

**INSTITUTE OF GEOLOGY, UNIVERSITY OF THE PUNJAB
LAHORE**

**COURSES AND SYLLABI
FOR
PhD APPLIED GEOLOGY
(PETROLEUM AND STRUCTURAL GEOLOGY)**

COURSE WORK: 18 CreditHrs

Course Code:	Course Title	Credit hrs
GEOL: 718	Carbonate Sedimentology	03
GEOL: 719	Applied Basin Analysis	03
GEOL: 720	Seismic Stratigraphy	03
GEOL: 721	Advance Seismic Interpretation	03
GEOL: 722	Reservoir Geophysics	03
GEOL: 723	Hydrocarbon Modeling	03
GEOL: 724	Geochemistry	03
GEOL: 725	Isotope Geochemistry	03
GEOL: 726	Paleoecology	03
GEOL: 727	Hazards Analysis	03
GEOL: 728	Tectonic Geomorphology	03
GEOL: 729	Petrophysical Analysis	03
GEOL: 730	Clastic Sedimentology	03
GEOL 731	Biostratigraphy	03
GEOL 732	Practical Structural Geology	03
GEOL 733	Principles Of Sequence Stratigraphy	03
GEOL 734	Laboratory Techniques	03
GEOL 735	Applied Structural Analysis	03
GEOL 736	Seismotectonics	03
GEOL 737	Petroleum Economics And Management	03
GEOL 738	Fluid Technology	03
GEOL 739	Drilling Operation	03
GEOL 740	Remote Sensing Mineralogy	03

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COURSES & SYLLABI FOR PhD APPLIED GEOLOGY (PETROLEUM AND STRUCTURAL GEOLOGY)

GEOL: 718 CARBONATE SEDIMENTOLOGY (03 Credit Hrs)

Constituents of Limestones: Non-skeletal grains, Skeletal grains, Matrix, Granulometric and morphometric properties, Grain orientation and packing, Limestone classification, Porosity.

Major controls on carbonate sedimentation: Organic productivity and sedimentation rates, Depositional processes and facies sequences in carbonate rocks.

Modern Carbonate environments: The Bahama Platform, Florida shelf, Trucial Coast.

Carbonate Depositional systems:

- 1) **Modern shoreline carbonate sand systems:** Environments and facies of shoreline sands, Beach ridge-strand plain sequences, Ancient shoreline carbonates, Shelf-margin sand bodies.
- 2) **Peritidal carbonates:** Peritidal environments, Sedimentary processes and products, Controls on the deposition of peritidal carbonates
- 3) **Lacustrine carbonates:** Sedimentary and Biological processes, Sedimentary features and facies models.
Reefs: Controls and process, Reef petrography, major controls on Reef morphology, Reefs facies.
- 4) **Deeper- water facies of pelagic and resedimented limestones:** Pelagic oozes and organisms, Controls on pelagic carbonate sedimentation, Depositional of modern pelagic carbonate facies, Tethyan pelagic limestone.
- 5) **Digenetic processes:** Diagenetic environments, Shallow-marine diagenesis, Meteoric diagenesis, Burial Diagenetic, Sequences and models,
- 6) **Dolomites:** Dolomite petrography, Trace element geochemistry, Stable isotope geochemistry, Models of Dolomitization.

Recommended Books

1. Carbonate Sedimentary By: Tucker and Wright (1990)
2. Wolfgang Schlager (2007). Carbonate Sedimentology and Sequence Stratigraphy.
3. Peter A. Scholle, Noel P. James and J.F. Read (1989). Carbonate Sedimentology and petrology, Part 3.
4. Christopher G. St C. Kendall, Abdulrahman Alsharhan (2012). Quaternary Carbonate and Evaporite Sedimentary Facies and their Ancient Analogues .
5. M.E. Tucker (2009) Carbonate Platforms: Special Publication 9 of the IAS.

GEOL: 719 APPLIED BASIN ANALYSIS (03 Credit Hrs)

Applied sedimentology, Principles and applications of sedimentary basin analysis. Sequence stratigraphy Controls on basin fill. Nature, origin, migration and accumulation of oil. Exploration techniques. Petroleum technology. Reservoir evaluation, source, seal, trap formation. Petroleum systems development, petroleum production and reserves, Controls on basin stratigraphy: Role of tectonics, role of sea level, eustasy versus isostasy, palaeoclimatic influences, global tectonic influences and an introduction to Sequence Stratigraphy. Depositional environments. Classification of basins: Classification schemes and classification associated with evolutionary style, Datasets, The concept of megasequences, Introduction to play fairway analysis Techniques, burial history, petroleum systems and play fairway analysis, Analogue basin identification.

Recommended Books

1. Basin Analysis: Principles and Application to Petroleum Play Assessment by Philip A. Allen, John R. Allen (2006).
2. Basin Analysis: Principles and Applications by Philip A. Allen, John R. Allen (2006)
3. Principles of Sedimentary Basin Analysis by Andrew D. Miall Andrew (2000)
4. Sequence Stratigraphy by Dominic Emery, Keith Myers(1996)
5. Principles of Sequence Stratigraphy (Developments in Sedimentology) by Octavian Catuneanu(2006)
6. Fundamentals of Basin and Petroleum Systems Modeling by Thomas Hantschel, Armin I. Kauerauf(2005).

