Course structure
&
Syllabus
(Under CBCS System)

B.Sc. (HONS.) GEOLOGY
2017-20

&

M.Sc. (Applied Geology)
2017-19

DEPARTMENT OF GEOLOGY
ALIGARH MUSLIM UNIVERSITY
ALIGARH
Programme: B.Sc. (Hons) Geology  
(Six Semesters)  
Session 2017-20  
Choice Based Credit System (CBCS)

### First Semester

<table>
<thead>
<tr>
<th>Type of Course</th>
<th>C. No.</th>
<th>Course Title</th>
<th>Marks distribution</th>
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<th>Contact hours</th>
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<td>a) Disaster Management</td>
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<td>b) Geoinformatics</td>
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**L = Lecture period, T = Tutorial, P = Practical Period**

### Sixth Semester

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<td>c) Marine Geology</td>
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<td>d) Gemology</td>
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**L = Lecture period, T = Tutorial, P = Practical Period**
Syllabus of B.Sc. (Hons.)
Session 2017-20
Semester I

Core Credit – 4, Period – 56

Paper B1: Earth Systems and Mineral Science

UNIT 1:
General characteristics and origin of the Universe. Solar System and its planets - The terrestrial planets and asteroids, the Jovian planets. Asteroids and meteorites.
Earth in the solar system - origin, size, shape, composition, mass, density, rotational and revolution parameters and its age.
Formation of the layered structure of the Earth – core, mantle, crust, hydrosphere, atmosphere and biosphere
Internal structure and constitution of the Earth – Physical and chemical layering.
The geomagnetic field
Earth’s energy budget – Internal heat and incoming solar radiation. Heat transfer within the earth and its atmosphere.

UNIT 2:
Concept of sea-floor spreading and plate tectonics
Origin of oceans, continents, mountains and rift valleys
Seismicity and seismic belts
Volcanism – Types, products and distribution of volcanoes
Geotectonic units of the Earth – Shields, Cratons, Platforms, Orogenic belts, Mid Oceanic Ridges, Transform faults, Island arcs and Deep-sea trenches.
Land-air-sea interactions, Atmospheric circulation, Ocean current systems, Weather and climate changes.
Concept of time in geological studies – Standard stratigraphic time scale.

UNIT 3:
Crystal: definition and its morphological elements (crystallographic axes and axial angles).
Laws of crystallography.
Concept of lattice: planar, space
Symmetry, symmetry elements and operations
Crystallographic notations for planes: Miller indices, crystal forms and their nomenclature
Point group symmetry and derivation of 27 classes
Herman-Maugin system of symmetry
Classification of crystals into systems and description of symmetry elements of normal classes.

UNIT 4:
Mineral and Mineral Science
Physical properties:
Properties based on interaction with light (color, luster, streak, play of colors, Chyatooyancy and Asterism, Luminescence)
Mechanical Properties (cleavage, parting, fracture, hardness, tenacity)
Mass related properties (density and specific gravity)
Miscellaneous properties (magnetism, radioactivity, piezoelectricity, proelectricity)
Rock forming silicate minerals and structures
Petrological microscope: parts and function
Optical properties of minerals (color, pleochroism, , refractive index, relief, , twinkling, birefringence isotropism / anisotropism, interference colors, extinction angle, twinning)
Books Recommended:

BL1: Lab work for paper B1

Reading topographic maps. Laboratory exercise on structural geology problems: Completion of outcrops, drawing and interpretation of cross-sections through elementary representative geological structures. Study of symmetry elements of at least one representative crystal from normal classes of seven crystal systems. Study of physical properties of minerals in hand specimen.
Paper B2: Elements of Petrology

UNIT 1
Introduction to common rock forming, ore forming and industrial minerals.
Radioactive minerals, Fuel minerals, Formation and types of mineral deposits, rock association.
Magma: Definition, physical properties and chemical composition, origin.
Crystallization of magma: Bowen’s reaction series, magmatic differentiation and assimilation.
Forms and structures of extrusive and intrusive igneous rocks.
Igneous textures: crystallinity, grain shape, size and mutual relationship of grains.
Bases of classification and types of igneous rocks.

UNIT 2
Sediments: origin, transportation, deposition and lithification.
Fabric and texture of sedimentary rocks.
Roundness of particles and its geological significance.
Classification of sedimentary rocks: terrigenous and chemical sedimentary rocks.
Important primary sedimentary structure-bedding, ripple marks, cross bedding and mud cracks.
Different methods of stratigraphic correlation.
Principles of nomenclature and classification of lithostratigraphic, chronostratigraphic, biostratigraphic and Tectonic/genetic facies.

UNIT 3
Introduction to Metamorphic rock and their significance.
Classification of Metamorphic rocks. Basic concepts of types of metamorphism.
Concepts of isograds and zones of metamorphism.
Relationship between metamorphism and deformation.

UNIT 4
Palaeobiology: definition, branches and scope.
Preservation potential of organisms, requirements of fossilization.
Fossils, processes of fossilization and different kinds of fossils.
Elementary idea about origin of life.
Brief account of life through geological time, major steps in evolution of life.
Classification of organism up to phylum level, their main characters and geological range.
Standard Geological Time Scale: broad subdivisions and absolute ages.
Brief account of geographical distribution of Palaeozoic, Mesozoic and Cenozoic rocks of India.

Books Recommended:
1. Magma and Magmatic Rocks-Middlemost.
2. Igneous and Metamorphic petrology-Best.
7. Fundamentals of Historical Geology and Stratigraphy of India-Ravindra Kumar.
8. Principles of Geomorphology - Thornbury
BL 2: Lab work for paper B 2

(a) Study of megascopic characters of Igneous, Sedimentary and Metamorphic rocks.
(b) Study of the optical characters of important minerals using polarizing microscope.
(c) Preparation and study of stratigraphic maps.
(d) Study of morphological characters of phyla included in the theory syllabus.
Semester III

Core

Credit – 4, Period - 56

Paper B3: Palaeobiology and Stratigraphy

UNIT 1
Methods of fossil identification, description and illustration.
Application of palaentologic studies in organic evolution, biostratigraphy, palaeocology, palaeogeography and palaeoclimatology.
Microfossils: definition, significance and a brief account of important groups.
Brachiopoda: Morphology and geological distribution.
Echinoidea: Morphology and geological distribution.
Trilobite: Morphology and geological distribution.

UNIT 2
Pelecypoda: Morphology and geological distribution.
Gastropoda: Morphology and geological distribution.
Cephalopoda: Morphology and geological distribution of Nautiloidea and Ammonoidea.
Origin of vertebrates and landmarks in vertebrate evolution.
Evolutionary history of Equidae.
Palaebotany: Broad classification of plant kingdom and application of palaeobotanical studies.
Morphology, classification and geological range of important Lower and Upper Gondwana flora.

UNIT 3
Precambrian stratigraphy of India.
Crustal evolution and cratonizing history of Aravalli craton: lithostratigraphy and geochronology of TTG gneisses and granitoids. Stratigraphic history and its branches, stratigraphic correlation, stratigraphic classifications.
Cratonic regions of India: Dharwar, Baster, Singhbhum, Bundelkhand, Aravalli and Marwar.
Archean basement complexes: Surgur Group, Older Metamorphic Group (OMG), Banded Gneissic complex (BGC)
Archean schist belts of south India and their correlation: Nuggihulli, Holenarsipur and Chitradruga Schist Belt.
Mobile Belts: Singhbhum, Eastern Ghats, Satpura and Pandyan belt.

UNIT 4
Proterozoic Sedimentary Basins of India : Aravalli, Delhi, Vindhyan, Singhbhum Cuddupah, Karnool Supergroups
Phanerozoic Stratigraphy of India: Vai克拉, Haimanta, Muth Quartzite, Permo-Carboniferous and Triassic of Spiti, Jurassic of Kutch, Cretaceous of south east coast of India, Siwaliks
Gondwana Supergroup, Deccan Traps and associated Magmatism
Evolution of Himalayas.

Books Recommended:
1. Invertebrate Palaontology- Woods.
2. The Elements of Palaeontology- Black.
3. Introduction to Paleobotany-Arnold.
4. Essential of Paleobotany-Shukla and Mishra.
5. Geology of India and Burma-Krishnan.
6. Fundamentals of Historicals geology and Stratigraphy of India-Ravindra Kumar
7. Precambrian Geology of India-Naqvi and Rogers.
BL3: Lab work for paper B3

Study of morphological characters of important fossil phyla designated in theory paper. Exercises in showing the major stratigraphic and litho tectonic units in hand drawn map of India.
Semester IV

Core Credit – 4, Period - 56

Paper B4: Earth Processes and Resources

UNIT 1.
Renewable and non-renewable energy resources.
Hydroelectric power. Energy from the sun, wind, hot springs and sea waves.
Use of conventional and non-conventional sources of energy. Energy efficiency and conservation.
Distribution of mineral deposits in space and time.
Physiographic, mineralogical, stratigraphic, lithologic and structural guides to ore.

UNIT 2
Systematic classification of minerals. Physical properties and chemical composition of the following classes of minerals:
- Silicates: (a) Nesosilicates – Olivine and Garnet groups; (b) Inosilicates – Pyroxene and Amphibole groups, (c) Tectosilicates – Quartz and Feldspar groups.
- Carbonates: Calcite, Aragonite and Dolomite groups.
- Oxides: Simple and multiple oxides.
- Sulfides: Copper, Iron, Lead and Zinc sulfides.
Geological setting, mineralogical characteristics and Indian distribution of metallic mineral deposits of iron, manganese, chromium, copper, gold, aluminum, lead and zinc.

UNIT 3
Ore forming minerals: metallic and non-metallic minerals.
Processes of ore formation.
Ore deposits related to magmatic activity.
Hydrothermal and skarn deposits – Role of replacement and colloidal deposition
Ore deposits formed by sedimentation.
Weathering products and Residual deposits.
Ore deposits formed by oxidation & supergene enrichment.
Ore deposits formed by biochemical activity.
Ore deposits formed by evaporation.
Metamorphism and ore deposits.

UNIT 4
Geological setting, mineralogical characteristics and Indian distribution of non-metallic mineral deposits related to and with examples from Indian stratigraphic records:
Materials for construction (building stones and cement), ceramics, refractories and fillers, organic chemicals and synthetics, precious and decorative stones, fertilizers.

Books Recommended:
Core Credit – 2, Period - 36

BL4: Lab work for paper B4

Study of physical and optical properties of metallic and non-metallic minerals/resources. Hand specimen study of different types of coal. Preparation of maps showing distribution of important ores and other economic minerals of India. Study of metallogenetic maps.
BOE1 - Fundamentals of Geology

UNIT 1:
Introduction and scope of geology.
The solar system – Planets, asteroids and meteorites.
Origin of the Earth – its position in the solar system.
Geological time scale. Internal structure and constitution of the Earth – Physical and chemical layering.
The hydrosphere, atmosphere and biosphere.
Interacting Earth systems.
Sea-floor spreading and theory of plate tectonics. Mechanisms of plate motions, Types of plate boundaries –
Divergent, convergent and transform.

UNIT 2:
Earthquakes – their mechanism and distribution
Volcanoes – their types and distribution
Minerals and their formation. Physical and optical properties of minerals. Classification of minerals. Uses of
minerals.
Formation of igneous rocks, Origin of magmas, Intrusive and extrusive igneous rocks, Classification of igneous
rocks.

UNIT 3:
Formation of sedimentary rocks – Weathering, erosion and transportation
Classification of sedimentary rocks – Clastic, chemical and biochemical.
Primary and secondary sedimentary structures.
Landforms and their origin. Fossils and the process of fossilization.
Formation of metamorphic rocks, heat and pressure
Types of metamorphism – Contact and regional metamorphism
Foliated and non-foliated metamorphic rocks.
Metamorphic rock textures.

