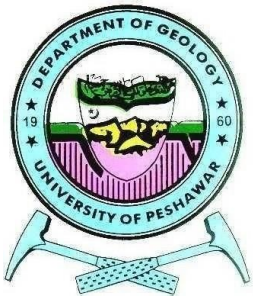
Curriculum



B.S Geology (4 years)

(Session 2004-05 and Onward)

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B. S. Part-I Geology
Geol. 111: Fundamentals of Geology
Total Marks=100

Learning Objectives:

To acquire knowledge about crystals, minerals, rocks, and processes involved in weathering and mass wasting.

Learning Outcomes:

After completing this course, the student should be able to perform the following.

a. Identification of minerals, rocks and crystal shapes of the normal class of the crystal system.
b. Understanding of the significance of processes involved in weathering and mass wasting.

Course contents: TheoryMarks=75

- Mineralogy
  - Definition of mineral
  - Physical properties of minerals
  - Examples of minerals
- Crystallography
  - Introduction to crystallography
  - Elements of symmetry
  - Crystal systems
- Igneous rocks
  - Crystallization of magma
  - Igneous textures
  - Classification of igneous rocks
  - Naming of igneous rocks
  - Occurrence of igneous rocks
  - Volcanic activity
  - The nature of volcanic activity
  - Materials extruded during an eruption
  - Volcanoes and volcanic eruptions
  - Volcanoes and climates
  - Fissure eruption and pyroclastic flow deposits
- Weathering and soil
  - Weathering
  - Mechanical weathering
  - Chemical weathering
  - Biological weathering
  - Soil
  - Controls of soil formation
  - The soil profile
  - Soil types
- Mass wasting and gravity processes
  - Mass wasting
  - Controls of mass wasting
  - Classification of mass wasting processes
  - Slump
  - Rockslide
  - Mudflow
  - Earthflow
  - Creep
  - Perfafrost and solifluction
- Sedimentary rocks
  - Types of sedimentary rocks
  - Changing sediments into sedimentary rocks
  - Classification of sedimentary rocks
  - Sedimentary environments and sedimentary structures
- Introduction to stratigraphy and paleontology
  - Definition and scope of stratigraphy
  - Definition and scope of paleontology
  - Fossils and index fossils
  - Fossilization and types of preservation
- Metamorphic rocks
  - Metamorphism
  - Agents of metamorphism
  - Textural and mineralogical changes
  - Common metamorphic rocks
- Economic mineral deposit
  - Mineral resources
  - Importance of mineral deposits
  - Common metallic mineral deposits
  - Common non-metallic mineral deposits
  - Energy resources

Practicals Marks = 25

Lab excrcises based on:-

- Mineral identification
- Rock identification
- Identification of crystals

Books Recommened

- Foster, R. J., 1986. General Geology. Merrill, Columbus.
- Press, F. and Siever, R., 1986. Earth. Freeman, New York.
- Sander, J. E., 1981. Principles of Physical Geology. John Wiley & Sons, New York.
- Tarbuck, E. J. and Lutgens, F. K., 1987. The Earth. Merrill, Columbus.

B. S. Part-I Geology
Geol. 112: Geological Processes
Total Marks=100

Learning Objectives:
To acquire knowledge of the following topics:

a. The origin of the Earth and tectonics
b. Geological processes related to surface water, ground water, glacier, desert, shoreline and earth quake.
c. Interior of the earth and rock deformation.

Learning Outcomes:
Upon completion of this course students will have learnt about the various geological processes in and on the Earth and its application to the past history of the earth. "Present is the key to the past".

Course contents: TheoryMarks=75

- Introduction to Geology
  - Scope of Geology
  - Origin of the Earth with respect to the origin of Universe, Galaxies, Stars and solar system
- Age of the Earth
  - Methods of age determination
  - Geologic Time Scale
- Surface water, Running water
  - Stream erosion
  - Transport and deposition of sediments by streams
  - Stream valleys
  - Drainage networks
  - Stages of valley development
- Underground water
  - Hydrologic cycle
  - Distribution of underground wate
  - The water table
  - Porosity and permeability
  - Movement of groundwater
  - Springs
  - Wells
  - Artesian wells
  - The geologic work of G.W.
  - Karst Topography
- Glaciers and glaciation
  - Formation of glacier
  - Movement of a glacier
  - Glacial erosion
  - Landforms created by glacies
- Deserts and winds
  - Deserts
  - Geologic processes in arid climates
  - Transportation of sediments by wind
  - Wind erosion and deposits-landforms
- Shorelines
  - Waves
  - Wave erosion
  - Shoreline features
  - Tides
  - Tides and Earth's rotation
  - Tidal power
- Earthquakes
  - What is an earthquake?
  - Seismology
  - Locating the source of an earthquake
  - Earthquake belts
  - Earthquake intesity and magnitude
  - Earthquake destruction
  - Earthquake prediction and control
- The Earth's inetrior
  - Internal structure of the earth
  - Phsical properties of the Earth interior
  - The Crust
  - The Mantle
  - The Core
  - Gravity and Isostasy
- Plate tectonics
  - Evolution of the concept of continental drifting
  - Sea floor spreading, paleomagnetism, earthquakes
  - Plate tectonics
  - Subduction-related processes
  - Rifting
  - Wilson cycle
  - Mountain building
- Rock deformation
  - Folds
  - Faults
  - Joints
  - Attitude of rocks-Dip and Strike
- Mountain types
  - Mountain building

Practicals Marks = 25

- Construction of profile section
- Construction of cross-section along a given line
- Structure contours
- Topographic contours and maps
- Reading and interpretation of geological maps
- Three point problems to determine dip and strike
- Simple geological maps and sections

Books Recommened:

- Foster, R. J., 1986. General Geology. Merrill, Columbus.
- Press, F. and Siever, R., 1986. Earth. Freeman, New York.

- Sander, J. E., 1981. Principles of Physical Geology. John Wiley & Sons, New York.
- Tarbuck, E. J. and Lutgens, F. K., 1987. The Earth. Merrill, Columbus.

B. S. Part-I Geology
Geol. 113: Physics
Total Marks=100

Learning Objectives:
To acquire knowledge of the following topics:

a. Vector, Kinematics, Laws of motion.
b. Gravitational forces, Rotational kinematics and dynamics.
c. Elasticity, viscosity and surface tension.

Learning Outcomes:
At the end of this course the students will be able to understand the basic principles of physics and its application in geophysics.

Course contents: **Theory Marks=75**

- Vectors
  - Definitions of scalar and vector
  - Resolution of vectors & product
  - Scalor field and vector field
  - Divergence & gradient of a vector
- Kinemetics & motion
  - Average and instantaneous velocity
  - Linear motion with constant acceleration
  - Velocity and coordinates by integration
  - Freely falling bodies
  - Velocity components and relative velocity
- Newton's laws of motion
  - Newton's Laws of motions & Inertia
  - Mass and weight
  - Systems of units
  - Application of Newton's laws of motion and gravitation
  - Inertial and gravitional mass
  - Centre of gravity
- Motion of projectile, Circular motion
  - Centripetal and centrifugal forces
  - Motion of a satellite
- Variation of g with earth's rotation
  - Effect of altitude on g
- Equilibrium, Moment of force
  - Equilibrium of rigid body
  - Conditions of equilibium
- Work, power and energy
  - Wor done by rigid body
  - Kinetic &Gravitational potentional energy
  - Power and velocity, Mass and energy
  - Conservation of energy
- Rotational kinemetics and dynamics
  - Angular velocity and acceleration
  - Rotation with constant angular acceleration
  - Relation between linear and angular velocity and acceleration
  - Torque & Moment of inertia
  - Kinetic energy and work
  - Angular momentum
- Elasticity
  - Stress & Strain, Elaticity and plasticity
  - Elastic modules and Harmonic motion
  - Ealstic force (Hook's law)
- Equation of simple harmonic motion
  - Pendulum & Angular harmonic motion
  - Phsical pendulum
  - Gravitimeter & Seismograph
  - Hydrostatistics and hydrodynamics
  - Pressure & Vacuum pump
  - Forces against a dam
  - Equation of continuity
  - Bernoullie's equation and its application
- Viscosity and surface tension
  - Viscosity, Poiseville's & Stoke's law
  - Reynold's number & Surface tension
  - Pressure difference across a surface film
  - Minimal surfaces & Constant angle
  - Capillarity
- Waves
  - Mathematical representation of travelling waves
  - Speed of transverse and longitudinal waves
  - Water wavesan d Standing waves on a string
  - Resonance
  - Interference of longitudinal waves
  - Sound waves (compressional waves)
  - Intensity level, Pitch, Application of sound waves and Beats, Dopler's effect
- Optics
  - Nature and propagation of light
  - Reflection, refraction and dispersion of light
  - Total internal reflection
  - Refration by a prism
  - Interference, diffraction and polarization
  - Lenses and optical instruments

