and seasonal data for 22 years (1998–2019). For this purpose, satellite data from the Tropical Rainfall Measuring Mission (TRMM) of seven stations were utilized. The satellite data was downloaded from freely available online sources (https://giovanni.gsfc.nasa.gov/giovanni/). During this study, extreme and severe drought was observed in Barkhan, Zhob, Lasbella, and Panjgur, from 2000 to 2002, 2004, and 2018 with values of -2.54 to -1.83. Quetta region has faced two extreme droughts in the monsoon season during 2002 and 2004 with a value of -2.08. These values represent extreme drought conditions in the given period. Furthermore, results from this study revealed frequent drought events in the region with an expected increasing trend in the future.

Geo-mechanical and geochemical evaluation of the Samana Suk Formation for construction industry at Sheikh Budin Hills, southern Khyber-Pakhtunkhwa

Asad Kamran[1]*, Liaqat Ali[1], Waqas Ahmad[1], Sobia Zoreen[2] and Shah Jehan[1]

[1]*National Centre of Excellence in Geology, University of Peshawar 25130, Pakistan*
[2]*Institute of Chemical Sciences, University of Peshawar 25120, Pakistan*
**asadkamran7704@gmail.com*

This study evaluated the geo-mechanical and geochemical characterization the Middle Jurassic Samana Suk Formation at the Sheikh Budin Hills, southern Khyber-Pakhtunkhwa. Samana Suk Formation is mainly composed of limestone, dolomite and intercalations of marl and shale. Petrographically, the limestone of the Samana Suk Formation is majorly consisted of ooids, peloids, bioclasts and calcite ($CaCO_3$) with trace concentration of the dolomite. The results of geo-mechanical characterization of the limestone as an aggregate material (i.e., bulk

density, water absorption, specific gravity, soundness, flakiness and elongation index, clay lumps and friable particles, Los Angles abrasion and unconfined compressive strength) are in agreement with the American Standard Testing Material (ASTM). Geochemical results demonstrated that the limestone of the study area is dominantly made up of calcite (>90%); while on average it is composed of 52.08 wt. % CaO, 1.13 wt. % SiO2, 0.66 wt. %, MgO, 0.80 wt. % Al_2O_3, 0.76 wt. % Fe_2O_3 and LOI is recorded as 42.13 wt. %. Whereas, P_2O_5, K_2O, Na_2O, MnO, and TiO_2 are in trace amount. The geochemical and petrographic examinations reveal that the limestone is innocuous in terms of Alkali Silica Reactivity (ASR). The findings of this study recommend the use of limestone of the Samana Suk Formation as a raw material in construction and cement industries.

Lithofacies and depositional environment of the Quaternary succession of Hana-Spin Karez area, District Quetta, Baluchistan, Pakistan

Muhammad Iqbal Kasi[1], Aimal Khan Kasi[2*], Akhtar Muhammad Kasi[1] and Razzaq Abdul Manan[2]

[1]Department of Geology, University of Baluchistan, Quetta
[2]Centre of Excellence in Mineralogy, University of Baluchistan, Quetta
**aimal_kasi@yahoo.co.uk*

The Quaternary succession of Hana - Spin Karez area comprises fluvio-lacustrine Spin Karez Group. The group is categorized into three units, which from lower to top are: Hana Lake Conglomerate, Hana Red Clays and Spin-Karez Conglomerate. The group is 800 m thick strata, which covers ~30 km2 surface area. Based on the field studies the group has been divided into 15 lithofacies which were grouped into 5 facies associations and 8 architectural elements. Lithofacies include 5 gravel, 7 sandstone and 3 mudstone facies. Facies associations include sandy/gravely braided-channel deposits, sheet-flood deposits, floodplain deposits, marginal lake deposits and deep-water lake deposits. Total of eight architectural elements were recognized in the Group, which include: channels, scour hollows, gravely bars and bedforms, sandy bedforms, gravity flows, elements of downstream accretion, laminated sand sheets and overbank fines. Both Hanna Lake and Spin Karez conglomerates characterize gravelly-braided channel system, although their behaviour differs at some localities. The facies of Hanna Lake Conglomerate bear a resemblance to the Scott-type architecture, characterized by high energy and low sinuosity proximal gravely braided channel system in the northern part of the study area. The conglomerate resembles the Donjek-type architecture, characterized by high sinuosity and low energy braided-channel system in the south of the study area. The facies of Hana Red Clays are characterized by fine-grained shallow lacustrine deposits. The facies of Spin Karez Conglomerate also resembles Scott-type braided-channel deposits. The Spin Karez Group grew in three stages: 1)

deposition of the Hana Lake Conglomerate started with the Scott-type braided channel system (proximal area) in the north and Donjek-type system (distal) in south; 2) deposition of the Hana Red Clays in shallow lake with episodic subaerial exposure, giving reddish-brown colour to the mud-dominant facies; 3) deposition of Spin Karez Conglomerate in Scott-type braided channel system above the lake deposits of the Hana Red Clays. It is postulated that the aggradation of 800 m thick strata in such a small basin (~30 km2) was mainly provided by continued subsidence of underlying soft shale of Ghazij Formation.

An upgraded seismotectonic zonation and hypocentral relocation of major earthquakes of Pakistan based on self-generated earthquake catalogue

Perveiz Khalid*, Shahzada Khurram and Muhammad Irfan Ehsan

Institute of Geology, University of the Punjab, Lahore
**perveiz.geo@pu.edu.pk*

Pakistan is situated in highly active seismotectonic zone where ongoing plate movement between the Indian and Eurasian plates is one of the main sources of seismicity. Due to recent major earthquakes in the region, the upgradation of seismotectonic zones is needed as the seismicity is shifted from Northwest Himalayan Fold and Thrust Belt to Makran Subduction Zone in the south. A self-generated earthquake catalogue containing more than 34000 events with Mw≥2.0 with focal depth more than 1 km from the period 1953 to December 2020 was prepared after consultation of international earthquake data bases for seismotectonic zonation and proper understanding of earthquake geometry and location. Based on probabilistic seismic hazard assessment, Pakistan was divided into 7 different seismic zones to find the values of peak ground acceleration (PGA) with their return period. 4.1 magnitude of completeness (Mc) was encountered for whole catalogue. Using probabilistic hazard assessment that peak horizontal ground acceleration with 50% probability of exceedance in 100 years (~ 144 years return period) is 0.19g. Mean values were taken from each zone on the basis of three distinct published ground motion attenuation equation. From the attenuation equation the PGAs values varied from 0.125g to 0.672 g according to the variation in zones description on the basis of seismicity and tectonic setting. Thus, these values of PGA can also be recommended for operational basis earthquake (OBE) with shear wave 760 m/sec for design purpose. The hypocenters of more than 180 significant earthquakes (Mw>6.0) were relocated using Modified Joint Hypocenter Determination method with the help of seven proposed velocity models with an average VP/VS = 1.73. Based on this relocation, these major earthquakes were distributed into four different groups of particular depth intervals.

Siah Diq porphyry Cu-Au prospect, a newly discovered porphyry copper-gold system in the Chagai volcano–magmatic arc, SW Pakistan

Yasir Shaheen Khalil[1,2,3*], Li Wenyuan[1,3], Syed Ali Abbas[2], Liu Lei[1] and Hong Jun[3]

[1]*School of Earth Science and Resources, Chang'an University, Xi'an, Shaanxi 710054, China*

[2]*Geological Survey of Pakistan, Quetta, Baluchistan*

[3]*Xi'an Center of Geological Survey, China Geological Survey, Xi'an, Shaanxi 710054, China*

**yasirshaheen2189@gmail.com*

The discovery of the Siah Diq Cu-Au porphyry system in the foothill of Neogene Dam Koh volcano, unconformably overlain by 46 m of alluvium, is a recent example of exploration success under cover in a traditional mining jurisdiction. Acquisition of geophysical data followed by drilling and logging played an important role in this discovery. Integrated geophysical surveys (magnetics, induced polarization and resistivity) in an area of 1859.50 Acres, pointed out magnetic low, induced polarization high and resistivity low anomalies corresponding to sulfide mineralization due to hydrothermal alteration. Three exploratory bore holes were drilled to verify the geophysical anomalies. After careful observation and geoscientific logging, porphyry style mineralization was revealed in the drill core samples. The porphyry system was further characterized based on host rock lithology petrography, alteration mineralogy, ore vein characterization, ore petrography, Cu/Au geochemical assays and fluid inclusion studies. Lithological rock units hosting the mineralization include porphyritic andesite, granodiorite porphyry, diorite porphyry and granite with such a pervasive mineralization and alteration that the original textures have been partially to completely obliterated. Hydrothermal alteration in this porphyry system is complex and multiple alteration zones overprint one another. Propylitic alteration is prevalent and dominant alteration in all the three bore holes. It is followed by phyllic, potassic and argillic alterations. Based on petrographic studies and logging, potassic and phyllic alterations are largely developed in granodiorite porphyry, granite, monzodiorite and porphyritic andesite while propylitic alteration is predominantly reported from the porphyritic andesite. Sulfide mineralization present as cross cutting stockwork vein system and disseminations including pyrite and chalcopyrite, mainly associated with phyllic alteration. Galena, sphalerite, magnetite and bornite are the other ore minerals present in veins stockworks. Average copper assays of drill core recovered from borehole 1 are 0.11%, from bore hole 2 are 0.27% and from borehole 3 are 0.13%, while gold assays collected at regular intervals from all the three bore holes on average are 0.78 ppm. The nature of liquid-vapor solid (LVS) and vapor-rich fluid inclusions observed in quartz from mineralized veins, indicate that ore

precipitation occurred at lower hydrothermal temperatures from intermediate to hyper-saline hydrothermal fluids.

Genetic oil typing of crude oils and condensates from the Adhi Oil Field, Upper Indus Basin, Pakistan

Adil Khan[1,2]*, Imran Khan[2], Syed Tallataf H. Shah[2] and Abid Ullah[2]

[1]Pakistan Petroleum limited, Pakistan
[2]COMSATS University Islamabad, Abbottabad Campus, University Road, Tobe Camp, Abbottabad
**kh_adil@ppl.com.pk*

In Pakistan, the Potwar subbasin contributes as a key petroliferous zone. This subbasin has been the subject of exploration for a long time. In this subbasin, exploration has been going on for a long time. Hydrocarbons (HC) are trapped in tiny to medium-sized trap features in the Potwar subbasin, which were formed by tectonic activity preceding the collision of the Indian and Eurasian plates. Despite the fact that the subbasin has multi-source rocks and many ages' reservoir rocks, the origin of the oil/gas found in these reservoirs, as well as its link to the numerous source rocks, are uncertain. Adhi Oil Field located to the east of the Potwar subbasin also reported having variable API gravity crude oils and condensates extracted from Cambrian and Permian reservoirs. The origin of these crude oils within this part of the basin is also not very clear. Here we use two condensate oils from Adhi Oil Filed i.e., Adhi-17 (APIo 56.6), Adhi-19 (APIo 57.78), and two normal oils i.e., Adhi-14T (APIo 32.17), and Adhi-26 (APIo 29.6), to look at the organic geochemical parameters that are derived from biomarker distributions and carbon isotopic ratios. The major aim was to understand the genetic relationship between these crude oils, their geographic distributions, as well as the potential migratory pattern at the field and regional levels. Two genetic crude oil families have been revealed on the bases of the distribution of diagnostic biomarker parameters and stable isotopes from the four studied samples. For the two waxy condensates of the Adhi Oil field, Larger Pr / Ph, diahopane / hopane, diasterane / sterane ratios, and low DBT / P, C19 tricyclic and C24 tetracyclic terpanes have a higher relative abundance, implying a terrestrial source of OM deposited in highly oxic/fluvio-deltaic conditions. The other two normal crude oils are exclusively nonwaxy marine oils; clastic-rich materials deposited in marine suboxic depositional environments are the primary sources. The PAHs distribution within studied crude oils also delineates it into two distinct groups on the bases of depositional environments and source OM variations. The two condensates show abundant biphenyls (BPs) and fluorenes (Fs), whereas two normal oils have a higher abundance of dibenzothiophenes (DBTs) with almost no to the negligible presence of dibenzofurans (DBFs) and Fs. The depositional environment of OM generally controls the relative abundance of heterocyclic aromatic hydrocarbons within the Adhi crude oils. The normal marine crude oils are enriched in sulfur compounds (i.e., DBTs), and non-

marine condensates oils have a higher abundance of oxygen compounds (DBFs) and Fs. Higher plant contributions in condensates oils are shown by the higher abundance of aromatic biomarkers. The thermal maturity of the Adhi Oil Field's crude oils was determined using a variety of saturated and aromatic hydrocarbon characteristics. Minor biodegradation up to level 3 has been witnessed in two normal crude oils of the Adhi Oil Field. The current research will aid in determining the area's future exploratory operations.

Structural modification of bentonite through pillaring and cation saturation for aflatoxin B1 adsorption

Ahmad Khan[1*], Mohammad Saleem Akhtar[1], Saba Akbar[1] and Youjun Deng[2]

[1]Institute of Soil and Environmental Sciences, PMAS-Arid Agriculture University, Rawalpindi, Pakistan
[2]Department of Soil and Crop Sciences, Texas A&M University, College Station, Texas, USA
**ahmadk78@gmail.com*

Aflatoxins are toxic metabolites of Aspergillus that occur as a contaminant in animal feed and human food. Natural smectites are effective binders for aflatoxin in aqueous solutions but have limitations in the in-situ gut environment due to interference and competition of biomolecules. A large mismatch between laboratory-measured adsorption capacity and the control has been reported through feeding trials. Pakistan has large clay deposits of medium to high grade with high potential for various industrial, biological, agricultural, and health applications. Yet, limited studies have been conducted on the mineralogy details of these clay reserves and their structural modification, which hindered their exploitation for specified uses. Efforts have been made to enhance the adsorption capacity and affinity of smectites for aflatoxins in the presence of biological compounds. The main objective of the present study was to modify the well-characterized indigenous bentonite structure by pillaring and cation exchange to enhance aflatoxin B1 adsorption capacity and selectivity. Smectite was pillared with Al and Al-Fe polycations or saturated with Ca, Mg, Zn, or Li. Structural changes in smectites with or without heat treatment were determined using X-ray diffraction and Fourier-transform infrared spectroscopy. Equilibrium aflatoxin B1 adsorption to the smectites was measured in an aqueous solution and simulated gastric fluid. Pillaring with the polycations expanded smectites in the z-direction to 18.6 Å and the expansion was stable after heating at 500°C. Changes in the Al–OH–Al infrared bands in the stretching region supported the formation of pillared clays. Migration of Mg, Zn, and Li into the octahedral sites of the smectite was observed as Mg and Zn saturation yielded a d spacing of 15 Å at 200°C which collapsed to 9.6 Å at 400°C. The 14.6 Å peak of the Li-saturated smectite collapsed to 9.6 Å at 200°C while the 15 Å Ca-saturated smectite peak was stable up to 400°C. The unheated Al- and AlFe-pillared smectites adsorbed significantly

more aflatoxin B1 from an aqueous suspension than did unpillared clay. In both water and simulated gastric fluid, heat treatment decreased aflatoxin B1 adsorption to pillared smectites, but heat treatment increased aflatoxin B1 adsorption to unpillared smectites. Without heat treatment, smectites saturated with divalent cations (Ca, Mg, Zn) adsorbed more aflatoxin B1 from an aqueous suspension than the smectite saturated with a monovalent cation (Li). Ca-saturated smectite showed the greatest aflatoxin B1 adsorption, 114 g kg–1, from aqueous suspension after 400°C heat treatment. The Zn-, Mg-, and Li-saturated smectites showed maximum aflatoxin adsorption of 107, 93, and 90 g kg–1, respectively, after 200°C heat treatment. From simulated gastric fluid with pepsin, the 200°C heated, Zn-saturated smectite had maximum aflatoxin B1 adsorption of 68 g kg–1. Pillared smectites effectively adsorbed aflatoxin B1 from aqueous suspension, but Ca- and Zn-saturated smectites after heat treatment might improve the selectivity of smectites for aflatoxin B1 over pepsin and enhance the efficacy of smectite as a feed additive.

Depositional environment and sequence stratigraphy of Kirthar Formation Rakhi Nala section Eastern Suleiman Ranges, Pakistan

Emadullah Khan[1*], Mubashir Mehmood[1], Maryam Saleem[2], Syed Wasim Sajjad[3] and Muhammad Shahab[4]

[1]Department of Geology, Abdul Wali Khan University Mardan, Pakistan
[2]Department of Earth & Environmental Sciences, Bahria University Islamabad Pakistan
[3]Department of Earth Sciences Quaid e Azam University Islamabad, Pakistan
[4]National Center of Excellence in Geology, University of Peshawar, Pakistan
**emadgeo@awkum.edu.pk*

Kirthar Formation is well exposed in the Rakhi Nala Section of Eastern Sulaiman ranges. Its lower contact with Ghazij Formation of Lower Eocene age is conformable. Its upper contact with Chitarwatta Formation of Oligocene age is transitional. Lower contact of Kirthar Formation is marked along the greenish grey massive shale of Baska Member of Ghazij Formation and upper contact of Kirthar Formation is along the reddish-brown iron ore. Late Eocene Kirthar Formation is divided into four members: Habib Rahi Limestone Member, Domanda Shale Member, Pirkoh Limestone Member and Drazinda Shale Member. These four members were deposited in response to sea level changes caused by tectonic activity. Habib Rahi Limestone Member was deposited during transgressive period after which regression started and caused the deposition of Domanda Shale Member. During second phase of transgression Pirkoh Limestone and Marl Member was deposited. The pattern of Habib Rahi Limestone and Pirkoh Limestone and Marl Member can be described by 'catch up' to 'keep up' deposition. Drazinda and Domanda Shale Members represent the regressive period. Facies of Kirthar Formation deposited in platform, shelf and deep-sea environments.

Electronic and optical properties of Titanium Dioxide (TiO_2): Role as environmental cleaner and renewable energy source

Fahim Ullah Khan and Matiullah Khan*

Department of Physics, Kohat University of Science and Technology (KUST), Kohat, Pakistan
**dr.matiullah@kust.edu.pk*

The titanium dioxide (TiO_2) is equally efficient in environmental cleanup and renewable energy sources. In this study, the photoelectrochemical response of TiO_2 is improved by shifting its absorption edge towards visible regime. Here, the effect of Cerium (Ce), Nitrogen (N), and Phosphorous (P) doping and co-doping on the electronic and optical properties of pure anatase TiO_2 is calculated using density functional theory. Comparison was made based on anatase TiO_2 single doped (Ce, N, P) and three different models of co-doped (Ce, N), (Ce, P), and (N, P). Single doped Ce, N, and P reduced the band gap of pure TiO_2 anatase from 2.12 eV and induced visible light absorption. Greater reduction in the band gap of intrinsic TiO_2 is found due to co-doping. The most prominent reduction in the band gap is reported for the tri-doped system. While investigating the absorption spectra of the developed systems, all doped systems shifted the absorption range of TiO_2 towards visible regime. The tri-doped system displayed the best visible light absorption among the developed systems. The improved visible light absorption would enhance the photocatalytic activity under visible light illuminations. This study would help in widening the application spectrum of TiO_2 and improve the efficiency of TiO_2 in photoelectrochemical applications.

Performance enhancement of waste heat recovery process using indirect evaporative cooler

Haris Khan[1*], Rasikh Tariq[2], Muzaffar Ali[1] and Syed Nasir Shah[3]

[1]Department of Mechanical Engineering, Faculty of Mechanical and Aeronautical Engineering, University of Engineering and Technology Taxila, 47080 Rawalpindi, Pakistan

[2]Facultad de Ingenieria, Universidad Autónoma de Yucatán, Mérida, Yucatán 97000, Mexico

[3]Department of Energy Engineering, Faculty of Mechanical and Aeronautical Engineering, University of Engineering and Technology Taxila, 47080 Rawalpindi, Pakistan

**hariskhan1662@gmail.com*

For an efficient and well-developed sustainable system, it is necessary to produce useful energy products. Today world demands more electricity production and less hazardous emissions like CO_2, NOX, SOX etc. Waste heat gases has direct environmental concerns. They cause global warming, pollute environment and effect human health. Researchers reveals that the overall thermal efficiency of waste heat recovery system could be improved by transforming waste heat into desired output work. The efficiency that they got from this system is minimal just 5% to 8% and unable to meet the cost and space requirements of this waste heat recovery system as well. Typically, the most used one cycles for waste heat recovery is Rankine cycle and Brayton cycle. Although these cycles are best cycles but this cycle has not as such maximum efficiency. By considering all these factors there is another way for waste heat recovery with enormous power generation and maximum efficiency is indirect evaporative cooler. Indirect evaporative cooler will be used in this present research for recovery of waste heat. Indirect evaporative cooler is beneficial in terms of achieving maximum efficiency, minimizing operating cost as well as attaining sustainable system. Indirect evaporative cooler is favorable in various applications of air conditioning like industrial, residential and commercial. This system is fully environment friendly with a very low impact on global warming. This current research will be based on indirect evaporative cooler that basically operates on Maisotsenko cycle (M cycle). The model of this system will be developed in Aspen Hysys software. Aspen hysys is a powerful tool for simulating model based on chemical and various other processes. The novelty of this research is modelling and executing indirect evaporative cooler on Aspen Hysys software. Moreover, Performance analysis such as Power generation as well as efficiency of this system will be analyzed in this research.

Precambrian organic geochemistry and the early evidence of life in the Indus Basin of Pakistan

Imran Khan[1*], Asad Ali[1] and Adil Khan[2]

[1]COMSATS University Islamabad (CUI), Abbottabad Campus University Road, Tobe Camp, Abbottabad (22044)
[2]Pakistan Petroleum Limited (PPL), Pakistan
**imrankhan@cuiatd.net.pk*

Perhaps the most fundamental and at the same time the least understood geological problem is the origin of life on the earth. It is central to many scientific problems. Since the formation of the earth and the rest of the solar system took place from the solar nebula almost ~4.6 Ga ago. The oxygen level was low to negligible to support any life on earth initially. The first indirect isotopic evidence for life on earth has been reported from Greenland Archaean rocks (3.85 Ga). The ~3.5 Ga old Apex Chert Pilbara, NW Australia contains what many claims are Earth's oldest microfossils. However, such microfossil artefacts could be formed by the displacement of amorphous carbon over time thus making the origin of these microfossils controversial and not universally accepted. The Pilbara stromatolites of 3.43 Ga could be the first direct evidence of the start of life on earth. The Great Oxidation Event (GOE) recorded between ~2.4-2.2 Ga, set the stage for a remarkable transformation by a dramatic rise in oxygen in the ocean resulting in organic complexity. The first fossil eukaryote (Grypania, a photosynthetic autotroph) has been reported from ~2.1 Ga (Paleoproterozoic) rocks. Later, more eukaryotes including cytoskeleton-bearing eukaryotes "Acritarchs" and red algae were reported from 1.49 Ga and 1.2 Ga old rocks. Sturtian and Marinoan were the two important glaciation events recorded in Cryogenian Period and marks the rise of algae and ciliatos. The 'Rise of Algae' created food webs with more efficient nutrient and energy transfers, driving ecosystems towards larger and increasingly complex organisms. The Earth's first animals (metazoans, 0.6–0.57 Ga old), in the form of animal embryos reported from Doushantuo Formation, China. By the end of the Ediacaran, oxygen levels rose, approaching levels sufficient to sustain oxygen-based life. Burrows found in the fossil record, dating to the end of the Ediacaran, reveal that worm-like animals had begun to excavate the ocean bottom. The Cambrian Period (541-485 Ma) witnessed a wild explosion of new life forms. The Neoproterozoic-Early Cambrian Salt Range Formation represents the oldest sedimentary sequence reported from the Indus Basin of Pakistan. The organic-rich black shales that occur towards the top of the Salt Range Formation represent an ideal condition for the preservation of biogeochemical signatures of the microbial communities that proliferated in those ancient paleoenvironments. The Salt Range Formation shales show the highest content of organic carbon (>47%) at relatively low thermal maturity (BRo~0.2-0.5), thus representing by far the most thermally immature Neoproterozoic rocks analyzed to date. An integrated study including biomarker and isotopic analysis is carried out on some selected Salt Range

Formation shale samples. Various biomarker proxies like C35 homohopane index, gammacerane/hopane, and presence of 25-norhopanes suggest a possible chemocline water column within a restricted marine setting occurred during the deposition of Salt Range Formation shales. The observed paleobiology and ancient niche of the Salt Range Formation shales appear to be unique for the Neoproterozoic-Early Cambrian settings.