GEOL: 720 SEISMIC STRATIGRAPHY (03 Credit Hrs)

Introduction: Philosophy and History, Geophysical Fundamentals, Breaking Out Operational Sequences, Introduction to Fault Interpretation, Chronostratigraphy Construction and Interpretation, Sea Level Curves, Accommodation Space, and Cycle Orders, Vail Sequence Theory and Sequence Hierarchy, Carbonate Sequences, Siliciclastic Sequences, Seismic Facies Paleo-Environmental Analysis, Geohistory Reconstruction, Optimizing Exploration

Recommended Books:

1. Paul P. (2007) Seismic Stratigraphy, Basin Analysis and Reservoir Characterization.
2. Robert E. Sheriff (1991). Seismic Stratigraphy.

GEOL: 721 ADVANCE SEISMIC INTERPRETATION (03 Credit Hrs)

Review of basics and picking seismic reflectors, Integrating non-seismic data, Seismic mapping and structural traps, Stratigraphic trapping styles, Depth conversion and prospect volumetrics, Lithological information from seismic: rock physics, Review of DHI's, Seismic attribute analysis, Surface attribute analysis, AVO, Seismic inversion.

Recommended Books

1. Alistair R. Brown. (2011). Interpretation of Three-Dimensional Seismic Data, Issue 42.
2. M. Bacon, R. Simm and T. Redshaw. (2003). 3-D Seismic Interpretation.
3. Ozdogan Yilmaz (2001). Seismic Data Analysis: Processing, Inversion, and Interpretation of Seismic Data.

GEOL: 722 RESERVOIR GEOPHYSICS (03 Credit Hrs)

Static Reservoir Modelling Overview, Explanation and discussion of the modelling process, Fault and Fault Seal Analysis, Recognition of faults in seismic and core, fault displacement models, fault seal analysis, Stratigraphic Analysis, Core- and log-based sequence stratigraphy
Seismic stratigraphy, Biostratigraphy, chemostratigraphy, magnetostratigraphy, pressure data, residual salt analysis, Facies Analysis, Facies analysis using cores and logs, Constructing depositional models, Constraining models with biofacies and ichnofacies, Use of analogues in facies analysis, Defining the most appropriate scale for facies, Geological analysis of seismic Reservoir Body Characterisation, Depositional models, Sandbody architectures, Petrophysical Characterisation, Review of petrophysical logging tools (conventional and advanced), Archie and non-Archie formation evaluation, Conventional and special core analysis, Seismic attributes and seismic inversion.

Recommended Books

1. William L. Abriel (2008). Reservoir Geophysics: Applications, Distinguished Instructor Short Course.
2. Dimri, V.P., Srivastava, R.P. and Nimisha. Fractal Models in Exploration Geophysics: Applications to Hydrocarbon Reservoirs.
3. Reservoir Characterization: Integration of Geology, Geophysics, and Reservoir Engineering: The Third JNOC-TRC International Symposium, February 20-23, 1995 at the TRC, Chiba, Japan.
4. Roger M. Slatt. (2006). Stratigraphic Reservoir Characterization for Petroleum Geologists, Geophysics, and Engineers.

GEOL: 723 HYDROCARBON MODELING (03 Credit Hrs)

Petroleum Systems Analysis (Top Down vs Bottom Up approach), Fundamentals of Basin Formation and Basin Classification. Play Fairway Analysis: Sources, Reservoirs, Traps and Seal distribution. Paleoclimatic Modelling to predict source and reservoir rock distribution.

Plate tectonic reconstruction as a means to constraining basin configurations, Source Rock Presence and Potential, Source Rock Classification (Organofacies), Source Distribution, Source Rock Analysis, Organic Richness and potential, Organic Quality, Kinetics, Estimating Ultimate Expelled Potential, Basin geometry, Generation and Expulsion History, Migration Styles, Fluid Flow Concepts, Overpressure and Effective Stress, Basin Modelling, Concepts, 1-D Modelling , Temperature Correction Methods, Burial History, Calibration, Sensitivity Analysis, Map-Based Modelling

Recommended Books

1. Michael T. Klein, Gang Hou, Ralph Bertolacini, Linda J. Broadbelt, Ankush Kumar(2005). Molecular Modeling in Heavy hydrocarbon Conversions.
2. Armin Iske and Trygve Randen. (2005). Mathematical Methods and Modeling in Hydrocarbon Exploration and Production.
3. Adam Robinson (2008). The Future of Geological Modeling in Hydrocarbon Development.
4. Brebia, C.A. (2002). Oil and Hydrocarbon Spill III: Modeling, Analysis and Control.

GEOL: 724 GEOCHEMISTRY (03 Credit Hrs)

Introduction, Basic concepts. The CO₂ –carbonic acid system and solution chemistry, Interaction between carbonate minerals and solutions, Coprecipitation and reaction and solid solution of carbonate minerals, The oceanic carbonate system and CaCO₃ Composition and source of carbonate sediments, Early marine diagenesis of sedimentary carbonates, Early nonmarinediagenesis of

sedimentary carbonates, Carbonate rocks in subsurface processes, sedimentary carbonate in evolution of earth's surface environment

Recommended Books

1. Geochemistry of Sedimentary Carbonates By J.W. Morse, F.T. Mackenzie (1990)
2. Petroleum Geochemistry and Source Rock Potential of Carbonate Rocks by J. G. Palacas (2009)
3. Geochemistry: Pathways and Processes By Harry et al., 2009
4. Francis Albarede(2003). Geochemistry: An Introduction.
5. Harry Y. McSwen, Steven McAfee Richardson, Maria E. Uhle (2003). Geochemistry: Pathways and Processes.
6. Brownlow, H. (1996). Geochemistry.
7. Barbara Sherwood Lollar (2005). Environmental Geochemistry.
8. Horst D. Schulz, Matthias Zabel (2006). Marine Geochemistry.