Practicals **Marks = 25**

- Measurnments, Vernier Caliper, Spherometer Micrometer
- Viscosity of Liquid & Surface Tension of Liquid
- Diffraction by Grating, Wave length of laser by diffraction Grating
- Resonance of Sound, Effect of sound in liquid and solid, Wave of light by photocells
- Microscope and Telescope

Books Recommended:

- Fread Man (University Physics)
- University Physics (Zeemarsky)
- University, 11th edition Physics Modern Physics by Hugh D. Young, Roger A. Freedman - July 25, 2003

- Sears and Zemansky's University Physics: Mechanics, Thermodynamics, Waves Acoustics Chapters 1-21, Student Solutions Manual by Hugh D. Young, Roger A. Freedman
  Avg. Customer Rating: 2001.

B. S. Part-I Geology

Geol. 114: Chemistry

Total Marks=100

Learning Objectives:

To acquire knowledge of the following topics:

a. Basic inorganic chemistry
b. Basic organic chemistry
c. Basic physical chemistry

Learning Outcomes:

Upon completion of this course students will have learnt about the basic of the chemistry and will help them in understanding the geochemistry, the chemistry of the earth crust and hydrocarbons.

Course contents: **Theory Marks=75**

Section- A ------Inorganic chemistry

- Classification of elements and their Chemistry
- Natural abundance of the elements
- Chemistry of the Earth metals & minerals
- Lithosphere: Organic & Inorganic
- Silicates, Quartz, Micas and Asbestos
- Modified Silicates: Ceramics, glass and cements
- Metals, alloys and Ores: Copper, Iron, Aluminum etc; Bronze, Steel etc and other important Metals

Section -B --------Organic Chemistry

- Organic Compounds and classification of functional groups
- Hydrocarbons (HC): classification, Saturated and Unsaturated HC, cyclic &Aromatic HC
- Alcohol, Phenols and Ethers
- Aldehydes & Ketones
- Carboxylic acid Ester
- Amines and amides
- Fossil fuels: Coal, Petroleum and Natural gas
- Carbon cycle
- Polymers & surfactants

Section- C----- Physical chemistry

- Fundamental concepts
- Chemical bonds
- Molecular geometry & hyberdization
- Orbitals and Quantum numbers
- Concept of mole
- Properties of matter
- Thermodynamic systems, laws, Gibbs free energy, chemical equilibrium
- Gases
  Gas Laws, ideal gas equation
  Deviation from ideal behavior
  Units of measurements of gaseous concentrations
  Diffusion, osmosis & Hennarey Law
  Intermolecular forces
  Liquifictions of gases
- Liquids
  Properties of liquids: Additive, colligative and constitutive properties
  Vapour pressure
  Molar volumes
  Surface tension
  Viscosity
  Density
- Solids
  Crystallization
  Crystal structures
  Liquid crystals
  Super cooling and amorphous substances

Practicals **Marks= 25**

- Qualitative analysis of at least five samples of a mixture of two salts for two acid and two basic radicals excluding insoluble and interfering elements
- Qualitative analysis of at least three available rock samples
- Preparation of ferrous sulphate crystals
- Preparation of copper sulphate crystals

Recommended books:

- W. Hill, D.K. Kolb; Chemistry of changing times, 8th Edu.
  Prentice Hall Inc. 1998.
- R. M. Harrison & S.J, DeMora; Introductory Chemistry for Environmental Sciences, 2nd Edu, Cambridge University press 1996.
- D.W. Oxtoby, N.H. Nachtrieb and W.A. Freeman, Chemistry, Saunders college Publishing 1990.

Any of the graphic software which helps in the design and evaluation of maps and graphics; this may include Corel Draw

- Introduction to Internet
  This should cover a range of activities over the Internet like searching for material via search engines like Google, email address creation and its usage for quick communication between the students and teachers and other research and academic community

B. S. Part-I Geology
Geol. 115: Introduction to Computing
Total Marks=100

Learning Objectives:
To achieve basic knowledge of computer and its application that will help a student in understanding computer and its usage. The second objective of the course is to make a student familiar with computer for use in different areas like report writing, presentations, map designing, computations and searching for material on internet

Learning Outcomes:
Upon completion of this course students will learn about the basics of the computer and will be able to use computer for report writing, presentations, map designing, computation and Internet.

Course contents: **Theory Marks= 75**

- Introduction to Computer
  Computer structure, parts of computer, classification of computer, computer software, what is data and information, languages, hierarchy and types of languages, compilers and interpreters, software and packages etc.

- Operating System(s)
  What is OS, types of OS, DOS and Windows, Directory and folder commands, formatting, copying, deletion, creation and deletion of directories/folders etc.

- MS OFFICE
  1. MS Word: should be covered which make a student able to write reports.
  2. MS Excel: should be covered, so that a student feels easy to perform computational tasks.
  3. MS PowerPoint: should be covered so that a student may design presentations based on different assignments.

- Graphic Software

Practicals **Marks = 25**

Books Recommended:

The following are some recommended books while a student may use any book related to the topics:

- Ali, A. S. and Nudrat, A., 2000. Fundamental concepts of computer systems. The Ayes, Peshawar.
- Windows Manual
- MS Office Manual

B. S. Part-I Geology
Geol. 116: English
Total Marks=100

Theory Marks = 75

Written

- Reading comprehension
- Skimming
- Scanning
- Word formation
- Non-lexical elements of reading
- Guessing and prediction
- Speed reading techniques
- Writing Skills
- Simple description
- Writing tasks centred around the expression of the rhetorical functions of classification, definition, process, cause and effect, and comparison and contrast
- Outlining
- Summarizing
- Parphrasing
- Puntuation
- Laboratory report writing
- Grammar
- Major grammatical structures found in scientific writing: passives, relative causes, conjunctions, prepositions, tense systems of verbs, models,

conditionals, adverbs/ connectives, comparative/ superlative adjectives, etc.

Oral Exam. Marks = 25

Books Recommended

- Barron, C. and Stewart, I., 1977. Nucleus Geology. Longman, Lodon.
- Bates, M. and Dudley-Evans, T., 1982. Nucleus
General Science. Longman, London.