Characterization of solid waste and study of recycling in University of the Punjab, Quaid-e-Azam campus, Lahore

Mehroz Khan* and Muhammad Abdullah

College of Earth and Environmental Sciences, Quaid-e-Azam Campus, University of the Punjab, Lahore-Pakistan
**mehrozkhan455@gmail.com*

Waste controlling systems are the greatest difficulties for sustainable development. For these schemes to be efficacious, the main step is to perform waste categorization studies. This research study aims to set the basis for the application of reclamation, decrease the amount of waste, and recycling controlling programs at the campus. Solid waste generation and characterization are the most important parameters that play a very significant role in sustainability of environment. This study determines the variations in components of waste within solid waste mass by seasonal conditions following the analysis conducted on characterization of solid wastes produced in University of the Punjab, Quaid-E-Azam Campus, Lahore. The time period of this research study was almost four months (December 20th to April 20th). We collected the data in two modes with two different categories. One mode is seasonal based and other is semester based (semester break or term time). We classified these categories in just two modes, as the data of winter season and semester break were collected together, and that of summer season and term time together. There are total 6 trolleys in University of the Punjab, Quaid-E-Azam Campus that collect waste from 6 different points of university. Out of these 6 points, 4 points or 4 trolleys were selected. It was noted that each empty trolley weighs about 5 tons, whereas each trolley with waste weighs about 7 tons. This shows that each trolley carries 2 tons of waste on daily basis. It means new campus of Punjab University produces 12 tons of waste per day, out of which more than 45% is re-usable, and could possibly be recyclable as well. The results of this study clearly show that a program for segregation, solid waste characterization, waste generation rate and recycling potential is viable in this university campus. This study showed that the native market for recyclable waste, the number of reprocessing companies can absorb all of these wastes.

Compositional variations of chromite in chromitites from the Zhob Valley Ophiolites: Implications for chromitite origin

Muhammad Ayoub Khan[1*], Thomas Ulrich[2], Muhammad Ishaq Kakar[1], Recep Melih Akmaz[3], Rehanul Haq Siddiqui[4] and Liaqat Ali[5]

[1]Centre of Excellence in Mineralogy, University of Balochistan, Quetta, Pakistan;
[2]Department of Geoscience, Aarhus University, Høegh-Guldbergs Gade 2, DK-8000 Aarhus C, Denmark
[3]Department of Geological Engineering, Bülent Ecevit University, 67100 Zonguldak, Turkey
[4]Balochistan University of Information Technology, Engineering and Management Sciences, Quetta, Pakistan
[5]National Centre of Excellence in Geology, University of Peshawar, Peshawar, Pakistan
**ayoub.cemuob@gmail.com*

Khanozai, Muslim Bagh, and Zhob chromitites, occur in mantle peridotites of Zhob valley ophiolites, are massive, disseminated and nodular which exhibit both magmatic and deformational textures. The Muslim Bagh and Khanozai chromitites exhibit Cr# = 0.66–0.85 while Zhob chromitite shows Cr# = 0.53–0.58 and are, therefore, classified into high-Cr chromitite and high-Al chromitite, respectively. The parental melts compositions of high-Cr chromitites and high-Al chromitites are showing similarities with boninitic melts and MORB melt affinity, respectively. High-Cr chromitite is in agreement with boninite while high-Al chromitite differs from boninite on MORB normalized major and trace element patterns. Olivine and amphibole inclusions in both type of chromitites is also noticed. These inclusions and their textures suggest that these represent crystallization products of trapped liquids during crystallization of chromite. The Field occurrences, textural and geochemistry characteristics, and the occurrence of hydrous (amphibole) silicate inclusions in the chromite grains, indicate that high-Cr chromitite were formed, possibly in supra subduction zone, by boninitic melt. Whereas, high-Al chromitite crystallized from MORB-like melt, probably originated in a back arc basin tectonic environment, during reaction with depleted mantle.

How earthquake influence groundwater system? Lessons learned from the coseismic liquefaction-induced deformation following the 2019 Mirpur earthquake, Pakistan

M. Younis Khan* and Syed Ali Turab

National Centre of Excellence in Geology, Peshawar, Pakistan
**myouniskhan@uop.edu.pk*

The Mirpur city and surrounding villages were severely damaged by extensive coseismic liquefaction within 6 km of the epicenter of the Mw 5.8 Mirpur earthquake on 24 September 2019. The earthquake induced coseismic deformation on the ground surface included sand blows, ground failure and lateral spreading, whereas subsurface coseismic signatures were observed in the form of elevated groundwater table, fractures, water-filled zones, sand dikes, and lenses of high conductivity. The geology of the study areas is dominated by the Quaternary alluvial deposits overlying a liquefied sandy soil. The inverted electrical resistivity models reveal three regional geoelectric layers having thickness ranging from 2 to 8 m characterized by resistivity values from about 25 Ωm to >100 Ωm. The fractures and elevated groundwater table were mapped on the resistivity sections. Coseismic deformational patterns were found within the area of ground shaking intensity of VI where residential buildings and key infrastructure (e.g., the Upper Jhelum Canal, bridges, and the main Jhelum–Jatlan road) were severely damaged. The geophysical results were in agreement with the field observations (sand blow, fissures etc.). Based on geological and geophysical data, we infer that earthquake induced changes in the groundwater system and associated deformation were primarily controlled by the local geological setting, and shallow groundwater table amongst other factors.

Seeking answers of the history of the earth and solar system by investigating lunar meteorite: Performing petrography, mineralogy and geochemistry of the Gadamis 003 sample

Sarah Khan* and Khalid Latif

National Centre of Excellence in Geology, University of Peshawar, Pakistan
**iamcarah@gmail.com*

Earth's closest neighbor, the Moon is a cornerstone of planetary science. Since 50 years of the Apollo 11, we have succeeded to land first humans on the Moon and have brought back 382kg of samples as lunar core, regolith, rocks, and dust. While other lunar unmanned missions, i.e., automated Soviet spacecraft and Chinese Chang'E 5 bagged samples of 300g and 1731g, respectively from unique sites, far away from Apollo landing and rover-ed vicinities. By observing remotely through telescopes and spacecrafts, and handling samples directly with robots on the moon and analyzing pristine return-samples on Earth, scientists have solved many mysteries. However, an important insight indicated that half a billion years of

information is still missing about the Earth. This research, thus focuses on the Moon, the geological time capsule to help identify on a broader scale the events and processes that happened during those gap years. Also, more specifically it tends to contribute to the unanswered questions about the origin of life. Out of 541 lunar recorded meteorites in the Meteoritical Bulletin Database, this study is aimed at investigation of Gadamis-003 sample, a sample similar to the ones collected by Apollo-16 mission from lunar highlands. The research contributes to the space-sciences by analyzing the petrographic, mineralogical and geochemical characteristics of the lunar meteorite, and at the same time, pushes to build a new cognition based on a case that it has put forward regarding the possibilities of bio-signatures in either known or agnostic forms on the lunar terrains and water reservoirs lurking at the shadowed poles and other sunlit surfaces based on the current scientific reports. This study also offers procedures for the identification and characterization of future meteorites to be analyzed in-house, and instinctively conduct inter-lab studies to compare the data of our control sample with already studied samples. Additionally, if targeted biosignatures are identified, higher chances of the precursors or primitive forms of life would be suggested on the Moon. Otherwise, more sensitive methods would be required to detect, store and analyze lunar meteorite samples to reach more accurate conclusion(s).

Past, present, and future carbon stock assessment of Khyber Pakhtunkhwa forests, Pakistan

Spogmay Khan and Sofia Baig*

Institute of Environmental Sciences and Engineering (IESE), National University of Sciences and Technology, H-12 sector, Islamabad, 44000, Pakistan
**sofia.baig@iese.nust.edu.pk*

Increasing carbon dioxide due to anthropogenic activities are the reason of great climate change like global warming which in return has led to sustainable development challenges. Increasing forest area is one of the effective ways to reduce global warming and mitigate increasing carbon dioxide levels. According to REDD+ survey, Azad Jammu and Kashmir has the highest forests followed by Khyber Pakhtunkhwa with 20.3 % and known as the most forested province of the country. The total cover area of Khyber Pakhtunkhwa forest is about 2.043 million hectares which is about 45% of total forest area of Pakistan and has high potential of storing carbon. The forestry sector of Khyber Pakhtunkhwa is a net sink of 1.84 million tons of Carbon dioxide per year. However, this sink has been tremendously increased by Billion Trees Afforestation Project during 2013-2018. Therefore, to understand and know why it is necessary quantitative analysis will be done. This study assesses the carbon sequestration to measure and compare the past and present changes in carbon stock in Khyber Pakhtunkhwa region by using carbon model. In this region of the Pakistan most of the forests are restored and many plantations has been done through afforestation project (BTTP). However,

for accurate measurements carbon model will be used to assess spatial changes over time by calculating tree cover and carbon stock for each forest type.

Assessment of heavy metals and its treatment through hydrophytes in groundwater along river Kabul in district Charsadda, Pakistan

Shehryar Khan[1], Sajid Ullah[2*], Shaukat Ali[3], Gul Rukh[4], Zakir Ullah[5], Shah Dherai Bibi[5], Sabeena Shaukat[6], Asghar Ghaforzai[2], Muhammad Zamir Stanikzai[2] and Syeda Kainat Izhar[4]

[1]School of Environmental Sciences and Engineering, Northeast Normal University, Changchun, Jilin 130024, China
[2]Department of Water Resoucres and Environmental Engineering, Nangarhar University, Jalalabad 2601, Afghanistan
[3]Department of Environmental Sciences, Karakoram International University, Gilgit 15100, Pakistan
[4]Department of Chemistry, Abdul Wali Khan University, Mardan 23200, Pakistan
[5]Department of Environmental Sciences, Abdul Wali Khan University, Mardan 23200, Pakistan
[6]Department of Chemistry, University of Swabi, Swabi, Khyber Pakhtunkhwa 23430, Pakistan
**sajidjalwan@gmail.com*

This study was about toxic heavy metals detection in groundwater and its treatment through phytoremediation along River Kabul in District Charsadda, Pakistan while assessing other physiochemical parameters such as pH, EC, TDS, turbidity, fluoride, phosphates, nitrites and nitrates as well. All these parameters were detected to be within the permissible limits of World health organization (WHO) and Pakistan-National environmental quality standards (PAK-NEQs) for drinking water except turbidity which was detected higher than the permissible limit of ≤5 NTU in four sampled areas with highest level of 9.99 NTU. Chemical parameters were also reported to be within permissible limits except toxic heavy metals i.e., arsenic (As), cadmium (Cd), lead (Pb), nickel (Ni) and zinc (Zn) which have higher concentrations in samples collected from S2 (15.20 µg/L), S1 (20.50 µg/L), S8 (17.60 µg/L) S9 (120.28 µg/L) and S10 (131.12 µg/L) according to (WHO) standard limits of 10 µg/L, 5 µg/L, 10µg/L, 100 µg/L and 1000 µg/L respectively, however the permissible limits were within the range of the standard limits set by PAK-NEQs as 50, 100, 500, 1000 and 5000 µg/L for each in ground drinking water. Heavy metals are capable of causing serious health and environmental problems even at low concentration. Hence the population of these four sampled areas are exposed to these toxic heavy metals pollution through groundwater usage that can cause different diseases. Therefore, the treatment of these toxic heavy metals through phytoremediation is more important to reduce it up to the permissible limits set by WHO and PAK-NEQs to protect human health and environment.

Virtual Water

Muhammad Umar Khan Khattak

Institute of GIS, NUST, Islamabad, Pakistan
**ukhattak@hotmail.com*

Among many challenges faced by Pakistan, the water-energy-food nexus is a major one. Pakistan owns a part of the so-called water tower, in the form of snow/glacier cover in the northern high mountains of Himalaya, Karakorum and Hindukush ranges. And the mean annual inflow of waters in the Indus water system of the last 75 years at 50% probability level is at ~140 MAF (~172 BCM). This annual inflow is augmented by nearly ~10 MAF (~12 BCM) of rainfall and at least 50 MAF (~62 BCM) of groundwater extraction. This amount of water used to be sufficient for all of our needs in 1976 (about the time when Tarbela reservoir was commissioned), but not now – our population and irrigated land has grown several fold. The 38% shortage in irrigation water supply reported by IRSA (2022) translates into 65-70% shortage after the conveyance losses at the farm gate. Climate change is going to inevitably worsen the impacts on the flow and rain patterns. Since the total fresh water budget cannot go up, and we cannot control our population growth, emergent water shortage will translate into lower agricultural productivity, low power generation, and compromised food and economic security and sovereignty of Pakistan. 90-93% of all available fresh water in Pakistan is used in irrigation (earning 26% of GDP) and the rest goes into industrial and domestic uses. There is an emergent need to improve our water use efficiency in irrigation (currently only 36%), our reservoir capacity (hardly 29 days currently), irrigation productivity per unit area and per unit volume of irrigation water. This paper presents a relatively new concept, to look at the water embedded within a product or a service, synonymously called as virtual water, water footprint, water demand, water consumption, or water use. Simply put, the water footprint is the virtual amount of water used in the country plus the commodities or services imported minus the products and services exported. The major imports of Pakistan are Refined Petroleum ($3.87B), Petroleum Gas ($2.24B), Palm Oil ($2.15B), Crude Petroleum ($1.92B), and Raw Cotton ($1.68B), importing mostly from China ($14.7B), United Arab Emirates ($5.34B), United States ($2.78B), Indonesia ($2.43B), and Saudi Arabia ($1.8B). In 2020, Pakistan was the world's biggest importer of Tea ($646M), Scrap Nickel ($259M), Jute and Other Textile Fibers ($43.6M), and Metallic Yarn ($39.5M). Fairly recently, Pakistan has been importing wheat (1350 L/kg), maize (2000 L/kg), and sugar (1500 L/kg). The top exports of Pakistan are House Linens ($3.61B), Rice ($2.14B, 82 % VW exports – rice to Iran, S Arabia, Kenya and Bangladesh, 8,500-18,000 L/kg = Cotton, 3,000 L/kg = rice), Non-Knit Men's Suits ($1.8B), Non-Knit Women's Suits ($1.06B), and Knit Sweaters ($950M), exporting mostly to United States, Germany, China, United Kingdom, and United Arab Emirates. Pakistan needs to cut down on exporting water intensive commodities, indirectly conserving on diminishing water resources in the

country. The science of virtual water is accommodated in the hydrologic cycle, particularly in water stressed countries.

Transportation a potential source of toxic air born pollutants in urban settings

Seema Anjum Khattak* and Eleasa Jacob

National Centre of Excellence in Geology, University of Peshawar
**s_anjum@uop.edu.pk*

Peshawar is the 6th largest city with a population of 2.2 million people affected by environmental pollution. This study addresses the issue of air born pollution due to vehicular emission in Peshawar, and is mainly focused on Particulate matter PM 2.5 and PM 10. Particulate matter pollutants are air born lethal pollutants having fine (PM 2.5) and coarse (PM 10) aerodynamic size and are important health risk factor responsible for different diseases like lung cancer, acute respiratory infections, chronic respiratory problems and cardiovascular diseases. During this study six major roads were selected for multiple sampling points and on spot air samples were collected and simultaneously analyzed by using Haz-dust EPAM 5000-US. These samples were collected on weekdays and weekends as well as at two different times of the day. The average values for PM 2.5 and PM10 was calculated as184 µg/m3 and 796 µg/m3 respectively. These calculated values for both PM10 and PM2.5 when compared with set standards of WHO and Pakistan NEQS have been found above the set standards. The human health risk assessment due to inhalation of these two types of particulate matter was also calculated and found in the moderate to high-risk category. It is worth to mention here that the Peshawar has been professed as the third most polluted city in Pakistan and the ninth most polluted in the world, in the 2021 World Air Quality report which is support findings of this study.

Vulnerability of the host facies to igneous intrusions and its implication on the reservoir character of Late Precambrian Utch Khattak Formation, Nizampur Basin, Pakistan

Salman Khurshid, Imran Ahmad*, Jawad Ullah, Azmat Ullah Khan, Mohsin Ali and Asad Muhammad

Department of Geology, University of Malakand, 18800 Chakdara (Pakistan)
**imran_geo@uom.edu.pk*

The Precambrian Utch Khattak Formation, widely exposed in the Attock Cherat Ranges, Nizampur Basin, Pakistan, provided an excellent outcrop analogue of the unaltered and it's hydrothermally influenced diagenetically altered counterpart facies. The investigated formation has been intruded by multiple episodes of igneous intrusions during Paleozoic rifting in Peshawar Basin. Extensive fieldwork was conducted to delineate the thermal effect of igneous intrusions/dykes and to scrutinize the coupled diagenetic events on outcrop level. Dykes with variable composition and thickness were studied in detail and hence, perceived that the width of thermally altered zones increases with the size of their respective dyke. Intensity of the diagenetic alteration observed in the studied formation varies significantly in the host facies. Petrographic study evidently designates that the mudstone microfacies remained unaffected during the thermal effect, packstone microfacies shows partial replacement, while the grainstone microfacies were completely dolomitized with fabric destruction. Stable isotopic ($\delta^{18}O$ & $\delta^{13}C$) signatures of the unaltered host limestone occur in the range of Late Precambrian marine signatures, while the altered facies exhibited highly depleted values of $\delta^{18}O$ and less depleted $\delta^{13}C$ composition, demonstrates hydrothermal effect. All the examined facies lie in direct contact with the intruded bodies has been metamorphosed. Sequential study of the altered zone illustrates that marble is present at the contact of igneous intrusion followed by completely dolomitized geobodies and trailed by partially replaced dolomitic limestone. Present study reveals that the grain-dominated facies are highly susceptible to diagenetic alterations by thermal effect as compared to mud-dominated facies. Bulk mineralogical study of the investigated diagenetic facies indicates that the partially replaced dolomites are nearly stoichiometric, while completely dolomitized samples exhibit non-stoichiometric composition. Reservoir character of the studied formation is greatly enhanced by dolomitization as observed in partially and completely replaced facies, whereas the late-stage calcite cementation has occluded most of the open vugs and fractures. Petrographic observations and analytical data interpretation evidently support the hydrothermal dolomitization model for the diagenetic alterations of the Late Precambrian Utch Khattak Formation.

Systematic geomechanical cave stability assessment: Malaysian case studies

Goh Thian Lai[1*], Abdul Ghani Rafek[2] and Ailie S. Serasa[3]

[1]Department of Earth Sciences and Environment, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor Darul Ehsan, Malaysia
[2]Engineering Geology Advisory, 11, SS21/12, Damansara Utama, 47400, Petaling Jaya, Selangor D.E., Malaysia
[3]School of Engineering (Petroleum), Asia Pacific University of Technology & Innovation (APU), Technology Park Malaysia, Bukit Jalil, 57000, Kuala Lumpur, Malaysia
**gohthianlai@ukm.edu.my*

The Malaysian limestone caves are utilized as sports recreation areas, and also locations of tourism and pilgrim's temples. Recently, the local state government of Perak, Malaysia proposed to legalize the illegal temples and occupancy in the caves in a policy of site disposal of limestone caves. Thus, the safety aspect of the caves has become essential in the implementation of this policy. The geological conditions of the cave roof and cave wall are the main factors of cave instability. Unlike slope faces, the assessment of cave stability is somewhat more complex as the cave consists of irregular size and orientation due to natural erosion with the influence of geological discontinuities. This study presents the results of selected cave stability assessmentusing a systematic approach of Slope Mass Rating (SMR), ratio of cave roof thickness and cave width and Q-system as well as cave width for Damai Cave, Matsoorat Cave and Naga Mas Cave, Lembah Kinta, Perak, Malaysia. By referring to the ratio of cave roof thickness with cave width, the results revealed that these caves are stable. The stability of cave walls for Damai Cave and Naga Mas Cave were classified as classes II to IV in SMR respectively. Based on the results of Q-system and cave width, the respective roof arc's stability of Damai Cave and Naga Mas Cave are identified as stable and required support. This study provides a basic approach for mitigation measures design of cave stability.

Emerging applications of CubeSats in geological exploration

Rehan Mahmood

IST, SSTRL, NCGSA
**rehan_59@hotmail.com*

CubeSats are small educational satellites primarily introduced for experimental purposes. Typically, the dimension of a single unit CubeSat is 10 cm x 10 cm x 10 cm with a mass of just above 1 kg. However, multiple unit CubeSats can also be built thus having bigger volume and mass resulting in more sophisticated payloads including earth observation instruments as well. In fact, these CubeSats are becoming a low-cost platform for taking such critical earth related measurements. Apart from this, they are being actively used as an in-orbit technology demonstration, educational experiments platform and even for commercial purposes. The main driving factor in the popularity of CubeSats is the use of COTS components resulting in less development time and cost and added to that, the launch cost is also low as compared to the large satellite missions. CubeSats are now commonly used in low Earth orbit for applications such as remote sensing, mineral mapping, atmospheric science, earth observation, surveillance, space weather monitoring, meteorology and telecommunication. Data gathered from CubeSat sensors is used for Earth applications like water and land management. The lecture will cover the importance of CubeSats and their applications in the field of geology. In addition, it will discuss already developed CubeSats deployed for this purpose and their future prospects.

Organic sources and elemental sulphur effect on mustard growth and oil quality in alkaline calcareous soil

Kouser Majeed Malik[1*], Khalid Saifullah Khan[2], Mohammad Saleem Akhter[2], Zummurad Iqbal Ahmed[3], Shah Rukh[4] and Asia Munir[1]

[1]Soil and Water Testing Laboratory for Research, Rawalpindi-46300, Pakistan
[2]Institute of Soil and Environmental Sciences, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan.
[3]Department of Agronomy, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan
[4]NCE in Geology, University of Peshawar-25230, Pakistan
**kousermajeed9@gmail.com*

Sulphur (S) plays an important role in the production of oilseed crops. Sulphur is ranked as the fourth major macronutrient after N, P and K, it is involved in various metabolic and physiological functions in plants like the synthesis of oil and chlorophyll, a constituent of vitamin A, biotine, thiamine (B1) and ferrodoxins (iron sulphur proteins). Adequate sulphur availability in soils is crucial for oilseed production as it is associated with the production of high nutritive and market quality end products. A field experiment was carried out during the winter season

at a farmer's field in district Attock, northern Punjab, Pakistan to elucidate the effect of elemental sulphur and organic sources on the growth, yield, and sulphur uptake and oil quality of the mustard crop. The experiment was laid out in a randomized complete block design with three replications. Elemental sulphur (ES) was applied at the rate of 100 kg/ha with or without organic sources i.e. farmyard manure (FYM), poultry litter (PL) and sugarcane filter cake (SF), each applied at the rate of 20 tons/ha. Mustard (*Brassica juncea* L.) crop was sown and the growth and yield parameters (plant height, number of siliquae per plant, biomass and grain yield) were recorded at maturity. Total S contents in seeds and biomass were determined, and sulphur uptake and use efficiency were calculated. Seeds of mustard were also analyzed for oil quality parameters such as oil contents, protein contents and fatty acid profile analysis. Elemental sulphur (ES) application significantly increased the growth and yield attributes of the mustard crop, however, combined application of organic sources and ES had a more pronounced effect than the ES alone. Seed yield was significantly higher with the combined application of ES and SF. Protein and oil contents increased significantly (add significant difference?/$P<0.05$ or $P<0.01$) in all the treatments but more with organic sources. Both the sulphur uptake and sulphur use efficiency by the mustard crop followed the trend: ES+SF>ES+PL>ES+FM>ES. Essential unsaturated fatty acids i.e. oleic acid, linoleic acid and linolenic acid were significantly increased with organic sources and ES addition, but maximum with SF. Non-essential saturated fatty acids like palmitic acid, eicosenoic acid and erucic acid decreased with the addition of ES and organic sources. The combined application of organic sources and ES proved better in improving the availability and use efficiency of sulphur in oilseed mustard crop. The complex organic C source i.e., sugarcane filter cake proved better than poultry litter and farmyard manure amendments.

