ENGINEERING BEHAVIOR OF PROBLEMATIC SOILD – CASE HISTORIES

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Abstract

Problematic soils are geological deposits presenting challenges because of their peculiar engineering behavior. As such, it is critical to understand their unique set of properties to develop site-specific solutions for construction with such soils. This talk will focus on presenting case histories of selected expansive/collapsible soils from different parts of the globe. Results of volume changes will be discussed to highlight the unique nature of this class of materials. This talk will be beneficial in understanding the impact of ground shifting on civil infrastructure.

SEDIMENTATION – A SERIOUS ISSUE FOR WATER RESOURCES AND DAMS

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Abstract

Tarbela dam is one of the largest earth filled dam in the world used for power generation and irrigation purposes. Indus basin is also regarded as backbone of Pakistan as it is the biggest source of electricity generation and is called as a food factory for Pakistan. Like all reservoirs the sediments inflow in the Tarbela reservoir has also resulted in reduction in water storage capacity and is also causing damage to the tunnels, the power generating units and ultimately to the plant equipment. The main source of the River Indus is the glacial melt water from the Himalayas with an annual flow rate of 94 MAF which carries along huge amount of sediments and the gross capacity of the reservoir has reduced. The annual suspended sediment load is about 430 million tons meaning that, over time, the reservoir will fill. The life of the dam and reservoir was estimated to be somewhere around fifty years in 1976 when the dam was constructed, meaning that the reservoir will be full of sediments by 2030 and will not be functional anymore unless maintained. This study presents life prediction of Tarbela reservoir in terms of its storage capacity, erosion rate and strength of the tunnels for different times of the year i.e. during flooding (summer) and drought (winter) situations.

In addition to the reservoirs of Tarbela and Mangla Dams; almost all barrages and most canals are reasonably full of sediments. Important issue with reservoirs to dredge out sediments is the closing of the dams as they are a major source of electric power as per most recommendations of experts. In addition, sediments are increased observed going into the tunnels hence damaging inner liners and turbine machinery and choking filters etc. This means without closing power supply, there is a great need to study the sediments flow patterns, dredging patterns, land slide patterns and many others.

As such kind of work has not been done so far in any of the hydel power plants in Pakistan; the numerical methods developed provide a base for the study of the behaviour of water and sediment flows in Tarbela Dam reservoir, spillways and tunnels and strength analysis of the tunnels using FSI. The developed methodology can also be implemented to study the water and sediment flow behaviour of water in other reservoirs, dams, rivers, barrages and canals present throughout in Pakistan in specific; provided the required data for those are available.

As Erosion is observed in the tunnels and of turbine blades and other components; so erosion rate density measurement studies due to sediments and cavitation are carried out with different compositions of sediments (Sand, silt, clay); different flow rates i.e. quantity of flow of sediments through tunnels; different sizes and shapes of particles (circular, triangular, square, etc) for line and area cutting; different injection techniques and others parameters.

Sedimentation Issue needs Serious Consideration as projects on other tunnels, and that can result in delta initiation for movement and suction of sediment. Inlets on Tunnels need to be raised to control sediments. Dredging of sediments needs to be considered through simulations. A comprehensive integrated plan for power generation, water management considering sediments needs attention. Academia / research organizations can help in indigenous studies and can help saving huge amount of foreign exchange.

CASE STUDY: GEOLOGICAL CONCERNS OF 32 KM LONG HEADRACE TUNNEL OF KARI MUSKHUR HYDRO POWER PROJECT ON CHITRAL RIVER

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Abstract

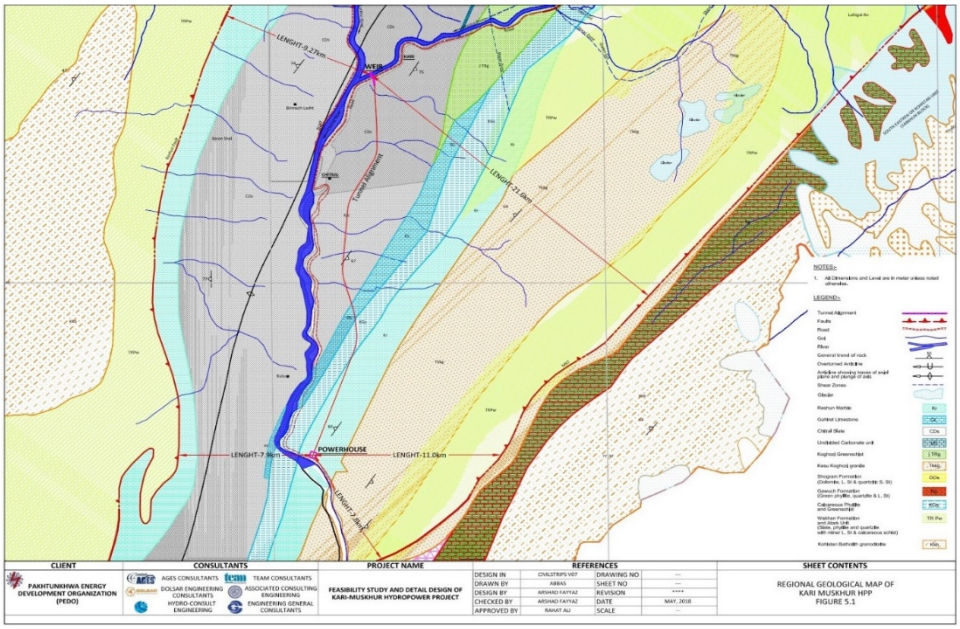
Kari Muskhur Hydropower Project (KMHPP) has been proposed on Mastuj River. The Weir site is located about 8 km upstream of Chitral Town. The location of powerhouse has been recommended 20 km from Chitral in front of Muskhur Village on the left bank of Chitral River

Kari Muskhur Hydro power Project is sandwiched between Upstream Turen More-Kari and downstream Gahrait-Swir Lasht hydropower projects. Feasibility reports of these projects have been completed in 2015 and 2014 respectively. Now the scheme under consideration could be developed within a specified stretch within predefined elevations.

Main Karakorum thrust (MKT) and Reshun Fault (RF) are running parallel to the head race tunnel. Main Karakoram Thrust is 21.6 KM from the proposed weir and 11.0 KM away from Powerhouse sites. Reshun fault is 9.27 KM, 7.9 KM away from the proposed weir and powerhouse sites respectively. This aspect of the existence of faults will be considered during preparation of Feasibility of the project.

Due to multiple valley glaciation in the project area, which is being controlled the development of landscape and thus producing thick valley fills during deglaciation time. These deposits are exposed from the base of the river to the top of the ridge near Chitral town. The head race tunnel may have problems with these fluvioglacial deposits exposed along the route. Geology plays a vital role for the placement of various structures related to Weir, sand trap, diversion tunnels, and outlet structures such as surge tank, Penstock, power house.

This paper deals with the contribution of geology to the hydro power projects on its various structures specifically its impact on the head race tunnel and solution to the problems are discussed. Numerous pictures and drawings will show the application of geology in specific instances. Examples of the ·application of geology to engineering work are also given (figure)



HIGH PERFORMANCE COMPUTING FOR ESTIMATION, PREDICTION AND FORECASTING IN EARTH SCIENCES

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Abstract

We are living in an uncertain world where the Earth is prone to various natural and human induced hazards at all spatial scales, ranging from local to global. Mitigation of the hazards along with sustainable utilization of various natural and man-made resources is the call of the day for better and safe future. However, integration, compatibility and processing of large volume of complex data is a real challenge for relevant community. High Performance Computing methods assist in timely and reliable predictions/estimation of various variables and state-variables with respect to space and time (spatio-temporal) in Earth and environmental sciences. Also, it will lead to sustainable utilization, improved planning and management system of various natural and man-made resources for future generations.

The satellite remote sensing systems produce enormous amount of periodic as well as sporadic spatio-temporal multimedia data. Compression of this big-data by identification and removal of redundant and nearly redundant data offer a knotty challenge to manipulate this big-data in real-time. Consequently, it can be very expensive both in terms of computational and human resources. Some GPS transceivers produce and accumulate data every few seconds that may produce huge amount of multimedia data in a very short period of time. Trajectory data is a sequence of temporally ordered GPS coordinates. According to statistics released by the department of transportation of United States, 53 Tera-Bytes of GPS data was produced in 2011 [1]. Consequently, this multimedia big-data will require high performance computing for various functions such as visualization and mining patterns etc.

The availability of big-data multimedia datasets and compatibility of high performance computing systems with satellite based remote sensing systems using advanced computer simulation models are opening new horizons for research in a number of inter-related domains such as optimized utilization of natural and man-made Earth resources, trajectory patterns mining, urban planning and spatio-temporal predictions/estimation and forecasting.

Sophisticated state of the art statistical and geo-statistical techniques (including; spatio-temporal interpolation and extrapolation, data assimilation methods, model simulations approaches) are extensively employed to make precise predictions for spatio-temporal patterns and trends. Contemporary computing technologies and simulation models are extensively arrayed to predict spatio-temporal patterns at all spatial scales (single point to global) of various land surface processes such as soil moisture, runoff, precipitation, evapotranspiration, seismicity, agriculture practices, water management and many other relevant disciplines. On the contrary, these spatio-temporal prediction models suffer some shortcomings, for instance, redundancy and inconsistency in datasets and extra ordinarily high cost of computing as well as human resources.

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A REVIEW OF POTENTIAL NATURAL DISASTER IN THE NORTHERN REACH OF CPEC PAKISTAN

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Abstract

China Pakistan Economic Corridor (CPEC) is an important segment of the President Xi Jinping of China, One Belt One Route (OBOR) philosophy to extend their reach to the global market by 2030. CPEC is considered a destiny changer for Pakistan, which will usher multitude of opportunities for economic, infrastructure and energy sector developments. The northern part of the CPEC route is faced with multitude of natural disaster such as earthquake, slope Instability in terms of rock fall, landslide, floods, Flash Floods and Glacial Lake Outburst Flood (GLOF). The frequency of earthquakes and its intensity in last two decades due to the plate tectonics of the region has made it the seismically the most active part of the world. The major slides leading to formation of lakes like Attabad, flash floods in the region and debris flows due to GLOF are some of the most recent natural disasters observed in the last two decades. To mitigate these impacts detailed analysis of various natural and manmade phenomenon is required which include Seismic Hazards/Vulnerability Analysis, Flood Hazard Analysis, Landslide Hazard Analysis , Forestation and Reforestation Analysis, Snow and Debris Hazard Analysis, Environmental Impact Assessment , Land Erosion Analysis – Climate Change Impact on Glaciers – GLOF etc. In this review paper a detailed account of the natural disasters experienced by the northern part of the CPEC has been provided with further recommendations for its mitigation. The success of CPEC in terms of economic prosperity of the region will also depend on the safety of the corridor from natural and man-made hazards.

Keywords- CPEC, natural disaster, GLOF, earthquakes

CHALLENGES AND OPPORTUNITIES FOR COAL UTILIZATION IN PAKISTAN

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Abstract

Pakistan is rich in Coal reserves ranging from lignite to sub-bituminous rank. The major on-going coal fired power plants in public/private sector utilize imported coal due to some technical demerits of indigenous coal reserves. The technical lecture will mainly focused to discuss the key challenges of current operational activies including coal transportation, handling and combustion methodologies with significant technological advancement for utilization of low rank utilization for mega projects in accordance to environmental policies. Furthermore a brief aspects of coal quality issues for on-going active coal mines in Pakistan along with recommendations for its visible solution to achieve clean coal combustion technologies for future country demand.

Keywords: Coal, quality issues, lignite, industrial utilization

MIXED SILICICLASTIC-CARBONATE TERTIARY DELTAIC DEPOSITS IN A PULL-APART BASIN, EASTERN OMAN

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Abstract

Over 1100 m thick mixed siliciclastic-carbonate sediments of the Musawa Formation were deposited in a structurally controlled Paleogene Abat Basin in Eastern Oman. The Abat Basin formed due to transtensional tectonic regimes during Late Cretaceous to at least Late Eocene deformation along the bounding faults and Masirah Transform Fault. The Abat Basin bounded by the Ja'alan fault to the south and by the Qalhat fault to the East recorded a great sediment thickness due to excessive sediment supply from active basin margin faults and very strong tectonic-related subsidence of the basin axis parallel drainage system. Mixed siliciclastic and carbonate sediments of the Abat Basin provide a good opportunity to study interaction of transitional marine depositional processes in a laterally restricted pull-apart basin. The formation shows two main facies successions over ten km distance, grading from a proximal delta-plain to a distal delta-front succession. Four major lithofacies associations based on their depositional significance are identified in the basin, namely the conglomerate lithofacies association, sandstone lithofacies association, overbank-fines lithofacies association, and carbonate lithofacies association. Each of these lithofacies associations are further divided and subdivided into a number of individual lithofacies on the basis of their depositional characteristics. The lithofacies association assemblage represents fluvial-dominated deltaic sediments that accumulated as a local siliciclastic feature in a carbonate dominated subtropical environment. The conglomerate and sandstone lithofacies associations were deposited by channels and shoreface processes, whereas coastal processes in delta-plain setting deposited overbank fines lithofacies association (including coal). The carbonate lithofacies association was deposited in open marine shelf conditions during transgressive events associated with delta-lobe switching.

The lateral lithofacies heterogeneity in a north-south elongated basin is due to changes in the depositional processes and relative sea-level changes controlled by the bounding faults. The lithofacies assemblages show deposition in a fluvial dominated delta that was rapidly prograding on a carbonate shelf.

RISE AND FALL OF THE TIBETAN EMPIRE AT 7-9TH CENTURY IN RESPONSE TO CLIMATE CHANGE

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Abstract

The Tibetan Empire was the only unified and powerful empire that ruled an area considerably larger than the Tibetan Plateau from the 7th to 9th centuries AD. The sudden rise and fall of the Tibetan Empire remains an enigma for historians. Here we present precisely dated multiple proxy records at a varved lake sediment core in the center of the Tibetan Empire. The records show that a warm and humid period coincided with the existence of the Empire. The ameliorated climate likely increase livestock and food production for rise of the Empire, which made it possible for the rise of a small tribe in Yarlung River and to grow to a mighty empire could to expand, and fight with Tang Dynasty to the east and the Arabians to the west. The deteriorated climate at the middle of 9th century may contribute to the collapse of the mighty empire.

CLIMATE CHANGE: A MAN-MADE CRISIS REQUIRING GLOBAL MITIGATION EFFORTS FOR ENSURING SUSTAINABLE DEVELOPMENT

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Abstract

Climate change is an inclusive term, for and global warming, environmental degradation, extreme and unpredictable weather conditions and changes in precipitation trend, to name a few. It is amongst the most potent threats to sustainable development and has, therefore, become a focus of intense scientific research and debate. According to the Fifth Assessment Report of the IPCC (2013-2014), global temperature has risen by about 0.8°C over the past 130 years, but some studies suggest a rise up to 1°C. With increasing accumulation of greenhouse gases–GHG (comprising apart from water vapor, CO2 and smaller quantities of N2O, Chlorofluorocarbons, and CH4 etc.), temperature increase is likely to accelerate. In order to circumvent this increase, The Paris Agreement 2016 (keeping the increase below 2°C, preferably not more than 1.5° C), was adopted as an implementation plan to combat climate change. In case the world fails to comply with this regulatory abatement, an increase in global temperature to 3°C or more will be the harbinger of global disaster. Temperature records since 1880 on land and oceans, heat contents of the ocean, and near surface (troposphere 50 years' satellite data) show increasing temperature trends. Rise in sea-level, increase in humidity, recession in glaciers, reduction in polar icecaps and increased coral bleaching provide additional buttress to climate change claims. Geological records show the impact of natural processes on climate change. However, the recent global warming and climate change are commonly attributed to anthropogenic activities, primarily accumulation of GHG in the atmosphere. GHG are released into atmosphere through plethora of sources such as burning of fossil fuels, methane release from agriculture activities, waste management and fluorinated gasses from industrial processes and consumer products.

Consequences of climate change can be disastrous, long lasting, and even irreversible. Changes in patterns of rainfall and snow, increased likelihood of drought and severe storms, decline in ice cover, melting of glaciers and glacial lake outbursts, floods, landslides, rise in sea level, higher humidity, changes in animal and plant behavior, faunal extinction and disappearance of coral reefs are some of the observed effects of climate change. All these effects create a vicious cycle of socioeconomic burden. Global warming can affect energy supply, infrastructure, socioeconomic patterns of livelihood, and living. Around 75% of world's population will be exposed to deadly climate conditions by 2100. It would have severe impact on agriculture sector, food security and its supply chain. Water borne & water related disease such as malaria, dengue, diarrhea, dysentery and typhoid, are likely to become epidemic. Global warming is projected to cause approximately 20,000 heat-related deaths among the elderly in 2030. Rising temperatures, floods, drought and limited supply of drinkable water will initiate human displacement/migration. All this will lead to increase the informal settlements, social conflicts, poverty and poor standard of life. The potential threats of climate change would presumably be severe to the less developed countries because of their lack of preparedness and lower resilience. According to the Global Climate Risk Index, Pakistan was ranked the 7th most vulnerable country in terms of the negative effects of global warming and climate change for the period 1996-2015. Many other Asian countries would be similarly vulnerable with crises of food insecurity and massive floods.

The situation is serious and demands global attention to minimize the climate change impact and to ensure sustainable development. Immediate actions on remedial steps, such as removal of CO2 from atmosphere, afforestation, use of clean energy, conservation and efficient use of water and other natural resources, and changes in our life style, are necessary to control earth's increasing temperature and climate change. Two approaches such as carbon sequestration and geo-engineering have garnered a lot of attention to protect earth from climate change. In summary, the danger of climate change is real. To minimize its impact, it is imperative to pursue suitable climate change adaptation and mitigation measures, along with good science, globally on emergent basis.

CPEC CHALLENGES IN EARTH SCIENCE AND CHINA-PAKISTAN COOPERATION

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Abstract

Challenges in Earth Science

China-Pakistan Economic Corridor (CPEC), about 3000km in total, is one of the six biggest Economic Corridors for the Belt and Road Initiatives. It also is the key area of Pakistan national strategy. However, the area along CPEC suffers great from frequent natural hazards, fragile ecological environment and fragile ecosystem which pose great threats to CPEC. To benefits the livelihoods and societies along the CPEC and to ensure the CPEC construction safety, disaster risk analysis and reduction and orderly utilization of ecological and environmental resources for the regional sustainable development need to be promoted. Based on the challenges in hazards, environment, ecology, resources and development faced by CPEC construction, environment data collection and mining under complex topography, earth surface natural hazards and risk control mechanisms, tectonic movement and effects on resources and hazards, regional sustainable development theory and technical model, as well as other key scientific issues have urgent needs to be addressed through cooperation in earth science and to strengthen regional scientific cooperation to benefit livelihoods and promote CPEC construction.

Needs and Foundation for China-Pakistan Cooperation

There has been good research cooperation foundation between China and Pakistan for decades. The scientific cooperation between China and Pakistan has lasted for a long period of time and achieved great significances, with the major positive influence of CAS. In 1960-1970, the Cold and Arid Regions Environmental and Engineering Research Institute involved in the construction of China-Pakistan KKH by analyzing the impact of glacial activates to highway. Since 2006, Institute of Mountain Hazards and Environment has participated in the extension construction work of KKH continuously and solved a series problem of disaster prevention for KKH. Besides above researches, many other Chinese institutions such as Tibet Plateau Institute, Institute of Atmospheric Physics and Institute of Geology and Geophysics, have carried out effective cooperation with Pakistan partners. Therefore, scientists from Pakistan Academy of Sciences, MoST, University of Peshawar, Pakistan Metrological Department, Geological Survey of Pakistan and other universities have involved the China-Pakistan collaboration and expressed actively supports for promotion and participation in China-Pakistan cooperation in earth science research.

LOW QUALITY COALS UTILIZATION – KEY COMMERCIAL, ENVIRONMENTAL AND PLANT EFFICIENCY CONSIDERATION

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Abstract

Coal blending process is practiced for combustion and gasification, particularly in coal-fired power generation. The Coal blending techniques go a long way in reducing the cost of power generation. The low-grade coals abundantly available in Pakistan can be mixed with high grade coal while retaining thermal performance of the boiler. Generally, any two coals can't just be blended. Successful blending occurs with respect to non-additive properties (likes combustion reactivity of coal, ash characteristics, grindability index, and swelling characteristics) of two coals.

Presently, coal utilization industries (cement, power generation, steel) are using single type coal which ultimately enhance fuel cost hence coal blending is strongly recommend to reduce overall plant cost and to sustain efficiency keeping in view environmental constraints.

Taking an environment-friendly approach in thermal power plants with coal blending requires an understanding of the interaction of inorganic components of coals in the blend process and how it affects ash behavior including its emissivity, and thermal conductivity. Conventional and advanced analytical techniques were used for characterization. Fuel ratio, burnout profile, ash chemistry and carbon burnout are key factors. This work will assist\ utilities to decide on the choice of coals for blending. Combustion efficiency and carbon loss of blended coal, other aspects of slagging, fouling and emission characteristics like NO_x, SO_x and emission of particulate matter are to be studied. Optimisation in process helps in ensuring cost effective and environment-friendly power generation in coal-fired thermal plants. The strict quality parameter monitoring for fuel (coal) recommended to reduce operational & maintaince (OM) cost of project and to use latest off-line and on-line (ash gauges) devices to control blending process.

The technical paper highlight the significance of coal raw mix and various blending methods such as blending in bed, blending by silo, blending by ground hopper and blending on moving belt economical viable for commercial applications. Among them, the most common is the blending on moving belt which is used for all coal processing industries.

Keywords: Coal Blending, Combustion, plant efficiency, environment

PETROLOGY OF THE CHILAS COMPLEX OF THE KOHISTAN ISLAND ARC IN THE KINER GAH AREA, CHILAS, PAKISTAN

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Abstract

The Chilas Complex is a ~40 wide and 300 long composite plutonic body exposed in the central part of Kohistan island arc, which formed first as intra-oceanic island arc in the Neo-tethyan oceanic crust and later transformed into Andean-type continental margin after the closure of back-arc basin. Two suture zones, i) the Northern suture (MKT) and the Southern suture (MMT) mark tectonic boundaries of the arc with the Karakoram micro-continent and the Indian continental plate respectively. The Chilas complex in the Kiner Gah area comprises gabbronorites, kyanite-garnet bearing tonalites, pyroxene quartz diorites, granites and amphibolites. Field studies suggest that the complex has intrusive contact with the the Kohistan batholith. A 2 km wide shear zone is present between Thalpan and Thak villages which is characterized by its north-south orientation, shear folds and the presence of sheared tonalite. Another major shear zone occupies the northern part where intense sheared rocks of the complex make them difficult to distinguish from the metasedimentary rocks of the Jaglot group. Major and trace elements study signify one common primary magma source composition for the plutonic rocks of the Chilas complex. Negative Nb and positive Sr anomalies indicate island arc type tectonic setting. Kyanite-garnet bearing tonalite, which is reported for first time from the Chilas complex in Kiner Gah area, indicates crustal contamination and amphibolite grade metamorphism.

GEOCHEMICAL SOURCE ROCK EVALUATION OF LATE JURASSIC TO EARLY CRETACEOUS ROCKS OF SULAIMAN RANGE, PAKISTAN: INTEGRATION OF OUTCROP AND WELL DATA

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Abstract

The present study focuses on Geochemical Source Rock evaluation of the Jurassic Chiltan Formation and Early Cretaceous Sember Formation. A total of 85 outcrop samples and 18 well cuttings were investigated to study the source rock potential of the rock units. The Sann #1 well data are integrated with the collected outcrop samples from the Mughal Kot section, Sulaiman Range. The techniques of the Rock-Eval pyrolysis and total organic carbon (TOC) tests were used. The analysis of both outcrop and well data sets revealed significant information regarding hydrocarbon generation potential of the Sember and Chiltan Formations. The source rock quality, Kerogen type, Level of maturity and expulsion/migration of hydrocarbons is determined by data plots of different geochemical parameters. The outcrop data of the Sember Formation reveals that the source rock quality ranges from poor to fair. The Kerogen type II in the lower most part while Kerogen type III in the middle and upper part with indigenous hydrocarbon potential was observed. The subsurface geochemical parameters of the Sember Formation in the Sann # 1 well confirmed the presence of very good values of TOC, Kerogen type II, immature to mature organic matter and no expulsion of hydrocarbon; pointing towards the presence of indigenous hydrocarbon potential. Similarly, the outcrop data of Chiltan Formation suggests poor to fair source rock quality in the upper part, very good to good in the middle part and poor to good in the lower part. The Kerogen type II, immature source rock with indigenous hydrocarbon generation potential is observed. The well data of Chiltan Formation shows good TOC with both Kerogen type II and type III, immature to mature source rock, having an indigenous hydrocarbon generation potential. The difference in the geochemical parameters like source rock quality, source rock maturity and hydrocarbon potential of the outcrop and well data is attributed to the overburden thickness, geothermal gradient, and environment of deposition.

MINERALGICAL AND BENEFICIATION STUDIES OF THE IRON AND ASSOCIATED COPPER ORES OF DAMMAL NISAR, SW CHITRAL, NW HIMALAYAS, PAKISTAN

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Abstract

Medium-grade iron and copper ore deposits occur in the Dammal Nisar area of lower Chitral, NW Pakistan. They are distributed as small to medium size lens-shaped bodies in the volcanic and metasedimentary rocks of the Gawuch Formation along the eastern contact of the Mirkani-Lawari plutons. A detailed mineralogical investigation using petrographic, X-ray Diffraction and SEM-EDX techniques shows that the deposits consist of magnetite, hematite, malachite and occasional bornite and pyrite as the principal ore minerals and quartz, garnet, epidote, calcite, pectolite, serpentine and foshagite as the main gangue phases. On the basis of field observations and mineralogical composition, the studied ore bodies may be classified as skarn-type magnetite deposits. Being medium-grade in their current form, different beneficiation techniques including gravity separation, magnetic separation and froth flotation were employed to assess the up-gradation potentials of the Dammal Nisar ore. The results reveal that Fe2O3 concentrates of 85.6 wt. % at 45% recovery and 87.2 wt. % at 63% recovery are obtainable by gravity separation after sample feeds with 72-75 wt. % Fe2O3 contents are ground at 20 and 25 minutes intervals, respectively. As such, the studied ores can be utilized in steel manufacturing. Furthermore, an average of 1.9 and 5.5 wt. % Cu is obtainable from the studied ore samples with 0.28 to 0.68 wt. % Cu through froth flotation. Besides, more than 60% of the sample grain size was reduced to <106 microns, when subjected to a grinding interval of up to 25 minutes, thereby, enhancing liberation of ore from gangue and hence a relatively high recovery of Fe and Cu.

Key Words: Iron and copper ores, mineralogy, beneficiation, Dammal Nisar, Chitral

FOLD-THRUST EVALUATION AND HYDROCARBON PROSPECT OF THE WESTERN MARWAT-KHISOR RANGE AND SHEIKH BUDIN HILLS, NORTH PAKISTAN

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Abstract
The Marwat-Khisor Range of the Trans-Indus ranges is a south-vergent fold-thrust belt that defines an east-west to northeast trending structural geometries and protrudes south to southeastward into the northwestern Punjab Foreland deep. This structural province is characterized by east-west to northeast oriented parallel to en echelon, plunging anticlines and synclines pairs that are asymmetric to overturn in the form of fold train and dominantly southeast vergent. The frontal foothills of the Khisor Range and Sheikh Badin Hills comprise a latest partially emergent thrust fault named as Khisor and Sheikh Badin Frontal Thrust. Surface projection to depth of the emergent structural elements suggests a thin-skinned structural mechanism for evolution of the Marwat-Khisor Range where gliding horizon for the frontal thrust sheet being located within the Jhelum Group rocks of Cambrian age at a maximum depth of 4~5km. The structural growth of the study area is dominantly attributed to the south directed transferal deformation mechanism along the basal detachment horizon being observed at the foot of Cambrian Khewra Sandstone. Along this basal detachment surface the Khewra Sandstone is exposed at surface and juxtapose to the sediments southeastward on top of the northwestern frontier of the Punjab Foreland Basin. Thrusting generally commenced subsequent to deposition of the Siwalik Group rocks, for the reason that these rocks involved in the latest thrusting phase. The Khisor Range front is the latest and dynamic frontal fracture zone of the northwestern Himalaya where deformation proceeds in the course of southward progression. The Khisor Thrust demarcates the northwestern proximity of the Punjab Foreland and is predominantly underlain by the shallow marine rocks of Permian to Triassic age in the region of Dhupsari. The stratigraphic framework of the Marwat-Khisor Range is significantly associated and correlative with the Surghar and Salt ranges with some exceptions. Permian strata of the Khisor Range comprise on Nilawahan and Zaluch groups rocks, where the top of the Nilawahan Group consists of the Sardhai Formation and bottom of the Zaluch Group consists of the Amb Formation. The Sardhai Formation was observed >40m thick and consists of dark gray to blackish gray and black carbonaceous shale while the basal parts of the Amb Formation consists of dark gray carbonaceous and calcareous shale of more than 20m thick, which is conflicting to the stratigraphic setting of the Surghar and Salt ranges. The structural geometries and stratigraphic framework of the Khisor Range suggests that the northwestern Punjab Foredeep is pertinent for the hydrocarbon exploration as thick carbonaceous shale facies of both formations are feasible potential source rocks. The area is comprised of the other prerequisite parameters vital for the construction of hydrocarbon kitchen, as trapping mechanism along with reservoir, seal and overburden rocks.

Keywords: Marwat-Khisor Ranges; Structural Geometries; Foredeep; Hydrocarbon Exploration.

PETROGRAPHY AND GEOCHEMISTRY OF THE MID-TRIASSIC TREDIAN SANDSTONE IN THE SALT AND TRANS INDUS SURGHAR RANGES, PAKISTAN: IMPLICATIONS FOR PROVENANCE

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Abstract

An excellent exposure of the Mid-Triassic Tredian Formation was studied in detail in the Nammal Nala, Landa Pasha and Gulakhel sections of the Salt Range and Trans Indus Surghar Ranges, Pakistan. The Tredian Formation principally consists of sandstone with some intercalations of carbonaceous shale and dolomite. Twenty-nine representative samples were examined in thin sections using polarizing microscope. Besides, eight of these petrographically investigated samples were analyzed for major and trace elements using XRF. The most abundant framework constituent in the studied samples is quartz (averaging 49 modal %). Although both the mono-crystalline and polycrystalline varieties of quartz are observed, the latter constitutes less than 1% of the total rock volume. Whereas some of the polycrystalline quartz grains contain <3, others contain >3 sub-grains. Most of the monocrystalline quartz grains display uniform extinction; however, undulatory extinction is noticed in a few of the larger grains. The type of grain contact ranges from pointed, long, concavo-convex to suture. Feldspar, including both alkali feldspar and plagioclase, constitutes only 14% of the total framework grains. The heavy mineral assemblage in the Tredian sandstone consists of tourmaline, rutile and zircon. The most abundant cementing material is calcite; however, silica, dolomite and iron oxide cements also occur in the studied samples. Petrographic and geochemical details suggest that the Tredian sandstone ranges from sub-feldspathic arenite to feldspathic arenite and hence is mineralogically sub-mature. The sub-angular to rounded outlines of framework constituents and moderate degree of sorting point to the texturally sub-mature to mature character of the sandstone. The petrographically and geochemically determined tectonic setting, physiography of the region and the southeast dominated paleo-current direction, as deduced from the observed sedimentary structures, all suggest Indian Craton as the most probable source area for the Tredian sediments. The nature and optical character of the major framework constituents and composition of the heavy mineral assemblage suggest that the sediments were largely derived from acidic (felsic) igneous rocks. The indices of alteration, weathering and compositionally variability, and major and trace element characteristics reveal arid to semi-arid paleo-climate and low to moderate degree of weathering conditions at the source area for the Tredian sediments and their deposition under oxidizing conditions in strongly continental environments.

DELINEATING STRUCTURAL STYLES AND GEOMORPHOLOGICAL PATTERNS USING SATELLITE IMAGERY AND SEISMIC IMAGES FOR AN IMPROVED INTERPRETATION IN A FOLD THRUST BELT AND ADJACENT FOREDEEP OF PAKISTAN

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Abstract

We combined a number of datasets to provide an enhanced and improved tectono-geomorphological and structural image using satellite imagery coupled with seismic images. The present study was carried out using the USGS ASTER DEM (30 m), Landsat 8 (OLI/TIRS) and 2D (strike & dip) seismic reflection profiles of the study area. Different band combinations and directional filters methods were used to identify the major structural styles in the area and were correlated with the subsurface seismic images for an enhanced interpretation. The panchromatic band (Band-8) was applied to the Landsat 8 satellite images in order to enhance the spatial resolution from 30 m to 15 m which aided in the investigation and comparative analysis of tectonic geomorphology and structural styles. Drainage patterns of Zindapir Anticline (ZA), Sakhi Sarwar (SS), Sulaiman Foredeep (SF) and Kingri Fault (KF) areas were generated using Strahler order of streams. The results suggested a combination of the dendritic network with a minor component of trellis pattern for ZP and SF areas hence proposing a more stratigraphic/lithological control, whereas the KF area indicated an element of a rectangular pattern suggesting a more structural influence in the western part in comparison to the eastern region. The presence of water gaps (WaGs) and active drainage network indicate lateral growth and propagation directions of the ZP and SS frontal anticlines following the Paleocene Epoch. The geomorphic evidences coupled with satellite data show that SFB is tectonically active. The stream courses are deflected or guided due to active folds and tectonics in the area characterized by the distinct fluvial erosional pattern on the flanks/limbs of ZA. The satellite imagery combined with 2D seismic images portray a compressional structural geometry of the area indicating a combination of mostly symmetrical folds, probably overturned at places, and reverse faults. 2D seismic images indicate amplitude anomalies at structural highs while the structural lows are indicated by dipping reflectors. Steep dips occur in some seismic reflection profiles, however, gentle dips are prevalent, particularly towards the SF area. The ZP is a highly deformed area whereas SF region is less deformed with reduced tectonic disturbances based on seismic images as indicated by parallel, continuous reflectors with negligible structural discontinuities across the basin. The eastern Sulaiman Fold Belt (SFB) is characterized by a series of north-south trending structural highs and lows developed during the Paleogene, and the area experienced folding, uplift, and subsequent erosion. Evidence from the study suggests that compressional deformation, uplift and erosion played a significant role in shaping of the structural and depositional architecture of the basin. It is proposed that the deformation in the SFB during the late Paleogene is related to the Indian-Eurasian oblique collision, while the subsequent late Tertiary collision of Indian Plate with the Afghan Block (an accreted part of southern Eurasia) further ensued compressive deformation. The results from this study elucidate the possible models proposed for this compressional regime with prevailing wrenching by presenting different dataset from previous studies for the surface and subsurface and are in agreement with the styles proposed for this area by previous researchers.

DIAGENETIC STUDIES OF THE MID-TRIASSIC TREDIAN FORMATION IN THE SALT AND TRANS INDUS SURGHAR RANGES, PAKISTAN: IMPLICATIONS FOR RESERVOIR CHARACTERIZATION

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Abstract

Distinguished into two members (namely, the lower Landa Member and the upper Khatkiara Member), the Mid-Triassic Tredian Formation is well exposed in the Nammal Nala section of the Salt Range and the Landa Pasha and Gulakhel Nala sections of the Surghar Range. All the three sections are measured, logged and sampled in detail to elucidate the diagenetic changes and assess reservoir potentials of the Tredian Formation. Twenty-nine samples were selected for diagenetic investigation, while representative samples were examined with Scanning Electron Microscope (SEM) and energy dispersive X-ray (EDX) analysis to determine their clay mineralogy.

The Tredian sandstone has undergone intense and complex diagenetic processes. The chemical and mechanical compaction, cementation, replacement, grain fracturing and dissolution are the major diagenetic signatures. Major authigenic cements in the sandstone include calcite (both early and late diagenetic), dolomite, quartz, iron oxide/hydroxide and clay minerals. The two Members of the Tredian Formation underwent compaction differently. The lower Landa Member shows variable grain contacts (point to long) and early calcite cementation which stopped mechanical compaction and led to loose packing of grains. However, the upper Khatkiara Member displays tight packing (concavo-convex grain contacts) and significant mechanical compaction. Chemical compaction and pressure induced dissolution of quartz grains provided silica that precipitated as cement thereby reducing inter-granular porosity.

The paragenetic sequence is interpreted with relative diagenetic timings. The process of compaction continued from early through to late diagenesis and produced closer packing of grains. The precipitation of chlorite on grain surfaces helped in preserving some of the micro-porosity by preventing quartz cementation as overgrowth; however, well-developed quartz overgrowths do occur in some of the studied samples. The feldspars show partial to complete alteration to clay minerals and dissolution during diagenesis. The clay minerals identified with the help of SEM/EDX are illite and chlorite. The SEM studies reveal both rosettes and honey-comb like morphology of chlorite occurring as grain coating and pore filling cement. Dissolution of feldspars may be the possible source of chlorite formation. Authigenic illite is present in the studied samples with hair-like fibrous and ribbon crystal habit. A markedly greater abundance of illite in the vicinity of altered detrital grains of feldspar strongly suggests formation of illite by alteration of feldspar. Iron oxide/hydroxide cementation took place during telogenesis and led to reduction of primary porosity. Thin sections stained with blue epoxy were used to estimate the visual porosity of sandstone using point counting and SEM images. The estimated visual porosity values vary between 0.5 and 8%; averaging 5%. The primary porosity was reduced mainly by compaction and cementation however, grain fracturing, dissolution of framework grains and authigenic cements have produced secondary porosity to make the Tredian sandstone a potentially good reservoir rock.

PETROGRAPHY, GEOCHEMISTRY AND PHYSICO-MECHANICAL PROPERTIES OF DOLERITE FROM OGHI (MANSEHRA) KHYBER PAKHTUNKHWA, PAKISTAN

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Abstract
Dolerite dykes having excellent exposures around Maira Chanser and Jodan Khatta of District Mansehra along Oghi-Tanawal road are studied in terms of their suitability for aggregates and dimension stone using a combination of petrographic, geotechnical and geochemical characteristics. Petrographically, these rocks, known as black granites in commercial market, are fine to medium-grained having ophitic to sub-ophitic texture with plagioclase and clinopyroxene as the major mineral phases, while opaques, quartz, biotite, amphibole, olivine, apatite, chlorite, orthopyroxene and epidote occur as minor to accessory phases. Geochemically, these dolerites exhibit sub-alkalic, metaluminous, tholeitic to alkalic basalt character and fall in gabbroic category. These rocks have relatively high TiO_2 contents and are ferroan in nature. The geotechnical properties such as unconfined compressive strength (32702psi-34965psi), unconfined tensile strength (485psi - 535psi), specific gravity (3.109 and 3.169), water absorption (0.14% - 0.61%), loss Angeles abrasion (17.34% - 17.36%), soundness (13.86 - 14.31), and flexural test values (30.065 N/mm^2 - 30.066 N/mm^2) show their suitability for construction work as aggregate for concrete and light foundation loads as well as indoor and outdoor dimension stones. The strength properties of all samples studied have inverse ratio with the plagioclase content. The samples of Jodan Khatta samples have a relatively small grain size and fractured nature showing slightly weak mechanical properties as compared to Maira Chanser dolerite. Similarly, Jodan Khatta samples show more alteration along their grain boundaries which also have affected their grain to grain relationship and thus have influenced their strength values. Moreover, their relatively fine-grained nature has also contributed to higher extent of alteration. The study confirms that mineralogical and textural variations do affect the mechanical properties of the studied rocks.

Key words: Dolerite, Petrography, District Mansehra, Mechanical properties, Aggregate, dimension stone.

KINGRI AND TOI NALA (GHOZE GHAR-SAVI RAGHA) COALFIELDS OF MUSAKHEL DISTRICT, BALOCHISTAN, PAKISTAN: FORESIGHT STRATEGY

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Abstract

The different coalfields of Musakhel District are located in the northeastern part of Balochistan Province and also Sulaiman foldbelt. Kingri-Aram-Gharwandi Coalfields (Latest Cretaceous coal) have been found in the Vitakri Formation of Nath Ghar and Sumat Ghar in the south (Kingri coalfield), Nishpa, Tor Sari, Aram and Shiren in the central part (Aram coalfield) and Manhi area like Surbol and Nath locality and Khagoon areas in the north (Alu Khan Kach/Gharwandi coalfield) and Indur Pur and Sarin Lahar in the east. There are two main coal horizons (coeval to dinosaur red mud beds) each capped by sandstone units. Each horizon shows lenticular and discontinuous lignitic and muddy coalseams with low heating value. In Kingri mine thin seam of metallic coal/graphitic coal is also observed. In Gharwandi (Nath) area and also northeastern Sumat Ghar the laterite and high sulphur is also associated with coalseams. Estimated reserves of lignitic and muddy coal of Musakhel district are about 81million ton/mt with breakup as measured 3.9mt, indicated 7.8mt, inferred 35mt and hypothetical 34.3mt. Estimation of reserves is purely tentative based on only outcrop because no exploratory holes have been drilled. Here mining is not successful due to need of metallic coal by mine owners which is found negligible. In Multan a drill hole by oil company show 3m coal may belongs to Latest Cretaceous Vitakri or Early Paleocene Hangu or Eocene Domanda coal which reveals extension of coal under Punjab plain.

Kingri-Shikar-Tor Shah Coalfields (Early Eocene coal) is found in Toi Formation exposed in the vicinity of metalled road from Kingri to Kot Khan Mohd-Musakhel. These coal seams started in Shikar area (about 5km NE of Kingri town) are extending toward NE direction in the Gidar Shikai, Chamoz, Tor Shah, etc. This coal is exposed on the eastern limb of anticline. This anticline is followed in the west by Tor Shah syncline and in the east by Gandhera syncline. There are 5 main seams, each showing 1 foot thick carbonaceous shale with minor metallic coal. Coal quality seems like Chamalang and Toi Nala (Dewal-Ghoze Ghar-Savi Ragha) coal. The tentative reserve of this coal is 1mt but of thin coal seam. This Toi coal seems to be promising for drillings.

Toi Nala (Dewal-Ghoze Ghar-Savi Ragha) Coalfield is found in Early Eocene Toi Formation of Drug Tehsil region (District Musakhel), exposures starting from south are Dewal, Ghoze Ghar, Miana, Tabai Khah, Takai and Alambadai (Savi Ragha). The coal is also exposed in Toi Nala at Plawan/Betar. There are 3 main coalseams with 5 minor coalseams hosted by shale and sandstone, caped and roofed by sandstone/limestone beds dipping (20^0-35^0) eastward. Toi Formation is about 30m thick in Alam Badai. Lower coal seam is about 1 foot thick, the middle and upper coal seams each about 9 inches or slightly less than 1 foot thick. Total estimated coal reserves of Toi Nala coalfield are 15.4mt with breakup as measured 1.2mt (upto 0.4km depth), indicated 2.4mt (from 0.4km depth to 1.2km depth), inferred 10.8mt (from 1.2km depth to 4.8km depth) and hypothetical 1mt (beyond 4.8km depth) but not verified by drilling. Coal quality is better than Chamalang's coal. This coalfield seems to be significant for development to start mining. Toi Nala coalfield is found in the eastern continuation of Chamalang coalfields in the Sulaiman (Middle Indus) Basin and its development will be another good addition to the coal fields of Balochistan.