GEOL: 725 ISOTOPE GEOCHEMISTRY (03 Credit Hrs)

Introduction, introduction and the Physics of the Nucleus, Fundamentals of Isotope Geochemistry, Definitions , Terminology, Standards, Basics of Radiogenic Isotope Geochemistry, Basics of Radiogenic Isotope Geochemistry,

Radioactive Decay, Nucleosynthesis,

Stable Isotope Fractionation: Properties of isotopic molecules, fractionation accompanying chemical reactions and phase changes, the Rayleigh equations, isotopic fractionation in open and closed systems, biological fractionations, sample collection, analysis, and quality assurance, sampling guidelines, analytical methods and instrumentation
The K-Ar and Rb-Sr systems, Stable Isotope Theory: Equilibrium Fractionations,

Stable Isotope Applications I: High Temperatures, Stable Isotopes in Paleontology, Paleoclimatology, The Carbon Cycle, Isotopes, and Climate ,

Recommended Books

1. Principles of stable isotope geochemistry by Zachary Sharp (2007)
2. Variations of Stable Isotope Ratios in Nature by Hoefs, Jochen (2005)
3. Stable Isotope Geochemistry by Hoefs, Jochen (2009)
4. Isotope Fractionation Processes of Selected Elements by Hoefs, Jochen (2010)
5. Theoretical and Experimental Principles by Hoefs, Jochen (2006)
6. Variations of Stable Isotope Ratios in Nature by Hoefs, Jochen (2005)

GEOL: 726 PALEOECOLOGY (03 Credit Hrs)

Origin of life, controversies regarding early earth's biosignals, paleoecology (life habits and environments) scientific process of paleontology, life and biodiversity, geological history and evolutionary trends, species and populations, ontogeny and heterochrony

biodiversity and evolution, geologic time, biological classification of organisms, the nature of fossils/fossil records, fossil dating methods. systematics and taxonomy, biostratigraphy, paleogeography, morphometry, biostratigraphy and correlation, sequence stratigraphy, global diversification,

Fossil ecology, fossil ethology, the biology of living representatives, the morphology of the hard parts, focusing on their function, taxonomy and higher level classification, Extinction events, Adaptations, natural selection and evolution, Taxonomy of ancient life.

Human history on Earth, extreme (paleo)environments, high-resolution paleoclimatic reconstruction, paleoenvironmental reconstruction, trace fossil applications, paleoecology of major fauna groups and their subsequent, Example where the fossil group was used to solve a problem in geology

Recommended Books

1. Paleontology, Paleocology, and Biostratigraphy by Ashton F. Embry, Donald J. Glass, N. J. MacMillan (1998)
2. Introduction to Paleobiology and the Fossil Record. Benton, M.J. and Harper, D.A.T. 2009
3. Trace Fossils: Concepts, Problems, Prospects by William Miller, III (2010)
4. Systematics and Paleocology of Devonian Stromatoporoids By Danielle Elizabeth Jannusch (1988)

GEOL: 727 HAZARDS ANALYSIS (03 Credit Hrs)

Part I: Natural Hazards/Disasters:

Geological Hazards

Introduction to Natural Hazards: Natural hazards, disasters and catastrophes relationships. How natural are natural hazards? Functional classification of Hazards. Relationship of Population Growth and hazards. Energy sources of natural hazards. Nature's Fury. Nature, causes, phases and effects of common natural hazards/disasters. Vulnerability and susceptibility of natural hazards/disasters/catastrophes. The environment, natural hazards, and sustainable development.

Earth as a dynamic planet. Introduction to the theory of Plate Tectonics. Tectonic framework, earthquakes, volcanisms and mountain building, Earthquakes, Volcanism, Landslides, Floods, Coastal Hazards, Atmospheric Hazards, Hydrologic, Desertification, Salinization, Drought Erosion and sedimentation, River flooding. Storm surges

Anthropogenic Hazards

These are hazards that occur as a result of human interaction with the environment. They include *Technological Hazards*, which occur due to exposure to hazardous substances, such as radon, mercury, asbestos fibers, and coal dust. They also include other hazards that have formed only through human interaction, such as acid rain, and contamination of the atmosphere or surface waters with harmful substances, as well as the potential for human destruction of the ozone layer and potential global warming.

Part II: Management of Natural Hazards/Disasters

Hazard and Risk Assessment. Introduction to hazards reduction planning. Disaster cycle. Planning matrix. Hazard tree analysis. Disaster assistance to international community. Evaluation, prediction/forecasting, monitoring, prevention and preparedness. Disaster information and risk assessment. Institutional frameworks for disaster mitigation hazard mapping and risk assessment, Disaster management, Buildings and earthquake risks. Environmental Health Management after Natural Disaster, Epidemiologic Surveillance after Natural Disaster, Emergency Vector Control after Natural Disaster, Health Education and Training of Refugee Health Workers

Recommended Books

1. Natural and Anthropogenic Hazards in Development Planning (Environmental Intelligence Unit) by Siegel (1996)
2. Disaster Management: Warning Response And Community Relocation By Amit Awasthy (2009)
3. Disaster Management: Warning Response And Community Relocation By Sundarand. Sezhiyan (2007)
4. Disaster on the Horizon: High Stakes, High Risks, and the Story Behind the Deep water well Blowout by Bob Cavnar (2010)
5. Assessing and Restoring Natural Resources In Post-Conflict Peacebuilding By David Jensen, Stephen Lonergan (2010).