B. S. Part-I Geology
Geol. 117: Mathematics & Statistics
Total Marks=100

Mathematics Marks 60

- Indices and logaroithum, and their application
- The principles of algebra
- Solution of quadratic equation
- Solution of two simultaneous equations
- Both linear
- One linear one quadratic
- Both quadratic
- Basic trgnometry
- Definition
- Trignometric ratios of general angle
- Trignometric identities
- Multiple angle and half angle formula
- Sum and difference formula
- Graph of trignometric functions
- Inverse trignometric functions
- Coordinate geometry
- Coordinates
- Change of coordinates
- Graph-Log and exponential
- The straight line
- Distance between two points
- Circle
- Parabola
- Differential calculus
- Limits
- Definition and properties of limits
- Continuity
- Derivatives
- Rules for differentiation (algebric, logarithmic, exponential, and inverse functions)
- Integration
- Introduction
- Integration of algebric, trignometric, exponential functions, and their combinations
- Integration by substitution
- Integration by parts
- Differential equations
- Definition and classification of differential equations of Ist order and Ist degree
- Solution of ordinary differential equations and of second order equations with constant coefficients

Statistics Marks 40

- Descriptive statistics
- The meaning of statistics
- The role of statistics in Geology
- Limitations and characteristics of statitics
- Grouped and ungrouped data
- Frequency distribution
- Relative and cumulative frequency distribution
- Histogram
- Frequency polygon and frequency curve
- Cumulative frequency polygon and cumulative frequency curve
- Measures of central tendency:
- A.M., G.M.H., Median, Mode, Percentile measures variability, range, quartile deviation, mean deviation, standard deviation, coefficient of deviation
- Satistical sampling study
- Sample and population
- Need of samples
- Designing and conducting the sampling study
- Simple stratified and systematic sampling (theoritical approach only)

Books Recommended

- *Basic Concepts of Mathematics*, by Elias Zakon, ISBN 1-931705-00-3, published by The Trillia Group, 2001.
- New Mathematics and Applied Mathematics Books July - August 2000 HG6024.A3.W554 1995 - Wilmott, Paul. Mathematics of financial derivatives: a student introduction. Cambridge University Press, Oxford; New York S-BKS. Elementary Statistics, Ninth Edition by Mario.F 1995.
- Mathematics by S. M. Yousaf.
Statistics by Bhattey

B. S. Part-I Geology
Geological Field Work

Total marks =100

Learning Objectives: Main objective of the field work is to familiarize students with rocks exposed in different parts of the country.

Learning Outcome: Students will be able to recognise various rock types exposed in different areas. They will have the first hand knowledge of rocks and structures in the mountainous areas.

B. S. Part-II Geology
Geol. 221: Structural Geology
Total Marks=100

Learning Objectives:
To acquire the knowledge of the basics about deformational structures, and their kinematics, dynamic and descriptive analyses:

Learning Outcomes:
After completion of this course the students will be able to identify and map the deformational structures in the field and synthesis their kinematics and dynamics.

Course contents: **Theory Marks: 75**

Descriptive analysis

- Introduction - geologic mapping
- Components of a geological map
- Mapping procedures

Kinematic analysis

- Strain
- Computing changes in length of lines
- Computing changes in angle between lines
- Strain ellipse and ellipsoid
- Rotational and non-rotational strain
- Strain equations and Mohr's circle strain diagram

Dynamic analysis

- Stress
- Stress vectors, normal stresses and shear stresses
- Stress ellipse and ellipsoid
- Stress equations and Mohr's stress diagram

Folds

- Introduction
- Geometric analysis of folds
- Shape and size of folds
- Fold classification

Faults

- Introduction
- Types of Faults
- Determination of Fault displacement
- Faults in three dimensions

Joints

- Introduction
- Classification of joints and extension fractures
- Physical characteristics of joint surfaces Joint related surfaces

Cleavage, foliation and lineation

- Types of cleavage
- Foliation
- Lineation

Practicals **Marks: 25**

- Attitude of planes
- Attitude of lines
- Stereographic projections
- Graphic projections
- Interpretation of topographic maps
- Exercises on geologic maps
- Exercises on stereographic and orthographic projection

Recommended Books

- Ramsay, J. G., Huber, M. I., 1987. The techniques of modern structural geology. Volume 2: Folds and Fractures. Academic Press, London.
- Davis, G. H., Reynolds. S. J., 1996. Structural Geology of Rocks and Regions. 2nd Edition, John Wiley & Sons, Inc. USA
- Hobbs, B. E., Means, W. D., Williams, P. F., 1976. An outline of Structural Geology. John Wiley & Sons, New York.
- Marshak, G., Mitra, G., 1988, Basic Methods of Structural Geology. Prentice Hall Englewood Cliffs, New Jersey.

B. S. Part-II Geology
Geol. 222: Optical Mineralogy, Crystallography and Petrography

Total Marks=100

Learning Objectives:
The main objectives of this course is to introduce the concept of

a. Properties of Light
b. Microscopes for identification of common minerals of rocks in thin sections.
c. Crystal system of different minerals

Learning Outcomes

a. Students will be able to interpret rocks types in thin sections under microscope.
b. Rock-Classification based on their mineral composition

Course Contents: **Theory Marks=75**

Section A ---- Optical Mineralogy

- Introduction
  Mineral - definition and specification
  Mineralogy and its division
  Scope and purpose of optical mineralogy
- Light
  Nature and propagation of light
  Terminology related to light
  Properties of light
  Reflection, Refraction
  Critical angle and total internal reflection
  Dispersion, Polarization
  Polarization by reflection/refraction
  Polarization by absorption
  Polarization by double refraction
- The polarizing microscope and its accessories
  Nicol prisms in the polarizing microscope and its structure and composition
  Polarization by nicol prisms
  Interference between crossed nicols
  Interference colours and colour chart
  Compensation and compensatory plates
  Addition and Subtraction
- Optical classification of minerals
  Determinative optical properties of minerals
  Properties in plane polarized light
  Relief & Relative refractive index
  Colour, pleochroism and absorption
  Properties in crossed nicols/light
  Extinction and its types
  Determination of extinction angle
  Elongation and its types
- Interference figures
  Uniaxial interference figures
  Optic axis-centred figure
  Off-centred figure & Flash figure
  Biaxial interference figures
  Acute bisectrix-centred figure
  Optic axis-centred & Off-centred figure
  Determination of optic sign
  Uniaxial & Biaxial minerals
  Optical Indicatrices &Isotropic indicatrix
  Anisotropic indicatrices
  Uniaxial & Biaxial Indicatrices
  Optic axial angle (2V)
  Dispersion and crystallographic orientation of X, Y and Z

Section B -------Crystallography

- Definition of crystals
- Internal structure of crystals
- Properties of crystals
- The concept of symmetry of crystals
  Reflection, Rotation, Inversion
  Reflection rotation, Rotary inversion
  Elements of symmetry of crystals Planes
  Rotation and rotary inversion axes
  Centre, Crystal notation
  Crystallographic axes
  Space lattices, Axial ratios
  Parameters, Indices, Forms, Crystal habit
- Stereographic projection in crystallography
  Combination of symmetry operations
- Derivation of all possible symmetry classes
  Crystal sysytems and their classes
  Measurement of the angle of crystals
  Compound or twin crystals, Laws of twinning

Section C----- Petrography

- Common textures in igneous rocks and minerals
- Common textures in metamorphic
- Common textures in sedimentary

Practicals **Marks = 25**

- The polarizing microscope
- Determination of the optical properties of minerals
- Relief and relative refractive index
- Colour, Pleochroism and absorption
- Pattern of cleavage traces (if any)
- Interference colour, Twinning (if any)
- Types of extinction & extinction angle
- Sign of elongation (determination of slow/fast ray directions in minerals)
- Interference figures, Determination of optic sign
- Recognition of some of the common minerals with the help of their optical properties
- Determination of the plagioclase composition (anorthite content) with the help of extinction angle
- Study of planes, axes and centre of symmetry classes
- Study of forms, parameters and indices in crystal models
- Study of all possible crystal classes though models
- Measurement of angles of crystals
- Recognition of common rock textures

Books Recommended:

- Crystallography by Gale Rhodes (Paperback - January 15, 2000)
- Petrology (A study of the Igneous, Sedimentary and Metamorphic Rocks) by Loren A Raymond, June 13, 2001).
- An Introduction to Optical Mineralogy by William D. Nesse 2003.
- Berry, L. G. and Mason, B., 1959. Mineralogy. Freeman, San Francisco.
- Bloss, F. D., 1961. An Introduction to the Methods of Optical Crystallography. Holt, Rinehart and Winston, New York.
- Dana, S. E. and Ford, W. E., 1962. A Textbook of Mineralogy. John Wiley & sons, New York.
- Hurlbut, C. S., Jr., 1971. Dana's Manual of Mineralogy. John Wiley & sons, New York.
- Kerr, P. F., 1959. Optical Mineralogy.