NEOTECTONIC CHARACTERIZATION OF THE JHELUM FAULT ZONE, NORTHWESTERN HIMALAYAS, AN INSIGHT FROM INTEGRATED GEOMORPHOMETRIC AND KINEMATIC ANALYSIS

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Abstract

The compression associated with India-Eurasia convergence along the Himalayan Arc is accommodated by a series of southward younging imbricate thrusts in its northwestern part between Main Mantle Thrust (MMT) at the north and Salt Range Thrust (SRT) to the south. To facilitate the differential compression the transpression is also active. The Jhelum Fault is one of these transpressional faults, forming the western boundary of the Hazara Kashmir Syntaxis (HKS) and separates it from the Potwar fold thrust belt. This study integrates the geomorphometric and structural datasets using Digital Elevation Model (DEM) data, surface geological maps and field data to assess the kinematic evolution and neotectonic activity along the Jhelum fault zone (JFZ). Eleven geomorphic indices: Basin Length, Basin Area, Basin Perimeter, Basin relative Relief and Relief Ratio, Hypsometric Integral, Asymmetry Factor, Elongation Ratio, Stream Length, Stream Number and Bifurcation Ratio Index, are calculated from DEM data to determine the relative tectonic activity along the JFZ. Total of 22 basins are selected for which these indices are calculated. The steep relief and elongated shapes of the basins and the deviation of a specific stream order from the normal orders shows that some kind of neotectonic activity is responsible for the development of the landscape. Furthermore the results of these indices shows that the drainage basins i.e. 1, 2, 3, 6, 10, 14, 15, 16, 20, and 21 have high degree of tilting and drainage basins i.e. 1, 2, 3, 4, 5, 6, 7, 8, 11, 12, 13, 14, and 19 are characterized by deep to moderate incision and erosion which indicates their development under high degree of tectonic activity and dominance of hillslope processes, rather than fluvial processes. Based on the results of all these indices, the basins along the JFZ are divided into three categories of tectonic activity i.e. highly active, moderately active and slightly active. The analysis of geomorphic indices and kinematic analysis reveals that the drainage basins evolution in the ambiance of the JFZ is controlled primarily by the Jhelum Fault, lithology, and the structures associated with JFZ.

FLUCTUATION IN GLACIAL LAKES IN SHIMSHAL VALLEY, GILGIT-BALTISTAN

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Abstract

The global warming effects on glaciers, lakes and rivers in the Shimshal valley, Hunza, Nagar District, Gilgit-Baltistan are prominent since past one and half century. But there is no such change in size and shape of the glaciers in the Shimshal valley as around the globe. This effect is known as Karakorum anomaly. This study is done to find the changes that have occurred in the glacial lakes of Shimshal valley in the past six years. The highest elevation point is 4578 m and lowest elevation point is 2753 m relative to sea level. The average slop of the valley is 2.3% while it is NW orientated. Shimshal valley is rich in glaciers and glacier related features. The valley has many glacial lakes which range from large to small in size, volume, shape, area and perimeter. The glaciers on eastern side of valley are more branched and vastly distributed while on western side they are less branched. Two different time's data are taken, for year 2008 and for year 2014. Lakes for both times have different areas. The average covered area for year 2008 is 0.0913 sq. km and for year 2014 is 0.0882 sq. km .The dataset for year two 2014 show that the volume of glacier in Shimshal valley has increased as compare to year 2008 and the volume of lakes has decrease as compare to 2008.

SEISMIC ATTENUATION-DISPERSION APPLICATIONS TO DELINEATE THE HYDROCARBONS SATURATIONS IN THE RESERVOIR ROCK

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Abstract

Sedimentary rocks partially saturated with reservoir fluids exhibits seismic waves attenuation and dispersion that can be explained by different theoretical and experimental approaches. One of the important phenomena describes the energy dissipation in heterogeneous clastic rocks is due to wave induced fluid flow at mesoscopic scale of heterogeneities. The mesoscopic scale lies in seismic range of frequencies (1-10^2 Hz) and is larger than the pore scale and smaller than the seismic wavelength. The attenuation-dispersion mechanisms are studied in the Cambrian Khewra Sandstone reservoir located in the Upper Indus Basin of Pakistan. The P wave attenuation and dispersion curves are plotted as a function of seismic frequency at different saturation levels of gas and brine. It is found that the substantial amount of attenuation occurs when small amount of gas is present the rock. Similarly, P wave dispersion (increase of seismic velocity with frequency) also show higher change at 12 % gas saturation. From our study it can be presumed that both energy attenuation and dispersion can be used to delineate the low gas reservoirs.

LITHOFACIES ASSOCIATION AND DEPOSITIONAL ENVIRONMENT OF MURREE FORMATION AT JENA KOR, FR PESHAWAR AND PANOBA SECTION, KOHAT BASIN

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Abstract

The Murree Formation was studied at two field sections; 1-Jena Kor and 2- Panoba, these sections are located in southern most Peshawar basin and northeastern part of Kohat basin respectively. The Murree Formation in the study areas mainly consists of interbedded maroon/reddish color sandstone and shale with subordinate conglomerate and siltstone. The Murree Formation is 850m thick at Jena Kor Section and 370m thick at Panoba Section. Channel conglomerate facies consists of relatively fine clasts at the lower part of the formation and depicts shallow channel whereas at the upper part the clasts become coarser and are embedded in sandy matrix showing a mixed load representing debris flow and deeper channel. Cross laminated sandstone facies suggests deposition on the inner bend of meander leading to the formation of gently sloping point bar profile. Trough cross lamination indicates shallow channels that cut into one another and displays relatively distal part of the point bar. Ripple cross-lamination and Planar horizontal lamination sandstone facies represent deposition in lower velocities regime at shallower depth. The ripple cross and horizontal laminations indicate deposition in the abandoned channel/oxbow lake or at the point bar or crevasse splays. Interbedded sandstone and shale (repeated deposition of sand and shale close to the channel edge) leads to the formation of a levee. Fine grained clastic sediments are deposited primarily from the suspension load of rivers. Deposits of mud, silt, and very fine sand therefore indicate deposition in floodplain areas. The repeatedly rhythmic sequence (cyclic deposition) of Murree Formation indicates a meandering river deposition. Moreover, the comparatively high proportion of overbank deposits relative to inchannel deposits designates a broad floodplain across which the channel meandered, or a rapid floodplain aggradation rate relative to the frequency of channel avulsion. One single cycle is the product of meandering tidal channels in a continuously subsiding foreland basin. The uplifting of Himalayas rapidly increased during Miocene time which resulted in the deposition of huge sediments. This deposition within the foreland basin is termed as Murree Formation.

CHAMALANG-LUNDA-NOSHAM COALFIELDS OF BALOCHISTAN, PAKISTAN: FORESIGHT STRATEGY AND POLICY

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Abstract

A good quality high calorific value coal has been found in Chamalang-Lunda-Nosham coalfields. These coalfields include Chamalang, Bala Dhaka, Lunda, Surghari, Nosham, Bahlol and Kali Chapri areas in Loralai, Barkhan and Kohlu districts of Balochistan. The Chamalang coalfields are eastern continuation of the Duki-Anambar coal fields of Early Eocene Chamalang (Ghazij) Group in the Sulaiman (Middle Indus) Basin and are another good addition to the coal fields of Balochistan. The rocks exposed in the coal bearing area are sedimentary rocks ranging in age from Jurassic to Pleistocene along with Subrecent and Recent surficial deposits. The coal bearing Chamalang Group comprised of thick sequence of shale/claystone, interbedded sandstone, limestone, marl, gypsum, with beds of coal are assigned in to five units/formations i.e. Shaheed Ghat Formation (lower Chamalang), Toi Formation (middle Chamalang), and Kingri, Drug and Baska formations (Upper Chamalang). Coal is developed in the Middle Chamalang (Toi Formation) with more than 20 coal seams; however the main coal seams are confined to 3 to 4 in number. The coal seams are generally lenticular and range in thickness from 1 to 6.5 feet. However, the fault systems and overturning of strata have also affected the normal behaviour of many significant coalseams. According to present investigation, the coals of these areas are generally medium to high in sulphur and ash contents. The sulphur content ranges from 3.44 to 6.93%, while ash in these coals ranges from 5.35 to 84.96%. The heating values of these coals are generally higher as compared to other coals of Balochistan which ranges from 1818 to 13569 BTU/lb. According to international ASTM classification, these coals could be ranked as lignite C to high volatile bituminous B coal. The present work has enhanced the proved reserves upto 5 million tons, and inferred reserves along with indicated and hypothetical reserves upto 25 million tons of 1 foot and more than 1 foot coal seams. The reserves (other resources) of more than 6 inches to less than 1 foot coal seams are estimated to be 70 million tons. In this way total reserve of Chamalang-Lunda-Nosham coalfields are estimated to be 100 million tons. The depositional environments of coal bearing Toi Formation were deltaic. The northern Lunda, southern Lunda and Nosham areas seems to be promising for further mining and drillings. Particularly the Nosham coalfields were abandoned and now started again, however previously (as in 1982) more than two decades of years ago its mining was in operation. The best coal seams pattern in Chamalang-Lunda-Nosham-Surghari shows the existence of some coal seams in the Lunda and further east in Nosham area which may extends eastward into Kali Chapri area. However, the size, thickness, extension and dimensions of Lunda and Nosham coalfields can be revealed by deep drillings. At least 3-5 drill holes of shallow depth of about 400-500 meter at specified sites of Lunda and Nosham can provide general idea of coal seams behavior and reserves. Drilling is recommended for evaluation of Lunda-Nosham coalfields. Further, the centre and also southern part of Lunda may have very significant coal seams but little bit more in depth. So deep drilling (about 500 meter) may reveal the good promising coal seams. The Lunda-Nosham coalfields are parts of the eastern continuation of Chamalang coalfields in the Sulaiman (Middle Indus) Basin and are another good addition to the coal fields of Balochistan.

PETROGRAPHIC STUDY OF METAMORPHOSED PANJAL TRAPS FROM THE KAGHAN VALLEY, NORTH PAKISTAN

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Abstract

Different metabasic rocks were sampled from the Higher Himalayan Sequence (HHS) of Kaghan Valley, northwest Himalaya, Pakistan. The sampled rocks are expected to be metamorphosed Permian Panjal traps reported elsewhere in the region. Detailed mineralogical and textural relationships lead to categorize them into four different groups: 1) eclogites, 2) amphibolitized eclogites 3) garnet amphibolites and 4) amphibolites. Eclogites mainly consist of garnet, omphacitic clinopyroxene and symplectite with minor rutile and epidote group minerals (including zoisite, clinozoisite and epidote). In contrast, amphibolitized eclogites are strongly overprinted by amphibolite facies minerals that omphacite only survived in relics. Growth of symplectite, secondary amphibole, biotite and titanite corona around the peak eclogitic rutile are the dominant retrogressive featured observed in these rocks. Based on mineralogy and textures, eclogites are interpreted to be deeply subducted rocks due to India-Kohistan collision followed by rapid exhumation resulting from the Himalayan uplift. Amphibolites, both foliated to weakly or non-foliated varieties are cropping out in the form of vertical to sub-vertical dykes with variable thickness and texture, in the foliated host rocks. They are further grouped into garnet bearing (with and without plagioclase) and garnet free (plagioclase bearing). Garnet amphibolites mainly consist of hornblende, garnet and quartz with minor rutile, ± epidote and ± plagioclase. Presence of ubiquitous garnet and rare occurrence or absence of plagioclase restraint the higher-pressure conditions of these rocks. Conversely, amphibolites with hornblende, plagioclase and quartz with minor rutile, ± titanite and ± epidote are presumed to be metamorphosed comparatively at lower pressure. The observed differences in the metamorphic grade is supported by their occurrence in the field; amphibolites are restricted to the south while garnet amphibolites and eclogites to the north of the valley which is consistent with the increasing grade of metamorphism towards the collisional boundary (MMT).

MICROFACIES ANALYSIS AND DIAGENETIC STUDIES OF EARLY EOCENE MARGALA HILL LIMESTONE, IMPLICATIONS FOR THE RESERVOIR CHARACTERIZATIONS, SOUTH EASTERN HAZARA, KP, PAKISTAN.

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ABSTRACT

This research was carried out for the determination of depositional environment, diagenesis and reservoir characterization of the Margala Hill Limestone in South Eastern Hazara. The formation consists of grey color limestone, medium to thick bedded, nodular and fractured. On the basis of petrographic studies and allochems to matrix ratio, six microfacies were identified in the Formation in the study area. These microfacies includes; larger benthic foraminiferal bioclastic packestone (MF-1), bioclastic Assilina packestone (MF-2), bioclastic Nummulitic packestone (MF-3), bioclastic larger benthic foraminiferal wackestone (MF-4), larger benthic foraminiferal wackestone (MF-5) and assilina wackestone (MF-6). These microfacies indicate that Margala Hill Limestone was deposited in distal inner to proximal middle to distal middle ramp setting. The processes of biogenic alteration, neomorphism, compaction, dolomitization, fractures, dissolution and nodularity are the manifestation of diagenetic processes occurring in the Formation. These processes indicate that Margala Hill Limestone had experienced marine, meteoric and burial diagenesis. The different porosity types on the basis of petrography includes intragranular, intergranular, moldic, vuggy and fractured porosity. The fractures are the dominant features (identified on the macroscopic and microscopic scale) that increase the porosity and permeability of the Formation. The SEM Studies show the dissolution has affected most of the Formation which is important for the enhancement of poroperm (porosity and permeability) values and migration of hydrocarbon. The diagenetic studies represent that Margala Hill Limestone were affected by diagenesis. The reservoir studies of the Margala Hill Limestone show a good secondary reservoir for the hydrocarbon accumulation.

PHYSICAL AND CHEMICAL CHARACTERIZATION OF PALEOCENE COAL OF PATALA FORMATION, EASTERN SALT RANGE, PAKISTAN

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Abstract

Coal quality assessment and characterization is the basic step to uplift economy of a country. Current research work is based upon chemical and physical analysis of coal exposed in Patala Formation (lateral variation of Hangu Formation) of eastern Salt Range between longitudes 73^0 to 73^0 05' East and latitudes 32^0 38' to 32^0 45' North. The coal seams range in thickness from 10 cm to 1.5 meters. Fresh coal samples were collected systematically from Manhiala and Dandot area. Laboratory studies were carried to evaluate the Gross Calorific Value, Carbon Sulfur Analysis, Free Swelling Index, Hardgrove Grandibility Index along with definite Proximate Analysis of the coal. Analytical data demonstrates moisture ranging from 6.4 to 7.8%; volatile matter from 41.5 to 45.3%; fixed carbon from 41 to 48.8%; ash from 6.6 to 7.6%; Calorific value from 5900 K cal/Kg to 6350 Kcal/Kg, Carbon from 76.9 to 80.2% and sulphur ranges from 3.8 to 4.3%. HGI value ranges from 44 to 48. Free swelling index is 2 indicating that coal is non-coking. These analyses proved that the coal from Patala Formation in eastern Salt Range is ranked as a high volatile bituminous coal which can be utilized in brick kilns and also can be of tremendous use in electricity generation.

ROLE OF NATURALLY SUBSTITUTED IRON IN CRYSTAL LATTICE OF ZINC SULFIDE MINERALS DURING LEACHING BY *ACIDITHIOBACILLUS THIOOXIDANS* AND *ACIDITHIOBACILLUS FERROOXIDANS*

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Abstract

Leaching of various metals, applying bacteria *Acidithiobacillus* spp is being done for the recovery of copper, zinc and uranium by heap, dump and in situ leach techniques on a commercial scale. Reportedly around 35 % of total copper is obtained through bacterial leaching processes. These bacteria are also used as catalysts in the biomining process. Sphalerite ((Zn, Fe)S) is a mineral that is the chief ore of zinc. It consists largely of zinc sulfide in crystalline form but almost always contains variable iron. When iron content is high it is an opaque black variety, marmatite. It is usually found in association with galena, pyrite, and other sulfides along with calcite, dolomite. Zinc sulphidic ore is available with different percentages of iron sulphide amended naturally. To check the role of naturally present iron associated with the zinc sulphidic ores Sphalarite (2% Fe), lens material (6% Fe) and Marmatite (12% Fe) on bioleaching behavior by combined effect of *Acidithiobacillus thiooxidans* and *Acidithiobacillus ferrooxidans* bacteria in bioreactor on lab scale experiments were performed. Chemical reaction of heavy metals sulphide by this acid as well as ferric iron resulted in production of sulphur in the form of passive film/layer. Effectiveness of *Acidithiobacillus thiooxidans* in removal of this passive film was also investigated. The rate of biodegradation of various zinc sulphide minerals by these bacteria was found to be affected by overall crystalline structure and the degree of iron substitution.

AGGREGATE PROSPECTS OF LOCKHART LIMESTONE OF WATLI AND SIRALI AREAS, EASTERN SALT RANGE, PAKISTAN

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Abstract

In the eastern Salt Range the Paleocene strata is represented by Patala Formation (shale and sandstone with coal; lateral variation of Hangu Formation) and Lockhart Limestone followed by Eocene Nammal (shale, marl and limestone) and Sakessar (mainly limestone, lateral variation of Margala Hill limestone) formations. The Sakessar limestone (dipping toward north; famous for aggregate and cement raw materials) is peak forming located on the Salt Range thrust. The Lockhart Limestone is second resistant formation just below the first resistant Sakessar limestone, both are sandwiched by the Nammal shale, marl and limestone of low resistant and more erosionable due to its dominant shale lithology. The present study focuses on the Paleocene Lockhart limestone for aggregate resources and construction materials. Physical characterization of aggregate is the leading stage to boost construction industry and emphasis on the quality as well as implementation complications recognized with their use in construction material. Current study deals with petrographic, physical and mechanical characterization accompanied by assessment of Alkali Silica Reactivity potential for Lockhart limestone aggregate exposed in Watli and Sirali area of eastern Salt Range to explore its potential for utilization as a construction material in the engineering projects. Various tests such as gradation, optimum moisture content, soundness test, aggregate impact value, flakiness index and elongation index, Los Angeles abrasion value, specific gravity and water absorption were performed in accordance with AASHTO, BS and ASTM standards. Results of these experiments for twelve bulk specimens reveal mean aggregate impact value (13.71%-15.40%), optimum moisture content (4.3%-5.4%), soundness test (2.85%-2.93%), flakiness index (16.11%-19.09%), elongation index (11.12%-12.23%), los angeles abrasion value (23.93%-26.22%%), specific gravity (2.63-2.72) and water absorption (0.62%-1.34%), which suggest that the values of the limestone aggregate are within specified limits of their respective standards. An inclusive petrographic observation of 35 samples has been carried out to identify specifically the presence of deleterious minerals. Petrographic investigation indicates the presence of 1% strained quartz in limestone that suggests the aggregate is not prone to ASR. The research depicts that the Lockhart limestone engineering properties fall within the specified limits and mineralogically does not comprise higher concentration of deleterious minerals, hence, can be used as aggregate source for construction purpose.

A COMPARATIVE STUDY OF ALOS-2 PALSAR AND LANDSAT-8 IMAGERY FOR LAND COVER CLASSIFICATION USING MAXIMUM LIKELIHOOD CLASSIFIER

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Abstract

This study examines ALOS-2 PALSAR L-band dual-polarization (HH and HV) SAR data and Landsat-8 optical imagery for land cover classification. The SAR data has been preprocessed first, which included radiometric calibration, geocoding, and speckle filtering. The HH/HV band ratio has been used to create the third band, and thus a synthetic RGB SAR image was created. The Landsat-8 data was also preprocessed for the classification process. For land cover classification of both SAR and optical datasets, the supervised maximum likelihood classifier was used. Training samples were selected from the Landsat-8 optical imagery with the support of information available in Google Earth; the same pixel locations of training data were used to extract training data from SAR image as well. The Landsat-8 optical imagery was classified and also used for visual assessment of the SAR land cover classification results. Accuracy assessment has been done for both the results of SAR and Landsat-8 data. The SAR classified output gives accuracy of 93.15% and the Landsat-8 classified map accuracy was 91.34 %, while the Kappa coefficient for SAR and Landsat-8 classified images is 0.92 and 0.89, respectively. Classification limitations exist in some cases, such as roads being merged in vegetation areas and some of the barren land is merged in settlements. The land cover classification can be expected to be further improved using polarimetric decomposition methods and fusion of SAR data with optical data.

HEAVY METAL HEALTH RISK ASSESSMENT THROUGH GROUNDWATER CONSUMPTION ALONG THE HATTAR INDUSTRIAL ESTATE, KHYBER PAKHTUNKHWA, PAKISTAN.

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Abstract

This study aimed to assess the groundwater quality and human health risk potential in Hattar Industrial Estate, district Haripur, Khyber Pakhtunkhwa, Pakistan. Groundwater samples (n = 40) were collected from different drinking water source like bore well, tube well and dug well in the study area. Samples were analyzed for heavy metal (Zn, Ni, Cr, Pb, and Cd) concentration through atomic absorption spectrophotometer (Perkin Elmer, AAS-PEA-700), and compared with World Health Organization (WHO) guideline values for drinking water. The mean metal concentration (µg/L) in groundwater samples were found in the order of Ni > Zn > Cr > Pb > Cd. Since, heavy metal are toxic, non-biodegradable, accumulate in environment and food chain. This contamination pose a risk to the environment and human health. Furthermore, chronic daily intake (CDI) and hazard quotient (HQ) were also calculated for adult and children who consume groundwater. Results revealed that the mean CDI value (µg/Kg-day) of heavy metal was found in the decreasing order: Ni > Zn > Cr > Pb > Cd both for adult and children. The HQ value were found > 1 for Cd, Ni, and Pb, suggesting that the exposed human beings could be at chronic risk. This could be attributed with the discharge of effluents and solid wastes from the existing industrial estate into the groundwater of the study area. Therefore, serious measures such as drinking water treatments and contamination controlling policies are needed to avoid the hazardous effects of toxic heavy metal in this industrial area.

PROBABILISTIC SEISMIC HAZARD ASSESSMENT OF 548 MW KAIGAH HYDROPOWER PROJECT, DISTRICT KOHISTAN, KPK, PAKISTAN

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Abstract

The Kaigah Hydropower Project is proposed on River Kandiah, near Village Karrang in Kohistan district of Khyber Pakhtunkhwa province, Pakistan. Physiographical province of the project area is the Kohistan Island Arc, a tectonically active region which is sandwiched between the converging Indian and Eurasian tectonic plates. The project region has been subjected to many damaging earthquakes in the past. It is therefore imperative that a study of tectonic and earthquake history of the region be conducted to determine the seismic hazard to which the proposed project may be exposed. So the realistic seismic design parameters for the safe design of the Dam and its appurtenant structures are evaluated. Based on current knowledge of the region, the project is located in the collision zone of the Indian and Eurasian plates; therefore the Kaigah Hydropower Project is faced by a severe earthquake hazard potential. Within the scenario of many destructive events in the region, it becomes important to be very cautious regarding the seismic hazard assessment for such a major public project. In this study the probabilistic seismic hazard assessment (PSHA) for Kaigah Hydropower project is done by means of available geological data, tectonic data and historical as well as Instrumental seismological data of the region. The aim of this dissertation is to assess the seismic design parameters in accordance with the ICOLD guidelines (Revised 2010). Hence, the Peak Ground Acceleration (PGA) for OBE (Operating Based Earthquake), DBE (Design Based Earthquake), SEE (Safety Evaluation Earthquake) and MCE (Maximum Credible Earthquake) are determined to be used for the seismic resistant design.

ASSESSMENT OF RADON CONCENTRATION IN THE WATER SOURCES OF TOWN 1 PESHAWAR AND ITS EFFECTS ON ENVIRONMENT

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Abstract

To determine the health risks associated with radon concentration in drinking water, samples from three different Union Councils (UC) were studied. In Peshawar Town-1 area 63 fresh water samples were collected in order to determine their radon concentration using RAD7 electronic apparatus. Among these sample 11 were collected directly from tube wells, 41 form tap water of tube wells, and 11 from bore holes. All these water samples were used for drinking purposes have a maximum, minimum and mean radon concentration value of 51.6 ± 2.9, 6.7 ± 1.1 and 29.0 ± 1.3, Bql-^{1} respectively. In average, 96% of the water samples used for drinking purpose showed higher radon concentration than the maximum contaminant level of 11.1 Bql-^{1} as per Environment Protection Agency standards. Mean annual effective doses received to stomach (ingestion), lung (inhalation) and ingestion plus inhalation (whole body) from drinking water sources in Peshawar Town-1 were computed to be 0.0062 ± 0.00033, 0.0732 ± 0.034 and 0.080 ± 0.0037 mSv, respectively. From UC Faqeerabad 22 water samples were studied which bear maximum, minimum and mean concentration values of 40.6 ± 2.9, 6.7 ± 1.1 and 21.2 ± 1.8, Bql-^{1}, respectively. Mean ingestion, inhalation and whole-body effective doses from drinking water sources in Faqeerabad were computed to be 0.00445 ± 0.00039, 0.5358 ± 0.0130 and 0.5804 ± 0.0050 mSv per annum, respectively. Similarly, 20 samples were collected from UC Shahi Bagh and showed radon concentrations of, 51.6 ± 2.9, 12.7 ± 1.7 and 33.5 ± 2.5 Bql-^{1} as their maximum, minimum and mean values, respectively. In Shahi Bagh mean effective doses i.e. ingestion, inhalation and whole body from water sources were computed as 0.007402 ± 0.00073, 0.08451 ± 0.0082 and 0.09155 ± 0.00883 mSv per annum, respectively. Furthermore, 21 samples were collected from UC Sikandar Town with maximum, minimum and mean radon concentrations of 41.7 ± 2.7, 23.2 ± 1.7, and 32.9 ± 1.3 Bql-^{1}, respectively. In this town the mean ingestion, inhalation and whole body doses were computed to be 0.00692 ± 0.00028, 0.8299 ± 0.0034 and 0.090 ± 0.0035 mSv per annum, respectively. The increasing trend of the radon concentration is observed to be from south to north and it is supposed that higher concentration of radon in the study area is due to the deposition of the thick sediments in the Peshawar basin.

LITHOFACIES ASSOCIATION AND DEPOSITIONAL ENVIRONMENT OF BOSTAN FORMATION, PISHIN BELT, BALOCHISTAN, PAKISTAN

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Abstract

Pleistocene Bostan Formation is widely exposed in the Pishin Belt in western Pakistan. This northeast-southwest aligned belt is bounded by Chaman Fault, and Afghan Block in the west and by Zhob Thrust, and Zhob Valley Ophiolite in the east. Thirteen distinct lithofacies have been recognized and grouped into eight facies associations. Lithofacies include clast-supported massive boulder conglomerate (Gcm(a)), clast-supported massive cobble conglomerate (Gcm(b)), clast-supported pebble to cobble conglomerate (Gcm(c)), clast-supported pebble conglomerate (Gcm(d)), Matrix-supported pebble conglomerate (Gmm), trough cross-stratified pebbly sandstone (St), horizontally stratified sandstone (Sh), trough cross-stratified sandstone (St), ripple cross laminated sandstone (Sr), massive sandstone (Sm), siltstone (F), massive mudstone (Fm), massive variegated mudstone (Fmv). The Lithofacies associations include channel facies association (CHA), floodplain facies associations (FPA), Debris flow facies associations (DBFA) delta plain facies associations (DPA), delta front facies associations (DFA), pro-delta facies associations (PDA), lacustrine facies associations (LAA), turbidites facies associations (TUA). The lithofacies associations suggest that Bostan Formation was deposited by gravelly braided channels which formed a large delta on the shore line of Pleistocene Bostan Lake. The fine sediments from delta front and from suspension further descended to make extensive layered lacustrine and deeper turbidite deposits.

SEQUENCE STRATIGRAPHIC AND PALYNOSTARTIGRAPHIC FRAMEWORK OF THE TOARCIAN- BATHONIAN STRATIGRAPHIC UNIT IN CHICHALI NALA, SURGHAR RANGE PUNJAB, PAKISTAN

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Abstract

The Toarcian-Bathonian Shinawari Formation exposed in the Chichali Nala, Trans Indus ranges has been studied for sedimentology, palynostratigraphy, and sequence stratigraphic frame work. This is mainly comprised of limestone, sandstone, carbonaceous shale, coal, marls, mudstone and presence of hardgrounds. Limestone has variable texture such as gray to dark gray color on fresh surface and dark brown to brown yellowish on weathered surface, medium to coarse grained and abundantly fossiliferous, while marl is gray to dark gray in color. The clastic units such as sandstone are maroon in color while shale is gray to dark gray and carbonaceous in color. The palynostratigraphy is established on the base of plants microfossils such as pollen, spores and acritarchs and correspond to two different assemblage biozones, i.e. 1) *Callialasporites turbatus* assemblages biozones (CTUABZ I) and 2) *Callialasporites trilobatus* assemblages biozones (CTLABZ II) representing Toarcian-Bajocian and Bajocian-middle Bathonian respectively. The sedimentological interpretation of the studied unit is based on the microfacies and palynofacies analysis. The microfacies with palynofacies analysis portrayed a wide range of environments ranging from continental to outer ramp platform settings. Furthermore, the sequence stratigraphic interpretations are based on integration of outcrop data, palynostratigraphy and sedimentology data. Almost 125 m thick carbonate and clastic stratigrphic unit of Shinawari Formation represented two 2nd orders and four 3rd orders local sequences i.e. TST and HST, while in same global time it represented three 2nd orders and twenty one 3rd orders global sequences i.e. TST, HST, SMW and LSW. The dividing agent of system tract are sequence boundary and maximum flooding surface. The sequence boundary is marked from the laterite beds, while maximum flooding surface are marked from the chert beds. The system tracts is further sub divided into 4th/5th order cycles, which are recognized from changes of retrogradational facies pattern to progradational pattern. The comparison of local sequences with the global sea level charts indicates that the tectonic and climate was the main controlling factor for the variation at 3rd and 4th order of cycles.

DISTRIBUTION AND GEO-ENVIRONMENTAL ANALYSIS FOR ECOLOGICAL RISK ASSESSMENT OF HEAVY METALS IN SOILS OF LOWER DIR, KHYBER PAKHTUNKHWA, PAKISTAN

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Abstract

The soil samples (n= 43) collected from Lower Dir were analysed for pH, EC, salinity, Na, K, Ca, Mg, Fe, Mn, Zn, Cu, Cd, Ni, Cr, Pb, Co and Ag. The physical parameters were measured through electrochemical analyser while major and minor elements were measured by using atomic absorption spectrometer. The calculated values of elements were compared with their background concentration as well with their normal levels in agricultural soil. The mean concentration of elements indicated that Mn, Fe, Cu, Cd and Ag were found higher than their background concentrations. The average concentrations in the soil samples of Lower Dir were found as 18.151, 75.561, 1.77, 17.731, 20.199, 2.052, 85.552 and 8.24 (in mg/Kgs) respectively for Cr, Cu, Cd, Co, Ni, Ag, Zn and Pb. These elements on the basis of highest to lowest average concentrations can be sorted as: Zn > Cu > Ni > Cr > Co > Pb > Ag > Cd. Contamination Factor (CF) analysis indicated very strong pollution for Ag, medium to moderate pollution for Mn, Cu, and Cd, moderate to strong pollution category for Fe and finally non to medium for Pb, Cr, Ni, Zn, Co, Ca, and Mg. The contamination degree of elements was found as 20.947, which satisfied the category of considerable degree of contamination because of natural inputs. The Pollution Load Index (PLI) for 12 elements was found as 0.857 in the soil of Lowe Dir which falls in the "No Pollution" category. Index of geo-accumulation results indicated that Ag showed moderate pollution while rest of the elements attributed unpolluted to moderately polluted intensity of pollution. Finally, Enrichment Factor (EF) analysis showed lowest degree of enrichment for Cr while highest degree of enrichment for Ag and Cd. The data concluded that possible sources of pollution for Ag and Cd are anthropogenic as their EF calculated values were found higher than 1.5, however, rest of the elements can be subjected to geogenic sources of pollution. By mutual comparing of EF calculated values of selected elements and seven categories of EF; the Cd and Ag compliance moderate enrichment category, Fe showed minor enrichment while the remaining elements resulted no enrichment class.

PALEOENVIRONMENTAL RECONSTRUCTION FROM CRETACEOUS PELAGIC SEDIMENTS OF KAWAGARH FORMATION IN NIZAMPUR BASIN AND KOHAT RANGE, PAKISTAN

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Abstract

The paleoceanographic conditions and its effects on the evolution of Cretaceous planktonic foraminiferal are evaluated from two stratigraphic sections i.e. Kahi Road Section and Thora Stana Section of the Upper Indus Basin. The Kawagarh Formation at Kahi Road Section in Nizampur area is mainly composed of marl and thin bedded limestone while at Thora Stana Section it is comprised of limestone and black shale. Prior to the evolution of Cretaceous planktonic foraminiferal and subsequent paleoceanographic reconstruction, the hemipelagic sediments of the Kawagarh Formation were put into a reliable time frame using the planktonic foraminiferal biostratigraphy. In Kahi Road Section two planktonic foraminiferal biozones i.e. *Dicarinella asymetrica* and *Globotruncanita elevata* are erected. Based on these two biozones Early Santonian to Early Campanian age is assigned to the Kawagarh Formation in Kahi Road Section. While in Thora Stana Section one planktonic foraminiferal biozone i.e. *Globotruncanita biozone* of early Campanian age is erected. The evolution of Cretaceous planktonic foraminifera is established on the basis of its species richness, rate of speciation, extinction, diversification, and turn over. To further authenticate the paleoceanographic conditions which have affected the evolution of Cretaceous planktonic foraminifera the microfacies details of the Kawagarh Formation are established. In this study a total of 13 microfacies are recognized in both stratigraphic studied sections. At Kahi Road Section, four microfacies i.e. MFKRK 1- MFKRK 4 are established, whereas MFKRK stands for Microfacies of Kahi Road Kawagarh. The microfacies details suggest deposition in in outer ramp and deep basin environment while in Thora Stana Section a total of nine microfacies MFTSK 1-MFTSK 9 microfacies are identified, MFTSK stands for Microfacies of Thora Stana Kawagarh. Based on the microfacies details the Kawagarh Formation in Thora Stana Section is deposited in middle to outer ramp settings.

GEOLOGICAL AND GEOTECHNICAL ASSESSMENT OF TUNNEL SITE OF THE KOTO HYDROPOWER PROJECT, DISTRICT LOWER DIR, KHYBER PAKHTUNKHWA, PAKISTAN

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Abstract

The Koto Hydropower Project lies in the vicinity of Main Mantle Thrust for which the site area was assessed geologically and geotechnically with special emphasis on Tunnel construction and stability. A total of 51 representative bore holes having overall depth of 980 m were drilled at different locations and samples were collected to evaluate Tunnel feasibility for construction and stability. The qualitative and quantitative techniques used during this study includes rock quality designation, core recovery, permeability, water pressure/Lugeon, standard penetration and cone penetration tests. The lithologies and discontinuities encountered in bore holes, were identified and assessed for Tunnel construction and stability. The results indicated that the Tunnel Site is mainly dominated by igneous intrusions like diorite, granodiorite and gabbronorite along with minor metamorphic rocks for example amphibolites. The Tunnel Site is also possessing a thin layer overburden/regolith. The thickness of overburden falls within the optimum feasible range for Tunnel construction, otherwise its presence generally reduces the feasibility. The overall bed rock strength is designated as R5 at Tunnel inlet and R3 at Tunnel outlet on manual index test respectively, and hence shows suitable lithologies at Tunnel inlet comparted to Tunnel outlet. Likewise, the permeability test, water pressure test and joints analysis showed suitability of Tunnel Site for construction and stability.

Key Words: Koto Hydropower, Geotechnical, Lower Dir, Pakistan.

MICROPALEONTOLOGICAL, BIOSTRATIGRAPHICAL AND STABLE ISOTOPE GEOCHEMICAL ANALYSES OF THE P/E BOUNDARY INTERVAL, NAMMAL GORGE, SALT RANGE, PAKISTAN

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Abstract

The Patala Formation, Nammal Gorge Section, Salt Range, Pakistan yielded significant micropaleontological, biostratigraphical and stable isotope geochemical signatures pertaining to the Paleocene-Eocene Boundary (PEB) interval. Four distinct lithological units were identified in the Patala Formation in stratigraphic order from bottom to top; unit-1: is composed of creamy and light grey thick bedded to nodular limestone interbedded with dark grey and greenish shales, unit-2: is dominantly composed of dark grey shales, unit-3: is yellowish, thick bedded larger foraminifera rich limestone interbedded with greenish to yellowish brown shale and unit-4: it is dominantly composed of greenish grey shale. The top of unit-3 hosts closely spaced three unconformities demarcated as U1, U2 and U3. These frequently occurring unconformities may be the reflection of the Himalayan orogeny in the earliest Eocene subsequent to the India-Asia collision. From bottom to top, the detailed study of facies sequence and variation along facies are indicated by deepening then shallowing which is further followed by the deepening of the basin. A negative shift of 1.61‰ in $\delta^{13}C$ indicating the Carbon Isotopic Excursion (CIE) in unit-2 is used to represent the PEB interval. Additionally, the first appearance of the cosmopolitan dinoflagellate species, i.e. "*Axiodinium augustum*" coinciding with the negative excursion in $\delta^{13}C$ is another indication of the PEB interval. The PEB interval is also represented by The Larger Foraminiferal Turnover (LFT) Tethys-wide and is indicated by the replacement of the orbitoidiform larger foraminifera by orthophragminids, *Alveolina* and *Assilina* in the Salt Range, Pakistan. The orbitoidiform larger foraminifera including species of *Setia* and *Orbitosiphon* in the Lockhart Limestone and lower part of the Patala Formation represent the late Paleocene Smaller Benthic Foraminiferal Zone 4 (SBZ4). The first appearances of *Alveolina vredengurgi*, *Discocyclina ranikotensis*, *Orbitoclypeus schopeni*, and *Assilina* sp. within the unit-3 of the Patala Formation represent the earliest Eocene SBZ5. The LFT coincides with the boundary between shallow benthic biozones SBZ4 and SBZ5 and closely correlates with the Paleocene-Eocene Thermal Maximum (PETM) and allows the recognition of the PEB interval in Patala Formation of the Indus Basin.

DRAINAGE ANALYSIS ALONG THE KALABAGH FAULT ZONE: IMPLICATIONS FOR NEOTECTONICS AND RECENT KINEMATIC HISTORY

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Abstract

Drainage morphology of a region contains the recent history of landscape development. Quantitative measurements of morphological parameters of a drainage system can help in identification of the influence of tectonic or erosional processes in drainage evolution. Digital Elevation Model (DEM) of an area, which is the digitally stored remotely sensed spatial data, can be used to digitally measure and analyze the drainage morphology in digital environment. This geomorphometric information can be integrated with surface geology data for structural and tectonic interpretations. DEM data of 30 meters spatial resolution is used in this study to compute regional scale geomorphometric indices and ascertain the neotectonic signal, structural geometry and recent kinematic history of the Kalabagh fault zone. The following morphometric data and related indices are used in this study: 1) Stream network characteristics and associated indices. 2) Morphological characteristics of drainage basins. 3) Basin relief and associated indices. 4) Indices related to geometry, shape and regional tilting of drainage basins. Quantitative assessment of drainage morphology revealed that the studied fault zone is tectonically active and possess a younger drainage system which is developing under the influence of tectonic control. Differential thrust propagation along the frontal thrust zone of NW Himalayan Foreland is accommodated by development of a transfer zone. Strike-slip faulting and fold and thrust development along the fault zone is accommodating the active southward advancement of Potwar Plateau allochthon in a right lateral sense. Neotectonic activity along the Kalabagh fault zone points toward the concentration of active tectonic deformation in the laterally adjacent internal zone of the Potwar Plateau.

EMPIRICAL MODELING EM: A GENERIC APPROACH APPLIED TO VALUATE MINE SUBSIDENCE, UPHEAVAL AND VALLEY SIEGE ALONG SHERWAN VALLEY, ABBOTTABAD

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Abstract

An approach for subsidence prediction through Empirical modelling EM has been established as an alternative for subsidence prognosis in the Sherwan area, Abbottabad. The acquired results have been endorsed by Distinct Element code UDEC with empirical fallouts and perceived caving activity. Locally compressive stress conditions pinpoints the deformations of the valleys with anticipation when the surface distorts in a drooping mode they are not expected when the surface deforms in a grabbing mode. Presumptions for valley cessation under the grabbing mode have considered undefined compressive stress redistributions in the horizontal plane, or block translations from the drooping mode. This research is investigating the possibilities of the block translation model. The subsidence data and resulting graphs in this scheme were acquired from mines in the area between the Sherwan mine zone and the Bheer Valley. This data was collected over a period of 12 months. More than half of the mines included in the analyses were mining the talc-nikra seam with exceptional workings in the soha-bandi seam. The predominant method of mining was by drift and shaft mining, although some pillar extraction data has been included. The link among S_{max}/M and F x W/H for solitary panels has been established. The data for predicting mine subsidence is collected from three major mines in Sherwan area i-e Khanda Khau, Bandi Nikra and Chellether. The statistical data for prediction of subsidence shows that, the mine in the Khanda khau and Bandi Nikra are in very critical situation and can collapse at any time even when small scale seismic activity is produced. Although subsidence cannot be eliminated in this area yet it can be reduced or controlled by adapting different methods such as proper ground support mechanism, back filling method and blasting controls.

INVERSION OF FAULT SLIP DATA FOR PALEOSTRESSES ALONG JHELUM FAULT AND SURROUNDING AREAS, HAZARA KASHMIR SYNTAXIS, PAKISTAN

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Abstract

In northeast Pakistan, the Hazara Kashmir Syntaxis (HKS) marks the northwest termination of Himalayan Arc. The steeply dipping N-S directed Jhelum Fault displaces the lateral continuation of Himalayan structures along the western limb of the Hazara Kashmir Syntaxis. The paleostress orientations were calculated by inversion of brittle fault-slip data at 17 outcrops along the Muzaffarabad-Kohala segment of the Jhelum Fault and surrounding areas. The systematic inversion of overprinted, coated (calcite/quartz) and uncoated striated fault surfaces helped us to constrain the temporal and spatial distribution of paleostress states within the antiformal Hazara Kashmir Syntaxis. The paleostress analysis separates three paleostress tensors. The earlier NE-SW compressional paleostress tensor occurs in the east of the Jhelum Fault. The NE-SW stress tensor formed the northwest trending and southwest verging open to close F_1-folds and southwest directed D_1-faults. The second E-W compressional paleostress tensor is local and overprint the NE-SW paleostress tensor. The Hazara Kashmir Syntaxis initially formed under the E-W compressional stress tensor. The most recent third NW-SE compressional and wrench stress tensor occurs along and hanging wall of the Jhelum Fault. This stress tensor is oblique to the N-S trending Jhelum Fault and perpendicular to the northeast trending and southeast verging open to close F_1-hanging wall folds and southeast directed *D1*-faults. This stress tensor initiated the pure to oblique left lateral sense of shear along the Jhelum Fault and the Main Boundary Thrust. The NE-SW directed earlier paleostress tensor has been reactivated during the present-day seismic activity along the Indus Kohistan Seismic Zone in the Hazara Kashmir Syntaxis. These results imply that regional deformation within the Hazara Kashmir Syntaxis is asymmetric with compressional faulting on the east and transpressional faulting on the west.