GEOL: 728 TECTONIC GEOMORPHOLOGY (03 Credit Hrs)

Introduction: A brief introduction to plate tectonics, Geomorphology and its early history, Inter relationships: plate tectonics, landforms, erosion and sediment production, Landscape Evolution and Tectonics

Evaluation of Regulate: Rock Surface and Weathering, Processes and Forms, Fluids, Flows and Fluxes in Geomorphology.

Active tectonics and models of landscape development: Geomorphic markers, Establishment of timing in landscape by dating methods, stress faults and folds and their relationship and controls on landscape Evolution.

Paleoseismology: seismic moment and moment magnitudes: Surface rupturing versus buried faults, displaced geomorphological features, indirect observation of faulting.

Rates of erosion and uplift: Conceptual framework: Sedimentary fluxes in rivers, Rates of erosion based on structural and stratigraphic controls, topographically constrained erosion rates, Long term erosion rates based on radiometric ages, Marine terraces, tectonic and surface uplift rates.

Holocene deformation and landscape responses: Base levels, Theoretical perspective on fluvial erosion and river profiles, Channel patterns and characteristics, Models for responses of meandering rivers to tilting across the floodplain, Effects of active fold growth on river concavity, Antecedent channel responses to rapid, differential uplift, Fluvial responses to localized uplift, Effect of localized uplift on stream-table channels.

Deformation and Geomorphology at Intermediate time scale: Tectonic Geomorphology at late Cenozoic time scales, Numerical Modeling of Landscape Evolution.

Recommended Books

1. The SAGE Hand Book of Geomorphology By: Gregory and Goudie (2011)
2. Tectonic Geomorphology By: Burbank and Anderson (2011)
3. Michael A. Summerfield (2000). Geomorphology and Global Tectonics.
4. Douglas W. Burbank and Robert S. Anderson (2000). Tectonic Geomorphology.
5. William B. Bull (2007). Tectonic Geomorphology of Mountains: A New Approach to Paleoseismology.

GEOL: 729 PETROPHYSICAL ANALYSIS (03 Credit hrs)

Introduction to petrophysics and its role in the oil and gas industry: Principles of petroleum exploration, development and production; basic understanding required to perform a simple reservoir evaluation; and integration of log and core data to fully describe variation in reservoir properties and how they are distributed.

Porosity and Permeability: Factors governing porosity, classification of porosity, fluid saturation, permeability and its classification, factors affecting magnitude of permeability, permeability-porosity relationship, Kozeny relationship, mathematical theory of flow units, reservoir zonation using normalized RQI, permeability from GR logs, Reservoir heterogeneity, statistical zonation techniques.

Formation Resistivity and water saturation: determination of formation water resistivity factor, spontaneous potential curve, resistivity of shaley reservoir, formation evaluation, core analysis, well log analysis, well log data analysis.

Capillary pressusre and wettability: derivation of caspillary pressure equation, Capillary pressure j-function, measurement of capillary pressure, theoretical calculation of inlet saturation, interfacial; tension, Wilhelmy Plate measurement of contact angles, evaluation of wettability, fluid displacement energy, alternation of wettability, effects of temperature and pressure, effects of wettability on electrical properties, dimensionless pressure, composite reservoirs.

Reservoir characterization: Acquisition and evaluation of routine (RCA) and special (SCAL) core analysis datasets. Reservoir volume, mobility units, j-function, analysis of reservoir performance, decline curves, material balance,

Recommended Books:

1. Petrophysics, Theory and Practice of Measuring Reservoir Rock and Fluid Transport Properties. 2012. Third Edition: By Djebbar Tiab and Eric C. Donaldson.
2. A Geoscientist's Guide to Petrophysics. 2007 By B. Zinszner, François Marie Pellerin
3. Advanced Petrophysics: Solutions. 2012. By Ekwere J. Peters.
4. Fundamentals of the Petrophysics of Oil and Gas Reservoirs. 2012. By Leonid Buryakovsky, George V. Chilingar, Herman H. Rieke and Sanghee Shin

GEOL: 730 CLASTIC SEDIMENTOLOGY (03 Credit hrs)

origin of terrigenous clastic grains. Origin of calcium carbonate grains. Evaporates, biogenic silica and phosphates. Grain properties. Fluid properties and fluid motion. Transport of sediment grains. Sediment gravity flows. Bedforms and structures in granular sediments. Bedforms caused by erosion of cohesive sediment. Biogenic and organo-sedimentary structures. Soft sediment deformation structures. Environmental and facies analysis. Deserts. Alluvial fans. River plains. Lakes, glacial environments. Physical processes of coast and shelf. Deltas, estuaries. Linear clastic shorelines. Clastic Shelves. Carbonate evaporate shorelines, shelves and basins.