  McGraw-Hill, New York.
- Tyrrell, G. W., 1963. The Principles of Petrology. Univ. Press, Aberdeen (UK).

B. S. Part-II Geology
Geol. 223: Invertebrate Paleontology
Total Marks=100

Learning Objectives:
The course is aimed at providing information about

a. Morphological features of major invertibrate fossils groups
b. Evolutionary trends of major fossil groups
c. Geological distribution of major fossil groups and their species through various time periods.
d. Distribution of such fossil groups in various rock types in Pakistan.

Learning Outcome:

a. To familiarize the students with important invertibrate fossil groups.
b. Identification of invertibrate fossil groups and their species.
c. Use of fossils to interpret geological time-Scale.

Course contents: Theory Marks=75

- A detailed study of the following fossils in terms of their morphological features, evolutionary trends, geological distributution, important types, and their importance and occurrences in Pakistan.
- Sponges
- Bryozoans
- Coelentrates
- Brachiopods
- Pelecypods
- Cephalopods
- Gastropods
- Trilobites
- Echinoids
- Crinoids
- Graptolites

Practicals Marks = 25

- Identification, drawing, labelling and description of fossil specimens.

Books Recommened

- Invertebrate Paleontology and evolution by E. N. K. Clarkson, et al (Paperback - November 1, 1998)
- Understanding Fossils : An Intrioduction to Invetebtate paleontology by Peter Doyle (Paperback - July 1996)
- Clarkson, E. N. K., 1979. Invertebrate Paleontology and Evolution. Allen & Unwin, London.
- Cotton, G., 1973. The Rugose Coral Genera. Elsevier, New York.
- Larwood, G. P., 1973. Living and fossil Bryozoa. Academic Press, London.
- Moore, R. C., 1959. Treatise on Invertebrate Paleontology. Univ. of Kensas Press, U. S. A.
- Moore, R. C., Lalicker C. G. and Fischer, A. G., 1952. Invertebrate Fossils. McGraw-Hill, New York.
- Raup, D., 1971. Principles of Paleontology. Freeman, San Francisco.

B. S. Part-II Geology
Geol. 224: Stratigraphy
Total Marks=100

Learning Objectives:
The main emphasis of this course is to educate students in

(a) Concepts of historic geology.
(b) Basics of Stratigraphy and its use in particular areas through geologic time.
(c) Stratigrahpic set-up of Pakistan from Protorozoic to Recent.

Learning Outcomes:
The student will be able to

(a) Workout the Stratigraphy of a particular area.
(b) Understand the rock-type and stratigraphic set-up of various sedimentary basins of Pakistan.

(c)

Course Contents: Theory Marks=75

- Definition, evolution and basic principles
- Geological Time Scale, its evolution and division
- Lithostartigraphic and biostratigraphic units
- Formations, their recognition and nature of their contacts
- Phsiographic and geological division of the Indo-Pakistan subcontinent
- Palaeont. and stratig. Characteristics of the major geological provinces of the subcontinent
- Detailed study (including the environment of deposition and economic significance) of the stratigraphic Formations in the four provinces of Pakistan and their extension into the adjoining areas of Afghanistan and Iran
- Study of the basement complex as exposed in Sargodha and Sind
- Discussion of the Cuddapa and Vidyan systems of Peninsular India and their relationship and correlation with those exposed in Pakistan
- The Precambrian stratigraphy of the Salt Range, Attock-Cherat Range and Kashmir-Hazara area
- The Cambrian and Ordovician stratigraphy and paleontology of Pakistan with special emphasis on the Salt Range
- Silurian and Devonian stratigraphy and paleontology of Pakistan
- The Silurian-Devonian Reef complex of Nowshera, Pirsabak, Akhora Khattak, Tangi and Khyber
- The Carboniferous of the Khyber Agency
- The significance of Devonian-Carboniferous boudary in the Khyber Agency
- The Permian sequence of the Khyber Agency, Kashmir and Chitral
- The Permian system of the Salt Range: the significance of the Tobra Fm. (Permian) in establishing the age of the Salt Range Fm. (Precambrain)
- The Permian rocks of the Salt Range as exposed in the Nammal gorge, Chhidru Nala, Kathwal section and Zaluch Nala
- The passage of marine Permian into marine Triassic: the contoversy of the Permo-Triassic boundary
- The three-fold division of the Triassic of the Salt Range
- The significance of (i) the Glossopteris Gangamopteris flora in the Permian and (ii) Ammonoids from the Triassic of the Salt Range
- The Jurassic stratigraphy of Pakistan and adjoining areas
- Marine transgression during the Jurassic period
- The Cretaceous stratigraphy of Pakistan
- The Tertiary stratigraphy of Pakistan and India, and the environments of deposition and economic significance of the Tertiary Fms.
- The upper Tertiary stratigraphy (Siwalik group) of Pakistan and India, and the significance of the vertebrate fauna in the Siwalik sediments
- The Fms. of the Siwalik basin, the supply of detritus

Practicals Marks = 25

- Making vertical stratigraphic coulmns on the basis of actual measurements of various stratigraphic units in a section and their identification
- Identification of rock samples collected from very well-known and typical stratigraphic units.

Books Recommened

- Kazmi and Jan 1997. Geology and Tectonics Of Pakistan. Graphic Publisher Karachi
- Kadri, 1995. Petroleum Geology of Pakistan PPL Karachi
- Krishnan, M.S., 1938. Geology of India and Burma. St. Martin Press, New York.
- Passoes, . H., 1936. A Manual of the Geology of India and Burma. Geol. Surv. India, Calcutta.
- Shah, S. M. I., 1983. Stratigraphy and Economic geology of Central Salt Range. Recr. Geol. Surv. Pak., Quetta, 52.
- Shah, S. M. I., 1977. Stratigraphy of Pakistan. Geol. Surv. Pak., Quetta, Mem. 12.
- Wadia, D. N., 1938. Geology of India. St. Martin Press, New York.