INTEGRATED SEQUENCE STRATIGRAPHIC INTERPRETATION OF THE LATE CRETACEOUS KAWAGARH FORMATION, GANDAB SECTION, KALA-CHITTA RANGE, PAKISTAN

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Abstract

The Late Cretaceous Kawagarh Formation is well exposed in Gandab Section, Kala-Chitta Range, Pakistan. In the present study, the biostratigraphy and microfacies analysis have been carried out to reconstruct sequence stratigraphic framework of the stratigraphic unit. The biostratigraphic investigations revealed abundant planktonic foraminiferal species of *Globotruncana, Heterohelix and Globotruncanita*. Based on these species, a single local planktonic foraminiferal biozone i.e. *Globotruncana-Heterohelix-Globotruncanita* assemblage is established. The biozonal information is integrated with previous published literature and Lower Santonian to Middle Maastrichtian age is assigned to the Kawagarh Formation and interpreted to be deposited from 84 MYA to 71 MYA. The microfacies details of this stratigraphic unit indicate four microfacies, including Planktonic wackestone, Bioclastic wackestone, Planktonic mudstone and Bioclastic mudstone microfacies. Based on these microfacies, the Formation is interpreted to be deposited in the outer ramp platform settings. A total of six parasequences have been demarcated which are bounded by six marine flooding surfaces in retrogradational stacking pattern. The Kawagarh Formation shows an overall transgressive system tract (TST).

THE PALEOENVIRONMENTAL ANALYSIS AND DIAGENETIC STUDY OF CALLOVIAN BATHONIAN SAMANA SUK FORMATION, TRANS INDUS RANGES, PUNJAB, PAKISTAN

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Abstract
The Samana Suk Formation is recognized as the most prominent stratigraphic unit in the Upper Indus Basin of Pakistan. The Sequence is extensively exposed in the Hazara Kashmir basin and southward extended to Lower Indus Basin with different nomenclature. It is an integral part of the Mesozoic era. For present comprehensive examination, the Chichali Nala section of the Surghar Range is chosen. Based on field, petrography and geochemical analysis it is concluded that the Formation possesses two decent lithologies i.e. limestone and dolomites. The dolomites are secondary in nature therefore only limestone unit is examined for the paleoenvironmental analysis. For the first time in the Indus Basin, the petrographic results are integrated with geochemical results for paleoenvironmental analysis. Based on the petrographic observation various microfacies are developed and interpreted. The Grainstone microfacies represent the near shore, high energy, shallow water bar, beaches and shoals environments. The Wackestone microfacies characterizes inner shelf environment below fair-weather wave base. The high bioclasts fragments of Grainstone and Wackestone microfacies signify stormy influence in the environment of deposition. Based on flora and fauna and physical factors, overall environment of deposition is professed to be inner to middle shelf environment. The trace element geochemistry is performed to find out the relation between the sea level fluctuation trace element content. The trace element shows a good response to the sea level fluctuations. The Sr values show the salinity level which increases and decrease with sea level. Likewise, the Fe and Mn values indicating the detrital influx which display a positive response to the sea level fall and rise. The Mg and $Caco_3$ curves also show a positive correlation in diagenetically unaltered unites. The diagenetic fabrics are deeply studied by linking field, petrographic and geochemical observations. The above-mentioned signatures reveal that the dolomitization is only restricted to the faulted zone. It is assumed that the fluid moves along the weak faulted horizon from the below clastic succession. The X-Ray diffraction peaks results show that the crystals of the dolomites are not well developed. Overall, the diagenetic fabrics and geochemistry show that the stratigraphic unit is subjected to shallow marine fresh diagenetic phase to deep burial diagenetic phase.

Keywords: Samana Suk Formation, Paleoenvironment, Diagenesis, Geochemistry

RUNOFF ANALYSIS TO DEVELOP A NEW RESERVOIR AT THE UPSTREAM OF KHANPUR DAM

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Abstract

The main problem in hydrology is to collect field data to describe the hydrological process acting on the earth. Only Remote Sensing is a tool, which produces spatial and temporal information in digital form with high resolution. Remotely sensed data provide spatial information about the various processes of the hydrological cycle. The utilization of remote sensing information along with distributed hydrological model, gives new potential outcomes for inferring spatially distributed time series for input variables. In this work, remote sensing techniques have been used to perform runoff analysis for the development of new reservoir at upstream of Khanpur Dam. Arc Hydro tools were utilized to find out catchments and drainage accumulation points of Haro River at the upstream of Khanpur Dam. The Digital Elevation Model of 30 m resolution is used for this study. By studying past 23 years data of average annual inflows, average annual spills and average utilization of water is 0.228217 MAF, 0.084164 MAF, 0.144053 MAF respectively at Khanpur Dam was also studied to find out the unutilized water at the Khanpur From these facts it is clear that half of water is spilled out from Khanpur Dam yearly at time of excessive rainfall due to less space in Khanpur Dam. To utilize this water there is a need for an additional storage on Haro River. For this purpose a new dam site is proposed at the upstream of Khanpur Dam near Dotara village. The storage capacity of new dam was also found. The results obtained from this research can be effectively utilized, for the construction of Dotara Dam in future.

SEQUENCE STRATIGRAPHY AND RESERVOIR CHARACTERIZATION OF THE MUGHAL KOT FORMATION, MUGHAL KOT SECTION, CENTRAL INDUS BASIN, PAKISTAN

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Abstract

The Mughal Kot Formation exposed in the Mughal Kot Section is studied in the context of sequence stratigraphy and reservoir characterization. The rock unit is composed of 1100m thick mix carbonate and sandstone sediments. A total of 86 samples were taken and analyzed. The petrographic studies indicate four microfacies namely Pelagic Mudstone, Orbitoidal Wackestone, Quartz Arenite and Quartz Wacke. The Orbitoidal Wackestone microfacies encounter the lowermost part of the rock unit which suggests deposition in the inner shelf environment. The Quartz Arenite and Quartz Wacke shows deposition in the outer slope settings while the Pelagic Mudstone microfacies indicate deposition in the deep marine settings. Such an expanded thickness of the hemipelagic sediments with alternated turbidity sandstone suggest sustained transgression with pulsated tectonics in this part of the Central Indus Basin. There are two 3rd-order sequences interpreted in the rock unit which shows TST, HST and LST. This is bounded by ten marine flooding surfaces and nine para-sequences. The sequence stratigraphic model of the strata does not show similar architecture with global eustatic curve because of the intense local tectonics in the region. Microfacies studies, SEM analysis and plug porosity/permeability data shows very less chances for petroleum accumulation because no remarkable porosity/permeability values have been examined and overall reservoir potential is characterized as very poor.

MORPHOMETRIC ANALYSIS OF ALVEOLINIDAE FROM EASTERN NEO-TETHYS, LOWER INDUS BASIN, PAKISTAN; IMPLICATION FOR BIOSTRATIGRAPHY, PALEOECOLOGY AND PALEOBIOGEOGRAPHIC RECONSTRUCTION

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Abstract

For the first time from eastern Neo-Tethys southwest Pakistan, the genera Alveolina is studied for detailed morphometry, biostratigraphy, paleoecology and paleobiogeography reconstruction. The late Paleocene and early Eocene Lakhra and Laki formations are selected for the present research. Four sections were logged and sampled including Khanu Brohi, Lakhra Anticline, Jurackpur and Bara Nala sections in the Laki Range, Lower Indus Basin, Pakistan. Morphological parameters such as proloculus (size and shape), various evolutionary stages (adult, nepoinic and geronitic), axial and equatorial diameters, index of elongation, basal width, whorl numbers and pattern, chamberlet arrangement, secondary chamberlets, and species shape are considered for morphometric analysis and species identification. Thirteen species of early Ypresian stage are identified. These species are *A. vredenburgi*, *A. avellana*, *A. ellipsoidlies*, *A. ellipitica*, *A. dedolia*, *A. pasticillata*, *A. subpyrenaica*, *A.* cf. *subpyrenaica*, *A. conradi*, *A. moussoulensis*, *A. aragonensis*, *A. decipiens* and *A. cylindrata*. From late Ypresian seven species are identified including *A. canavarii*, *A. oblonga*, *A. haymanensis*, *A. ilerdensis*, *A. ruetimeyeri*, *A. Lehneri* and *A. cosigena*. From Lutetian stage, four species are identified including, *A. cuspidata*, *A. rakoveci*, *A. azzarolii* and *A. stercusmuris*. The reported species represent biostratigraphical zones ranging from (Smaller Benthic Foraminiferal Zone) SBZ 5 to SBZ 13. *A. subpyrenaica, A. cf. subpyrenaica, A. decipiens, A. oblonga, A. canavarii, A. haymanensis, A. ruetimeyeri* species represent proximal inner shelf settings, while *A. vredenburgi, A. ellipsoidlies, A. avellana, A. pasticillata, A. moussoulensis, A. aragonensis, A. ellipitica, A. conradi A. cylindrata, A. cosigena, A. lehneri, A. ilerdensis, A. cuspidata, A. rakoveci, A. azzarolii, A. stercusmuris species* represent distal inner shelf setting. The above mentioned assemblages of Alveolina are reported from across the Tethys during early to middle Eocene time including; (1) Laki Range, Lower Indus Basin, Pakistan, (2) Salt Range, Upper Indus Basin, Pakistan, (3) Malaysia, (4) Madagascar, (5) Northern Egypt, (6) Sicily, (7) Greece, (8) Turkey, (9) Central Italy, (10) North East Italy ,(11) Northern Spain , (12) Pyrenean Basin, Pyrenean, (13) Southern France. It is noted that these assemblages were distributed in both hemispheres 43˚ N and 43˚ S across equator in Tethys. The minimum temperature requirement for the living LBFs is 18˚C which is hardly possible upto 34˚N and 34˚ S in the existing oceans. Based on the minimum temperature requirement (i.e., 18˚C), the habitat of extant foraminifera of similar genus (i.e. Alveolina) is restricted to tropics. Therefore, the widespread occurrences of Alveolina in the early Eocene times reaching to relatively higher latitudes (i.e. 43˚ N and 43˚ S) in both hemispheres is attributed to early Eocene warming due to which the oceans at even higher latitudes became warmer and favorable for the survival of foraminifera like Alveolina.

Keywords: Alveolina, Morphometric Analysis, Biostratigraphy, Paleoecology, Paleobiogeography

PROVENANCE OF BARA FORMATION, SOUTHERN INDUS BASIN, PAKISTAN

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Abstract

The Bara Formation at Bhit Nala Section (BHNS) deposited during Middle Paleocene in southern Indus basin is evaluated for its provenance based on petrography, major element geochemistry and heavy mineral analysis. Lithologically, the Bara Formation is mainly composed of sandstone which is interbedded with conglomeratic sandstone, siltstone, carbonaceous shale, and mudstone. The petrographic study reveals the fine to very coarse quartz grains along with subangular to subrounded grain shape and poor sorting. The feldspar and lithic fragments are in traces with abundant ferruginous cement and matrix. Based on modal analysis of Bara Formation sandstone it is dominantly Ferruginous Quartz Arenite and Ferruginous Quartz Wacke. Its sediments were originated mainly from craton interior along with the influence from recycled orogen setting. The Bara Formation sandstone is rich in silica, iron, calcium and aluminum while the other major elements are in low concentration. The plotting of major element geochemical data of CHNS (Carbon, Hydrogen, Nitrogen and Sulfur) on discriminatory diagrams show that the studied sediments were produced dominantly from passive margin (PM) along with few samples plot in Active continental margins (ACM) and in granitic/felsic provenance field. The intense chemical weathering is established by the high CIA (Chemical Index for Alteration) values. The heavy minerals of Bara Formation are in low concentration ranging from 0.1% to 1.4% with an average of 0.4%. The low ZTR (Zircon, Tourmaline and Rutile) index values of Bara Formation sediments exhibit cratonic provenance while the high concentration of ultra-stable heavy minerals shows intense chemical weathering. The Bara Formation sediments were dominantly produced at passive continental margin (PM) from cratonic rocks along with some influence from active continental margin. Its depositional site was situated close to the equatorial region, where chemical weathering was moderate to intense. Therefore, the sediments of Bara Formation were derived from Indian craton exposed in the south east of study area while the source of southern Indus basin sediments was located close to the equatorial region.

EFFECTS OF INTRINSIC PROPERTIES ON THE PHYSIO-MECHANICAL CHARACTERS OF MAFIC-ULTRAMAFIC ROCKS FROM THE JIJAL COMPLEX, NORTHERN PAKISTAN

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Abstract

The intrinsic characteristics including textures, mineralogy and degree of weathering of the mafic and ultramafic rocks of the Jijal complex are investigated and correlated with their respective physical, mechanical and aggregate properties. The studied samples include clinopyroxenite (CP), serpentinite (SP), garnet granulite (GG) and hornblendite (H). The former three rock types are ranging from fine to medium grained, while the hornblendite is very coarse-grained rock. The clinopyroxenite exhibit granular texture with very less degree of alteration. The serpentinite contains abundant serpentine as a secondary mineral which is formed by the alteration of primary clinopyroxene and olivine. The mono-mineralic hornblendite have prominent fractures both in hand specimen and microscopic view. The garnet granulite sample contains highly fractured garnet with hornblende and chlorite as secondary product formed due to the alteration of primary clinopyroxene. The physio-mechanical and aggregate properties including unconfined compressive strength (UCS), unconfined tensile strength (UTS), specific gravity, porosity and water absorption, ultrasonic velocity (USV), Los Angeles abrasion (LA), impact value (AIV) and bulk density of the studied samples were also determined. The UCS and UTS values for clinopyroxenite and serpentinite falls in category of strong rocks while hornblendite and garnet granulite sample shows relatively weak character. Based on the mechanical tests results, the clinopyroxenite samples are recommended to be used as coarse aggregate in construction projects. Due to higher degree of alteration, the serpentinite and garnet granulite are relatively proved to be low quality aggregates while hornblendite is not recommended to be used as aggregate material due to its low strength and coarse-grained nature. The statistical analysis between intrinsic features and physio-mechanical properties reveals an adverse effect of weathering degree on the strength, elastic moduli, LA and USV. Higher degree of weathering not increases the abrasion of rocks but also enhances the strain during compressional conditions.

PALYNOLOGY OF THE RHYTHMITE DEPOSITS OF PESHAWAR BASIN, NW PAKISTAN

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Abstract

The preservation of organic matter (OM) in the rhythmite deposits of Peshawar Basin can be used as one of the important tools for determining the paleo-climatic conditions and the source of OM during the time of deposition as they are sensitive towards the fluctuations in the environmental conditions caused by climatic and/or anthropogenic sources. Conventionally, palynofacies are determined using the Tyson Ternary Chart which limits its applications to marine environments, and it is inadequate to apply the same model in order to develop terrestrial facies. Alternatively, we used the abundance of each particulate organic matter to carry out the palynofacies analysis of the studied sections. Composite samples from five different sections were prepared and processed for palynofacies analysis. The constituent Phytoclasts, Amorphous organic matter, pollen and spores were studied, and their respective percentages are used to assign depositional environment to these rhythmite deposits. Some important age diagnostic species are also identified which belong to the Pleistocene age. Based on the palynological correlation it is found that all these sediments were deposited in relatively calm environment preferably of lacustrine origin. The rhythmites present are also typical of low energy lacustrine deposits and burrowing activities were also observed during the field studies in two of the studied sections which are preserved in massive mudstone beds intercalated within the rhythmites.

KINEMATIC EVOLUTION OF THE EARLY CAMBRIAN AMBAR FORMATION, KHYBER PAKHTUNKHWA USING FINITE STRAIN

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Abstract

Penetrative strain analyses in the Early Cambrian Ambar Formation were conducted by microscopic measuring the state of strain to establish the tectonic setup of the study area in regional tectonic context. The state of finite strain was calculated for the Ambar Formation, using elliptical ooids and quartz grains. Strain ellipses were generated for four oriented samples, having abundant strain markers on the photomicrographs, obtained from the oriented thin sections using the Fabric 8 software. These strain ellipses were obtained using the normalized Fry method. Analyses of elliptical ooids, strongly oriented quartz grains, elongated clasts, tectonic stylolites and differentiated cleavages in the oolitic limestone/dolomite and calcareous quartzite of the Ambar Formation display a systematic regional arrangement. Overall, they accommodated NE-SW shortening. The opening of veins perpendicular to these structures accommodated extension in the SE-NW direction. Analyses of elliptical ooids and quartz grains show an overall 14.59 % shortening in the region. The SE-NW trending Swabi Synclinorium and Shewa Anticlinorium correspond with the NE-SW shortening in the region. Being a part of the SW limb of the Swabi Synclinorium, the Ambar Formation would have been deformed in the SE-NW direction during the evolution of the Swabi Synclinorium and Shewa Anticlinorium. Analyses of microscopic structures and penetrative finite strain direction in the oolitic limestone of the Ambar Formation accommodated shortening parallel to the trend of the Swabi Synclinorium and Shewa Anticlinorium.

EFFECT OF LIME AND WHEAT STRAW ON OPTIMUM MOISTURE CONTENT AND MAXIMUM DRY DENSITY OF CLAYEY SOILS

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Abstract

Compaction characteristics of soil are of significance for any of a civil engineering project. Adequate degree of compaction is necessary prior to the construction of a structure in or on the surface of earth. In many of these cases without adding stabilizing agents the required degree of compaction may not be achieved. The addition of soil stabilizing agents may also change the optimum moisture content (OMC) and maximum dry density (MDD) of the soil. Therefore, prior to compaction, it is necessary to determine the effect of soil stabilizing agents on the compaction parameters. In this paper the effects of lime and wheat straw were investigated on OMC and MDD. A series of test was conducted using various percentages of lime and wheat straw added into the clayey soil. After dry mixing of stabilizing agents with soil, the samples were tested through modified proctor compaction to determine the OMC and MDD. The test results suggest that by the increase in lime and wheat straw contents, there is increase in the optimum moisture content of the soil and decrease in the maximum dry density. For instance, the optimum moisture content increased from 16% to 24% by adding 10% of wheat straw and similarly, the optimum moisture content increased from 16% to 22% by adding 10% of lime in to the soil. On the other hand; the maximum dry density decreased by 18 kN/m3 to 15.5 kN/m3 and 18 kN/m3 to 12.8 kN/m3 by adding 10% of lime and wheat straw respectively.

TO EVALUATE THE ENGINEERING PROPERTIES OF CLAYEY SOIL THROUGH GLASS POWDER AND QUARRY DUST

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Abstract
Soil is one of the most important and primary media for any construction work. The strength and durability of any structure depends on the strength properties of soil. Soil also performs a range of ecosystem services like nutrient cycling and water filtration. Engineering geology and Geomechanics is very significant in civil engineering, but also as the root of sustainability. The soil behaves as an engineering material and provide a valuable resource for construction. Whenever soil act as an engineering material and load applied on it so failure occur in it which is General, local and punching shear failure and other types etc. The study shows the techniques of soil that are considered as they improve soil quality, strength and other engineering properties, while reducing the industrials wastes such as glass powder and quarry dust. The research uses slide software to find out the strength of the soil that is sustainable. In this study, survey was conducted and low strength soil were collected, glass powder and quarry dust were added in percentage (5 to 15%). The condition of soil was determined by a series of modern techniques, while keeping the strength of soil in our mind, increases upto addition of glass powder and quarry dust 10%. We have performed some of test like Modified Proctor Test (MPT),CBR, EDAX, SEM, Specific gravity test and Atterberg limits to visualize engineering properties of soil. The result demonstrated that slide software can adequately measure the strength of soil, quality and reducing industrials wastes (Glass Powder and Quarry Dust).

Keywords: California Bearing Ratio (CBR), Energy Dispersive X-ray spectrometry (EDAX), Scanning Electron Microscope (SEM), Atterberg limits

INVESTIGATION OF GROUND CONDITIONS FOR THE UTLA DAM PROJECT, GADOON REGION, NORTHERN WESTERN PAKISTAN

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Abstract

The detailed investigations of ground conditions prior to the construction of dam or any other large engineering structure is the prime aim of engineering geological studies. An adequate assessment of geological and geotechnical conditions of dam-site is one of the most important aspects of a dam safety evaluation. The ground conditions of a Utla Dam have been examined in the current study. The Utla dam is a small-scale dam, proposed by Government of Khyber Pakhtunkhwa in Gadoon region, Swabi district, NW Pakistan mainly for the water storage for drinking and irrigation purposes. The feasibility of the Utla Dam site has been established through various field tests and site exploration and assessment. The site exploration of the case study has been conducted through boreholes where in-situ testing has been conducted. The data of the two boreholes, coded as BH1 (35m) and BH2 (20m) have been accessed which were drilled along the axis of the proposed dam sites. The detailed borehole logging indicates that majorly the over-burden is underlain by felsic rocks i.e. Utla granites. The overburden is largely comprised of compacted soil, gravels and boulders of plutonic nature. The geological investigation for ground conditions have been done via different in-situ testing procedures including field permeability test and water pressure test. These procedures determine the water loss in the overburden and bedrock. The granites which constitutes largely the bedrock are physically and mechanically hard enough to bear the capacity of the proposed dam foundation. The smaller values of the field permeability tests conclude that natural permeabilities barriers are present in the over-burden. The over-burden of the study area consists of clasts of igneous origin, finer sand, silt and clayey materials that fills the pore spaces and resist the channel flow, hence cause subtle water loss. Such conditions are always sound to the construction of small- or large-scale engineering structure. The lugeon values, obtained from the water pressure test in the boreholes are varying greatly with increasing depth. These values are low at shallow depth which points towards the well grouted conditions of the shallower log units. The leaching of finer material from the over-burden into the shallower units has been the most probable reason of joints filling at shallower depth. The higher values of Lugeon tests at greater depth suggests open jointing of bedrocks at certain depth. Grouting has been suggested for thorough filling of joints and reducing the water loss under controlled conditions.

IDENTIFICATION OF POTENTIAL UNSTABLE CUT SLOPES AT INTAKE AREA OF TARBELA 4TH EXTENSION HYDRO POWER PROJECT".

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Abstract

A rock mass engineering of the geotechnical parameters was Tarbela dam 4th extension hydropower project site area, near Topi village district Haripur KPK which lies in the mountain terrains of lesser Himalayas and consists of mainly three formations namely Abbottabad formation, Hazara formation and Salkhala formation.

Dam play a vital role in water supply, flood control, irrigation, navigation, sedimentation control, and hydropower production. The study was done to determine the stability of rock slopes along the intake area of Tarbela dam for the purposes to prevent any type of slope failure, to prevent any erosion of surface material and to avoid any type of rock mass weathering due to change in climatic conditions. Any kind of slope failure may lead to disruption in vertical shafts of Tunnel T-3 &T-4. This study consists of three parts: field, laboratory and office works. The field work is comprised of Detailed Engineering Geological Mapping of excavated Slopes on the base map with the help of survey machine (i.e., Total Station). Orientation/discontinuity data (dip/ strike/ dip direction) was recorded for all marked zones with the help of Brunton Compass. Geological map prepared in the field was finalized, colored and reproduced in Auto CAD and Detailed Scan line Survey carried out by ISRM Suggested Methods. And also utilizing data of ten bore holes in the intake area. Laboratory test show that the unconfined compressive strength (48mm sample diameter) of dolerite rock average strength 95.55 Mpa, these rock are strong. The unit weight test was also conducted which result show that average unit weight is 90.225. Kinematic analysis and limit equilibrium analysis was carried out by using softwares Rocscience Dips 5.1 for plane failure, Rocscience swedge for wedge failure and Rocscience rocplane for factor of safety to evaluate the rock mass engineering is used to determine the stability of rock slopes. From the results three slope failures namely plane failure in (JS-O1), wedge failure in (JS-01 / JS-02 and JS-02/JS-03) and toppling in (JS-01 and JS-04) were identified and factor of safety were less than one which is potentially unstable slopes.

CHARACTERISTICS AND SIGNIFICANCE OF THE PILLOW LAVA GEO-HERITAGE IN QUNRANG OF SHIGATSE, TIBET

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Abstract

The pillow lava originates from the pillow basaltic lava in the mid-ocean spreading ridge, including basalt and spilite, and there is a lava geo-heritage located in the joint area of three villages: Qunrang, Gangta and Duigang of Jiacuosong Township, Sangzhuyi District, Shigatse City, Tibet, China. Exposure pillow lava is distributed in the hillside of the south bank of the downstream Nyangchu River on the northern slope of the Himalayas. The colors of the rocks vary from deep gray to green gray, and appear rusty due to weathering. The pillow length differs from centimeters to meters, and the rocks appear either pulvinate or spherical, spherical, ellipsoidal, cylindrical, tubular and kidney-shaped, with pillow, vesicular, almond-like and breccia structures. The heritage lies in the mid-northern part of the Yarlung Zangbo Suture Zone characterized by the Ophiolite. The heritage is located in the upper layer of the Shigatse Ophiolite Zone. And as originated from the seabed basalt eruption in the Tethys ridge and the plate subduction that led to the ultimate close of the Hymalayas-Tethys Ocean, it has typical character of the tholeiitic basalt in the mid-ocean ridge, providing evidence of collision between the Eurasian and the Indian Plate. Furthermore, it has significant meaning in research of the geological history and evolution of Tibet Plateau.

A NOVEL APPROACH TO VALUE AND CONSERVING THE GEOHERITAGE OF PESHAWAR BASIN, KP PAKISTAN: IN ASPECT OF GEOSCIENTIFIC AND ACADEMIC IMPORTANCE

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Abstract

Every region has various distinctive geological and geomorphologic landscapes which establish its geoheritage. With the passage of time, the development processes demolishes many of these features and this loss compels the conservation of typical and/or spectacular features which explain the geological process over geological time or otherwise attract interest due to their splendid chromatic physiognomies. Geoheritage has been abandoned feature in the conservation landscape of Pakistan, particularly in Khyber Pakhtunkhwa province. The proposal of this work is aimed at creating an opportunity to raise awareness of the most venerable geological features present in the different areas of Khyber Pakhtunkhwa Pakistan. In Pakistan, particularly in Khyber Pakhtunkhwa province, there is little awareness of the significance of our geological heritage outside academia and industry. There is a need to develop and conserve this geological distinctiveness identifying and understanding the scientific value of the features and landforms. This article presents the results of a detailed geological field work to Nowshera reef complex and Gaju Gundai (Gohati Rhyolite). These two outcrops are very important on Geo-heritage perspective. The first Nowshera reef complex is the only coral reef body which represent all the three part i.e. back reef, core reef and front reef in Pakistan. This formation is important for studying the Paleozoic Paleogeography, paleoclimatology and paleotectonic configuration in Pakistan. Furthermore, this formation is also important to establish the relation of Peri-Tethyan Indian domain to Tethyan and Peninsular Indian domain. The second igneous body is the Gohati rhyolite (Gajju Gundai). This formation has its own scientific importance as it represent the lone easily accessible Cenozoic volcanic activity in Pakistan. This is an isolated body where students and researchers of Geology can easily observe all the volcanic activities from lava flow to volcanic ash (tuff). Scientifically, it is deposited by a hot spot which make it important in formulation of plate movement and it regional placement in continues time domains. Importantly, these outcrops are closely located to major scientific research centers in the country. It is in these range of less than 100 km of major 10 universities and federal and provincial capitals which make it easy and economical to research these outcrops. These important features are under constant threat of extinction because its pervasive use for building material. In addition, protection of the described geosites, and in general of the geological heritage of the whole Peshawar basin, would be possible through the introduction of a specific regional law, Considering the fact that criteria for geodiversity valuation are neither agreed upon nor acknowledged by regulations. This may also happen through public initiatives aimed at increasing a consciousness about the richness of this geological heritage within the local population.

FORAMINIFERAL BIOSTRATIGRAPHY AND MICROFACIES ANALYSIS OF THE PALEOCENE (THANETIAN) LOCKHART LIMESTONE FROM YADGAR SECTION, MUZAFFARABAD AND NAMMAL ROAD SECTION, MIANWALI, PAKISTAN

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Abstract

This study mainly involves the biostratigraphy and microfacies analysis of the Lockhart Limestone from two different sections i.e. Yadgar Section, Muzaffarabad, and Nammal Road Section, Mianwali, Western Salt Range. The second part of the study includes the correlation of both sections. Both sections were studied in detail during field investigations and were also petrographically analyzed. Both sections report significant abundance of genus Miscellinidae, especially the species *Miscellanea miscella*, present throughout the whole thickness. Furthermore, genus Lockhartia and genus Ranikothalia are also found quite abundantly. The basal part of Lockhart Limestone in Yadgar Section represents a restricted lagoonal or tidal flat environment. The middle part is characterized by shallow shelfal waters with moderate circulation and genera which indicate an open lagoon, lagoonal channel and subtidal environments. The upper part is characterized by higher energy sediments with reworked fossils, closely packed together displaying a shift toward shoreface, representing a depositional setting of tidal flat environment. The environment of Lockhart Limestone at Nammal Road Section is comparable to Yadgar Section, but the facies shift pattern varies. Here, the bulk thickness of the Lockhart Limestone is characterized by the reworked fossils and relatively higher energy deposits, typical of shoal environment. The major portion of middle part is characterized by lagoon deposits. As a whole both sections represent inner ramp settings.

DEVELOPMENT AND UTILIZATION OF OILFIELD GEOTHERMAL RESOURCES IN PAKISTAN

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Abstract

Geothermal energy is a clean, independent from meteorological conditions, environment friendly and economical source of energy. Geothermal energy has remarkable prospective for the utilization of space heating, cooling and power generation and can make a considerable contribution to global energy supplies. Current study discusses the growth status of geothermal energy, possible resources, exploitation and consumption modes, advantages and drawbacks of oil-field geothermal resource in Pakistan. Due to high heat requirement in oil and gas fields, geothermal energy development and utilization can be effectively replace fossil fuels, and has intensive prospects. The idea of utilization of abandoned oil and gas wells for low cost development of electricity generation by using binary power plant is also discussed. This study presents a pathway of power generation system for feasible electricity generation at two different basis temperatures (i.e.142°C, 157°C).Furthermore, this study suggest that a 12- inch borehole heat exchanger at depth of 3000 m, can extract satisfactory heat energy to run a 3 MW turbine. The key issues limiting oil-field geothermal energy development and consumption are also demonstrated in this study along with economic assessment, lack of planning, lack of principles in resource assessment, and absence of incentive policies. From the outcome of our study it can be concluded that purposed concept will not only overcome the energy demands of progressing countries like Pakistan, but also reduce the investment of petroleum industry.

HYDROCARBON POTENTIAL OF LOWER INDUS BASIN, PAKISTAN

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Abstract

Lower Indus Basin is one of the most studied sedimentary basins of Pakistan.This basin is bounded to the north by Central Indus basin, to the northwest by the Sulaiman and Kirthar basins in the south west. The main factors which controlled structures and sedimentology of Lower Indus basin is rifting of the Indian plate. In the context of petroleum exploration and success ratio, it is the more successful basin. A total of 201 wells are drilled in the basin,out of which 35 oil wells and 37 gas wells makes a very good successful ratio up to 36%, which differentiate this basin from all other basins of the region. The lower Indus platform basin is underlain by infra-Cambrian to recent clastics and carbonates. In this basin,a total of six proven and possible plays are identified, where a complete petroleum system exists. In this part,the early Cretaceous rocks are considered as the potential source rocks for hydrocarbon generation. Similarly, Cretaceous to Eocene carbonates and clastic rocks are considered as best reservoir rocks. Some of the rocks are also acting as seal rocks including Cretaceous intra-formational shales. The Indus Basin is accompanied by different structural events that makes a unique way of traping mechanism. Such combination of source, reservoir, seal and traping mechanism made Lower Indus Basin the more potential basin in the context of petroleum accumulation.

PORE SIZE DISTRIBUTION AND RESERVOIR EVALUATION OF THE EOCENE BEACH-BAR SANDSTONE, DONGYING DEPRESSION, CHINA BY USING MICP, NMR AND MICRO-CT

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Abstract

The pore size distribution and associated heterogeneities of thinly bedded beach-bar sandstone reservoir from upper fourth member of Eocene Shahejie Formation (Es4s) are characterized with the help of mercury injection capillary pressure (MICP) and nuclear magnetic resonance (NMR) transversal relaxation time ($T2_)$ data. Permeability and porosity are two represented important characteristics of rocks that control the movement and storage of fluids. The aim of this paper is to establish relationships between pore throat sizes and reservoir quality. The results derived from thin-section petrography, scanning electron microscopy (SEM), MICP, NMR T_2 relaxation time, and 3D micro-CT (μ-CT) are compared to characterize pore space dimensions and types comprehensively. The average pore throat size from MICP ranges between 0.47μm to 2.83 μm while the maximum pore throat size ranges between 2.48 μm to 7.36μm.The combination of pore size distribution obtained from MICP, NMR seems appropriate to cover the range of pore sizes from beach-bar sand and overcome the individual method limits. Afterwards, Digital 3D μ-CT tomographic images are used to characterize and visualize pore space and pore network model and compare those with the experimental data. MICP and NMR experiment show generally bimodal (meso and micro) pore size distribution. Usually mesopore corresponding to intergranular pores are dominant, while the heavily cemented sandstones show large amounts of intercrystalline micropores. Thus the evaluation of the complex and heterogeneous beach-bar sandstone reservoir requires a comprehensive study program.

Key Words: NMR T_2; MICP; Pore size distribution; porosity; 3D μ-CT; Pore network model.

INTERPRETATION OF PALEODEPOSITIONAL ENVIRONMENT USING BIOMARKERS AND CARBON ISOTOPE ($\Delta^{13}C$); A CASE STUDY FROM TALANG AKAR FORMATION, SOUTH SUMATRA BASIN, INDONESIA

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Abstract

Understanding depositional environment of a source rock is critical to source rock characterization. Upper Oligocene, Talang Akar Formation is a proven hydrocarbon source rock in South Sumatra basin, Indonesia. The formation contains dominant shale at the top, with some sandstone interbeds. Whereas it contains coarse to very coarse sandstone beds at the bottom. The lower sandstone unit also contains carbonaceous shale and some coal seams. This study uses 3 crude oil sample and 10 well-cutting obtained from two well (SMT-1 & SMT-2) in Prabumulih oil fields, South Sumatra Basin. Biomarkers and carbon isotopes ($\delta^{13}C$) data used to determine the paleodepositional environment of Talang Akar Formation. The biomarkers data were obtained from gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS) analysis of normal alkanes, isoprenoids, triterpene, and steranes. Carbon isotopes ($\delta^{13}C$) include saturated and aromatic fractions. The pristine (Pr) to phytane (Ph) ratio is a good indicator of the depositional environment. Higher values of Pr/Ph ratio i.e. $\geq$3.0 indicate oxidizing conditions i.e. terrestrial while lower values in the range of 1.0-3.0 suggests siliciclastic-dominated marine conditions. However, very low values i.e. $\leq$ 1.0 indicate reducing conditions or fresh and brackish water conditions. The results in this research show that Pr/Ph ratios range from 7.90-16.66, characteristic of high wax crude oils, primarily originated in fluviatile and deltaic environment containing a significant amount of terrestrial organic matter. Similarly, the resultant ratios of Pr/n-C_{17} and Ph/n-C_{18} in SMT-1 and SMT-2 wells range from 0.91-10.72 and 0.11-1.29 respectively, which reflect that most of kerogen was derived from humic source and tend towards an oxidative environment of deposition. Cross-plot of carbon-13 isotopes ($\delta^{13}C$) shows saturated versus aromatic fraction. The resultant plot indicate a deltaic to marginal marine environment for SMT-2 well and a more marine environment for SMT-1 well. The oil/source rock correlation analysis using biomarker data shows that the oils in Prabumulih field is correlated with the oils in source rock of Talang Akar Formation. This study concludes that the source rock contains abundant humic organic matter that was deposited in a transitional (Fluvio-deltaic) to marginal marine environment under oxic conditions

PETROGRAPHICAL AND PETROPHYSICAL ASSESSMENT TO EVALUATE THE RESERVOIR POTENTIAL OF THE UPPER PERMIAN ZALUCH GROUP, UPPER INDUS BASIN, PAKISTAN

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Abstract

The Late Permian Zaluch Group is researched and modelled for their reservoir properties using petrographic and petrophysical analyses in the Upper Indus Basin. Three outcrops sections, i.e. Zaluch, Nammal, and Gulakhel gorges and ditch cuttings from Bahu-01 Well were used for petrographic studies. Petrophysical data was used from Isakhel-01, Dhermund-01, Khaur Oxy-01 and Bahu-01 wells located in the Potwar sub-basin.

The petrographic studies showed, that only one facies, i.e. the siliciclastic wackstone of the Amb Formation represemted good porosity values which is uniformly distrubuted in the basin. The quartz wackstone and dolomite facies of the ovlerying Wargal Formation indicated good porosity value, however the distribution of quartz wackstone is restricted to western corner of Upper Indus basin, while dolomite facies is uniformly distributed within it. In Chhidru Formation, only sandstone facies can be treated as prospective facies in terms of porosity which showed great thickness in southern part of the basin. Based on petrophysical analysis, Average porosity (Φ_A) and Effective porosity for the Amb Formation (Φ_E) increased towards northeast and decreased towards southwest. Permeability increased in the Trans-Indus Basin, while Cis-Indus Basin showed fair permeability (k) values. The Volume of shale (Vsh) is higher in Potwar Basin as compared with the Punjab plain. For Wargal Formation, Average porosity (Φ_A) and Effective porosity (Φ_E) increased towards south and decreased towards north. The Permeability increased in the Trans-Indus Basin, while Potwar Basin, Punjab plain and Central Indus Basin showed fair to poor permeability (k) values. The volume of shale (Vsh) is low in the Potwar Basin and high in the Punjab plain. For Chhidru Formation, Average porosity (Φ_A) and Effective porosity (Φ_E) increased towards south and decreased towards north. Permeability increased in the Cis- and Trans-Indus basins, while Punjab plain and Central Indus Basin showed fair to poor permeability (k) values. The volume of shale (Vsh) is lower in the Potwar Basin and higher in the Punjab plain. The primary porosity is severely destroyed by diagenetic events, hence producing secondary porosity, making them good reservoirs across Potwar sub-basin.

DEVELOPMEMT AND DISTRIBUTION OF LATE PERMIAN WARM WATER CARBONATES ON SUBTROPICAL DYNAMIC TETHYAN INDIAN SHELF

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Abstract

The warm water Late Permian Zaluch Group, i.e. Amb, Wargal and Chhidru Formations were researched for their development and basinal distribution on microfacies level through petrographic and petrophysical data in the Upper Indus Basin. For petrographic analysis, the data of three Outcrops i.e. Zaluch, Nammal, and Gulakhel gorges and ditch cuttings from Bahu-01 Well were used. The petrophysical analysis is carried out with well data from Isakhel-01, Dhermund-01, Khaur Oxy-01 and Bahu-01 wells. The basin-wide distribution of the formations showed, that during Late Permian, the carbonate shelf was continuously shifting from south-east to north-west. In Late Permian, the Wordian Amb formation marked the most extended carbonate on the Peninsular Indian and Tethyan shelf. It is extended from Rajistan basin in SE India and culminated in Kohat basin in NW with maximum thickness within upper Punjab platform. The Capitanian Wargal Formation is restricted to the Upper Indus Basin with depocenter in eastern Salt Range. The Changhsingian Chhidru Formation further moved to northwest with limited presence in NW of Upper Indus Basin having depocenter in Trans-Indus basin. Overall, the shelf moved to northwest from south east during Late Permian time. The Amb Formation yielded four microfacies, i.e. bioclastic packstone (AM-1), silicicalstic bioclastic wackestone (AM-2), bioclastic wackstone (AM-3), and siliciclastic wackstone microfacies (AM-4). The facies modelling showed that facies AM-1 is thickly deposited in the south and northeastern part of the basin, while facies AM-2 is mainly present in north of the basin. Facies AM-3 and AM-4 are uniformly distributed throughout the basin. The overlying Wargal Formation contained five microfacies, i.e. bioclastic peloidal grainstone (WR-1), algal stromatolitic mudstone (WR-2), quartz wackstone (WR-3), dolomitic mudstone (WR-4) and bioclastic packstone microfacies (WR-5). Facies WR-1 and WR-5 decreased in thickness towards SE and increased towards NW. The facies WR-2 showed good thickness in the north while facies WR-3 is restricted to the west of the basin. Facies WR-4 is found to be uniformly present in the basin. The Chhidru Formation had four facies, including siliciclastic mud-wackestone (CF-1), sliciclastic packstone (CF-2), siliciclastic wackestone (CF-3) and sandstone facies (CF-4). The facies CF-1 and CF-3 are widely and evenly distributed in the basin. Facies CF-2 is comparativley more thick in north, while facies CF-4 is thick in the south. Overall, the changes in thickness and composition of microfacies showed a continuously changing dynamic paleoenvironment and fluctuating sea level in the Late Permian time.

CHARACTERIZATION OF PETROGRAPHIC AND PETROPHYSICAL PROPERTIES FROM 3D DIGITAL ROCK IMAGES: A CASE STUDY ON BEACH-BAR SANDSTONE OF BOXING SAG, EAST CHINA

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Abstract

To identify and elucidate pore types, connectivity and distribution in a texturally low maturity, thin bedded, medium to low permeability silt to sand sized clastic reservoir, precise and fine mapping of minerals, pores and microporous phases with 3D X-ray micro-computed tomography (3D μ-CT), 2D back-scattered scanning electron microscope (BSEM) imagery and 2D quantified, automated SEM-EDS mineral analysis (QEMSCAN) can play a significant role in reservoir characterization. In this paper, an integrated core to pore scale approach is adopted to compute macro scale petrophysical rock parameters such as porosity, permeability, formation factor, and pore throat size and distribution directly from 3D digitized rock images. A sub-plug of sandstone was imaged in 3D μ-CT in dry and saturated states. A quantified, 3D pore space map, including microporosity, was created by registering into perfect geometric alignment the two tomograms. Quantified, 3D mineralogical mapping along with association of pore and grain structure was performed by registering the high-resolution BSEM image and quantified 2D mineral map with the 3D μ-CT images. The association was characterized by the matching of microporosity to the mineralogical information. Interconnectivity of primary and secondary porosity and nature of secondary porosity was also determined and quantified. Computational results of porosity and permeability from digital rock show good agreement with laboratory core measurements. Results show that the computed properties from this technique are reliable and can be used for reservoir quality assessment and field development programs. Imaging and visualization of core material with 3D μ-CT at the pore scale and subsequent analyses give significant insights into properties of low permeability reservoir core material and further developments will make this technique more common and easy to use.

Keywords: 3D μ-CT; BSEM; QEMSCAN; Porosity; Permeability; Digital rock images

RESERVOIR CHARACTERIZATION OF THE SAMANA SUK FORMATION FROM KHAWRI KHWAR SECTION, NIZAMPUR BASIN, KHYBER PAKHTUNKHWA

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Abstract

The middle Jurassic Samana Suk Formation is logged and sampled for facies controlled diagenesis and reservoir rock characterization. The facies analysis of the Formation revealed ooidal-peloidal grainstones, bioclastic-peloidal grainstones, bioclastic-intraclastic-peloidal grainstones, bioclastic-peloidal packstones, peloidal-ooidal-bioclastic wacke-packstones, peloidal- bioclastic wackestones, bioclastic mudstones, spicule rich mudstone microfacies anddolostone facies. The facies assemblages of the Formation indicate inner ramp shoals to outer ramp depositional settings. The diagentic features of the Formation includecementation, dissolution, micritization, fracturing, stylolite, recrystallization, pyrite mineralization and dolomitization and are explained by meteoric, marine and burial diagenetic history of the rock unit. XRD studies revealed dolomite, calcite, and ferruginous clays cementation within Samana Suk Formation. Based on SEM analysis the porosity encountered is mainly dissolution porosity, inter-granular porosity and intra-granular porosity. The dolomitization, dissolution and intergranular porosity is more pronounced in mudstone and wackestone facies, while fracture, intergranular and intragranular porosity is captured by the packstone and grainstone facies of the Formation.