UNIT 4:
Introduction of folds, faults, joints, cleavage, foliation, lineation and unconformities. Isostasy; Introduction to plate
tectonics, mountain building processes.
Mineral and energy resources from the Earth
Non-renewable energy resources – Coal, petroleum & natural gas, nuclear fuel materials
Renewable energy resources – Solar, Wind, wave, Tidal, Hydroelectric, Geothermal and Biomass
Surface and groundwater resources

Books Recommended:
   University Press. 815p.
   Issues. 322p.
   150p.
Semester V  
Core  
Credit – 4, Period – 56

Paper B5: Igneous Petrology and Geodynamics

UNIT 1
Mantle petrology: Mineralogy and Chemistry.
Primary and parental magma: Physical and Chemical properties, volatile contents.
Magmatic differentiation: Fractional crystallization, magma mixing, crystal settling, liquid immiscibility, assimilation.
Major and trace elements in magmas; application of trace elements in igneous petrogenesis.
Classification of igneous rocks, bases of classification, IUGS classification.
Igneous rock associations in space and time; Mineralogy and chemical characteristics of the following Precambrian igneous rock assemblages: (a) Komatiites (b) Anorthosites and (c) Tonalite-trondhjemite-granodiorite (TTG).

UNIT 2
Basic principles of equilibrium thermodynamics;
Concept of system, phase and component; Chemical potential and phase rule.
Phase equilibria of the two and three component silicate systems:
Binary System- Albite-Anorthite, Diopside-Anorthite, Nepheline-silica, Forsterite-silica,
Diopside-Anorthite-Albite, Nepheline-Kalsilite-Silica ternary systems.
Basaltic magmatism in relation to plate tectonics. Concept of igneous rock series.
Mineralogical Characteristics and origin of the following rock types:
(i) Granite, Granodiorite, Diorite, Rhyolite (ii) Basalt, Dolerite, gabbro (iii) Syenites, nepheline-syenite, trachyte (iv) Preidotites

UNIT 3
Internal structure, mineralogical constitution and chemical composition of various layers /spheres of the earth.
Geochemical evolution of the earth. Mantle geochemical components.
Geophysical conditions of the earth: gravity, magnetism, heat flow.
Concept and theories of isostacy.
Plate tectonic theory: the mechanism of the plate tectonics, orogenic and epeirogenic phases.
Nature and types of plate margins. Sedimentation and metamorphism at plate margins.
Geometry and driving mechanism of plate motion.

UNIT 4
Plate tectonics with time, Evolution of continents and oceans.
Magnetic anomaly patterns in the ocean basins and sea-floor spreading.
Origin, Significance and distribution of divergent margins, mid oceanic ridges.
Origin, Significance and distribution of subduction zones, Islands arcs and trenches.
Tectonics of continental rifts, continental margins, shelves, marginal basins and intracratonic basins.
Relationships of magmatism, metamorphism and metallogeny and orogeny.
Neotectonics: Active fault system.
Indicators of recent techtonic activity.

Books Recommended:
1. Principles of igneous and metamorphic petrology- Philpots
2. Magma and magmatic rocks- Middlemost
3. Igneous and metamorphic petrology- Best
4. Plate tectonics and crustal evolution- Condie
5. Aspects of Tectonics- Valdiya
6. Global Tectonics- Kearey and Vine
7. Igneous petrology- M.K.Bose
8. Igneous petrogenesis- M.Wilson
10. Igneous Petrology – Alexander R. Mc Birney
UNIT 1
Mechanical Principles: Definition of force, stress and strain, stages of rock deformation, stress-strain diagram. Effects of geological factors on mechanical behavior of rocks-confining pressures, temperature, time, solutions, pore pressure, anisotropy and inhomogeneity.

UNIT 2

UNIT 3

UNIT 4
Planar structures, their identification and description. Type of cleavage and schistosity and their origin, relation of cleavage and schistosity to major structures. Types of lineations, their origin and their relation to major structures. Geological criteria for determination of stratigraphic superposition, on the basis of biostratigraphy, fossil disposition, volcanogenic structures, cleavage bedding relationship and external form and internal organization of sediments.

Books Recommended:
2. Structural Geology of Rocks and Regions-Davis
UNIT 1

Particle size of detrital rocks – grade scales in Phi and mm. Significance of grain size in sedimentological investigations. Shape and sphericity of clastic particles. Zingg’s and Folk’s shape classes. Chemistry of weathering processes. Concept of sedimentary facies. Basic principles of paleoenvironment and paleoclimate analysis.

UNIT 2

Basic ideas about depositional environments and their classification. Reynold number and Froude number. Laminar and turbulent flows and flow regimes. Morphology of important primary sedimentary structures and their significance. Biogenic structures and ichnofossils and their significance.

UNIT 3


UNIT 4


Books Recommended:

Paper B8: Natural Environment and Remote Sensing

UNIT 1
Environmental Geology: Concept and interdisciplinary approach. Earth as closed system, understanding hazardous earth processes. Natural ecosystems on the earth and their interactions (atmosphere, hydrosphere, lithosphere and biosphere): Cycles in earth system: carbon energy cycle, biogeochemical cycle, rock cycle, geochemical cycle

UNIT 2

UNIT 3

UNIT 4

Books Recommended:
1. Environmental Geology-Keller
2. Groundwater Hydrogeology-Todd.
5. Remote Sensing-Principles and Interpretation-Sabins.
7. Groundwater Assessment, Development and Management – Karanth
8. Remote Sensing and image interpretation – Lillesand and Keifer
BL5: Lab work for paper B5 and B7

Hand specimen study of different types of extrusive and intrusive igneous rocks, Microscopic study of igneous textures, mineralogy and petrogenetic features of igneous rocks.

Hand specimen study of different types of clastic and chemical sedimentary rocks, Study of Primary sedimentary structures in hand specimens. Microscopic study of sedimentary textures, mineralogy and diagenetic features in sedimentary rocks.
BL6: Lab work for paper B6, B8 & BE1


Study and analysis of vulnerable regions of India. Exercises on various disasters in India. Disaster vulnerability Index and its relevance. Exercises related to river basin water availability, drought assessment and flood prone regions.
Core (Elective) BE1 Credit – 4, Period - 56

(a) Disaster Management

UNIT 1

UNIT 2

UNIT 3

UNIT 4

Books Recommended:
1. Disaster Management by Mukesh Kapoor
2. Disaster Management: Future challenges and opportunities by Jagbir Singh
3. Disaster Management: Edited by H K Gupta, Universities Press, Hyderabad
5. Disaster Education and Management – R.K. Bhandari (2014). Springer, New Delhi,
(b) Geoinformatics

UNIT 1

UNIT 2
Spatial and non-spatial data. Data representation on maps, Aerial photographs and satellite images. Concept of vector and raster GIS. Digitization of spatial data at state and national level: land records, industries, urban centres. Geo-data in census operations: collection, editing, compilation, representation, update and analysis. GIS applications in census data. GIS and e-governance.

UNIT 3

UNIT 4
Georeferencing of maps and images. Open source vs commercial software in GIS and remote sensing. Overview of ArcGIS, ENVI and ERDAS software. Basic components of GPS in data collection and compilation. Information extraction and thematic mapping. Applications in geosciences.

Books Recommended:
1. Fundamentals of GIS by Micheal Demers
2. Remote Sensing and Geographic Information System by Anji Reddy
3. Remote Sensing and Geographic Information System by A.M. Chandra
5. www.GISdevelopment.net
(a) Geological Field Techniques

UNIT 1

Introduction to field geology, Objectives of field work, Instruments used in field. Parts, functions and use of Compass-clinometer, GPS, Altimeter. Importance of field safety. Preparedness for field survey: base map, toposheets, web based satellite image display systems. Reading toposheets, interpretation of contour patterns.

UNIT 2

Observations made during field work. Recording of important field information. Establishment of relative ages: cross-cut relations, xenoliths. Recognition of faults and unconformities. Concept of dip and strike, Recording orientation of dipping planes, linear features, measuring thickness of inclined strata. Recording features of sedimentary, igneous and metamorphic rocks. Recording structural data, transferring data to base map, locating position in map by triangulation method, forward bearing, backward bearing, quadrant reading azimuth reading.

UNIT 3

Importance of Field photographs. Oriented samples. Mapping techniques: traverse mapping, contact mapping, exposure mapping. Stereographic projections, map symbols. Mapping folds, foliations, linear structures (mineral stretching, boudins, mullions, rods), faults and shear zones (displacement and geometry). Joints, veins and stylolites, Polyphase deformation. Studying map patterns and map interpretation, cross sections and report writing.

UNIT 4


Books Recommended:

(b) Geostatistics

UNIT 1


UNIT 2


UNIT 3


UNIT 4


Books Recommended:

Geological Field Survey

Field work including geological mapping of structurally complex area. The field report should be based on the mapping as well as laboratory work on the rock samples collected during the field work.
Semester VI

Credit – 2, Period - 28

Paper B9: Metamorphic Petrology

UNIT 1
Metamorphic processes and a detailed account of agents and their role in metamorphism.
Texture and structures of metamorphic rocks and their significance.
Types of metamorphism - contact, regional, cataclastic and metasomatism.
Cataclastic metamorphic and its products.

UNIT 2
Barrovian zone of regional metamorphism and principles of isograd mapping.
Rosenbusch’s zones of thermal metamorphism, contact aureole.
Contact metamorphism of carbonate rocks. Regional metamorphism of pelitic rocks.
Metamorphism in relation to plate tectonic. Paired metamorphic belts.

UNIT 3
Metasomatism: types, mass transfer and products, anatexis and granitisation.
Depth zone in metamorphic rocks.
Nucleation. Chemical equilibrium in metamorphic rocks - crystallization & recrystallization in metamorphic rocks.
Concept of metamorphic facies and facies series.
Low pressure and medium to high pressure facies (field relation and mineralogy).

UNIT 4
P-T-t diagrams and projective analysis.
Graphic representation and nomenclature of metamorphic facies.
Principle chemical classes.
Representation of mineral paragenesis of metamorphic rocks.
Classification and nomenclature of metamorphic rocks.

Books Recommended:
1. Metamorphic Petrology - Turner.
UNIT 1
Classification of coal: Peat, lignite, bituminous and anthracite coal. Petrology of coal: lithotypes and macerals.
Gondwana and Tertiary coalfields of India. Coal bed methane: prospects and challenges.
Origin, migration and accumulation of hydrocarbons. Source and reservoir rocks. Structural, stratigraphic and mixed oil traps. Hydrocarbon exploration techniques—geological and geophysical methods. Onshore and off-shore distribution of petrolierous basins in India.

UNIT 2
Application of remote sensing techniques in mineral exploration.

UNIT 3

UNIT 4
Principles of mineral economics. Bore-hole logging and deviation testing.
Strategic and critical minerals. Mineral production in India.

Books Recommended:
2. Text Book of Coal—Chandra, Singh and Singh.
UNIT 1
Urban geology: scope and dimensions, geohydrogeological constrains in urban planning. Collection of urban geo-
data (Borehole logs, geophysical record, soil and rock properties) their interpretation, storage, retrieval and
presentation. Foundation problems, Impact of urbanization on land use. Impact of urban waste disposal, liquid
waste disposal their management and control. Environmental legislation in India.

UNIT 2
Medical geology: its present and future prospective: geological factors of environmental health. Trace elements and
human health, chronic diseases and geologic environment. Trace elements associated vector and carcinogenic
diseases. Exposure of human (active/passive) to trace metal borne health hazard (occupational and dietary). Water
borne diseases-cause and remedies. Ores and rock processing industries and their impact on human health.

UNIT 3
Introduction to hydrogeology: Hydrologic cycle and its component. Rock properties affecting groundwater. Vertical
measurement. Groundwater pollution in relation to water use. Sources and causes of groundwater pollution

UNIT 4
Introductory knowledge about common analytical instrument; flame photometer, spectrophotometer, AAS, XRF,
XRD and ICP. Study of minerals as gem identification parameters important qualities, association and occurrence.
Synthetic gems and their manufacturing. Mineral processing and beneficiation: method and size reduction and
screening.