Clays and ceramic mineral resources of Koh Sulaiman Range, South Punjab, Pakistan

M. Sadiq Malkani

Geological Survey of Pakistan, Muzaffarabad, Pakistan
malkanims@yahoo.com

The various clay deposits hosted in Eocene Chamalang and Kahan groups, Oligocene-Early Pliocene Vihowa Group and middle Pliocene to Holocene Sakhi Sarwar Group of Koh Sulaiman Range in South Punjab. White, brown and grey and non-swelling clay with high percentage of calcium called Bentonite which is redeposited after decomposition of lavas, volcanic ash and tuffs. Base Exchange methods can convert non-swelling bentonite into swelling sodium-bentonite. Bentonite clay is found in west of Daman belt area and foothills of Koh-Sulaiman Range under the territory of districts of South Punjab like Dera Ghazi Khan, Rajanpur and Taunsa. Bentonite clay can be used for leakage control and also for drilling purposes by using soda ash and Carboxymethyl-cellulose addition. Fuller

earth consists of dominantly magnesia and it is non plastic. It makes pure and decolorized to ghee and oil (vegetable), fats and petroleum, steel and insecticide. This fuller earth is deposited on flood-plains during Cenozoic river systems. It feel is soapy and colors are greyish green, brownish green and bluish. The major productions come from Mahoi, Kot Qaisrani/Kot Kaisrani and Zin/Zain areas of Taunsa district. Hilal A. Raza observed large and thick (upto 30m) reserved of fuller-earth in Baska and Domanda formations of Sebdi and Rakhi rudkohi/nalas. Recent research by Malkani shows thick and huge/immense reserves of fuller-earth in Baska and Domanda shales in Daman and adjoining areas located in foot mountain of Koh Sulaiman Range. The samples of fuller earth collected from shale of Drazinda and Domanda in Mahoi and Zain areas (Zinda Pir anticline) of Taunsa district show 9.79-17.18% Al2O3, 50.86-64.01% SiO2, 3.10-6.89% Fe2O3, 2.01-5.64% MgO, 6.41-12.20% CaO, Nil P2O5 and 8.87-12.60% volatiles/loss on ignition. The eastern part of Koh Sulaiman Range hosts large and huge reserves of fullers earth (and also possible fire clays) found in Domanda and Drazinda shales of Kahan Group, Baska shales of Chamalang Group and shales of Sangiali, Vihowa and Sakhi Sarwar groups. Recently Malkani estimated 10 million ton reserves of fuller earth clays (upto easy mineable 200m depth in areas of Zinda-Pir anticline and greater than 1billion ton in the eastern part of Koh-Sulaiman Range (Giandari Chachar-Kaha Harand-Sakhi Bor Bakhsh-Khaan-Rakhi Gaj-Khandhor-Ronghan-Sorra-Kachiwanga-Jisa Sharif and Manjhail Kharar areas). Fire clay is resistant to corrosion, abrasion and shrinkage at high-temperature and withstands thermal-spalling. It is mostly associated with horizons of coal and carbonaceous-shale. Fire clay has lower iron-oxide (<2%) and higher alumina (24 to 45%). The fuller earth and fire clay deposits here considered are same. Ochre/limonite/iron found from Vitakri, Rakhi Gaj, Chitarwata and Drazinda formations and Vihowa Group, and some silica-sand in Pab sandstone and Vihowa group (Chitarwata sandstone in Zinda Pir area), and significant porcellaneous nature limestone and marl found in Habib Rahi and Pirkoh formation of Taunsa, Dera Ghazi Khan and Rajanpur districts.

Large cement raw materials and gypsum resources of Koh Sulaiman Range of South Punjab, Pakistan

M. Sadiq Malkani

Geological Survey of Pakistan, Muzaffarabad, Azad Kashmir, Pakistan
malkanims@yahoo.com

Koh Sulaiman Range and its Daman areas are located on the eastern margin of Sulaiman foldbelt and central part of Sulaiman/middle Indus basin. The western part of Rajanpur, D.G.Khan and Taunsa districts of South Punjab are located in Koh Sulaiman Range which consists of large cement raw materials and gypsum resources. Rajanpur district hosts Giandari-Chachar-Kaha Harand-Sakhi Bor Bakhsh-Khaan gypsum deposits (2billion tons/bt upto 200m depth; 33million ton/mt upto easy mineable 50m depth), Paleocene Dungan Limestone at Chachar-

Maarri (1bt), Kaha-Harrand (1bt) and Sakhi Bor Bakhsh (small deposits) areas, and Chacha-Beakar-Kalchas (3bt) of western limb of Fort Munro-Maarri anticlinorium, Eocene limestone of Drug, Habib Rahi and Pirkoh formations in eastern limb (30bt) of Fort Munro-Maarri anticlinorium, and vast and huge deposits of shale/clay in Shaheed Ghat, Domanda and Drazinda formations at Chachar-Maarri-Kaha-Harrand-Sakhi Bor Bakhsh-Khaan areas. Dera Ghazi Khan district hosts Rakhi Gaj-Khandor gypsum deposits (1bt upto 200m depth; 22mt upto 50m depth), southern part of Zinda Pir anticlinal gypsum deposits (2bt upto 200m depth; 44mt upto 50m depth), 1bt of Late Cretaceous Fort Munro limestone exposed at Rakhi Gaj, Girdu and surrounding areas, 1bt of Paleocene Dungan Limestone at core of southern Zinda Pir anticline, Eocene limestones of Drug, Habib Rahi and Pirkoh formations in Rakhi Gaj-Khandhor area (20bt) and southern Zinda Pir anticline (20bt), and vast and huge deposits of shale/clay in Shaheed Ghat, Domanda and Drazinda formations at Rakhi Gaj-Khandhor-Ronghan areas and southern Zinda Pir anticline. Taunsa district hosts gypsum deposits at northern Zinda Pir anticline (2bt upto 200m depth; 44mt upto 50m depth), Sorra-Kachiwanga-Jisa Sharif belt (1bt upto 200m depth; 22mt upto 50m depth), Manjhail Kharar (3bt upto 200m depth; 66mt upto 50m depth), Parh limestones (Early Cretaceous) exposed at Hinglun-Burg Pusht area (1bt), Dungan limestones at northern Zinda Pir anticline (1bt), eastern limb of Hinglun-Rarkhan thrusted anticline (3bt; Manjhail Pachadhi nala, Hinglun and Kachiwanga Luni areas), northern plunge of Fort Munro anticline (3bt; Mubarki-Sorra, Pir Gahno and Kharar areas), Eocene limestones of Drug, Habib Rahi and Pirkoh formations at Sorra-Kachiwanga-Jisa (20bt), Manjhail syncline (30bt), and northern Zinda Pir anticline (20bt), vast and huge deposits of shale/clay in Shaheed Ghat, Domanda and Drazinda formations at southern Zinda Pir anticline, Manjhail and Sorra-Kachiwanga-Jisa areas. Gypsum chemical analyses show CaO varies from 30.84 to 32.24%, SO3 from 45.75 to 48.36%, and H2 O from 17.62 to 18.62%. Vast deposits of late Cretaceous marl/shale of Mughalkot Formation are found discontinuously in the core of Mubarki-Hikbai-Fort Munro-Chitri-Dragal-Maarri anticline. Pakistan has lowest per capita cement consumption and paying several hundred million rupees every year for calcium chemicals. It is vital to take step for installing more cement, lime and calcium chemicals industries especially in Zinda Pir Ziarat, Sorra, Kharar (Kharat), Pir Gahno, Kachiwanga Luni, Jisa, Chachar-Maarri and Kaha-Harrand, Rakhi Gaj due to close occurrence of huge raw materials like gypsum, limestone and shale/clay which can be provided by belts and available water resources from adjoining stream. These cement industries will provide cement easily to Balochistan and for export to earn foreign exchange.

Dilband ironstone deposits and their extension, Balochistan Province, Pakistan

M. Sadiq Malkani[1*] and Akhtar Ahmad Kakepoto[2]

[1]Geological Survey of Pakistan, Muzaffarabad, Azad Kashmir, Pakistan
[2]Geological Survey of Pakistan, Quetta, Pakistan
**malkanims@yahoo.com*

Dilband ironstone deposits are located in the Koh Dilband and surrounding areas, accessible 20Km/kilometer northeast of Johan village and 100Km from Mastung town and Kolpur railway station. Dilband and surrounding area is a broad anticlinorium. The ironstone consists of hematite (and minor limonite) with calcite, quartz and chlorite. The overall reserves estimated are 200 million ton/mt. with average 35-48% Fe_2O_3. Ironstone found in Latest Jurassic(150-145Mya) Dilband Formation (5-30m) which is an uppermost member of Triassic-Jurassic Sulaiman Group. Dilband Formation (30m thick in type area) shows lower grey to brown and white Jarositic clay, middle reddish ironstone and upper green glauconitic shale. Thisoolitic-pisolitic ironstone exposed in Dashtari, Hoshi-Sabrin, Gorjat, Gorjat Nala and Dilband-Shikaraplocalities varies in thickness from 0.75m (in Dilband) to 5m (in Gorjat Nala). Dashtari ironstone 23samples show Fe_2O_3 47.25-68.67%, SiO_2 12.57-29.88%, P_2O_5 0.1-1.0, TiO_2 traces-0.5%, Al_2O_3 2.14-9.89%, CaO 1.4-11.21%, MgO traces to 6.91%, S traces-1.66% and LOI 7.02-16.95%. Proved iron ore reserves of Dashtari area are 40.50mt based on average 2.5m thickness, 3.0 specific gravity (in all) and 5.4 Km2areas. Hoshi-Sabrin ironstone 21samples show Fe2O3 40.28-73.63%, SiO2 1.16-33.70, P2O5 0.0-3.27%, TiO_2 0.0-0.8%, Al_2O_3 0.0-9.07%, CaO 1.96-15.14%, MgO 0.0-4.84%, S <0.1% and LOI 7.3-20.7%. Hoshi proved ironore reserves are 49.53mt based on average 2m thickness and8.25Km2area while Sabrin ironstone reserves are 1.62mt based on over 0.27 Km2areas and 2m thickness. Gorjat ironstone 24samples show Fe_2O_3 40.93-70.8%, $SiO_2$11.6-24.52, P_2O_5 0.0-3.3%, TiO_2 0.0-0.64%, Al_2O_3 0.0-14.84%, CaO 0.0-16.2%, MgO 0.0-5.83%, S upto 0.14% and LOI upto 16.48%. Proved iron ore reservesof Gorjat area are32.637mt based on average 3m thickness and3.956Km2area. Gorjat Nala ironstone 17samples show Fe_2O_3 40.05-58.64%, $SiO_2$14.20-31.64%, P_2O_5 0.08-0.82%, TiO_2 0.01-0.40%, Al_2O_2.20-12.55%, CaO 3.36-18.57%, MgO 0.80-5.64%, upto 1.16% and LOI 7.10-20.27%. Proved iron ore reservesof Gorjat Nala area are39.375mt based on average 3.5m thickness and 3.750Km2area.Dilband-Shikarap ironstone 20samples show Fe_2O_3 35.29-54-85%, SiO_2 9.60-25.54%, P_2O_5 0.0-2.76%, TiO2 0.00-0.1%, Al2O1.18-14.56%, CaO 5.04-25.28%, MgO 0.08-4.83%, S <0.41% and LOI 8.51-16.84% (Kakepoto, 2014). Proved iron ore reserves of Dilband-Shikarap area are36mt based on average 1m thickness and 12 Km2areas.This ironstone is suitablefor exploitation due to its large reserves, gentle dips, open pit mining, suitable elemental compositions and close to Mach and Kolpur railwaystation. The installation of gravity fall belt from peak to downward plain base station on the bank of Moro (Morov) river where truck can load and shift

ironstones to Mach railway-station. Another option is shifting ore from site to Kolpur railway station by truck and then by railway. The recent investigation shows ironstone isolated lense shaped extension in the north upto Murdar Ghar (Quetta, in the east upto Dirao area, in the west Koh Siah and Koh Maran, and in the south upto Nur Gama Zahri of Khuzdar.

Windowed/Fenestra and Faden Quartz found in sedimentary strata of Sulaiman and Balochistan basins of Balochistan Province, Pakistan

M. Sadiq Malkani[1*], Syed Muzyan Shahzad[2], Nasir Somro[3], Syed Jawad Arif[3] and Ghulam Akbar[4]

[1]Geological Survey of Pakistan, Muzaffarabad, Azad Kashmir, Pakistan
[2]Central South University, Changsha, China
[3]Geological Survey of Pakistan, Islamabad, Pakistan
[4]Geological Survey of Pakistan, Quetta, Pakistan
**malkanims@yahoo.com*

Quartz veins in igneous rocks are reported in Balochistan magmatic arc, western Indus suture (Khuzdar, Muslimbagh and Zhob areas) and northern Pakistan. While quartz veins in sedimentary rocks are rare which were reported by MSM in 2011-2020. Windowed/fenestra quartz includes window shape inside the crystal with inclusions, while faden quartz consists of fuzzy milky-line sometimes curvy-trail. In Sulaiman/middle Indus basin, the quartz veins/vugs were reported in Khagoon Range of Alu Khan Kach/Gharwandi area, west of Allah Din house (Survey of Pakistan toposheet 39F/10), Kingri Tehsil, Musakhel District, Zhob Division, Balochistan Province, Pakistan. Quartz vugs include both skeletal fenestra quartz and faden quartz with thin thread and a few ribbons. These quartz crystals are transparent to translucent rarely coated (thinly) by chlorite tinge. "Faden quartz study via fluid inclusion microthermometry (to know thermal history), x-ray computed tomography (clarity) and cathodoluminescence microscopy (differentiate between natural and artificial/synthetic gemstones; understand geological history) revealed quite stunning results with a very rich history (verbal communication with Estibalitz Ukar, University of Texas, USA during May 2022)". Quartz veins were found in sandstone and shale of Late Cretaceous Mughalkot Formation of Fort Munro Group. Tectonically Gharwandi locality is found in the eastern extremity of Murgha Kibzai imbricated thrust faults which are refolded and again faulted. These intensely imbricated and refolded thrust faults are represented by the Cretaceous strata. Westward from imbricated faults, the folding of mostly Mesozoic with rare Cenozoic and uppermost Paleozoic strata are observed, and eastward from imbricated thrust faults, the major foldings of Cretaceous to Holocene strata were observed. The repeated thrusts and its refolding show strong tectonic intensity (in the area hosting window and faden quartz) which is responsible for fissuring and fracturing, then deposition of quartz as vugs in fissures and further breaking of quartz crystals by

geodynamic and tectonic earth movements and then filling by fast cement accumulation and quick healing. Quartz formed in fissures but further opening of fissures/fractures via geodynamic and tectonic events will break the quartz, then quick healing and cementing was done by crystallizations of hydrothermal solutions or silica gel. Many geodynamic events of Indo-Pakistan subcontinent were printed from Late Cretaceous to so far. In Siahan-Makran Range of Balochistan basin under Panjgur and Kharan districts of Balochistan Province, the quartz veins/vugs in sedimentary strata were found in Eastern Waro (Survey of Pakistan toposheet 35M/16), Siagari Shand area (Survey of Pakistan toposheet 31A/11) and many other places quartz-carbonate veins including stibnite in the core. Eastern Waro locality was found in eastern plunge of Waro syncline and here network of thin quartz vugs/veins hosted in sandstones and shales of Oligocene Panjgur Formation. A major quartz vein (with 0.458ppm gold) was found in Siagari Shand area (southern slope of mountain; north of Sabzap) which is thick upto 2m and long about half kilometer in Eocene Siahan shale and sandstone. Quartz crystals upto 1cm length is common. Siahan Range has enriched imbricated/repeated thrust faults (trended east west) which created high temperature and pressure for deposition of window and faden quartz.

Construction stones and decorstones resources of South Punjab, Pakistan

M. Sadiq Malkani[1], Nasir Somro[2*], S.J. Arif[2], M.S.I. Dhanotr[3], Tehseen Zafar[4] and M.I. Alyani[5]

[1]Geological Survey of Pakistan, Muzaffarabad, Azad Kashmir, Pakistan
[2]Geological Survey of Pakistan, Islamabad, Pakistan
[3]Pakistan Atomic Energy Commission, Lahore, Pakistan
[4]Institute of Geochemistry, Chinese Academy of Sciences, Beijing, China
[5]Geological Survey of Pakistan, Lahore, Pakistan
**nasirsomro11@gmail.com*

South Punjab has very large and huge deposits of dimension and construction stones like limestone, sandstone, shale, conglomerate, gravels, sand and muds found from Taunsa, D.G.Khan and Rajanpur districts (Koh Sulaiman Range and its foot mountains Daman areas). Vast deposits of sand are found in Indus river and its rudkohi/tributaries, limestones from Fort Munro, Dungan, Drug, Habib Rahi and Pirkoh formations, sandstone from Pab, Vitakri and Rakhi Gaj formations and Chitarwata, Litra and Chaudhwan formations, gravel, sand, silt and mud from Chaudhwan, Dada, Sakhi Sarwar formations, terrace, fan and present river gravel and alluvium deposits. Taunsa District represents Early Cretaceous Parh limestone reserves (1 billion ton/bt; from exposure to 200m depth for all), Maastrichtian Fort Munro limestones (small deposit), Paleocene Dungan limestone (7bt), and Eocene Drug, Habib Rahi and Pir Koh limestones (70bt). Shale reserves are 4bt from Cretaceous Mughal Kot, Fort Munro, Pab and Vitakri formations, 5bt from Paleocene Sangiali, Rakhi Gaj and Dungan formations,

300bt from Eocene Shaheed Ghat, Drug, Baska, Domanda and Drazinda formationsand 50bt of Oligocene-Holocene strata. Sandstone reserves are 250bt from Cretaceous Pab and Vitakri formations, 3bt from Paleocene Sangiali and Rakhi Gaj formations,400bt from Oligocene-Pliocene Vihowa Group (Chitarwata, Vihowa, Litra and Chaudhwan formations) and Pleistocene-Holocene Sakhi Sarwar Group (Dada and Sakhi Sarwar formations). Dera Ghazi Khan District hosts Parh Limestone (small deposits), Fort Munro limestone (1bt), Dungan limestone (1bt), and Drug, Habib Rahi and Pirkoh limestones in Rakhi Gaj-Khandor area (20bt) and in southern Zinda Pir anticline (20bt). Shale reserves are 4bt from Cretaceous, 5bt from Paleocene, 200bt from Eocene and 50bt from Oligocene-Holocene strata, and sandstone reserves are 250bt from Cretaceous, 3bt from Paleocene and 250bt from Oligocene-Holocene strata. Rajanpur District hosts Fort Munro limestone (1bt), Dungan limestone (6bt) and Drug, Habib Rahi and Pir Koh limestones and marls (30bt). Shale reserves are 1bt from Cretaceous, 5bt from Paleocene, 300bt from Eocene and 100bt from Oligocene-Holocene strata, and sandstone reserves are 200bt from Cretaceous, 2bt from Paleocene and 350bt from Oligocene to Pliocene strata. These deposits are easily accessible from D.G. Khan and Shadan Lund railway stations. Large reserves of limestone (commonly used as marble) occur widely in the Koh Sulaiman Range like Fort Munro and Dungan limestones in Harand, Maarri and Chacha-Beaker-Kalchas of Rajanpur, Rakhi Gaj, Khandor, Fort Munro, Bawata and surroundings and southern part of Zinda Pir anticline of D.G.Khan district, northern part of Zinda Pir anticline, Hikbai-Mubarki, Kharar, Ronghan-Sorra, Poadhi and Pachadhi nalals of Manjhail to Pir Gahno, Hinglun to Luni Kachiwanga and Burg Pusht areas of Taunsa district can be used as dimension stones and tiles preparation. Beautiful pebbles, cobbles, chalcedonic silica like chert, flint, jasper and others are found as detritial in placer deposits like conglomerate and conglomeratic sandstone/gritstone of Vihowa and Sakhi Sarwar Groups and also in terrace and present-day river/streams/channels in eastern Koh Sulaiman Range and its Daman areas.

Geochemical investigation of cadmium (Cd) in various types of coal and their health implications

Hafiza Seerat Maryam*, Amna Ahmad, Muhammad Asad Abbas, Rahib Hussain and Sajid Rashid Ahmad

College of Earth and Environmental Sciences, University of the Punjab, Lahore 54590, Pakistan
**seeratmaryam39@gmail.com*

The present study aimed to evaluate the cadmium (Cd) concentration in various types of coal located elsewhere in the world. The results show that the cadmium (Cd) concentration (mg/kg) in higher rank Bituminous coal was 0.8 and in lower rank Bituminous coal was 0.07. However, the Cd concentration in US coal was 0.47 mg/kg, Chinese late carboniferous coal 0.17 mg/kg, Chinese Boehmite coal

0.25 mg/kg, Chinese late Permian Sichuan Guxu coal 0.56 mg/kg, and the world hard coal was 0.22 mg/kg. The study revealed that the high concentration (mg/kg) of Cadmium in coal may release into the surrounding environment, which may cause various health problems. Breathing high levels of cadmium dust/air may damages the lungs and can cause death. Large amounts of cadmium can severely irritate the stomach, kidneys, lungs, and liver and can also cause vomiting and diarrhea in short-time inhalation. Exposure to the low-level cadmium in air, food, water, and particularly in tobacco smoke over time may build up cadmium in the kidneys and cause kidney disease and fragile bones. Cadmium is considered a cancer-causing agent. The present study concludes that the coal mining activity and its resultant waste should be managed to reduce the health consequences and save the environment from being polluted with heavy metals like cadmium.

Seismic Hazard analysis of hydro power projects in Hunza Valley, Gilgit Baltistan

Syed Kazim Mehdi[1*], Zahid Shahzad[1] and Talha Muhammad Kakar[2]

[1]Water and Power Development Authority, Pakistan
[2]Mari Petroleum Company (Ltd.), Pakistan
**sspkazim@gmail.com*

This study deals with the Seismic Hazard Analysis (SHA) of four Hydro Power Projects (HPP's), located in the Hunza Valley of Gilgit Baltistan. The complete project comprises construction of two HPP's at Batur and Sumayar and upgradation of two HPP's at Hassanabad and Chalt. According to Building Code of Pakistan Seismic Provision 2007, the area around Hunza is located in seismically active Zone 3. Northern and western sections of Pakistan are more sensitive to earthquake activity than the other sections because they are surrounded by the micro plates of Afghanistan, Iran and India. The Hunza valley of the western Karakoram has been known for instabilities due to moderate to major earthquakes. Seismically active fault lines are located in this region that could make the population vulnerable to this disaster. The critical active tectonic features within 200 km of the site, which governs the ground motion at the project site are the Main Karakoram Thrust (MKT), Main Mantle Thrust (MMT), Karakoram fault and the Hindukush Seismic Zone (HSZ). The root cause of most seismic events can be associated to tectonic processes in the upper portions of the earth crust. The seismicity of this area is depicted by moderate to major earthquakes. The historical earthquake data shows that intensity up to VIII has been felt in the Hunza Seismic Region (300 km radial distance around Hunza) while instrumental seismic data shows this region is mostly generating seismic events of $Mw \geq 4.0$. The SHA carried out in this report were in accordance with the guidelines and recommendations contained in the International Commission on Large Dams (ICOLD), Bulletin 148 (2016) and Seismic Provision Building Code of Pakistan (BCP, 2007). The recommendations by the U.S. Army Corps of Engineers, ER 1110-2-1806 (2016) for the Earthquake Design and Evaluation for

Civil Works Projects and US Federal Guidelines for Dam safety (Earthquake Analysis for Design of Dams) were also consulted. Bore Hole Logs available from the Intake and Power House locations of four Hunza HPP's were studied and it was discovered that according to Table-4.1 of BCP the subsurface comprises of soil profile type Sc with VS30 = 600 m/sec. For the SHA both Deterministic and Probabilistic hazard assessments have been carried out. The results of the deterministic analysis show that MKT is the most critical tectonic feature which can cause maximum ground motion at the four Hunza HPP's sites. The PGA of 0.30g is associated with the Maximum Credible Earthquake (MCE) along this fault. The appurtenant structures of the Intake and Power House at the four Hunza HPP's are recommended to be designed for PGA of 0.25g which is associated with ground motion of Design Basis Earthquake (DBE) having return period of 475 years. The PGA of 0.17g having a return period of 145 year is recommended for ground shaking associated with Operating Basis Earthquake (OBE).