PETROLOGY AND GEOCHEMISTRY OF DOLERITE AND LAMPROPHYRE SILLS IN MESOZOIC SUCCESSIONS OF WESTERN SULAIMAN FOLD–THRUST BELT, PAKISTAN

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Abstract

In Western Sulaiman Fold–Thrust Belt, NW Pakistan, the sills are intruding mainly Triassic-Jurassic successions of Indian platform sediments. They are petrographicaly identified as dolerites and lamprophyres. The dolerites are texturally basaltic, doleritic and gabbroic and are altered compare to lamprophyres. Lamprophyres are classified as sannaite, comptonite, minette and damtjernite. Geochemical signatures of dolerite, olivine dolerite and lamprophyres suggest that these rocks belong to alkali series by classification, may be alkaline in nature. Normal mid oceanic ridge basalts (NMORB)–normalized plots of dolerites, olivine dolerites and lamprophyres show higher enrichments of large ion lithophile elements (LILEs) relative to high field strength elements (HFSEs) and marked positive anomalies on Nb which confirm their origins from an enriched mantle source. While the ocean island basalt (OIB)-normalized plots of these rocks exhibit patterns almost alike to those of OIB suggesting a source similar to OIB. The tectono-magmatic discrimination plots of dolerite, olivine dolerite and lamprophyres plots them in OIB field and indicate that they are alkaline rocks in nature. Petrogenesis and tectonic setting of these rocks suggest that they are OIB type in nature and may represent the Late Cretaceous magmatic activity that erupted as hotspot fluid through the crust of Indian Plate during Late Cretaceous. It is much similar to other hot spot related rocks that intruded Parh Group and Bela Ophiolite mélange. It is concluded that such as the magmatism of Deccan trap and the Chagos-Laccadive ridge, these rocks may be the melt of a hotspot possibly Reunion that intruded the Indian Plate margin when it had passed over it during Late Cretaceous.

Keywords: Dolerite, lamprophyre, sills, alkaline, Petrogenesis, tectonic setting

KEY INDICATOR MINERALS AND CHEMISTRY FOR CARBONATITES: A REVIEW

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Abstract

Over the past 50 years, the study of carbonatites has been significantly increased due to their growing economic importance. Carbonatites are commonly significant repositories of economically valuable elements; however, the debate over the origin of carbonatites is still ongoing including the problem of distinguishing carbonatites from sedimentary carbonate rocks metamorphosed to marble. Minerals like calcite, apatite, phlogopite and magnetite are common in both carbonatite and marble; however the presence of pyrochlore can be a good indicator of carbonatite. But its absence cannot characterize marble. The presence of aluminous minerals like anorthite, scapolite or spinel is generally a reliable indicator of marble. In addition, the mineral assemblage of the rocks, trace elements analysis can supply critical high Sr and REE data including absence of europium anomaly, which usefully differentiate carbonatites from marbles. The MnO and SrO contents of carbonate minerals may be used as indicators to distinguish carbonatites from marble. For instance, MnO and SrO contents in carbonate minerals higher than 0.50 wt. % and 0.15 wt.%, respectively, are typical of carbonatites. Moreover, SrO content in carbonate minerals is a more sensitive indicator than MnO to distinguish carbonatite from sedimentary carbonate rocks metamorphosed to marble. The above mentioned characteristic factors are applied to the Leo-Shilman and Sellai Pattai carbonatite complexes in the Peshawar plain alkaline igneous province. Both of these complexes contain pyrochlore and their SrO content of carbonate minerals ranges from 0.74-3.94 wt.% and 0.12-1.55 wt.% in Leo-Shilman and Sellai Pattai, respectively, consistent with igneous origin for the carbonates of the carbonatites. In contrast, the Jambil carbonatites, however, lack such evidences, and require further study to determine their igneous or meta-sedimentary origin.

A NOVEL METHOD TO GENERATE ELECTRICITY BY UTILIZING LOW TEMPERATURE GEOTHERMAL RESOURCES

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Abstract

In present energy position and petroleum cost inclination, oil and gas companies are energetically seeking additional innovative behavior to decrease operating costs and to enlarge the life of ageing fields. Many mature oil and gas fields are described by a huge amount of co-produced water having water cut up to 90%, which is required to be treat constantly and cannot be deliver to the environment. The produced water is required to dispose or re-inject into the reservoirs. This practice needs a lot of cost and decrease the net profit value of the petroleum companies. Co-produced steam can be a valuable source for the generation of electricity, as in the oil and gas fields with high water cut, the produced water temperature is up to 100˚C, which is sufficient enough to produce electricity by using Binary power plant. Electricity production from produced water with high water cut will be a profitable source for oil and gas producers. Current study proposes a method for electricity generation using hot fluids (oil, water) produced from oil reservoir for which a pilot binary power plant of 300 KW could be a most suitable system whose payback time is round about 5 to 6 years. The daily water production from oil reservoir is about 17000 m^3 with temperature up to 100 ˚C.The predictable electrical power is about 3.5 MW and could be improved to 100 MW by raising the production of water.

GRAIN SIZE DISTRIBUTION, MINERALOGY AND GEOCHEMISTRY OF SURFICIAL SEDIMENTS OF SAUDI RED SEA COAST; AN OVERVIEW TO INTERPRET PALEOENVIRONMENT AND PALEOCLIMATE IN RESPONSE TO NATURAL AND ANTHROPOGENIC ACTIVITIES

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Abstract

Red Sea is a semi-enclosed water body, connected to Gulf of Aden by small strait at Bab-al-Mandeb. Sediment yield in northern and southern part is controlled mainly by amount of episodic discharge from temporarily active wadis and the bioproductivity, whereas, in central part, anthropogenic activity prevails the sediment input. Texturally, surficial sediments in the eastern Red Sea coast can be classified as gravel, sand and mud. Sand dominates in nearshore areas and fine fraction increases with increase in depth. The major mineralogical constituents of the surficial sediments are carbonate minerals (calcite and aragonite) and detrital siliciclastic minerals (quartz and feldspar). Some evaporites are also noted in the sediments depicting extreme arid environment. This grain size variability in conjunction with mineralogical assemblage present in the surficial sediments controls the distribution and abundance of major and trace elements, CaCO3 and organic content. Sand friction is composed of carbonate material eroded from coralline terraces and terrigenous detrital material transported by seasonal wadis during flood event and contains high concentration of Ca, Mg and Sr, whereas, trace element concentrations are positively correlated with mud, Fe, Al, Ti, Mn, Cu, Ni, Co, Cr, V and B contents.

GEOCHRONOLOGY AND GEOCHEMISTRY OF ADAKITIC DYKES IN XIGAZE FORE-ARC BASIN ZONE: IMPLICATIONS FOR MIOCENE E-W EXTENSION

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Abstract

The east-west extension, the adakitic magmatism, and the potassic-ultrapotassic magmatic activity are three important tectonic-magmatic events in the Southern Tibet during Miocene. However, it remains unknown when the east-west extension started. This study analyzed the chronology and geochemistry of the E-W trending diorite porphyritic dyke and the near N~S trending fine grain dioritic dyke (cut across by former) exposed in Xigaze fore-arc basin zone. Geochemistry and geochronology of dioritic dykes in different directions and cross cutting reveal the three events during Micocene. Both dykes show adakitic signature, characterized by high aluminum, high sodium, high Sr/Y ratio, and high La/Yb ratio. All samples collected from the porphyritic and fine grained dioritic dykes exhibit light rare earth element(LREE) enrichment, heavy rare earth element(HREE) depletion, no obvious Eu anomaly, together with enrichment of large ion lithophile elements(LILE, Th, U, K, Pb, Sr, etc), and strong depletion of high field strength elements(HFSE, Nb, Ta, Ti). The E~W trending diorite porphyritic dyke yielded zircon U-Pb age of 14.8Ma, and the emplacement time of the N~S trending dyke is slightly earlier. All of the above characteristics indicate both of these dykes have the same source area which is likely to be the thickened juvenile lower crust. According to the previous studies on the adakitic rock in the southern Tibetan region during Miocene, the partial melting of the thickened mafic crust is likely to be caused by the delamination of the lithosphere of the Lhasa terrane. This important geodynamic change induced upwelling of asthenosphere material, which led to adakitic magmatic activity and east-west extension. Age of adakitic dykes in Xigaze fore-arc basin zone constrains initiation of east-west extension earlier than 15Ma.

APPLICATION OF WELL LOG ANALYSIS TO ASSESS PETROPHYSICAL PARAMETERS OF JOYA-MAIR OIL FIELD UPPER INDUS BASIN PAKISTAN

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Abstract

Potwar province is one of the most productive and one of the oldest hydrocarbon productive province of Pakistan. The early productions in this province dates back in 1943 till that and number of wells have so far been drilled in this province. The current study is concerned with the Petrophysical evaluation Joya Mair oil field located in Potwar province. Two wells names Minwal X-01 and Joyamair-04 is selected for research, where the prevailing assessment involves identifying, marking, analysing and interpreting the reservoir zones from well logs and computational analysis through different formulas. Several well logs were used comprising sonic log, gamma ray log, density log, neutron log, and resistivity logs. These analysis were carried out in order to evaluate the petrophysical parameters such as the shale volume (Vsh), total porosity (PHT), effective porosity (PHE), water saturation (Sw), hydrocarbon saturation (Sh), and pay zone. After the analysis and interpretation of well logs it was concluded that the best possible reservoir in study area is Chorgali and Lockhart limestone respectively in Minwal X-01 and Joyamair-04. These reservoirs have good net pay zones thicknesses ranges from 20 feet to 52 feet. Based on well log data, these reservoirs are investigated as a fine class reservoir rocks which is evident from high effective porosity and hydrocarbon saturation.

A REVIEW ON THE POTENTIAL, PRODUCTION, TRADE AND OTHER RELEVANT DETAILS ALONG WITH RECOMMENDATIONS /VIEWS FOR BAN ON THE ASBESTOS MINERAL IN PAKISTAN

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Abstract

Asbestos is a generic name given to six fibrous minerals that have been used in manufacturing a number of commercial products. It is an industry term rather than a mineralogical term that is applied to specific fibrous mineral particles that possess high tensile strengths, large length to width ratios, flexibility and resistance to chemical and thermal degradation. The asbestos deposits found in Khyber Pakhtunkhwa (KPK) are located at Alpurai Prang Ghar, Qila, NewiKili, Kuchian, Bucha, Danish Kool, AnmbarKot, Hero Shah and BehramDheri district Charsadda and at Boya, Khost Valley in Waziristan. The prominent localities in Balochistan are Zabar Creek area 8 to 10 Km North of Muslimbagh. Mining is carried out by primitive methods such as blasting and hammering and results in waste upto 65%.The asbestos of Mohmmand, Malakand, South Waziristan agencies, district Charsadda and Swat are classified to host chrysotile, antigorite and tremolite. Almost 90% of the discovered deposits in KPK are in production. Asbestos is also imported as raw and in the form of scraps of old ships (asbestos sheet) from Canada, USA, Europe and South Africa. The imported asbestos varieties include chrysotile and anthophyllite. In Pakistan, asbestos containing products including electric heaters, drainage, sewerage and insulation pipes, furniture (tables, beds) and doors. Pakistanasbestos consumption in year 2000-2004 was estimated to be increased from 1,590 to 9170 tonnes in a short span of two years .Asbestos alternate substitutes are available but it involves high cost, additional manufacturing cost, product design cost and product manufacturing. When asbestos fibers become airborne and are inhaled, they are so small that the lungs cannot expel them. Major diseases caused by asbestos include asbestosis, mesotheliomaand cancer of the larynx. So far 1,500 cases of general incidence and cohort cases of mesothelioma were reported during1992-2004, that figure had risen to 6,000 during 2007 in Khyber Pakhtunkhwa. In Pakistan, no protective and precautionary measures were adopted during all types of mining, milling, cutting, product manufacturing and use of asbestos, asbestosiform talc. Seventy percent of mines now producing asbestos in Pakistan became operational between 2000-2007; there were no standards or regulations to protect the mine labor. Measurements taken during 2005 showed colossal airborne asbestos levels at the mine itself and extensive contamination of mine worker clothes and groundwater. The innocent people are highly exposed to huge amount of respirable asbestos and are at risk to various fatal diseases.

Unmechanised mining, milling and industrial processes adopted for the recovery of asbestos and product manufacturing is the main factor responsible for the unsustainable management of the mineral resources in Khyber Paktunkhwa. Government should take steps for regulating/ban of asbestos and create awareness among masses.

MICROFACIES ANALYSIS AND DIAGENETIC FABRIC OF THE LOCKHART LIMESTONE EXPOSED NEAR TAXILA, MARGALLA HILL RANGE, PUNJAB, PAKISTAN

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Abstract

The microfacies analysis and digenetic fabric of the Lockhart Limestone are studied at an outcrop section exposed in the Margalla Hill ranges. The Lockhart Limestone is predominantly comprised of medium to thick bedded, nodular and occasionally brecciated, highly fossiliferous limestone with thin interbeds of marl and shale. On the basis of detailed petrographic investigation, four microfacies and twelve sub-microfacies have been identified. The microfacies identified includes packstone (mixed bioclastic, bioclastic foraminiferal and bioclastic algal foraminiferal); wackestone (bioclastic foraminiferal, bioclastic miscellanea rich, bioclastic algal foraminiferal and siliciclastic bioclastic rich); wackestone-packstone (bioclastic foraminiferal, bioclastic miscellanea rich and bioclastic algal foraminiferal) and mudstone-wackestone (mixed planktic-benthic foraminiferal and bioclastic foraminiferal). Based on the microfacies analysis, the Lockhart Limestone is interpreted to have been deposited in the inner ramp lagoon, inner ramp foraminiferal shoal and fore-shoal open marine depositional environments. The diagenetic fabric of the Lockhart Limestone is characterized by several diagenetic features such as micritization, neomorphism (aragonite to calcite transformation and development of microspar), compaction, pressure dissolution (microstylolites) and cementation (calcite filled microfractures). Such diagenetic features are developed in marine, meteoric and burial diagenetic settings.

DIAGENESIS AND RESERVOIR CHARACTERISTICS OF THE LOWER EOCENE MARGALLA HILL LIMESTONE, SOUTHEASTERN HAZARA, PAKISTAN

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Abstract

The sedimentological features of the Lower Eocene Margalla Hill Limestone at Darkot Section, southeastern Hazara (northern Pakistan), were scrutinized to unfold its microfacies, diagenetic fabric and reservoir character. The microfacies analysis, suggests that the Margalla Hill Limestone is deposited in the proximal middle ramp to proximal outer ramp platform settings. It is highly affected and modified by different diagenetic processes which have either reduced or enhanced the reservoir potential of the Formation. The micritization, neomorphism, cementation, dissolution, replacement, limestone nodularity, mechanical compaction, chemical compaction, fracturing and calcite veins contribute to the various diagenetic processes. Three diagenetic environments that are marine phreatic, meteoritic phreatic and burial environments have been interpreted on the basis of observed diagenetic features. The porosity is observed both mesoscopically and microscopically, including inter-granular and intra-granular porosities. Most of the porosity is developed during dissolution and fracturing phase of diagenesis, which is generally secondary in origin. The MHF-3 (*Assilina Bioclastic Wackestone Microfacies*), represents bulk of the Formation. It contains some unfilled fractures and shows dolomitization at places that makes it a good reservoir, relatively. Whereas, the fractures in other microfacies are mostly filled with micritic matrix and neomorphic cements, and hence, represent poor reservoirs.

INTRODUCTION TO DIGITAL ROCKS: RESEARCH, DEVELOPMENT, AND APPLICATION

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Abstract

Digital Rocks technology utilizes high-resolution 3D rock images, advanced modeling and simulation techniques to "measure" petrophysical properties of the rock. Digital Rocks provides an alternative method to measures the basic rock properties which are used for reservoir characterization and performance prediction. A number of publications have been published on Digital Rocks, however these are generally limited in term of scope, and emphasis on single aspects, or present an individual application example. Here we describe the research and development of Digital Rocks, and explains how this technology can be applied to the petroleum industry. We describe the undertaken research, and the development of technology which includes extensive verification and validation of results. After research and development, the industrial application is a key challenge for this emerging technology. The fundamental capabilities required for Digital Rocks technology, including x-ray micro-CT imaging, image processing, numerical simulation are described in this paper. The given technology development and application examples to petroleum reservoir examples are specific to static rock properties. The presented results, includes comparisons of image-based porosity and simulated permeability, formation factor, and pore size distribution with conventional laboratory experimental data obtained from core plugs. Results show that Digital Rocks technology has the ability to improve reservoir evaluation and recovery methods. The quick numerical experiment can reduce the cycle time for appraisal, 3D visualization and reproducible numerical experiments at multiple conditions can reduce subsurface uncertainty and increase decision making power.

Key Words: Digital Rocks; Micro-CT; Reservoir Characterization; Petrophysics.

CAUSES OF DEFORESTATION AND ITS GEOLOGICAL IMPACTS IN SWAT DISTRICT, KHYBER PAKHTUNKHWA, PAKISTAN

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Abstract

The most alarming threat to the forest are human being, their actions results transformation of forest lands representing one of the excessive forces in worldwide ecological change and one of the great drivers of biodiversity loss. Human activity is continuous and has a profound impact. Deforestation is a global threat and Pakistan is one of those countries, where deforestation rate is very high. This study was designed in order to find out the causes and impacts of deforestation and forest degradation in District Swat, Khyber Pakhtunkhwa, Pakistan, by incorporating the view of local people through a questionnaire. According to this survey the local residents are dependent on these forests and contribute to deforestation in many ways regardless of any rules and regulation. Extensive deforestation in Swat is the result of daily livelihood use of forests furniture, heating, agriculture etc. Unemployment and poverty also plays a key role in forest degradation. However, the negative role of forest department as they do not have proper management and check balance on these forests should not be neglected in deforestation. In the current study the geological impacts like landslides and soil erosion has also been discussed as 78% of the local residents were also aware of the fact that with degradation of forest this hazard increases.

IMPACT OF CLIMATE CHANGE ON FLOOD FACTORS AND EXTENT OF DAMAGES IN THE HINDU KUSH REGION

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Abstract:
Hindu Kush is a high mountain system located in the immediate west of Karakorum and Himalayas. It is the greatest watershed of River Kabul, River Chitral, River Swat and River Panjkora in Pakistan and the Amu River in Central Asia. Hindu Kush system host numerous glaciers, snow clad mountains, fertile river valleys, support large population and provides year-round water to recharge streams and rivers. The study region is vulnerable to a wide range of hazards including floods, earthquakes, landslides, drought and desertification. However, in the Hindu Kush region, riverine and flash floods are frequently occurring and deadliest extreme hydro-meteorological events. The upper reaches experiences characteristics of flash floods, whereas the lower reaches dominates the scene of river floods. In the upstream areas, flash floods are sudden and more destructive in nature. Every year in summer, monsoonal rainfall together with the heavy melting of snow, ice and glaciers accelerate discharge in rivers. The climate change has a strong relationship with trend in temperature and resultant changes in rainfall pattern and river discharge. In wake of observed climate change, there is a rising trend in temperature, which indicates the early and rapid melting of snow and glaciers in the catchment areas. The analysis reveals that during the past three decades a radical change in behavior of numerous valley glaciers have been noted. Similarly, a fluctuation in the amount of snowfall occurrences together with its timing and seasonality have been recorded. In addition, the spatial and temporal scales of violent weather events have been grown during the past thirty years. Such changes in water regimes including the frequent but substantial increase in heavy precipitation events and rapid melting of snow in the headwater region, siltation in active channels, excessive deforestation in the past three decades, human encroachments onto the active flood channel and the bursting of temporary dams have further escalated the flooding events. The analysis reveals that Hindu Kush region is beyond the reach of existing weather RADAR network and hence flood forecasting and early warning is ineffective. In the study region, almost every year, the floodwater overflows the levees and cause damages to standing crops, infrastructure and sources of livelihood earnings and incurs human casualties.

INTEGRATING FORMATION EVALUATION AND PETROPHYSICS IN GAS BEARING RESERVOIRS DRILLED IN EOCENCE SUCCESSION IN QADIRPUR AREA, CENTRAL INDUS BASIN, PAKISTAN

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Abstract

The Gas bearing Reservoirs of Eocene age in the Qadirpur area, Central Indus Basin are the second largest prolific reservoirs in Pakistan. In 1990, Gas was discovered in Eocene Limestone in Qadirpur area. Till today around 25 wells have been drilled for extensive development of the field. Sui Main Limestone (SML) and Sui Upper Limestone (SUL) are the main producer while limestone of Habib Rahi (HRL) overall ismeasured as tributary reservoir. The Ghazij Shales act as cap for SML and SUL while Sirki Shales over HRL act as a cap rock.The present study focused on the formation evaluation and integrating it with petrophysics based on well log data in Eocene reservoirs in Qadirpur area. Computer-assisted log analyses were used to evaluate the petrophysical parameters such as the shale volume (Vsh), total porosity (PHT), effective porosity (PHE), water saturation (Sw), hydrocarbon saturation (Sh), flushed zone saturation (Sxo) and true resistivity (Rt). Cross-plots of the Petrophysical parameters versus depth were illustrated for lithology determination, gas effect and bulk volume of water (BVW). Eocene reservoirs in the Qadirpur area are carbonates and gas producing. The BVW shows that the reservoirs are at reducible or nearly irreducible water saturation hence will produce the water free hydrocarbon. This study marks the expected reservoirs to be Habib Rahi Limestone and Sui Main Limestone, Whereas Sui Upper Limestone is non-reservoir as a whole, and only parts of it can be producing where hydrocarbon (gas) saturation and effective porosity are high. In the Qadirpur area the Gas in place in cubic feet, was calculated successfully for the wells i.e. Qadirpur-03, 11, 15, 16 and17. Based on well log data, the Eocene reservoirs are interpreted as a good quality reservoir rocks which is evident from high effective porosity and hydrocarbon saturation.

SEDIMENTOLOGY AND BIOSEQUENCE STRATIGRAPHIC MODELLING OF THE KAWAGARH FORMATION IN THE NIZAMPUR AND MARGALLA HILLS RANGE, NW PAKISTAN: IMPLICATION FOR HYDROCARBON RESERVOIR CHARACTERIZATION

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Abstract

The Kawagarh Formation has been studied in detail for carbonate microfacies, depositional environment, bio-sequence stratigraphy and reservoir characterization from two stratigraphic sections i.e. Khwari Khwar Section from Nizampur Basin and Khanpur Dam Section from Margalla Hills Range and Tolanj-01 well. Two main microfacies were identified i.e. mudstone and wackestone. The environment of deposition interpreted on the basis of microfacies for the Kawagarh Formation is proximal to distal outer ramp setting. The biostratigraphic biozones identified in the Kawagarh Formation in Khwari Khwar Section are *Dicarinella asymetrica*, *Globotruncanita elevata* and *Globotruncana ventricosa* biozones while in Khanpur Dam Section are *Dicarinella asymetrica*, *Globotruncana ventricosa* and *Globotruncanita calcarata* biozones. Based on planktonic foraminifera biostratigraphy the Kawagarh Formation represent Santonian to Campanian age in Khwari Khwar Section and Santonian to Maastrichtian age in Khanpur Dam Section. The deposition of the Kawagarh Formation occur as a result of transgressive cycle with magnitude of age ranging from 87 to 76 m.y in Khwari Khwar Section and 87 to 74 m.y in Khanpur Dam Section. The Kawagarh Formation is also modified by various diagenetic features including micritization, dolomitization, microfractures, stylolitization, dissolution, neomorphism, spar-filled fractures and cementation representing meteoric and marine phreatic with mixing zone and burial diagenetic environments. Fracturing, dolomitization and dissolution are the diagenetic processes enhancing the porosity while compaction, micritization and neomorphism reducing the porosity. The total visual porosity of the Kawagarh Formation estimated by Image J software is 1.6% and 2.2% in Khwari Khwar and Khanpur Dam sections respectively. The minerals present in the Kawagarh Formation are mainly calcite and dolomite with minor amount of quartz, aragonite, kaolinite and muscovite. The dominant porosity types recognized are intercrystalline/interparticle, intracrystalline/intraparticle, vuggy and fracture porosity in surface data while vuggy and intercrystalline porosity in subsurface data. The petrophysical parameters of the Kawagarh Formation calculated are water saturation (67%), volume of shale (14%), average porosity (3%), effective porosity (2%) and hydrocarbon saturation (33%) in Tolanj-01 well. However, due to low LLD value at different depths and the absence of cross over between neutron and density porosity Kawagarh Formation may not be recommended as hydrocarbon reservoir around study area.

LARGER BENTHIC FORAMINIFERAL BIOSTRATIGRAPHY AND SEQUENCE STRATIGRAPHY OF THE EARLY EOCENE MARGALLA HILL LIMESTONE, SOUTHEASTERN HAZARA, NORTHERN PAKISTAN

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Abstract

The Eocene carbonates in Pakistan (Eastern Tethys) show substantial abundance and diversity of larger benthic foraminifera (LBFs). The Paleocene-Eocene global warming episode possibly favoured this abundance and diversity of LBFs in the Eastern Tethys. A significant larger foraminiferal turnover (LFT) has been recorded during the Paleocene-Eocene transition in the Eastern Tethys and other parts of the world. LBFs are widely used for biostratigraphy and paleoenvironmental reconstruction. The well-exposed Margalla Hill Limestone in the southeastern Hazara (northern Pakistan), is an Early Eocene carbonate sequence. It hosts abundant and well-preserved larger benthic foraminifera (LBFs). It has been studied for microfacies analysis to reconstruct a depositional model and a bio-sequence stratigraphic framework. These studies led to the interpretation of a depositional environment, ranging from proximal middle ramp to proximal outer ramp, for the Formation. The age of Middle-Illerdian 2 (54–52.8 m.a, Early Eocene) has been assigned to the Formation, based on the presence of age diagnostic larger benthic forams (*Nummulities atacicus, Nummulities globulus*). Fourteen $4^{th}/5^{th}$ order depositional sequences (parasequences), bounded by thirteen marine flooding surfaces in a retrogradational stacking pattern have also been identified, which shows an overall transgressive system tract (TST). The Formation is also comparable to age-equivalent deposits from other parts of the Tethys Ocean.

SEDIMENTOLOGY AND RESERVOIR CHARACTERIZATION OF UPPER CRETACEOUS KAWAGARH FORMATION, QAMAR MELA SECTION, NIZAMPUR BASIN, KHYBER PAKHTUNKHWA, PAKISTAN

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Abstract

The Upper Cretaceous Kawagarh Formation has been studied in detail for sedimentology and reservoir characterization from Qamar Mela Section, Nizampur Basin. To explore the reservoir potential, we studied the impact of diagenesis on reservoir potential, supplemented by plug porosity and permeability, and SEM analysis. The outcrop is mainly composed of limestone and marl. Fifteen samples were studied from 45m thick section and two main microfacies are identified. The microfacies includes; (1). Mudstone microfacies (planktonic foraminifera mudstone and dolomitic mudstone sub-microfacies), (2). Radiolarian bioclastic planktonic foraminifera wackestone microfacies. The environment of deposition interpreted on the basis of microfacies for Kawagarh Formation is proximal to distal outer ramp setting. Various diagenetic features modified the Kawagarh Formation including compaction, dolomitization, dissolution, pyrite precipitation, cementation and spar filled fractures representing meteoric to marine phreatic with mixing zone and burial diagenetic environments. Dissolution, fracturing and dolomitization are the diagenetic processes enhancing the porosity while cementation, pyrite precipitation and compaction reducing the porosity of the Kawagarh Formation. Plug porosity and permeability of four rock samples averages 1.69% and 0.267 Ka/md, respectively. SEM analysis shows different types of porosity includes vuggy, shelter and intergranular. The low porosity and permeability levels of Kawagarh Formation suggest only a modest reservoir potential.

DEPOSITIONAL AND DIAGENETIC STUDIES OF THE PATALA FORMATION CARBONATES EXPOSED IN PIR SOHAWA SECTION, HAZARA BASIN, PAKISTAN: IMPLICATIONS FOR RESERVOIR CHARACTERIZATION

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Abstract

A Section of the Patala Formation exposed at Pir Sohawa area, Hazara Basin is measured, logged, and sampled for microfacies analysis, depositional environment and reservoir potential assessment. Total measured thickness of the studied section is 60 meters. Based on Dunham (1962) classification two microfacies, mudstone and wackestone were identified and based on the recorded fauna and depositional fabric, seven sub-microfacies were interpreted including Algal-bioclastic mudstone (MF1), Miliolid-nummulitic mudstone (MF2), Miliolid mudstone (MF3), Unfossiliferous mudstone (MF4), Miliolid wackestone (MF5), Bioclastic wackestone (MF6) and Nummulitic-miscellanea wackestone (MF7). These microfacies indicate lagoonal, restricted to open marine inner ramp and lagoonal, restricted to open marine platform interior environment of deposition for carbonates of the Patala Formation. Micritization, neomorphism, compaction (physical and chemical) and cementation are the noticed diagenetic features in the studied formation. The micritization occurred in the shallow marine environment. The neomorphism and cementation evaluated in the meteoric diagenetic conditions. The compaction took place in the burial diagenetic settings. Porosity is grouped according to the microfacies types. Highest porosity (i.e. 6.89 %) is recorded from the MF4 then followed by 4.01% porosity in MF6. Likewise, 3.19 %, 2.94 % and 1.96 % porosity values are noted in the MF3, MF2 and MF5 respectively. The studied carbonates are highly fractured but filling of these fractures by calcite cement has greatly reduced the reservoir quality. Based on the present study, the Patala Formation is interpreted as poor quality reservoir.

MICROFACIES ANALYSIS AND DEPOSITIONAL SETTING OF LOCKHART LIMESTONE MANHIALA AREA, EASTERN SALT RANGE, PAKISTAN

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Abstract

The current research deals with microfacies analysis of Lockhart Limestone exposed in the Manhiala area, eastern Salt Range. The Lockhart Limestone is primarily comprised medium to thick bedded, fractured, nodular and also extremely fossiliferous limestone with subsidiary shales. Inclusive petrographic observation of 30 samples reveals presence of 94% calcite, 2% clay, 1% strained quartz and 3% hematite. Calcite occurs as micrite, sparite and signifies rhombohedral cleavage occasionally. Calcite veins are ubiquitous and overlap each other forming en-echelon vein pattern. Petrography also demonstrates presence of cementation, stylolites, micritization and neomorphism settled in particular diagenetic environments comprising meteoric, marine and burial. Comprehensive microscopic study depicts three microfacies containing mudstone, wackestone and packstone. On the basis of age indicative foraminifera including Lockhartia conica, Lockhartia conditi, Miscellanea miscella, Lockhartia tipperi, Ranikothalia sindensis and Discocyclina ranikotensis, the Paleocene age has been specified to the Lockhart Limestone. Microfacies analysis suggests depositional settings of Lockhart limestone in outer, mid ramp as well as fore-shoal mid-ramp.

DIAGENETIC STUDIES AND RESERVOIR POTENTIAL OF THE CRETACEOUS KAWAGARH FORMATION, KALA-CHITTA RANGE, PAKISTAN

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Abstract

The Cretaceous Kawagarh Formation is well exposed in the Kala-Chitta Range, Northern Pakistan. It is mainly composed of limestone and marls. The Formation is 96m thick at the studied section. The lower and upper contacts are conformable with the Lumshiwal and Hangu formations respectively. The studied unit of the Kawagarh Formation is measured, logged and sampled for the diagenetic studies and their effect on reservoir quality. A total of thirty three samples were collected from the subject formation from bottom to top at equal intervals of three meters. The noticed diagenetic features includes micritization, neomorphism, compaction (physical and chemical) and cementation. Mostly stylolitic and minor vuggy and fracture porosity types are recorded in the studied formation. Under the petrographic microscope, the visually estimated porosity ranges from 2.66 % to 3.88 %. The diagenetic features observed has greatly reduced the reservoir potential of the Formation. The rock unit is intensely fractured but filling of these fractures due to the precipitation of calcite cement has greatly reduced its reservoir quality. Overall, the reservoir potential of the Kawagarh Formation is characterized as very poor.

SEDIMENTOLOGY AND BIOSTRATIGRAPHY OF THE CRETACEOUS MUGHAL KOT FORMATION, RAKHI GORGE SECTION, SULAIMAN RANGE, PAKISTAN

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Abstract

This study is focused on sedimentology, palynofacies and biostratigraphy of the pelagic to hemipelagic sediments of the Mughal Kot Formation, Rakhi Gorge Section, Sulaiman Range, Pakistan. The depositional model is described using detail microfacies and palynofacies analyses. The biostratigraphic studies involving planktonic foraminifera is used to assign relative age to the Mughal Kot Formation. The bio-stratigraphic ages and depositional environments are integrated to find out a possible petroleum system within the Mughal Kot Formation. Two microfacies i.e. mudstone and wackestone were identified, suggesting a deep marine to an outer/middle ramp environment. The palynofacies analysis shows a high percentage of amorphous organic matter (AOM), indicating a deep marine to an outer/middle ramp environment under suboxic-anoxic distal basin condition. The palynofacies interpretation coincides with microfacies interpretation in establishing depositional environment. In Mughal Kot Formation one bio-stratigraphic biozone i.e. *Globotruncanita calcarata* of late Campanian age is identified and its age is further extended into early Maastrichtian based on the presence of associated Maastrichtian planktonic and benthic foraminifera within the *Globotruncanita calcarata* biozone. The evolution of the planktonic foraminifera and larger benthic foraminifera in this part of the Tethys Ocean confirmed a shallowing upward sequence on the basis of test coiling and increase in test size. The coexistence of the two species the opportunists and the specialists confirm that the Mughal Kot Formation show the same evolution pattern as evident globally in the late Campanian and early Maastrichtian time. The low species richness in each sample is due to high sedimentation rate in this time span. On the basis of microfacies a sea-level curve is constructed showing pulsation due to local tectonic conditions.

Key words; Mughal Kot Formation, Cretaceous; Rakhi Gorge, Sulaiman Range; Pakistan.

MICROFACIES AND DIAGENETIC SETTINGS OF CHORGALI FORMATION IN TALHAR SECTION, ISLAMABAD, PAKISTAN

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Abstract

The Chorgali Formation of Eocene age is measured, logged and sampled for facies analysis, diagenesis and reservoir characterization. The two (2) microfacies and four (4) sub-microfacies with discrete texture, fossils content and allochem types are mudstone to wackestone microfacies and wackestone microfacies, sub microfacies are Larger foraminiferal mudstone to wackestone sub-microfacies, larger benthic wackestone sub-microfacies, bioclastic wackestone sub-microfacies and Nummulitic wackestone sub-microfacies. The depositional texture and faunal association indicates that the microfacies represent deposition in a low energy that is inner to middle shelf settings. Numerous diagenetic changes which shows compaction, stylolitization, aragonite to calcite transformation (neomorphism), fractures and calcite veins passing from marine to meteoric diagenesis through burial diagenesis which were induced tectonically, are indicated in the formation through further analysis. The type of porosity is fractured porosity as indicated by visual estimation. The average porosity calculated through visual estimation for limestone of Chorgali Formation is 11.26%. SEM shows porosity type is vuggy and fracture. X-ray Diffraction indicates quartz, calcite and dolomite in limestone of Chorgali Formation.

FACIES ARCHITECTURE, PETROGRAPHIC AND GEOCHEMICAL ANALYSIS OF TOBRA FORMATION, SALT RANGE, PAKISTAN

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Abstract

Present research work is aimed to mark litho-facies and to understand sedimentology of Tobra Formation through petrographic and geochemical analysis. Three sections were selected for sampling, Zaluch Section in western Salt Range, Pidh and Tobra Sections in eastern Salt Range. The field studies comprise of measuring designated litho-sections, collection of representative samples and recording for sedimentary features. This research work determined 7 litho-facies of Tobra Formation i.e. Matrix-Supporter Conglomerates Facies, Clast-Supported Conglomerate Facies, Claystone-Conglomerate Facies, Claystone Facies, Massive Clay Facies, Massive Sandstone Facies and Pebbly-Sandstone Facies. These Facies expresses glacial influenced debris flow to stream flow deposits. The petrographical analysis revealed that the sandstone of Tobra Formation is quartz arenite to lithic arenite and immature to submature. It is interpreted as recycled orogenic tectonic regime deposits during semi humid to humid climate conditions. The conglomerates are Diamictite, mostly clasts are derived from igneous origin. The framework grains observed under polarizing microscope are monocrystalline and polycrystalline quartz, alkali feldspar, plagioclase, microcline, biotite, chert, muscovite and number of lithic fragments from distinct origins. The geochemical analysis (XRD) finds that quartz, dolomite and albite are the major mineral constituents, whereas aluminium, magnesium, sodium, palygorskite and dickite are minor constituents. Major element analysis finds out that Tobra Formation sandstone are lithic-arenite and non-marine deposits with increasing maturity and subalkaline, basic to acidic rocks.

FACIES ANALYSIS AND SOURCE ROCK INVESTIGATION OF GRIESBACHIAN-SPATHIAN MIANWALI FORMATION IN KHISOR AND SURGHAR RANGES, UPPER INDUS BASIN PAKISTAN

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Abstract

The Greisbachian-Spathian Mianwali Formation is studied at Narmia, Sayiduwali, and Paniala sections of Trans-Indus Khisor Range and Surghar ranges Field investigations along with microscopic studies were performed, which resulted into identification of five different lithofacies; 1. Dolomite facies, 2. Packstone-wackestone limestone facies, 3. Shale facies, 4. Laminated sandstone facies and 5. Sandstone and shale facies. Based on facies association, it is concluded that Mianwali Formation has been deposited from open marine to beach shallow marine environment. The Total Organic Carbon (TOC) revealed that the Mianwali Formation has poor to moderate hydrocarbon generation potential.

AGGREGATE BASE COARSE AND MEASUREMENT OF THEIR PROPERTIES OF E-35 CHINA-PAK ECONOMIC CORRIDOR

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Abstract

In this research investigation of aggregate base coarse was carried out of project E-35 (phase-1) China-Pak economic corridor. The methodology in current research is based on tests i.e. sieve analysis, plastic index, proctor, California Bearing Ratio, los angeles, sand equivalent and specific gravity. The results of these tests for different layers were compared with AASHTO and NHA specification. The various tests results shows that the embankment, subgrade and sub base layers were composed of silt, sand and gravel respectively while the aggregate base coarse was composed of sand, aggregate and less amount of fine material (Clay). The sieve analysis test shows that soil and aggregate base coarse has less clay and high silt and sandy material and plastic index demonstrate that material is plastic to low plastic which is appropriate for the construction. California Bearing Ratio shows that the soil and aggregate base coarse have high load bearing capacity. Los angeles abrasion reveal that the sub base and aggregate base coarse are resistive. Sand equivalent show that aggregate base coarse have high sand material. Specific gravity illustrate aggregate base is dense material. The current research shows that soil and aggregate base coarse is suitable for construction of road in project E-35 (phase-1) China-Pak economic corridor.

PALEONTOLOGICAL AND BIOSTRATIGRAPHICAL ANALYSIS OF THE FORT MUNRO FORMATION, RAKHI NALA SECTION, LOWER INDUS BASIN, PAKISTAN

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Abstract

A Paleontological and biostratigraphical study on *Orbitoides* specimens collected from the Fort Munro Formation, Rakhi Nala Section, Lower Indus Basin, Pakistan was carried out. Paleontological investigations including the measurement of different biometric parameters and taxonomy (i.e. systematic description) of genus *Orbitoides*. The specimens are discoidal, lenticular, and symmetrically biconvex and their diameter range in size from 2mm to 6mm. Embryo is trilocular to quadrilocullar and the shape varies from spherical to elliptical. For biometrics analysis, three peri-embryonic parameters (i.e., number of peri-embryonic chambers directly originating from embryo, total number of peri-embryonic chambers, initial growth steps (neanic stage)) and two embryonic parameters (i.e. size of the embryo and shape of the embryo) were measured. The number of peri-embryonic chambers directly originating from embryo range from 4 to 5, total number of peri-embryonic chambers range from 12 to 16, and the average initial growth steps range from 0.28 to 0.32. The relatively stable values or very small fluctuation in average initial growth steps values show no positive progress in the nepionic acceleration from bottom to top of the Fort Munro Formation. The average size of embryo does not show a strong correlation with the average numbers of peri-embryonic chambers originating from embryo as the increase in size of embryo should be followed by the increase of embryonic chambers. Most of the specimens show the average embryo size and number of chambers directly originating from embryo values in the range of *Orbitoides media* therefore, the whole population is attributed to the *Orbitoides media*. Based on the correlation of *Orbitoides media* zone with the *Globotruncana ventricosa* zone middle to late Campanian age of the Fort Munro Formation is confirmed.

PALYNOFACIES-BASED PALEOENVIRONMENTAL SETTING OF THE MIDDLE PERMIAN (WORDIAN) SARDHAI FORMATION, SALT RANGE, PAKISTAN

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Abstract

The current research appreciates the palynofacies analysis of the Middle Permian (i.e. Wordian) Sardhai Formation, Salt Range, Pakistan. The Sardhai Formation is studied for palynofacies analysis at two stratigraphic sections of the Salt Range, i.e. Pail section (Central Salt Range) and Zaluch Nala section (Western Salt Range). A total of 18 samples were collected and processed for palynofacies analysis. Two palynofacies, i.e. Palynofacies-1 (PFPS-1) and Palynofacies-2 (PFPS-2) are identified in the Pail Section, Central Salt Range. Similarly, two palynofacies, i.e. Palynofacies-1 (PFZS-1) and Palynofacies-2 (FPZS-2) are identified in the Zaluch Nala Section, Western Salt Range. The palynofacies PFPS-1 and PFZS-1 are characterized by high percentages of phytoclasts when compared to amorphous organic matter and suggest marginal dysoxic-anoxic shelf settings. The palynofacies PFPS-2 and palynofacies PFZS-2 have greater percentages of amorphous organic matter than the PFPS-1 and PFZS-1 and suggest a proximal suboxic-anoxic shelf setting for these palynofacies. Thus on average a shallow marine setting is asserted for Sardhai Formation from this analysis.

SEISMIC HAZARD STUDIES OF PESHAWAR BUS RAPID TRANSIT PROJECT

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Abstract

For the Seismic Hazard Studies (SHS) of the Peshawar Bus Rapid Transit (BRT) Corridor Project, an assessment of regional geological and tectonic information collected from the existing literature and maps has been carried out. On the basis of available data, the critical tectonic features affecting the Project region has been identified and Seismic Hazard Studies (SHS) has been conducted using Probabilistic Seismic Hazard Analysis (PSHA) approach, for selecting the seismic design parameters of the Project, in accordance with the Building Code of Pakistan (BCP), Seismic Provisions (2007). The studies have been conducted by using the single site EZ-FRISK software developed by Fugro Engineering Consultants, USA. The Project region was divided into seven area seismic source zones based on their homogeneous tectonic and seismic characteristics. Latest NGA (2008) equations developed under Pacific Earthquake Engineering Research (PEER) Centre by Abrahamson & Silva, Boore & Atkinson, and Campbell & Bozorgnia were used. The Project falls in Zone-2B of Building Code of Pakistan Seismic Provisions (2007). The seismic range of Zone-2B is from 0.16g to 0.24g. The Building Code of Pakistan Seismic Provision 2007, specifically places Peshawar in Zone-2B and explicitly defines that "Z" Value of Zone-2B is 0.20. The total hazard curve obtained from probabilistic seismic hazard analysis gives a horizontal Peak Ground Acceleration (PGA) of 0.23g for a return period of 475 years and 0.20g for a return period of 320 years. For other Soil Profile types, necessary application of the amplification factors should be used as given in BCP Seismic Provisions (2007).