Books Recommended:
2. Environmental Sciences-Miller.
4. Techniques in Mineral Exploration-Read man.
5. Geochemical Exploration-Bjorklund.
BL7: Lab Work on B9 and B10

Identification of important foliated and non-foliated metamorphic rocks. Microscopic study of mineralogy and textures of metamorphic rocks. Laboratory exercises in graphic plots for petrochemistry and interpretation of paragenetic diagrams.

Exercises in showing the distribution of important economic minerals, coal, hydrocarbon and atomic resources in maps of India. Exercises aimed at promoting investigation, discussion, critical thinking, and balanced use of various sources of energy viz., biomass, coal, geothermal, hydropower, natural gas, petroleum, solar, wind and atomic.

BL8: Lab Work on paper B11 & BE2

B 11 and Water resource management: Drawing of hydrogeological cycle, presentation of rainfall data-arithmetic mean, isohyetal map, exercises on porosity, exercise on grain size, exercise for evaluation of permeability, preparation of depth to water table map. Preparation and interpretation of water table maps. Representation of chemical analyses data. Identification and use of water on the basis of quality. (drinking, irrigation and industrial purpose)

Geochemistry: i) Calculation of petrologic indices
   ii) Calculation of norms
   iii) Exercises on igneous rock classification

Gemmology: i) Study of gemstones in hand specimen for their physical properties
   ii) Determination of RI using Refractometer and RI liquids
   iii) Study of gemstone under spectroscope
Core (Electives) BE2 (Any two may be opted)

Credit – 4, Period - 56

Paper BE2(a) – Water Resource Management

UNIT 1
Global scenario of water resources - key challenges and needs. Water resources scenario in India. Surface water and groundwater resources. Hydrological cycle, components of hydrologic cycle, precipitation, evapotranspiration, infiltration, runoff and their measurements.

UNIT 2

UNIT 3

UNIT 4

Books Recommended:

UNIT 1

UNIT 2
Classification of trace elements: trace element groupings in periodic table, trace element behavior in magmatic system: compatible elements, incompatible elements, high field strength (HFS), large ion lithophile (LILE), elements, Raoul'ts law, Henry's Law. Partition co-efficient.

UNIT 3
Geological control on the distribution of trace elements. Element mobility, partial melting, crystal fractionation, Rare earth elements (REE), chemistry of REE, Presentation of REE data. Eu-anomaly. Interpreting REE patterns. Bivariate plots.

UNIT 4

Books Recommended:
UNIT 1:

UNIT 2:

UNIT 3:

UNIT 4:

Books Recommended:
UNIT 1
Formation of minerals, basic qualities (beauty, durability, rarity), classification of gem materials, weight and measures. Physical character of gem stones: hardness, cleavage, fracture, parting, specific gravity optical characteristics.

UNIT 2
Nature of light: electromagnetic spectrum, transparency, light reflection and refractive index and its measurement. Colour and its causes, pleochroism, dispersion, absorption spectroscopy luminescence phenomenal effects, chatoyancy, asterism, sheen, aventurescence, play of colour, change of colour etc.

UNIT 3
Description and identification of inorganic gem material: Apatite, bery (aquamarine, emerald etc.), corundum (ruby, sapphire), chrysoberyl (alexandrite), Calcite, diamond, diopside, epidote, feldspar (moonstone, labradorite etc.), garnet (almandine, pyrope, spessaritite, grossular, andradite etc.), opal, quartz (crystalline, chalcedony), spinel, kyanite, sillimanite, topaz, tourmaline, turquoise, malachite, lapis lazuli, zoisite,

UNIT 4
Description and identification of organic zircon, amber, coral, jet and pearl. Gemstone cuts: basic and simple style of cut. Fashioning of gemstone: cutting, polishing of various cabochms styles sand facilited cut.
Ability Enhancement (Discipline Centric) BAE 4  Credit – 4

Seminar/Project/Comprehensive Viva: Assessment based on in-depth knowledge of Geology
Course structure
&
Syllabus

M.Sc. (Applied Geology) Part I & II

DEPARTMENT OF GEOLOGY
ALIGARH MUSLIM UNIVERSITY
ALIGARH
# Programme: M.Sc. (Applied Geology)  
**(Four Semesters)**  
Session 2017-19

## First Semester

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**Total 24**

## Second Semester

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**Total 24**
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<td>c) Sedimentary Environments and Sedimentary Basins- II</td>
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<td>g) Impact of Geology on Environment – II</td>
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<td>Grand Total ( I\textsuperscript{1}+I\textsuperscript{2}+I\textsuperscript{3}+IV\textsuperscript{4}) Semesters</td>
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L = Lecture period, T = Tutorial, P = Practical Period
M. Sc. (Applied Geology): Part - I
Semester - I

Core

Paper M 1: Ore Geology and Mining Geology

Unit-I
Modern concepts of ore genesis.
Spatial and temporal distribution of ore deposits – A global perspective.
Comparison between Earth’s evolutionary history and evolutionary trends in ore deposits. Ore deposits and Plate Tectonics.
Mode of occurrence of ore bodies – morphology and relationship of host rocks.
Textures of ores and their genetic significance.
Ore bearing fluids, their origin and migration. Wall-rock alteration.
Structural, physico-chemical and stratigraphic controls of ore localization.
Petrological Ore associations with Indian examples wherever feasible:

Unit – II
Inversion points, exsolution textures and stable isotopes as indicators of depositional temperatures. Geochemistry of ores- major, trace elements, REE and isotopic studies
Ores of mafic-ultramafic association- diamonds in kimberlite; REE in carbonatites; Ti-V ores; chromite and PGE; Ni ores; Cu, Pb-Zn.
Ores of silicic igneous rocks with special reference to disseminated and stock work deposits, porphyry associations.

Unit –III
Ores of sedimentary affiliation-chemical and clastic sedimentation, stratiform and stratabound ore deposits (Mn, Fe, non-ferrous ores), placers and palaeoplacers.
Ores of metamorphic affiliations-metamorphism of ores, Ores related to weathering and weathered surfaces laterite, bauxite. Contemporary ore-forming systems e.g., black smokers, mineralized crusts, Mn nodules. Mineralogy, genesis and important Indian distribution of ore minerals related to: Mn, Au, Sn, W and U.

Unit – IV
Application of rock mechanics in mining.
Planning, exploration and exploratory mining of surface and underground mineral deposits involving diamond drilling, shaft sinking, drifting, cross cutting, winzing, stoping, room and pillar, top-slicing, sub-level caving and block caving.
Types of drilling methods. Mining hazards: mine inundation, fire and rock burst.

Books Recommended:
10. Mining Geology II Ed. – H.E. McKinstry, 1962. Asia Publishing House,
Paper M 2: Mineralogy, Instrumentation and Analytical Techniques

Unit-I
Indicatrix- concept and application.
Orthoscopy- pleochroism and absorption schemes, Interference colours, dispersion
Conoscopy- interference figures (uni- and biaxial)
Determinate mineralogy – Refractive index, axiality, optic sign, and optic axial angle (2V) by microscope
Description and function of microscopic aids- compensation plates and wedges, Universal stage.
Sample - Definition, field samples, sampling methods. Sample preparation for geochemical analysis.
Thin Section Studies-Etching and Staining techniques particularly for feldspars, carbonates, dolomite, paragonite and quartz
Model analysis and techniques, Polished Sections and determination of micro hardness.
Scanning and Transmission Electron Microscope (SEM & TEM) : Principle, parts, function and application. Diffraction and imaging
Electron Probe Microanayser (EPMA): Principle, parts, operation and application
Principles, instruments and geological applications of Cathodo luminescence and thermo luminescence.

Unit-II
Properties associated with bond types (ionic size, radius ratio, coordination principle, coordination number)
Polymorphism, polytypism, pseudomorphism
Atomic structure, mineral chemistry, and mode of occurrence of following mineral groups
(a) Nesosilicates-Garnet, Olivine, (b) Sorosilicates- Epidote
(c) Ionosilicates – Pyroxene, Amphibole (d) Phyllosilicates - Mica, Clay minerals
(e) Tectosilicates-Quartz, Feldspar, Feldspathoids, Zeolites, Spinel.
P.T. stability diagrams and their significance with suitable examples

Unit-III
Chemical composition, crystal structure and mode of occurrence of following groups of non-silicate minerals.
Native elements: Gold, Silver, Copper. Platinum, Iron, Sulfides- Cu, Fe, Pb, and Zn sulfides.
Sulfosalts-Ag, Cu and Pb sulfosalts , Oxides-simple and multiple oxides excluding SiO$_2$
Hydroxides- Brucite, Gibbsite, Goethite, Limonite, Psilomelane, Carbonates-Calcite, Magnesite, Rhodochrosite, Dolomite, Siderite
Mineral assemblages- Assemblages and phase rule, Assemblages and rock types
Gem and Semi-precious minerals – identification, diagnostic properties, classification, important deposits of India

Unit-IV
Powdering methods, tools, contaminations
Concepts in analytical Chemistry-Terms & definitions, Units of measurement, accuracy and precision.
X-rays: Nature, generation and spectra of X-ray, Diffraction, Bragg’s law,
X – rays and Crystal structure
X-ray Diffractometry , X-ray diffractrometer (XRD) : Principle, parts, operation
X-rays and Petrochemistry
XRF (wave length dispersive and Energy Dispersive): Principle, parts and function
Rock digestion through acid treatment, Rock digestion through fusion with alkali salts, Soil samples digestion, Water samples.
Conventional analytical methods and Instruments:
Classical, Photometric, Flame photometric and Titration (EDTA)
Rapid methods and Instruments:
Determination of ferrous iron, Determination of water & CO₂.
Optical spectrometry - Principles, Nature of light, Absorption and emission of light
Instrumentation for optical spectrometry, Monochrometers, optical filter, slits, photon detectors etc
Principles, parts, operation mechanism, advantages and limitations of the following:
Atomic Absorption Spectrometer - Single and double beam (AAS)
Inductively Coupled Plasma - Atomic Emission Spectrometer (ICP-AES)
HPLC (for water analysis)
Mass Spectrometry & Instruments: Principles and Types
Theoretical working knowledge of the following instruments:
(a) ICP-Mass, (b) Thermal Ionization-Mass, (c) Gas Source-Mass

Books Recommended:
4. Spear, F.S. 1993: Mineralogical Phase Equilibria and Pressure-Temperature-Time paths-
Mineralogical 5.Society of America Publ.
Paper M 3: Structural Geology

Unit-I
Mechanical principles and properties of rocks and their controlling factors. (confining pressure, temperature, time, pore fluid pressure etc). Concept of stress. Stress analyses of deformed objects in structural geology.

Unit-II
Concept of strain. Homogeneous and inhomogeneous strain. The fundamental strain equation. Two dimensional strain analysis. Types of strain ellipses and ellipsoids, their properties and geological significance. Strain marker in naturally deformed rocks.

Unit - III
Description of componental parts of Folds. Mechanics of folding and buckling, Flexure folds; flexure flow folds. Distribution of strains in folds.

Unit - IV

Books Recommended:
Core

Credit – 2, Period - 28

Paper M 4: Geotectonics

Unit-I

Unit-II
Sea-floor spreading, Marine magnetic anomalies, geomagnetic reversals, Magnetostratigraphy, Dating the sea-floor. Oceanic ridges: Ridge topography, structure of the upper mantle beneath ridges, Heat-flow and hydrothermal circulation, transform faults and oceanic fracture zones.

Unit-III

Unit-IV
Subduction zones: Oceanic trenches, Morphology of island arc systems, rock assemblages, Structure deciphered from earthquakes, Volcanic and plutonic activity, High pressure Metamorphism, Gravity anomalies of subduction zones.
Orogenic belts: Ocean-continent convergence, Compressional sedimentary basins, Continent-Continent collision, arc-continent collision, suture zones.