Books Recommended:

1. Sedimentology by Prothero 1996.
2. Sedimentary Rocks by F.J. Pettijohn 1975.
3. Sedimentary Environments by H.G. Peading 1996.
4. Sedimentology Process and Product by M.R. Leeder 1982.

GEOL 731 BIOSTRATIGRAPHY (03 Credit hrs)

Detailed study of different groups of faunal remains specially foraminifera, radiolarians, conodonts and nanoplankton and their significance with reference to hydrocarbon exploration in Pakistan. Foraminiferal biostratigraphy of Jurassic, Cretaceous and Tertiary times and the biozones established by important groups of fossils and their applications in Pakistan biostratigraphy.

Books Recommended

1. Devesh K. Sinha (2006). Micropaleontology 1st edition, Narosa Publishing House, New Delhi and Alpha Science International Oxford, UK.
2. David Barnard Ericson and Goesta Wollin (1962). Micropaleontology, 1st edition, Freeman, San Francisco.
3. James D. McLean (1959). Micropaleontological Techniques, 1st edition, Mclean Meteorological Laboratory, Alexandria.
4. Martin F. Glaessner (1947). Principles of micropaleontology 1st edition, John Wiley & Sons, N.Y. USA.
5. James Douglas McLean (1963). Manual of micropaleontological stratigraphy 2nd edition, Mclean Paleontological Laboratory Alexandria Victoria. U.K.
6. Ronald E. Martin (2000). Environmental Micropaleontology (Topics in Geobiology) 1st edition, Kluwer / Plenum.
7. Martin F. Glaessner (1947). Principles of micropaleontology, 1st edition, John Wiley & Sons, New York, USA.

8. James Douglas McLean (1963). Manual of Micropaleontological Stratigraphy, 2nd edition, McLean Paleontological Laboratory, Alexandria Victoria. U.K.
9. Ronald E. Martin (200). Environmental Micropaleontology (Topics in Geobiology) 1st edition Kluwer / Plenum. Hardback.

GEOL 732 PRACTICAL STRUCTURAL GEOLOGY (03 Credit hrs)

Attitudes of lines and planes. Outcrop patterns and structure contours. Interpretation of Geologic Maps. Geologic Structure Sections. Stereographic Projection. Folds. Stereographic Analysis of Folded Rocks. Parasitic Folds, Axial-Planar Foliations, and Superposed Folds. Faults. Dynamic and Kinematic Analysis of Faults. A Structural Synthesis. Rheologic Models. Brittle Failure. Strain Measurement. Construction of Balanced Cross Sections. Deformation Mechanisms and microstructures. Introduction to Plate Tectonics.

Books Recommended

1. David. D. Pollard, Raymond C. Fletcher (2005). Fundamentals of Structural Geology.
2. Haakon Fossen (2010) Structural Geology.
3. Robert J. Twiss (1992). Structural Geology.
4. Richard H. Groshong (1999) 3D Structural Geology: A practical Guide to Surface and
5. D.G. De Paor (1996). Structural Geology and personal Computers.
6. Charles Kenneth Leith (2012) Structural Geology.
7. R.G. Park (2013) Foundation of Structural Geology.

GEOL 733 PRINCIPLES OF SEQUENCE STRATIGRAPHY (03 Credit hrs)

Introduction, history, concept and significance of sequence stratigraphy, Seismic reflections and facies. Sea level changes, their causes and effects. Accommodation, eustatic sea level curve. Hierarchy of sequence stratigraphy elements. Types of sequences and systems. Tracts.

Books Recommended

1. Silici-clastic Sequence Stratigraphy in well Logs, Cores and Outcrops by Van Wagoner, J.C, et.al, 1990, AAPG Meth Expl. Ser. No. 7.
2. Sea level changes an integrated approach by Wilgus, B.S. et.al., 1988, SEPM.
3. Seismic Stratigraphy: Application to H-Carbon Exploration by Payton, C.W., 1977, AAPG Mem. 26.
4. Sequence Stratigraphy and Facies Association by Posamentier, H.W., et. Al., 1993, Blackwell.
5. Sequence stratigraphy by Emery, D., & Myers, K.J., 1996, Oxford, Blackwell.

GEOL 734 LABORATORY TECHNIQUES (03 Credit hrs)

Introduction, instrumentation and production of X-rays. The interaction of X-rays with matter, X-ray dispersion and detection, X-ray diffraction, X-ray fluorescence, Emission spectroscopy, Atomic Absorption Spectrometry, Atomic Emission Spectrometry, Infra-red absorption. Scanning Electron Microscopy, Transmission Electron Microscopy Inductively coupled plasma spectrometry. MS Spectrometer. Electron Microprobe. Thermal analysis (DTA/TG).

Discussion and application of the theory to the following methods of determining the physical properties of geological material: Powder and particle size measurements (sieving and sedimentation), density / SG, and automated methods (Coulter counter), surface area measurement (gas absorption, permeability, and BET equation), colour measurements (colour specifications, spectrometric curves).

Books Recommended

1. Williams, K.L., 1987. Introduction to X-ray Spectrometry, Allen and Unwin, London, U.K.
2. Jenkins, R., 1986. Introduction to X-ray Spectrometry, John Wiley and Sons, New York, USA.
3. Nuffield, E.W., 1966. X-ray Diffraction Methods, John Wiley and Sons, New York, USA.
4. Gamina, R., John, S., Adams and Gasparini, P., 1970. Spectrometry of Rocks, Elsevier Publishing Company. Amsterdam, London, U.K.
5. Allman, M. and Lawrence, D.F., 1972, Geological Laboratory Techniques, Arco Publishing Company Inc. New York, USA.
6. Moore and Reynolds (1986). XRD and the identification and analysis of clays Minerals, Oxford University Press, UK.