ALTERNATIVE PAVEMENT PRESERVATION STRATEGIES USING MULTI CRITERIA DECISION MAKING (MCDM) APPROACH TO REDUCE CARBON FOOTPRINTS

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Abstract
Roads make a crucial contribution to economic development. CPEC is a collection of infrastructure projects and is intended to rapidly modernize Pakistani infrastructure by construction of modern transportation networks. CPEC is mostly a network of roads, deterioration of road starts as the road opens to traffic and environmental conditions. Whenever, roads are built, then pavement distresses occur which includes cracking, rutting, distortion or other types of surface deterioration which indicates a decline in pavement's surface condition or structural load carrying capacity. The study aims at sustainable pavement preservation treatments which improve pavement quality, durability and extend pavement service life, while reducing energy consumption and Green House Gas (GHG) emissions. This research uses MCDM approach for selecting the cost-effective and ecofriendly treatment in the light of performance measures; cost, PCR, design life, energy consumption and CO_2 emissions. In this study, visual survey was performed and pavement conditions were determined using PCR technique which is modern technique instead of conventional inspection methods. Moreover, we proposed some of treatments like mill and fill, micro surfacing and Hot in Place recycling (HIR) for multiple distresses in the road. The results demonstrated that using MCDM approach could enhance performance of road in terms of cost, PCR, design life, energy consumption and CO_2 emissions.

Key words: CPEC, Pavement preservation, Carbon footprints, MCDM, Distresses, PCR

MODEL BASED VELOCITY INVERSION IN DHULIAN ANTICLINE BY INTEGRATED GEOPHYSICAL DATA SET, UPPER INDUS BASIN, PAKISTAN

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Abstract

Potwar sub basin is considered to have a significant hydrocarbon potential among all basins due to variation in sedimentary deposition and salt tectonism. The conventional exploration methods applied, particularly for Paleocene, Eocene and Miocene deposits have been tested by many companies over the past decades. This paper mainly focuses on the reservoir characterization and sedimentary characteristics of Dhulian Anticline based on porosity calculation through velocity inversion technique and attribute analysis. Dhulian Anticline is a regional symmetrical East West trending anticline extending in the subsurface which is also having surface exposure near Pindi Gheb in central Potwar, Upper Indus Basin and is one of the major oil producing fields of Pakistan. Tectonically, it is a part of compressional regime resulted due to thrust faulting caused by the collision of Indian and Eurasian plate. Basically, the structure is considered as a salt cored anticline developed due to salt tectonics phenomenon. Pop up Anticline can be clearly observed in the seismic lines acquired in that area. Targeted reservoirs in the area are mostly Carbonates (Chorgali, Sakesar and Lockhart Formations) precipitated in non-clastic settings of Paleocene and Eocene age. The porosities calculated through petrophysics and seismic inverted data have been correlated to a satisfactory level. For delineating the subsurface, seismic structural interpretation has been performed which shows eastward plunging anticline and thrust faulting which were further confirmed by the mapping of the targeted strata. Seismic Attribute Analysis is performed for the better upsurge of the reservoir which affirms the hydrocarbon anomaly at the Chorgali and Sakesar level. Instantaneous amplitude highlighted the high amplitude zone embaded between low zones but no bright spot was detected. Low frequency patches and high energy zones are also encountered at different Limestone levels indicating the presence of fluid. Petrophysical analysis on well Dhulian-43 is performed for marking the hydrocarbon bearing zones that can produce fluid. The log data of Chorgali Formation was not provide but one zone in Sakesar Limestone was marked having thickness of 5.1m with average effective porosity 8-10%, average Vsh 18-20% and average Sh 45%. Velocity Inversion is performed along the Control line for evaluating the trend of porosities in Reservoir Formations particularly at Chorgali and Sakesar formations. Velocity pull ups were encountered on the control line which represents relatively high porosity zones having good reservoir characteristics and correlation with that of porosity calculated from the well. The porosity calculated from a single well point is interpolated over the entire cube of reservoir zone with confidence.

Key Words: Dhulian Antcline, Model Based Inversion, Eocene Carbonates, Velocity Inversion, Porosity.

STRUCTURAL INTERPRETATION USING SEISMIC DATA OF SINJHORO AREA, LOWER INDUS BASIN, PAKISTAN

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Abstract
The southern Indus basin is a part of complex structural and stratigraphical history. Located at western margin of Indian plate, this passive basin received sediment from two sources, Aravali mobile belt and in modern time from Himalayan mobile belt respectively, that is why it so prolific in hydrocarbon potentional. The research is carried out on sample data of seismic and wells of Sinjhro area, located in Southern Indus Basin. Tectonically, study area is bounded in the east by Indian Shield, in the west by Kirthar Foldbelt, in the south by Karachi Trough and in the north by Mari-Bugti Inner Folded zone. Horsts and graben structures are dominant in the area, which were originated as a result of rifting between India and Seychelles in Late Cretaceous. Chiltan Limestone of Jurassic age The Jurassic age Chiltan Limestone underlies the more deltaic to shallow marine sequence of Sembar and Lower Goru Formation of cretaceous age with an unconformity. Stratigraphic correlation indicates south to westward dipping of the Formations in the area owing to slope deposition of sediments. The preview of research involves the velocity modeling on the base of interval velocity variation with respect to time and attribute analysis of zone of interests. The seismic data incorporated comprised of migrated sections of four dip lines 2001-SNJ-03, 2001-SNJ-14, 2001-SNJ-15, 2001-SNJ-16 and one strike line 2001-SNJ-24. Well tops data of Hakeem Daho-01, Barhun-01 and Chak 63-01 is used for the stratigraphic well correlation in the study area. The sample seismic data used for identification of tectonostratigraphic traps and entire play system couple with well tops of sample data. Four prominent reflectors named Khadro, Parh, Lower Goru and Chiltan are marked at the seismic sections. Horst and Graben are identified and marked on these seismic sections which formed due to extensional tectonics. The Two-way time contour maps of the marked lithologies Khadro, Lower Goru and Chiltan have been prepared to determine the spatial variation of time. Interval velocity models are generated to observe the variation of velocities with time in the subsurface. Entrapment of low velocities ranging from 1600 m/s to 1800 m/s and 2500 m/s to 2750 m/s depicts the probable zones of hydrocarbon in Lower Goru Formation. The Basal Sands of Lower Goru Formation is the primary reservoir in this area. These sands are proven producer in wells Barhun-01 and Chak 63-01. The stratigraphic correlation of wells indicates that Formation thin out toward west because of slope deposition. Average porosities for these sands are ~11% in the prospect area. For further validation of the interpretation, certain attributes like Frequency and Phase have been run at the level of reservoir. The high frequency value in attribute analysis is showing gas accumulations in Lower Goru Formation. On the basis of these results, reservoir zones are determined in the Basal sands and Massive sands of Lower Goru Formation with good hydrocarbon potential.

Key words: Horst and Graben, TWT, Contour Map, Interval velocity models, Attributes

GEOLOGICAL MAPPING ON 1:50000 SCALE OF THE (KHANOZAI) KAREZAT AREA,DISTRICT PISHIN, BALOCHISTAN, PAKISTAN

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Abstract

The (Khanozai) Karezat Quadrangle includes Khanozai and surrounding areas which is situated 70 kms northeast of Quetta. Geologically, the area falls in the Urak Basin in the south, ultramafic, igneous and Traissic-Jurassic Basin in the middle portion, and Kakar Khorasan (Back Arc) Basin in the North Western portion. The study area is covered by the rocks ranging in age from Triassic to recent / subrecent, and can be divided structurally, into three domains, Tungi-Ahmadun Syncline Area, Khanozai-Torkhula Ophiolite Segment and Murgha Zikriazai Flysch Segment. The Tungi-Ahmadun area is marked by a large syncline. This syncline is represented by the Urak Group of Miocene to Early Pleistocene, where all the three formations of the the Urak Group like Uzdapasha, Shinmati and Urak are well exposed. The Urak Group is thrusted by the Alozai Group (Triassic) in the north and by the Parh and Babai formations (Cretaceous) in the south. In the south eastern corner it has a thrusted contact with the Loralai Formation (Jurassic), Sember, (Cretaceous) and Shaheed Ghat (Eocene) formations. The Khanozai-Torkhula Ophiolite area is mostly covered by the Spingwar Formation (Triassic) and Loralai Formation (Jurassic) of Alozai Group. Both formations are intruded by the volcanics and ultramafics. In this area the ultramafics consist of huge potential of chromite, and it is the part of the Muslim Bagh Ophiolite. The Murgha Zikriazai Flysch Segment (Pishin Flysch Basin) includes the Nisai Formation (Eocene), Murgha Faqirzai Shale Member (Oligocene) and Shaigalu Sandstone Member (Miocene) of Khojak Formation. The Nisai Formation is comprised of fossiliferous limestone and shale at the base, thick sequence of multicolour shale in the middle and medium to thin bedded fine grained sandstone, shale and brecciated cliff forming limestone in the upper part. The central part of the Karezat Quadrangle is covered by alluvial cover which is represented by the Bostan Formation (Pleistocene) and Recent to Sub Recent material. In the North of Khanozai, some structures exist which may be favourable sites for the hydrocarbons, near the Karez Haji Daudulla and Murgha Zikhazai areas. This part of the mapped area is recommended for geophysical survey to show the subsurface sequence for interpreting the Hydrocarbon Potential.

Keywords: Khanozai, Karezat, Urak Group, Alozai Group, Triassic, Kakar Khorasan (Back Arc) Basin, Pishin Flysch Basin, Muslim Bagh Ophiolite, Chromite, Quetta, Pakistan.

COMPREHENSIVE INVESTIGATION OF RIVER BED MATERIAL (RIVER KABUL) IN HMA PAVEMENT

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Abstract

Roads are the integral part of the transport system. For construction of roads huge amount of aggregate is required. Alternate aggregate sources need to be explored in addition to existing one. Margalla Quarry is mostly used in Pakistan. Avoiding depletion of Margalla quarry we should explore other sources of aggregates. The aim of this research is to find the suitable and cheap aggregate at the local level in Peshawar or regions near Peshawar (District Charsaddah etc.), rather transporting from other regions. This will ultimately reduce transportation costs as well as environmental hazards. Taking the bed of River Kabul (Khayali River, Charsaadah) as a source of aggregates. They were crushed first and all the tests were performed according to ASTM, AASHTO and BS standards. For bituminous mix, Marshall Mix design was carried out using NHA aggregate bend of class 'B' and bitumen with a penetration grade of 60/70. The results indicated that River Bed aggregates of Khayali River are suitable for HMA construction in Peshawar and also anywhere in Pakistan. The road network that is to be built in the regions near Peshawar by CPEC, these aggregates can be efficiently used there. It will be much economical and will avoid the depletion of the present aggregates sources in Peshawar.

FORAMINIFERAL BIOSTRATIGRAPHY & MICROFACIES ANALYSIS OF THE LOWER EOCENE CARBONATE SUCCESSION IN PARTS OF HAZARA, AZAD KASHMIR AND ISLAMABAD, PAKISTAN

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Abstract

In this study, the Eocene carbonate succession including Margalla Hill Limestone and Chorgali Formation representing the lower units of the Early Eocene Cherat Group have been investigated in the Margalla Hill Ranges and Hazara-Kashmir Basin. The field sections included, 1) Shahdara Section (Islamabad), 2) Khaira Gali Section (Galiat-Abbottabad) and 3) Yadgar Section (Muzaffarabad-Azad Jammu & Kashmir). Lithologically, these formations are comprised of predominant limestone units with occasional shale interbeds at places. Some notable fauna from the foraminiferal assemblage includes; *Assilina spinosa, A. subspinosa, A. dandotica.*, *A. granulosa, Lockhartia conditi, L. tipperi, Nummulites atacicus, N. globulus, N. mamillatus, Discocylina* sp.*, Ranikothalia* sp. etc. Presence of all these biostratigraphically significant shallow benthic foraminifera confirms that the deposition of Margalla Hill Limestone and Chorgali Formation occurred in Shallow Benthic Zones (SBZ 5/6 - SBZ12) of Ypresian time. The integrated depositional environment for Early Eocene Margalla Hill Limestone and Chorgali Formation from the studied sections is interpreted to occur between restricted inner ramp and distal mid ramp settings of carbonate platform. Restricted inner ramp, shoal, proximal mid ramp and distal mid ramp are important facies types represented by varying depositional textures of the studied carbonate succession. A very preliminary approach towards establishing stable isotopic stratigraphy at Paleocene/ Eocene boundary in one of the studied sections i.e. Yadgar Section is initiated. This study encounters a decrease in $\delta^{18}O$ values along with pronounced decline in $\delta^{13}C$ indicating quiet abrupt global extinction phenomenon at Paleocene/ Eocene Boundary.

APPLICATION OF GIS AND RS TOOLS FOR REGIONAL GEOLOGICAL MAPPING OF CHAKWAL AND ITS SUBURBS

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Abstract

Regional geological mapping particularly for expanding cities like Chakwal has a significant value due to its impact on exploration of mineral, economic and environmental resources. The present study attempts to highlight the use of Geographic Information System and Remote Sensing techniques in geological mapping of Chakwal quadrangle bounded by the Survey of Pakistan topographic sheet No. 43-D/7 at a scale of 1:50,000. The project area lies at the southern periphery of Potwar plateau just north of the Salt Range. Gee has mapped the Salt Range and part of the study area whereas the area of Potwar region has been mapped by various authors. Generally, the sedimentary sequence ranging in age from Eocene to Recent is exposed in the area with marked unconformities between late Eocene to Oligocene. The sequence becomes older to younger as we move from south to north direction. SRTM DEM of 90m resolution was used to extract topographic details for the purpose of geological information. The structure of the southern area is complex due to series of folding and faulting events. However, the northern part is having relatively simple rolling structure with Siwaliks cropping out along nala cuts. Crude oil, bentonite and building stone are major economic resources present in the area which can be exploited for the local dwellers in particular and for our beloved homeland in general.

Key words: Chakwal, Geological Mapping, GIS, RS, SRTM DEM.

SEDIMENTOLOGICAL STUDY AND RESERVOIR CHARACTERIZATION OF KINGRIALI FORMATION EXPOSED IN ZALUCH NALA, WESTERN SALT RANGE, PUNJAB, PAKISTAN

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Abstract

Well-exposed Kingriali Formation of late Triassic age has been studied in details at Zaluch Nala section, western Salt Range, Pakistan. Extensive fieldwork was conducted to investigate sedimentological features and diagenetic events on outcrop level and used well logs data for its impact on the reservoir characterization of Kingriali Formation. 36 representative samples were collected from 76m thick sequence to delineate microfacies for the interpretation of paleo-depositional environment of the Kingriali Formation. Petrographic studys show that the studied formation is composed of three main microfacies, i.e. mudstone, packstone and boundstone. Furthermore, these microfacies are divided into sub-microfacies including fenestral mudstone and bioclastic mudstone sub-microfacies, fenestral ooidal packstone and peloidal packstone sub-microfacies. Petrographic study revealed that the dolostone of Kingriali Fromation is of secondary nature for which the precursor limestone was deposited on intertidal to subtidal and inner shelf restricted marine environment. Stoichiometric study explains that dolomite of Kingriali Formation seldom displays any significant variation in crystal ordering. Reservoir characterization was carried out by using visual porosity in the field, diagenetic alteration during petrographic study, SEM analysis and petrophysical analysis. Visual porosity ranging from 1.8 to 10% was determined with the help of Image J software. Diagenetic processes involved in reservoir modification were dissolution, dolomitization, micritization, compaction, neomorphism and cementation. Diagenetic events like dissolution, dolomitization and mechanical compaction showed positive affect on the reservoir character of the target formation, while the chemical compaction, micritization, neomorphism and cementation played a negative role by decreasing the reservoir potential of Kingriali Formation. 3-D microporosity in the form of vugs, fractures, inter and intracrystalline pores spaces were observed out through Scanning Electron Microscopy. Petrophysical analysis suggested an average effective porosity upto 8% and average sonic porosity ranges from 8 and 12% for Kingriali Formation in Isakhel-01 and Chonai-01 wells respectively, which falls in the range of a good reservoir. However, due to low Laterolog Deep (LLD) value at different depth and the absence of cross over between neutron and density porosity, the Kingriali Formation may not be recommended as hydrocarbon reservoir.

COMPOSITION, DIAGENESIS AND RESERVOIR ROCK CHARACTERIZATION OF MIDDLE JURASSIC DATTA FORMATION, SALT RANGE, PAKISTAN

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Abstract

In the Salt Range of Pakistan, the sandstones of Middle Jurassic Datta Formation has been explored for reservoir potential. This study is based on 16 thin sections, supplemented by porosity and permeability determination, SEM analysis and petrophysical analysis. Detrital mineral composition of the Datta Sandstone shows that sandstones are lithic greywacke to sub litharenite. The Datta Sandstone is fine to coarse grained, moderate to well sorted with poor to moderate sorted and has sub-angular to well-rounded grains. Mineralogically and texturally the Datta Sandstone is immature, submature to mature. The Datta Formation sandstones contain evidences for numerous diagenetic processes which includes compaction and pressure solution, cementation and alteration, dissolution, dolomitization, and fracturing. Based on textural relationships, we set out a provisional diagenetic history (paragenesis) for the Datta Sandstone. These diagenetic processes occur in Eodiagenesis (early), Mesodiagenesis (burial) and telodiagenesis (uplift) stages.

The compaction, cementation and dolomitization reducing the reservoir quality while dissolution, pressure solution, alteration and fracturing enhancing the reservoir quality of Datta Sandstone. The average visual porosity of outcrop samples of Datta Sandstone range from 1-13%. The porosity types identified under SEM include intercrystalline, intracrystalline/intraparticle, vuggy and fracture. The petrophysical aspects of the Datta Sandstone was carried out by using the wire-line logs of Chonai-01 well which suggests effective porosity (0.151%), average porosity (0.241%), density porosity about 0.217%, saturation of water averages 0.986% and saturation of hydrocarbons about 0.0139%. These parameters show that Datta Sandstone may not be recommended as hydrocarbon reservoir around the study area.

AN INTEGRATED GEOPHYSICAL AND REMOTE SENSING APPROACH TO EXPLORE AND MODEL SUBSURFACE GROUND WATER; QUETTA A CASE STUDY

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Abstract

Quetta valley is an essential geological entity of Quetta Basin which is located in Baluchistan, Pakistan. The climate is typical desert to semi desert elsewhere, low rainfall (~100 mm/yr) and extreme temperature variations. The rapid increase in population, quick rise of annual mean temperature and low precipitation bring Quetta into serious water problem. Water scarcity leads this project to address this need for assessment, exploration, mapping and development of groundwater resources. The area is diversely studied in terms of Geology, Geophysics, Remote sensing, Geochemistry, Drilling, and Probabilistic modeling, for potential water reservoirs. Quetta Valley consists of a tectonic depression, buried valley, and karstic bedrock. Rock formations range from Jurassic to recent alluvium deposits mostly limestone and shales. The extensive faulting and jointing suggest opportunities for groundwater entrapment in these fractured systems. To evaluate these sweet zones an integrated set of remote sensing, Geological and Geophysical data are used. The remote sensing data include Landsat TM Mosaics, Digital Topography (SRTM 30m) and spatial drainage patterns. The geological data includes geologic maps, fault maps and soil maps. Based on that data surface water movement, their possible storage and potential to be future Aquifer are modeled for the Quetta and surrounding areas. The geophysical studies are involved in surface water exploration and modeling. The Electromagnetic (EM) data is used to find out the subsurface faults and lithology types. Based on EM data, the subsurface lithology of Quetta is divided into different zone in term of water bearing potential, keeping in view the fractures and faulting systems. The Resistivity survey successfully marked subsurface reservoir zones. The data model shows that northern part of the Quetta is a depression as compare to southern part. There are some local depressions which also act as reservoir in southern most proximity. Aquifers are located near the foothills of the Murdar and Mian Ghundi regions. In the NW part of the Quetta valley, there is a 10 km wide water gap between Saumungli and Baleli, which connects the Quetta Basin with Bostan-Pishin Plain. The drainage of the Quetta Basin finds its way out through this gap and joins the Pishin Lora River. To the NE of Quetta there is gap which connects Quetta to Kach Basin.The area is faulting and fracturs bear good potential for water. In Subsurface, there are three water bearing zones in unconsolidated alluvium. The carbonates, which is Jurassic Chiltan limestone also act as reservoir but due to thick unconsolidated alluvium succession it is difficult to reach these reservoirs. Furthermore, the publish observation data shows that water level is depleting here with a rate of 1m/year in south and 1.5m/year in north in unconsolidated alluvium while carbonate depletion rate is 4-6m/year.

PALYNOSTRATIGRAPHY, LITHOFACIES AND PLAYNOFACIES ANALYSIS OF THE EARLY PERMIAN DANDOT FORMATION, SALT RANGE, PAKISTAN.

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Abstract

The current study focuses on the palynological and lithofacies aspects of the Dandot Formation which is the lower part of the Carboniferous-Permian Nilawahan Group in the Salt Range area, Pakistan. The palynostratigraphic and palynofacies analysis were carried for two sections i.e. Choa Saidan Shah Section and Pail Kata Section. Two Oppel Biozones are recognized in the Dandot Formation i.e. the Praecolpatites-Potonieisporites-Striatopodocarpites-Urmites spore-pollen Oppel biozone and Lueckisporites-Alisporites-Scheuringipollenites spore-pollen Oppel biozone, suggesting an Early Permian to Middle Permian age for the Dandot Formation. The Lithofacies analysis indicates seven lithofacies in the Dandot Formation i.e. 1: dark greenish shale lithofacies (L1), 2: bioturbated sandstone lithofacies (L2), 3: massive bedded sandstone lithofacies (L3), 4: cross bedded sandstone lithofacies (L4), 5: flaser bedded sandstone lithofacies (L5), 6: herringbone cross bedded sandstone lithofacies (L6), 7: lenticular bedded sandstone lithofacies (L7). The lithofacies analysis suggests shallow marine to intertidal environment for the Dandot Formation. The Dandot Formation shows two types of palynofacies associations namely, palynofacies 1 and palynofacies 2. The Palynofacies 1 is having high percentage of amorphous organic matter, reflecting deposition in marginal dysoxic-anoxic basin condition while palynofacies 2 is comprised of high amount of phytoclasts, showing deposition in distal suboxic-anoxic basin. The combination of lithofacies and palynofacies data represents that the Dandot Formation was deposited in shallow marine to intertidal environment.

Key words: Dandot Formation, Early Permian to middle Permian; Salt Range; Pakistan.

GEOCHEMICAL CHARACTERISTICS OF PEGMATITES FROM LESSER HIMALAYAS, PAKISTAN: IMPLICATIONS FOR FRACTIONATION AND ECONOMIC MINERALIZATION POTENTIAL

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Abstract

Highly fractionated pegmatites, which are genetically related to per-aluminous S-type granites, are designated as LCT-type (Li, Cs and Ta rich pegmatites). Such pegmatites are mined for strategic metals (SMs) and rare earth elements (REEs) around the world. The S-type granitic suites of the Lesser Himalayan sequence, specifically the Mansehra Granitic Complex (MGC) of northwestern Pakistan, have not been studied so far from this perspective. Geochemical signatures of the MGC pegmatites were investigated using Inductive Coupled Plasma Mass Spectroscopy (ICP-MS) to assess the degree of their fractionation and economic mineral potential. In general, the REE patterns of the studied bulk rock pegmatite display tetrad effect and low total REE abundances, strong positive Eu anomalies, weak negative Ce anomalies and relative enrichment in heavy REE. Similar features were also observed in the REE patterns of their feldspar extracts. However, the REE patterns of muscovite extracts reflect preferential enrichment and possess moderate to high total REE abundances, negative Eu anomalies, prominent negative Ce anomalies and relative enrichment in heavy REE.

Relationships between the concentrations of a number of trace elements (and their ratios), e.g. Ta versus Cs, K/Rb versus Rb and Th/U versus K/Cs, were used to assess the economically viable mineral potential of the studied pegmatites. The concentrations of most of the relevant components fall below the mineralization line and confer either barren or low-level mineralization potential of the MGC pegmatites for SMs (e,g. Ta and Nb) and REEs. The close spatial association with parent granitic rocks and absence of zoning also reflect the low degree of fractional crystallization and barren nature of the MGC pegmatites.

GIS-BASED INTEGRATED APPROACH FOR IDENTIFYING POTENTIAL GROUNDWATER RECHARGE SITES IN SEMI-ARID ENVIRONMENT USING SAATY'S ANALYTICAL HIERARCHICAL PROCESS (AHP)

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Abstract

This study aims to identify and map the groundwater potential recharge sites in a semi-arid area, district Lakki Marwat of Khyber Pakhtunkhwa, Pakistan. Groundwater is a precious source of fresh water and one of the major components that sustains and supports entire water supply ranging from domestic use to irrigation purposes. Assessing these groundwater potential recharge sites are very important for the protection of water resource, its management systems and water quality. This study emphases a standard methodology by integrating Geographical Information System (GIS) and remote sensing (RS) methods using various variables/parameters which have an impact on groundwater recharge. These variables include; elevation, slope, drainage density, lineaments density, soil, geology, land use / land cover and rainfall. These parameters were prepared and classified using GIS, and then weightage and classes of each parameter were assigned values using the well-known Saaty's Analytical Hierarchical Process (AHP) technique. It is an operative tool for solving the complex decision and may support the best possible options for decision makers. The total ranking score of different parameters were summed up and weighted. The resultant groundwater potential sites were classified into five categories i.e., very high, high, moderate, low and very low. These classes were compared to Tube well data from the study area in order to evaluate usability and applicability of the said approach. This groundwater potential information will be useful for effective identification of suitable locations for extraction of groundwater. The model will help resolve water related issues in a region with heavy dependence on groundwater. It can further be used for sustainable water resource planning.

THE PETROGRAPHIC CHARACTERISTICS OF CRETACEOUS LUMSHIWAL FORMATION, KHWARI KHWAR SECTION, NIZAMPUR BASIN, PAKISTAN.

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Abstract

The Cretaceous Lumshiwal Formation was studied for its petrographic characteristics and presuming provenance by using 27 outcrop samples in Khwari Khwar Section, Nizampur Basin. The formation is mainly composed of sandstone with minor intercalations of shales and having a limestone bed at the top. The texturally sub-mature to mineralogically mature sandstones, classified as quartz arenites, generally represent as first order cycle of deposition. The constituents are dominated by monocrystalline non-undulose quartz (85%), some polycrystalline quartz (5%) and orthoclase feldspar (5%), few rock fragments (1%), micas (2%) and a suite of heavy minerals (1%). Whereas the rock fragments are well rounded, the heavy minerals include garnet, tourmaline, rutile, monazite, glauconite and biotite mica. The grains characteristics reveal that the source rock was acidic plutonic igneous, present in the craton interior, having semi humid to humid climate condition. The sandstones are poorly to moderately sorted and cemented by silica. The optically continuous quartz overgrowth, close packing of grains with planar to sutured contacts, presence of stylolites and alteration of feldspar into clay suggest phyllomorphic phase of diagenesis. Total absence of matrix, abundance of framework grains and presence of glauconite suggest high energy shallow marine environmental conditions. The topmost limestone bed is glauconitic bioclastic limestone, representing middle shelf environmental conditions and first sign of transgression before deposition of overlying Kawagarh Formation.

PETROCHEMICAL AND GEOCHRONOLOGICAL STUDY OF THE ROCKS OF INDUS SUTURE ZONE AND KAMILA AMPHIBOLITES, SWAT, KP, PAKISTAN

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Abstract

Geologically the northern most part of Pakistan has formed as a result of collision of two mega plates namely Asian plate at the north and Indian plate at the south. Kohistan Island Arc (KIA), a cretaceous arc has developed as a result of intra oceanic subduction of Tethys Ocean and separated from the Indian plate by Indus suture zone. Rock samples from Charbagh to Madyan area Swat were collected for petrography, geochemisty and geochronology to investigate the age relationships with the eastern extension in Pakistan. The rocks formed along the suture zones are metamorphosed quartz mica schist showing anhedral stressed quartz grains embedded in the laths of coarse grained mica, mainly muscovite. The rocks of kamila amphilote are highly altered to less altered and dominantly consisting of medium to coarse grained anhedral to subhedral amphiboles, quartz, plagioclase, ore minerals, sericite and feldspars (dominantly microcline). The fine to medium grained amphibolites are under less stressed with no visible banding while the coarse grained altered amphibolites from the contact area are under high stresses. Rocks of Kamila amphibolite belt falls in the region of intermediate with SiO_2 content ranges (45.26% to 57.37%), TiO_2 (0.55% to 0.97%), Al_2O_3 (12.51% to 18.82%), Fe_2O_3 ranges (5.11% to 12.05%), MnO (0.13% to 0.23%), MgO (1.17% to 6.07%), CaO (8.13% to 22.37%), Na_2O (0.14% to 3.64%), K_2O (0.00% to 1.40%) and P_2O_5 (0.05% to 0.38%). The rocks are plotted in the sub-alkaline/tholeiitic basaltic field on silica versus total alkalis diagram, while they are further divided into tholeiitic and calc-alkaline fields on the AFM diagram. Tectonically the rocks are plotted in the zone of island arc basalts or boundary between island arc and mid oceanic ridges basalts. Eleven samples are selected for zircon U-Pb geochronology and they were crushed and mounted in expoxy resins. Cathodoluminescence images of the zircons selected for geochronology were obtained and selected areas of zircons will be run on LA-ICP-MS.

TRANSITION OF MELTING REACTION IN TSONA LEUCOGRANITE: AN INDICATOR TO THE MOTION OF THE EAST-WEST EXTENSION IN EASTERN HIMALAYA

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Abstract

The Himalayan orogen is created by the northward continent-continent collision between India and Asia starting at about 55 Ma. It has been an ideal place to study the geologic processes related to collisional orogenesis because of its youthfulness and spectacular exposure. Widely spread leucogranites provide records of the crustal conditions, and maybe a useful proxy indicator to reveal the evolution of Himalayan-Tibetan orogen after the collision. Here we present a study of geochemistry, zircon U-Pb chronology and Hf isotopes on the Yamarong leucogranites from Tsona area, Eastern Himalaya, to explore the petrogenesis of the rocks, and to further expain related problems of continental crustal anatexis. The zircon U-Pb dating displayed two ages of magmatism, 14.4 Ma and 17 Ma respectively. Combined with the published data, the time of anatexis in Tsona had a duration of 5 Ma at least. We found that the Yamarong leucogranites have high SiO_2 (71.85% ~ 72.91%), Al_2O_3 (15.3% ~ 15.67%), but low TFe_2O_3 (0.58% ~ 0.9%), CaO (0.72% ~ 1.05%), and the A/CNK ratios range from 1.08 to 1.22. Calculation through zircon titanium thermometry demonstrates that the 17 Ma leucogranites have a higher melt temperature (690 ~ 740 ℃, mean = 721 ℃) than the 14.4 Ma samples (600 ~ 700 ℃, mean = 661 ℃). Moreover, the 17 Ma samples display higher $\varepsilon_{Hf}(t)$ values and Rb/Sr ratios, lower Ba contents compared with the 14 Ma leucogranites. The differences of zircon titanium thermometry, $\varepsilon_{Hf}(t)$ value and the covariant relation of Rb/Sr and Ba among the two stages of magmatism show that Tsona leucogranties originated from more than one melting reactions, they had experienced the change from dehydration melting to fluid fluxed melting, and the reason respond to this transformation may be the start of the E-W extension in Southern Tibet.

LANDSLIDE SUSCEPTIBILITY ASSESSMENT BY APPLYING WEIGHT OF EVIDENCE METHOD FOR DISTRICT MUZAFFARABAD, NW HIMALAYAS, PAKISTAN

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Abstract
Northern Pakistan is prone to frequent and devastating landslides. This study develops a landslide susceptibility map using a data-driven approach for the district Muzaffarabad, northwest Himalaya mountain ranges of Pakistan. The Muzaffarabad district was severely affected by the 2005 Kashmir earthquake triggered landslides. Therefore, landslide susceptibility map is required to assess the distribution of landslides and accordingly mitigate their negative impacts. A landslide inventory was prepared from remote sensing imageries and 459 landslides were identified and subsequently verified in the field. These landslides were divided into training and validation samples for susceptibility assessment. About 321 landslides were used as training sites and compared with the nine selected causative factor to develop a landslide susceptibility map for the region. The selected causative layers include land cover, lithology, slope angle, elevation, distance to drainage, distance to faults, distance to roads, aspect and slope curvature and analyzed with the weight of evidence modelling technique to develop landslide susceptibility map. Spatial distribution analysis were also assessed. The validity of the developed susceptibility map was assessed with Success Rate Curve (SRC) while prediction efficiency was analyzed through Prediction Rate Curve (PRC). The validation results reveal fine compatibility between landslides and obtained posterior probability model of the area. The efficiency of classification is 89% and efficiency of prediction is 86.2%. To generate posterior probability, the Cumulative Area Posterior Probability (CAPP) curve was used to reclassify the continuous posterior probability scale map into four classes. According to the results of weights calculated through Arc-SDM, land cover, lithology and slope angle are significantly influencing the spatial distribution of landslides in the study area. The develop landslide susceptibility map can be used by the concern agencies to develop and implement landslide management strategies.
Keywords: Weight of evidence; Arc-SDM; Landslide susceptibility; Himalayas.

DEVELOPMENT OF EXPLORATION TOOLS USING MORPHOLOGY AND ALLOY COMPOSITION OF ALLUVIAL GOLD: A CASE STUDY FROM DISTRICT NOWSHERA, KHYBER PAKHTUNKHWA, PAKISTAN

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Abstract

Alluvial gold is abundantly available in Quaternary deposits in the vicinity of River Kabul and River Indus in the district Nowshera, Khyber Pakhtunkhwa Pakistan. Alluvial gold is being mined at small scale from Gilgit, Chilas, Besham to Attock along River Indus. The morphology and alloy composition of gold grains in alluvial environment have greater exploration impact and will help to develop new techniques specifically for source identification. Gold grains from the panned concentrate samples were collected and detailed morphological features and the alloy composition was studied using SEM-EDS in the University of Peshawar and Electron Microprobe at the University of Leeds, UK. The studied morphological features of gold grains include roundness, folding, flattening, surface textures and outline. High value of the flatness index of the gold grains along with other morphological features suggests that these have been transported to a greater distance from their sources. Chemical analyses of 58 gold grains were performed using electron microprobe in order to get information about the sources and hence the provenance. Significant correlation is found between Ag vs Cu (> 0.4%) for Shaidu, Akora Khattak and River Kabul. The ternary plots Au–(Ag x 10)–(Cu x 100) show that gold from Shaidu, Akora Khattak and River Kabul give indication of gold to be derived from various mineral deposit types. River Indus and Kabul in the vicinity of study area are the main carrier of alluvial gold and deposited in the quaternary deposits of district Nowshera at suitable locations.

INDUSTRIAL EVALUATION OF SAKASAR LIMESTONE EXPOSED IN WESTERN SALT RANGE, PAKISTAN

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Abstract

Pakistan has large, exploitable reserves of limestone. Nammal limestone of Middle Eocene was evaluated for different end uses. For this purpose, the physical properties of raw stone, optical properties of pulverized product, percentage purity, calcium carbonate index and its pH in water were measured. Finally, quick lime was prepared for each sample by shock calcination of each sample at different temperatures ranging from 950oC to 1150oC, at an interval of 50oC. All other factors, which may affect the quality of quick lime, were kept constant. Chemical properties and physical properties of quick lime were measured and a relationship between them, with respect to the increase in calcination temperature, was established in order to study the effect of rise in temperature on properties of quick lime. The study revealed that siliceous impurities are prominent in Sakesar Limestone. Optical properties of Sakesar Limestone are good enough to be recommended for use in paints, paper and rubber industry. While the maximum high-quality lime of medium reactivity is prepared from Sakesar Limestone at temperature ranging between 950^{o}C – 1000^{o}C.

PETROLOGY OF THE CHILAS COMPLEX OF THE KOHISTAN ISLAND ARC IN THE KINER GAH AREA, CHILAS, PAKISTAN

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Abstract

The Chilas Complex is a ~40 wide and 300 long composite plutonic body exposed in the central part of Kohistan island arc, which formed first as intra-oceanic island arc in the Neo-tethyan oceanic crust and later transformed into Andean-type continental margin after the closure of back-arc basin. Two suture zones, i) the Northern suture (MKT) and the Southern suture (MMT) mark tectonic boundaries of the arc with the Karakoram micro-continent and the Indian continental plate respectively. The Chilas complex in the Kiner Gah area comprises gabbronorites, kyanite-garnet bearing tonalites, pyroxene quartz diorites, granites and amphibolites. Field studies suggest that the complex has intrusive contact with the the Kohistan batholith. A 2 km wide shear zone is present between Thalpan and Thak villages which is characterized by its north-south orientation, shear folds and the presence of sheared tonalite. Another major shear zone occupies the northern part where intense sheared rocks of the complex make them difficult to distinguish from the metasedimentary rocks of the Jaglot group. Major and trace elements study signify one common primary magma source composition for the plutonic rocks of the Chilas complex. Negative Nb and positive Sr anomalies indicate island arc type tectonic setting. Kyanite-garnet bearing tonalite, which is reported for first time from the Chilas complex in Kiner Gah area, indicates crustal contamination and amphibolite grade metamorphism.

ASSESSMENT OF RADON CONCENTRATION AND ITS HEALTH-RELATED HAZARDS IN THE DRINKING WATER SOURCES OF HAYATABAD TOWN AND ADJOINING AREAS, PESHAWAR, PAKISTAN

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Abstract

The radioactive gases, radon (^{222}Rn), as well as its decay products present in the environment are considered to be the main causes of radiation dosage to the community from radioactive materials. Presence of radon in drinking water causes radiation related health hazards both through the processes of inhalation and ingestion. A total of one hundred and three (103) drinking water samples were collected from different phases of the Hayatabad Township, Peshawar for the determination of their radon concentration with the RAD7 electronic apparatus. Out of a total of one hundred and three (103) water samples, tube wells, offices/parks, houses, schools, markets, and hospitals represent 25, 7, 34, 12, 8, 12 and 5 samples, respectively. The drinking water samples collected from Hayatabad Township have an average minimum, average maximum and average mean radon values of 7.33 $Bq1^{-1}$, 9.71 $Bq1^{-1}$ and 8.66 ± 0.11 $Bq1^{-1}$, respectively. Highest value of 18.5 ± 0.6 $Bq1^{-1}$ was recorded in the water sample from the southern Hayatabad in a tube well from Phase-I. The Lowest value of 1.34 ± 0.1 $Bq1^{-1}$ was recorded in the water sample of a storage tank of a house in Phase-II, southern Hayatabad. The mean annual effective dose to the stomach and lung due to ingestion and inhalation of radon gas for the residents of both the southern and northern Hayatabad have been computed to be 0.0018 ± 0.0002 mSv a^{-1} and 0.022 ± 0.002 mSv a^{-1}, respectively. The mean annual total effective dose due to ingestion and inhalation for the resident of the Township has been computed to be 0.023 ± 0.002 mSv a^{-1}. The mean annual effective dose of 0.0018 ± 0.0002 mSv a^{-1} due to drinking of water from different phases of the Hayatabad Township is lesser than the mean annual effective dose of 0.0025 mSv a^{-1} of UNSCEAR for ingestion. The average annual effective dose of 0.022 ± 0.0021 mSv a due to Inhalation from the drinking water of the Township is also lower than the maximum recommended dose of 0.025 mSv a^{-1} of UNSCEAR for inhalation. The average concentration of radon in tube well water of the southern Hayatabad is slightly higher than the average concentration of radon in tube well water of the northern Hayatabad. It has also been noted that tube wells which are in close proximity to the streams have elevated radon concentrations. All the dose levels are well below the action level of 0.1 mSv a^{-1} of WHO and the European Union (EU) as an annual effective dose received from the consumption of radon-rich drinking water.

STATUS OF GEOLOGICAL MAPPING IN PAKISTAN & MINERAL MAP OF PAKISTAN; A TRANSFORMATION FROM PICTORIAL REPRESENTATION TO GEODATABASE MANAGEMENT

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Abstract

Geological Survey of Pakistan is currently working on a project titled "Status of Geological Mapping in Pakistan & Mineral Map of Pakistan - A Transformation from Pictorial Representation to Geodatabase Management", owing to growing demands for both pictorial as well as digital information pertaining to the present and the future geological mapping and mineral potentials of Pakistan which are steadily, sometimes abruptly, increasing in the recent past especially after the introduction of CPEC in Pakistan. Consequently there has been a growing realization for carrying out a more centralized, elaborated and accelerated programme of geological mapping and mineral exploration in the country. This first-of-its-kind compilation work involves development of a centralized geodatabase using data integration, by means of GIS and Remote Sensing techniques, of previous geological and mineral exploration literature of Geological Survey of Pakistan. The geodatabase for map showing status of geological mapping mainly includes the fields like toposheet number, province, district, map title, authors, year of publication, scale of map, area of toposheet, hyperlink to other related maps/reports/field photographs/satellite imagery and so on. Similarly, the geodatabase for Mineral Map of Pakistan includes mineral name, province, district, locality, toposheet number, reserve tonnage, mineral genesis, structural control, metallogenic zone, associated minerals, host rock, age of the host rocks, mining status, recommendations and so on. Data compilation, being the first step involved the incorporation of previous published data of GSP in the form of geological maps, mineral maps, reports etc., data rectification is further performed in which the incorporated data is rectified using GIS and remote sensing techniques. Data analysis is the best part of this project. Further data integration and geospatial analysis is applied on this developed geodatabase will ultimately help in detailed study of the lateral extension of known mineralization along with a systematic investigation of the regions which are still unexplored or inaccessible. As the regional geological mapping is always a prelude to systematic mineral exploration, the mapping data shown on the status map and the geodatabase developed at the backend will facilitate in proper understanding and critical appreciation of the strategy and priorities of mapping adopted by the GSP in the last seven decades and in the targets set for achievement during the next work plan. Yet, the GSP is incorporating its own geological data in the database, after its completion, the GSP will collaborate with other organizations, like provincial-federal mineral departments, academic institutions, independent researchers etc., to develop a centralized and an integrated database to better assist the mobilization of natural resources for betterment of the nation.