B.S Part-II Geology
Geol. 225: Environmental Geology
Total Marks=100

Learning Objectives:

The course is designed to know about

a) Environmental geology and significance
b) Geological processes
c) Environmental impacts of geological processes

Learning Outcomes:

Students attending this course will be able to

a) Understand earthquakes, their types and causes
b) Volcanoes and related hazards
c) Flooding: their causes, related hazards and mitigation
d) Coastal degradation
e) Landslides

Introduction: Introduction and significance of environmental geology, geological processes and their environmental effects, concept about natural resources and geological hazards

Geological Hazards:

- Earthquakes, types and causes of earthquakes, seismic waves, ground motion, intensity and magnitude, Richter scale, locating their focus, epicentres and depth, related hazards such as fires, tsunami, landslides or evalanches, plate margin activity and earthquakes, prediction and mitigation
- Volcanism, magma sources and types, location and types of volcanoes, hazards related to volcanoes such as lavaflows, pyroclastic materials, lahars, release of toxic gases, atmospheric turbidity and climate effects, volcanic precursors and prediction of volcanic eruptions
- Flooding in perennial rivers, its causes, frequency, magnitude, seasonality and depth. Stream hydrographs, flood frequency curves, environmental effects of river flooding (direct and indirect damages), floodplain evolution, effects of development and its consequences. Mitigation through dams and reseviors, levees, chanellization and retention ponds.
- Hill torrents and seasonal floods in ephemeral streams, causes and effect
- Landslides and avalanches; types, of mass movement, i.e. creep, falls, slump, slide and flow; scales and rates of movement; slope stability and effects of slope angle, lithology and structures, fluids, vegetation, earthquakes, human activities. Hazards related with land-sliding/ avalanching. Possible preventive measures
- Coastal degradation: nature of shorelines, long shore and rip currents and their effects on sediment transport, cliff and beach erosion, emerging and submerging coastlines, causes and effects of sea-level changes, effects of storms/ tsunami. Mitigative strategies

Practical **Marks = 25**

⇒ Geologic maps.
⇒ Fluvial processes and flood hazards.
⇒ Earthquakes and seismic risks.
⇒ Slope stability and mass movements.
⇒ Building / construction stones.
⇒ Waste management and site selection.
⇒ Geology and health hazards.

Recommended books

- Carla Montgomery, 2005. *Environmental Geology*. 7th Edition. McGraw Hill Science.
- Edward A. Keller, 2002. *Introduction to Environmental Geology.* 2nd Edition. . Prentice Hall, Upper Saddle River, New Jersey.
- De Wit, Andrew, 1998. *Environmental Geology: An Early System S*cience Approach. Hall, Upper Saddle River, New Jersey. W.H. Freeman.

B. S. Part-II Geology
Geol. 228: Pakistan & Islamic Studies
Theory Marks=100

As for the college B. A. & B.Sc. classes

B.S Geology Part- II
Geol. 227: Field Work

Total Marks=100

Learning Objectives:
To get familiar with various rock types, land forms, structural features in different type of terrains.

Learning outcomes:
The students will be able to understand the basic principals of geological surveying.

B. S. Part-III Geology
Geol. 331: Igneous and Metamorphic Petrology
Total Marks=100

Learning Objectives:

The course is design to explain

a. Genesis of magmatic rocks
b. Origin of magma
c. Rocks formation from various types of magma
d. Tectonics and Magmatic processes
e. Metamorphic grades and zones.

Learning Outcomes:

Student should be able to

a. Classify igneous rocks according to their genesis
b. Place various igneous rocks in their Tectonic position.
c. Classify metamorphic rocks according to the grade of metamorphism

Course Contents: Theory Marks=70

Section- A Igneous Petrology

- Magma Series
  - Origin, Migration and Emplacement of magmas
  - Magmatic differentiation
  - Magmatic crystallization
  - Mode of occurrence of igneous bodies
- Rock Series
  - Igneous minerals and their classifications
  - Geological setting of igneous activity
  - Characteristics of igneous rocks
  - Classification of igneous rocks
  - Igneous Rock Clans
- Ophiolites (Spilite-Keratophyre sequence)
- Basalt-Andesite-Rhyolite association
  - Flood Basalts - Tholoiitic and Alkaline basalts
  - Potash-rich basaltic rocks
- Granitic batholiths and stocks
  - Anorthosite plutons
  - Diabase dykes and sills
- Lamprophyres
- Nepheline syenite and related soda-rich rocks

Section B Metamorphic Petrology

- Metamorphism
  - Definition, Nature & Scope
  - Controlling factors
  - Types
  - Types of metamorphic rocks
  - Metamorphic grades and zones
- Textures and structures of metamorphic rocks
  - Introduction to metamorphic rock groups
- Basic facies concet.
- Metasomatism
- Metamorphic Differentiataion

Practicals Marks = 30

- Systematic study of common igneous and metamorphic rocks and their textures under the microscope.

Books Recommended

- Best, M. G., 1982. Igneous and Metamorphic Petrology. Freeman, New York.
- Carmichael, S. E., Turner, F. J. and Verhoogen, J., 1960. Igneous and Metamorphic Petrology. McGraw-Hill, New York.
- Hyndmann, D. W., 1972. Petrology of Igneous and Metamorphic Rocks. McGraw-Hill, New York.
- Mason, R., 1981. Petrology of Metamorphic Rocks. Allen & Unwin, London.
- Turner, F. J. and Verhoogen, J., 1960. Igneous and Metamorphic Petrology. McGraw-Hill, New York.

- Turner, F. J., 1981. Metamorphic Petrology: Field and Mineralogical Aspects. McGraw-Hill, New York.

B. S. Part-III Geology
Geol. 332: Sedimentology
Total Marks=100

Learning Objectives:

The course is designed to explain

a. Origin of sediments
b. Grain fabrics
c. Deposition of Clastic and Non-Clastic rocks
d. Sedimentary rocks classification

Learning outcomes:

Students attending this course will be able to

a) understand formation and internal fabric sedimentary rocks.
b) Classification of Sedimentary rocks
c) Classification & depositional system

- Introduction: Historical review, Significance, Applications
- Weathering and Sedimentary Cycle:Biological, Physical, and Chemical Weathering processes and products
- Physical properties of particles: Particle size and statistical parameters, Surface Textures, shape, roundness and sphericity, Porosity and permeability, Origin, types and morphology of pores.
- Transportation and Sedimentation:
- Aqueous Processes (traction, low and high density turbidity currents), Eolian Processes (deposition from traction carpet, from suspension), Glacial Processes (mode of transport and mechanism of deposition), Gravity flow processes (Debris flow, grain flow, Fluidized flow)
- Sedimentary Structures: Biogenic, Pre-, Syn-, and Post- depositional, Miscellaneous; Paleocurrent analysis and its significance (collection, presentation and interpretation of data)
- Depositional Systems: Overview, Classification, Sedimentary facies concept and applications, Sedimentary models (Concept and applications) Overview of Sedimentary cycles (sequences and cyclostratigraphy)

- Diagenesis: Subsurface Environments (Temp, Pressure and subsurface fluids) Fluid flow in sedimentary basins (meteoric, compactional, convective)
- Classification of Clastic sedimentary rocks: Mudrocks (sapropelites, oil shales and source rocks), clay minerals; Pyroclastic rocks; Sandstone (Classifications, Diagenesis and Porosity evolution) Conglomerates and Sedimentary Breccias (origin and classifications).
- Carbonate Rocks: Carbonate minerals, constituents, Classification, digenesis and porosity types and their evolution, Dolomite and dolomitization)
- Coal: Origin, types macerals and environments
- Sedimentary Iron ores: Oolitic and banded ironstones
- Phosphates: Origin and minerals
- Evaporites: Gross lithological characteristics, Carbonate Evaporate cycles, Halite-Potash cycles, Salt tectonics, Economic significance
- Cherts: Nomenclature, nodular and banded chert, origin
- Sedimentary Basins: Basic concepts and terminology, Basin forming mechanisms, Classification, Basin evolution and Petroleum Systems

Lab. Work:

Practical exercises based on grain size plots and interpretations, Hand sample descriptions, Petrography of selected rocks, Identification and interpretation of sedimentary structures, Graphic plots of Sedimentology data, Facies and Stratigrahpic correlations.

Recommended Books:

- Selley, R.C. 2000. Applied Sedimentology 2nd edition. Academic press, USA. 521p.
- Blatt. H. (1992) Sedimentary Petrology. W.H. Freeman and Co. 2nd Edition, 514p.
- Reading, H.G. (1985) Sedimentary Environments and Facies. 2nd Edition. Oxford Press.
- Pettijohn, F.J. (1985) Sedimentary Rocks. 4th Edition. Harper and Row.
- Walker, R.G. (1984) Facies Models. 2nd Edition. Geoscience Canada. Reprint series 1
- Allen, J.R.L (1982) Sedimentary Structures their character and physical basis. Elsevier.
- Friedman, G.M and Sander J.E. (1978) Principles of Sedimentology. John Wiley & Sons.