GEOL 735 APPLIED STRUCTURAL ANALYSES (03 Credit hrs)

Fold morphology, fold orientation (projection techniques), fold classification, fold sections profiles, fold mechanism (single layer, multilayers), strain & small scale structure in folds, super posed folding, fault geometry and morphology, faults and construction of balanced cross sections, mechanical analysis of fractures, ductile & brittle shear zone, joints.

Books Recommended:

1. The techniques Modern Structural Geology Vol. 2 by Ramsay, 1987.
2. Structure and tectonics principles by Badgley 1965.
3. The use of stereographic projection in structural Geology by F.C. Philips 1971.
4. Structural Methods for the Exploration Geologists by Peter C. Badgley 1959.

GEOL 736 SEISMOTECTONICS (03 Credit hrs)

Stress and strain, tensor analysis, rheology, brittle vs. ductile deformation, fracture, fault mechanics, friction, stable and unstable sliding, double-couple representation of earthquake sources, moment tensors, Coulomb failure stress changes, earthquake triggering, stress drop, Kostrov's summation, comparative seismotectonics.

Books Recommended

1. (1986). Active Tectonics, National Academy Press, Washington.
2. Agrawal, P.N. (1991). Engineering Seismology, Oxford and IBH Publisher Company.
3. Benjamin., Howell, J.K., (1990). An Introduction to Seismological Research History and Development, Cambridge University Press.
4. Boit, B.A. (1978). Earthquakes a Primer, W.H. Freeman and Company.
5. Farah, A. and DeJong, K.A. (1979). Geodynamics of Pakistan, Geological Survey of Pakistan.
6. Gupta, H.K., and Delaney, F.M. (1981). Zagros-Hindukush-Himalaya, Geodynamic Evolution, Geodynamic Series, Vol. 3 American Geophysical Union Washington, D.C. Geological Society of America.
7. Malinconico, L.L. and Lillie, R.J. (1983). Tectonics of Western Himalayas Special Paper, 232, Geological Society of America, Colorado, USA.

8. Park, R.G. (1988). Geological Structures and moving Plates, Chapman and Hall Publishers.
9. Roberts S. Yeats, (1997). Geology of Earthquakes, Oxford University Press.
10. Richter, C.F. (1958). Elementary Seismology, W.H. Freeman and Company.
11. Sherma, P.V. (1986). Geophysical Method in Geology, Elsevier.
12. Slemmons, D.B., Engdahls, E.R., Zoback, D. and Blackwell, D.D. (). Neotectonics of North America, Geological Society of America.
13. Verma, R.K. (1985). Gravity Field Seismicity and Tectonics of the Indian Peninsula and the Himalayas, Allied Publishers.
14. Verma, R.K. (1991). Geodynamics of the Indian Peninsula and Indian Plate Margin, Oxford and IBH Publication Company.
15. Wincander, R. (2001). Physical Geology Exploring the Earth, A Division of Thomson Learning Canada.
16. Windly, B.F. (1982), The Evolving Continents, Second Edition, John Willey and Sons.

GEOL 737 PETROLEUM ECONOMICS AND MANAGEMENT (03 Credit hrs)

The historical, geopolitical and economic framework to the modern world of international petroleum. Sovereignty, the state and the ownership of the petroleum resource. The petroleum legislation and key issues within it. The Ministry of Petroleum and the Petroleum Licensing and Monitoring Unit.

Major legal and technical issues for the twenty-first century: Host Communities, Native Title and Petroleum Licensing and the impact of the Islamic (Sharia) Law on the international trade in oil and gas (arbitration, Islamic economics, the ownership of oil and gas, upstream contractual arrangements- the buy-back agreement, interest and cost recovery, petroleum taxation)

The State Oil Company. Ten key steps in petroleum licensing and an example of modern petroleum legislation. Petroleum leases, concessions, agreements and contracts. The modern Equity (Royalty-Tax) Agreement. The modern Contractor (Production Sharing) Agreement. Technical issues in petroleum agreements: term (duration), work programme (duration and content: seismic and wells), exploration periods and relinquishment, exploration and production licences, discovery , the development plan.

Legal and contractual issues in petroleum agreements: the rights, duties, obligations and liabilities of the parties. Financial issues in negotiations: royalty, tax, additional profits taxes, OPEX, CAPEX, cost oil, profit oil, the Equity Agreement versus the Contractor. New legal, banking and financing issues in modern petroleum agreements. Understand profit sharing.