Seismic microzonation of Gilgit, Nomal and Naltar for Master Plan 2040

Syed Kazim Mehdi[1*], Zahid Shahzad[1] and Talha Muhammad Kakar[2]

[1]Consultant Seismologist, Ex Chief Seismologist, WAPDA, Pakistan
[2]Mari Petroleum Company (Ltd.), Pakistan
**sspkazim@gmail.com*

This study deals with the seismic microzonation of Gilgit, Nomal/Naltar for Master Plan 2040. According to Building Code of Pakistan Seismic Provision 2007 (BCP), the area is located in seismically active Zone 3, while in its close vicinity more active area of Seismic Zone 4 is present. Based on the geological reports/maps, geophysical data/reports, satellite imaginary and desktop study of research papers, the region is divided into nine seismic zones. All seismic zones are active with maximum earthquake potential of M 7.5- 8.0. Historical and composite instrumental earthquake data within 300 km radial distance from Gilgit and Nomal/Naltar (GNN) region were developed for the studies. Historical earthquake catalogue stipulates that GNN has experienced earthquakes intensities upto VIII, while seismic events upto M 6.3 have originated from the GNN Region. To determine the soil profile types in accordance with Table 4.1 of BCP, the study area is classified into six seismic units. The most suitable way of presenting the result is in terms of horizontal hazard curves and spectra. Graphs are developed for return periods of 475, 975 and 2475 years. In accordance with recommendations of BCP the probabilistic seismic hazard analysis (PSHA) is carried out using single site EZ-FRISK software developed by Fugro Engineering Consultants, USA. The ground motion value (g) in case of Vs30 = 750 m/sec for SB (dense soil/soft rock) is resulted as 0.24g at seismic units of Naltar Valley and Nomal Valley while it is 0.25g at the four seismic units of Gilgit. The structures can be safely constructed after accessing the condition of material present at the desired location and according to seismic values. Available areas with such

properties are best suitable for further development/progression. However, the areas with SD type (stiff soil) are least suitable and may be avoided for further changes/expansions. For safety monitoring purposes, it is recommended to install a Micro Seismic Monitoring System (MSMS) with the latest version of ANTELOPE Software (used for data processing/analysis), for seismic safety monitoring purposes.

Seismotectonic study of Domeli-Diljaba Thrust, Eastern Potwar by using integrated datasets

Mona Lisa[1], Said Mukhtar Ahmad[1] and Saad Khan[2,3*]

[1]Department of Earth Sciences, Quaid-i-Azam University, Islamabad 45320, Pakistan
[2]Department of Geology, Bacha Khan University Charsadda, Charsadda 24420, Pakistan
[3]National Centre of Excellence in Geology, University of Peshawar, Peshawar 25130, Pakistan
**saadkhan@bkuc.edu.pk*

This study envisages to understand the structural trend and active nature of the Domeli-Diljaba Fault that is recognizable in the geological record, by integrating structure delineation on the satellite images, sub-surface structural marking over the seismic data, and interpreting the neotectonics interest using seismological data obtained from various local and international sources. Focal Mechanism Solutions (FMS) of available events have been analysed to confirm the recent active nature of faults present in the area. The areas of Dina and Rajian from eastern Potwar have been selected for the study. A total of sixteen seismic lines were interpreted and six horizons (Cambrian Succession, Paleocene succession, Eocene, Miocene and Post Miocene Kamlial, Chinji Formations) have been marked from base to top. Seven faults are mapped including Domeli Thrust. The thrust shows the same nature in both Dina and Rajian area along which the Murree Formation thrusted over the Chinji Formation trending in the NW-SE direction. The subsurface structural interpretation of both Dina and Rajian areas reflects the Pop-up structures but the Rajian area is intensely deformed due to the Domeli-Diljaba thrust which is closely spaced to Salt Range Thrust. Field observation of Dina-Domeli area also shows the same trend of the Domeli Thrust as interpreted on seismic lines. It is concluded that, the area of Dina-Domeli is characterized by the Transpressional deformation both on the surface as well as in the subsurface as indicated by FMS (thrusts with strike slip components). It is concluded that the Domeli-Diljaba Thrust is a neo-tectonic feature caused by transpressional tectonics.

Feasibility study of metasediments use in concrete composition as a coarse aggregate from Chakdara area, Dir Lower, Khyber Pakhtunkhwa, Pakistan

Asad Muhammad*, Syed M. Wasim Sajjad, Bashir Ahmad, Akif Saeed, Kiramat Ullah, Nasar Khan, Jehanzeb Khan and Imran Ahmad

[1]Department of Geology, University of Malakand, Chakdara (18800), Lower Dir, Khyber Pakhtunkhwa, Pakistan
**asad@uom.edu.pk*

In concrete, about 65-70% volume is primarily comprised of rock aggregates. Excellent outcrops of the Lesser Himalayan's metasediments are of keen interest for their economical usage. To find out the physical characteristics of these rocks, a geological fieldwork was carried out in the vicinity of Chakdara area, North Pakistan. During field investigations, it was revealed that the studied complex is composed of light brown compact marbles, cross cut by multiple episodes of calcite veins. Best exposure, easily accessible, hard and compact nature of these metasediments were used as base for its suitability for concrete formation. Furthermore, petrographic study of the representative samples reveals that essential mineral composition is calcite, plagioclase and quartz with mica and opaque minerals in trace concentrations. Suitability of the studied rock mass for concrete formation was further supported by its physical properties including specific gravity (2.68), soundness (2.1%), los angeles abrasion value (34%), unit weight (1.52 g/cc), flakiness and elongation (4.20%) as per international standards (AASHTO and ASTM). The observed values of the investigated marble lies within the standard required limits. Moreover, excellent exposure with huge quantity and easier accessibility demarcates it as a suitable rock aggregate for any nearby construction projects. Based on the aforementioned parameters and analysis, the investigated metasediments exposed in Chakdara area can be considered as potential coarse aggregate for construction in various ongoing megaprojects including CPEC, Dir and Swat Motorway Phase-II developmental schemes.

Fracture porosity estimation using open-hole logs: An example from North Pakistan

Irfan Muhammad[1], Asad Taimur[2], *Kaleem Ullah[2] and Mansoor Ahmed[2]

[1]*MOL Pakistan Oil and Gas Co, Pakistan*
[2]*Vizdom Solutions Oil and Gas Services, Pakistan*
**kaleem@vizds.com*

Fractured reservoirs are quite uncommon globally. These less-understood reservoirs are mainly producing in offshore Vietnam, Yemen and fold-thrust belt in north Pakistan. As fractured reservoirs are highly heterogeneous with complex nature of flow regimes, estimation procedure of such reservoirs is not a straight forward problem. To address the challenge, a number of techniques have evolved over time. The interpreter-dependent image log is gaining popularity and becoming an industry standard practice, yet it is prone to human error. This work relies on integrating various open-hole logs to identify the conductive fracture porosity of low matrix porosity carbonates. Using resistivity, compressional slowness, density and neutron porosity logs, we estimate fractures in Paleocene carbonate reservoir interval of 164 m drilled in the structurally complex north Pakistan fold-thrust belt. The fracture system is distributed irregularly, in which micro-fractured zones are spread along surfaces of macro-fractures. Resistivity of non-fractured rock is considerably high reaching thousands of ohm. The open porosity is low, less than 5% and estimated fracture porosity in the range of of 2-3%. The fractures estimated from our proposed workflow are in complete agreement with production logs (PLT) and fracture image (FMI) data, thus highly efficient and cost-effective. We also discuss the advantages and limitations of the proposed workflow in complex environment.

Cryosphere changes and its impacts in the Upper Indus Basin

Sher Muhammad

International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal
sher.muhammad@icimod.org

The concentration of glaciers surging in the Karakoram (more than one hundred surging glaciers has been reported) is also linked to Karakoram anomaly. These surges bring various risks for the people living nearby, blocking access to various resources across the glacier, damaging agriculture and infrastructure. We observed the Shisper glacier surge velocity, terminus advance, lake formation and outburst, as well as its downstream impacts on agriculture and livelihood in the Karakoram, Pakistan. A latest surge started in late 2017 with increased velocity since April 2018 and a resulting terminus advance from June 2018. Bi-modal peak velocity of ~19 m/day was observed in April-May 2018 and May-June 2019. Also, the terminus advance blocked the river from the adjacent Muchuhar Glacier

repeatedly since November 2018. Lake outbursts were observed in June 2019 and in May between 2020 and 2022. The lake burst also partially damaged the Karakoram Highway, nearby settlements, hydropower, a bridge on the Karakoram Highway, and other land resources. Our observations show that at high discharge, damages were mainly observed along the main river channel, causing strong bank erosion rather than widespread inundation of land. The ice-dammed lake is potentially hazardous until the blocked stream completely disappears in future. The downstream Hassanabad faced economic losses of 4 million USD due to the recurring GLOF. To reduce the future damages in the valley, installation of gabion walls along the Hassanabad stream to overcome erosion, building barriers to reduce the flood water flow, and installation of an early warning system are recommended.

Influence of coal mine drainage (CMD) on groundwater in Darra Adam Khel, Kohat Pakistan: Emphasis on pollution source and human health risks associated with heavy metals

Taj Muhammad[1, 2*], Seema Anjum Khattak[2] and Shah Jehan[2, 3]

[1]Pakistan Mineral Development Corporation (PMDC), Petroleum Division, Ministry of Energy, Islamabad, Pakistan
[2]National Centre of Excellence in Geology, University of Peshawar, Peshawar 25130, Pakistan
[3]Department of Earth Sciences, Indiana University-Purdue University Indianapolis (IUPUI), Indianapolis, IN 46202, USA
**am-geology@pmdc.gov.pk*

Groundwater quality studies of coal mining areas are very important due to coal mining, dumping of huge quantity of over burdens, and subsequently mixing with the coal mine drainage areas. The main objective of this study was to evaluate the possible influence of coal mine drainage (CMD) on groundwater in terms of major ions, trace elements and identifying the hydrogeochemical characteristics in Darra Adam Khel, Kohat Pakistan. For this purpose, ground water sample (n=26) from bore well, dug well, hand pump and tube well were collected and analyzed for physico-chemical parameters, major and trace elements. Various statistical techniques like descriptive statistic (range, mean and standard deviation), Pearson correlation, cluster analysis (CA) and principal component analysis (PCA) were applied in order to define the contribution of pollution sources. The concentration of physiochemical parameters and heavy metals (HMs) in groundwater samples showed that most of the samples were under the guidelines values as suggested by World Health Organization (WHO). However, Pb, Ca and Mg concentrations were found above in 15%, 97% and 95% samples, respectively. The heavy metals concentration in water samples were found in the increasing order of Zn>Cr>Pb>Co>Ni>Cd>Cu>Fe>Mn. The PCA results identified six significant loading factors which clearly define natural and anthropogenic sources which deteriorate environmental matrices in the study area. Health risk assessment

(HRA) was calculated for HMs in drinking water samples by using average daily dose (ADD), health quotient (HQ) and hazard indices (HI). Based on HM concentrations the health risk assessment indices were calculated. The value of ADD were found in the decreasing order of Cr>Pb>Cd>Co, and the value of HI is found greater than 1 showing moderate health risk.

Influence of climate change on the emergence of infectious diseases and human health

Bareera Munir* and Attiya Munawer

College of Earth and Environmental Sciences, University of the Punjab, Lahore, Pakistan
**bareeramunir@yahoo.com*

The aim of this work is to overview the influence of climate change on infectious diseases. Climate is a key determinant of health. Climate change is not just the change in the global temperature but it is also affecting the weather patterns by increasing variability and unpredictability. Upward trend in global temperatures have been identified by climatologists and estimates a rise of 2.0 degrees C by the year 2100. Temperature affects the geographic range, reproduction, pathogen incubation time period as well as biting rates of infectious diseases and their vectors. Weather also influences the time, intensity and outbreak location. Climate plays important role in influencing pathogen, vector, their habitat and host defense mechanisms. Mosquito borne diseases are sensitive to climate; include malaria, dengue, chikungunya and West Nile fever and it also contributes to the increased range of vectors which transmit tick-borne encephalitis and lyme disease. Higher sea surface temperatures, sea levels and extreme precipitation events leads to higher rates of water borne outbreaks and toxin related illnesses. Increased rate of food borne diseases are occurring due to longer summer season. Human susceptibility to infections is further aggravated by malnutrition due to stress on agriculture by climate change. Humans'immune system is influenced by increased flux of ultraviolet rays. Increasing change in climate is a big threat to society and public health. Recent studies have identified increased morbidity and mortality as a direct result of climate change throughout the world. Preventive strategies can be optimized by understanding the relationship between ecological and climatological changes which act as determinants of disease emergence and redistribution throughout the world.

Provenance and reservoir characterization of Gurguri sandstone, North Western Kohat Basin, Pakistan

Muhammad Muslim*, Muhammad Hanif, Irfan Ullah Jan and Faheem Ahmed

National Centre of Excellence in Geology, University of Peshawar, Peshawar, Pakistan
**muslimkhan@uop.edu.pk*

This study was carried out to determine the Provenance and Reservoir characterization of Gurguri sandstone. The Gurguri Sandstone located in the north western part of Kohat basin is a fine to medium grained, cross bedded and coarsening upward sandstone. The petrographic and modal compositional studies of the sandstone shows that it is mainly comprised of quartz and lithic fragments of sedimentary rocks. The framework grains are angular to sub-angular and poor to moderate sorted with the quartz varieties exhibiting anhedral to subhedral, non-undulose to undulose characteristics. Based on petrography and geochemical data obtained from XRF major oxides analysis, the sandstone is classified as lithic to sub-lithic arenite. The Gurguri sandstone is both mineralogically and texturally immature. The provenance analysis based on both petrography and geochemistry data shows that the source of the clastic sediments of Gurguri Sandstone is quartzose sedimentary and felsic igneous rocks. North Waziristan and kurram mélange zone are the probable source area for these sands. Active continental margin is interpreted to be the depositional setting of these sediments based on major oxides plots. The sandstone falls in the category of ultra-low and low porosity and permeability based on qualitative and quantitative reservoir property examinations. Different diagenetic alterations such as compaction and massive calcite cementation have reduced the porosity and permeability to a great extent which shows that diagenesis has a negative impact on porosity and permeability of Gurguri Sandstone.

Tetonostratigraphy of Nizampur Basin and Attock-Cherat Range: correlation of Pleistocene sedimentary sequences, variations in sediment supply and geomorphic controls

Umair Mussawar[1*], Shah Faisal[1], Suleman Khan[2], Muhammad Yasir[1], Subhan Ullah[3] and Muhammad Sadiq[1]

[1]NCE in Geology, University of Peshawar, Pakistan
[2]Departement of Geology, University of Peshawar, Pakistan
[3]Department of Earth and Space Sciences, University of Swat, Pakistan
**umairmusswar@uop.edu.pk*

Pleistocene depositional patterns of Nizampur basin show a complex history of synchronous tectonostratigraphic settings. Deposition of various sediments in episodic sequences portray that the tectono-sedimentary molasses of Nizampur Basin is controlled by tectonic entities mainly Main Boundary Thrust (MBT) and

its associated splays. Since correlative successions developed in this stress regime are utilized to reconstruct the tectonomorphic history of the basin. Due to intermittent tectonic events that resulted from compressional stresses, variations in sediment supply to the basin is observed, that is ultimately contributed towards the Himalayan orogeny. This later on provided grounds to some of the major thrust systems carving the present tectonic geomorphology of the basin. In addition to this sporadic deformation active in the stress regime, tectono-sedimentary units also portray kinematic history of events in the form of syn-orogenic deposition in the adjacent ranges. This synchronicity of events in terms of tetonostratigraphy within the northwest Himalayan basins represent a distinct geodynamic entity that resulted in the correlative series of these extensive tectonic phases and lithostratigraphic divisions.

Geology of Zhob Ophiolite, Balochistan, Pakistan

Abdul Naeem[1,2], Muhammad Ishaq Kakar[2*], Rehanul Haq Siddiqui[2,3]
Andrew C. Kerr[4] and Muhammad Ayoub Khan[2]

[1]Geological Survey of Pakistan, Quetta, Pakistan
[2]Center f Excellence in Mineralogy, University of Baluchistan, Quetta, Pakistan
[3]Saindak Metals Limited, Quetta Pakistan
[4]School of Earth and Ocean Sciences, Cardiff University, Main Building Park Place, Cardiff, Wales CF10 3AT,UK2
**kakarmi.cemuob@gmail.com*

The Zhob Ophiolite has been divided into three detached blocks, Naweoba, Omzha, and Ali Khanzai. It has six mappable units with fault-bounded contacts. They are crustal plutonic rock, mantle section rock, metamorphic rocks, basalt chert, hyaloclastite-mudstone, and sedimentary rock. The Crustal Plutonic Rock is mainly composed of hornblende, pyroxene and olivine gabbro with minor amount of granitic bodies. Mineralogically, gabbro consists of plagioclase, clinopyroxene, chlorite, and opaque minerals. The Basalt Chert is composed of plagioclase and clinopyroxene phenocrysts while clinopyroxene and plagioclase, chlorite, and epidote occur as groundmass. It has aphanitic, hemi-crystalline, inequigranular, porphyritic, and sub-ophitic textures. The Hyaloclastite-Mudstone consists of plagioclase, clinopyroxene, orthopyroxene, and minor olivine, opaque, and glassy materials. The petrology of harzburgites exhibits porphyroclastic textures. Dolerite is fine to medium-grained with aphanitic, allotriomorphic, intergranular, and sub-ophitic textures. It contains plagioclase, and clinopyroxene as primary minerals and quartz, calcite, and zeolites as secondary minerals. The geochemistry classifies Basalt Chert into basalt, trachy-basalt, basalt andesite, and dacite with tholeiitic characteristics while classifying Hyaloclastite-Mudstone is classified as foidite, picro-basalt, and tephrite-basanite. The Basalt Chert is tholeiitic and Hyaloclastite-Mudstone is alkaline in nature. The multi-element plots show that tholeiitic rocks are like N-MORB while alkaline rocks are like OIB. The geochemical results suggest that the tholeiitic

lava has been formed in a supra subduction zone setting while the alkali lava has been intruded as intraplate magmatism. Basalt Chert lava may have been erupted along the mid-Tethyan ridge and Hyaloclastite-Mudstone lava erupted when the Neo-Tethys oceanic lithosphere had passed over a hot spot. The gabbro chemistry indicates that it has been formed in an arc-related tectonic setting relative to N-MORB. The Zhob lavas are, therefore, likely to represent the floor of a branch of the Ceno-Tethys Ocean and may have obducted over the Indian Plate passive continental margin during the Late Cretaceous. The Zhob Ophiolite may have been formed in an already proposed Late Jurassic-Cretaceous segmented Ceno-Tethyan convergence zone along with several other arcs and back-arc basins including Muslim Bagh, Waziristan, Semail, Zagros, Chagai-Raskoh and Kohistan-Ladakh and obducted on to the north-western margin of Indian plate in Maastrichtian. The geochemical data of gabbro, basalts, and dykes of this study are transitional between an island arc and mid-oceanic ridges setting which suggests a supra subduction zone origin for the Zhob ophiolite.

Effects of heat treatment on mechanical properties of rocks

Abid Nawaz[1*], Muhammad Sajid[2] and Waqas Ahmad[1]

[1]National Centre of Excellence in Geology, University of Peshawar, Pakistan.
[2]Department of Geology, University of Peshawar, Pakistan.
**abidgeo88@gmail.com*

The effect of temperature variation on physico-mechanical properties of various rocks have been studied. The rocks were selected from Northern Pakistan which included a broad spectrum of rocks including gabbronorite, garnet granulite, amphibolite, rhyolite, dolerite gneiss, quartzite, sandstone and limestone. Various physical (specific gravity, water absorption and porosity, ultrasonic pulse velocity) and strength properties (unconfined compressive strength, point load and schmidt hammer test) were investigated at room temperature. Subsequently the rocks were exposed to multiple temperature ranges of 150ºC, 300ºC, 600ºC, 800ºC, and 1000ºC for 24 hours and the similar physical and strength properties were determined at each temperature. It was found that temperature has adverse effect on mechanical properties of rocks. With increase in temperature, the strength decreases. The average UCS value of dolerite at room temperature is 110 KN and after treating the sample at 1000ºC, UCS value decreases to 25 KN. Changes in physical and strength properties depend upon constituent minerals of a rock. Some rocks are less sensitive to higher temperatures as compared to others i.e., the dolerite is more resistant as compared to limestone and sandstone.

Geotechnical and Petrographic investigations of Dir volcanics as a dimension stone, Upper Dir, North Pakistan

Muhammad Nawaz, Waqas Ahmad, Liaqat Ali and Muhammad Muslim*

National Centre of Excellence in Geology, University of Peshawar, Peshawar 25130, Pakistan
**muslimkhan@uop.edu.pk*

The present study is designed to investigate the physical and strength properties of volcanic rocks from the Kohistan Island Arc to assess their use as dimension stone. On the basis of the composition, colour and texture, five varieties of andesites (MMA, PMA-1, PMA-2, CMA and FMA) and two varieties of agglomerates (AG-1 and AG-2) were identified. These were characterized in terms of their petrography (compositional and textural), physical properties (specific gravity, water absorption, porosity) and strength properties (Unconfined compressive strength and Unconfined tensile strength). Two non-destructive tests (Ultrasonic pulse velocity test and Schmidt Hammer) were conducted and the degree of polishing was evaluated. In addition, correlation analyses were carried out to establish possible relationships among these parameters. The presence of chlorite, epidote, sericite and recrystallized quartz showed the signs of low-grade metamorphism in andesites. The results showed feldspar, amphibole and quartz imparted good physical and strength properties to the samples MMA, CMA, FMA, AG1 and AG2. Whereas, the abundance of alteration products such as chlorite, sericite and epidote in PMA-1 and PMA-2 reduced the physical and strength properties. The unconfined compressive strength showed a strong correlation with ultrasonic pulse velocity, dry density, porosity and water absorption. The values of ultrasonic pulse velocity and Schmidt hammer were considerably affected by the weathering grade. The samples PMA-1 and PMA-2, due to their high-water absorption and low strength values, were not recommended for use in load-bearing masonry units and outdoor applications. Whereas, the excellent properties, i.e., high strength and good polishing, the samples, FMA and MMA suggested their use as a decorative and facing stone, in the external pavement, ashlar, rubbles and load-bearing masonry units.

Synergistic impact of two autochthonous saprobic fungi in phytoextraction of heavy metals in *Brassica juncea* L. and *Vigna radiata* L.

Aisha Nazir[1], Wajiha Sarfraz[2], Allah Ditta[3*], Noreen Khalid[2], Mujahid Farid[4], Muhammad Shafiq[1] and Firdaus-e-Bareen[1]

[1]Institute of Botany, University of the Punjab Lahore-54590, Pakistan
[2]Department of Botany, Govt. College Women University, Sialkot, Pakistan
[3]Department of Environmental Sciences, Shaheed Benazir Bhutto University Sheringal, Dir (U), Khyber Pakhtunkhwa, Pakistan
[4]Department of Environmental Sciences, University of Gujrat, Hafiz Hayat Campus, Gujrat, 50700, Pakistan
**allah.ditta@sbbu.edu.pk*

A combined phyto- and mycoremediation treatment mechanism was evaluated to boost plant biomass and remove cationic and anionic heavy metals from tannery solid waste (TSW). In greenhouse trials, Brassica juncea and Vigna radiata were grown in pots under TSW contaminated soil in the presence of two autochthonous saprobic fungal strains i.e. *Trichoderma pseudokoningii* and *Aspergillus niger*. The results showed distinct variations in morphological attributes under different TSW concentrations and fungal treatments. A single application of *A. niger* promoted growth and ion contents (Na, Ca, and K) in B. juncea. T. pseudokoningii had a beneficial impact on morpho-characteristics and ionic contents in V. radiata. The maximum increase in plant biomass was recorded with co-inoculation of both the autochthonous fungi. However, uptake of heavy metals such as Cd, Cr, Cu, and Zn was also improved simultaneously. In conclusion, metals could be extracted from tannery solid waste using autochthonous saprobic fungi. Advancement in such findings would assist in understanding the mechanisms and enhancing the ability of other native microbes to remediate metals.