TARGETING THE RARE-EARTH ELEMENTS (REES) MINERAL DEPOSITS IN KHYBER PAKHTUNKHWA: THE PRODUCTIVE IMPRINT OF PAKISTAN-CHINA ECONOMIC CORRIDOR (CPEC)

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Abstract

The production of REEs is dominated by China for number of years. The demand of these elements is increasing day by day due to their use in many modern instruments and devices including rechargeable batteries, catalytic converters, fluorescent lightings, cell phones etc. Due to wide range of applications, REEs are regarded as seeds for modern technologies. The applied as well as research sector organizations of developed countries are the major consumers of REEs as they increase the efficiency of solar cells, wind turbines and other renewable energy systems. These elements are primarily hosted in minerals like apatite, monazite, chevkinite which are found in alkaline rocks including alkali granites and carbonatites, in major. These rocks are distributed in different regions of Khyber Pakhtunkhwa (KP) in the northern portion of Pakistan and occur along, around 170km non-linear mountain belt, known as Peshawar Plain Alkaline Igneous Province (PPAIP), formed due to single geological event. The constituent rocks majorly include alkali granites, syenites, nepheline syenites, carbonatites and albitites, all known as the major producers for REE bearing deposits. The different locations in KP where these rocks are exposed include Tarbela, Ambela (Buner), Jambil (Swat), Warsak (Peshawar), Sillai Patti (Malakand) and Loe-Shilman (Khyber Agency).

Besides REEs, these rocks are also enriched in other metallic minerals including Zinc, Lead, Lithium and several gemstones. The enrichment of these minerals is reported in old literature but has not been adequately addressed due to lack of proper mining and analytical facilities in Pakistan. The CPEC provides a platform where a project incorporating exploration of these deposits in KP can be initiated using the expertise and advanced instrumentation of the world's largest producing country of REEs i.e. China. The organization of mineral exploration projects is essential to strengthen the mineral sector in Pakistan as it will open bunch of applied and research opportunities for the fresh graduates, scientists and engineers.

AGGREGATE POTENTIAL OF THE CARBONATE UNITS IN THE KHYBER FORMATION, KHYBER AGENCY, PAKISTAN

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Abstract

This study is aimed at evaluating the Precambrian carbonates of the Khyber Formation in terms of their mineralogical, chemical and physico-mechanical properties for assessing their suitability as an aggregate source both in asphalt and concrete works. The Khyber Formation is extensively exposed in the eastern and central parts of the Khyber Agency. The Limestone units of the Khyber Formation dominantly comprise of Calcite ($CaCO_3$) with minor to trace concentration of dolomite, undeformed quartz and ores, classified as Algal laminated micritic mudstone. They are light to dark-grey, fine to medium-grained, hard, compact and thin to medium-bedded and at places thick-bedded. The algal stromatolites and laminations are the common features. The stylolites, calcite-filled veins and neomorphism are the common diagenetic modifications. The limestone of the Khyber Formation is composed of 54.72-58.4 wt. % $CaCO_3$, 0.5-0.9 wt. % MgO and based on 0.02-0.22 wt. % combined values of K_2O and Na_2O, it is classified as low to high alkali limestone. Massive outcrops of dolomitized-limestone have also been identified sporadically along the exposed outcrops of the Khyber Formation e.g. in Besai area and along Khyber Pass. The petrographic and chemical investigations reveal that the limestone units of the Khyber Formation are innocuous in terms of Alkali Silica Reactivity (ASR) and Alkali Carbonate Reactivity (ACR). However, the dolomitized horizons must be avoided, owing to the ACR potential when selecting a quarry site for aggregate extraction. The physical properties of the limestone units of the Khyber Formation as an aggregate material (i.e. soundness, water absorption, Los Angles abrasion and specific gravity) are in accordance with the ASTM standards. The petrographic, geochemical and geotechnical details of the limestone units in Khyber Formation approve their suitability as an aggregate source in both concrete and asphalt construction works.

SPATIO-TEMPORAL ANALYSIS OF GROUNDWATER RESOURCES OF PESHAWAR CITY USING GIS AND REMOTE SENSING

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Abstract

The menace of Population growth, unplanned urbanization, industrialization and other human activities are increasing stress and, also have devastating impacts on groundwater and other natural resources. Groundwater is an economical and more convenient source of drinking water around the world. In a developing country like Pakistan, the water quality in general and groundwater in particular is of great concern. About 74.4% population does not have access to clean water and is observed as one of water resources stressed country. In this study, Geographical Information System and remote sensing (GIS/RS) based methods have been utilized to investigate spatio-temporal variations in groundwater resources due to the dynamic phenomena, such as, population growth, unplanned urbanization and industrialization. This article primarily covers the qualitative analysis of the groundwater impacted by these dynamic phenomenon in Peshawar (Pakistan). The main objectives of this study are; A) Physiochemical changes of groundwater quality since 1985. B) Geospatial analysis and Mapping of different contamination distribution. C) To illustrate the vulnerable Wards (Union Councils) due to contaminated groundwater. The temporal data for urban growth since 1985 has been estimated from satellite images, and population data have been collected from the Pakistan Bureau of Statistics for the years 1981 and 1998 and projected for 2016. The groundwater data collected by TNO (Toegepast Natuurwetenschappelijk Onderzoek) the Netherlands for WAPDA in 1985, and recent samples of groundwater from 78 tube wells in a field survey with GPS locations in 2016 were analyzed in this study. Utilizing the spatial overlay analysis of GIS, the temporal and spatial variations in groundwater quality have been correlated with the mentioned dynamic phenomena. This study has exposed a general decline in the groundwater quality due to these dynamic phenomena. Based on results from this study, the Urban Wards in the study area have been divided into three classes of groundwater quality; 1) Highly venerable 2) Moderately venerable 3) Low venerable. Our results show that more than half of the population of Peshawar are highly venerable due to contaminated groundwater.

Keywords: Groundwater quality, GIS, Remote Sensing, Urban Growth

DELINEATION AND CHARACTERIZATION OF A TECTONICALLY ACTIVE GARORI THRUST USING RADON MEASUREMENT TECHNIQUE IN THE SOUTHERN KOHAT PLATEAU, PAKISTAN

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Abstract

The technique of radon gas measurement can successfully be employed as a very useful geological tool in the confirmation of active geological faults, prediction of upcoming earthquakes and exploration of hidden uranium deposits. This study was aimed to check the suitability of the radon measuring technique in the study of an active Garori Thrust in the eastern part of the District Karak, Khyber Pakhtunkhwa. RAD7, a radon-in-air monitor of Durridge Company was employed for the onsite soil air radon levels measurement in crisscrosses made across the Garori Thrust on its either side. In this survey 31 measurement points were carefully chosen along five traverses across the fault. Elevated levels of radon were detected in the soil air at points on or adjacent to the trace of the fault as compared to the points away from the fault line on its either side. The values were high by a factor of 3-15 times above the background values. This evidently, points out that the procedure of soil air radon measurement can successfully be used as a genuine tool in the recognition, characterization and mapping of the faults on surface and concealed active geological faults.

GEOLOGICAL & GEOPHYSICAL APPRAISAL OF MASHKI CHAH PORPHYRY (CU-AU-MO) PROSPECT IN THE NEOGENE BALUCHISTAN VOLCANIC ARC BELT

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ABSTRACT

The work is focused on the copper and gold exploration near Mashki Chah area of Neogene Baluchistan Volcanic Arc Belt which is one of the potential segments of porphyry copper gold rich Tethyan Metallogenic Belt. Integrated geophysical surveys (Magnetics, Induced Polarization & Resistivity) in an area of 1859.50 Acres, pointed out sulfide mineralization of huge dimension in this area in the foothills of Neogene age Dam Koh Volcano. Three exploratory wells were drilled to check the presence of sulfide mineralization. The geological work involved logging of the drilled cores, ore mineralogy, identification of alterations zones associated with porphyry system, petrography and geochemistry for gold, copper, molybdenum and silver.

Andesite porphyry and diorite porphyry are the main rock units encountered in the drilled cores are with considerable alteration. The ore minerals observed include, pyrite, chalcopyrite, magnetite, molybdenite, galena etc. in decreasing order of abundance. The alteration zones of a typical porphyry system are also present including propylitic and potash, while, some phyllic and argillic alteration has also been observed.

A total of 37 samples were randomly selected for geochemical analysis by applying standard AAS technique. The percentage of copper in the 37 randomly selective samples varies from 0.013 to 2.2 %; however, one sample had shown an anomalous concentration of 7.98% of copper. The geochemical concentration of gold varies from 0.2 to 3.08 ppm; silver concentration varies from 0.4 to 0.6 ppm while that of molybdenum varies from 6.5 to 290 ppm.

Keywords: (Baluchistan Volcanic Arc, Chagai, Porphyry Deposits, Geophysical Survey, Tethyan Metallogenic Belt)

THE LATE PALEOGENE REMNANT SEA TO FORELAND BASIN SEDIMENTATION ALONG THE WESTERN MARGIN OF THE HIMALAYAS, AN INSIGHT INTO EARLY HIMALAYAN EVOLUTION

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Abstract

The well preserved Late Paleogene sedimentary record of the north Sulaiman Range offers a unique record of the early Himalayan evolution along its western margin. This study is focused on the provenance, biostratigraphy and sedimentary facies analysis of this important sedimentary archive. The petrographic and geochemical analysis of the late Paleogene sandstone units reveals their derivation dominantly, from a recycled orogenic and suture belt zone of the nascent Himalayas in the north with some contributions from Indian fore bulge and or cratonic areas in the east-northeast. The source rocks for these sandstones are acidic igneous and low to medium grade metamorphic and uplifted fold and thrust belt sedimentary rocks within a semi humid to humid tropical settings. The biostratigraphic and sedimentary facies analysis shows that epicontinental marine sedimentation took place in inner to outer shelf settings in middle Lutetian to Priabonian times, the deposition in the lower Oligocene time occurred in mid to high tidal flat settings prior to subsequent filling of the north Sulaiman Basin in upper Oligocene and Miocene time with fluvial sediments in response to the uplift associated with India-Asia collision.

TRACE ELEMENT CONTAMINATION OF GROUNDWATER AROUND KIRANA HILLS, DISTRICT CHINIOT, PUNJAB, PAKISTAN

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Abstract

Thirteen groundwater samples and one river water samples were collected from wells and water source in Rabwah area, District Chiniot, Punjab in July 2017, in order to analyze trace elements composition of water. The water samples were directly analyzed using an inductively coupled plasma mass spectrometry (ICP-MS). Judging from the maximum contaminant level (MCL) and secondary maximum contaminant level (SMCL), and Maximum Contaminant Level Goal (MCLG) as defined by USEPA and WHO Guidelines for Drinking-water Quality, the concentration of 5 elements, As, Mn, Cl, Br and S, in groundwater samples exceeded the standards. In particular, the contamination of As (max. 25.1 μg/l) and Mn (max. 443 μg/l) is high level, which may cause negative effect if continuously drink the contaminated water. High concentration of As (max. 161 mg/kg) and Mn (max. 355 mg/kg) is also detected in the Precambrian meta-volcano sedimentary rock samples collected from the Kirana Hills, according to the aqua regia digestion ICP-ES/MS analysis. The groundwater contamination by As and Mn is possibly caused by a rock-water interaction in the subsurface zone. High salinity of groundwater is inherent in the area, but the contamination by Cl, Br, and S is probably accelerated by anthropogenic origins such as septic tank and wastewater.

Keywords: Groundwater contamination, Trace elements, Rock-water interaction

GEOLOGICAL MAPPING AND TECTONIC EVOLUTION OF PART OF SULAIMAN FOLD AND THRUST BELT, EAST OF ZIARAT, BALOCHISTAN.

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Abstract

The Sulaiman Fold and Thrust Belt (SFTB) is one of a broad lobate feature developed in the north-western Himalayas in Pakistan. The lobate geometry of the SFTB is construed by transpression as a result of the left-lateral strike-slip motion along the Chaman fault zone and southward thrusting along the western boundary of the Indian Plate. The Structural evaluation and the stratigraphic setup of a part of Western SFTB has been examined in this study incorporating the Chautair, Shirin, Ghunza and surrounding areas. The Quetta Syntaxis lies in the southwest, the Zhob-Ghazaband Thrust in the north whereas, the Sulaiman Ranges confines the eastern boundary of the study area. The rocks exposed in this area range from Jurassic to Eocene with three major unconformities present at the top of Jurassic, Cretaceous and Eocene rocks. The lithologies are comprised of shales, mudstone and limestones, which makes low to high topographic relief and rugged mountainous landscape. The only Eocene (Shaheed Ghat Formation) rock unit is exposed in the southern part of quadrangle, demarcating the footwall block of the Khilafat Thrust, whereas, the Shirinab Formation of Jurassic is limited to the northern flank exposed along a major fault. There are several igneous intrusions (mostly sills) intruded at various locations in the Shirinab Formation. The hand specimen study of these sills shows that these are basaltic in nature. Structural analysis and field mapping together with collection of rocks fracture data interpreted that the area is mainly influenced by thrust tectonics of the regions. The major structural trend is WNW-ESE with alternating anticlines and synclines bounded on either side by thrust faults. The structures are fault-related folds having asymmetrical axial planes, close to tight interlimb angle and mono to doubly-plunging fold axis. At places, particularly in the central part of study area, the folds are slightly to moderately overturned. The faults are thrust to reverse in nature with their fault planes dipping (30-75°) towards the north. The fracture study at 50 discrete locations leads to the conclusion that the major tectonic transport direction is from north.

CALCIFIED CYANOBACTERIA FOSSILS FROM THE MICROBIALITIC BIOHERMS IN CAMBRIAN SERIES 3 AND FURONGIAN OF SHANXI PROVINCE, NORTH CHINA PLATFORM

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Abstract

This study examines the sedimentary features of the fossilized calcimicrobes and the development of the microbialitic bioherms in response to relative sea-level changes within Series 3 Gushan Formation and Furongian Changshan and Fengshan formations. Abundant *Lithocodium* fossils developed in the ground mass of micrite and microspar in Gushan Formation of Cambrian Series 3, which constitute the major composition of the bioherms. The Furongian bioherms developed as dense undifferentiated microbial boundstones known as leiolites in response to forced regression during third-order relative sea level fall. These bioherms have well-preserved calcified cyanobacteria fossils of *Epiphyton*, *Girvanella* and *Renalcis*, which define the recovery phase of microbial carbonate and the first episode of cyanobacteria calcification event during the Phanerozoic in the absence of metazoans reef builders. The fossilized calcimicrobes are the calcification product of the cyanobacteria dominated microbial mats, which provide a clue of microbial activities and show that the microbialitic bioherms might be a product of the cyanobacterial refined precipitation together with other calcimicrobes. The presence of chambered-shaped *Epiphyton* thalli from Furongian bioherms in the North China Platform refutes the theory of *Epiphyton* extinction at the end of Cambrian series 3. This study offers significant implications towards the features associated to the sedimentation pattern in the shallow skeleton-deficient sea during Furongian before the metazoan radiation of the Middle Ordovician. The sedimentary composition and particular sequence stratigraphic position of the microbialitic bioherms from Series 3 and Furongian series of Shanxi Province provide significant information for the future understanding of the formation mechanism of bioherms during "the first episode of the Cyanobacteria Calcification Events in the Phanerozoic" or "a resuscitate period of microbial carbonate from Cambrian to the Early Ordovician".

IMPACT OF BUILT ENVIRONMENT ON SURFACE RUNOFF: A CASE STUDY OF PESHAWAR, PAKISTAN

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Abstract

This paper attempts to explore the challenging research area of the expansion of built environment, its trend and impacts on the increase of surface runoff generation in district Peshawar, Pakistan. The study area has been experiencing rapid population growth and urban expansion which has been continuously consuming the fertile farmland and replacing the natural ground by impermeable surfaces. The required data for this study was acquired through primary and secondary sources from various organizations. Remote Sensing (RS) and Geographical Information System (GIS) methods were used to monitor and detect the development of built environment and its probable impacts on the accelerated surface runoff. Analysis reveals that Physical, infrastructural and socio-economic developments were identified as the major factors of land take and conversion of natural ground into Impervious Surface Cover (ISC). Such alterations have been producing negative effects on urban environs and water resources of the study area. Findings of the study further reveals that population of Peshawar has increased from 1.113 million in 1981 to 4.2 million in 2017. Rapid population growth is responsible for the increase of built-up areas, urban expansion and infrastructural developments, during the study period (1981-2014) have increased the impermeable surfaces from 3.70 % to 16.27 %. As a result, it has also intensified the surface runoff which has in certain cases created urban and flash floods. Rapid urban growth and the resultant physical and infrastructural developments need to be properly checked and monitored so that its adverse impacts on surface runoff generation could be minimized.

Keywords: Built environment, ISC, population growth, urbanization, RS, GIS, Surface runoff.

THERMAL RESPONSE CHARACTERISTICS OF MARBLE FROM CHITRAL, NW PAKISTAN: IMPLICATIONS FOR THE PHYSICO-MECHANICAL PROPERTIES

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Abstract

The study of physico-mechanical properties of rocks under different temperature conditions is necessary to access their suitability in various engineering applications. In marble, temperature changes play an important role in its degradation, evident by the progressive loosening of rock cohesion, micro-fracturing as well as the transformation of the mineral constituents. This work is focused on the effect of thermal severity of the selected carbonate rocks (marbles) in Chitral. The samples are subjected to thermal cycles for 12, 24 and 48 hours in an electric muffle furnace, ranging from 100 to 300 ^{o}C. After each cycle, several non-destructive and semi destructive tests are conducted including bulk density, water absorption, porosity, ultrasonic pulse velocity as well as the petrographic study and rock strength analysis. The qualitative and quantitative modifications induced in fabric, physical and mechanical properties are discussed. The results highlight the fundamental role of petrographic fabric that, together with mineralogical composition, represents the most significant discriminating factor in the response of rocks to thermal stresses.

LANDSLIDE INVENTORY, SUSCEPTIBILITY MODELING AND MONITORING ALONG THE CPEC, NORTHERN PAKISTAN.

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Abstract

The China-Pakistan Economic Corridor (CPEC) is a strategic project between China and Pakistan with economic, cultural, historical and geo-political significance. However, this ambitious venture is prone to frequent disruption by the geological hazards along the route in northern Pakistan and mountainous region of China. The proposed CPEC traverses through the Himalayan-Karakoram mountain ranges in northern Pakistan which are one of the most rapidly rising mountain ranges on earth with extreme topographic and climatic environment. The route also touches along the largest glaciers outside the Polar Regions, and therefore, is also prone to the glaciers associated hazards. A combined impact of geo-hazards including earthquakes, landslides, debris flows, glacial erosion, flash floods, river incision and unpredictable input of the monsoonal rains make it a region of very high geodynamic activity. The existing Karakoram Highway (KKH), along the CPEC route, has been frequently subjected to damages, human loss and disruption by rock fall, sliding of debris and rock, debris flow, mudflow and flash floods. Different types of mass movements along the KKH are triggered by natural factors including the presence of well-developed rock discontinuities, extensive unconsolidated deposits, high relief, steep natural slopes, torrential rains and seismically active nature of the region. The anthropogenic factors including uncontrolled blasting for roads and buildings construction on slopes also contribute to the landslides in the region. However, for most of the northern areas in Pakistan, landslide susceptibility maps are not available, which can be used for landslide hazard mitigation. This study aims to generate a remote sensing based landslide inventory, analyzing their spatial distribution and develop landslide susceptibility map. A comprehensive landslide inventory is developed through the visual image classification of fine resolution remote sensing images supported with field verification. Landslide causative factors including slope, aspect, land cover, geology, proximity to road, proximity to fault line and proximity to stream network were analyzed to evaluate their influence on the spatial distribution of landslides. The developed landslide inventory map was compared with the landslide causative factors, to evaluate their impact on the spatial distribution of landslides. The derived correlations were used in the Weights of Evidence Modelling and Analytical Hierarchical Model to developed landslide susceptibility maps. The selected landslides along the KKH are being monitored using Time Lapse Camera and UAVs. The derived results shall assist the cornered agencies for mitigating the devastating impacts of landslides along the CPEC.

RELIABILITY OF PHYSICO-MECHANICAL PROPERTIES ON THE PETROGRAPHIC CHARACTERISTICS OF THE AMBAR FORMATION, PESHAWAR BASIN, PAKISTAN

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Abstract

The present research work is carried out to study the rocks of the Cambrian Ambar Formation exposed in the Ambar section, to assess its suitability as a construction material. Four bulk samples were collected and an integrated approach has been deployed to understand the effect of petrographic studies on the physico-mechanical properties. A comprehensive petrographic study has classified the carbonate unit of the Formation as dolomitic packstone. The unconfined compressive strength (UCS) values of the studied rocks fall within the range of moderately strong to very strong while the unconfined tensile strength (UTS) values also suggests its suitability as a construction material. Variations in the strength values are mainly due to the abundance of fractures and the presence of stylolites. Similarly, the values of specific gravity are very high while the values of water absorption and porosity are very low which allow them to be used for heavy construction. Mechanical properties (unconfined compressive strength and unconfined tensile strength) and physical properties (water absorption, specific gravity and porosity) of the Ambar Formation suggest its suitability for use as construction material. By considering the petrographic characteristics, the studied carbonates may not be feasible for its use as concrete and asphalt aggregates because it has a potential of causing alkali carbonate reaction (ACR) and alkali silica reaction (ASR). However, they can be used for other construction works.

STUDY ON ASSESSMENT OF AXLE LOAD MANAGEMENT SYSTEM IN CONTEXT OF CROSS BORDER TRADE (CPEC, AFGHAN BORDER, IRAN ETC.)

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Abstract

An efficient and well-maintained transportation system serves as the backbone for all economic activities. Efficient transportation systems move goods and people throughout local, regional, state, national and international economies in a safe, timely, and reliable manner. The effect of axle loading and, in particular of over loaded vehicles, on the requirement for the road maintenance is considerable. For example, a single axle load of 36,000 lb. will cause about 16 times the damage as an 18,000 lb. In this study, marginal pavement damage cost (MPDC) was estimated for National Highways of Pakistan. For model estimation, cost data were obtained from the MR&R strategies. Total traffic load (ESALs) were calculated using AADT and WIM data. Statistical model was estimated using OLS regression techniques. Lastly, a comparison is carried out between current road use toll and actual damage incurred by different truck classes to pavement for N-5.

The increase in maintenance budgets is due to overloading. Marginal PDC was estimated to be Rs. 0.59/ ESAL km - (2016 fixed rupees) per share of the load. PDC as Rs. 0.475 / ESAL- km (2016 fixed rupees) (80% share of the load in the cost of damage to the pier) for the national highway system. It was revealed from the comparison of the current toll and the cost of actual damages, that it is appropriate to charge vehicles based on PDC. Moreover, rate of fines and tolls on the national highway system must be based on the damage (ESALs) resulting from each vehicle class. The transporters pay Rs. 1500 (maximum) due to overloading for every 2000 km/weight station travelled on the national highways which cause damages. Distance between the weight station of about 2000 km is much more to control overloading vehicles. In order to overcome these damages, it is concluded that the overloaded vehicle would be fined as per mileage. In addition, the increase in the large vehicle due to CPEC project it is necessary to increase number of weight station. Hence, it is essential to update and enforce the axle load management regulations in accordance with the international standards.

AN INTEGRATED STUDY OF SITE CHARACTERIZATION TO MEASURING THE SOIL CORROSION POTENTIAL USING GEOTECHNICAL AND GEOPHYSICAL SURVEY FOR THE CONSTRUCTION OF POWER PLANT

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Abstract

In the present era, advanced technology, latest instrument and software have been playing a vital role in the field of construction. To construct the multi storey building, dam, bridges and foundation, pre quality assurance is an essential part. Sub surface lithology and material identification using geotechnical and geophysical tools are widely used all over the world. Therefore, these facilitations are very useful in engineering site characterization. This work is related to the construction of a 45 MW coal based energy generation plant situated near Jamber Kalan, Tehsil Pattoki, District Kasur, Pakistan. For the execution of the work standard penetration tests was carried out, where 15 boreholes up to 50 meter depth were drilled at site. According to the USCS soil classification system, silty clay (CL-ML) was interpreted as a dominant material in all the boreholes at shallow depth. Poorly graded sand (SP) and silty sand (SM) was found having variable depth in almost every borehole. According to the laboratory analysis A-6 silty clayey, as specified in AASHTO soil classification system was encountered. Water table was found at 4.5 meters depth. These results were correlated with the geophysical measurements, by electrical resistivity survey using Wenner configuration. Vertical electrical sounding technique was used at three points namely VES1, VES2 and VES3 to find out the soil corrosion potential. The true resistivity of the subsurface material up to 20 meters depth is in the range of 20 to 59.5 Ωm. However, in near subsurface at depth interval 1.8 to 4.1 meters the resistivity is ranging from 19.9 to 23.4 Ωm, which is very favorable for the design of earthing system for power plant installations. Based on the resistivity values of the near-surface material, moderate soil corrosion potential at all three observation points is interpreted, which require nominal corrosion protection measures.

DETAILED GEOPHYSICAL SURVEY FOR THE DELINEATION OF METALLIC MINERALS IN BELA OPHIOLITIC BELT UTHAL AREA, DISTRICT LASBELA, BALOCHISTAN PAKISTAN

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Abstract

An integrated geophysical survey has been carried out at the southeastern margin of Uthal area Lasbela District, Balochistan, targeting the Bela ophiolitic belt to delineate its minerals potential and structural settings. The Bela ophiolites extend 450 km in length and 10 km in width that constitute the largest ophiolitic belt in Pakistan. This work is focused to confirm the presence of copper mineralization and other associated minerals as depicted by the aeromagnetic anomaly as well as to establish their structural control. A detailed magnetic survey is executed with a total of two thousand magnetic observations, aided by the vertical electrical sounding (VES) and IP survey. The survey was performed in a north-south grid pattern and profiling covering an area of 25 km^2. The periodic repeating magnetic base station was established to monitor Diurnal variations. The base magnetic values recorded for the ophiolitic sequence are 44000 nanoTesla (nT) and the total magnetic field values range from 44300 to 47300 nT. The raw field data are refined and the total magnetic intensity, reduction to pole, horizontal gradient, upward continuation and residual magnetic maps are prepared using computer oriented software, MagPick and MagMap. The total magnetic intensity fluctuates in a range from -1110 to 1624 nT, reduction to pole value from -2180 to 2470 nT, an upward continuation from -1020 to 900 nT and residual magnetic value from -2131 to 2262 nT. The magnetic survey delineated three anomalous zones; two high magnetic zones (zone 1 & 2) in the south-eastern side and one narrow zone of low magnetism (zone 3) in the NW-SW direction. The copper anomaly shown in the aeromagnetic map in low magnetic zone 3 is also confirmed using VES and IP Surveys having values from 35 to 110 ohm.m and 0.78 to 4.1 mV/V respectively. Results from these surveys confirm lack of copper mineralization; however, this zone is demarcated as a shear zone having deposition of silt and clay. The depths to the centre of anomalous zones are determined using peter half slope method, with the promising depth of 100 meters (zone 1), 40 meters (zone 2) and 60 meters (zone 3). The geomagnetic cross section is also drawn that shows the area has undergone tectonic stretching, having an extensional regime of orogenic forces. All these results confirm that study area has no copper mineralization, contrary to the aeromagnetic anomaly; however, two anomalous zones of probable manganese mineralization can be demarcated.

BIOAUGEMENTATION: A MICROBIAL TOOL TO DEGRADE TOXIC HYDROCARBON RAPIDLY

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Abstract

Bio-augmentation is a tool used successfully to overcome the catastrophic effect of accidental spillage of petroleum hydrocarbons over the terrestrial environment. The objective of this study was to evaluate the fate of bio-augmentation to enhance degradation of toxic hydrocarbons present in petroleum contaminated soils. For that purpose hydrocarbon degrading microbes were isolated from the petroleum stress environment nearby oil fields. Consortium was prepared from Bacillus cereus (Acc KF859972), Bacillus altitudinis(Acc KF859970), commomonas (Acc KF859971) belonging to family Comamonadaceae and Stenotrophomonas maltophilia (Acc KF859973). The rate of degradation of the hydrocarbons was determined with the GCFID chromatogram and linked with the increase in bacterial colony forming units with consortium. The result of this study shows that the bio-augmentation accelerate the rate of degradation of short carbon chain hydrocarbons considered to be toxic to flora and fauna whereas presence of middle and long carbon chain hydrocarbons had no effect on the flora and fauna under stress environment. It is concluded from this study that bio-augmentation can be used successfully to remediate petroleum hydrocarbon contaminated soils.

SHALE HYDROCARBON MODELING FOR THE LOWER CRETACEOUS SEMBAR FORMATION BY APPLYING THE CONVENTIONAL WORKFLOW OF 1-D PETROLEUM SYSTEM MODELING

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Abstract
The Southern Indus Basin of Pakistan has been selected in this study to evaluate the shale hydrocarbon potential of the Lower Cretaceous Sembar Formation, an organic-rich rock interpreted to have sourced conventional oil and gas accumulations. The workflow of the conventional 1-D Petroleum System Modeling (PSM) was proposed and applied to assess the Sembar maturity, comparative retention capacity, remaining kerogen, formation pressure and the remaining volume of the hydrocarbon (oil and gas) in shales of the Sembar Formation. The study was conducted based on data from the public domain of petroleum industry in Pakistan, including vertical well sections, well logs, seismic sections, regional geological sections and base maps. Results of Petroleum System (PSM) indicated that shales of the Sembar Formation are in the thermal window for gas and oil generation with an average maturity of vitrinite reflectance (R_o) of 1.9 %. Hydrocarbon generation was found to have started in the Upper Cretaceous with a rapid burial started at 100 Ma when the rate of the hydrocarbon retained in the shales of the Sembar Formation was 0.4 million tons/Ma while at present the rate of the hydrocarbon retained in the Sembar shale is 0.2 million tons/Ma with an amount of remaining kerogen ranges between 9 to 34 megatons (Mtons). Shales of the Sembar Formation are interpreted to be over-pressured at present. The average modeling volume of the remaining shale gas is 9.44 billion cubic feet (bcf) and the average modeling volume of the remaining shale oil is 24.32 million barrels (Mbbl). This study concluded that Sembar Formation has potential shale hydrocarbon resources within the Southern Indus Basin as there is momentous retention capacity within the shale with substantial remaining amount of kerogen, formation is over-pressured and model shows remaining volume of shale oil and gas within the Sembar Formation at present.

Key Words*:* Shale Gas, Shale Oil,the Southern Indus Basin, Petroleum System Modeling (PSM), Retention Capacity, Formation Pressure, Remaining Kerogen

THE IMPACT OF DEPOSITIONAL-CUM-DIAGENETIC FABRIC AND SEQUENCE STRATIGRAPHY ON SHALLOW MARINE RESERVOIRS: AN INSIGHT FROM LOWER CRETACEOUS SEDIMENTS OF THE UPPER INDUS BASIN, PAKISTAN

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Abstract

The Early to Middle Cretaceous Chichali and overlying Lumshiwal formations from the Upper Indus Basin, Pakistan have been investigated to link the reservoir quality with stratal deposition, diagenetic modifications and sequence stratigraphy. The Chichali Formation revealed laterite, glauconitic sandstone and carbonaceous green shale lithofacies, representing middle to outer ramp depositional environment. The presence of bioclastic sandy limestone, quartz arenite and glauconitic sandstone lithofacies within the overlying Lumshiwal Formation showed an inter tidal to inner ramp depositional settings. The calcite, hematite, smectite, ferroan dolomite and glauconite occured as cement in the coarse grained lithofacies of the Chichali Formation, thereby reducing the porosity, however, grain fracture porosity, and dolomitization, intergranular and dissolution porosity resulted in increase in the porosity. The overlying Lumshiwal Formation showed both physical and chemical compaction, authigenic mineralization, cementation, and late-stage dissolution. The dominant cement types in the Lumshiwal Formation are calcite, ferroan dolomite, smectite, illite and quartz-overgrowth cements. The primary intergranular porosity and late-stage diagenetic dissolution- and dolomitization-induced secondary porosity added to the reservoir quality of the Lumshiwal Formation. The sequence stratigraphic analysis revealed that Chichali Formation is deposited during transgressive system tract of 2nd order depositional cycle. The transgression-associated glauconitic sandstone lithofacies of the Chichali Formation acts as a good reservoir within the formation, which is bounded by carbonaceous green shale associated with maximum flooding surface. The Lumshiwal Formation is deposited in the regressive 2nd order cycle. This regression is represented by the intertidal lithofacies. The quartz arenites in the intertidal lithofacies bears excellent reservoir potential.

INTERPRETATION OF TOTAL ORGANIC CONTENT IN SHALE GAS RESERVOIRS FROM CONVENTIONAL WELL LOGS USING MULTI-LINEAR REGRESSION METHOD

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Abstract

South Sumatra Basin is a prolific basin in Western Indonesia. The stratigraphy ranges from Eocene-Recent and consists of various lithologies. Some shale intervals in this basin have been proven as a good source rock for several oil and gas fields in the vicinity. This also creates an opportunity for the development of shale gas exploration in the basin.. The biggest challenge in the development of shale gas here is the lack of reference to shale gas fields that have been in production. The sub-surface information of many oil and gas fields is insufficient to develop shale gas exploration. Cost efficiency is also a big issue to exploration. In relation to shale gas reservoir, Prabumulih field only have very limited information of the sub-surface in terms of total organic content (TOC). In this research, seventeen core samples obtained at various depth were studied in laboratory to calculate the TOC. The aim of this work is to acquire the TOC data from mathematical relationship by using Multi-linear regression method. We estimated the TOC information as a function of depth by applying this method. Conventional well logs like gamma ray (GR), density (RHO), neutron porosity (NPHI), sonic (DT) and resistivity were utilized. In this method, we cross plotted various log curves like GR, resistivity, RHO, DT, NPHI and obtained a coefficient for each curve. The coefficient was further used to write function for calculated TOC. The TOC log modelling has been conducted with data limitations at certain depth points and calibrated with laboratory data analysis. The correlation between the TOC obtained from laboratory test, and the one calculated using Multi-linear regression obtained a similarity upto 92%, which proves that this method is easy, reliable and cost effective. Increasing the number of laboratory data samples increases the accuracy and reliability of this method.

HOST ROCK PETROGRAPHY AND GEMMOLOGICAL PROPERTIES OF GEMSTONES ALONG THE INDUS SUTURE ZONE IN THE BARANG AREA OF BAJAUR AGENCY, NW PAKISTAN.

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Abstract

The studied samples represent rocks of the Indus Suture Zone exposed in Bajaur agency, northwestern Pakistan. These include serpentinite, talc carbonate, amphibolite, epidosite and the intruding felsic veins. The serpentinites are inequigranular, fine to medium-grained and comprises of serpentine (antigorite) majorly, olivine (metamorphic), magnesite, magnetite and chromite. These characteristics points to their formation via alteration (serpentinization) and subsequently metamorphism of dunites already present along the Indus Suture Zone. The talc carbonate is medium to coarse-grained, subequigranular and comprises of abundant carbonate, talc, quartz, serpentine, chromian muscovite (fuchsite), and green spinel or chromite. Detailed field and mineralogical studies suggest that these rocks were probably formed by talc-carbonate alteration of the spatially associated, previously serpentinized ultramafic rocks in the area. The samples of green schist are inequigranular and fine to coarse-grained and consist of amphibole including actinolite, plagioclase, quartz, epidote, carbonate, ilmenite, rutile, ore mineral(s) and a substantial amount of clay. This mineralogy suggests its formation through subduction-related metamorphism of an originally basic igneous rock. The close spatial association with altered and metamorphosed mafic and ultramafic rocks and modal mineralogy suggest that the epidosite is derived from an originally basic igneous rock through a process involving introduction of large amounts of calcium. The source of calcium is most probably the fluid related to serpentinization of the associated ultramafic rocks. The talc carbonates are invaded by quartzo-feldspathic veins. These comprise mainly of quartz, alkali feldspar, biotite, carbonate and tourmaline grains. The injection of these hydrothermal veins, which are believed to be genetically linked to the emplacement and crystallization of younger granitoids in the region probably, led the formation of chromium muscovite and beryl (and emerald) in the investigated area. Gemological properties including external observation with 10x loupe, hardness, internal observation, specific gravity, polariscopic study, pleochroism, absorption spectrum, ultraviolet light, Chelsea colour filter and refractive index were also determined. The studied varieties of epidote exhibit recommended external physical properties but show slight variation in their optical properties, however, this variation falls within the range of parameters for gem-quality epidote. The studied actinolite also duplicates the properties of gem-quality actinolite. The particular form (six-sided crystals) and other physical and optical properties of green beryl positively confirm its identification and are similar to the standard values for gem-quality beryl.

ANALYSIS OF SEISMIC WAVE PROPAGATION THROUGH SUBSURFACE MEDIA

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Abstract

Fluid saturation in subsurface media, substantially influence the characteristics of seismic waves during its propagation through deformable saturated porous media. The propagating wave apply stress on the media which results into pressure gradient at multiples scales. This scenario results into fluid flow and ultimately into wave attenuation and dispersion. Particularly, partial saturation and fluids of different nature significantly cause wave attenuation and dispersion due to well-known phenomenon of wave-induced fluid flow at different frequencies and scales. Especially, fluid flow at scale greater then microscopic scale but much less than macroscopic scale (mesoscopic scale) significantly influence wave propagation characteristics at frequencies below 1 kHz. For better understanding of wave propagation through fluid saturated subsurface rocks, an improvement in measuring attenuation and dispersion characteristics from seismic data can assist in measuring hydraulic properties of subsurface rocks. Number of theoretical models were proposed to understand wave propagation characteristics through fluid saturated deformable porous media. Some of these theoretical models were numerically validated by providing the solution of wave equations. Seismic numerical modeling technique provide most suitable way for the simulation of wave propagation through subsurface rocks. Also, it play an essential role in seismic interpretation, seismic inversion and in evaluating and designing a seismic survey. Different approaches were proposed for numerical modeling in which the solution of wave equations were given. In current study, a 2D finite difference modeling method is applied for the estimation of wave attenuation and dispersion in a subsurface heterogeneous media. The outcomes of our research reveals that, this study will enhance our understandings about wave propagation through subsurface media and will also assist in detecting and discriminating subsurface materials.

STRESS ANALYSIS AND NUMERICAL VALUES OF MOMENT TENSOR SOLUTION TO DRAW FOCAL MECHANISM FOR THE SIGNIFICANT EARTHQUAKES (Mw>6.0) IN PAKISTAN

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Abstract

A focal mechanism solution – result of the analysis of the wave form generated from an earthquake and recorded at seismological observatories – is an important tool to describe earthquake event, tectonic forces and the movement along the fault plane due to this event. Most specifically the fault geometrically is represented by the beach ball solution or focal mechanism. Fault plan solution is a powerful technique to show the stress orientation in the lithosphere and stress moment tensor values. In Pakistan, Northern area is seismically highly active due to ongoing collision of two crustal plates whereas the whole country is situated on active seismic belt and large-scale magnitude earthquake have been come. For this purpose an earthquake catalogue namely earthquake catalogue self-generated (ECSG) for magnitude Mw>6.0 up to 300 km depth for the period Jan 1976 to December 2017 is generated. The stress map of Pakistan has generated through the CASMO stress model shows the stress analysis. Stress analysis and numerical values of moment tensor are analyzed for major earthquakes of Pakistan to understand the stress phenomenon and associated deformation. Matlab codes are generated to compute the fault parameters of nodal plane 2 or the auxiliary plane. Based on these results fault plane solutions have drawn to show the geometrical representation of fault on the earth. In this work using ECSG 14 number of earthquakes of Mw>6.0 have utilized for the determination of the beach ball phenomena and values of the moment tensor for Pakistan region. These moment tensor values interpret the seismic source process to identify the earthquake source geometry.

UNRAVELING THE LATE CRETACEOUS TO PALEOCENE RECORD OF TECTONOSTRATIGRAPHIC AND PALEOENVIRONMENTAL CHANGES IN THE NORTH-WESTERN SHELF OF THE INDIAN PLATE ALONG NAWANSHEHR SECTION, ABBOTTABAD, PAKISTAN

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Abstract

Detailed lithostratigraphic and biostratigraphic description of the Cretaceous-Paleocene succession (Nawanshahr Section) is documented in this thesis. Additionally, the microfacies data has been established for the studied stratigraphic section. All these informations are integrated for unravelling the tectonostratigraphy of the studied succession. The studied area exposes the Cretaceous Kawagarh Formation, Paleocene Hangu Formation, Lockhart Limestone and Patala Formation. The biostratigraphy of the Kawagarh Formation is based on the presence of dominant planktonic foraminifera. The biostratigraphic results from the age diagnostic foraminifera i.e. *Globotruncana ventricosa*, *Globotruncanita elevata*, *Dicarinella asymetrica* and *Rotalipora cushmani* suggest Middle-Late Cenomanian to Campanian age for the Kawagarh Formation. In the Lockhart Limestone Larger Benthic Foraminifera and dasycladacean green algae are recorded. The biostratigraphic results from the age diagnostic foraminifera i.e. Miscillena miscella, Lockhartia conditi, Lockhartia haimei and Ranikothalia sindensis revealed shallow Benthic Foraminiferal Zone SBZ 4 of Thanetian age for the Lockhart Limestone. The presence of deep marine planktonic foraminifera and radiolarians recorded in the MFK1-MFK4 microfacies within the Kawagarh Formation shows its deposition in outer shelf-deep marine settings. The petrographic studies of the Hangu Formation shows its quarzitic nature with hematite as cementing material and absence of any marine fauna suggesting deposition in marginal marine conditions. The larger benthic foraminifera, algae and millolids rich microfacies MFL1-MFL5 are recorded within the Lockhart Limestone, suggesting inner ramp lagoonal to distal middle ramp settings. The radiolarians rich microfacies MFP is reported from the Patala Formation, suggesting outer ramp to deep basinal settings.

Keywords: Tectonostratigraphy, planktonic foraminifera, Biostratigraphic zonation, paleoenvironments, Kawagarh Formation,

IMPROVEMENT OF LANDSLIDE DETECTION TECHNIQUE "HORIZONTAL DISPLACEMENT FROM MULTI TEMPORAL IMAGERY" BY INTEGRATING VEGETATION, DRAINAGE AND TOPOGRAPHIC INFORMATION

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Abstract

Landslide is one of the major geologic hazards in mountainous areas. Detection and monitoring of which, is an important task for decision support systems and policy makers. However, accessibility to high mountainous regions is challenging for preparing landslide inventories. These problems have been addressed by modern methodological advance technique, assembled in the form of software package called Co-Registration of Optically Sensed Images and Correlation (COSI-Corr) Although this technique for the automatic detection of landslide on sub-pixel level proves to be one of the best techniques even then it suffers from some minor problems of having high number of false positive values. The noise is produced by numerous factors like platform changing attitude during the scanning operation of the images, digital elevation model (DEM) errors, natural features (vegetation change, shadowing effects, erosion and sedimentation) and man-made structures (urbanization). These false positive values degrade the interpretability of the data and decrease the accuracy of the results. Hence, landslide automatic identification based on displacement measurement technique from the bi-temporal imagery alone may not be adequate to detect landslides effectively. Therefore, a detection approach that incorporates data from other sources may thus be more effective than the one based solely upon the displacement measurement from bi-temporal remote sensing images. In this paper, the influence of factors (*i.e.*, vegetation, sedimentation, erosion and builtup areas) contributing to false positives values has been investigated and addressed. In this study we used pre- and post-event ASTER level 1A imagery with a time span of 4 year, obtained for November 14th 2001 and October 27th 2005. Additional pre-and post-event (IKONOS and Quickbird) images were used for GCPs collection and validation dataset preparation. Satellite images were ortho-rectified, resampled and then projected onto the ground according to their viewing geometry. Then phase correlation method has followed for the calculation of relative offset between the two imageries. Results shows that the main reason for noise or false positive values in and along the drainage lines (streams, river banks and meanders) were inundation and sedimentation by the streams and rivers. This was predominantly visible along the meandering sides of the river Neelum and some narrow stream valleys of Khata Shawai. Various false positives were also identified in the correlation images due to several natural and man-made changes in urban areas (*i.e.*, new built-up areas, roads pavements, erosion, terracing ground deformation, subsidence, etc.) either located on very gentle slopes or flat terrain. These were eliminated by masking the plane areas from the results. After the application of the plane area mask to the correlation results the true positive rate (sensitivity) remained the same but false positive rate decreased from 0.87 to 0.74, a total of 0.13 decreases. Spatial and temporal changes in vegetation over time create significant variation, therefore those areas where vegetation changes had occurred were detected as changed patches and ultimately as landslides. In the past NDVI has been effectively adopted to differentiate landslides from other changes. An effort was made to solve the problem of false positives caused by vegetation changes by masking the areas with vegetation or eliminating areas having NDVI value greater than 0.1. After the application of NDVI

mask false positive rate (1-specificity) greatly decreased from 0.74 to 0.14 (figure 3). But at the same time sensitivity also decreased from 0.96 to 0.84 (84%). Now for threshold 0.1 the sensitivity was 0.84, corresponding to only 16% probability of an omission error. This study presents a systematic approach by using a stepwise binary masking idea to enable a significant reduction of false positive from the correlation images, caused by many spatial and temporal changes. The false positives are sequentially eliminated from the landslide class by removing the noises resulting from drainage, urban sprawl and vegetation phonology. The results showed a great improvement in term of increase in true positive rate and decrease of false positive rate. The best threshold found was this for which error of omission and error of commission was less than 20%. The results also showed that medium scale imagery like ASTER could be used in a rough topographic area like Himalayas to automatically detect above 80% of landslides. The application of this method with some well-developed masks will further improve the automatic detection of landslides on regional scale in an economical way. This approach will also eliminate the need for extensive data analysis with huge rule-sets.