Books Recommended

1. Economics of Petroleum Production: Value and worth. 2004. By Sheila Noeth.
2. The Changing World of Oil: An Analysis of Corporate Change and Adaptation. 2012 by Jerome D. Davis.
3. Petroleum Economics. 1990. edited by Jean Masseron.
4. Environmental Economics and Management: Theory, Policy and Applications. By Scott J. Callan, Janet M. Thomas

5. Oil and Gas Exploration and Production: Reserves, Costs, Contracts. By Nadine Bret-Rouzaut, Jean-Pierre Favennec

GEOL 738 FLUID TECHNOLOGY (03 Credit hrs)

1. Introduction to fluids and fluid technology, identification of types of reservoir fluids, Properties of reservoir fluids, properties of black oils, analysis of field data for black oil correlations, bubble point pressures at reservoir temperatures, solution gas oil ratios of reservoir oils, coefficient of isothermal compressibility of reservoir oils, Densities of reservoir oils, oil formation volume factor, viscosities of reservoir oils, properties of oil field brines.
2. Phase behavior, phase diagrams for: a pure substance, two component mixture, three component mixture and multicomponent mixtures. The ideal gas, equation of state for an ideal gas, mixtures of ideal gases, the compressibility of equation of state. Behaviour of real gases and law of corresponding states.
3. Five reservoir fluids and their identification. Black oil phase diagram, laboratory analysis of black oils. Volatile oils, their phase diagrams and laboratory analysis of volatile oils. Retrograde gases, their phase diagrams and laboratory analysis. Wet gases, field identification and analysis. Dry gases, their phases and gas formation volume factor.
4. Gas liquid equilibrium. Ideal solutions, Raoult's and Dalton's equation, Compositions and quantities of equilibrium gas and liquid phase of ideal solution, Non ideal solutions, compositions and quantities of equilibrium gas and liquid phase of real solutions, flash vaporization
5. Properties and composition of oilfield waters, Bubble point pressure of oilfield waters, formation volume factor, coefficient of isothermal compressibility of water, solubility of water in natural gas and hydrocarbon liquid. Gas hydrates.

Books Recommended

1. Handbook of Hydraulic Fluid Technology 2011. By George E. Totten, Victor J. De Negri
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4. Manual of Drilling Fluids Technology, N.L. Baroid, Petroleum Services

GEOL 739 DRILLING OPERATION (03 Credit hrs)

Rig equipment: overall efficiency of Engines, Blocks, Drilling line and Derrick Load. Crown Block Capacity, line pull efficiency factor, mud pumps, energy transfer, offshore vessels.

Well Path Design: average curvature-average dogleg, vertical and horizontal curvatures, bending angle, tool face angle, borehole torsion, Well path length calculations, Types of designs, tool face angle change, horizontal displacement, tortuosity, well profile energy, magnetic reference and interference, wellbore trajectory uncertainty.

Fluids: Equivalent mud weight, mud weighting, common weighting materials, diluting mud, base fluid-water oil ratios, fluid loss, acidity-alkalinity, marsh funnel, mud rheology, plastic viscosity, yield point and zero-sec-gel.

Hydraulics: equivalent mud weight, equivalent circulating density, hydraulics: basic calculations, bit hydraulics, Bingham Plastic Model, Power Law Model, Gel breaking pressure, hole cleaning – cuttings transport, transport velocity.

Tubular Mechanics and Stresses: Drill collar length, bending stress ration (BSR), pipe wall thickness, tensions, drag force, side force calculation, torque and makeup torque, length change

calculations, stresses. Bending stress magnification factors, slip crushing, cumulative fatigue calculations.

Drilling Tools: stretch and back, over-pull/ slake-off and motor calculations, precaution hammer, Rotor nozzle sizing, down-hole turbine, Jar calculations, specific energy.

Pore Pressure and Well Control: formation pressure, leak off pressure, kill mud weight, length and density of the kick, hydrostatic pressure due to the gas column, leak-off pressure, maximum allowable annular surface pressure, accumulators, driller's method operational procedure.

Casing and Cementing Design: drilling the pay-zone-selecting the interval and initial design, initial completion design, casing design. Cementing, supplementary problems.

Drilling Problems: Stuck-point calculations, differential sticking force, spotting fluid requirements, mud weight increase due to cuttings, Hole cleaning-slip velocity calculations, transport velocity and transport ratio, key seating

Books Recommended

1. Formulas and Calculations for Drilling Operations (2011) by Robello Samuel, John Willey & Son Corporation.
2. Working Guide to Drilling Equipment and Operations (2010) by Lyons William, Elsevier Incorporation.
3. Petroleum Rock Mechanics: Drilling Operations and Well Design (2011) By Bernt Aadnoy, Reza Looyeh, Elsevier Incorporation.
4. Oil and gas exploration and drilling operations (2013), By Chris Termeer
5. Managing drilling operations (1991), Ken Fraser, Jim Peden, Andrew Kenworthy, Elsevier Applied Science, 01- 246 pages.

GEOL 740 REMOTE SENSING MINERALOGY (03 Credit hrs)

Introduction, The Nature of EM Radiation, Radiation Principles and Sources, Electromagnetic Spectrum, Energy Available For Sensing , Atmospheric Effects, Atmospheric Scattering, Atmospheric Absorption, Atmospheric Emission, Energy Interaction Mechanisms on the Ground, Reflection Mechanism, Transmission Mechanism, Absorption Mechanism, Earth's Emission, Basic Arrangement for Laboratory Spectroscopy, Energy States and Transitions – Basic Concepts, Electronic Process, Vibrational processes , Spectral Features of Mineralogical Constituents, Visible and near-Infrared Region(VNIR) (0.4-1.0 um), SWIR Region(1-3 um) , Thermal-IR Region, Spectra of Rocks, Solar Reflection Region (VNIR + SWIR), Thermal-Infared Region, Laboratory vs. Field Spectra, Spectra of Other Common Object

Identification Of Mineral Assemblages ___Remote Sensing in Mineral Exploration, Main Types Of Mineral Deposits and their Surface Indication, Surface Indications, Stratigraphic –Lithological Guides.