Evaluating dynamics of glaciers along northern areas in Pakistan using temporal remote sensing images

Amara Nisar*, Javeria Faisal and Rahib Hussain

College of Earth and Environmental Science, University of the Punjab, Pakistan
**ammarachauhan786@gmail.com*

The world's greatest freshwater storage reservoirs are glaciers. The northern area of Pakistan is home to some of the world's greatest midlatitude glaciers. However, the data on variations in glaciers in northern Pakistan is scarce. As some glaciers in Pakistan's Karakoram Himalaya advance to rapidly diminishing glaciers in other sections of the Himalayas, the ongoing space-based evaluation of glaciers across the Himalayas reveals that there may be spatial variations in glacier fluctuations related to topography and climatic dynamics. The inconsistent results have been produced during the recent research on the region which shows the

advancing, retreating, or remaining stability of glaciers in the Karakoram Mountains, leading to the moniker "Karakoram anomaly." In this work, to assess the temporal dynamics of the Ghulkin, Batura, Gulmit, and Passu glaciers in northern Pakistan, temporal Landsat satellite pictures obtained in the years 1999, 2001, 2007, 2009, 2014, and 2021 were used. NDSI and slope gradient were used to retrieve the contours of the glaciers, then manually edited. The fine-resolution WorldView-2 satellite picture and field observations were used to verify the Landsat-derived glacier inventories. The selected glaciers are retreating, according to the temporal glacier inventories, but then again, the melting rate varies depending on the supra-glacier debris cover. The average yearly precipitation and temperature records have an impact on glacier melting and advancement. The research should aid in forecasting the region's future climate.

The salt tectonic hazards: A potential threat to the M-2 Motorway, Central Salt Ranges, Pakistan

Abdur Rauf Nizami[1*] and Muhammad Fahim[2]

[1]Institute of Geology, University of the Punjab, Quaid-i-Azam Campus, Pakistan-54590
[2]Regional Laboratory, Highway Circle, Gujranwala
**rauf.nizami@gmail.com*

The present study was concentrated on “The Salt Tectonic Hazards: A Potential Threat to the M-2 Motorway, Central Salt Ranges-Pakistan”. The M-2 Motorway is crossing the Main Frontal Thrust (MFT), Central Salt Range, Cis-Indus Salt Ranges, and Sub-Himalayas-Pakistan. The study area comprises a fifty km road section of the Lahore-Islamabad Motorway: M-2 from its entrance into the Main Frontal Thrust (MFT) near the Lilla Interchange while traveling towards the Kallar Kahar. This section of the motorway was constructed in 1997-98 through the rugged hilly terrain of the Central Salt Range. Unfortunately, the important activity and impact of the salt tectonics was overlooked by the designers of this motorway at the time of construction of this part of the motorway. Actually, the area under-discussion was subjected to the perpetual salt tectonic activity coupled with intensive compressional tectonic settings. While, a thick pile of plastic and low-density rock salt of the Pre-Cambrian Salt Range Formation was present in the subsurface along with overlying high density younger sedimentary cover / rocks. The loading and unloading phenomenon of overlying higher density rocks by geomorphological processes active at various locations of this section of motorway and around it propelled the differential erosion along this route. Along with other geological factors the rock salt moves upward and/or downward very slowly at an average annual speed of 2cm due to density contrast with accompanying sedimentary rocks. During this very slow pace of upward and/or downward movement of the rock salt, the various parts of the road sections, constructed on host rocks, were cracked, fractured and wrecked. A fair number of these locations were physically visited and checked to scan the damages produced due to this salt tectonic hazardous activity and were documented and illustrated.

The collected data demonstrated the high extent of damages inflicted to the different parts of motorway along the discussed route.

Performance of global precipitation measurement (GPM) rainfall product over the diverse climatic conditions, Khyber Pakhtunkhwa, Pakistan

Jabir Nazir and Muhammad Ali*

GIS and Space Application in Geosciences Laboratory (GSAG-L), National Centre of Excellence in Geology, University of Peshawar.
**aliumarzai@uop.edu.pk*

This study aims to evaluate the performance of the Global Precipitation Measurement (GPM) product namely Integrated Multi-satellite Retrievals (IMERG_v06) against rain gauge data over the diverse climatic conditions of the Khyber Pakhtunkhwa (KP), Pakistan from 2018 to 2020 on yearly average mean monthly data (mm/day). GPM is a high-resolution rainfall product available in both high temporal (30 mins) and spatial (0.1°) resolution and combines data from all passive microwave instruments in the GPM constellation. The GPM performance over the diverse climatic conditions over the study area still awaits. Climatic conditions influence the atmospheric phenomenon and it is needed to investigate the effects of varying climatic conditions on satellite measurements. According to the Koppen classification, KP is categorized into Bwhw (desert hot with dry summer), Csa (temperate cold with dry summer), Bshw (steppe hot with dry summer), Cfa (temperature cold with fully humid), and Bsh (steppe hot with fully humid) climatic regions. Results from this study revealed that the average correlation coefficient (r) over DI Khan, Chitral, Bannu, Parachinar, and Peshawar was 0.75, 0.85, 0.68, 0.81, and 0.77, respectively. The best performance has been observed at Chitral and Parachinar and moderate has been recognized at DI Khan, Bannu, and Peshawar. Average Root mean square deviation (RMSD) was observed for DI Khan (1.20 mm/day), Chitral (0.96 mm/day), Bannu (1.66 mm/day), Parachinar (2.96 mm/day) and Peshawar (1.32 mm/day). Maximum and minimum mean errors have been observed as 0.60 mm/day (Bannu) and -1.47 mm/day Parachinar). It was depicted that the satellite rainfall product is overestimated over Bannu and underestimated in Parachinar. After the detailed analysis, it is concluded that the GPM satellite rainfall product (IMERG_v06) was found as a reliable source for rainfall measurements under various climatic conditions over the study region.

Environmental impacts of trace elements and coal mining activities

Faiza Noor*, Sunya Ramzan and Rahib Hussain

College of Earth and Environmental Sciences, University of the Punjab, Lahore, Pakistan
**faynoor14@gmail.com*

The study was conducted to study the environmental impacts of trace elements and coal mining activities. The coal mining activities are compulsory hyperlinks with the manufacturing of acidic drainage and airborne compound inclusive of fly ash and backside ash with high metallic content material. The essential sink for the trace elements released by human sources is soil and water. So, the availability and ecological risk of trace factors and heavy metals near the coal mining areas is of maximum importance because of its implications for environmental fitness for understanding. The data for the study has been taken from the previously published literature. In which several soil samples were being collected from the target areas. The soil sample was treated with hydrofluoric acid (10ml), aqua regia (20ml), and 20 ml of hydrogen chloride (HCl). All the samples of soil were analyzed for major heavy metals and trace elements using Perkin Elmer atomic absorption spectrophotometer equipped with a graphite furnace. The results showed that the average concentration (mg/kg) of trace elements in the target area are 301.6, 8.8, 152.3, 58.8, 144.7, 359.4, 32.5, 1097, 2508, 787, 2572, 4088 and 690 for Chromium (Cr), Cadmium (Cd), Lead (Pb), Nickel (Ni), Copper (Cu), Cobalt (Co), Iron (Fe), Magnesium (Mg), Manganese (Mn), Sodium (Na), Potassium (K) and Calcium (Ca). Different parameters such as pollution load index, ecological risk index, and geo-accumulation index were also observed for determining the human sources. The study confirmed that the majority of trace elements contribute to soil pollution and water pollutants, however, additionally have a negative impact on surroundings. Therefore, coal mining in the target vicinity is the most important reason for high ecological hazards. There is an essential need for mitigation and remedial measure in the area that could assist to reduce environmental pollution.

Characterizing major sedimentary rocks types using ASTER data: A case study of North East Kohat Plateau

Muhammad Nouman[1,2*], Muhammad Hanif[1, 2], Saleem Ullah[2, 3] and Muhammad Shafique[1, 2]

[1]GIS and Space Applications in Geosciences Lab, National Centre of GIS and Space Applications, Pakistan
[2]National Centre of Excellence in Geology, University of Peshawar, Pakistan
[3]Institute of Space Technology, Islamabad, Pakistan
**mnouman@uop.edu.pk*

The advancement in remote sensing provides a cost and time effective substitution for exploring various economic earth's natural resources. The sedimentary rocks in Kohat Plateau of sub-Himalayas in Pakistan are known for various commercial and economic natural resources. In this research the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data is experimentally tested to efficiently delineate the different sedimentary rock classes (form marine crystalline carbonates and evaporites to fluvial clastic). Various advance remote sensing techniques adopted here include false color composites (RGB) of reflectance, principal component analysis (PCA), minimum noise fraction (MNF), independent component analysis (ICA) and band rationing (BR). Although, all applied techniques exhibited a significant potential to discriminate among the surface exposed lithological units, FCC, PCA and BR proved to be the most effective methods for capturing the maximum variations in lithologies. Integration of field observations revealed certain limitation caused due the presence of vegetation cover, weathering and local topography. Finally, Spectral Angel Mapper (SAM) method is applied to produce classified lithological map. For this pupose, the original image pixel spectral response is compared with the reference spectrum created for every lithological class exposed in the study area. The accuracy assessment is performed to evaluate the authenticity of classified lithological map. The overall accuracy is found to be considerably efficient. Among all the mapped lithological classes, the carbonates and evaporites displayed relatively higher accuracy due to their weathering and topographic behavior.

Integrated geospatial techniques for estimating soil erosion using RUSLE and weight of evidence techniques in Nowshera District, Pakistan

Maaz Ur Rahman, Muhammad Ali* and Shah Rukh

National Centre of Excellence in Geology, University of Peshawar, Pakistan
**aliumarzai@uop.edu.pk*

Soil erosion is a major geo-environmental hazard in Pakistan. Soil loss is caused by natural processes and anthropogenic activities. Revised Universal Soil Loss Equation (RUSLE) model is integrated with geospatial techniques to evaluate soil erosion in Nowshera District, Pakistan. In the current model, five geo-environmental factors i.e., soil erodibility (K), rainfall erosivity (R), cover management (C), slope length (LS), and supporting practices (P) were considered to produce soil loss map of the area. This study estimated about 7.29 tons/hectare/year soil loss in the study area for the year 2020. In this study, it was found that 94.2% area falls under soil erosion class of low to very low, while 5.2% of the area falls in moderate and high soil erosion category. Very high soil erosion (greater than 5.5-tons/hectare/year) was found in about 0.6% of the study area. Various geo-environmental factors of the RULSE model were evaluated through Weight of Evidence (WoE) model. For this purpose, an inventory map of soil erosion was prepared from Google Earth imagery and verified in the field. Inventory map was correlated, using WoE, with the parameters of RUSLE model in order to evaluate the impact of each factor on soil erosion. Among the causative factors, Slope length (LS) was found to be the most influential factor for soil loss in the study area. Soil erosion hotspot area map was developed from the resultant map of soil erosion using different tools. The results of this study can be helpful for the decision and policy making system regarding soil fertility, agriculture productivity and irrigation practices.

Integrated geophysical and GIS techniques to identify hydro geophysical potential in Southern Punjab

Irfan Raza*, Perveiz Khalid, Muhammad Irfan Ehsan and Zia Ud Din

Institute of Geology, University of the Punjab Lahore
**syedirfanraza.geo@gmail.com*

In the southern Punjab inhabited with dry and hot climate conditions, identification of fresh water aquifers is major area of interest in this area. Most of the sub-surface aquifers concentrated with highly dissolved sediments at shallow depth. The short fall of rains and intensive urbanization rapidly increased the salinity of aquifers in the study area. Therefore, subsurface water is a fundamental source of urbanization and agricultural use so that delineation of fresh water from saline water is primary area of concern. In order to map ground water condition, a combine technique of satellite data, GIS, electrical resistivity, and analytical hierarchy process (AHP) provides fruitful results. Several prepared thematic layers, including geological formations, land use land cover (LULC), rainfall, drainage network, lineament density, soil type, slope, and stream power index (SPI), were assigned with a weight, depending on their influence on groundwater potential. We have used AHP technique in this work to perform comparative contribution of normalization. The groundwater potential zone's cumulative score was categorized into five classes: very good, good, moderate, poor, and very poor. In this research we have also performed electrical resistivity ID inversion data to investigate the groundwater conditions in Muzaffargarh. Our resistivity modeling results shows three to five layers of geo electric layer in the study area consisting of organic content, silty clay, fine to coarse sand and gravels at some profiles. The resistivity inverse model depicts saline water at the depth of 4-11 meter. The mapping of fresh and saline water zones is aided by 2D generated resistivity maps. The saline water with clay enriched is identified at low range of resistivity. It is also identified that fresh water zones are trending from east to west.

Evaluation of natural laterite and kaolinite deposits of Northern Pakistan as potential sorbents for arsenic removal from aqueous solution

Ambreen Rehman[1], Shah Rukh[1*], Seema Anjum Khattak[1], Ayaz Mehmood[2], Ahmad Khan[3], Kouser Majeed Malik[4], Hikmat Salam[1] and Liaqat Ali[1]

[1]National Center of Excellence in Geology, University of Peshawar, Peshawar-25130, Pakistan
[2]Department of Soil and Climate Sciences, The University of Haripur, Haripur-2120, Pakistan
[3]Institute of Soil and Environmental Sciences, Pir Mehr Ali Shah Arid Agriculture University Rawalpindi, Rawalpindi-46300, Pakistan
[4]Soil and Water Testing Laboratory for Research, Rawalpindi-46300, Pakistan
**shahrukh.nceg@uop.edu.pk*

Arsenic (As) contamination to groundwater is a worldwide concern due to its chronic effects on human health. The objectives of the study were to characterize natural inexpensive raw laterite (RL) and kaolinite (RK) for their potential use as As sorbent and to understand the mechanism of As sorption by employing sorption and kinetic models. Raw laterite and RK were tested for EC, pH, XRF and CEC as basic parameters. Batch sorption and kinetic experiments data were fitted in the sorption (Langmuir and Freundlich) model and kinetic (pseudo-first and pseudo-second order) reaction equations. Morphological and structural changes were observed in RL and RK samples before and after As saturation by employing FTIR and SEM. The major constituent in RL was Fe and Al oxides while in RK major oxides were silica and Al. Freundlich sorption model well explained the experimental data indicating a greater sorption capacity of RL on a hetero-layered surface compared to RK. The kinetic reaction equations showed that equilibrium was achieved after a contact time of 240 min and the adsorption was chemisorption in nature. The HB-12 among RL and Tarkano-1 among RK was most effective for the removal of As with rate constants of 3.89 and 3.05 g mg-1 min-1. Structural and morphological characterization reveals the role of Fe and Al oxides in the case of RL and Al oxides in the case of RK in the adsorption of As. Hence this study concludes that these naturally occurring inexpensive resources can be used as sorbent agents for As-contaminated drinking water treatment.

Continent-continent collision, deep subduction, and Ultrahigh-Pressure metamorphism in the Himalayan orogen: solved issues and future problems

Hafiz U. Rehman

Kagoshima University, Japan
hafiz@sci.kagoshima-u.ac.jp

Himalayan Orogenic Belt extends over 2500 km as a regional tectonic structure that played significant role in mountain building processes such as crustal thickening, regional deformation, ore mineralization, moon soon control, land form and glaciation, and active tectonics. Geologically, this region marks a global-scale orogenic belt composed of magmatic and metamorphic rocks of the Indian Plate, Tethys Oceanic crust, the intra-oceanic Kohistan-Ladakh Island Arc (KIA), and the Eurasian/Karakoram Plate. These geological units are widely studied for almost half a century. The 6th International conference "Earth Sciences Pakistan 2022" is an ideal plate-form to commemorate the 50 years' work on the geology of northern Pakistan since the emergence of the idea of the India-Asia collision and the discovery of the intra-oceanic island inbetween, first reported by Prof. Tahirkheli in 1979. Till date, a treasure of published literature enhanced our understanding on regional tectonics and provided state-of-the-art education in Earth Sciences. Published work, available in the form of geological maps, analytical data, and technical reports, attracted local and international earth scientists to this wonderful natural geological laboratory. Extensive field and geochemical results, aided with computer simulations elucidated major geological events in the Himalayan region. Textural investigations, whole-rock and mineral bulk and in-situ geochemical analysis, and zircon U-Pb geochronology confirmed the timings of the initial crustal growth of the oceanic arc within the NeoTethys (~150 Ma), mantle upwelling and closure of the Neo-Tethys (120 Ma), India-Eurasia collision ~55 to 50 Ma, Ultrahigh-pressure (UHP) metamorphism at mantle-depths (> 90 km) around 45 Ma, and exhumation of the deeply subducted Indian crust back to shallow levels after 40~30 Ma. In addition, stable (oxygen, carbon) and radiogenic (Sr-Nd-Hf) isotope data extend our knowledge regarding the crustal or mantle source of the rocks and their paleoclimatic conditions. Micro-scale spectroscopy combined with multi-mineral geochemistry enabled us to extract pressure-temperature conditions under which these rocks/minerals crystallized/recrystallized, or metamorphosed, and to understand the regional tectonics and associated magmatic or metamorphic episodes. However, a number of issues exist that need investigation. For example (1) the timings of India-Asia collision either coherent or diachronous is still enigmatic. Collision-related eclogite facies metamorphic event in Kaghan is reported around 46 Ma, in Tso Morari around 55 Ma, In Stak around 30 Ma, In Nepal/Tibet at 15 Ma, a discrepancy that needs reevaluation. (2) Massive Carboniferous-Permian (and/or Oligocene?) calc-alkaline magmatism in the Peshawar Plain Alkaline complex (including carbonatites) but their tectonic scenario and relation with the regional

deformational events is yet to be understood. (3) Genesis and inter-relationship of various mafic/ultramafic units of the KIA, Waziristan, Chagai, and Muslim Bagh areas and their relation with the regional tectonics. (4) Petrogenesis and source of chromitites, the least studied topic, and (5) the digitization of the geologically mapped areas and their association with the local and global geographic mapping systems to help locating the economic ore deposits. In this talk, I will present our research results obtained from some high-tech analytical methods and point out some key questions as a take-home message.

Azurite-bearing Quartzolite in Kohistan Island Arc: Implications for petrogenesis and economic potentials

Hafiz U. Rehman[1], Asghar Ali[2], Mohammad Yaqub Shah[3]* and Zahid Hussain[4]

[1]Kagoshima University, Japan
[2]Department of geology, University of Peshawar, Pakistan
[3]Global Mining Company, Islamabad, Pakistan
[4]Marine Science Department, Zhejiang University, China
**yaqubshah02@gmail.com*

A complete section of oceanic crust and seafloor sedimentary rocks are exposed in the shape of Kohistan Island Arc (KIA) in northern Pakistan. The KIA was initiated as an intra-oceanic arc within the Neo-Tethys Ocean as a result of subduction and associated magmatism. Ultramafic, mafic, and felsic rocks generated from mantle and partial melting of crust. Copper, silver, gold and other ore mineralizations commonly associated with these rock suites as massive sulfide deposits, disseminated, local veinlets, hydrothermally altered zones and skarn mineralization. Here, we report preliminary petrographic and geochemical results on the Azurite-bearing (Cu-Au-Ga-Mo-rich blue rounded spots in a white fine-grained matrix) felsic rocks termed here quartzolite are sporadically exposed in the KIA. These rocks are apparently similar to the granitic rocks (known as K2nite) found in the vicinity of Mount K2, within the Karakoram microplate. However, petrographically the Azurite-bearing felsic rocks of the KIA are texturally and tectonically different form the K2nite. Textural features of K2nites show granitic rocks composed of alkali-feldspar, plagioclase, quartz and two-mica, however the Azurite-bearing quartzolite consists of > 80% quartz with minor plagioclase, muscovite and sphene. Polished slabs on fresh surfaces or interior parts also display Cu-rich blue rounded spots with nodular or irregular shaped metallic Cu ore within and around the blue spots. Geochemical mapping of major and trace elements on polished surfaces of the 2~4 cm long cut rock slabs/chips, using Xray Guided Tube (XGT-5000) of Rigaku, Japan provides promising signatures for the abundance of Cu-Au-Mo, and other trace elements, indicating higher concentration of these economically important ore minerals. Previous studies conducted by PMDC showed metallic mineralization, and this study confirm such mineralization in the KIA. Rare-earths and metallic ores if properly exploited can contribute significantly in reviving the country's economy. Whole-rock major and trace element geochemistry

also indicate higher abundance of Cu (580 ~ 38963 ppm), Ga (~ 17 ppm), and Au (~ few hundred ppb). Based on these results, we conclude that KIA Cu-bearing rocks have higher economic potentials and need proper exploration and subsequently development in to mining ventures. Azurite mineralization in an exclusive quartz rich quartzolite suggests late stage magma crystallization of tin-tungsten mineralization.

Seismological and field observations regarding the Harnai earthquake (October 07, 2021, Mw = 5.9), Balochistan, SW Pakistan

Khaista Rehman[1*], Rahat Ullah[1, 2], M. Qasim Jan[1] and Mohibullah Mohibullah[3]

[1]National Centre of Excellence in Geology, University of Peshawar, 25130, Pakistan
[2]Geological Survey of Pakistan, Quetta
[3]Department of Geology, University of Balochistan, Quetta
**rehmannceg@uop.edu.pk*

The Harnai area is part of the Suleman fold and thrust belt, between latitudes 28.00 and 32.00 °N and longitudes 66.00 and 70.00 °N. This region is characterized by Sulaiman seismic zone dominated by shallow depth earthquakes. This paper presents seismicity analysis and field geology of the October 07, 2021 Harnai earthquake (depth=11 km; 30.19°N, 67.99°N) of Mw 5.9. Seismicty analysis is considered in terms of seismic clusters and seismicity rate changes. The present work utilizes the global catalog of National Earthquake Information Center, United Stated Geological Survey, for the area of Harnai. This catalog contains 887 earthquakes with magnitude range 3.2-7.5, depth range 1.8 to 97.3 km for the duration 1909 to 2021. Innovative approaches of K-means and Z-statistics have been used in this study. We conducted the observations near the epicenter and surrounding region following the October 07, 2021 earthquake. The fieldwork was mostly concentrated on the measurement of surface cracks, landslides, and individual rock-fall for understanding the nature of the earthquake and its geological impacts. Similarly, the damage and destruction to the infrastructure and resulting causalities were also noted for estimating the effect on population and determining the intensity of the earthquake. The results of K-means clusters (K=4 and K=7), seismicity rate changes (in and around epicentral region) and field survey are discussed in the context of the seismotectonics and current state-of-the-art.

Seismically induced landslides hazard zonation using geospatial techniques, Hattian Bala, Azad Jammu and Kashmir

Malik Talha Riaz*, Muhammad Basharat, Saad Wani, Muhammad Tayyib Riaz, Ahmad Hammad Khaliq, Abdul Mateen Awan and Syed Ali Abbas Kazmi

Institute of Geology, University of Azad Jammu and Kashmir, Muzaffarabad 13100, Pakistan
**talha.riaz@ajku.edu.pk*

The Himalayan region, a rugged mountain zone is among the most susceptible zones to the landslide hazard due to its terrain, geography, and active tectonics. This evaluates landslide hazard potential areas in terms of landslide susceptibility and hazard mapping, which is essential to minimize future risks and adopt mitigation measures. The current study was designed to analyze and assess landslide susceptibility using statistical and advanced ML approaches for District Hattian, NW Himalayas, Pakistan. The experimental design utilized 349, 393, and 735 landslide inventories of 2005, 2007, and 2012. Two ML approaches i.e., Random Forest (RF) and Logistic Regression (LR) and three data-driven statistical models, i.e., Weight of Evidence (WoE), Information Value (IV), and Frequency Ratio (FR) were used to analyze the landslide susceptibility for District Hattian, NW Himalayas, Pakistan. Thirteen landslide causative factors (LCFs) including topographic, environmental, geologic, and anthropogenic were selected to analyze the landslide susceptibility in the region. Training landslide samples (70%) were used to train the models and validating landslide samples (30%) were used to check the model's prediction accuracies. Comparative analysis of different LSMs was assessed by the Receiver Operator Curves (ROC-AUC), Accuracy, MAE, RMSE, Kappa, Precision, Recall, F1 and found that the RF model outperformed than the other models in terms of SRC 33 99.87%, 99.03%, 99.79% and PRC 93.57%, 89.24%, 98.271%. However, among statistical models, IV and WoE are more effective. The order of accuracies is RF, LR, WoE, IV and FR having PRC values 93.5%, 87.2%, 85.7%, 82.5%, and 80.4% for 2005, 89.2%, 87.6%, 87.5%, 80.4%, and 77.5% for 2007, and 98.2%, 97.1%, 80.7%, 87.7%, 88.3% for 2012 respectively. According to the result, as the hazard zone for mass movement activity increases without the influence of an earthquake, the area is active for the continuous happening of mass movement activities. To minimize life loss and potential economic damage, concerned authorities must implement effective landslide management methods for optimal prevention and mitigation.