SUITABILITY OF NON-DESTRUCTIVE TESTING FOR THE PHYSICO-MECHANICAL CHARACTERIZATION OF THE SELECTED ROCK TYPES

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Abstract:
The mechanical and physical properties of rocks are important geological factors to access their suitability in designing engineering projects. The focus of the current approach is the evaluation of suitability among nondestructive testings (NDTs) i.e. ultrasonic pulse velocity and Schmidt hammer method, for describing the mechanical and physical characterization of the most commonly used rock types for construction. These include granites from Malakand and Utla, Marble from Nowshera Formation and Sandstone from Murree Formation. The mechanical properties encompass the compressive and tensile strengths whereas, the physical properties include specific gravity, porosity, water absorption and dry density. The ultrasonic pulse velocity was measured with 54 kHz natural frequency of the probes and Schmidt hammer rebound values were achieved by an L-type hammer with an impact energy of 0.735 Nm on cylindrical specimens. The factors that induce variations on both the NDTs such as moisture contents and weathering grades are also provided. Additionally, statistical correlations between ultrasonic pulse velocity and Schmidt hammer for the mechanical and physical properties are presented and discussed. The major output of the work confirms the reliable testing among NDTs for a preliminary prediction of mechanical and physical properties. This is of much interest as NDTs require less or no sample preparation, is relatively easy and economical in comparison to direct mechanical and physical testing.

ANALYSING THE RAINFALL AND TEMPERATURE VARIATION IN LAST 20 YEARS FOR DERA ISMAIL KHAN District

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Abstract

Pakistan is one of those countries highly exposed and vulnerable to climate change. The country has experienced many several droughts, floods and storms over the last decades. The main focus of this study is to find out the weather variation in D.I khan. To this end, we worked on a 20 years (1996-2015) dataset of minimum temperature, maximum temperature and rain fall from Regional Meteorological Center Peshawar (RMC). Data of meteorological elements of the station DI Khan, like maximum temperature, minimum temperature, mean temperature and rainfall for the last twenty years (1996-2015) was averaged and then analyzed for 2 spans of 10 years by using statistical methods, like Deviation from Normal, Percentage Deviation from Normal, Correlations, Coefficient of Determination or R^2, Mean Median, Mode and STDEV. The monthly average rainfall result shows that there was no large excess rainfall recorded in any month during last 20 years from (1996-2015) and the average annual precipitation in DI Khan measured over a period from (1996-2015) is about 302.1 mm. The maximum precipitation is recorded in the months of July 69.7mm and August 69.4mm over a period of last twenty years. The average monthly temperature in D. I. Khan shows a relatively hot period from June until September with mean maximum temperature exceeding from 38.0 °C. In winter the average monthly temperature drops below 20.0 ° C in December and January. In monthly minimum temperature the coldest month is January whereas the daytime temperatures will generally reach highs of around 19.0 (°C). At night the average minimum temperature drops down to around 4.0 (°C). In recent times the lowest recorded temperature in January has been 2.5 (°C) in year 2007.The annual mean maximum temperature in DI Khan measured over a period from (1996-2015) is about 36.1(°C). The annual amount of temperature received is normal. The maximum / hottest temperatures are recorded in the months of Jun, July and August with average maximum temperatures 40.1 (°C), 38.4 (°C) and 37.4 (°C) respectively over a period of last twenty years. The maximum temperatures during summer season remained between 38.0(°C) to 40.0(°C) and 22.0(°C) to 19.0(°C) in winter season. The highest maximum temperature has been recorded in the month of June, 2014 with 42.6 (°C). On the bases of twenty years' study period, on meteorological parameters, (temperatures and rainfall) from (1996-2015) it has been calculated that there was no significant variation in weather climate was observed in DI Khan region. The annual percentage departure from normal rainfall and annual departure from normal minimum and maximum temperatures are showing normal behavior.

LITHOFACIES AND BIO STRATIGRAPHY OF NARI FORMATION AROUND THANA BULA KHAN, LOWER INDUS BASIN, SINDH, PAKISTAN

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Abstract

The study of benthic foraminifera of Nari Formation in the Lower Indus Basin reveals some major changes across the Rupelian-Chattian boundary of Lower Indus Baisn. The very base of the Chattian is characterized by the bloom of the benthic foraminifer Asterigerinoides guerichi (>70%). A biohorizon referred to as "Asterigerina Horizon". Other significant bio-events with in the Rupelian and presented as a regional zonal scheme based on the sedimentological and biostratigraphic study of the Nari Formation from the key stratigraphic section of the Thana Bola Khan area of Lower Indus Basin, Pakistan. The stratigraphic thickness of the Nari Formation is 200 feet. In Nari Formation, A total of 75 species have been identified in which 49 benthic foraminifera. The smaller benthic foraminifera are identified up to generic and species level. Based on detail petrographic study four microfacies have been identified in the Nari Formation namely alveolina wack-packstone microfacies, assilina grainstone microfacies, nummulities pack-grainstone microfacies and discocyclina microfacies. The forams identified in this study include: *Rotaliidae, Lituolidae, Fusulinidae, Nonionidae, Camerinidae, Ophthalmidiidae, Ammodiscidae, Anomalinidae, Silicinidae, Trochamminidae, Amphisteginindae, Planorbulinidae, Cymbaloporidae, Cymbaloporidaae, Lagenidae, Cassidulinidae, Miogypsinidae, Alveolinellidae, Nonionidae, Miliolidae and Discocyclinidae.* The benthic foraminifera such as A. acutus, Cibicidoides species, and Lenticulinids are moderately abundant at the base of this formation, such that they have been defined as the midway faunas. They indicate shallow marine environment.

Keywords: Nari Formation, Oligocene, lithofacies, depositional environments and bio-zonation

ASSESSMENT OF CLIMATE CHANGE IMPACTS ON LAL SOHANRA BIOSPHERE RESERVE, PAKISTAN, USING SATELLITE DATA

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Abstract

Countries and communities globally are hit hard by climate change but worse affected are those with higher vulnerability. The most serious climate change impacts include environmental, social and economic. Pakistan being an emerging economy is at high risk due to climate change and inadequacy of resources to mitigate and adapt. This research examines the impacts of climate change at Lal Sohanra biosphere reserve Pakistan by incorporating satellite data (1999 to 2017), rainfall and temperature data (1999 to 2015) Landsat 4-5 TM year 2000, and Landsat 8, 2017 imagery. The results indicate that the monthly average maximum rainfall for Bahawalpur city occurred in the months of July (80 mm) and August (45 mm) and the annual average rainfall exhibited decrease from 100mm to 50mm during the period of 1999 to 2015 with 2002 and 2014 being relatively dry. The monthly normal minimum and maximum temperature recorded for Bahawalpur City during 1999 to 2015, showed rise from April till September with June as the hottest month (35^{o}C) and December (15^{o}C) and January (14^{o}C) as coolest months. The average minimum and maximum temperature per year for Bahawalpur City manifested, the average maximum temperature during 2002 as 34.5^{o}C along with minimum of 18^{o}C in 2014. Results from the climograph of annual average conditions for Bahawalpur city showed that maximum rainfall was recorded in 2015, that resulted in a decrease in the temperature. The land cover changes in and around Lal Sohanra National Park exhibited decrease in total surface water and increase in forest/cultivated vegetation during 2017. Significant decrease of water was observed in Patisar Lake during 2017 resulting in a marked increase in vegetation cover. The research finds that these land cover changes were mainly due to the water scarcity, land degradation and not least by mismanagement of the resources.

INVESTIGATION OF GROUND CONDITIONS OF A SMALL-SCALE DAM PROJECT IN NORTHERN WESTERN PAKISTAN

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Abstract

The detailed investigations of ground conditions prior to the construction of dam or any other large engineering structure is the prime aim of engineering geological studies. An adequate assessment of geological and geotechnical conditions of dam-site is one of the most important aspects of a dam safety evaluation. The ground conditions of small-scale dam site have been examined through various field tests and site exploration and assessment. The site exploration of the case study has been conducted through boreholes where in-situ testing has been done. The data of the two boreholes, coded as BH1 (35m) and BH2 (20m) have been studied which were drilled along the axis of the proposed dam site. The detailed borehole logging indicates that majorly the over-burden is underlain by granitic rocks. The overburden is largely comprised of compacted soil, gravels and boulders of plutonic nature. The geological investigation for ground conditions have been done via different in-situ testing procedures including field permeability test and water pressure test. These procedures determine the water loss in the overburden and bedrock. The granites which constitutes largely the bedrock are physically and mechanically hard enough to bear the capacity of the proposed dam foundation. The smaller values of the field permeability tests conclude that natural permeabilities barriers are present in the over-burden. The over-burden of the study area consists of clasts of igneous origin, finer sand, silt and clayey materials that fills the pore spaces and resist the channel flow, hence cause subtle water loss. Such conditions are always sound for the construction of small- or large-scale engineering structure. The lugeon values, obtained from the water pressure test in the boreholes are varying greatly with increasing depth. These values are low at shallow depth which points towards the well grouted conditions of the shallower log units. The leaching of finer material from the over-burden into the shallower units has been the most probable reason of joints filling at shallower depth. The higher values of Lugeon tests at greater depth suggests open jointing of bedrocks at certain depth. Grouting has been suggested for thorough filling of joints and reducing the water loss under controlled conditions.

INTEGRATED SEQUENCE STRATIGRAPHY OF JHELUM GROUP KHEWRA GORGE, SALT RANGE, PAKISTAN

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Abstract

The Jhelum group of the Cambrian age which consists of Khewra Sandstone, Kussak Formation, Jutana Formation and Baghanwala Formation has been investigated for lithofacies, petrography and sequence stratigraphy. Based on the lithofacies analysis the Khewra sandstone consisted of inter-bedded shale and sandstone lithofacies, channelized sandstone lithofacies, planner bedded sandstone lithofacies, channelized sandstone interbedded with shale lithofacies and conglomerate lithofacies, based on the lithofacies, the delta plain to delta front depositional environment is suggested for the Khewra Sandstone. The Kussak Formation consisted of glauconitic sandstone and shale interbedded lithofacies, borrowed glauconitic sandstone lithofacies, based which a shallow marine depositional settings is suggested. The Jutana Formation consisted of algal laminated dolostone lithofacies, glauconitic sandstone lithofacies, thick bedded dolostone lithofacies, sandy dolostone lithofacies and shale lithofacies, based on the lithofacies a shallow marine depositional setting is suggested. The Baghanwala Formation consisted of shale lithofacies, variegated siltstone lithofacies and reddish sandstone lithofacies, based on these lithofacies, the Baghanwala Formation represented fluvial dominated deltaic depositional setting. Based on the petrographic studies, using Gilbert (1982) classification of sandstone the rock type identified from the Khewra Sandstone is quartz wackes and feldspathetic wackes. The rock type identified in Kussak Formation is quartz wackes and feldspathetic wackes, while the Baghanwala Formation is represented by quartz wackes and mud rock. Under sequence stratigraphy investigation, three sequences have been identified from the Jhelum Group. The deposition of Khewra Sandstone is represented by three regressive system tracts and three transgressive system tracts. The Kussak Formation is deposited during two transgressive and three regressive system tracts. The Jutana Formation is deposited during two transgressive system tracts and three regressive system tracts, while the Baghanwala Formation represents overall regression while the base of the formation is marked by first transgression.

Keywords: Sequence stratigraphy, Lithofacies, Paleoenvironments, Jhelum Group, Cambrian

MICROFACIES, PALEOENVIRONMENTS, DIAGENESIS, PALYNOFACIES AND SEQUENCE STRATIGRAPHIC STUDY OF THE CAMBRIAN DARWAZA FORMATION OF THE ATTOCK CHERAT RANGE, NORTHWEST, PAKISTAN

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Abstract
This integrated research work deals with the carbonate microfacies, diagenesis, palynofacies and sequence stratigraphy of the Cambrian Darwaza Formation of the Attock Cherat Range. Thirty-one representative samples were collected for the petrographic study. In light of detail petrographic and palynological studies, three microfacies, i.e. mudstone, siliciclastic mudstone and algal laminated mudstone and one palynofacies i.e. palynofacies Darwaza Formation the Darwaza section-1 (PDD-1) have been recognized in the Darwaza Formation. The microfacies types indicated an intertidal to supratidal depositional environment. In the studied strata, various diagenetic processes including cementation, dissolution, compaction (both mechanical and chemical) and microfractures have been identified in most of the samples. Three stages of diagenesis, i.e. marine, shallow and deep burial environments are recognized. The Cambrian strata of Attock Cherat Range is largely affected by various diagenetic events which indicated low hydrocarbon reservoir potential. The main factor which adds to the reservoir characterization ability is fracturing which are observed both on macro and micro scale. Due to absence of fossils in the studied sections of Attock Cherat Range, the microfacies types and their depositional environments have been used for the interpretation of depositional sequences followed by parasequences and their relative sea level curves. The Darwaza Formation is comprised of one composite sequence and fourteen parasequences of third order cycles.

Keywords: Microfacies, Paleoenvironments, Palynofacies, Sequence stratigraphy, Cambrian, Darwaza Formation.

DETERMINATION OF DYNAMIC SOIL PROPERTIES USING CYCLIC TRIAXIAL APPARATUS ALONG JAMRUD ROAD, PESHAWAR

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Abstract

The characterization of dynamic soil properties such as shear modulus and damping ratio is important for the seismic design and analysis of any geotechnical system that undergoes dynamic loading such as during the earthquakes, blasts, rail and traffic vibrations, wind, and ocean waves. In addition to the requirement of strict structural earthquake design guidelines, it is important to obtain the dynamic soil properties to study the soil-structure interactions, site response, and prediction of the ground motion. Earthquake-induced dynamic soil behaviour can be hysteretic, highly nonlinear and plastic. In this study, strain-controlled cyclic triaxial tests are carried out to obtain the dynamic response of subsoil along the Jamrud Road, Peshawar. Five boreholes were drilled at various locations to obtain the undisturbed soil samples using the Shelby tubes. Three samples of standard sizes from each tube were tested under the increasing confining pressures and strains rates. From the tests, stress-strain hysteresis loops are obtained and the values of shear modulus and damping ratio are calculated for each cycle. The results show that both the shear modulus and damping ratio decrease with increasing the number of cycles. Similarly, the shear modulus decreased with increasing strain level whereas, the damping ratio initially increased for strains 0.01 and 1%, and then decreased for strains 2, 2.5 and 5%. The plots of shear modulus and damping ratio vs. shear strain at different confining pressure suggest that the confining pressure has greater influence at strains 0.01 and 1% that progressively reduces at larger strains at 2 and 2.5%.

SPATIOTEMPORAL ANALYSIS OF CLIMATE CHANGE IMPACT ON KURUMBAR VALLEY GLACIERS GHIZAR DISTRICT PAKISTAN

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Abstract

Climate change impact on the water resource particularly on glaciers is one of the important issues of today's era on the Earth surface. Glaciers located on the mountain ranges of the World namely Alps, Himalaya, Karakoram and Hindu Kush have thousands of glaciers and glacial lakes. Among the aforementioned ranges, Hindu Kush glaciers are visible indicators of the Climate Change as they show shrinkage of glacier cover area, formation of nascent glacial lakes and rise in glacial lake outburst flood events. This study presents spatiotemporal analysis of precipitation and temperature trends and GIS & RS based investigation of the glacier dynamics in Kurumbar valley of District Ghizar in Gilgit Baltistan region. Temporal glaciers were delineated using objected based classification couple with manual digitization of accurate glacier outlines in debris cover area on high resolution imagery. Final results were validated with field assessment and ICIMOD inventory data. Kurambar valley is located in Ishkoman tehsil, Ghizar District that borders with Yarkhun valley of Chitral in Northwest and District Hunza in East. The valley is at about 45 km from District headquarter Gahkuch. This valley covers an area of about 1856.45sq.km having 53 sub watersheds, 149 glaciers and 30 glacial and alpine lakes. Trend and correlation analysis for period from 1990 to 2010 at 2 Climate stations and 10 weather monitoring posts (WMPs) show that there is rise in 1.2 Degree of annual temperature and increase of 20 mm precipitation. Temporal dynamics of glaciers in Kurumbar valley show that there is decrease of snow and glacier cover area from 261.49 to 241 sq.km and increase of debris cover from 73.54 to 88.93 sq.km between years 2000 to 2015. Overall glaciers of the Kurumbar valley are in retreating phase and dire need of monitoring of glaciers behavior with respect to climate change impact.

GLACIAL LAKE OUTBURST FLOOD MODELLING OF KHURDOPIN GLACIER ICE DAMMED LAKE USING HEC-RAS

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Abstract

Hydro meteorological hazards like flood, flash flood, snow avalanches and glacial lake outburst flood (GLOF) which caused loss of lives, damages to the properties and infrastructure yearly in northern area of Pakistan especially in the region of Hunza river basin particularly in shimshal valley. Advancement of glaciers and damming of the rivers and streams is common phenomena in glaciated region of world, particularly Himalayas, Karakoram and Hindu Kush ranges. Region wise karakoram glaciers are well known to create glacial lakes due to glacier surges which lead to trigger glacial lake outburst floods. Khurdopin glacier is located in upper reaches of Shimshal valley in Hunza district is one of the notorious for triggering GLOFs as it surges in cyclic manner. Due to exponential surging of glacier it reaches adjacent valley, thus blocking the Shimshal River and creating lake upstream. Historical data shows that it advances roughly in every two decades, i.e. 1960, 1980, 1999 and most recently in May 2017. Initially the lake size grew up to 700 meters in May 2017, which later drained gradually in August 2017 that damaged 10 kilometers of road section, 2 bridges and developed land. Although hazard was eased for time being, but surging did not stop. A much large lake was spotted in 31 October 2017 on Satellite image, which posed much larger threat to the communities living downstream in form of GLOF. In this study we used high resolution (2 meter) Digital Terrain Model (DTM) and field data of critical sites acquired through Total Station and GPS. The GLOF zones were delineated using HEC-RAS. The results of modelling were verified from field and as well as with pre and post GLOF event imagery through change detection techniques. The proper mapping and monitoring of these hazards generate early warning mechanism for future is critical to increase the resilience of vulnerable communities living in low lying areas and sustainable development in hazard prone site of shimshal valley.

PERMIAN FELSIC DYKES IN THE NEO-PROTEROZOIC NAGAR PARKAR IGNEOUS COMPLEX: EVIDENCE FROM IN SITU ZIRCON U–PB AGE BY LA-ICP-MS

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Abstract

We report a first discovery of the Permian felsic dykes in the Neo-Proterozoic Nagar Parkar Igneous Complex (NPIC). The complex is the oldest known magmatic rock suite exposed at the junction of the Thar Dessert and Rann of Kutch in the Sindh Province of Pakistan. The dominant lithological units are mainly granites of Neo-Proterozoic age (750 ~1000 Ma) that have been emplaced in the basement rocks (amphibolites). A number of mafic and felsic dykes intrude the basement as well as the granitic rocks. Granitic bodies in the area have been subdivided into two major varieties as riebeckite-aegirine gray granite and biotite-hornblende pink granites. Previous workers reported six major magmatic episodes of intrusive and extrusive activities as (1) basement rocks (amphibolites and related dykes), (2) riebeckite-aegirine gray granites, (3) biotite-hornblende pink granites, (4) acid dykes, (5) rhyolite plugs, and (6) basic dykes. The oldest basement forming lithologies are mafic to tonalitic rocks metamorphosed under epidote amphibolite- and greenschist facies conditions. Gray and pink granites are emplaced in the basement rocks, hence likely younger than the former rocks. Rehman et al. (2018; Gondwana Research in press) reported precise U–Pb zircon age data, determined by the LA-ICP-MS technique. Zircons in gray granites yielded U–Pb mean ages of 748 ± 9.5 Ma (MSWD = 0.23). In addition, zircons in pink granite yielded U–Pb mean age of 713 ± 32 Ma (MSWD = 1.5) with concordia intercepts at 726 Ma ± 41 Ma (MSWD = 1.9). Mafic and felsic dykes intruding both varieties of granites were inferred to be of Cretaceous age based on their intrusive nature within the granites and correlation with the nearby mafic magmatism of the Deccan Traps. In this study, we report, for the first time, dyke intrusion in NPIC during the Permian (272 ± 5.4 Ma, MSWD = 0.53), evidenced from the in situ zircon U–Pb analysis from a dyke sample (NV90-09) using the LA-ICP-MS technique. Our newly obtained age data indicates the existence of magmatic activity in the NPIC possibly associated with the rifting of the Cimmerian microcontinent from the Gondwana during the Permian as evidenced by the alkaline magmatism ca. 315 ± 15 to 297 ± 4 Ma in Ambela area, Pakistan and the mafic Panjal Trap volcanism ca. 284 ± 4 to 262 ± 1 Ma.

RADON CONCENTRATION IN DRINKING WATER SOURCES OF THE LAKHARAI VILLAGE, PESHAWAR, KHYBER PAKHTUNKHWA, PAKISTAN.

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Abstract

The study area is part of Peshawar basin which is filled by meandering and braided river sediments. The unlithified sediments of the basin are predominantly lacustrine silt with fluvial sand and gravels. The current study reported Radon concentration in drinking water of the Lakharai village for the first time. About 32 drinking water samples from different sources including hand pumps, open wells, and tap water in Lakharai village, north of University of Peshawar. All the samples were analyzed with RAD7 electronic device for determination of radon concentration. Results showed that the water samples have a minimum, maximum and mean radon value of 7.07 Bq l^{-1}, 44.5 Bq l^{-1}, and 15.1 Bq l^{-1} respectively. Out of the total number of drinking water samples from different sources (hand pumps, open wells and tap water etc), about 60% were found to have radon levels in excess of the EPA recommended maximum contaminant level (MCL) of 11.1 Bq L^{-1}. The annual effective dose from radon in water due to its ingestion and inhalation per person has also been estimated. The mean radon concentration and mean annual effective dose due to radon in water of study have been compared with different localities of the World and Pakistan. The mean annual effective doses of 30 samples are lower, 1 of them is equal and 1 is greater than the reference level of 0.1 mSv a^{-1} for drinking water of WHO and EU Council. It is concluded from this study that drinking water of the Lakharai village is not safe due to presence of high levels of radon gas in drinking water sources of a region. The radon gas is responsible for the radiation related health hazards, both, through ingestion and inhalation. The ground water taken for domestic uses can influence humans and causes stomach and lungs cancer, if concentration of radon is high. It is recommended that drinking water of the area should be ventilated and then stored in water storage tanks for longer duration before use to reduce its radon level. Boiling water from these sources before its final use for drinking purpose will also be advantageous.

FLASH FLOOD SUSCEPTIBILITY MODELING USING GEOMORPHOMETRIC RANKING APPROACH IN PANJKORA BASIN, EASTERN HINDU KUSH, PAKISTAN

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Abstract

Flash floods are highly unpredictable and worst hydro-meteorological disaster in Panjkora Basin. They are generated by torrential rainfall causing human losses and damages to human property and infrastructure. Number of quantitative and qualitative approaches exists in scientific literature for flash flood modeling within a watershed. This study focuses on Geographic Information System (GIS) based flash flood susceptibility modeling using geomorphometric ranking approach in Usherai Basin- a sub-basin of Panjkora river system. The phenomenon has frequently affected the study in terms of human and economic losses since 2005. Advance Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) is used in GIS environment for watershed modeling and mining primary morphometric parameters comprised of spatial and attribute information. Hortonian model is applied to quantify secondary morphometric parameters. Morphometric results were analyzed using simple statistical techniques and then ranking score for each parameter is defined. The results are linked to the geo-database for spatial visualization of sub-basins into very high, high, moderate and low susceptibility zones. The study can assist the disaster management authority in initiating flood risk reduction strategies in highly susceptible zones of the Usherai Basin.

A CASE STUDY: SUCCESSFUL EXECUTION OF COMMUNITY BASED FLASHFLOOD EARLY WARNING SYSTEM (CBFEWS) AT SHERQILLA, DISTRICT GHIZER

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Abstract

Climate change is a global phenomenon and it has wide-range of impact on mountainous region of Pakistan. The frequency of disasters has increased in the last two decades causing enormous damages to agriculture, livelihood and economy of the local communities reducing their capacity. Sherqilla village of district Ghizer in Gilgit Baltistan is one of the most vulnerable villages prone to flashflood hazard. This village was selected for installation of pilot early warning system for flashflood based on 1) dominance of hazard i.e. flash flood, 2) exposure of community to the hazard, and 3) availability of mobile network and enough leap time for early warning. In May 2017 the system was installed in close collaboration with GBDMA (Gilgit-Baltistan Disaster Management Authority) and WWF (Worldwide fund for Nature). The early warning system is comprised of three major parts i.e. water content sensor with WRTU (Wireless Remote Terminal Unit), Data collection platform and ARTU (Audio Remote Terminal Unit or siren system). Moreover automatic rain gauge is also installed to record/monitor precipitation data which is being used to set the precipitation thresholds for future projects. This System works on simple principle i.e. when flood (Debris/water) touches the water content sensor it transmits information through Audio Remote Terminal Unit to Data Collection Platform (DCP) via GPRS and if internet is not available then through radio waves. DCP (Data Collection Platform) transmits the information further to ARTU and then siren is triggered. On 3rd August 2017 at 4:30am a flashflood event was occurred as it reached the sensor Early Warning was executed. The flood reached the village at around 5:30am, during this leap time the vulnerable population of Sherqilla successfully evacuated to the safer areas saving the precious lives and livelihood. The installation and effectually execution of system and early warning is appreciated at both government and community level and other vulnerable communities are also demanding such early warning systems to be installed along their streams. Government and other agencies can out scale and upscale and easily replicates this early warning system to other regions of Pakistan.

CHANGE OF EQUILIBRIUM LINE ALTITUDE (ELA) IN RESHUN GLACIER, CHITRAL, KP, PAKISTAN

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Abstract

The global climate change and associated phenomena has resulted not only in disappearance of some of the glaciers of the world but is also an eminent threat to the existing glaciers. This has resulted in a severe repercussion on the availability of natural water resources for the agricultural, civil and industrial purposes. This study reveals to find out the fast retreating of Reshun Glacier. Chitral lies in the northern temperature zone having high elevated peaks with glaciers. Reshun Gol is comprised of two main valley glaciers, Shahkoh and Lotshal with many tributaries. The data was collected through yearly field visits from 2009 to 2017 and Geographic Information System (GIS). The data obtained from the glaciers shows 29 m snout recede from 2009-2013 and 61 m recede from 2013- 2017 in Shahkoh Glacier. Similarly, 44 m snout recede has been recorded from 2009-2013 and 71 m recede from 2013-2018 in Lotshal Glacier. This study shows that these glaciers are retreating at a very fast rate. If this continues, within a few decades the glaciers in Reshun Gol will disappear. Recommendations are made for reducing the fast rate of retreating of the Reshun glaciers by controlling overgrazing, afforestation and modern methods like glacier sheeting.

GEOTECHNICAL, PETROGRAPHIC AND GEOCHEMICAL STUDY OF SHEKHAN FORMATION, SHEKHAN NALA SECTION, KOHAT BASIN

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Abstract

Limestone being a valuable sedimentary rock, is largely used in the construction and chemical industries in all parts of the world. This work investigates petrography, geochemistry and mechanical properties of the Eocene limestone of the Shekhan Formation for its suitability as a concrete aggregate. The limestone is yellowish-grey in colour, medium-thin bedded with interbedded shale partings, compact and fossiliferous at its type locality. Petrographic analysis shows that calcite is present in the form of micrite (fine-grained calcite) with lesser amount of sparite (coarse-grained calcite). Fractures as micro-veins are observed, mostly filled with carbonates. The rock is dense and has a low porosity. Geochemical analysis of the studied limestone suggests CaO is a dominant mineral whereas SiO_2, MgO, Fe_2O_3, Na_2O, K_2O, TiO_2, Al_2O_3, MnO, P_2O_5 are in trace amounts. The loss on ignition (L.O.I) has an average amount of 40.94 wt. %. The alkali-silica and alkali carbonate reactivity tests indicate the innocuous nature of the aggregates and verify the petrographic observations. The tested Shekhan limestone (SL) samples i.e. SL1, SL5, and SL6 show higher Unconfined Compressive (UCS) and Tensile Strength (UTS) values and occurs in moderately strong to strong category while, SL2, SL3 and SL4 show low UCS and UTS values which can be correlated to the presence of an abundance of micro-fractures, stylolites and bioclasts. All the physico-mechanical properties of aggregates of the studied limestone (i-e., Specific gravity, Water absorption, Unit weight, Los Angles abrasion value, Clay lumps, Flakiness, Elongation, Aggregate crushing value, Aggregate impact value and Soundness) are generally in accordance with the American Standard for Testing Materials (ASTM) for aggregates to be used in concrete.

TOWARDS SOLELY REMOTELY SENSED OPERATIONAL EVAPOTRANSPIRATION ESTIMATION OVER HETEROGENEOUS LAND SURFACE USING TWO SOURCE ENERGY BALANCE MODEL

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Abstract

Spatio-temporal variability and distribution of evapotranspiration (ET) are crucial for weather and climatic systems and its variable patterns over the earth surface from local to regional scales. ET is an important component of the water cycle. It is a highly dynamic process and may vary on a very short temporal scale. The controlling factors include; incoming net radiation (R_n), temperature, wind, vegetation and other meteorological variables. In situ methods are more accurate and precise for measuring ET. However, being point-based, these methods cover very small footprint and hence unable to capture the spatio-temporal trends in ET for vast heterogeneous land surfaces. In situ methods are mostly utilized to validate ET products calculated from remote sensing data. This data especially with its recent spatial, spectral and temporal advancements, are most suitable for mapping spatio-temporal variability and distribution for large heterogeneous surfaces. Energy balance approaches have been developed for various remote sensing data. Based on energy balance approach, one source models (OSM) and two source models (TSM) are developed and modified from time to time. Being sensitive towards canopy level micrometeorological variations, the TSMs are capable of estimating separate evaporation and transpiration from soil and vegetation, respectively, hence TSMs are preferred over OSMs. In this study, ALEXI (Atmospheric Land EXchange Inverse), a two source energy balance model, was applied to remotely sensed energy fluxes and vegetation data on catchment scale in the west of Germany, the Rur catchment, near the borders of Belgium and The Netherlands. First, hourly time series of the latent heat flux (LE_{EBM}) was estimated for a period of five years (2011-2015), and then the estimated hourly time series was compared to in situ latent heat flux (LE_{in_situ}) measured through direct micrometeorological eddy covariance technique (EC). The LE_{in_situ} was only used for validating the remotely sensed fluxed without incorporating it into the ALEXI model. The LE_{EBM} showed a correlation coefficient (r) of 0.83, 0.80, 0.84, 0.90, 0.85 and a root-mean-square difference (RMSD) of 63.41, 75.41, 66.16, 118.25 and 150.00 W/m^2 with in situ latent heat (LE_{EC}) at five sites in the Rur catchment (Germany), namely, Selhausen, Merzenhausen, Selhausen-Ruraue, Rollesbroich and Wuestebach, respectively. Later the latent heat fluxes were converted from W/m^2 units to mm/hour and mm/year. The present study reveals a high ET rate (mm/year) during 2011 (dry year) and a low ET rate in 2012 (wet year) with respect to all test sites. In general, the ET rate shows an increasing trend toward 2015. This approach, exclusively based on remotely sensed data, allows for the quantitative estimates of evapotranspiration and can be extended towards catchments with no or limited in situ networks. Also, it may help to better plan hydrological risk management, e.g. to evaluate the effect of hydrological extremes (floods and droughts) while incorporating into water balance of the catchment.

PETROGRAPHIC, GEOCHEMICAL AND GEOTECHNICAL CHARACTERIZATION OF LOCKHART LIMESTONE, NIZAMPUR BASIN, KHYBER PAKHTUNKHWA, PAKISTAN

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Abstract

Limestone is an important raw material which is extensively used in construction and chemical industries throughout the world. Pakistan is bestowed with enormous deposits of limestone which are widely used in the construction of infrastructures. The huge deposit of Lockhart Limestone in Nizampur basin was petrographically, geochemically and geotechnically investigated in order to assess its feasibility as a potential source of construction aggregate. Petrographically, the Lockhart Limestone has been categorized according to Dunham classification as mudstone, wackestone and packstone having calcite and bioclast as major constituents. Under the thin section, quartz and dolomite were found in trace amount in the form of fine-grains while chalcedony, crystobalite and other deleterious minerals were not observed. Similarly, the geochemistry of studied rock indicates that CaO ranges from 49.41 to 55.08 % by weight, MgO 0.34-1.86%, SiO_2 0.00-1.95% and other oxides such as Fe_2O_3, TiO_2, Al_2O_3, MnO, K_2O, P_2O_5, and Na_2O are in trace amounts. The average values of physical tests on aggregate, such as apparent specific gravity is 2.698, bulk oven dry specific gravity is 2.657, bulk saturated surface dry specific gravity is 2.673, water absorption is 0.531%, porosity is 0.74%, bulk unit weight is 1.56 gm/cc, clay lumps and friable particles is 0.47%, soundness is 2.14%, Los Angeles abrasion value is 23.85% and Impact value is 14.66%, and are under the specific limits of the ASTM. Other geotechnical properties such as UCS and UTS were statistically compared with petrographic features using linear regression analysis. The results show that the strength and durability of Lockhart Limestone are directly related to calcite content and inversely related to bioclasts and porosity. The petrographic, geochemical and geotechnical analyses show that the Lockhart Limestone of Nizampur basin is a potential source of aggregate for the construction industry.

IDENTIFICATION OF SUITABLE LANDFILL SITES USING GIS-MULTI-CRITERIA ANALYSIS IN KOHAT CITY, PAKISTAN

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Abstract

There has been a steady increase in the urban population in the Kohat city in the last two decades. This increase in population resulted in increasing generation of solid waste causing a serious problem of the pollution in the surrounding environment due to inappropriate disposal of solid wastes. In this study an effort was made to use Geographic Information System (GIS) and Remote Sensing (RS) for the identification of suitable landfill sites for the proper disposal of the solid wastes produced. In this case study ten parameters were used in order to satisfy all environmental, social and economic conditions. SPOT satellite image and land capability maps were used as a base maps. Land use, airport, roads, waterbodies, slope, elevation, land values, water table and land capability were the parameters used as a criterion for site selection of landfill sites. ArcGIS software was used for the processing and finding result. Different analysis tools were applied to perform different analysis functions. Multi influencing factor (MIF) used to assigned weights according to their importance or percent influence. Final results were in the form of suitability map by using the Weighted Overlay tool. Resulted map shows the area in three regions, not suitable, moderate and high suitable for landfill sites. The highly suitable areas were mostly located in the southern and western part of the Kohat city.

LAND USE LAND COVER CHANGE ANALYSIS OF TEHSIL PABBI, DISTRICT NOWSHERA

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Abstract:

Land use of an area reflects the patterns of natural and human environment. In physical terms it varies from natural topography to water bodies and natural resources of an area. On the other hand, it also focus and narrate the human activities, which had been carried out in the past. These activities include urban structure growth, its temporal variation, infrastructure routes constructions and upgradation, agricultural land use spatial and temporal pattern change and industrialization etc. Land use land cover changes are considered one of the most important components while defining current and in-future strategies for managing natural resources and monitoring environmental changes. Unplanned land use land cover modifications have largely resulted in deforestation, biodiversity loss, global warming and increase of natural disaster flooding. Therefore, to ensure a sustainable management of natural resources, it is of vital importance to understand and quantify the processes of landscape changes locally as well as globally. However, a main problem is that still for mapping and monitoring of these changes, traditional techniques are used; that are considered laborious and time consuming. Satellite remote sensing is a potentially powerful means of monitoring land-use change at high temporal resolution and lower costs than those associated with the use of traditional methods. Satellite remote sensing data as a good alternate provides a systematic, up-to-date and precise overview of land cover at regular time intervals for mapping and monitoring of land use land cover and the associated changes over time. The main objectives of this study were to quantify land use land cover change from 1996 to 2015, using remote sensing and to explore the spatio-temporal pattern of land use land cover in Tehsil Pabbi, District Nowshera.

In the analysis Landsat imagery downloaded from USGS Earth explorer (*https://earthexplorer.usgs.gov/*) for 1996, 2001 and 2015 were utilized. The analysis was carried out in ArcGIS-10.2. Pre-processing steps like cloud, haze removal and filtering were carried out. The images were pan sharpened using panchromatic band in Landsat-8 images. To analyze the data, false color composite was created to ensure a better visibility for vegetation and stack layers together. The 1996 image was not pansharpend due to unavailability of panchromatic band. Supervised classification method was performed. For the validation of results accuracy assessment was carried out and the overall accuracy was found to be 79.6%.

ROCK MASS CHARACTERIZATIONS AND SAFE SUPPORT DESIGN OF POWER TUNNEL OF NANDIHAR HYDROPOWER PROJECT IN DISTRICT BATTAGRAM, KPK.

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Abstract

The current study encloses the estimation of engineering rock mass properties and safe support design of power tunnel of Nandihar Hydropower project. Empirical and numerical methods were used and compared in this study in order to achieve safe design of tunnel. The proposed length of tunnel is 6km. Detailed field studies were carried out which includes, geotechnical investigation, geological mapping, sampling and thorough discontinuity surveys. Rock mass were characterized by using two methods, namely rock mass rating (RMR), tunneling quality Index (Q). RMR and Q-system rating were determined by using field data and the mechanical properties of intact rock samples were evaluated in the laboratory. Empirically support design was calculated on the basis of RMR and Q-system rating. Geological strength index (GSI), was used to estimate geotechnical parameters of rock masses. Hoek-Brown parameters and rock constants were determined by using RocLab 1.032 (RocScience) program. Squeezing of tunnel was determined by empirical relations. Support designs were proposed according to rock mass condition by RMR and Q-system. Computer software Phase2 8.0 (RocScience), (a 2D finite element program) was used as numerical method. The parameters calculated by empirical methods were used as input parameters for numerical modeling. RMR results point out that all the rock mass situated along tunnel can be categorized as fair rock and has therefore classified in class III except at some places where it is categorized as poor rock and categorize as class IV. As per outcomes established from Q-system, rock mass along tunnel alignment belongs to very poor, poor, and fair rock regarded as in classes Q3, Q4 and Q5 respectively. According to deduction from empirical and numerical analysis, some stability issues were noticed along tunnel route specially in shear zone and at large overburden which shows significant displacement, yielded elements and plastic zone without support. In numerical modeling, subsequent to application of support (rock bolt and shotcrete) recommendation from empirical methods illustrate that there was a significant reduction in displacement, number of yielded elements and size of plastic zone. Thus comparison of two results suggests that a more reliable and safe design could be achieved by using a combination of empirical and numerical methods.

ENGINEERING PROPERTIES AND SLOPE STABILITY ANALYSIS OF LIMESTONE IN BADSHAPUR AND MAGHAL AREAS, CENTRAL SALT RANGE, PUNJAB, PAKISTAN

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Abstract

This research is an attempt to evaluate the engineering properties and slope stability of limestone in Badshapur and Maghal areas, Central Salt Range, Punjab, Pakistan. Geological mapping was undertaken to record necessary surface geological information. Drilled boreholes data was analyzed to interpret subsurface lithology whereas the engineering properties of rocks were determined by laboratory experiments. The surface and subsurface studies showed that geology of the Badshapur-Maghal area comprised a succession of Chorgali formation, Sakesar limestone and Namal formation. In order to determine engineering properties of limestone five core samples from each formation were taken from boreholes and different laboratory tests (Schmidt rebound hammer value, Uniaxial compressive test, Point load test) were performed. Result shows that UCS value by Schmidt rebound hammer test for Choragali formation is 71.42 Mpa) which depicts medium strength rock according to ISRM (1979), average value for Sakesar limestone is (76.32 Mpa) which correspondences to medium strength. The Namal formation with (61.93 Mpa) also corresponds to medium strength. By Uniaxial compressive test, average UCS value of Chorgali formation is (30.29 Mpa) showing moderate strong rock, Sakesar limestone with UCS value (50.05 Mpa) is medium strong, and Namal formation with average UCS (38.62 Mpa) is moderately strong. The UCS value determined by Point load test for Chorgali formation, Sakesar limestone and Namal formation is 58.32, 63.21, and 60.28, respectively and showed that all three formations show medium strength. In order to determine slope stability of rock masses two scaneline surveys were conducted and kinematic/stereographic analysis were performed by computer program "DIPS 5.1 (RocScience)". The scan line survey showed that there are two major sets of joints. J1 has average 75/260 dip/dip direction and J2 has average 60/070 dip/dip direction. The kinematic analysis showed that plane failure is likely to occur along many joints of joint set-1 and. From surface and subsurface studies it is concluded that all the formations are suitable for building engineering structures but along joint set-1 remedial measure should be necessary in order to avoid plane failure.

ENGINEERED CEMENTITIOUS COMPOSITE EVALUATION UNDER AGGRESSIVE ACIDIC ENVIRONMENT

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Abstract

The durability of hydraulic structures lined with mortar, especially under acid environment, has become a worldwide problem. Its durability parameters are highly considerable in current ages. The paper probed the feasibility of applying ductile engineered cementations composites (ECC) as substitute to conventional mortar in hydraulic structures to mint its performance that are subjected to acidic environment.