Recommended Books

1. Remote Sensing Geology, 2nd edition, Author: Gupta
2. Geographical Information System. Author: Ian Heywood

(Prof. Dr. Shahid Ghazi)
Director

GEOL: 729 PETROPHYSICAL ANALYSIS (03 Credit hrs)

Introduction to petrophysics and its role in the oil and gas industry: Principles of petroleum exploration, development and production; basic understanding required to perform a simple reservoir evaluation; and integration of log and core data to fully describe variation in reservoir properties and how they are distributed.

Porosity and Permeability: Factors governing porosity, classification of porosity, fluid saturation, permeability and its classification, factors affecting magnitude of permeability, permeability-porosity relationship, Kozeny relationship, mathematical theory of flow units, reservoir zonation using normalized RQI, permeability from GR logs, Reservoir heterogeneity, statistical zonation techniques.

Formation Resistivity and water saturation: determination of formation water resistivity factor, spontaneous potential curve, resistivity of shaley reservoir, formation evaluation, core analysis, well log analysis, well log data analysis.

Capillary pressure and wettability: derivation of capillary pressure equation, Capillary pressure j-function, measurement of capillary pressure, theoretical calculation of inlet saturation, interfacial tension, Wilhelmy Plate measurement of contact angles, evaluation of wettability, fluid displacement energy, alteration of wettability, effects of temperature and pressure, effects of wettability on electrical properties, dimensionless pressure, composite reservoirs.

Reservoir characterization: Acquisition and evaluation of routine (RCA) and special (SCAL) core analysis datasets. Reservoir volume, mobility units, j-function, analysis of reservoir performance, decline curves, material balance,

Recommended Books:

1. Petrophysics, Theory and Practice of Measuring Reservoir Rock and Fluid Transport Properties. 2012. Third Edition: By Djebbar Tiab and Erie C. Donaldson.
2. A Geoscientist's Guide to Petrophysics. 2007 By B. Zinszner, François Marie Pellerin
3. Advanced Petrophysics: Solutions. 2012. By Ekwere J. Peters.
4. Fundamentals of the Petrophysics of Oil and Gas Reservoirs. 2012. By Leonid Buryakovsky, George V. Chilingar, Herman H. Rieke and Sanghee Shin

GEOL 737 PETROLEUM ECONOMICS AND MANAGEMENT (03 Credit hrs)

The historical, geopolitical and economic framework to the modern world of international petroleum. Sovereignty, the state and the ownership of the petroleum resource. The petroleum legislation and key issues within it. The Ministry of Petroleum and the Petroleum Licensing and Monitoring Unit.

Major legal and technical issues for the twenty-first century: Host Communities, Native Title and Petroleum Licensing and the impact of the Islamic (Sharia) Law on the international trade in oil and gas (arbitration, Islamic economics, the ownership of oil and gas, upstream contractual arrangements- the buy-back agreement, interest and cost recovery, petroleum taxation)

The State Oil Company. Ten key steps in petroleum licensing and an example of modern petroleum legislation. Petroleum leases, concessions, agreements and contracts. The modern Equity (Royalty-Tax) Agreement. The modern Contractor (Production Sharing) Agreement. Technical issues in petroleum agreements: term (duration), work programme (duration and content: seismic and wells), exploration periods and relinquishment, exploration and production licences, discovery , the development plan.

Legal and contractual issues in petroleum agreements: the rights, duties, obligations and liabilities of the parties. Financial issues in negotiations: royalty, tax, additional profits taxes, OPEX, CAPEX, cost oil, profit oil, the Equity Agreement versus the Contractor.

New legal, banking and financing issues in modern petroleum agreements. Understand profit sharing.

Books Recommended

1. Economics of Petroleum Production: Value and worth.2004. By Sheila Noeth.
2. The Changing World of Oil: An Analysis of Corporate Change and Adaptation.2012 by Jerome D. Davis.
3. Petroleum Economics. 1990. edited by Jean Masseron.
4. Environmental Economics and Management: Theory, Policy and Applications. By Scott J. Callan, Janet M. Thomas
5. Oil and Gas Exploration and Production: Reserves, Costs, Contracts. By Nadine Bret-Rouzaut, Jean-Pierre Favennec

GEOL 738 FLUID TECHNOLOGY (03 Credit hrs)

- 1.Introduction to fluids and fluid technology, identification of types of reservoir fluids, Properties of reservoir fluids, properties of black oils, analysis of filed data for black oil correlations, bubble point pressures at reservoir temperatures, solution gas oil ratios of reservoir oils, coefficient of isothermal compressibility of reservoir oils, Densities of reservoir oils, oil formation volume factor, viscosities of reservoir oils, properties of oil field brines.
2. Phase behavior, phase diagrams for: a pure substance, two component mixture, three component mixture and multicomponent mixtures. The ideal gas, equation of state for an ideal gas, mixtures of ideal gases, the compressibility of equation of state.Behaviour of real gases and law of corresponding states.
3. Five reservoir fluids and their identification. Black oil phase diagram, laboratory analysis of black oils. Volatile oils, their phase diagrams and laboratory analysis of volatile oils. Retrograde gases, their phase diagrams and laboratory analysis. Wet gases, filed identification and analysis. Dry gases, their phases and gas formation volume factor.
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