Diagenetic evolution of mixed-carbonate siliciclastic succession of Upper Cretaceous Carbonates of Sulaiman Range from Rakhi Nala Section, Lower Indus Basin, Pakistan: Implication for paragenetic sequence interpretation

Muhammad Rizwan*, Muhammad Hanif, Shuja Ullah and Muhammad Ishaq

National Centre of Excellence in Geology University of Peshawar
**mrizwan.pk333@gmail.com*

The Upper Cretaceous mixed-carbonate siliciclastic succession of the Sulaiman Range, Lower Indus basin in Rakhi Nala section was investigated for paragenetic sequence interpretation of diagenesis through petrographical and advance geochemical evidence. The succession is about 200 m thick at the studied section and is comprised of thin- to thick-bedded limestone with interbedded marls, shale and sandstone. Based on field observations, detailed petrographic investigation of stained thin sections, and geochemical analyses (i.e., stable C and O isotopes and x-ray diffraction) a variety of different diagenetic processes and stages have been observed respectively. The paragenetic sequence reveals the three stages of diagenesis i.e., the eogenesis, mesogenesis, and talogenesis. The eogenetic stage of diagenesis includes the meteoric and marine diagenetic environments and is reflected by the process of micritization, dissolution, neomorphism (inversion), internal geopetals microsparite cement, cavities and pore lining cement, non-ferroan blocky calcite, and turbid syntaxial overgrowth on echinoid fragments. Micritization is the common process of marine diagenetic environments in the studied samples whereas, intensity of micritization varies from partial to complete destruction of skeletal allochems thereby producing cotoids in some of the microfacies. The mesogenetic stage includes shallow to deep burial diagenetic environments and is characterized by aggrading neomorphism, compaction (mechanical and chemical), fracturing, a variety of cements (blocky, drusy, late stage syntaxial overgrowth, and skeletal pore filling), and replacive dolomites. The talogenetic or uplifting stage is evidenced by multiple direction or cross relation ship of calcite filled fractures. The stable isotope values of carbon and oxygen for whole rock (i.e., matrix and grains) show range from -3.472 to 2.131 and -3.071 to 0.3 respectively. The $\delta^{18}O$ and $\delta^{13}C$ values of micro drilled samples data from blocky calcite cements of undoubtedly burial stage range from -9.97 to -3.68 and -1.58 to 3.05 respectively. The cross plot of $\delta^{18}O$ versus $\delta^{13}C$ of whole rock samples mostly fell in the category of warm-water skeletons and revealed the marine diagenesis. The depleted $\delta^{18}O$ values of the later probably reflects the cementation during deep burial diagenesis with elevated temperature.

Dynamic response and liquefaction potential of soil in Bahria Town, Rawalpindi, Pakistan

Malik Muhammad Saad[1*], Waqas Ahmad[1], Muhammad Hassnain[1] and Syed Samran Ali Shah[2]

[1]National Center of Excellence in Geology, University of Peshawar, Pakistan
[2] School of computing and Engineering, University of West London, London, UK
**saadiimalik96@gmail.com*

To prevent the civil infrastructure from devastating effects of earthquakes, understanding the dynamic response of soil to seismic waves is very important. Laboratory techniques to determine shear modulus and damping have been designed by several researchers. This study reports the Cyclic Triaxial tests results to determine the site-specific soil dynamic properties. Undisturbed soil samples were collected in Shelby tubes from Bahria Town, Phase 8, Rawalpindi. The soil samples were classified as Sandy Silty Clay as per the Unified Soil Classification system. Cyclic Triaxial tests were performed on samples of 50 mm diameter and 100 mm height at confining pressures of 100 kPa, 150 kPa and 200 kPa against strain levels of 0.5%, 1%, 2% and 2.5%. The relationship between shear modulus and damping ratio with the number of cycles, confining pressure and strain levels were studied. It was observed that shear modulus decreases with an increase in the number of cycles and strain levels. Whereas, damping ratio increases with an increase in the number of cycles and shear strain up to a strain level of 1%. Beyond 1% shear strain, due to a decrease in effective stresses, the damping ratio also decreases with an increase in the number of cycles and shear strain. Lastly, the soil samples from the study area were reported as non-liquefiable as they did not fulfill the conditions of liquefaction during cyclic loading.

Rock mass characterization of a hydropower project in Kalam, Khyber Pakhtunkhwa, Pakistan

Malik Muhammad Saad[1], Muhammad Hussnain[2]*, Mian Sohail Akram[1] and Muhammad Shahab[2]

[1]Institute of Geology, University of the Punjab, Lahore, Pakistan
[2]National Center of Excellence in Geology, University of Peshawar, 25130-Peshawar, Pakistan
**nainder12@gmail.com*

The present study aims at characterization and classification of rock mass along with support assessment for the proposed route of 11 km long headrace tunnel of a hydropower project in Kalam valley, KP, Pakistan. Investigation of important discontinuity parameters is essential for the classification of rock. Consequently, comprehensive rock mass characterization and classification studies using empirical rock mass classification methods such as RMR i.e., Rock Mass Rating and Q i.e., Tunneling Quality Index have been carried out. For this research work,

extensive field studies were conducted in Kalam valley from Kalam town to Asrit. Discontinuity surveys (DS) were carried out to obtain rock mass parameters. Samples were collected from each of the 10 discontinuity survey locations along the proposed tunnel route and were examined in the laboratory for mineralogical composition. In the view of petrographic analysis, the rock units mainly comprised Quartz Diorite, Gabbro, and Granodiorite along the tunnel alignment. The prominent discontinuities sets were evaluated by exporting discontinuity data to DIPS. Rock Tunneling Quality Index (Q) was determined by calculating, its parameters, Q values range between 3.74-17.00, 3.74 (poor at DS-04), 7.08-7.33 (fair at DS-01, DS-11, and DS-18), and 10.07-17.00 (good at DS-02, DS-09, DS-13, DS-14, DS-17, and DS-19), whereas, RMR values ranges from 47-60 (fair at DS-01, DS-02, DS-04, DS-09, DS-11, DS-13, DS-14, DS-18, DS-19) to 64 (good at DS-17). The rock support according to RMR (Rock Mass Rating) scheme suggests fully grouted systematic bolting 3 to 4 m in length and 1.5 to 2.5 m spaced and 50-100 mm shotcrete in the crown and 50 mm in sides, while Q-system suggests spot bolting to Systematic bolting with 40-100 mm unreinforced shotcrete.

Integrated biostratigraphy and depositional environment of the Goru Formation, Sulaiman Fold-Thrust Belt, Lower Indus Basin, Pakistan

Mahnoor Sabba[1]*, Muhammad Hanif[1], Mohibullah Mohibullah[2], Mukhtiar Ghani[3], Shuja Ullah[1] and Irshad Ahmad[1]

[1]National Centre of Excellence in Geology, University of Peshawar, Peshawar-25120, Khyber Pakhtunkhwa, Pakistan
[2]Department of Geology, University of Balochistan, Quetta, Pakistan
[3]Geological Survey of Pakistan, Quetta
**mahnoorsabba57@gmail.com*

The Middle Cretaceous hemi-pelagic succession (Goru Formation) in the western Sulaiman Fold-Thrust Belt is dominantly comprised of limestone, shale and marls. The Formation was studied at two selected sections i.e. Harnai and Loralai. The planktonic foraminifera and calcareous nannoplankton were used to establish biostratigraphy of the unit. The locally erected planktonic foraminiferal include *Biticinella breggiensis, Rotalipora ticinensis, Rotalipora appenninica, Rotalipora globotruncanoides, Rotalipora cushmani, Whiteinella archaeocretacea, Helvetoglobotruncana helvetica* and *Marginotruncana sigali*. The calcareous nannoplankton biozones are comprised of *Prediscosphaera columnata* zone (CC8), *Eiffellithus turriseiffelii* zone (CC9), *Microrhabdulus decoratus* zone (CC10), *Quadrum gartneri* zone (CC11) and *Lucianorhabdus maleformis* zone (CC12). Based on the biozones, Middle Albian to Late Turonian age has been assigned to the Goru Formation. In Harnai Section, four microfacies were identified while the Loralai Section, hosts thirteen microfacies. The microfacies reflect deposition of the Goru Formation in a middle-outer carbonate platform

setting. On the basis of planktonic foramininferal paleoecological groups, shallow to open marine deep water paleoecological conditions are interpreted to prevail during the deposition of this studied interval. The planktonic foraminifera assemblages suggest that the Goru Formation bioprovince belongs to the Subtropical, warm water environment of the Cretaceous Tethyan realm. The paleobiogeographic reconstruction also suggests that the Neotethys at the studied site was well-connected with the Tethyan Ocean during the Albian-Turonian time interval. The smaller benthic foraminifera represent middle neritic to upper bathyal setting. The paragenetic sequence shows carbonate modification during various phases of diagenesis.

Dolomite geometry and distribution in the Late Jurassic Samana Suk Formation, Salhad Section, Lesser Himalayas, North Pakistan

Syed M. Wasim Sajjad, Asad Muhammad*, Junaid Mehmood, Usman Said, Salman Khurshid, Imran Ahmad, Shakeel Ahmad and Syed Mamoon Siyar

Department of Geology, University of Malakand, Chakdara (18800), Dir Lower, KP
**asad@uom.edu.pk*

The current study characterizes the dolomite geometry and distribution within Late Jurassic Samana Suk Formation, Salhad area, Southern Hazara Basin of Lesser Himalayas, Pakistan. Field observations in conjunction with petrographic and geochemical investigations revealed that the host limestone is diagenetically modified by various dolomite phases. During field studies it has been noticed that 75% lithology of the studied formation is unaltered limestone, while 25% has been dolomitized. Limestone is characterized by depositional features such as ooids, shell legs lag, mold and cast of fossils and burrows, whereas dolomite is hard and exhibits dark grey to brown color. Dolomite in field as well as during petrographic study was observed as patches, bedding parallel geobodies as well as cavity/fracture filling cement. Easily distinguishable contacts between limestone and dolomitized zones were observed along the bedding plane, joints and fractures. Diagenetic processes involved in the modification of Samana Suk Formation were captured in the form of filled veins and fractures, dissolution induced vugs and stylolites. Petrographic examination illustrates that ooidal-peloidal packstone to grainstone microfacies of the host limestone is more susceptible to dolomitization as compared to mud-dominated facies. Micritized grains and matrix were preferentially altered by selective replacement dolomitization. Based on crystal shape, size and distribution, dolomites were classified into coarsely crystalline euhedral dolomites (D-I), medium crystalline anhedral dolomites (D-II) and medium-coarsely crystalline euhedral dolomites (D-III). D-I and D-II were observed in matrix as well as in grain dominated facies of the host rock demonstrating the early phase of replacive dolomites. D-III are associated with the amplitude of stylolites, fractures and cavities, exhibiting late

stage of diagenetic alterations. Highly depleted values of stable isotopic signatures (– 8.87 to – 4.47‰ V-PDB) of the studied samples do not corresponds to the original marine signatures of Late Jurassic age and suggest burial hydrothermal dolomitization.

Serpentinized peridotites in the Speen Thal area; a dismembered sliver from the Waziristan Ophiolite Complex, Pakistan

Hikmat Salam[1, 2, 3]*, Syed Ali Turab[3], M. Qasim Jan[3], Asghar Ali[4] and Norasiah Sulaiman[2]

[1]Khushal Khan Khattak University, Karak, Pakistan
[2]Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia
[3]National Centre of Excellence in Geology, University of Peshawar, Pakistan
[4]Department of Geology, University of Peshawar, Pakistan
**hikmatsalam4@gmail.com*

The N−S trending Bela, Muslim Bagh, Zhob and Waziristan ophiolites that border the westernmost margin of the Indian Plate are widely studied for tectonic significance and chromite deposits. Western head on collision followed by strike slip tectonic components severely dismembered and deformed the Waziristan Ophiolites. One such dismembered ophiolite unit is exposed at a distance of 1 km south of the Thal town; at the junction between Hangu, Kurram and Waziristan districts of Khyberpakhtunkhwa. The outcrop comprises the Tethyan ophiolite package with combination of sedimentary and accretionary mélange deposits. The sole of the ophiolite nappe comprises serpentinized peridotites carrying a bulk of information regarding development of the ophiolite complex during the continental collision. Metagabbro and thick pillowed metabasalt are altered with relics of plagioclase and clinopyroxene. Serpentinization has occurred at the base and at depth as the color of the rock has turned dark with completely destroyed internal fabric of the parent peridotite. Above the base, intensely sheared serpentinite shows light green color according to the degree of variation in deformation. The rock is systematically cross cut by a number of dark seams of serpentine and magnetite respectively. These seams are observable in hand specimens and under a microscope. Several generations of serpentine are observed based on the filling and density of cross cutting veins. Remnant olivine grains are rimed by magnetite that formed by serpentinization of mantle peridotites the primary mesh texture is successively cross cut by other serpentine veins as secondary episodes of crystallization. Superimposing mesh textures and interlocking vein network shows several generations of serpentine crystallization in course of the serpentinization process during oceanic obduction and mantle rock interaction with the water. Accordingly, each generation of serpentine is formed under varying temperature and pressure conditions and chemical exchange during the serpentinization process. Hence, the ophiolite sliver at Speen Thal area provide essential information on the fluid rock interaction and

development of the oceanic plate during the Indian plate convergence with Afghan–Asia plate that ultimately resulted in continental collision during Paleocene–Early Eocene.

Hydrocarbon potential of middle sand unit of Lower Goru Formation in Lower Indus Basin

Malik M. Usman Sani[1, 2]*, Khalid Latif[2] and Atif Hussain[3]

[1]Oil & Gas Development Company Limited, Islamabad,
[2]National Centre of Excellence in Geology, University of Peshawar
[3]Pakistan Petroleum Limited, Karachi
**usman.saani@yahoo.com*

Cretaceous clastic sequence of Lower and Middle Indus Basin comprising of Goru and Sembar formations is one of the prominent and prolific play contributing to petroleum reserves of Pakistan. Lower Goru is comprised of interbedded sand and shale units, which are divided into sub members based on third order sequence. These heterogeneous units have distinct reservoir potential and productivity, hence they require separate evaluation to tap their true hydrocarbon potential. The current study aims to evaluate reservoir potential of the middle sand unit of the Lower Goru Formation, its spatial distribution and factors effecting its reservoir quality. An integrated approach is adopted to combine well log and petrophraphical and geomechanical data for reservoir characterization, building depositional model, and demarcation of Lower Indus Basin into different risk categories with respect to middle sand hydrocarbon prospects. Isopach maps have suggested that the middle sand unit is distributed across the study area, where net sand thicknesses decrease from southeast to northwest. Petrophysical evaluation of well logs have shown varying porosity ranging from 3 to 12 %, and water saturation ranging from 15 to 45%. Depositional environment of the middle sand unit ranges from delta front to distal open marine. These well sorted, coarse grained and clean sands of delta front and upper shoreface have greater reservoir potential with good porosities and permeability. The sand unit deposited at lower shore face are fine grained and poorly sorted, having poor reservoir quality. Petrographic study has shown quartz overgrowth in finer sands, thus further reducing its porosity. Drilling data verified the deductions where finer sands tend to weld together, becoming stiff enough to create high stress. They become impermeable enough to cause pore pressure near wellbore, amounting to borehole pressure, and ultimately creating breakouts. Risk map constructed based on the current study suggests that risk of encountering middle sand unit with good reservoir quality increases from southeast to northwest.

Structural set-up and stratigraphy of Kurez to Kalaya area of Lower Orakzai, Khyber Pakhtunkhwa, Pakistan

Husn Us Sawab*, Syed Ali Turab, Muhammad Hanif, Shuja Ullah and Muhammad Younis Khan

National Centre of Excellence in Geology, University of Peshawar, Peshawar, Pakistan
**husnussawab555@gmail.com*

This research work focuses on the detailed structural mapping, stratigraphic validation and upgradation, cross section construction and tectono-stratigraphic interpretation of Kurez to Kalaya area of lower Orakzai, Khyber Pakhtunkhwa, Pakistan. An attempt has been made to validate the field observations in road cuts and stream beds through structural interpretation of the main structural features for developing subsurface fold-thrust kinematics and construction of fault geometries that are geologically viable. The rocks exposed in the study area are from the Jurassic (Shinawari Formation) to Miocene (Murree Formation). However, Middle Eocene rocks (Kohat Formation) are missing. The area is highly deformed which is evident from the presence of intense folding and thrust faulting. The folding and faulting is pervasive from cm to km scale and is developed due to compressional stresses. All the rock units and faults dip towards north indicating a southward transport direction of the thrust sheets. The mapped thrust faults are interpreted to be forming an imbricate thrust system and connected to the Main Boundary Thrust (MBT) at deeper levels. The MBT acts as a basal detachment for these faults. Overall, the deformation in the study area is mainly controlled by thrust tectonics. Missing Eocene strata can be explained by an episode of non-deposition during middle Eocene re-flooding event of Kohat Basin, or alternatively, by a phase of erosion during late Eocene-Miocene uplift and erosion event.

Back analysis of Langarpura landslide

Ayesha Shafiq*, Mian Sohail Akram and Luqman Ahmed

Institute of Geology, University of the Punjab, Quaid – e – Azam Campus, Lahore 54590, Pakistan.
**ayesha.shafiq333@gmail.com*

North Pakistan is characterized by extreme and high slopes that undergo slope instability problems along the road and the settlements. The prolonged rains and earthquakes are the two major triggering factors. One of the challenges perceived to counter these issues is the adoption of realistic parameters that can provide precise mechanisms of failure and the magnitude of the threat. In the present study, the Langarpura landslide, triggered by the 2005 earthquake was back analyzed to adopt the soil/rock parameters at the time of failure. The slope characteristics were gathered through detailed discontinuity surveys performed on the rock exposures. The field data, laboratory testing results, and detailed analyses in Slide 2D software were used to estimate the slope parameters. The slip surface analyzed in the field and observed in Slide 2D software were found to be consistent, confirming the validity of the model. Based on the results, the realistic material parameters on the verge of failure indicated that the Geological strength Index of sandstone and shale were 55 and 25, respectively. Similarly, the uniaxial compressive strength was 27.79 MPa and 6 MPa for sandstone and shale respectively. These parameters can be confidently used to evaluate slopes with similar materials, characteristics, and drainage conditions by the researchers and professionals.

GIS and remote sensing in geosciences, from theory to practice

Muhammad Shafique

GIS and Space Applications in Geosciences (GSAG) Laboratory
shafique@uop.edu.pk

Given the physical, environmental and climatological setting, Pakistan is repeatedly witnessed to devastating natural hazards. Nevertheless, the country is blessed with immense natural resources including economic minerals, water and forest resources, with the potential to uplift the socio-economic settings of the country. The "GIS & Space Applications in Geosciences (G-SAG)" laboratory established at the National Centre of Excellence in Geology, University of Peshawar strive to effectively utilize the techniques of GIS, remote sensing and in-site measurements for the investigation of the lab themes, including geohazards, geological applications, water and forest resources. The GSAG lab is managed by a team of 9 faculty members and 13 dedicated researchers equipped with the required hardware, equipment and data. The lab is committed to utilizing the advanced GIS techniques and remote sensing data to assess and evaluate the landslides induced hazard, vulnerability and risk assessment; and seismic micro-

zonation maps, which can be further used for developing and implementing the geohazards management strategies. The space and airborne hyperspectral satellite images and image interpretation techniques are applied for seamless mapping of lithological units and demarcation and characterization of the mineral zones to assist in mineral exploration. The G-SAG also aims to investigate the temporal dynamics and characterize the water and forest resources to evaluate the trends and assist in their categorization and sustainable utilization. Capacity building of the relevant officials and researchers is a critical component of the lab, and thus a series of training workshops and awareness seminars are organized. Moreover, collaboration is established with the relevant government and non-government organizations to assist in the activities related to the lab themes. For the up-gradation and sustainability of the lab, a close partnership with academia and relevant industry and organizations is developed to foster the research and applications of GIS and remote sensing in geosciences.

Pollution status and health risk assessment of heavy metals via consumption of surface and groundwater of Lower Dir District, Pakistan

Shafiullah*, Seema Anjum Khattak, Mohammad Tahir Shah and Liaqat Ali

National Centre of Excellence in Geology, University of Peshawar, Pakistan
**shafi4pk100@yahoo.com*

This study was conducted to investigate the pollution status and health risk assessment of surface water (Punjkora River and its tributaries) and groundwater of Lower Dir District, Khyber Pakhtunkhwa, Pakistan. For this purpose, water samples were collected and were analyzed for physicochemical parameters pH, electrical conductivity (EC), total dissolved solids (TDS), salinity, turbidity, total hardness, sulfate, nitrate, and fluoride, major elements (i.e., Na, K, Ca, Mg, Fe, and Mn) and heavy metals (Cd, Cu, Ni, Pb, Co, Cr, and Zn). Health risk calculation such as average daily dose (ADD), hazard quotient (HQ), and hazard indices (HI) was also conducted for the population exposed to heavy metals in surface water and groundwater of the study area. The surface water and groundwater were desperately contaminated with turbidity, nitrate, Fe, Pb, and Cd compared with the given guidelines of Pak-EPA and WHO. The arithmetic mean concentration of heavy metals were found in the order of Fe > Pb > Cu > Mn > Zn > Co > Cd > Cr > Ni and Fe > Zn > Pb > Cu > Mn > Co > Cr > Cd > Ni for the surface and groundwater samples, respectively. Further, the calculated results of HQ and HI for heavy metals illustrated that Pb and Cd can cause non-cancer effects in the community exposed to both surface water and groundwater. Moreover, mean calculated values of HQ were found in the order of Pb > Cd > Cu > Cr > Mn > Zn > Ni and Pb > Cd > Cu > Zn > Cr > Mn > Ni respectively for surface water and groundwater of Lower Dir. The possible sources of water pollution were attributed to anthropogenic-induced pressures such as the

application of fertilizers, pesticides, animal manures, wastewater, and solid waste disposal.

Future mineral prospects: challenges and way forward in mineral sector development of Pakistan

M. Tahir Shah

National Centre of Excellence in Geology, University of Peshawar, Pakistan
tahir_shah56@yahoo.com

The geology of Pakistan has been divided into nine tectono-stratigraphic zones such as Karakoram fold and thrust belt, Kohistan-Ladakh island arc, Indus suture zone, NW Himalayan fold and thrust belt, Indus platform and fore deep, Baluchistan ophiolite and thrust belt, Sulaiman Kirthar fold belt, Chagai magmatic arc and Makran accretionary zone. These kinds of tectonic zones are characterized for hosting specific types of mineral deposits world over. Therefore, there is the possibility of occurrence of metallic and non-metallic industrial mineral deposits, gemstones and hydrocarbon resources in these specific tectonic zones in Pakistan. Strategizing the exploration of various types of deposits in these tectonic zones is the need of the day. Some of the world class mineral deposits have already been explored but extensive exploration is needed for the specific type of deposits expected to occur in these tectonic zone. Pakistan has the world largest salt, coal and copper reserves. There are other un-tapped resources of industrial minerals, building stones, metallic ores and gemstones, but these resources have not been properly managed so far. Pakistan is very rich in terms of its natural resources in the world but due to many challenges in the mineral sector development, these resources have not been properly managed. The main factor is the poor governance of the country which could be due to 1) political turmoil, 2) deteriorated law and order, 3) Uncontrolled corruption and 4) non-continuity of the policies. These kinds of unfavorable conditions and poor management of resources have adverse impact on the economy and society in the country which need to be addressed seriously. This can only be done if the leadership of the country take serious steps in exploration and exploitation of the mineral resources and their scientific management. In order to take maximum benefit from natural resources, there is the need of technical education of the people involved in resources exploitation and management which will help in discovering the potential mineral resources by using state of the art advance techniques such as remote sensing and air born survey etc.