Books Recommended:
1. Plate tectonics and crustal evolution - K.C.Condie
2. Aspects of Tectonics- K.S.Valdiya
3. Global Tectonics- Kearey and Vine
Paper M 5: Hydrogeology-I

Unit-I

Hydrologic cycle and its components. Ground water origin, types, importance, occurrence, renewable and non-renewable ground water resources. Sub surface movement and vertical distribution of groundwater


Unit-II

Hydraulic properties of aquifer and aquitard and their controlling factors, transmissivity, storativity and Specific yield, Well Hydraulics, Darcy’s law and its validity, confined, unconfined steady, unsteady and radial flow. Determination of permeability in the lab and field. Ground water flow equations.

Unit-III


Unit-IV

Surface and subsurface geophysical and geological methods of ground water exploration. Hydro geomorphic and lineament mapping using various remote sensing techniques. Surface geophysical methods: resistivity, seismic, gravity and magnetic methods. Well logging for delineation of aquifers and estimation of water quality, electrical resistivity and SP, radiation logging, Gamma, Gamma Gamma, Neutron Caliper and temperature logging

Books Recommended:
5. Raghunath, N.M., 1982: Ground Water-Wiley Eastern
Core Credit – 2, Period – 36

ML 1: Lab Work: Exercise related to Ore Geology, Mining Geology, Structural Geology, Geotectonics and Survey

(a) Megasscopic study of structures and fabrics of different ores and their associations. Examination of a number of important physical and optical properties of opaque ore minerals under the polarizing reflected light microscope, and how they are displayed by different minerals. Identification of the most common ore minerals and interpretation of textural relationships in ore-forming processes using polarized reflected light microscopy. Preparation of polished sections of ore minerals.
(b) Diagrammatic representation of open cast and underground mining. Methods of mining survey. Exercises on mine sampling and determination of tenor, cut-off grades and ore reserves.
(c) Preparation and interpretation of geological maps and sections. Structural problems concerning economic deposits. Recording and plotting of field data. Plotting and interpretation petrofabric data and resultant diagrams.
(d) Study of large scale tectonic features of the Earth.
(e) Surveying of point, line and area features using a handheld GPS receiver. Repeated measurements of point locations for assessment of accuracy. Transfer of GPS data to ArcGIS of any other appropriate GIS application software. Georeferencing maps and satellite images. Transference of GPS data onto maps and satellite images. Use of GPS-based coordinates to find pre-determined locations.

Core Credit – 2, Period - 36

ML 2: Lab Work: Exercise related to Mineralogy, Instrumentation and Analytical Techniques, and Hydrogeology

(a) Microscopic study of rock forming minerals using optical accessories. Exercises on thin section and polished section making, etching and staining.
(b) Exercises in sample dissolution, determination of elemental composition of minerals and rocks by flame photometer and AAS, sample preparation for powder diffraction by XRD and interpretation of X-ray diffractograms of common minerals and components of the bulk rocks.
Elective (Discipline Centric) ME 1

Credit – 4, Period - 56

(a): Coal Petrology

Unit I
Coal Petrology- Definition, Formation of coal, varieties of coal.
Coal rank - physico-chemical coalification, processes associated with rank change
Maturation concept: physico-chemical coalification – rank change
Origin and Indian distribution of coal, stratigraphy of coal measures. Methods of coal exploration

Unit II
Petrographic composition of organic matter and types, Proximate analysis, Ultimate analysis
Biochemical coalification : The maceral concept, Mceral groups and sub-groups, Vitrinite group and sub-groups,
Inertinite macerals, Liptinite macerals, Telovitrinite
Detrovitrinite subgroup, Gelovitrinite subgroup, Liptinite group, Sporinite
Chemical affinities of the Liptinite macerals: cutinite, suberinite, resinite, liptodetrinite, alginite, bituminite, exsudatinite.
The inertinite group: fusinite, semifusinite, inertodetrinite, macrinite, micrinite, funginite, secretinite, microlithotypes
Organic petrological methods: v chirine reflectance, optical properties of vitrinite and their influence on measurements, relationship of reflectance to other optical properties Techniques for measuring vitrinite reflectance:
use of various immersion media, mean maximum reflectance, Random measurements but with polar, Random reflectance carbonization: mesophase development in natural bitumen, natural coke, little limestone coal, visean, meta-exsudatinite

Unit III
Industrial application of coal- Coal carbonization, Hydrogenation, Liquification and gasification, underground coal
gasification, Coal bed Methane, coal mining methods

Unit IV
Coal hazards and mitigation measures- Environmental impact of coal mining, acid mine drainage, mine subsidence,
groundwater inundation, spontaneous combustion of coal, environmental impact of coal based power plants,
disposal of coal ash, carbon sequestration.

Books recommended
2. Petrology-Gebruder Borntraeger, Stuttgart
   Book Agency, Varanasi.
5. Stach, E., Mackowsky, M.T.H., Taylor, G.H., Chandra, D., Teichmuller, M. and
   Teichmuller, R., 1982: 7.Stach’s Text Book of Coal Petrology- Gebruder Borntraeger,
   Stuttgart
(b): Oceanography

UNIT 1:
Topography of the ocean floor. Sea-floor features – Shelf, slope, rise, basin, oceanic ridges, seamounts, trenches and island arcs.
Physical and chemical properties of sea-water and their spatial variations.
Residence time of elements in sea-water. Major water masses of the world’s oceans.
Ocean currents, waves and tides. Important current systems.
UNIT 2:
Thermohaline circulation and the oceanic conveyor belt.
UNIT 3:
Atmospheric turbulence and boundary layer. Cloud formation and precipitation processes, air-sea interactions on different space and time scales. Insolation and heat budget, radiation balance, general circulation of the atmosphere and ocean. Climatic and sea level changes on different time scales.
UNIT 4:
Coupled ocean-atmosphere system, El Nino Southern Oscillation (ENSO). General weather systems of India, - Monsoon system, cyclone and jet stream, Western disturbances and severe local convective systems, distribution of precipitation over India.
Marine and atmospheric pollution, ozone depletion.
Biological productivity in the oceans.

Books Recommended:
(c): Glaciology

Unit I
Climatic and glacier: Snowline altitude in different mountains and continents, effect of precipitation effect of latitude, effect of solar radiation, terminal altitude of glaciers, Cirque and glacier development

Unit II
Spatial snow, ice and glaciers: Physical and Chemical Properties of Ice, Global Hydrological Cycle and snow and ice component, Water Inventory and snow and ice on earth, snow covered areas covered on the Globe

Unit III
Glacial Geomorphology: ice scoured basins, roche moutonneses, meltwater valleys, cirque, arete, horn, hanging valley, glacial trough, truncated spur, glacial drift, till, outwash, glacio-lacustrine sediments, glacio-tectonic drift, moraines, eskers, kame, valley train and outwash plain

Unit IV
Climate change and glaciers: Snow cover evolution and glacier evolution, Causes of ice ages, Orbital parameters, Milutin Milankovitch cycle, role of CO₂ and other green house gases, weathering, mountain building etc., Impact of Climate change on Himalayan glaciers: The records of glacier retreat and advancement in centuries with spatial distribution

Books Recommended:
1. Field Techniques in Glaciology and Glacial Geomorphology by Bryn Hubbard and Neil F. Glasser, wiley International
6. Snow and Glacier Hydrology, 2000, P. Singh, Vijay P. Singh
Ability Enhancement (Discipline Centric) MAE 1 Credit – 2

Field Geology/Industrial/Laboratory Training-I
M. Sc. (Applied Geology): Part – I
Semester - II
Core Credit – 4, Period – 56

Paper M 6: Paleobiology and Indian Stratigraphy

Unit-I
Origin of life, Pre-Cambrian fossil record and major events in the history of life.
Organic evolution: evidence, causes, mechanism, and patterns; determining phylogenetic relationship.
Species concept in palaeontology: definition, origin, biologic and palaeontologic methods of species
determination species problem in palaeontology.
Ontogeny and growth of organisms: types of growth, isometric and anisometric growth, rates and
causes, interpretation of growth curves. Functional morphology: methods of functional morphologic
analysis with examples from the fossil record
Taphonomy: taphonomic processes, types of fossil assemblages and their application.

Unit II
Application of fossils in palaeoclimatic interpretations, climatic bioindicators, use of stable isotopes in
palaeoclimatic studies.
Major groups of microfossils with special reference to morphology and geological applications of foraminifera.
Origin and evolution of early vertebrates: fishes and amphibians, major groups, general characters and geological
distribution.
Reptiles: general characters, major groups, their geological distribution, evolution and extinction of dinosaurs.
Aves and mammals: evolution, general features and geological distribution, adaptive radiation of Cenozoic
mammals.
Evolutionary histories of Proboscideans and Homonidae.

Unit –III
Precambrian stratigraphy of India.
Crustal evolution and cratonic history of Aravalli craton: lithostratigraphy and geochronology of
TTG gneisses and granitoids. Contrasts between BGC-I and BGC-II.
Aravalli Supergroup: basement, age and lithostratigraphy.
North Delhi Fold Belt and South Delhi Fold Belt: Contrasts, age and lithostratigraphy.
Bundelkhand craton : lithology and radiometric ages of TTG gneisses, granitoids and mafic dyke
swarms.
Singhbhum craton : Older Metamorphic Group, Iron Ore group, Singhbhum Granite, Newer Dolerite,
Chhotanagpur terrain.
Bastar craton : Gneisses and granitoids, Sprarcrustal sequences, Mafic dyke swarms.
Dharwar Craton: lithological and age contrasts between Western Dharwar Craton and Eastern
Dharwar Craton, Gneisstone belts, Closepet granite.
Mobile belts : Eastern Ghat Mobile Belt, Central Indian Tectonic Zone.

Unit – IV
Basin configuration, stratigraphy and sedimentary evolution of the following basins. Vindhyan,
Chattisgarh and Cuddappah.
Paleogeographic and paleoclimatic conditions prevailing in Indian subcontinent during Paleozoic,
Mesozoic and Cenozoic eras. Igneous activity in Indian subcontinent in relation to break up of
Gondwanaland. Mountain building activities in Indian subcontinent during Cenozoic Era.
Archean-Proterozoic: Proterozoic-Cambrian
Permian- Triassic and Cretaceous-Tertiary boundary problems in Indian subcontinent.

Books Recommended:
Paper M 7: Igneous and Metamorphic Petrology

UNIT 1
Mineralogy and chemistry of earth’s mantle; Mantle components.
Physics of magma generation in the mantle, their nature. Physical properties of magma: temperature, density, viscosity, volatile components their nature,
Factors affecting magma and evolution of magma. Norms - CIPW
Criteria for classification of igneous rocks and IUGS classification.
Introduction to igneous rock series. Magmatism in relation to plate tectonics.
Mantle plumes and associated magmatism.

UNIT 2
Phase equilibrium of the following silicate systems, its relation to magma genesis and crystallization in the light of modern experimental work:
Physico-chemical interpretation of igneous textures including spinifex, rapakivi, intergrowths, reaction rims.
Petrogenesis of the following igneous rock types:
Ultramafic (Peridotite and Picrite, Komatiite), Basalts, Andesites, Granites, Syenite, Carbonatite, Anorthosite

UNIT 3
Mineralogical Phase rule of closed and open systems. Factors and processes of matamorphism, diffusion, nucleation. Fabric of metamorphic rocks, mylonite.
Metasonatism-types, principle of polarity.
Metamorphic facies, detailed description of each facies of low pressure, medium to high pressures and very high pressure with special reference to characteristic metamorphic zones and subfacies: albite-epidote hornfels, hornblende - hornfels, pyroxene hornfels, sanidinite, greenschist, amphibolite, granulite, prehenite - pumpellite, glaucohane-lawsonite (blueschist), eclogite.

UNIT 4
Metamorphic differentiation. Anatexis and origin of migmatites. Regional metamorphism and paired metamorphic belts.
Chemical zoning and its relation to tectonism.