In this research the resistance of control mortar samples (CM) and two different mixes of ECC specimens were scrutinized. The mockups were exposed to 5% HCl solution for period of 90 days. The visual observation, weight loss and compressive strength of the samples were comparatively examined. Microstructure level X-ray diffraction (XRD) and Scanning electron microscopy (SEM) analysis were carried out to investigate the microscopic mechanism of ECC replaced prisms subjected to aggressive acidic environment. The research finding demonstrates that the ECC gives a good resistance to aggressive acidic environment, while visual examination shows that ECC is less affected by the aggressive environment, and the compressive strength of ECC after acid attack is more than the control specimen. From the XRD results the silica compound formation is observed which make ECC as a self-healing material. From SEM analysis the effect of acid on specimens is studied which shows that inner structure of ECC specimen is less affected by acid as compared to control specimen.

SANDSTONE TYPE URANIUM RESOURCES OF PAKISTAN: ENCOURAGING HUGE STRATA

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Abstract

The uranium (and may be thorium and other radioactive minerals) may occurs primarily in the igneous rocks especially in the Chagai, western and northern Indus Suture, Khyber-Hazara, Kohistan-Ladakh, Karakoram and Hindukush blocks. As secondary mineral, it is found and at places enriched in the the foreland sedimentary fold and thrust belt (Indus Basin) and also in clastic sandstone of different ages because of porous and permeable nature. Possibly the main deposits of Uranium are present in the Dera Ghazi Khan and Taunsa areas with main localities like Baghalchur, Nangar Nai, Taunsa, Barthi, etc. In general cutoff grade of Uranium is 0.03% and maximum grade is 0.1%. So far known deposits of uranium in Pakistan are small to medium in size. Main sources of uranium are clastic formations. Radioactive minerals like primary minerls e.g. (Uraninite) and secondary mierals such as tyuyamunite, carnotite are commonly existed and enriched by water at places in cavities in Vihowa Group (Oligocene Chittarwata, Vihowa, Litra and Chaudhwanan formations) and may be hosted in coal and sandstone bearings formations. Fluviatile cross bedded sandstones of the Vihowa group host the uraniferrous placers. It is traced along 200 kms North-South oriented outcrop along the foot mountains of Sulaiman Range, in the territory of Dera Ghazi Khan, Rajan Pur and Dera Ismail Khan. Further south it extends to Dera Bugti, Kohlu and Sibbi districts and further north it extends to Kohat and Potwar basin. Uranium, thorium and **Iridium** anomalies expected in the KT boundary laterite, muds and coal in the Musakhel district areas like Gharwandi, Aram, Kingri, Vitakri, Fort Munro, Shirani and other areas of Vitakri Formation. Primary minerals like uraninite, coffinite, pitchblende are found below water table while secondary minerals like uranophane, metatyuyamunite, carnotite are found in the the oxidized environments/above water table hosted by Vihowa group in Sulaiman, Manchar/Vihowa group in Kirthar and Potwar group in Kohat and Potwar basins.

SLOPE STABILITY ANALYSIS OF KHATINJ DEFORMED SLOPE, CHITRAL (PAKISTAN) USING 2D LIMIT EQUILIBRIUM METHOD AND 3D FINITE DIFFERENCE METHOD

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Abstract

Landslides constitute a major geological hazard in the world due to their high financial cost and their nondiscriminatory nature and are the main natural hazards occurring in the mountainous area situated in the Chitral, Pakistan. The study area Khatinj, Chitral, as a part of Hindu Kush range, northern Pakistan, situated over the NW corner of collision region of Indian and Eurasian plate. Khatinj deformed slope is located in the Upper Chitral valley is an ongoing downward movement along tension cracks across several slopes in 1.5 km2 area. According to Kazmi and Jan (1997) the area is bounded by the Tirich Mir fault in the north, Reshun fault in the north-east, Ayun fault and Main Karakorum Thrust in the south, and Karakorum fault in the west. It is one of the most tectonically active regions because of the abduction processes of Eurasian plate. That is why it is one of the most disaster-prone regions to devastating impacts of landslides on the communities. The region is frequently subjected to damages, human loss and disruption by rock fall, sliding of debris and rock, debris flow, mudflow and flash floods. The Chitral District, located in extreme northern Pakistan is very prone to frequent and devastating landslides, mainly due to rough terrain, climatic conditions, climate change indicators, tectonics and seismic activities and anthropogenic activities on unstable slopes. This research focuses on slope stability analysis with the Limit Equilibrium Method computer program Slope/W and the Finite Difference (FD) method computer program FLAC3D under three working conditions i-e (1) Natural state condition (2) Rainstorm condition (3) Earthquake condition and a comparison of the analyzed result. The result shows that the deformed slope is slightly stable under natural condition but is unstable in rainstorm condition and under seismic load. The principal difference between these two analyses approaches is that the LE methods are based on the static of equilibrium whereas Finite Difference (FD) method utilize strength reduction method. The factors of safety obtained with two different approaches are compared and discussed in this research. The majority of published information is in regards to the slope stability analysis methods of Limit Equilibrium and Finite Difference and not the software packages themselves. Several studies have suggested that FD methods provide greater benefits than the LE method; however other studies have suggested that the simplicity of the LE method outweighs the complexity of FD methods. The study area is tectonically active region and tension cracks are present throughout the valley. Previously no such study was conducted in these areas, therefore, this research can be used for stability of slopes wherever is required. A comprehensive methodology adopted in the present research involves the geotechnical parameters investigation, numerical modeling with the help of MIDAS GTX NX, FLAC and Slope/W.

STUDY ON THE USAGE OF PLASTIC BAGS, THEIR DISPOSAL AND ADVERSE IMPACTS ON ENVIRONMENT OF RABWAH CITY, DISTRICT CHINIOT

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Abstract

A changing life style, alongside the advancement of technology has led to a large number of environmental problems. One of the major problem is the use of Plastic bags that jeopardize our environment. Disposal of plastic bags poses serious environmental problems especially for human health. The purpose of current study is to assess the usage of Plastic bags and their environmental impacts in Rabwah city, District Chiniot. A questionnaire was prepared to collect data from 180 randomly selected respondents of different areas of Rabwah city. Data were also collected from the retailer and shopkeepers of the City. The result of the study indicate that more than 90% (91.6%) of respondent frequently used plastic bags as compared to other plastic products regardless of their age, occupation and educational status. The result of the survey revealed that low price /without cost (86.10%), easy availability (80.5%) and the lack of alternative material are the main reasons for the utilization of plastic bags. The practice being used for the disposal of plastic bag wastes is open dumping (72.27%) that was almost common among the respondents. One of the problems was blockage of sewage/drainage lines (61.1%) in addition to deterioration of natural beauty of an environment (57.2%). The results of the study also indicated that the utilization of plastic bags is increasing from time to time. The data collected from shopkeepers revealed that the usage of plastic bags in Rabwah city is 170 kg/ per day which is approximately equal to 72000 plastic bags. In order to reduce the impact of plastic bags on the environment it is recommended that local community be educated about the hazards of plastic bags and help them to use either biodegradable plastic bags or bags made by paper or clothes. Effective legislation is also recommended against the indiscriminate free distribution/use of plastic bags by retailers and their disposal by users.

INITIATION AND FAILURE MECHANISM OF ROCK FALLS ALONG THE KARAKORAM HIGHWAY (BESHAM-CHILAS SECTION)

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Abstract

Nowadays, rock fall has great importance due to its inclusion in China Pakistan Economic Corridor (CPEC). Rockfalls in addition to other slope failures are major threats to safety of travelers along the KKH. In this study, we try to analyze the initiation and failure mechanism of the rockfalls along Besham-Chilas section of the KKH. It passes through porphyry granite and gneisses of Indian plate and then through ultra-mafics and mafics of Kohistan Island Arc. Steep slopes and deep gorges characterize this section prone to rockfall hazard. Presence of multiple joint sets with an adverse impact on slope stability have preconditioned to ongoing rock falls. Furthermore, intense rainfall triggers these rock falls. We mapped twenty five rock falls along this section. A detailed field survey was conducted to acquire all necessary parameters to explain initiation and failure mechanism of these events. Precipitation and temperature data was obtained from the Climate Forecast System Reanalysis (CFSR) to determine rainfall as possible triggering factor. Kinematic analysis were performed on Dips 7.0 for each rockfall events. According to the results, rainfall triggered most of the rockfalls in the study area. Based on kinematic analysis, wedging and planer failures are dominant failure processes between Besham and Chilas section. Whereas, toppling is an important failure mode between Pattan and Sazin. Furthermore, stress release joints with short persistence in the Chilas Complex are responsible for hazardous rock falls of huge blocks (6m3) between Dynter Valley Bridge and Sazin.

KEY FACTORS FOR STRUCTURAL EVOLUTION OF HAZARA KASHMIR SYNTAXIS IN NORTHERN PAKISTAN

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Abstrtact

Hazara Kashmir syntaxis is an antiformal structure in northern Pakistan. Three important factors are instrumental in its evolution and present appearance. The presence of salt in region below western limb provide decollement for thrust sheets to move above it forming an elongated stretched western limb and absence of salt below eastern limb make it short and more deformed. Secondly there was an initial dome over which different thrust sheets were overridden. Finally the counterclockwise rotation of underlying block produced sinisteral shearing in the apex region of HKS forming it presently the most evolved structure of the northern Pakistan. The exceeding sinisteral shearing and continued anticlockwise rotation of under laying block had altered the NS transport direction into NW SE transport direction and facilitated the present orientation of Balakot Bagh fault in the region.

GEOLOGICAL EXAMINATION OF TUNNELLING FROM A SMALL-SCALE HYDROPOWER PROJECT IN NORTHERN PAKISTAN: IMPLICATIONS FROM PETROGRAPHY AND ROCK MASS CHARACTERIZATION

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Abstract

A tunnel from a small-scale hydropower project in northern Pakistan has been examined in detail to investigate the rock mass characterization, discontinuity analysis and other important geological parameters. The area dominantly contains meta-sediments of Precambrian Formations intruded by Cambrian granite. The detailed petrographic investigations of samples collected at regular intervals reveal the presence of following dominant rock types across the tunnel i.e. garnetiferous schist, quartz-mica schist, calcareous schist, schistose marble, hornblende bearing quartz mica schist and micaceous marble. All rock mass classification systems, consider a few of the key rock mass parameters and assign numerical values to the classes within which the parameters lie for a given rock type. Rock mass quality system (Q-system) has been used for the current project. After the estimation of pertinent rock mass parameters for each rock mass type, a Q-value has been calculated upon rating of each parameter. The petrographic studies and rock mass characterization reveal that quartz mica schist, schistose marble and micaceous marble are weak and intensely jointed rocks, falling in the category of class B, C and D i.e. good, fair and poor rock mass classes respectively. While garnetiferous schist, calcareous schist and quartzite, being relatively strong and intact rocks, are characterized in class A, B and C. Few of the rock types like quartz mica schist fall in class E and F (very poor rock mass class) which is attributed to their maximum jointing, water dripping conditions and discontinuities orientation. Support estimates are also proposed based on rock mass characterization using the Q–system ratings. The ultimate supports for rock class D, E and F are systematic bolting, fibre reinforced shotcrete > 9-12 cm + bolting and fibre reinforced shotcrete > 15 cm + reinforced ribs respectively. The class A, B and C can withstand without giving any major support, however, spot rock bolting may be applied in certain desired regions. A geological longitudinal section of the tunnel has been constructed which represents its division into different domains based on distinct rock types and rock mass classes i.e. domain-I dominantly comprises quartz mica schist and garnet bearing quartz mica schist (Class D), domain-II contains quartz biotite schist and garnet mica schist and marble (Class C), domain-III holds calcareous schist and marble (Class A and B), domain-IV covers Garnet mica schist (Class D), domain-V contains quartzite and quartz mica schist (Class E and F) and domain VI which dominantly have Garnet mica schist and calcareous schist (Class A and B).

DOLOMITIZATION IN JUTANA FORMATION (CAMBRIAN), SALT RANGE, PAKISTAN: PRIMARY OR SECONDARY IN ORIGIN?

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Abstract

Jutana Formation (Cambrian) is mostly comprised of two distinct units; (i) Oolitic-pisolitic, medium to thick bedded interlayered dolostone and sandstone, and (ii) massive dolostone in the eastern Salt Range (Pakistan). Field observations revealed that dolostone mostly comprised of dirty white, light green, hard, micaceous, sandy towards the base and light green to dirty white massive towards the top of the formation. In the lower unit, sandstone is mostly whitish grey in nature. Primary sedimentary structures preserved in the sandstone are trough-, herring bone- and hummocky-cross bedding structures are the characteristic features of the sandstone unit, while preserved ooids and faunal assembleges are restricted to dolomite beds. Based on field observations and petrographic studies, three dolomite phases have been identified ; (i) fine crystalline dolomite (Dol-I), (ii) medium-coarse crystalline dolomite (Dol-II) and (iii) fracture associated saddle dolomite (Dol-III). Stable isotope studies indicate less depleted δ 18O values for Dol-I (i.e., -6.44 to -3.76‰ V-PDB), slightly depleted δ 18O values for Dol-II (-7.73 to -5.24‰ V-PDB), and more depleted δ 18O values for Dol-III (-7.29 to -7.20‰ V-PDB) respectively. In addition, δ 13C values of the corresponding dolomite phases are well within the range of Cambrian sea-water signatures. Furthermore, δ26Mg-δ25Mg signatures (Dol-I; δ26Mg= -0.19 to -0.67, δ25Mg =-0.61 to -0.86 and Dol-II; δ26Mg=-1.43 to -1.59, δ25Mg=-0.75 to -0.83) revealed that dolomitization occurred in three diagenetic settings. Appendix 1 2. In conclusions, initial stage of dolomitization occurred in mixing zone condition, followed by dolomitization associated with burial conditions in later stages.

Keywords: Dolomites, Jutana Formation, Salt Range, Isotopic studies.

LITHOSTRATIGRAPHY, ECONOMIC AND VERTEBRATE SIGNIFICANCE OF FORT MUNRO ANTICLINORIUM, DERA GHAZI KHAN AND RAJANPUR DISTRICTS OF PUNJAB AND DERA BUGTI AND BARKHAN DISTRICTS OF BALOCHISTAN, PAKISTAN

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Abstract

Doubly plunging Fort Munro anticlinorium is located in Eastern Sulaiman Foldbelt. The oldest rock exposed in Shadiani Gorge is Early Cretaceous Parh Limestone. The Late Cretaceous Mughal Kot (marl/mudstone and sandstone), Fort Munro Limestone and Pab Sandstone, and Latest Cretaceous Vitakri Formation (sandstone and red muds) of Fort Munro Group are exposed in the Shadiani, Rakhi Gaj and other gorges as core strata. The tourism places and peaks (about 2000m AMSL) are Fort Munro and Mari. The North-South trending peak consists of exposed Paleocene Sangiali Limestone (a few meter thick), Rakhi Gaj Formation (more than 100m of Girdu ferruginous sandstone and Bawata shale) and Dungan Limestone of Sangiali Group. At places the exposures of Pab Sandstone and Vitakri Formation (host of dinosaurs and associated vertebrates which are found just below the K-T boundary) are exposed in the areas of Mian Ghundi, Fort Munro, Chitri and on both limbs of anticlinorium. The eastern and western limb formations are Early Eocene Shaheed Ghat (shale), Drug (rubbly limestone), Baska (gypsum and shale) of Chamalang (Ghazij) Group and Middle Eocene Habib Rahi Limestone, Domanda shale, Pirkoh marl/limestone and Drazinda shale of Kahan Group, Oligocene Chitarwata (ferruginous sandstone, conglomerate and shale), Miocene Vihowa (red muds and sandstone) and Litra (greenish grey sandstone with some red muds) and Pliocene Chaudhwan (alternated sandstone and maroon muds) of Vihowa Group and Pleistocene Dada (conglomerate) and Holocene Sakhi Sarwar (clays, sandstone and conglomerates) of Sakhi Sarwar Group. The eastern limb shared with Barthi-Baghal Chur Syncline and western limb shares with Beaker, Mat Khetran, Chacha, Rakhni and Manjhail Kharar Syncline. The Paleocene and post Paleocene rocks plunge in the south at Mari and Kalchas and in the north at Hinglun-Sora Tangi. Due to plunge the trends of Paleocene to Holocene rocks shifted from north-south to gradually east- west forming arc in the southern and northern plunge areas. In the south after the plunge the main structures found are Sui, Zin, Uch, Loti, Pir Koh, which produce petroleum/gas. The significance of this anticlinorium is many economic commodities and paleontological findings. The economic mineral commodities are fuller earth, gypsum and other cement raw materials like limestone and shale, building stone and construction materials like Dungan Limestone and some beds of Habib Rahi Limestone and conglomerates of Pleistocene Dada and Holocene Sakhi Sarwar formations, millstone and quartzite from Pab, iron from Chitarwata and Girdu member or Gorge beds of Rakhi Gaj formations. This iron may be used for cement/steel industry like the Satta Post red mud which is being used by D.G.Khan Cement Industry. Some coal showings are also tried for mining in the Domanda and Chitarwata formations in the eastern limb but now minings are abandoned. Recently the most famous vertebrates reported are dinosaurs (Titanosaurian sauropods facies and abelisaurian and Noasaurian theropods facies), mesoeucrocodiles and pterosaurs-the flying reptiles, Middle Eocene walking whale, the king of basal whales (*Sulaimanitherium dhanotri)*, Oligocene Baluchitheria-the largest land mammals (*Baluchitherium osborni* and *Buzdartherium gulkirao)* and crocodile (*Asifcroco retrai)* and Miocene large proboscideans (*Gomphotherium buzdar*i).

INDUSTRIAL MINERAL DEPOSITS OF PAKISTAN: SIGNIFICANT FOR SUSTAINABLE DEVELOPMENT OF PAKISTAN

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Abstract

This study attempts to summarize our current knowledge about the industrial mineral deposits which are significant for the sustainable development of Pakistan. Stibnite is reported from the Chitral state, Qila Abdullah, and Siahan and North Makran ranges. The estimated reserves of stibnite veins of Makran and Siahan ranges seem to be 1000 tons (small). Arsenic minerals orpiment and realgar are reported from Chitral state. They are associated with marbles and calcareous shales of probable Cretaceous age. Small deposits are also reported in the other places of Chitral state. The arsenopyrite, chalcopyrite and pyrite also occur in Dainyor and Jotiyal nalas in Gilgit. Mercury and silver mineralization are reported as network of veins in the Oligocene Panjgur formation of western and eastern Waro area of Makran and Siahan ranges. Chemical results show highly anomalous mercury, silver and iron while slight anomalous Pb, Zn, Ni, Co, Cu, Mn, Cd and Au. Copper is best suited with subduction zone like Chagai, Raskoh and Wazhdad magmatic arcs, and Kohistan magmatic arc, spreading centre located far south of Pakistan and margins of lithospheric plates like northern and western Indus Suture (Waziristan), and Karakoram-Hindu Kush block. Boya, Dir, Drosh, Waziristan, Dasht Kain, Talaruk, Saindak, Other porphyry copper deposits in Chagai district is explored recently. It is estimated that Chagai region has large reservesof copper (averaging 0.4 to 0.6%) and associated gold (0.2 to 0.5gm/ton). Lead-zinc deposits are discovered from the Las Bela-Khuzdar region. The mineralization is found in the upper part of Lower Jurassic Shirinab Formation. Main deposits are Shekran, Ranj Laki, Malkhor (NW of Khuzdar), Gunga, Surmai (SW of Khuzdar, and Duddar (SE of Bela). The estimated lead zinc reserves of Pakistan are about 16mt. The Makki Chah is a zinc deposit. Bismuth, cadmium and cobalt are reported from the Lahor and Pazang areas 3 km N and SE of Besham, Besham nappe. Chromite occurs mostly in the Indus Suture (Western and Northern Indus Suture). Main localities of Chromite are Chilas, Besham Jijal, Kohistan, Harichand-Sakhakot-Qila west of Dargai, Kot-Pranghar (Mohmand), Bucha (Mohmand), Boya (Waziristan), Muslimbagh, Zhob, Bunap and Rayo Ras Koh, Wad, Sonaro and Ornach. The ophiolite contains lenticular or disseminated bodies of chromite. Liaqat et al. in 2012 mentioned anomalous Ni, Cr and Co at Teru, Yasin, Pakora and Bargot areas of Shyok Suture, North Pakistan. Asbestos is found in serpentines of the ophiolitic complex near Wad (Khuzdar), Muslimbagh and Naweoba (Zhob), Boya, Kaniguran (Waziristan), and Sakhakot-Qila area (Mohmand/ Malaknd). Manganese ore are ophiolite related mineralization in Kassai area of Lower Mohmand Agency, Sakhakot-Qila, Kot Pranghar, Qila, Behram Dheri, Narai Obe, Bucha, Newe Kili and Hero Shah and Shangla area of Swat; Thal, Shinkai Waziristan; Lahor-Pazang area, near Besham; from Galdanian, Chur Gali; The more important localities are Kharari

Nai, Siro Dhoro, Sanjro Dhoro, Bhampani Dhoro, Gadani ridge and Dadi Dhoro. The estimated total reserves of manganese in Pakistan is 0.5 million tons with manganese range from 15-48%. Nickle occurs in Malam Jabba; Souch (Kaghan) and Swat and Shangla-Alpurai areas. Tungston occurs in Oghi Hazara, Susagali granite, Amalaf Chagai and Miniki Gol area of Chitral. The placer sheelite occurs in the Siran River sand (Mansehra district) and in the Indus River of northern areas where it is estimated 96 tons of detritial tungsten minerals in about 40 million tons of placers. Mica/muscovite has been done near Baltit, Dassu, Mogh, and Kasu northeast of Drosh. In the Kohistan magmatic arc, mica has been worked at Khadong Banda (near Dir). In the Himalayan crystalline zone, mica deposits have been reported from Astor, Bagarian, Hawa Gali, and in the Neelam valley of Azad Kashmir. Among these the better deposits are the ones in the Neelam valley and near Astor. Significant deposits are found in Rajdhwari pegmatites (significant, 0.2-3%) and Tangali hill of Hazara district. Lithium/Lepidolite occurs in Shengus of Nanga Parbat Massif; Bagarian, Hawa Gali, Giddarpur and Koga areas. Niobium and platinum occur in Chilas, Jijal, Sakhakot Qila (west of Dargai) and Loe Shilman of Khyber Agency. Rare earth occurs in Koga (Swat), Sillai Patti (Dargai), Loe Shilman (Khyber Agency) and Sakhakot-Qila (Malakand) areas. Sulphur at Sanni occurs as veins or as replacement of sandstone matrix in the Nari Formation. The reserves are estimated at about 58,000 tons. Koh Sultan deposit is located in the Koh Sultan volcano with 738,000 tons reserve. Alum has been manufactured in the past from pyritiferous shales of Gajbeds from Maki Nai, shales of Ranikot group and Nari/Gaj group and at Shah Hassan near Trimi. Bituminous alum shale has occurs possible Carboniferous age near Shahidmena in Khyber Agency, in Jatta and in a gorge near Dozha Banda in Kohat area. Nearly pure alunogen occurs in veins in sulphur at Sanni. Alum occurs in Koh Sultan (Nok Kundi area).Alum shales occur in two horizons in the Salt Range near Kalabagh. One in Eocene rocks (10feet alum shale), and other in Jurassic age (alum shales 25-40feet thick).The shale from which alum is manufactured contains on average 9.5% sulphur. Many salts deposits and lakes are located in the vicinity of Makran coast and Hamun Mashkel area. Alum may also be associated with these salts. Soapstone/Talc deposits occur in Kharwala Nala (Kurram Agency), Jamrud (Peshawar), Khyber Agency; Derai (Swat), Sherwan (Abbottabad) and Golen Gol (Chitral) areas. The Sherwan deposit is the major producer of soapstone in the country. Soapstone deposits of Kurram agency have been estimated to contain 1.6 million ton of reserves. The ophiolitic and volcaniclastic rocks in the Wazhdad area and its vicinity show soapstone mineralizations. Graphite occurs in Chalt, Chhelish, Bola Das and Mohriwal Baikh of Gilgit area, Stak-Pondu Shigar Nala Baltistan, Chota Kazi Nag mountain northern slope of Jhelum river. It is found in Shah Salin, Momi village, Mohzigram Gol and Barzin valley of Chitral state; Norang and Babusar pass, Sherwan, Haripur and Garhi Habib Ullah of Hazara district, Sper Tor (Landi Kotal). Shahidmena and Lowaramena of Khyber Agency, Majk to Kundi and Dheri village in Mardan district, Loe Agra in Malakand. It has also been reported from Sheikh Wasil of Mashelakh Range. Kyanite quartz veins in mica schist occur in the near south of Jabba of Hazara district. Kyanite schists occur in south of Kuza Banda rest house at Oghi-Batgram road. It is also found in Landakai at frontier boarder of Malakand-Saidu Sharif road and near Tindodog police post in Swat state. Vermiculite deposits (11 mt) are reported from Doki River on the northern edge of the western Raskoh. The vermiculite contents vary from 5-20%. Exfoliation tests at 775 ^{0}C resulted in tenfold increase in the particle size. Further pumice from Chagai area, millstone and quartzite from Pab quartzite/sandstone (more than 2bt of the Fort Munro anticlinorium above the ground surface) of D.G.Khan, lake Salt and associated trona from Sindh has been reported so far.

TECTONICS AND GEODYNAMIC EVOLUTION OF INDO-PAKISTAN PLATE: CLOSURE OF TETHYS FROM PAKISTAN

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Abstract

Tectonics and geodynamic study of Indo-Pak is significant due to its present contact with Asia but past contact with Gondwana. Ironstone and ferruginous brown strata of Jurassic-Cretaceous boundary provide a clue of separation from Madagascar and start of northward journey at 135 Ma. Marine strata was dominant in the Lower Cretcaeous while clastic sandstone were dominant in the Upper Cretaceous. Eastern part of upper Indus shows a wide range of erosion where Precambrian Salt Range Formation in Eastern Salt Range and Cambrian dolomite in Tatta Pani, Kotli are capped by Infra Tertiary boundary Indus Formation (bauxite/ laterite). This erosion show a long journey of more than 5000 km in a period of 67 Million years (135 Ma–68 Ma) with average speed of 8-10cm/year. When Indo-Pak plate came close to Asian plate, the stress created subduction of Tethys at the line of Karakoram Suture under Hindukush- Karakoram resulted. Further stress at later created subduction of Tethys sea plate at the line of Northern Indus Suture under Kohistan-Ladakh belt resulted in the form of Kohistan-Ladakh magmatic arc. Indo-Pak collided first time with Afghan block at Latest Cretaceous about 68 Ma. Western Indus suture (UthalBela-Wad Khuzdar-Nal- western Sorab- Kardgap/western Shirinab- Sheikh Wasil- west Quetta/Samungli- Kuchlak-Muslimbagh- Qila Saifullah- Zhob- western Waziristan- Kurram- Mohmand) and northern Indus suture (Mohmand-Swat-Besham-Chilas-Haramosh-Astore-Shontar top-south Deosai-Kargil-Ladakh) well developed by the obduction of ophiolites. Later on left lateral Chaman transform fault into existence by further northward moving of Indo-Pak plate. Indo-Pak plate docked with Kohistan-Ladakh Tethyan belt. During Early Paleocene the sea transgressed in these areas. During Late Paleocene, sea regressed from western Sulaiman, northern Balochistan, upper and uppermost Indus due to further uplift and continued collision. This collision is responsible for the birth of Paleo Indus River Systems generally flows from north to south and northwest to southeast. As a result of collision and continued northward movements, the northwestern margin of Indo-Pak became elevated creating a terrestrial environments for the deposition of Latest Cretaceous Vitakri Formation (overbank red muds and meandering sandstones) in the lower and middle Indus while the Indus Formation (bauxite and laterite) in the upper Indus. During Early Eocene the Northern Indus Suture and surrounding areas were uplifted enough to originate the Paleo Indus River systems supplying first time detritials/clasts from northwest and north and generally flows from northwest to southeast in Sulaiman (middle Indus) and north to south in upper and uppermost Indus. During Eocene the Paleo Indus river systems deposited the Shagala Group in Balochistan basin, Chamalang (Ghazij) in middle Indus, and Nammal, Panoba and Kuldana groups in upper Indus. Tethys further regressed and permanently closed from uppermost, upper and middle Indus of Pakistan during Late Eocene while the Lower Indus was under Tethys Sea. At Latest Eocene (40–35 Ma) Indo-Pak plate collided hard with Asia which resulted in the uplift, folding and faulting (mainly south verging thrusts) and deposition of terrestrial Potwar/Vihowa (Siwalik) Group. From Lower Indus Tethys closed permanently during Early Miocene. The last major geoevent at Pliocene- Pleistocene boundary created further uplift, folding and faulting and the deposition of Sakhi Sarwar Group (Dada conglomerate and Sakhi Sarwar sand and clays). This orogeny is responsible for creating highest peaks and present morphology.

IRON, LATERITE, BAUXITE AND OCHRE DEPOSITS OF PAKISTAN: EMPHASIS ON FEASIBLE DILBAND AND LOW GRADE FORT MUNRO IRONSTONES

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Abstract

For the sustainable development of Pakistan, there is an urgent need to utilize indeginous deposits of iron, laterite, bauxite and ochre, whivh will reduce the cost of import. Iron, laterite, bauxite and ochre deposits are mainly located along disconformities in the Foreland basin. These deposits also contain many resistant minerals like rutile, zircon, ilmenite, etc in laterite and alluvium placer. Laterite is reported from Ziarat-Sanjawi area (Balochistan), Kathwai, Daud Khel and Zaluch Nala of Salt Range, Moza Mungiwali, Gakkar, Pind Trer and several localities in Kalachitta Range, Mazari Tang and Marai Bala in Kohat district, Samana range16 km from Hangu; Langrial area 32 km south of Abbottabad and Kalabagh area. The infra Tertiary disconformity in Muzaffarabad, Dhaman Jhal-Niazpur, Kotli Tehsil areas like Salhun, Nikial, Khander-Karela, Shiester, Giain, Dandili, Kamroti and Sangar Marg show lateritic and bauxitic deposits. The disconformity in the Eocene Sohnari Formation has limonite and ochre at Lakhra, Meting and Makli hills of Sindh. Malkani in 2010 mentioned Vitakri Formation (latest Cretaceous to Cretaceous-Paleogene (K/Pg) boundary) in Sulaiman foldbelt which is significant for ochre and lateritic materials. Significant deposits of ochre occur in Reshian region of Azad Kashmir and Uchhali, Kutki, and Pirkahar of Salt Range. Small deposits occur in the southern part of the Kirthar Range near Jhal Dhand, Sohnari Dhand and Noriabad. The lateritic beds found at Katha Nasral area of Punjab, in Dadu and Thatta districts of Sind, in Ziarat and Vitakri areas of Balochistan contains ochre, which is being used locally for paint making and other industries. The possible low grade but large deposits of ochre/iron from Chitarwata, Vihowa, Rakhi Gaj, Vitakri, Domanda and Drazinda formations of Sulaiman Foldbelt seems to be significant. Recently Malkani and Mahmood in 2016 reported micaceous hematite from Muzaffarabad and limonie/ochre from Reshian valley of Hattian Bala District, Azad Kashmir. Katha-Pail bauxite-laterite-clay bed (1-7m thick) occurs at the (K-Pg) boundary between Wargal or Amb formation and Hangu Formation. Chhoi-Akhori deposits occur in a 20-25km long belt in the Kalachitta hills. It occurs at K-Pg boundary between Lumshiwal and Hangu formations and lower down between the Jurassic limestone and the Triassic Kingriali formation. The upper horizon comprises of upper 3m thick oolitic or pisolitic laterite and lower 4m thick bauxitic material. The bauxite contains 32-76% Al_2O_3, 2.5-43% SiO_2, 0.25-12% Fe_2O_3, and 2.2-4.2% TiO_2. The lower lateritic horizon at the base of Datta Formation is more widely distributed and contains alumina clays, claystones and alumina. Muzaffarabad -Kotli deposits occur in between the Cambrian limestone of Sirban Formation of Abbottabad Group and overlying shales of Eocene Patala Formation. Aluminous rocks may be associated with red beds of Vitakri, Domanda and Drazinda formations and Vihowa group. Dammer Nissar iron deposits are 32 km south of Drosh in Chitral district. The magnetite deposits (lenticular and irregular in shape) of metasomatic nature occur in garnet epidote metavolcanosedimentary rocks intruded by granodiorite found close to Karakoram Suture/Shyok Suture. Langrial iron deposit is lateritic hosted within limestone of K-Pg boundary (Hangu Formation) or may be lateral extension of

Chichali iron. The ore is 6-7 m thick consisting of oolitic, lateritic or ferruginous sandy materials. The ore is 45 km long. Mineralogically the deposit is divided into three classes like chamositic-limonitic type, hematite-limonitic type and lateritic type. Kalabagh iron deposits are 300 million tons occur in Cretaceous Chichali Formation comprised of glauconitic sandstone and shale. This belt is exposed from Makerwal to Kalabagh and Sakesar in Salt Range. Pezu iron deposits are located 2.5km SE of Pezu village. It is low grade lateritic iron ore occurs in the Chichali Formation. Nizampur iron deposits (100 m.tonnes) is of sedimentary type hematitic iron 25-35 % and is found at the base of Datta Formation. Pachin Koh-Chigendik iron deposits are located 88 km and Chigendik 40 km NW of Nokundi town. It is comprised of magnetite and hematite. It is volcanogenic in nature and occurs as intercalations with andesites of Sinjrani volcanics. Chilghazi iron deposits are located 52 km NW of Dalbandin town. Dilband iron deposits is 70km from National Highway and 100 km from Kolpur railway station. The ore is found in Dilband Formation of J/K boundary time with low to gentle dips. The iron horizon is 1-7 m thick with an average value of 2 m. Mineralogically it consists of hematite with calcite, quartz and chlorite. It contains 35-48% iron. The estimated reserves are 200 million tons. Chemical analyses of iron ore represents Fe 45.7-48.03%, FeO 2.30-2.95%, SiO_2 13.7- 14.6%, CaO 2.23-2.4%, MgO 1.6-2.2%, MnO 0.09-0.11%, Al_2O_3 5.30-6.04%, TiO_2 20.32-0.35%, P 0.24-0.34%, Cu 0.01-0.012%, S 0.12-0.19%, Zn 0.07%, Loi 4.5-7.45% (Abbas et al, 1998). Presently this ironstone extension upto Zahri area in the South and Regwash in the east are observed. According to present research by Malkani et al. in 2016 the estimated deposits are about 500 million ton or 0.5 billion ton. Recently Malkani in 2010 and Malkani and Mahmood in 2016 reported Fort Munro iron deposits in Paleocene Girdu (Gorge beds) member of Rakhi Gaj Formation of Sangiali Group. This iron is found in the Fort Munro and its vicinity areas like Khar, Top Girdu, Mian Ghundi, Rakhi Gaj, Bawata, Kingri, Badhi, Chitri, etc. This low grade deposits extends upto Mughal Kot and Shirani areas of D.I.Khan district. It is found in the territory of D.G.Khan, Rajan Pur, Musa Khel, Dera Bugti, Barkhan, D.I.Khan districts. It is widely exposed on the both limbs of Fort Munro anticlinorium, Kingri, Pekal, Aram and Badhi-Dhaola anticlines. This ironstone deposits are very large but low grade ($Fe_2 O_3$ 14-21%). It's testing for steel, cement and other industries should be make, and it may prove worthy. The extensive iron beds thickness varies from 2 to 50 m. Its reserves seem to be 400 million tons from surface exposure to easily mineable depth 200 m. The Fort Munro iron deposits seems to be feasible due to availability of huge but low garde raw materials, peacefull and favourable locations on metalled road and near to D.G.Khan railway station. It is located in the centre of Pakistan and ideal location for all provinces. The Rhodo and Satta Post deposits (Taunsa area, District D.G. Khan) of iron bearing red/chocolate shale found by present author in the upper part of Domanda Formation is being mined for the D.G. Khan (Zinda Pir) Cement Industry. This chocolate colour mud/clay/shale is about 30-50 m thick. Its estimated deposits may be more than 200 million tons upto easily mineable 200 m depth in the Rajan Pur, D.G. Khan, Barkhan, Musa Khel and D.I. Khan districts of eastern Sulaiman fold and thrust belt.

CEMENT RESOURCES AND GYPSUM DEPOSITS OF PAKISTAN: URGENT INSTALLATION OF CEMENT INDUSTRIES IN DAMAN OF SULAIMAN RANGE

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Abstract

Due to rapidly increasing population in Pakistan, it is highly desirable to take step for extending cement, lime and calcium chemical industries, so that the country will be self-sufficient and able to export these materials to earn exchange. Cement Industry raw materials are huge in Pakistan, especially in Sulaiman foldbelt. The inexhaustible reserves of limestone and shale are found in Pakistan. Large deposits of gypsum are found in Sulaiman fold belt 28.5 billion tons, Kohat-Karak 4.7 billion tons, Saiduwali Khisor 220 million tons, Salt Range 137 million tons, and Dadu 10.4 million tons. The easily minable reserves (upto 50 meter depth) of gypsum of Sulaiman foldbelt are 764mt. Present research resulted 28.5bt of all estimated reserves (measured, indicated, inferred and hypothetical) from Sulaiman foldbelt. The breakup of total gypsum reserves includes 14.5bt in Balochistan Province (Barkhan 4.25bt, Kohlu 5.5bt, Sibi 1bt, Dera Bugti 1.75bt, Musa Khel 2bt); 11bt in Punjab (Rajan Pur 2bt and D.G.Khan 9bt); and 3bt in Khyber Pakhtunkhwa (D.I.Khan). The Balochistan Province with detail as Barkhan District includes Lakha Kach or Rakhni 1bt, Kodi More-Nodo-Ishani-Gadumra 2bt, Khurcha 0.25bt, Anokai-Bahlol 0.5bt and Bala Dhaka-Karher Buzdar 0.5bt; Kohlu District includes Nisau-Safed 3bt, Kahan-Khatan 1bt, Mawand 1bt, Lunda-Bahney Wali 0.25bt and Janthali 0.25bt; Dera Bugti includes Sham-Kulchas, Phailawagh-Jiandari, and Pirkoh 1.75bt, Sibi district includes Spintangi 1bt; and Musa Khel district includes Drug-Toi Nala-Zamaray 2bt, Kingri 1mt and Chamoz Khan Mohd Kot 1mt; Punjab province with detail as Rajan Pur district 2bt and D.G.Khan district 9bt; Khyber Pakhtunkhwa province with detail as D.I.Khan district 3bt and South Waziristan 0.1bt. Easily minable (upto 50m depth) resources of gypsum are 451 million ton in Balochistan (Barkhan 121.3mt, Kohlu 228.7mt, Musa Khel 57mt, Sibi 16mt and Dera Bugti 28mt), 231mt in Punjab (Rajan Pur 33mt and D.G.Khan 198mt), 82mt in Khyber Pakhtunkhwa Province (D.I.Khan 77mt and Waziristan 5mt. Due to these recent discoveries, the Sulaiman gypsum is considered as the first largest deposits in Pakistan. Several cement industries can be installed, especially in Zinda Pir Ziarat, Zin, Mahoi, Gulki/Taunsa, Rakhi Gaj, Dalana, etc areas of D.G.Khan; Harand (Kaha) area of Rajan Pur; Drabin, Domanda, Mughalkot, Shirani, etc areas of D.I.Khan; Sham, Phailawagh, Beakar, Pirkoh, Habib Rahi, etc areas of Dera Bugti; Lakha Kach, Kodi, Nodo, Ishani, Gadumra, Bala Dhaka, Bahlol, etc areas of Barkhan; Chamalang, Nisau, Bohri, Safed, Mawand, etc of Kohlu; near Loralai; and Kingri, Drug, Zamri, etc areas of Musa Khel districts due to close existence of its raw material like limestone, gypsum and shale. At present only one cement factory is working in Zinda Pir D.G.Khan district. The close occurrence of inexhaustable raw materials which will be provided to industry only by belts (and not by trucks), peaceful and favourable locations in the centre of Pakistan and ideal location for all provinces strongly suggests for installation of new cement industries. The installation of more than a dozen new cement industries in D.G.Khan and Rajan Pur districts will be an accelerated innovation for the sustainable development of the areas, provinces and Pakistan. Further Pakistan can earn sufficient foreign exchange by cement export.

Microfacies, Benthic Foraminiferal Biostratigraphy and Paleoenvironment of The Eocene Nammal Formation Exposed in Nammal Gorge, Western Salt Range, Pakistan

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Abstract

In this study, stratigraphic section of Nammal Formation (Early Eocene) of the Western Salt Range exposed in the Nammal Gorge is measured, sampled and logged. The 76m thick section of Nammal Formation at Nammal Gorge consists of predominantly slope forming limestone with interbedded shale, recessive limy siltstone and marl. The recessive beds are generally exposed above and below the limestone beds. The upper part of the Nammal Formation is exposed in a very steep cliff of wavy to flat bedded lime mudstone to packstone sequence. Four microfacies have been identified on the basis of petrographic studies; as Wackestone to Packstone Microfacies (NMF-1) deposited in middle ramp settings, Planktic Foraminiferal Mudstone to Wackestone Microfacies (NMF-2) representing open marine conditions of outer ramp settings, Wackestone Microfacies (NMF-3) showing deeper water environment of the outer ramp and Packstone Microfacies (NMF-4) depicting high energy conditions towards inner ramp.

The various allochemical constituents of the formation have been identified which include different varieties of foraminifers e.g. Benthic Foraminifera; *Assilina dandotica, Assilina laminosa, Assilina leymerie, Assilina spinosa, Nummulites globulus Leymerie, Nummulites atacicus Leymerie, Nummulites mammalitus, Discocyclina dispansa, Discocyclina ranikotensis, Lockhartia conditi, Operculina, Bigenerina, Miliolids, Textularia* and Planktic Foraminifera; *Globigerina* along with some *echinoderms and algal fragments* often embedded in sparry calcite or lime mud. The bioclasts outnumber all other grain types present. The occurrences of various key age diagnostic foraminiferal assemblages suggest maximum stratigraphic ranges through foraminiferal shallow benthic biozones (SBZ 8/9-11) of Ypresian time. On the basis of fossil assemblages and textural relationships, the environment of deposition is interpreted to occur dominantly in the middle to outer ramp and less dominant towards inner ramp settings of the carbonate platform.

Keywords: Western Salt Range; Nammal Formation; Microfacies; Biostratigraphy; Shallow Benthic Zones (SBZ); Paleoenvironment.

Sedimentary features of ooids from the Cambrian Series 3 of North China Platform: A case study of Xiaweidian section, Beijing

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Abstract

This paper describes the sedimentary characteristics of oolitic grainstones from Xuzhuang, Zhangxia and Gushan formations of Cambrian Series 3 at Xiaweidian section in the Western part of Beijing, China. Petrographic and morphological techniques were applied to describe the sedimentary features of ooid grains. Observations made on dominant ooids are size distribution, mineralogy, morphology, and internal and external cortical architecture. Radial-concentric ooids with or without nucleus, micritic, superficial, composite,- pseudo ooids, neomorphosed and geopetal ooids are observed under microscope. The principal carbonate minerals are calcite, its unstable polymorph aragonite and dolomite. The twofold role of microorganism during and after the formation of ooids can be recognized under the microscope, which make them unique. Firstly, the dark laminae in several ooids most probably shows the remains of filamentous cyanobacteria taking part in the construction of ooids. Secondly, in several ooids the microorganisms e.g., *Solentia* sp. and *Hyella* sp. destroy the cortex through boring, which is subsequently filled by aragonite. The morphology of the ooids from Cambrian Series 3 strata characterize their development in high energy shallow water environment with an active role of microbe.