Regional-scale landslide risk assessment of Ghizar, Gilgit Baltistan, northern Pakistan along with CPEC project and surrounding areas

Nisar Ali Shah[1,2*], Muhammad Shafique[1] and Muhammad Ishfaq[1]

[1]National Centre of Excellence in Geology, University of Peshawar, Pakistan
[2] GIS and Space Applications in Geosciences (GSAG) Laboratory, National Centre of GIS and Space Applications (NCGSA), Institute of Space Technology, Islamabad, Pakistan
**geologist.nisar07@gmail.com*

Landslides are one of the most destructive natural hazards in northern Pakistan. Apart from the loss of lives, landslides have significant negative effects on property and the environment. In disaster-prone areas, landslide hazard, vulnerability, and risk assessment maps are used in the decision-making process that includes urban planning. The purpose of this study is to evaluate the landslide risk using semi-quantitative techniques in the project area. The precision of these analyses is directly related to the quality of spatial data required and the methods used to obtain the data. Geographic information systems and remote sensing techniques are effectively used to develop landslide inventory, causative factors, susceptibility, hazard, and risk assessment maps including detailed field surveys in the project area. A landslide susceptibility map was generated by using the frequency ratio model. The susceptibility map and the triggering indicator maps were combined to create a Landslide Hazard Index map. For the vulnerability stage, spatial multi-criteria evaluation techniques were adopted in the ArcGIS by considering land cover, buildup and population density data. These indicators were combined to get the vulnerability map which was then multiplied by the landslide hazard map to generate the risk index map of the study area. The resulting landslide risk index map (LRI) would be useful for future detailed risk analyses since it highlights landslide risk hotspots on a regional scale.

Fault-based probabilistic seismic hazard assessment for part of North-West Himalayan Thrust System, Pakistan

Syed Tanvir Shah[1]*, Basit Ali[1], Asad Ali Khan[2], Basit Iqbal[2], Umar Aziz[2], Jansher Khan[2] and Mudasir Abbas[2]

[1]Abdul Wali Khan University Mardan, Pakistan
[2]University of Swabi, KP, Pakistan
**stshah.geo@awkum.edu.pk*

The NW Himalayan thrust of Pakistan is characterized by a system of complex active faults, which have generated large magnitude earthquakes in the past e.g., Kangra earthquake, 1905 and Kashmir earthquake 2005. The objective of this study is to perform probabilistic seismic hazard assessment (PSHA) for the region using fault-based approach and contemporary ground motion prediction equations of NGA West-2 project. The active fault model and associated parameters are compiled from updated geological map of Pakistan, previously conducted studies in the region, and available earthquake catalogue of International Seismological Center (ISC). The PSHA results for the region are presented in the form of hazard maps of 500- and 2500-year return period. Moreover, hazard curves and deaggregation curves for important cities in the vicinity are also computed. The hazard results shows that the expected Peak ground acceleration (PGA) value for 475-Year return period ranges between 0.3g- 0.6g for the region. Among the selected cities, Muzafarabad is expected to experience a PGA value of 0.7g for 475-year return period.

Integrated geochemical and spectral techniques for exploration of chromite in the ophiolitic belt along the main mantle thrust (MMT): A case study from Tangi and Hero Shah Area, North Pakistan

Muhammad Shahab[1, 2]* and Liaqat Ali [2]

[1]GIS and Space Application in Geosciences Lab, (G-SAGL), National Center for GIS and Space Application (NCGSA)
[2]National Center of Excellence in Geology, University of Peshawar, 25130-Peshawar, Pakistan
**shahabgeo07@gmail.com*

Discovery of metallic minerals resources through remote sensing is a valuable addition to conventional methods used for exploration of mineral deposits. During this study chromite deposits of Tangi and Hero Shah Area were investigated using geochemical and spectral techniques. . These deposits are of low-grade but economically significant, having lens-shaped bodies with an average thickness of 10 to 14 m surrounded by ultramafic host rocks such as dunite, serpentine and associated rocks. Extensive field work followed by geochemical study of the host rocks and ore samples have been carried out using X-Ray fluorescence (XRF) and

Atomic Absorption spectroscopy (AAS). Spectroradiometer was also used for recording spectral features of the collected rock samples. The geochemical results showed that Cr2O3 is ranging from 22%-31% and Fe2O3 from 6%-10.5% in the ore bodies of the study area while the spectral features were interpreted through DARwin sp10 software and correlated it to the United States Geological Survey (USGS) spectral library (https://speclab.cr.usgs.gov). The results concluded that the combination of field based geochemical and spectral data can be used as a robust technique for exploration of Chromite ores with low cost. These techniques can, therefore, be applicable for the exploration of other metallic mineral deposits.

Rhizoremediation of petroleum waste contaminated soils

Asim Shahzad[1] and Samina Siddiqui[2*]

[1]Mohi-Ud-Din Islamic University AJK, Pakistan
[2]National Centre of Excellence in Geology, University of Peshawar, Pakistan
**saminasddq@yahoo.com*

Rhizoremediation is successfully adapted to remediate hydrocarbon contaminated soil commercially. This is a technique in which an interaction is established between plants and microbes to remediate oily waste contaminated sites. This study was designed to establish an interaction between PGPR and alfalfa (Medicago sativa) or maize (Zea mays) to degrade total petroleum hydrocarbons (TPH) in petroleum waste soils rapidly. Consortium was prepared from the bacterial strains Bacillus cereus (Acc KR232400), Bacillus altitudinis (Acc KF859970), Comamonas (Delftia) belonging to family Comamonadacea (Acc KF859971) and Stenotrophomonasmaltophilia (Acc KF859973) isolated previously. GC-FID results shows that when petroleum contaminated soil (30% v:w, oil:soil) was spiked with consortium, short carbon chain hydrocarbons (nC10 to nC12) were degraded rapidly than long carbon chain hydrocarbons (nC19-nC29) over a short period of time. Fertilizer addition alone or with consortium had no significant effect on the degradation of TPH at the end of the incubation period. Maize (Zea mays) was more tolerant to hydrocarbon contamination than alfalfa (Medicago sativa) at the end of the incubation period. Alfalfa (Medicago sativa) and Maize (Zea mays) with consortium accelerate the degradation of TPH than consortium alone in petroleum contaminated soils over a short period of time. This study revealed the contention that consortium with Alfalfa (Medicago sativa) or Maize (Zea mays) accelerate the degradation of TPH over a short period of time. Thereafter the degradation of TPH was greater in soil with Maize (Zea mays) than alfalfa (Medicago sativa).

Assessment of e-waste management practices in developed and developing nations

Sidra Shakil* and Yumna Sadef

College of Earth & Environmental Sciences, University of the Punjab, Lahore, Pakistan
**sidrashakil59@yahoo.com*

Since the 1970s, the electric and electronic product market grew at a very fast pace and this is increasing further over time. New technology renders lots of gadgets useless before the end of product life. Due to a lack of end-of-life management options, such electronic products are either discarded into landfills or sent to recycling centers. Both of these scenarios raise concern for environmentalists and environmental agencies to develop and implement environmentally sustainable strategies and methodologies for unsustainable management of the e-waste stream. Electronic products contain a chemical that is commonly known as brominated flame retardants. These are deliberately added to the product to prevent it from fire hazards. These chemicals slowly leach out from the product during its usage, disposal, or recycling and start to accumulate in the biotic and abiotic environmental compartments. When they reach a threshold limit, they start creating serious consequences in the form of thyroid dysfunction, neurological disorders, and sometimes cancer. Many countries don't produce numerous electronic gadgets but they usually receive them from developed countries either as second-hand goods or for recycling. Weak legislation, a cheap labor force, and poor socio-economic conditions make recycling a profitable business for such countries. Therefore, e-waste management is considered to be a hot topic for the international waste stream. This paper reviews the current status of the e-waste management system in developed and developing countries, focusing on problems associated with e-waste management in developing countries. This paper also highlighted the efficiencies of implemented systems, laws, and legislation. Factors necessary for the sustainable development and implementation of an e-waste management plan with special emphasis on environment, occupational health and safety are also discussed.

Vulnerability analysis and risk assessment of lead (Pb) concentration in drinking water of southern parts of Khyber Pakhtunkhwa Pakistan, using statistical and geo-statistical analysis

Huma shakoor[1]*, Iftikhar Alam[2], Liaqat Ali[3] and Shahla Nazneen[4]

[1]International University of London LGS, Peshawar
[2]AEMC, REO Peshawar, Pakistan
[3]National Center of Excellence in Geology, University of Peshawar, 25130-Peshawar, Pakistan
[4]Department of Environmental Sciences, University of Peshawar, Pakistan
**humashakoor85@gmail.com*

Exposure to lead (Pb) through drinking water has adverse health impacts that are particularly severe in children. The main objective of this study was to determine lead contamination levels in drinking water of southern parts of Khyber Pakhtunkhwa and vulnerability analysis and risk assessment of the exposed population. Lead concentration in drinking water samples using atomic absorption spectrophotometric technique (AA) ranges between 0.02mg/l- 1.572mg/l. Data analysis show that the lead concentration level in 44 samples is more or less with in the permissible limit of WHO (0.05mg/l), 2002.While in 99 drinking water samples out of 145 had high value of Pb than the permissible exposure level of 0.05mg/l set by WHO, 2002. The hot spot areas include district Kohat, Hangu, D.I.khan, Bannu, and District Karak ranges from 0.581mg/l - 1.572mg/l. The overall interpretation indicates the lead concentration level is many folds higher in 99 samples collected from the above-mentioned locations as compared with the permissible exposure limits ((0.05mg/l) set by WHO for drinking water. On the basis of observed data in the study area different types of care strategies were suggested to control the effects of Pb in the vulnerable sites of the study area to protect human and environment from the exposure to lead toxicity.

Diagenetic impact on the reservoir quality of Lower Cretaceous Lumshiwal Formation in Nizampur area, Pakistan

Kamran Shehzad[1, 2*], Shiqi Zhang[1], Muhammad Hanif[3], Muhammad Awais[4], Khalid Latif[3], Muhammad Sadiq[3] and Muhammad Kashif [5]

[1]*School of Geosciences, China University of Petroleum (East China), Qingdao, 266580, China*
[2]*Department of Geology, Khushal Khan Khattak University, Karak, 27200, Pakistan*
[3]*National Centre of Excellence in Geology, University of Peshawar, Peshawar 25200, Pakistan*
[4]*Departemen of Geology, University of Swabi, Swabi, KP, Pakistan*
[5]*Department of Earth Sciences, University of Sargodha, Sargodha, 40100, Pakistan*
**kamrangeoscientist@gmail.com*

The petroleum reservoirs are strongly affected by depositional as well as diagenetic factors. Among them, several factors hinder the porosity while others improve it. The constituent grains and their fabric is primarily controlled by the depositional environment where sediments are accumulated. Then comes the diagenetic processes and their relative sequence which determines the reservoir properties at the end. This article relates diagenetic features, events and their relative sequence to the reservoir quality of Lumshiwal Frmation. The Early Cretaceous Lumshiwal Formation has been selected at three different outcrop sections namely Gandab village, Kahi village and Tora stana village. The formation is mainly composed of sandstone, limestone and dolostone units in the investigated area. Adapted research methods are thin section Petrography, Scanning Electron Microscopy (SEM) and Cathoduluminescence (CL) microscopy. Different microfacies including Quartz arenites, Arkoses, Calcareous sandstones, Glauconitic sandstone, sandy limestone, lime mudstone and ferroan dolostones have been identified. The investigations reveal that the formation was mainly deposited in a shallow marine depositional environment. After deposition, it has undergone several diagenetic processes which modified the rock fabric quite extensively. Mechanical and chemical compaction were both actively operative. Grains deformation is indicated by fractured quartz and plastically deformed mica grains. Stylolites and dissolution seams are quite frequently encountered. Various kind of cements include quartz overgrowth, poikilotopic calcite, Hematite, Glauconite and Siderite. These cements were deposited in different conditions and in multiple stages. At certain stages, dissolution have taken place, creating pores and minor secondary porosity while at several locations, the dissolved minerals have been reprecipitated to block the existing pores. Diagenetic studies show that the depositional fabric is thoroughly disturbed by the digenetic events. Compaction and cementation has greatly affected porosity and permeability. Compaction in eogenetic stage resulted in tight packing and decreasing pores size and numbers. Then various kinds of cements during eogenetic and mesogenetic stages occluded the empty pores in the rocks and obliterated porosity quite significantly. Tectonically induced fractures were produced in telogenetic stage

which were later on filled by mineral matter and thus preservation of secondary porosity is rather poorer. The near-surface processes have resulted in the iron-oxide cements which occupied the inter-granular pores and dissolution spaces and cavities in the later stages of diagenesis. Overall, the diagenesis has resulted in diminishing of primary as well as secondary porosity and the reservoir quality is adversely affected. This study concludes that the Lumshiwal formation is a poor quality reservoir at the studied sections.

Potentially toxic elements in drinking water and associate risk in district Swabi Khyber Pakhtunkhwa Pakistan

Muhammad Tariq*, Liaqat Ali and Seema Anjum Khattak

National Centre of Excellence in Geology, University of Peshawar
**muhammadtariq332@gmail.com*

This study investigate the physiochemical and potentially toxic elements (PTEs) concentration in drinking water (surface and sub-surface water) samples of the District Swabi, Pakistan. The study aimed to determine the potential health risk and its associated impacts on local population. PTEs were analyzed using atomic absorption spectrometer equipped with graphite furnace and MHS 10 (Perkin Elmer, AAS- PEA-700) and were compared with standard permissible limits by World Health Organization (WHO) and Pakistan Environmental protection Agency (Pak. EPA). Health risk assessment like chronic daily intake (ADD), hazard quotient (HQ) Cancer risk were calculated .ADD were found in the order of Ni > Co > Cu > Pb > Cr > Cd > As and the valve of HQ were >1 for some PTEs in drinking water indicating health risk Furthermore, univariate and multivariate statistical analysis like inter-metal correlation, cluster analysis (CA) and principal component analysis (PCA) results revealed that geogenic and anthropogenic activities were major sources of water contamination in the study areas.

Source rock characterization of organic-rich shales of the Salt Range Formation, Upper Indus Basin, Pakistan

Abid Ullah[1*], Imran Khan[1], Muhammad Akif[1] and Adil Khan[2]

[1]COMSATS University Islamabad, Abbottabad Campus, University Road, Tobe Camp, Abbottabad
[2]Pakistan Petroleum Limited, Pakistan
**fa20-rer-001@cuiatd.edu.pk*

Salt Range Formation possesses small carbonaceous shale beds in the topmost part. These shale beds are considered important source rock within the eastern part of the Potwar subbasin. The current study is aimed to assess the hydrocarbon generation potential of these shales within the eastern and central Salt Ranges. Twelve shale samples of Salt Range Formation shales collected from two outcrops i.e. Khewra Gorge and Peer Da Khara section were used to assess the source rock potential of the formation based on Total Organic Carbon (TOC), and Rock-Eval pyrolysis. The results show that the black shale samples collected from the eastern Salt Range (Khewra Gorge) are extremely rich in organic carbon having TOC up to 41.75 wt% and have excellent source rock potential. The samples from Khewra Gorge show the kerogen Type-I to Type-II showing predominantly marine-lacustrine inputs (oil-prone). The samples from the Peer Da Khara section show the predominance of Type-III kerogen (gas prone). Both eastern and central Salt Range samples depict good-excellent source rock potential of Salt Range Formation shales. However, based on parameters from Rock-Eval Pyrolysis, these shales are significantly immature-early mature and may have not contributed to the already generated hydrocarbons within the basin. The total sulfur contents (TS, wt.%) of the Khewra Gorge samples range from 0.5% to 1%, and samples from the Peer Da Khara section range from 0 to 0.3%, thus both indicating the deposition within restricted marine conditions (lacustrine environment).

Groundwater budget of Quetta Sub-Basin, Balochistan, Pakistan; 2019-2020

Hameed Ullah[1, 4]*, Akhtar Muhammad Kassi[2], Imran Hameed Durrani[1], Shahzada Adnan[3] and Muhammad Zahir[4]

[1]Quetta Water and Sanitation Authority, Balochistan, Pakistan
[2]Department of Geology, University of Balochistan, Pakistan
[3]Pakistan Meteorological Department, Islamabad-44000
[4]Centre of Excellence in Mineralogy, University of Balochistan, Pakistan
**hameedullah_g@yahoo.com*

The Quetta sub-basin, a part of the Pishin River Basin, situated in northern part of the Kirthar Fold belt, comprising lithological units of Lower Jurassic through Holocene age, covering an area of 603 km2. The sub-basin comprises of two types of aquifers; 1) Alluvial aquifer, comprising horizontally-lying Quaternary alluvial deposits, composed of siltstone, mudstone, sandstone and conglomerate, having primary porosity; 2) Limestone aquifer, composed mostly of Jurassic Chiltan Limestone, having secondary porosity. This study aimed to estimate groundwater budget of the two aquifers of the Quetta sub-basin for one Water-Year (April 2019 to March 2020), based on the acquired data of groundwater recharge and discharge. Concept of the groundwater budget requires that balance exists between recharge and discharge of two aquifers of the sub-basin. Groundwater recharge was estimated using "well-level data method", which is considered as the most accurate for estimation of recharge of a basin. Total annual recharge of the Water-Year (April 2019 to March 2020) in the Quetta Sub-basin was estimated as 67.455 million Cubic Meters per Year (MCMY), whereas, total annual discharge from the Sub-basin, by tube wells of the various public and private sector institutions, was 97.650 MCMY. Therefore, the groundwater budget of the Quetta sub-basin was estimated as -30.195 MCMY; this budget deficit resulted in rapid decline of the static water level in both the limestone and alluvial aquifers. The continued budget deficit, and the resulting decline of the static water level, of the Quetta sub-basin is creating an alarming situation in the Quetta sub-basin, therefore immediate drastic measures are mandatory, in order to properly manage the ground-water recharge and cope with the acute situation of water shortages in the Quetta city.

The emplacement history and tectonic setting of RasKoh metamorphic sole rocks in a forearc setting: Evidence from geology, petrology, and geochemistry

Inayat Ullah[1]*, Chuandong Xue[2], ZhiPeng Xie[2], Mohammad Ishaq Kakar[1] and Ghaffar Abdul[1]

[1]Centre of Excellence in Mineralogy, University of Balochistan, Quetta, Pakistan
[2]Department of Earth Science, Kunming University of Science and Technology (KUST), Kunming 650093, China
**inayat.cem@um.uob.edu.pk*

In the southeast of the RasKoh range, western Pakistan, metamorphic rocks are exposed, beneath the sheared serpentinites of the RasKoh ophiolite. Geology, petrology, whole-rock geochemistry and Sr-Nd isotopic data are presented here for the metamorphic sole rocks of RasKoh ophiolite. These sole relics have an igneous protolith. Petrographically, these metamorphic presents three types; amphibolites (Hbl + Cpx + Plag+Mus + Ttn ±Biot+ Opq), epidote amphibolites (Hbl + Epd + Chl + Biot ± Plag ±Cpx + Opq) and mica-schist amphibolites (Hbl + Plag+ Mus ±Cpx ±Act ±Biot ± Qtz ±Opq), with a well-defined porphyroblastic, granoblastic, and grano-nematoblastic textures. Amphiboles from RasKoh metamorphic sole are of calcic-type amphiboles placed in the range from magnesio-hastingsite, magnesio-hornblende, edenite, and tschermakite. The plagioclases are grouped into albite to anorthoclase and from albite to oligoclase, whereas, the clinopyroxenes are of metamorphic diopsides with a compositional range of Wo44–49En34–42Fs8–19. Two compositional groups have been identified on the basis of whole-rock geochemistry, and Sr-Nd isotopes, Tholeiitic-Amphibolites exhibit depleted light rare earth element (LREE) signatures (La/Yb)N= 0.88 to 1.31, (87Sr/86Sr)i values are 0.706103 to 0.706303 and εNd(t) ranges from + 5.81 to + 7.47. However, Alkaline-Amphibolites present enriched-LREE patterns (La/Yb)N= 11.47 to 11.60, and Sr-Nd isotopic ratios of (87Sr/86Sr)i are 0.705481 to 0.706128 with lower εNd(t) ranges from + 2.24 to + 2.32. The multi-element normalised, as well as other tectonomagmatic discrimination diagrams further confirm the igneous protolith for Alkaline-Amphibolites depict oceanic island basalts (OIB). Tholeiitic-Amphibolites are correlated with mid-oceanic ridge basalts (MORB) having arc signatures. According to geothermobarometric calculations based on the comparability of minerals stability and paragenesis in these rocks and microprobe investigations, these sole relics exhibit amphibolite facies (=690 C with 6.5 kbar), which corresponds to a depth of c.18-23 km. We propose that at an early stage enriched-type magma (OIB), at a later stage depleted-type magma (IAT) accreted beneath the base of the obducted plate. Both types of magmas have been described as igneous protolith of amphibolites, showing emplacement in a typical supra subduction zone (SSZ)-type forearc tectonic environment.

Evaluation of petrographic and physico-mechanical properties of the quartzite units in Ghundai Sar Formation, Khyber Agency

Irfan Ullah[1]*, Nowrad Ali[2], Muhammad Zeeshan Ullah[1], Aamir khan[1], Wali Muhammad[1] and Owais rabbani[1]

[1]National Center of Excellence in Geology, University of Peshawar, Pakistan
[2]Department of Geology, University of Peshawar
**irfanullahuthmani@uop.edu.pk*

Quartzite units of the Ghundai Sar Formation (Silurian-Devonian) in eastern part of Khyber Ranges has been investigated in terms of their petrographic and physico-mechanical properties and their interrelationship. 4 bulk samples for physico-mechanical properties and twenty five rock samples for thin sections were collected in Shahid Mena area along Mullagori road, Khyber Agency. Field observations and their detailed petrographic studies reveal that these rock samples to be quartz arenite having 85-96% quartz along with matrix, chlorite, biotite, muscovite, sphene, rutile and opaque minerals in trace amount. They have varying grain size ranging from very fine- (B-02) to coarse-grained (B-01) and possess vey rounded to sub-rounded and low to moderate spherical shapes. Among physico-mechanical properties, unconfined compressive strength (75.43 – 98.21 MPa), Schmidt hammer test (58.5 – 65), specific gravity (2.66 – 2.68), water absorption (0.13 – 0.18 %), porosity (0.35 – 0.48), and unit weight (2.60 – 2.67) were determined. After evaluation of interrelationship of petrographic features and physico-mechanical properties, it was found that fine-grained samples were found to be of greater strength due to their abundant quartz, least matrix and rarity of intra- and inter-granular fractures. Beside variations in physico-mechanical properties, these rocks were found to be within ranges of international standards for use in construction material. However, it is recommended that these rocks should not be used with ordinary Portland cement to avoid alkali-silica reactivity in concrete due to having excessive silica and preferably be used with low alkali-cement in concrete.

Petrogenetic investigations of felsic rocks along the Timergara-Wari road, Lower Dir, North Pakistan

Muhammad Zeeshan Ullah[1*], Liaqat Ali[1] and Muhammad Sajid[2]

[1]National Centre of Excellence in Geology, University of Peshawar, Peshawar, Pakistan
[2]Department of Geology, University of Peshawar, Peshawar, Pakistan
**m.zeeshan@uop.edu.pk*

Felsic rocks intruded within Kamila Amphibolites, exposed along the Timergara-Wari Road Lower Dir North Pakistan, have been investigated and compared in terms of their petrographic and geochemical characteristics (major oxides) for their petrogenetic origin. These rocks occur either as veins or plutons whereas

veins mostly occur in the vicinity of Timergara town and are gradually replaced by plutons moving northward towards Wari town. Geochemically, all the studied rocks are found to be calc-alkaline and per-aluminous. The petrographic studies reveal that the veins are e highly altered tonalite with abundant plagioclase, quartz and subordinate epidote, alkali feldspar, muscovite, clay minerals, apatite and zircon.The plutonic rocks of Wari area are granodiorites having abundant quartz, plagioclase and alkali-feldspar while amphiboles, epidote, biotite, muscovite, chlorite, sericite, clay minerals and opaques are occurring as minor and accessory phases. Available data reveals Timergara tonalities are most probably the product of partial-melting of the host rock (Kamila Amphibolites) due to heat advection associated with either subduction or the intrusion of Chilas Complex and are not the product of ascending mantle magma, because these occur in the form of isolated lenses as well as veins. Wari granodiorites are probably the product of crystal-fractionation of mantle-derived melt with imprints of supra-crustal contamination during fractionation process. They have the characteristics of apparently stage-2 granitic intrusions of Kohistan batholith indicated by the absence of apparent penetrative fabric and their calc-alkaline nature.