Books Recommended:
Paper M 8: Remote Sensing in Geosciences

Unit-I
Spectral Characteristics of solar radiation.
Transmittance of the atmosphere. Spectral reflectance of land covers: soil, water and vegetation
RS Satellite characteristics-orbits and swaths. Sensors used in remote sensing.
Types of satellite remote sensing data used in earth system studies. Image interpretation and analysis. Applications of Remote Sensing techniques in geological investigations-Mapping lithology, lineaments and minerals.

Unit-II
Photogrammetry: Applications and recent advances.
Aerial photographs and their geometry. Errors in aerial photographs and their correction, swing, tilt, pitch, yaw.
Parallaxes: parallax bar, Parallax formula, height and slope determination. Scale determination of aerial photographs on uniform and variable terrain.

Unit-III

Unit-IV
Geomorphological studies: geomorphic processes and resulting landforms. Characteristics of common landforms on satellite images and aerial photographs. Digital image processing techniques: radiometric and geometric corrections. Image registration and correction, basic concept of geocoding, digital image classification and image enhancement, spatial filtering, band ratioing, FCCs, principal component analysis, IHS and NDVI images. Supervised and unsupervised classification and its utility in land-cover mapping. Application of GIS and RS in geohazards monitoring (landslides, floods, droughts, cyclones, earthquakes). Examples and case studies from India.

Books Recommended:
6. Thornbury, W.D. Principles of Geomorphology
7. Craig, R.G. and Craft, J.L Applied Geomorphology
9. Encyclopedia of Applied Geology - Finkiel
12. Geomorphology by Bloom
Paper M 9: Geophysical Exploration

Unit-I

Unit-II

Unit-III

Unit-IV
Seismic methods: Fundamental principles of wave propagation, Refraction and reflection surveys of single interface, Horizontal and dipping cases, Concept of seismic channel and multi-channel recording of seismic data, End-on and split spread shooting techniques, CDP method of data acquisition, soring, gather stacking and record section.

Books Recommended:
Paper M 10: Hydrogeology-II

Unit – I
Methods of pumping test and analysis of test data.
Interpretation of pumping test data for hydrogeologic boundaries: positive and negative boundaries

Unit-II
Water well technology, well types drilling methods, (cable tool, direct rotary, and reverse rotary), yield tests, construction and design, development and maintenance of wells. Salt water intrusion in coastal aquifers and their remedial measures.
Electrical and Mathematical modeling, data requirement and application of model; Finite difference and finite element method.

Unit-III
Chemistry of natural water. Mineral stability in Eh-pH diagram. Types of chemical reaction in water, chemical activities, carbonate equilibrium, oxidation potential, SAR, CEC, major ionic species, hydrochemical facies, major constituents, minor constituents, trace elements of natural waters.
Isotope hydrology: tritium, radio carbon dating of ground water.
REE in sea and river water.
Ground Water quality, estimation and methods of treatment for various uses.

Unit – IV
Hydrochemical provinces of India.
Problem of arsenic and fluoride, radioisotopes in hydrogeological studies.

Books Recommended:
5. Raghunath, N.M., 1982: Ground Water-Wiley Eastern
Elective (Discipline Centric) ME 2 Credit – 4, Period – 56

(a) Geodynamic Processes and Crustal Evolution

Unit-I

Unit-II

Unit-III

Unit-IV

Books Recommended:
1. Plate Tectonics and Crustal evaluation-Condie.
2. Aspects of Tectonics-Valdiya.
(b) Global Climate Change

Unit I

Unit II
Composition and structure of the atmosphere, Importance of atmosphere to human life. Change in atmospheric composition in the recent time. Burning of fossil fuel, deforestation, global land use/land cover changes. Green house gases and their effects.

Unit III

Unit IV
Sea level rise- causes, impacts and adaptation measures. UNCCC-role, summits, declarations, and protocols on climate change and its mitigation. Role of IPCC in policy making.

Suggested books:
MAE 2: Exercise related to
(a) Recognition of fossil groups in an assorted assemblage and identification of their classes. Study of important fossils from Indian stratigraphic horizons. Measurement of dimensional parameters and preparation of elementary growth-curves and scatter-plots.
(b) Exercises on stratigraphic classification and correlation. Exercises on interpretation of seismic records for stratigraphy study of palaeogeographic maps of all geological periods.
(c) Megascopic and microscopic study of igneous lithotypes. Calculation of CIPW Norms, Preparation of variation diagrams.
(d) Megascopic and microscopic study of metamorphic rocks of different facies. Time relationship between deformation and recrystallisation. Graphic construction of ACF, AKF and AFM diagrams. Estimation of pressure and temperature from important models of geothermobarometry. Interpretation of reaction textures.

MAE 3: Exercise related to
(a) Delineation of drainage pattern. Interpretation and identification of common rock types on aerial photographs. Morphometric analysis using aerial photographs based on watershed and water divide. Scene identification of IRS and Landsat data using NRSA website. Cultural details on images, land use and land cover mapping using IRS data. Mapping of geomorphological landforms on remote sensing data.

(b) Study of gravimeter, magnetometer and seismographs. Resistivity survey. Interpretation of underground structure on the basis of seismic data.
(c) Pumping test: time-drawn down and time-recovery tests and evaluation of aquifer parameters. Step drawn down tests, Electric resistivity sounding for delineation of fresh and saline aquifers. Study of geophysical well logs resistivity and SP logs. Estimation of TDS. Exercises on groundwater exploration using remote sensing techniques.
M. Sc. (Applied Geology): Part - II

Semester - III

Core Credit – 4, Period –56

Paper M 11: Fuel Geology (Coal, Petroleum and Atomic Minerals)

Unit-I
Definition, origin, rank, and types of coal.
Classification: Indian and International.
Physical and petrographic characters: concept of Lithotypes, microlithotypes, and macerals.
Chemical characterization: proximate and ultimate analyses.
Utilization of coal: preparation of coal, carbonization, gasification and hydrogenation.
Application of coal petrology in solving geological problems and in hydrocarbon exploration.
Sedimentology of coal bearing strata, coal forming epochs in geological past, coal deposits of India and their distribution
Case study of some coal fields of India, prospecting and reserves estimation, and production
Coalbed Methane: generation and exploration, coal as reservoir of methane.

Unit-II
Nature of petroleum: chemical composition and physical properties of organic matters and hydrocarbon.
Origin of petroleum: organic and inorganic theories.
Migration of oil and gas: evidence of migration, primary and secondary migration.
Transformation of organic matter into Kerogen, organic maturation, thermal cracking of kerogen.
Diagenesis, ketagenesis and metagenesis.
Formation of petroleum in relation to geological processes: temperature, time, and pressure.
Timing of oil and gas generation.
Petroleum exploration- surface indication of oil and gas, sequence of exploratory steps, wells site geology.
Role of sedimentology in oil exploration, subsurface interpretation of sedimentary environments from curves, cutting and well log.

Unit – III
Methods of subsurface geological mapping.
Reservoir rocks: sandstone reservoirs, carbonate reservoirs and fractured reservoirs.
Trapping mechanism for oil and gas, characteristic of structural, stratigraphic and combination traps.
Oil fields- water, oil and gas occurrence.
Formation evaluation: well logging, types of well logs, interpretation of lithology, quality and quantity of formation fluids from well logs.
Sedimentary basins: mechanism of sedimentary basin formation, oil bearing basins of India and the world.
Geology of productive oil fields of India, position of oil and gas in India, future prospects and the economic scenario.

Unit-IV
Physico – chemical behaviour of U and Th, classification of radioactive minerals.
Mode of occurrence and association of atomic minerals in nature, atomic minerals as source of energy.
Methods of prospecting and productive geological horizons of India.
Geology, geochemistry and origin of hydrothermal, syngenetic, pegmatitic and carbonatitic deposits of U and Th
Placer deposits of Th : origin and distribution.
Nuclear power stations of the country and future prospects.
Books Recommended:
Paper M 12: Engineering Geology

Unit-I

Unit-II
RQD, engineering classification of rock mass.
Terzaghi’s rock mass classification, coates, C-factor, Q-system and geochemical classification. Improvements of properties of rock mass: grouting, gnuting, rock bolting, cable anchorage.
Active faults, features of active faults, Earthquakes and seismicity, seismic zones of India, Paleoseismic indicators.

Unit-III
Alkali aggregate reactions, artificial aggregate.

Unit-IV
Mass movements with special emphasis on landslides and causes of hill slope instability.
Geological consideration for evaluation of dams and reservoir sites, dam foundation rock problems.
Geotechnical evaluation of tunnel alignments and transportation routes, methods of tunneling, classification of ground for tunneling purposes, various types of support. Geotechnical investigations for bridges and coastal barriers. Case history of the following engineering projects:
(a) Sardar Sarovar hydroelectric project (b) Tehri hydroelectric project

Books Recommended:
1. Sharma, P.V. (1986)-Geophysical Methods in Geology-elsevier
Paper M 13: Geochemistry and Radiogenic Isotopes

**Unit-I**
Cosmic abundances of elements, nucleosynthesis, meteorites.
Periodic Table: Atomic structure, physical and chemical properties of different element groups.
Geochemical classification of elements: major elements, trace elements, transition elements, Compatible and incompatible elements, HFSE, LILE, LFSE, PGE, REE.
Special properties of alkali elements (AE), alkaline earth (AEE), transition (TE) and rare earth elements (REE).

**Unit-II**
Behaviour of trace elements including REE in igneous, metamorphic and sedimentary rocks.
Distribution of elements during crystallization of magma.
Partition coefficient: general principle and determination in natural and experimental systems.
Trace elements modeling of partial melting, crystal fractionation.

**Unit-III**
Radioactive decay law, radiogenic isotopes.
Radioactive decay schemes of U-Th-Pb.
Geochemistry of U and Th, their decay series, growth of daughter isotopes U, Th, Pb methods of dating. U-Pb concordia, analytical methods of zircon dating, dating of individual zircons.
Decay scheme of Sm-Nd, growth of daughter isotopes, geochemistry of Sm and Nd, age determination, CHUR, epsilon and model dates.

**Unit-IV**
Geochemistry of Rb, Sr, decay scheme and growth of daughter isotopes. Dating of minerals and whole rock, isochron dates, errorchrons, initial ratio.
Principles and methodology of K-Ar dating.

**Books Recommended:**
Paper M 14: Sedimentology

Unit-I
Earth surface systems: Liberation and flux of sediments.
Fundamentals of fluids laminar and turbulent flow.
Reynolds number, Froude number, velocity profiles and bed roughness.
Flow regimes- Idealized sequence of structures in lower and upper flow regimes. Hyulstroms diagram.
Particle transport by sediment gravity flow. Boumas ideal sequence.

Unit-II
Processes of transport and generation of sedimentary structures,
Controls on the sedimentary rock records, Geometry and significance of sedimentary bodies.
Facies definition, Facies association, Walther’s law of Facies and Application.
Sedimentary cycles and cyclotherms

Unit-III
Classification of sedimentary environments.
Facies Models of alluvial-fluvial, lacustrine, desert-aeolian and glacial sedimentary systems.
Shallow coastal clastics, Marine and continental evaporates

Unit-IV
Deep sea basins.
Modern carbonate sediments- shallow water carbonates, deep sea carbonates, fresh water carbonates, evaporitic carbonates, Eolian carbonates, Mineralogy and chemical composition of carbonate minerals.
Genetic concept of classification of limestone. Petrography and genesis of carbonate rocks.
Dolomite: mineralogy, occurrence and mechanism of formation.
Limestone Facies: stromatolitic (Tidal Flat), biohermal, cross-bedded winnowed shelf, nodular limestone, chalk (Pelagic) and evaporitic carbonatic facies.