B. S. Part-III Geology
Geol. 333: Geotectonics
Total Marks=100

Learning Objectives:

To acquire the knowledge about different types of plate boundries, their kinametics and dynamics.

Learning Outcomes:

After completing this course the students will be able to undwrstand the characteristic rock association and structures found in different types of plate settings.

Course Contents: Theory Marks=70

- Morphology of continents and ocean basins
- Mountains, palins, plateaus, volcanoes
- Continental shelf, slope, rise and basins
- Active vs passive margins
- Midocean ridge system, trenches, transform faults
- Strtaigraphy of ocean floor
- Island arcs and related features
- Mechanism of plate movements
- Introduction to plate tectonics: nature of plates, driving mechanism
- Distribution of major and minor plates
- Plate margins (divergnet, convergent, shear)
- Stages of ocean floor development
- Rift and associated processes (aulocogens)
- Plate kinemetics
- Absolute vs relative plate motions
- Plate interaction (vector diagrams)
- Regional deformation
- Migration of boundaries, triple junctions
- Processes associated with plate tectonics
- Orogenic processes, and Metallogeny
- Melanges, olistrostromes and ophiolites
- Seimicity and volcanic activity (hot spots)

Practicals: Marks = 30

- Seismograms & Seismic waves
- Earth quake location
- P-waves traval time model
- Gravity gradient
- Density Distribution

Books Recommended

- Cox, A., 1988. Plate Tectonics: How it works? John Wiley & Sons, New York
- Keary, P. And Vine, F. J., 1990. Global Tectonics. John Wiley & Sons, New York
- Windley, B. F., 1987. Evolving Continents. John Wiley & Sons, New York

B. S. Part-III Geology
Geol. 334: Economic Geology
Total Marks=100

Learning Objectives:
To acquire the knowledge of the following topics

a. Geology and Geochemistry of Ore Deposits
b. Mineral Prospecting and Exploration.

Learning Outcomes:
Upon completion of this course the students will be able to understand the different types of ore deposits, their association in different environments and the basic principal of mineral exploration and exploitation techniques.

Course Contents: Theory Marks=70

- **Introduction.**

  Introduction to economic minerals and rocks
  Classification of ore deposits.

- **Magmatic ore deposits.**

  Ultramafic Cr, Ni-PGE deposits
  Chromite deposits
  Kimberlites
  Carbonatites
  Sn- W deposits

- **Hydrothermal and sedimentary mineral deposits.**

  Epithermal/mesothermal precious metal deposits
  Porphyry deposits
  Archean Gold deposits
  Volcanogenic and sedimentary exhalative (SEDEX) deposits
  Mississipy Valley Type (MVT) deposits
  Sandstone uranium-vandium-copper deposits
  Iron deposits of sedimentary affiliation
  Gold and diamond placer deposits

- **Metamirphic and metasomatic deposits**

  Skarn deposits

- **Metallic and non-metallic mineral deposits of Pakistan.**

  Chromite, Manganese, Copper-Lead- Zin, Uranium, Iron, Marble, Gypsum, Barite, Salt, Bauxite
  Building stone, Industrial rocks, Coal and Hydrocarbons.

- **Exploration of mineral deposits.**

  Geophysical methods: Air born survey, magnetic survey, Gravity methods, Resistivity, Radiomitstics, Ground radar, seismic method.
  Geochemical method. Concepts of geochemical dispersion, sampling and analytical techniques during soil survey and stream-sediments survey. Geochemical data analysis.

- **Economic evaluation of mineral deposits.**

  Mineral economics
  Geostatistics

Ore reserve calculation
Prospect evaluation
Mining, management and environmental problems

Recommended books

- Edwards R. & Atkinson, K., 1996. *Ore deposits Geology.* Chapaman and Hall, New York.
- Evans, AM., 1980. *An introduction to ore Geology*. Blackwell, oxford.
- Ahmad, Z., 1969. *Directory of mineral deposits of Pakistan* Geological Survey of Pakistan
- Kazmi & Abbasi, 2001. *Mettallogeney and mineral deposits of Pakistan.* Orient Petroleum Inc. Islamabad.
- Evans, AM., 3rd eds, 2003. *Ore geology and Industrial Minerals*, An introduction Blackwell Science Ltd.
- Evans, AM., 1995. *An introduction to mineral exploration.* Blackwell Science Ltd.
- Robb, L., 2005. *Introduction to ore-forming processes.* Blackwell Science Ltd.
- Moon, C.J., Whateley, M.K.G and Evans, AM., 2006. *Introduction to mineral exploration.* Blackwell publishing.
- Rose, AW. Hawks, H.E. and Webb, J.S., 1981. *Geochemistry in mineral exploration*. Academic Press Inc. Ltd.
- Ahmad, Z. & Siddiqi, R.A, 1992. *Minerals and rocks for industry*. Geological Survey of Pakistan

Practicals
Marks=30

- Identification of minerals, Ores and industrial minerals.
- Identification of minerals and Ores by XRD.
- Sampling techniques.
- Eastimation of reserves.

B. S. Part-III Geology
Geol. 335: Micropaleontology
Total Marks=100

Learning Objectives:

The focus of the course is to introduce the students to:

a. Interpretation of depositional environments with the help of micro-organisms
b. Description of major microfossil groups such as foraminifers, radiolarians, ostracodes and conodonts.

Learning Outcomes:

The students will be able to interpret Depositional system of major sedimentary Basins by studying microfossils.

Theory Marks=70

- Introduction
  - Scope of micropaleontology
  - Role of micropaleontology in the interpretation of environments of deposition and the structural history of the basin
- Applied micropaleontology
  - Detailed description of the following fossils
  - Foraminifera
  - Radiolarians
  - Ostracods
  - Conodonts

Practicals **Marks = 30**

- Detailed microscopic study and description of the listed microfossils.

Books Recommended

- An Introduction to marine micropaleontology by Bilal U. Haq, Anne Boersma , March 1, 1999)
- Cushman, J. A., 1959. Foraminifera. Harvard Univ. Press, Cambridge.
- Davies, A. M., 1971. Tertiary Faunas. Allen & Unwin, London.
- Haq, B. U. and Boersma, R., 1987. Marine Micropaleontology. Elsevier, New York.
- Hedley, R. H. and Adams, C. G., 1974. Foraminifera. Academic Press, Lodon.
- Horowitz, A. S., and Potter, P. E., 1971. Introductory Petrography of Fossils. Springer-Ver;ag, New York.
- Jenkins, 1993. Applied Micropaleontology. Kluwer Acad. Publishers, Dovdrecht.
- Jones, D. J., 1956. Introduction to Microfossils. Harper, New York.
- Kummel, B. and Raup, D., 1965. Handbook of Paleontological Techniques. Freeman, U. S. A.
- Lindstrom, M., 1964. Conodonts. Elsevier, London.
- Moore, R. C., 1959. Treatise on Invertebrate Paleontology. Univ. of Kensas Press & G. S. A., U. S. A.

B. S. Part-III Geology
Geol. 336: Descriptive Mineralogy
Total Marks=100

Learning Objectives:

The course is aimed at introducing students with the concepts of:

a. Phase Diagram
b. Binary & Ternary Systems
c. Properties & Texture of major silicate minerals
d. Common Oxide minerals and nuclear minerals

Learning Outcome:

The students after taking the course will be able to understand the internal structures and composition of major mineral groups such as silicates, oxides and radioactive minerals.