Subsurface pore pressure and fracture pressure evaluation using wireline logs and drilling data, for Kal oil field, District Chakwal, Punjab Province, Pakistan

Rizwan Ullah

National Centre of Excellence in Geology, University of Peshawar, Peshawar, Pakistan
geoscient777@gmail.com

The purpose of this study is to use different methodology for predicting pore pressure and fracture pressure. Such an approach can be an invaluable tool for attaining a detailed and consistent description of drilling problems, which can be helpful before drilling, for safe, economic and efficient drilling and nonproductive time can be reduced to an appreciable amount. If fracture pressure is known, hydraulic fracturing job can be done in a better way to increase production. This approach was applied to real data set of well Kal-2. Kal well no.2 was drilled by O.G.D.C., which is located in the Gujar Khan E.L., District Chakwal of Punjab Province. Pore pressure and Fracture pressure prediction was done by using wire line logs data and drilling data. The issues tackled in this thesis can be broadly divided into four parts. First, Gamma ray log was used to determined lithology, volume of shale and Poisson's ratio. Second, Sonic trend line was generated from the Sonic log data. Third, drilling data especially drilling parameters were used to calculate corrected D exponent value and trend line for them. Which then finally used to predict pore pressure by using Eaton's method and Ratio method and fracture pressure through Eaton's methods. The results of both data and methods for pore pressure and fracture pressure was compared with each other. And their results was also matched with the real time data, obtained from the Drill stem tests

and Repeat Formation tests, conducted on the concerned well. Finally the compared results was shown in different charts.

Application of visible light activated thiolated cobalt doped ZnO nanoparticles towards arsenic removal from aqueous systems

Sajid Ullah[1, 2]*, Dilawar Farhan Shams[2], Syed Aziz Ur Rehman[3], Seema Anjum Khattak[4], Muhammad Noman[5, 6], Gul Rukh[7], Hamida Bibi[8], Muhammad Ateeq[7], Liaqat Ali[4], Naheed Bibi[9] and Perveen Fazil[10]

[1]Department of Water and Environmental Engineering, Nangarhar University, Jalalabad 2600, Afghanistan
[2]Department of Environmental Sciences, Abdul Wali Khan University, Mardan 23200, Pakistan
[3]Department of Environmental Sciences, University of Veterinary and Animal Sciences, Lahore 54000, Pakistan
[4]National Centre of Excellence in Geology, University of Peshawar, 25130, Pakistan
[5]School of Environmental Science and Engineering, Tianjin University, No. 92, Weijin Road, Tianjin 300072, China
[6]College of Environmental Science and Engineering, Donghua University, Shanghai 201620, China
[7]Department of Chemistry, Abdul Wali Khan University, Mardan 23200, Pakistan
[8]Department of Soil and Environmental Sciences, The University of Agriculture, Peshawar 25130, Pakistan
[9]Department of Chemistry, Shaheed Benazir Bhutto Women University, Peshawar 25000, Pakistan
[10]Department of Chemistry, University of Karachi, Karachi 75270, Pakistan
**sajidjalwan@gmail.com*

Populations at large are exposed towards Arsenic (As) contamination worldwide making it unfit for drinking and human consumption. This study was designed to assess As removal efficiency of newly developed thiolated chitosan cobalt-doped zinc oxide (Co-ZnO) nanoparticles (NP) under visible light spectrum. In this study the Co-ZnO-NPs of sizes (40–60 nm) were prepared through the co-precipitation method. Removal of As with Co-ZnO NP was investigated in batch tests experiments alongside determining the optimal dose of NP dose, kinetic rates, effect of light, pH and ultra-sonication. This was followed by a continuous flow test with Co-ZnO layered on Whatman filter paper 42. Overall, the Co-ZnO NP effectively treated As i.e. in sunlight (100%), neutral pH (100%), ultra-sonication (100%) and in continuous-flow system (100%). The removal of As was maximum (88%) at NP:As ratio of < 1:5 and minimum (25%) at 1:100. Similarly, darkness (21.4%) and (11.1%) uptake at low and high pH respectively. It was found that Co-ZnO NP can efficiently reduce As to non-toxic state i.e. below the WHO permissible limit (10 µg/L) in drinking water.

Paleoenvironmental and bio stratigraphic analysis of the Cretaceous pelagic carbonates of eastern Tethys, Sulaiman Range, Pakistan

Shuja Ullah[1*], Irfan Ullah Jan[1], Muhammad Hanif[1], Khalid Latif[1], Mohibullah Mohibullah[2], Mahnoor Sabba[1], Mukhtiar Ghani[3] and Muhammad Muslim[1]

[1]National Centre of Excellence in Geology, UoP, Peshawar, Pakistan
[2]Department of Geology, University of Baluchistan, Quetta, Pakistan
[3]Geological Survey of Pakistan, Quetta, Pakistan
**shuja_nceg@uop.edu.pk*

The pelagic carbonate succession of Cretaceous Goru Formation was studied in detail in the study area i.e., Hanna Lake Section, Sulaiman Range for its paleoenvironment and bio stratigraphy. Eight planktonic foraminiferal biozones are identified that is *Muricohedbergella planispira* interval zone, *Ticinella primula* interval zone, *Biticinella breggiensis* interval zone, *Rotalipora appenninica* interval zone, *Rotalipora cushmani* total range zone, *Whiteinella archeocretacea* Partial Range zone, *Helvetoglobotruncana helvetica* Total Range zone and *Marginotruncana sigali* Partial Range zone from the Albian-Turonian age. The petrographic studies reveal five microfacies that is; a) Planktonic Foraminiferal Packestone Microfacies (MF-1), representing deposition in distal outer ramp setting; b) Radiolarian rich planktonic foraminiferal wacke-packestone microfacies (MF-2), representing deposition in distal outer ramp setting; c) Planktonic foraminiferal wackestone microfacies (MF-3), representing deposition in distal middle ramp setting d) Planktonic foraminiferal wacke-packestone microfacies (MF-4), representing deposition in proximal outer ramp setting and e) Mixed bioclastic to planktonic foraminiferal packstone microfacies (MF-5), representing deposition in proximal part of outer ramp setting. Based on the microfacies analysis, the pelagic eastern Tethys carbonates in the form of Goru Formation is deposited in a distal middle to distal outer ramp setting in the absence of turbidites and resedimented deposits.

Effect of contact pressure on lateral capacity of piles

Walli Ullah*, Kiramat Ali, Irfan Jamil and Aqeel Ur Rehman

University of Engineering and Technology Peshawar, Pakistan
**wali7662@gmail.com*

In this research work an experimental approach was used to investigate the influence of contact pressure on the pile capacity. In the first stage, a total of six single pile model tests were performed which includes, five single pile lateral load tests under-various surfaces and single pile raft test. In the second stage, numerical modelling was performed using finite element code Plaxis-3D to simulate the experimental work. For model pile, galvanized iron pipe and for confining pressure a rigid Aluminum plate having a rectangular slot at it center for placing pile was used. In numerical modeling using Plaxis-3D, pile was modeled as volume, with an interface soil, surrounding the pile was used, to simulate the relative displacement between the piles and surrounding soil. In this work an increase in axial and lateral capacity of pile due to contact pressure from the raft is estimated using experimental models. This study also covers the finite element modeling of special interface between pile/raft and the surrounding soil to take into account the effect of confinement and limitation of the default interface in finite element software Plaxis-3D. It was found that considerable increase in the pile axial and lateral capacity is achieved when the contact pressure is increased. Moreover, by comparing the results of single pile rigidly connected to the raft, to the single pile under same contact pressure it was found that pile rigidly connected to the raft takes less axial load due to the raft to pile interaction. Similar results were shown by Plaxis-3D when volume pile was surrounded by an interface soil instead of using the already available interface surface function.

Assessment of spring water quality in Pakistan: a case study of Galliyat, District Abbottabad, Khyber Pakhtunkhwa

Zakir Ullah[1], Sajid Ullah[2]*, Ahmad Raza[3], Muhammad Waseem[3], Gul Rukh[4], Shah Dherai Bibi[1], Sabeena Shaukat[5], Asghar Ghaforzai[2], Muhammad Zamir Stanikzai[2] and Syeda Kainat Izhar[4]

[1]Department of Environmental Sciences, Abdul Wali Khan University, Mardan 23200, Pakistan
[2]Department of Water Resoucres and Environmental Engineering, Nangarhar University, Jalalabad 2601, Afghanistan
[3]Department of Environmental Sciences, Quaid-i-Azam University Islamabad, 45320, Pakistan.
[4]Department of Chemistry, Abdul Wali Khan University, Mardan 23200, Pakistan
[5]Department of Chemistry, University of Swabi, Swabi, Khyber Pakhtunkhwa 23430, Pakistan
**sajidjalwan@gmail.com*

The current study was designed to monitor the drinking water quality of 25 selected springs of Galliyat district Abbottabad, Pakistan which are influenced by anthropogenic and natural activities. The water samples were collected from permanent public water points in different times of the year at study area. The water samples were analyzed for physiochemical and bacteriological contamination according to the standard methods for water quality testing. The physiochemical parameters include pH, electric conductivity, hardness, total dissolved solids, chloride, sodium, potassium, calcium, magnesium, sulphates, nitrates and turbidity. The water samples for bacteriological quality were analyzed for coliform contamination. This study presents the results of analysis from sample collected in four (04) consecutive years of water quality monitoring program i.e. 2018-2021. Overall, the physical and chemical quality of spring water was found good and within the recommended level of WHO. However, the water samples were found bacteriologically contaminated. The microbial quality of water samples revealed that all the samples were heavily loaded by microbial growth and considered unsafe for drinking purposes. Presence of coliforms and fecal coliforms clearly revealed that water is unfit for drinking purpose in the different sampling sites of study area.

The effect of chromium mining on human health

Hamza Waheed*, Kamran Ahmad and Hasan Iqbal

COMSATS University Islamabad, Abbottabad Campus, University Road, Tobe Camp, Abbottabad
**hamzawaheed437@gmail.com*

Chromium is mainly used in the chemical industry in tanning, electroplating, metal alloys, dyeing, and metal-ceramics. It has both positive and negative effects on human health and the environment. Chromium is added to the environment through natural and man-made processes and can have a direct impact on human health. The trivalent chromium is regularly utilized by the steel and leather industry and is important for the regular operation of human metabolic and vascular systems. However, severe intake can cause several skin diseases. In addition, hexavalent chromium is more dangerous for health as it may cause many health problems such as skin rash, nose irritations, allergic reactions, nosebleed, weakened immune system, ulcers, genetic material alteration, liver, and kidney damage. Due to seepage from chromite mines or improper supplies of tools and disposal of industrial manufacturing equipment, groundwater contamination is the main issue for health. Air quality can affect by chromium through coal manufacturing, which can cause further contamination of soil and water. Some of the other main problems caused by chromium intake in the body include it lowers the ability of a body to fight against disease, it can cause respiratory problems, infertility, birth defects, and tumor formation. Proper regulations are required to avoid such health risks in the country.

Temporal susceptibility assessment for co-seismic landslides: a case study from the NW Himalayas, Pakistan

Saad Wani[1]*, Muhammad Basharat[1], Malik Talha Riaz[1], Muhammad Tayyib Riaz[1], Ahmed Hammad Khaliq[1], Syed Ahsan Gardezi[2] and Ahtesham Gardezi[3]

[1] Institute of Geology, University of Azad Jammu & Kashmir
[2] Geological Survey of Pakistan
[3] Department of Earth Sciences, Quaid-i-Azam University, Islamabad
**saad.wani@ajku.edu.pk*

The Himalayas are the youngest mountain range in the world, where the orogenic processes are continued. The disastrous Earthquake of 2005 in the Azad Jammu and Kashmir has jolted the study area extremely, particularly district Muzaffarabad causing thousands of landslides. The present study deals with Spatio-temporal landslide distribution and landslide hazard assessment to understand the landslide-prone area in the district Muzaffarabad, Azad Jammu, and Kashmir, Pakistan. Temporal landslide inventory of the three years (2005, 2007, and 2012) was updated and produced to know the temporal variation of the

landslide distribution. For this purpose, thirteen Landslide Causative Factors (LCFs) were selected are Slope gradient, Aspect, Elevation, Curvature, Plan curvature, Profile curvature, Lithology, Topographic Wetness Index (TWI), Distance to streams, Distance to faults, Distance to roads, Normalized Difference Vegetation Index (NDVI), and Landcover. Furthermore, the Landslide Susceptibility Maps (LSMs) were produced using three bivariate that are Weights of evidence (WoE), Frequency Ratio (FR), and Information value (IV), a multivariate Logistic Regression (LR), and a machine learning Random Forest (RF) approaches. The model is produced utilizing a 70/30 (training/testing) ratio. The GIS-based toolbox i.e., ArcSDM, LSAT, and LSM in ArcGIS was utilized to evaluate the models which are quite time-saving and accurate. The resulting susceptibility models and the collected data were validated further through field investigation and the Receiver Operator Curve (ROC) approach. A total of 1386, 1370, and 1438 landslides have been identified in 2005, 2007, and 2012, respectively. Temporal analysis suggests a slight decrease in 2007 and then increments in a landslide in 2012 with distribution variation. Spatial analysis reveals that landslides are mostly distributed on the southeast facing slopes with 41-50^{o} with maximum concentration in >50^{o} slopes. The distribution analysis suggests that a higher concentration is present in 0-250m zone around faults having 5% of the total area. Muzaffarabad, Murree, and Panjal formations have higher concentrations of landslides due to the proximity of active faults. Distance to streams and distance to the road is also responsible for landsliding in the area as classes <100m depict higher landslide concentration. The susceptibility maps were then divided into four hazardous zones, namely very low, low, moderate, and high-hazard zones. The findings depict that the high hazardous zone is associated with the tectonically active areas along with topographic, anthropogenic, and lithological factors. The order of the accuracies is RF, LR, WoE, IV and FR having Prediction Rate Curve (PRC) value 93.5%, 88.3%, 71.1%, 82.17%, and 82.27% for 2005, 96.8%, 87.88%, 88.8%, 90%, and 89.52%% for 2007, 96.3%, 88.3%, 74.5%, 80.9%, and 80.8% for 2012 respectively. In the comparative analysis, the highest metrics and AUC are evaluated in the machine learning RF method followed by the multivariate LR among other statistical models. Due to higher prediction accuracy, RF hazard zonation map is recommended for the prediction of landslide-prone areas and can be utilized for landslide hazard prevention, proper urban planning, mitigation measures, and geo-environmental development in district Muzaffarabad.

Spatial distribution, multivariate analysis and quality assessment of groundwater from Shah Faisal Town, Karachi: A case study

Maria Abdul Wasay*, Erum Bashir and Shahid Naseem

Department of Geology, University of Karachi, Karachi-75270, Pakistan
**maria.abdulwasay963@gmail.com*

Major physicochemical parameters of selected samples from Shah Faisal Town, Karachi have been determined to assess the quality of groundwater, estimated variation and to show the multivariate distribution of chemical constituents along Malir River and Chakoar drain. All samples showed pH concentration >7, alkaline and those samples which are adjacent to drains showed very high TDS concentration due to contamination of groundwater. According to WQI value and status, 60% of samples were categorized as a good type while only 40% were placed in poor type water. According to the result of irrigation quality parameters, all samples were in the range of desirable limit but have high conductivity values as it is interlinked with TDS. Gibbs plot showed that all samples were in the category of evaporation dominance while the hydrogeochemical facies of water is CaCl type. The current study indicated that a maximum number of samples showed ionic tendency of Na+K>Mg>Ca, Cl>SO4>HCO3+CO. Spatial analysis concluded that TDS, HCO3, SO4, Ca, Mg and Na concentrations are high along Chakoar drain while pH, CO3, Cl, Ca and K are high along Malir Naddi. Correlation matrices concluded that pH has a positive correlation with CO3 only while Na is highly interlinked with Cl with the value of .980. SO4 also possesses a positive correlation with Ca, Na, and K but mostly interlinked with Mg with the value of .877. Cluster analysis showed that samples 22 & 23, 6 & 8, 17 & 20, and 24 & 25 are strongly interlinked with each other while based on physicochemical parameters pH and TDS, Cl and Na are strongly interlinked with each other. It is concluded from the present study that groundwater quality was not good along the drains of Shah Faisal Town due to contamination while away from drains its quality was better.

Integrated approach to reservoir characterization of Cretaceous Kawagarh Formation exposed along Bagnotar-Baragali section: Constraints from fracture analysis and petrography

Muhammad Yaseen[1, 3]*, Muhammad Shahab [2,3], Abdullah [2], Abbas Ali Naseem [4] and Muhammad Zeeshan[1]

[1]Department of Geology, Abdul Wali Khan University Mardan, Pakistan
[2]National Center of Excellence in Geology, University of Peshawar, Pakistan
[3]GIS & Space Applications in Geosciences (GSAG), National Centre of GIS & Space Applications (NCGSA), IST, Islamabad, Pakistan
[4]Department of Earth-sciences, Quaid-i-Azam University, Islamabad, Pakistan
**yaseengeo@awkum.edu.pk*

The current work deals with the reservoir characterization of Cretaceous Kawagarh Formation exposed along Bagnotar-Baragali Section, Lesser Himalaya Northern Pakistan. Surface fracture data were collected including orientation (Dip/Strike), fracture density (F.D), frequency and their distribution. The methodology adopted includes fracture data collection by scanline, circle inventory method and statistical calculations by Monte Carlo equation. The data was collected from 19 different stations with 25 fractures inventories. The fracture data compared with the petrography, SEM and EDX data already available. Further, the natural fracture reservoir (NFR) system was used to classify the reservoir based on the comparative analysis. Moreover, stress analysis displays those major stresses are in NW whereas minor stresses were acting in ENE direction. The Stereonet diagram show that the maximum fractures are NW-SE oriented, medium amount of fracture are NE-SW oriented while Minimum amount of fracture are oriented in NEE-WSW direction. The fractures direction shows three sets of joints making X shape, which indicate that these fractures are interconnected and due to which the reservoir potential is enhanced. The average Fracture Density, Porosity and permeability were calculated as 0.043136, 3.212509 and 0.282299 respectively. Relation between FD vs. Porosity and Permeability is weak which decrease reservoir potential while Relationship between Fracture, Porosity and permeability is very strong which yields in enhancing reservoir potential of Kawagarh formation. The analyzed formation shows intermediate to low porosity and permeability and classified as Type 2 or Type 3 NFR based on the Visual porosity from petrography and the fracture data from the outcrop. This further shows that, the fractures provide essential permeability only in case of type 2 while in case of type 3 the fractures provide a permeability assistance. Based on NFR (Nelson, 2001) classification and comparative analysis justify that Kawagarh formation is type 3 reservoir.

The control of composition, texture and weathering on the physical and strength properties of selected intrusive igneous rocks from North Pakistan

Muhammad Yasir[1], Waqas Ahmed[1]*, Muhammad Sajid[2] and Umair Mussawar[1]

[1]NCE in Geology, University of Peshawar, Peshawar,25120, Pakistan
[2]Department of Geology, University of Peshawar, Peshawar, 25120, Pakistan
**waqas.nce@uop.edu.pk*

This work characterizes intrusive igneous rocks from north Pakistan in terms of their mineralogy, texture and weathering grades and their effect on the physical and strength properties. The mafic and intermediate rocks showed a low cumulative percentage of quartz, feldspar and plagioclase with high specific gravity, strength and ultrasonic pulse velocity values compared to the felsic rocks. Likewise, samples with anhedral grain shape, irregular boundaries, fine to medium grain size showed higher compressive and tensile strengths. The weathering grades assigned to the investigated samples, such as fresh, slightly weathered and highly weathered corresponded well with the physical and strength properties, that is, as the grade increased from fresh to highly weathered, the porosity and water absorption increased, whereas the specific gravity, compressive strength and tensile strength decreased. The presence of quartz affected rock strength; however, no significant correlation was observed for strength with maximum and mean grain sizes of different minerals.

Impacts of climate change and glaciers melting in Pakistan

Fareeha Zaib* and Farah Tariq

University of the Punjab, Lahore, Pakistan
**fareehazaib19jan@yahoo.com*

Climate change have a global potential towards glacial landscape and environment. Pakistan is anticipated to be negatively affected by climate change. Pakistan's glaciers cover an area of around 16933 km2. In Pakistan, the Himalayas, Karakoram, and Hindu Kush towering mountain ranges converge, holding more than 5000 glaciers within Pakistani geographical boundaries that provide snow/ice melt water to the Indus River System together with summer monsoon. Pakistan is ranked 135th in the world in terms of global greenhouse gas emissions per capita, but 16th in terms of climate change sensitivity. On the valley glaciers, signs of black carbon have been found, speeding up the melting process. Frozen water resources have been losing their reserves at an unprecedented rate, not only, reducing the ice mass but increasing the number and extent of glacial lakes. Glacial Lake Outburst Floods (GLOFs) are the devastating mountain hazards which have started occurring with increased frequency during the recent years. Pakistan’s low adaptive capacity due to limited financial resources and

shortage of physical resources, and continual extreme climatic events have persistently threatened the ecosystem. Rapid glacier decline, if not complete extinction, will result in a loss of tourism revenue. It is imperative to anticipate and adjust to cumulative repercussions immediately. ALOS data could be utilized to detect changes in the glaciated area by comparing it to historical data. The Mountain Institute (TMI) and ICIMOD's Global Glacial Lake Partnership effort is a step forward in managing such lakes to limit the potential losses from their outburst. Also, concerned organizations should improve their capacity to grow the density of their glacier/lake monitoring network, enhance monitoring processes, employ unique research approaches, construct reliable infrastructure, and develop early warning systems to ensure sustainable approach toward catastrophic aspects of climate change.

Climate change mitigation techniques

Muhammad Hamza Zaman and Muteeb Ahmad Sheikh*

College of Earth & Environmental Sciences, University of the Punjab, Lahore, Pakistan
**muteebahmad.sh@gmail.com*

Climate change is the drastic long-term changes in the climate, i.e., weather patterns and temperature, due to anthropogenic and natural activities. Climate change is the primary concern of the twenty-first century. The emission of greenhouse gases, mainly from anthropogenic activities, causes a 1.0℃ rise in Earth's temperature. It is estimated that this increment will rise to 1.5℃ by 2030 – 2050 if the rate of emission of greenhouse gases remains constant. Major natural environmental incidents occurred due to climate change in 2018. About 68.5 million people were affected, and the economy lost $131.7 billion worldwide, of which floods, wildfires, and droughts accounted for 93% loss. California wildfires were the fatal wildfires that damaged the economy and took so many lives. Other resources under attack by climate change are water, food, health, habitat, infrastructure, and ecosystem. Paris agreement was signed in 2015, according to which only a 2℃ rise in temperature is acceptable till 2100, and every country is making efforts to lessen its greenhouse emissions. Few strategies to reduce climate change, such as negative emissions technologies, conventional mitigation technologies, and radiative forcing geoengineering, are discussed in this article. The aim of negative emissions technologies (also known as Greenhouse Gas Removal (GGR)) is to remove carbon dioxide from the atmosphere. Conventional mitigation strategies aim at lessening the fossil fuel-based carbon dioxide from the ecosystem. Lastly, radiative forcing geoengineering focuses on the alteration of Earth's radiative energy to reduce the temperature of Earth. Conventional mitigation technologies are not enough to reduce greenhouse gas emissions to meet the Paris agreement's goal of temperature. Combining different strategies can help, but as mentioned earlier, these technologies are not mature enough, so biogenic-based sequestration techniques can be installed as these are mature to a certain extent.

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