Books Recommended:
Paper M 15: Environmental Geology - I

Unit-I
Spectrum of environmental geology, global changes in the Earth system and climate Anthropogenic impacts on the atmosphere, local impacts changing the landscape, role of geology in understanding atmospheric changes

Unit-II
Thermal inversion, suspended particulate matter, heavy metals, carbon mono oxide, sulfur dioxide, nitrogen oxide, volatile organic compounds, ground level ozone, natural sources, smog and tropospheric ozone.
Impact of circulation in atmosphere and oceans on climate, rainfall and agriculture, wind system, global circulation, Coriolis effect
Thermal interactions between oceans and atmosphere, advective and convective processess, Heat budget of ocean, ocean ecosystem, ocean currents, general pattern of oceanic circulation.

Unit -III
Structure and evolution of atmosphere, recent structure, chemical evolution of atmosphere, role of volcanism, volcanism and recent atmospheric changes, Global warming in present atmosphere due to indiscrete exploitation of fossil fuel, volcanic eruptions and deforestation. Global climatic changes, causes impacts, assessment. Examples and case studies. Climate change impacts on water resources and agriculture.

Unit – IV
Nitrogen oxide and ozone layer, cycling of carbon, records of paleotemperature in ice cores of glaciers, palaeo-temperature changes during the glacial ages, glacial ages, last ice age, causes of glaciation, Limestone deposits and climate change.
Cenozoic climate extremes, evolution of life especially the impact on human evolution.

Books Recommended:
2. Keller, E.A., 1978: Environmental Geology-Bell and Howell, USA
ML 3 (Exercise related to Coal, Petroleum and Atomic Minerals, Engineering Geology, Environmental Geology and Computer Applications)
(a) Maps and exercises related to coal geology, Study of geological maps and sections of important oilfields of India, Exercises and maps related to petroleum geology, Study of geological sections of U-Th bearing rocks of the country, Megasscopic study of some uranium and thorium bearing minerals and rocks.
(b) Study of properties of common rocks with reference to their utility in engineering projects, Study of maps and models of important engineering structures as dam sites and tunnels, Interpretation of geological maps for landslide problems.
(c) Study of seismic and flood-prone areas in India. Analyses for alkalinity, acidity, pH and conductivity (electrical) in water samples. Classification of ground water for use in drinking, irrigation and industrial purposes. Presentation of chemical analyses data and plotting chemical classification diagram.
(d) Computer applications in petrology, geochemistry, hydrogeology, structural analysis and other branches of geology using different software packages

ML 4 Exercise related to Geochemistry and Radiogenic Isotopes, Sedimentology
(a) Rock/Soil/sediments/water analysis. Calculation of mineral formulae from concentration of various oxides in minerals.
(b) Study of Primary, secondary and biogenic sedimentary structures in hand specimens, in photographic atlases, field photographs and wherever possible on the outcrops. Exercises related to palaeocurrent data from different environments. Tilt corrections of palaeocurrent data.
Elective (Discipline Centric) ME 3

Credit – 4, Period - 56

a. Advance Remote Sensing in Geosciences – I

Unit-I
Types and geometry of aerial photograph, tilt and relief distortion, elements of photogrammetry, scale variation on aerial photographs, vertical exaggeration, height and slope rectification of aerial photographs. Model deformation. Concept of UAV and its applications.

Unit-II
Microwave remote sensing: EMR and spectrum. SAR, LIDAR, RADARSAT, SEASAT, MEOSAT, SIR missions. Thermal and infrared remote sensing and their applications in forest and coal mine fires, volcanic eruptions and urban heat island.

Unit –III

Unit-IV
Hyperspectral remote sensing-Imaging spectrometry, Characteristics of hyperspectral data, reflection and absorption processes, causes of absorption, spectral signatures and spectral libraries, atmospheric corrections applied to hyperspectral data, Data analysis software, Methodology, Availability of data, Application of hyperspectral remote sensing for geological mapping and exploration.

Books Recommended:

7. Encyclopedia of Applied Geology – Finkel
9. Remote sensing and Geographic Information System by A.M. Chandra
b. Exploration Geochemistry - I

**Unit-I**
Geochemical cycle. Geological controls on geochemical data, Tectonic control on magmatic & sedimentary geochemistry.
Geochemical data analysis- evolution of quality of data.
Interpretation of Chemical data.
Major and trace elements data- Rock classification, Variation diagrams
Discrimination between tectonic environments of magmatic rocks, clastic sedimentary rocks. Application of Enrichment and depletion diagrams

**Unit-II**
Distribution of elements, primary dispersion, secondary dispersion.
Geochemical exploration methods-lithogeochemical, hydrogeochemical, atmogeochemistry.
Formation of soil, soil types, soil survey, pediochemical methods, overburden geochemistry.
Drainage survey, stream sediment survey-bed sediments, flood plain geochemistry, lake sediments.

**Unit-III**
Geochemistry of petroleum- paraffins, napthenes, aromatics, heterocomponnds.
Chemical composition of crude oil, chemistry of kerogen.
Sulfur, carbon and nitrogen and their isotopes in petroleum.

**Unit-IV**
Geochemistry of coal.
Cellulose and lignocellulose, resins, fats, salts, organic, acids, paraffins, sulfur, phosphorus, silica. Sulfur carbon and nitrogen and their isotopes in coal.

**Books Recommended:**
c. Sedimentary Environment and Sedimentary Basins – I

Unit –I
Silisiclastic sediments-classification, description of major types and their analysis in relation to provenance. Volcaniclastics- formation and general characteristics, types of pyroclastics, transportation and deposition, ignimbrite, tuffs, epiclastic deposits, methods used in studying modern pyroclastic deposits.

Unit –II
Carbonate grains-skeletal and nonskeletal, mineralogy and chemical composition of carbonate minerals. Dolomite-mineralogy, control of dolomitization, occurrence and mechanism of formation.

Unit-III
Clay deposits-physical properties, mineralogy, chemistry and genesis. Evaporites-mineralogy, physico-chemical controls on precipitation and dissolution. Phosphorites- mineralogy, occurrence, origin of various types of cement.

Unit- IV
Trace fossils- occurrence, association and petrographic characteristics, use of trace fossils, stromatolites, thrombolites and related structures in paleoenvironment analysis, methods of paleocurrent determination and basin analysis. Sedimentation and plate tectonics-basic model concept, basin classification, basin models, clastic petrofacies.

Books Recommended:
d. Micropalaeontology - I

Unit-I
History of micropalaeontological research with special reference to India
Surface and subsurface collection of samples for micropaleontological analysis
Treatment of samples, separation of microfossils, picking, mounting and preparation of microfossil slide, sectioning
storage & repository of microfossils

Unit – II
Illustration of microfossils: use of Camera lucida microphotography and scanning electron microscope
Environmental significances of microfossils and their use in interpretation of paleoenvironments
Applied micropaleontology: use of microfossils in exploration of petroleum.

Unit-III
Foraminifera: living animal, life cycle and dimorphism
Test morphology of smaller foraminifera: composition, evolution of different test types, sutures, apertures and their modifications
Test ultrastructures: Lamellar characters, pores and canals
Significance of variation studies in foraminiferal taxonomy with reference to Jurassic nodosariids
Ecology and palaeoecology of foraminifera
Stratigraphic distribution of foraminifera
Use of foraminifera as indicators of marine pollution

Unit-IV
Outline of modern foraminiferal classification
Larger foraminifera: living cell and test morphology, brief classification
Major groups of larger foraminifera their morphological features and geological distribution
Ecology paleoecology and evolutionary trends larger foraminifera
Biometrics of important larger foraminifera and their significance

Books Recommended
e. Advance Ore Geology – I

Unit – I
Ore-genesis: Ore bearing fluids. Depositional environment. Control of Mineralization.
Detailed Study of Principal Mineral groups: Sulfide group of minerals. Oxide group of minerals. Carbonates group of minerals.
Textures and structures of ores:

Unit – II
Physiographic divisions of the ocean and their potential mineral deposits. Mineral deposits in the continental shelf regions-phosphorite, shell, placer and sand & gravel deposits.
Subsurface sea-bed deposits-petroleum, methane hydrate.
Heavy metal deposits on the deep-seafloor-ferromanganese nodules.
Exploitable mineral and petroleum resources of the Indian Ocean.
Ore mineral assemblages in extraterrestrial environments-meteorites and lunar rocks.

Unit –III
Paragenesis and zoning of ores and their significance.
Significance of ore mineral textures.
Textures formed due to deposition in open spaces.
Textures formed due to crystallization from melts.
Textures formed due to replacement.

Unit – IV
Ore deposits related to mafic intrusives
Ore deposits related to intermediate intrusives
Ore deposits related to felsic intrusives
Ore deposits related to submarine volcanism
Ores of vein association-Origin, kinds of veins, zoning in veins.

Books recommended:
f. Advanced Hydrogeology - I

Unit-I


Unit-II

Forces and laws of groundwater movement: Forces acting on groundwater, Water table, infiltration, soil moisture, theory of unsaturated flow water Table recharge, aquifer characteristics, homogeneity and isotropy. Principle of groundwater flow: mechanical energy, hydraulic head, force potential and hydraulic head, Darcy Law in terms of force potential.

Unit – III

Step draw down test (SDT) and its application in evaluation of well performance. Aquifer performance test (APT), determination of aquifer parameters using Theis recovery, Boultons and distance draw down methods. Hydrogeological boundaries; recharge boundary condition and barrier boundary. Determination of aquifer boundaries.

Environmental impact of ground water extraction: Lowering of water table, compaction and surface subsidence

Unit-IV

Geology of groundwater occurrence with special reference to India: crystalline rocks, volcanic rocks, lithified clastic sediments, limestone terrain including karst terrain, fluvial deposit, eolian deposit, coastal deposit and lacustrine deposits, their hydraulic characteristics, aquifer distribution and yield.

Books Recommended:

g. Impact of Geology on Environment - I

Unit-I

Unit-II
Environmental impact on mineral development, remedial measures. Impacts of mining activities on the Environment and remedial measures. Dumping of ore, fly ash and mine waste, source of hazardous waste, waste disposal, radioactive waste management

Unit - III
The nature of earth resources.
Renewable and non renewable resources, alternative sources of energy. Energy from solar radiation, geothermal energy, tapping geothermal energy, Energy from Biomass, Alternative fuel, Nuclear energy options.

Unit-IV
Impact of Human settlement, population, urbanization, global warming and climatic changes, Anthropogenic Impact of Environment, Depletion of Stratospheric ozone, ozone layer, chemistry of ozone layer, ozone hole, effects of ozone depletion.

Books Recommended:
As given for Paper-XIII
h. Petroleum Exploration - I

Unit-I
Physical-chemical properties of natural hydrocarbon
Important factors controlling petroleum occurrence
Identification and characterization of petroleum source rocks
Formation of petroleum in relation to geological processes-temperature, time and pressure
Timing of oil and gas generation
Amount and type and maturation of organic matter

Unit-II
Oil and source rock correlation- correlation parameters, oil-oil correlation, oil and source rock correlation
Locating petroleum prospects based on principles of petroleum generation and migration-Geological modeling

Unit – III
Quantitative evaluation of oil and gas prospects through geochemical studies
Reconstruction of the ancient geothermal gradient
Migration modeling
Geological setting of oil and gas reserves, age distribution of petroleum reserves

Unit-IV
Direct oil finding methods
Geological exploration methods
Elements of geophysical methods of exploration: magnetic, gravity and seismic
Interpretation of seismic data in basin analysis and preparation of subsurface geological maps
Application of Remote Sensing techniques in basin analysis

Books Recommended:
2. Tissot, B.P. and Welte, D.H., 1984: Petroleum Formation and Occurrence-Springer Verlag
i. Gemology - I

Unit-I
Historical background and scope of gems and gemstones. Formation of minerals, basic qualities and classification of gemstones, nature of light, electromagnetic spectrum) units of measurement.

Unit-II
Nature of crystals: distinction between crystalline and amorphous material, crystal symmetry, Twinning, parallel growth, crystal form, crystal habit, seven crystal system. Identification of rough stones.