Course Contents: Theory Marks=70

Phase diagrams

- Intorduction to phase rule
- Definition of the basic terms
- PT diagram of water e.g. one component system

Binary system

- PTX diagram, isothermal and isobaric sections
- Binary systems with no solid solution
- Further examples with solid solution and having compounds within the system

Ternery system

- Way of plotting
- Simple examples showing isotherms and field boundaries
- Examples of more complicated ternary systems

Descriptive Mineralogy

- Structure classification of silicates
- Physical properties, structure, detailed chemistry and paragenesis of the various silicates and non-silicates
- Ortho and ring silicates
- Olivine group
- Garnet group
- Alumino-silicate polymorphs
- Epidote group
- Humite group
- Zircon, sphene, idocrase, mullite, topaz, chloritoid, beryl, cordierite
- Tourmaline group
- Axinite, datolite, sappharine, larnite, merwinite, eudialite, rosenbuschite, lawsonite, pumpellyite and melilite group
- Chain silicates
- Pyroxene group including details regarding the different compositional series and individual members belonging to the group
- Amphibole group including calssification and details of the different compositional series and idividual members within the group
- Sheet silicates
- Micas (inluding both di- and tri-octahedral subgroups)
- Talc, serpentine, chlorite
- Franework silicates
- Feldspars (including alkali feldspars and plagioclase series)
- Feldspathoids (including nepheline, leucite and sodalite groups)
- Non-silicates
- Brief description of common oxides including spinel group, sulphides, hydroxides, sulphates, carbonates and phosphates

Practicals Marks = 30

- Study of phase equilibrium diagrams and working on related problems
- Detrmination of the optic axis of uniaxial garins
- Orientation of the optic symmetry planes of biaxial grains
- Determination of optic axial angle by orthoscopic and conoscopic methods
- Microsopic study of the vaious minerals in thin section of igneous, sedimentary and metamorphic rocks
- Calculation of Norms and niggli values from rock analysis
- Determination of mineral formula from chemical analysis

Books Recommended

- Deer, W. A., Howie, R. A. and Zussman, J., 1966. Introduction to the Rock-forming Minerals. John Wiley & Sons, New York
- Ehlers, E. G., 1972. The Interpretation of Geological Phase Diagrams. Freeman, San Francisco.

B.S Geology Part- III
Geol. 337: Field Work

Total Marks=100

Learning Objectives:

To get familiar with varevous rock types, land forms, structural features in different type of terrains

Learning outcomes:

The students will be able to understand the basic principals of geological surveying.

B.S. Geology Part-IV
Geol. 441: Petroleum Geology & Petroleum Engineering
Total Marks=100

Learning Objectives:
To acquire the knowledge of the following topics.

a. To understand the process involved in formation, migration and accumulation of petroleum in rocks
b. To understand various techniques used for the exploration and exploitation of petroleum.

Learning Outcomes:
After completion of this course the students will be able to understand the following

a. To explore the source and reservoir rocks
b. Will be able to work as a well site Geologist.

Course Contents: Theory Marks = 70

Section- A------Petroleum Geology
Introduction

- Petroleum Geology as a field of study
- Basic vocabulary
- Basic statistics
- Historical development

The nature and origin of petroleum

- Composition of petroleum Hydro Carbon (HC)
- Origin of petroleum HC
- The conversion of organic matter to petroleum
- Source sediments
- Oil field waters
- The variety of petroleum HC

Migration and accumulation of Petroleum

- Porosity and permeability
- Reservoir rocks
- Pressure conditions in the reservoir rocks
- Migration of oil and natural gas
- Trapping mechanism of oil and gas

Petroleum exploration and exploitation

- Petroleum basins
- Petroleum and plate tectonics
- Case studies of selected oil and gas fields of Pakistan

Section- B ---- Petroleum Engineering

Introduction:
Scope and practices of petroleum engineering

- Drilling engineering
- Reservoir engineering
- Production engineering

Drilling Engineering

- The drilling testing and abandonment operations
- Drilling rigs and equipments
- Abnormal formation pressures
- Types of Drilling Fluids and Functions

Reservoir Engineering

- Scope and Practices of Reservoir Engineering
- Reservoir rock properties, Porosity, Compressibility, Permeability, Resistivity, Surface forces & fluid Saturations.

Petroleum Reservoirs

- Natural Driving Mechanisms
- Pressure Maintenance
- Enhanced oil recovery techniques

Reservoir fluid Properties

- Different Types of Well Logs
- The use of wireline log to deduce lithology, porosity and formation fluids

Production Engineering

- Surface facilities for oil and gas production operations
- Casing and cementation
- Well completions

Practicals **Marks = 30**

- Labelling of standard rotary drilling rig
- Lag time calculation
- Lithological description of samples using binocular/hand lens
- Preparation of lithological logs
- Various types of log interpretation
- Determination of porosity and permeability
- Rock strength determination
- Preparation of cross sections
- Visit to drilling well site
- Visit to an oil refinery
- Preparation of isometric projection
- Lithofacies - Regional structures
- Lithofacies - Local structures
- Regional lithofacies analysis
- Conversion of isopach data to an isometric panel diagram
- Isochore - Isopach
- Petrographic studies of well cuttings

Recommended Books

- North, F. K., 1985. Petroleum Geology. Unwin Hyman, Boston.
- I. Levorsen,. 1967. Geology of Petroleum. W. H.
- Freeman & Company, San Francisco
- David A. T. Donobue & Karl. R. Lang, 1986.
- Petroleum Technology. Boston, USA.

B.S. Geology Part-IV
Geol. 442: Geophysics
Total Marks=100

Learning Objectives:

To acquire the knowledge of the following topics.

a. Type of seismic waves and it recording instruments, Seismic refraction.
b. Transformation of refraction data into geological structure.
c. Gravity magnetic and electrical prospecting.

Learning Outcomes:

At he end of this course the students will have the basic knowledge of geophysics and will be able to work on the seismic images and interpret subsurface structures.

Course Contents: **Theory Marks = 70**

- Introduction and scope: Geophysics as tool in petroleum and mieral exploration
- Nature of seismic waves: Compressional and shear waves, wave propagation, attenuation, reflection, refraction, diffraction of elastic waves, mechanisms for generation of seismic waves for prospection, measuring seismic waves characters.
- Seismic recording instruments: Geophones, analogs and digital recordign equipment, acquisition of seismic reflection data, field procedures, nature of noise, energy sources.
- Transformation of reflection data into geologic structures. Geometry of reflection paths, corrections used, determination of seismic veolcities, presentation of seismic data, interpretation of reflection data, resolution and precision, reflecion data for mineral and oil exploration and stratigraphic investigations.
- Seismic Refraction: Refraction versus reflection, time distance relation for horizintal layers, dipping beds, across faults, a sequence with continuous change in speed, refraction records, common shooting techniques, corrections, presentation and interpretation of data.
- Gravity prospection,: Nature of gravity, its relation to oil and mineral deposits, gravitational effects over subsurface bodies having discrete shapes, instruments for measurement of gravity on land and sea, bore hole gravity meter, determination of density, reduction of gravity data, gravity anomalies and subsurface geologic structures.
- Magnetic and electrical prospection: Basic concepts, magnetic and electrical properties of rocks, their use in mineral and oil exploration, various techniques for measuring magnetic and electrical properties of rocks.

Practical **Marks = 30**

- Collection of seismic data, its interpretation, Use for oil and mineral industry.
- Collection of gravity data and its interpretation.
- Use of seismic meter, and other electrical methods for prospection.

Recommended Text

- Applied Geophysics by W. M. Telford, et al - October 26, 1990).
- An Introduction to Geophysics by John M. Reynolds January 7, 2000)
- Field Geophysics (Geological Field Guide) by John Milson. 1992.
- Dobrin, M. B., 1976. Introduction to Geophysical Prospecting. McGraw-Hill, New York.
- Granlard, G. D., 1971. Introduction to Geophysics. W. B. Saunders Company.
- Parasnis, D. S., 1972. Principles of Applied Geophysics. Chapman & Hall, London.
- Runcorn, S. K., 1966. Methods and Techniques in Geophsics. Interscience Publications.