Unit-III
Physical properties including optical properties
Hardness, cleavage, Fracture, parting, specific gravity, Estimation of Hell of a gem material.

Unit – IV
Optical properties: laws of reflection importance in gemology; lusture, sheen chatoyancy, asterism. Laws of refraction, Refractive Index and measurement of R.I; colour and its causes pleochroism and dichroism singly and doubly refractive gems. Absorption spectroscope, luminescence aventure scence, play of colour, change of colour etc. use of Chelsea filter, Infra-red ultraviolet and x-rays in gem identification.

Books Recommended:
j. Engineering Geology and Geotechniques - I

Unit - I
Site Investigation and exploration. Geotechnical Investigations-targets and techniques. Surface and sub-surface Investigations.
Geophysical techniques for near surface studies.
Gravity survey-acquisition and correction analysis and interpretation of gravity data, Geological applications.
Magnetic Survey-data acquisition and interpretation, engineering applications.

Unit – II
Seismic Survey-Reflection and Refraction, application in mapping fracture zones, shallow faults and cavities, depth to bed rock, dam site investigations.
Resistivity Survey-Profiling and sounding, Apparent resistivity, electrode configurations, applications in engineering geology.
Ground Probing Rader-basic principles and engineering application. Tomography in geophysical geotechnical applications.

Unit-III
Slope Stability-Stability analysis, Terzaghi’s theory, critical slope, slope control, stabilization, Reinforcement.

Unit – IV
Failure of Rock-Griffith’s theory of fracture initiation in rock mass, failure propagation of jointed rock mass.
Discontinuities-Geometry, surface features, roughness, JRC, Rock Quality Indices, RQD, fracture frequency, C-factor, mass factor, velocity ratio, strength of discontinuity.

Book Recommended:
1. Environmental and engineering geophysics-P.V. Sharma.
2. Principles of Engineering Geology and Geotechnics-D.P. Krynine and W.R.Judd
5. Rock Mechanics-W.Wittke
k. Rock Deformation and Structural Analysis - I

Unit-I

Unit-II

Unit-III
Fold shape classifications and projection techniques of fold orientations. Mechanism of single layer and multilayer folds and associated structures. Superposed folds. Pi and beta diagrams.

Unit-IV
Study of various types of fractures. Application of fracture analysis. Significance of fractures and brittle and shear zones. Determination fabrics in deformed rocks and interpretation.

Books recommended:

2. Structural Geology of Rocks and Regions-Davis.
5. A Manual of Problems in Structural Geology-Gokhle
1. Glaciology - I

**Unit I**
Climatic regimes and glacier: Snowline altitude in different mountains and continents, effect of precipitation effect of latitude, effect of solar radiation, terminal altitude of glaciers, Cirque and glacier development

**Unit II**
Spatial and temporal distribution of snow, ice and glaciers: Physical and Chemical Properties of Ice, Global Hydrological Cycle and snow and ice component, Water Inventory and snow and ice on earth, snow covered areas covered on the Globe, Northern Sea Ice, Southern Sea Ice, Permafrost, present ice volume, Ice Volumes in Distant Past, Present-Day Antarctica, Present-Day Greenland, Alaskan Ice, Ice in Western USA, Distribution of the snow and ice in Himalaya.

**Unit III**
Glacial Geomorphology: Types of ice body: niche, cirque, alpine, piedmont, floating, ice cap, ice sheet, glacier mass balance, equilibrium (frrn) line, glacier process: abrasion plucking (quarrying), sediment load: subglacial, englacial, supraglacial, landforms: ice scoured basins, roche moutonnes, meltwater valleys cirque, arete, horn, hanging valley, glacial trough, truncated spur, glacial drift, till, outwash, glacio-lacustrine sediments, glacio-tectonic drift, moraines, eskers, kame, valley train and outwash plain

**Unit IV**
Ice Ages: Causes of ice ages, Orbital parameters, Milutin Milankovitch cycle, role of CO₂ and other greenhouse gases, weathering, mountain building etc., Reconstructions of the ice volume, inferring ice volume in the past using isotopes, SPACEMAP ice volume in the past, Rate of change of ice volume, ice cores, Ice ages in Himalaya, ice cores study in Himalayan glacier.

**Readings:**

Field Techniques in Glaciology and Glacial Geomorphology by Bryn Hubbard and Neil F. Glasser, willey International
Holmes’ Principles of Physical Geology Paperback 1993, P. McL. D. Duff and Arthur Holmes
Himalayan Glaciers, 1999, Syed Iqbal Hasnain, Allied Publishers
Himalayan Glaciers, 1999, Naseeuddin Ahmad and Sarwar Rais, Allied Publishers
Snow and Glacier Hydrology, 2000, P. Singh, Vijay P. Singh
Ability Enhancement (Discipline Centric) MAE 3  

Credit – 4

Field Geology/Industrial/Laboratory Training - II
Core

M. Sc. (Applied Geology): Part – II
Semester - IV

Paper M 16: Geochemistry and Stable Isotopes

Credit 2, Period - 28

Unit-I
Geochemical characteristics of different mantle geochemical components: HIMU, EM – 1, EM- 2, PREMA and DUPAL.
Isotopes as petrogenetic indicators.
Stable isotopes: nature, abundance and fractionation.
Oxygen and hydrogen isotopes in water and water vapour, SMOW.

Unit-II
Carbon isotopes in modern biosphere and in sediments, fossil fuels, marine and non-marine carbonates.
Nitrogen-isotopic fractionation, nitrogen isotopes of igneous, meteorite and lunar rocks, nitrogen on the surface of the earth, fossil fuels.
Sulfur-biogenic fractionation, sulfur isotopes in recent sediments, petroleum and coal.

Unit-III
Laws of thermodynamics, concept of free energy, activity, fugacity and equilibrium constant, thermodynamics of ideal, non-ideal and dilute solutions. Principles of ionic, substitution in minerals, element partitioning in mineral/rock formation.
Concept of simple distribution co-efficient and exchange reaction distribution coefficients.
Elements partitioning in mineral assemblages and its use in P-T estimation.

Unit-IV
Rock weathering and soil formation.
Elementary mobility in surface environment.
Soil geochemistry, sediment geochemistry.
Concept of geochemical-biogeochemical cycling and global climate.
Identification and evaluation of geochemical anomalies.
Atmosphere composition, evolution of atmosphere and differentiation of elements through geological times.

Books Recommended:
Core

Paper M 17: Applied Sedimentation

Unit-I
Textural and mineralogical maturity of clastic rocks.

Unit-II
Evaluation of sedimentary basins: tectonics and sedimentation; craton facies, geosyncline and related facies. Sedimentary basins and plate tectonics: intraplate basins, divergent margin basins, Rifts, failed rifts, aulacogens, convergent margin basins, trench, subduction complex, fore arc, back arc, and inter arc basins.

Unit – III
Clastic petrofacies: paleoclimate and paleoenvironment analysis.
Application of trace element, rare earth element and stable isotope geochemistry to sedimentological problem. Field and laboratory techniques in sedimentology: recording of sedimentary structures, preparation of lithologs, rocks and thin section staining, cathodoluminescence.

Unit-IV
Paleocurrent and basin analysis: use of various sedimentary structures like ripple marks, cross bedding, sole marks in reconstruction of paleocurrents. Impact of paleocurrents on size shape, roundness, fabric and bed thickness. Distribution of paleocurrents in space and time and usefulness in paleogeographic reconstruction and basin analysis.

Books Recommended:
Unit-I
Pollutants and contaminants. Behaviour of contaminants in environment. Point and non-point sources. Assessment and impact of contamination for surface and ground water quality due to industrialization and urbanization. Induced pollution, water quality criteria for different uses.

Unit-II
Water logging, problems of water logging due to indiscrete construction of canals, reservoirs, dams, water logging problem in India, Floods, causes of floods, flood hazard, management of floods

Unit –III
Soil formation and their classification, soil nature, soil profile, soil types of India, soil erosion by running water, wind, soil deterioration by agricultural and engineering practices. Soil pollution and soil amendments, effects of fertilizers, pesticides and insecticides

Unit-IV

Books Recommended:
2. Keller, E.A., 1978: Environmental Geology-Bell and Howell, USA
8. Vulnerability, threats and analysis-Case Studies from India, TERI, The Energy & Resources Institute, New Delhi.
Paper M 19: Geomorphology

Unit 1

Unit 2
Fluvial geomorphic cycle. Characteristics of various Stream types. Drainage patterns and their significance. Linear, areal and relief parameters of a drainage basin. Landforms formed by rivers- terraces, alluvial fans, flood plains, natural levees, point/channel bars, ox bow lakes, paleochannels, cut off meanders etc. Identification of landforms on satellite images.

Unit 3

Unit 4
Glacial landforms- arte, cirque, moraines, hanging valleys, drumlins, etc. Landforms formed by volcanoes- cindra, plateaue, flows, taphra, crater, etc. Coastal processes and resulting landforms. Concept of Tectonic geomorphology.

Books Recommended:
Core

Credit 2, Period - 28

Paper M 20: Planetary Geology

UNIT 1:
General characteristics and origin of the Universe, Solar System and its planets. The terrestrial and Jovian planets. Earth in the solar system, Basic planetary data; Atmospheres, surface and interiors; Magnetic fields and magnetospheres; Observation and exploration of the terrestrial planets – Mercury, Venus, Earth and Mars.

UNIT 2:
Tools and techniques of planetary geology – Telescopes, spectroscopy, computer modeling. Basic planetary data; Atmospheres, surface and interiors; Magnetic fields and magnetospheres; Observation and exploration of the Jovian planets – Jupiter, Saturn, Uranus and Neptune.

UNIT 3:
Small bodies of the inner solar system: Asteroids and meteorites. Asteroid types, Orbital groupings of asteroids, Geological processes on asteroids, Zonation of asteroid belt, Evolution of asteroids, Types of meteorites.

UNIT 4:
The Kuiper Belt and dwarf planets – Basic astronomical data: Atmospheres, surfaces and interiors of Pluto, Eris and Ceres. Comets and the Oort Cloud, Structure, Composition, Orbits and exploration of Comets.

Books Recommended:
ML 5: LAB WORK  Exercise related to Geochemistry, Applied Sedimentation and Environmental Geology
   
a)  Calculation of weathering indices in soil and sediments. Presentation of analytical data.
c)  Evaluation of environmental impact of air pollution, groundwater, landslides, deforestation, cultivation and building construction in specified areas.

ML 6: LAB WORK  Exercise related to Geomorphology, Planetary Geology and Computer Applications
   
(a)  Drainage analysis of basin watershed on linear, aerial and shape aspect. Slope suitability analysis based on SOI toposheet, characterization and prioritisation of watershed on the basis of standard methods. Profiles of water valleys and their interpretation. Geomorphological mapping based on remote sensing data. Study and interpretation of various types of drainage pattern.
(b)  Exercises related to planetary geology
(c)  Computer Applications
Elective (Discipline Centric) ME 4  
Credit – 4, Period - 56

a. Advance Remote Sensing in Geosciences – II

Unit-I
Remote sensing applications in geosciences: visual interpretation of satellite images for geological, geomorphological, tectonic and structural features. Application of remote sensing in identification, delineation and characteristics of lineaments, joints, fractures, faults, folds etc. Techniques of image interpretation using spectral, spatial and temporal information. Spectral signatures of natural objects, interpretation of landuse/landcover under different climatic conditions and physical setup.

Unit-II
Watershed characterization and mapping. Application of remote sensing in drought monitoring and assessment-hydrological drought, agricultural drought and meteorological drought. CAPE and CADA missions of Indian government. Sediment yield index- role of remote sensing and GIS. Case studies and examples.

Unit-III
Digital image processing. Principles and functions of ERDAS, ENVI and ArcView. Digital image processing techniques: data formats, enhancement, filtering, preparation of false colour composite image, unsupervised and supervised classification, preparation of training sets, extraction of information, HIS, PCA and vegetation indices and their utility in image interpretation.