Depositional Processes
Classification of Deep marine Clastic Systems
Turbidity Currents and Turbidity Deposits
Deep sea Sediments

Practicals **Marks = 30**

Books Recommended

- Emery and Myers, 1996. Sequence Stratigraphy. Publ. BP Exploration, Strockley Park, London
- Siliciclastic Sequences, Stratigraphy: Concepts and Applications. SEPM Sep. Publ. 1999.
- Siliciclastic Sequences, Stratigraphy in well-logs, cores and outcrops AAPG Sep. Publ. 1990
- Reineck and Sigh, 1973. Depositional Sedimentary Environments Springer-Verlag New York
- H.G. Reading, 1996. Sedimentary Environments: Blackwell Processes, Facies

B.S. Geology Part-IV
Geol. 443: Sequence Stratigraphy
Total Marks=100

Learning Sequence Stratigraphy

Concepts and Principals
Relative Sea Level, Tectonics and Eustacy
Sediments Supply
Sequences and Sediment Tracts
High Resolution Sequence Stratigraphy and Parasequences
Basic Concepts of Seismic Stratigraphy
Seismic Interpretation
Seismic Reflection Pattern
Recognition of System Tract on Seismic data
Outcrop and Well Data
Sequence Stratigraphy of outcrops and cores
Sequence Stratigraphy of wireline logs
Biostratigraphy
Fossil Groups and zonal Schemes
Paleoenvironment analysis
Biostratigraphy and Sequence Stratigraphy

Environment of Deposition

Fluvial Systems
Channel Pattern
Fluvial Environments and their Deposits
Fluvial Architecture
Alluvial Fans
Coastal and Deep marine Clastic Systems
Deltas
Structure of Delta
Subenvironments of Deltas
Development of lateral and vertical Sequences
Beach and Shelf Systems
Geomorphology of beach sands
Morphology of shore-line
Vertical Sequences of coastal sands
Shelf Sediments
Deep Marine Clastic Systems

B.S. Geology Part-IV
Geol. 444: Sedimentary Depositional Systems
Total Marks=100

Learning Objectives:

The objectives of the course are:

a. Sedimentary Basins and their depositional setup
b. Details of major depositional systems operating in different parts of the basins
c. Continental, Transitional and Deep marine systems.

Learning Outcomes:

The students will be able to understand

a. Basin mechanisms
b. Environment of depositionSedimentary rock deposits in various depositional settings

Course of Contents: **Theory= 70**

Introduction:

Overview of Sedimentary Process, Classifications concept of Sedimentary Facies.
Statistical Parameters.

Principles of Stratigraphy & Basin Analysis:

Concept of facies, Walthers Law, Principles of Sedimentation.

Basin Analysis Techniques:

Sediment body geometry, Provenance, Trends in texture of sedimentary particles, Paleocurrents.

Depositional Systems:

1. **Lacustrine Systems:**
General Characteristics, Types, Chemical & Physical characteristics, Sedimentary Facies.

2. **Desert Systems:**
General characteristics, Sub-environments, Sedimentary structures, Alluvial fans.
Sabkhas & Playas.

3. **Glacial System:**
Processes, Sediments, Sediments bodies, Sub-environments.

4. **Fluvial System:**
General Characteristics, Types if rivers and their facies.

5. **Delta System:**
Deltaic types & Processes, Sediment types, Morphology, Classification of deltas.

6. **Intertidal Environments:**
Sediments & Sedimentary structure, Clastic dominated, Carbonate dominated, Facies types.

7. **Estuaries & Lagoons:**
General characteristics, Estuarine sequences, Diagnostic features.

8. **Barrier Islands System:**
Morphology & depositional elements, Barrier sequences.

9. **Terrigenous shelves & shallow seas:**
Controlling factus, Shelf processes, Criteria for recognitions.

10. **Reef & Carbonate Platform Systems:**
Reef types, Biological & Physical parameters.

11. **Continental Slop & Rise System:**
Characteristics, Types: shelf slope break, Outer margin canyon – fan system.

12. **Deep Ocean System:**
Physical Processes, Sources, Classification, Diagnostic Characteristics.

13. **Turbidites:**
Processes & deposits.

Practicals: **Marks= 30**

- Lab exercises based on examples from known sedimentary systems of Pakistan.
- Fence diagrams, correlation of facies and construction of 2D models, based on given data.

Books Recommended:

- Depositional Systems by Davies R.A.
- Depositional Environments & Facies. Sedimentary Structures. 1983
- Sedimentar Environments: Processes, Facies and Stratigraphy. H.G.Reading. Blackwell
- Depositional Sedimentary Environments Reineck and Sigh. 1980

B.S Geology part-IV
Geol. 445: Structural Methods
Total Marks=100

Learning Objectives:
To get familiar with the advance level understanding of various structural elements found in the earth crust and types of illustration used in structural analysis.

Learning Outcomes:
After completion of this course the students will be able to conduct structural analysis in different types of terrains and will be able to prepare different type of surface and subsurface maps and cross sections

Course Contents: **Theory Marks: 70**

Mapping procedures

- Introduction
- Geological maps
- Descriptive analysis of geologic maps
- Structure contour maps
- Construction of contour maps
- Isopach and isochore maps

Folds

- Introduction
- Fold classification using layer thickness variation
- Dip isogons
- The Busk construction
- Fold orientation: projection techniques
- Fold sections and profiles
- Fold mechanisms – single and multi layers

Faults

- Normal faults
- Strike-slip faults
- Thrust faults
- Terminology of folds and thrust belts
- Construction of balanced cross sections
- Drawing a deformed-state cross-sections
- Restoring a cross-section

- Evaluating and improving a section
- Regional shortening calculations
- Applications of balanced cross sections

Joints and deformation bands

- Introduction
- Geometric classification of joints
- Joint analysis in uniformly dipping strata
- Joint analysis in folded strata
- Deformation band shear zones

Foliation and Lineation

- Primary and secondary foliations
- Morphology of foliations
- Continuous foliation
- Spaced foliation
- Mechanisms of foliation development
- Geological context of foliation and lineation development
- Mineral lineation

Practicals **Marks: 30**

- Exercises on interpretation on geological maps
- Exercises on construction of structure contour maps
- Exercises on construction of fold profiles by Busk and Kink methods
- Exercises on construction of balance cross-section
- Plotting planar and linear structures using stereographic projections

Recommended books:

- Ragan, D. M., 1973. Structural geology, an introduction to geometrical techniques. 2nd Edition, John Wiley & Sons, New York.
- Ramsay, J. G., Huber, M. I., 1987. The techniques of modern structural geology. Volume 2: Folds and Fractures. Academic Press, London.
- Marshak, G., and Mitra, G., 1988. Basic Methods of Structural Geology. Prentice Hall Englewood Cliffs, New Jersey.
- Price, N. J., Cosgrove, J. W., 1990. Analysis of geological structures. Cambridge University Press. Cambridge.
- Twiss, R. J., Moores, E. M., 1992. Structural Geology. Freeman and Company, New York.
- Tearpock, D., Bischke R., 2002. Applied Subsurface Geological Mapping with Structural Methods 2nd Edition.

B.S Geology Part- IV
Geol. 447: Thesis / Project Repot
Total marks =100

Learning Objectives:
The students will be assigned projects in any discipline of geology of their interest. Individual or group of students will work under the supervision a faculty member and will learn how to prepare workflow of a given project and basic procedure of report writing.

Learning Outcomes:
At the end of this exercise each student will have the skills of preparing project reports assigned to him in any geological organization.