Unit-IV
Digital elevation models, Types of DEMs, Methods for obtaining elevation data used to create DEMs, Use of DEMs in topographic and geologic mapping, mineral exploration, morphometric analysis, Floodplain mapping and analysis, Watershed management, Erosion control, Commercial applications of DEMs, Availability of global elevation data.

Books Recommended:
7. Encyclopedia of Applied Geology – Finkie
9. Remote sensing and Geographic Information System by A.M. Chandra
b. Exploration Geochemistry - II

Unit-I
Geobotanical survey, biogeochemical survey
Radon as a geochemical exploration tool-generation, migration, radon measuring methods, applications in exploration
Fission tract plateau dating
Thermolumisence dating
Marine and Lacustrine sediments dating with $^{210}$ Pb

Unit-II
Radionuclides and their use in geochemical exploration
Cosmogenic radionuclides in ground water
Production of $^{10}$ Be $^{26}$ Al, Residence times in ocean, Dating sediments with cosmogenic radionuclides: marine sediments, Mn nodules, biogenic silica, continental sediments and soils

Unit-III
Oxygen and hydrogen isotopes in hydrosphere and atmosphere-fractionation, applications to exploration.
Carbon isotopes in modern biosphere and sediments and their use in geochemical exploration
Carbon isotopes in hydrothermal ore deposits

Unit-IV
Nitrogen isotopes-fractionations, nitrogen on the surface of the earth and applications.
Sulfur- biogenic fractionation, sulfur in recent sediments, sulfur in the environment and its implications to exploration
Sulfur isotopic evolution of marine sulphate
Sulfur isotope fractionation among sulfide minerals

Books Recommended:
c. Sedimentary Environment and Sedimentary Basins-II

**Unit –I**
Sedimentary cycles, rhythms and cyclothems. Analysis of sedimentary facies and preparation of facies maps. Lithofacies, biofacies, dynamics and primary structures associated with the environments - desert, alluvial fan, river plains, glaciers, deltas, estuaries, clastic shoreline, clastic shelves, marine evaporite basins, carbonate platforms, deep sea and ocean bottoms, deep sea trench and rise.

**Unit –II**
Sedimentation pattern and depositional environment of selected undeformed sedimentary basins of India representing Precambrian, Phenerozoic and contemporary basins.

**Unit-III**
Sequence stratigraphy-historical perspective, concepts and principles, sequence stratigraphic tools, application to depositional system.

**Unit –IV**

**Books Recommended:**
d. Micropalaeontology-II

**Unit-I**
Ostracoda: Appendage and body morphology
Detailed carapace morphology of ostracoda
Ecology and Palaeoecology of Ostracoda
Evolution and biostratigraphy of ostracoda
Outline classification of ostracods

**Unit-II**
Conodonts: Soft parts, origin, morphology of skeletal elements
Brief classification of conodonts
Mode of growth and function of skeletal apparatus
Paleoecology, evolutionary trends and biostratigraphy of conodonts

**Unit-III**
Calcareous nanofossils: morphology of coccolithophores
Outline classification of coccoliths
Ecology and biogeography of coccolithophores
Biostratigraphy of coccolithophores
Radiolarians: morphology of hard parts and outline classification
Ecology and biostratigraphy of radiolarians

**Unit-IV**
Palynology: branches and application in various disciplines
Palynofossils: morphology of spores and pollen
Use of palynofossils in paleoclimatic and paleogeographic interpretation
Biostratigraphic use of palynofossils with special reference to Indian stratigraphy
Stable isotope studies on foraminifera and their paleoecologic and paleoclimatic significance

**Books Recommended**
e. Advance Ore Geology - II

Unit- I
Detailed study of ore deposits formed as:
Mechanical accumulations: Placer deposits.
Ore deposits formed by weathering: Bauxite deposits, Laterite deposits.
Significance of stratiform and stara bound ore deposits of sedimentary affiliation and those of metamorphic affiliation.

Unit-II
Mineral economics and its concept.
Mineral legislation in India-Major and minor minerals, mineral concessions, claim system and royalty.
Production and marketing of major minerals in India-taxes and duties, imports and exports.
Some important world resources of minerals.

Unit – III
Quantitative methods in ore microscopy-Reflectance and microindentation hardness.
Methods of fluid inclusion studies and their applications.
Textures formed due to cooling.
Textures formed due to deformation and annealing.
Transformation Textures.
Applications of textural characteristics to ore dressing.
Economic Mineral Deposits related with terrestrial Impact Sturctures

Unit –IV
Geological modeling for mineral exploration. Geochemical modeling of ore deposits.

Books recommended:
   and books given in Paper I.
Unit-I

Unit – II
Trace elements: source, trace element and health hazards. Trace elements as Nutrients: Sources and impact on water quality.

Unit-III
Isotope hydrology: tritium, radiocarbon dating of groundwater, stable isotope of oxygen and hydrogen and other isotope. Fossil water and its significance. Salt water intrusion, Ghyben – Herzberg relation between fresh and saline water shape of fresh and salt water interface, control of saline water intrusion

Unit-IV
Groundwater modeling: Physical scale model, analog models; their principal characteristic application and limitations. R-C analog model Mathematical models: analytical and numerical approaches.
Numerical model: finite difference and finite element models.
Conceptualization including defining the aquifer system and its boundaries.
Discritization and data requirement.
Groundwater contamination and modeling: Principles and concepts.
Classification of groundwater contamination models.

Books Recommended:
g. Impact of Geology on Environment - II

Unit-I
Sediment pollution, siltation, contamination of sediment, sources of contamination of water, ground water contamination, pattern of marine water, urbanization and climate of cities, disposal of solid wastes.

Unit-II
Geotechnical consideration and Environmental implication of Roads and Canal construction, Dams and Reservoirs. Landslides and related phenomenon.

Unit – III
Flood and Flood Management, Causes, flood hazards in India, Management of Flood, Coastal hazards, Hazards on Indian coasts, Cyclones and their mitigation methods.

Unit-IV

Books Recommended:
As given for Paper-XXV
h. Petroleum Exploration - II

Unit-I
Rig and their components
Elements of well drilling-cable tool drilling, rotary drilling, directional drilling, dyna drilling and horizontal drilling
Various types of drilling units, Types of drill bits, drag bit, tricone bit, diamond bit and reamer

Unit – II
Formation with the help of geological systems, Standard geo logging system- Offline, Online
Drilling fluids-types and system,
Types of pressure surges in the well kick, blow out: causes and control, well completion

Unit-III
Applied Micropalaeontology-palaeoecologic, biostratigraphic, and palaeogeographic significance of microfossils
A brief account of major groups of microfossils used in petroleum exploration with special reference to Foraminifera, Ostracoda, spore & pollens, and nannoplanktons
Sampling procedure and preparation of samples in commercial micropalaeontological labs, preparation of microfaunal slides for study, identification of microfossils and preparation of range and oscillation charts
Use of microfossils in dating and correlation, determination of paleofacies and paleotectonism, palaeogeography and source rock maturation.
Significance of organic reefs as petroleum reservoir, types of modern fossils reefs and their hydrocarbon potential

Unit-IV
Reservoir characterization, reserve calculation and production methods, preliminary volumetric reserve calculation and post discovery reserve calculation, water drive gas cap device, dissolve gas device, artificial lift and enhanced recovery
Nonconventional petroleum resources-plastic and solid hydrocarbon, tar sand, oil shale, shale gas, coal bed methane
Further prospects and probabilities of petroleum prospects appraisal, geological and economic aspects, assessment of basin and global aspects
Application of logs in petrophysical and facies analysis

Books Recommended:
2. Tissot, B.P. and Welte, D.H., 1984: Petroleum Formation and Occurrence-Springer Verlag
i. Gemology - II

Unit-I
Synthetic, Composite and limitation Gemstones; methods of synthesis, stones synthesized, identification techniques, characteristics, manufactures and trade name.

Unit-II
Description and methods of identifications of all gem varieties of the following
INORGANIC : Apatite, Beryl, Chrysoberyl, Corundum, Epidote, Enstatite, Fluorite, Feldspar group

Unit – III
Diamond, Garnet group, Jadeile, lolite, Lapis Lazuli, Opal, Peridot, Sillimanite Quartz group, Spinel, Tanzanite Topaz, Tourmaline Turquoise, Zircon.
ORGANIC : Amber, Coral, Jet, Pearl (Natural cultured, imitation), Ivory;
Varieties, species, occurrence and recovery of the above gem materials.

Unit-IV
Fashioning of gem stones, Description of the following gemstones cuts including diagrams:
Brilliants (with proportion for diamond) Cabochons, mixed, rose, step (Emerald) cut, Scissors or cross cut etc.
Importance of Orientation and Valuation.

Books Recommended:
j. Engineering Geology and Geotechniques - II

Unit-I

Unit-II
Geotechnical Classification of soil.
Geotechnical issues related to foundations in problematic soils eg gravels, sands, silts, Loess, Clays, tills, fills.
Foundation structures-footings, Rafts, Piers, Piles.
Ground treatment methods.

Unit-III
Dams-Geotechnical requirements, Forces on dam, Sliding failure, Settlement and Rebound problems.
Reservoirs- geotechnical investigations, leakage, sedimentation in reservoir.
Reiver engineering-River control, Flood Regulation.

Unit-IV
Beach engineering-Erosion, Shoreline Investigations, Protective barriers.
Bridges and pavements-abutment and Piers of a bridges, bridge foundations.
Tunnels-Technical classification, Pressure Relief phenomena, Payline and overbreak, Rock and Soft ground tunnel.

Book Recommended:
1. Environmental and engineering geophysics-P.V. Sharma.
2. Principles of Engineering Geology and Geotechnics-D.P. Krynine and W.R.Judd
5. Rock Mechanics-W.Wittke
k. Rock Deformation and Structural Analysis - II

Unit-I
Stress strain relationship. Two and three dimensional strain and stress analysis and its application in deformed rocks. Brittle failure and ductile deformation.

Unit-II
Folding mechanism and fold geometry. Classification of folds based on layer shape. Buckling, oblique shear and flow folding. Kinking and formation of chevron folds.

Unit-III
Shear stress and brittle failure. Fault orientation in relations to stress and strain axes. Thrust systems. Strike slip fault systems. Shear zones.

Unit-IV

Books recommended:

2. Structural Geology of Rocks and Regions-Davis.
5. A Manual of Problems in Structural Geology-Gokhle
1. Glaciology - II

Unit I
Glacier variations and Climate: Response to Climate Changes; Mass Balance study of glaciers, Glacier Advance and Retreat, Linear-Systems Model for a Glacier, Surging glacier. Impact of Climate change on Himalayan glaciers: The records of glacier retreat and advancement in centuries with spatial distribution

Unit II
Glacial Hydrology and Hydrochemistry: Glacial hydrological system, meltwater process, mechanism of water discharge, characteristics of glacier runoff, diurnal and annual cycle, longterm variation, process of solute acquisition two component mixing model, chemical weathering process, meltwater character of Himalayan glacier

Unit III
Glaciological Techniques: Reconstructing Pleistocene climate based on landforms, glacier mass balance determination, Glacier runoff measurements, Glacier ice core studies, palynology, Lichenometry, Tree rings studies, optically stimulated luminescence (OSL) use in glacier dating, GPR (Ground Penetrating Radar) for thickness determination.

Unit IV
Application of Remote sensing and GIS and GPS in Himalayan Glaciology: Snow cover evolution, Inventory and mapping of glaciers, glacier evolution, velocity, Snow/ice differentiation, Determination of TSL and ELA on glacier surface, Mass balance and snowmelt runoff, Temporal change in glacier DEMs and climate change, LIDAR, and SAR technology and glacier study.

Readings:
Field Techniques in Glaciology and Glacial Geomorphology by Bryn Hubbard and Neil F. Glasser, willey International
Holmes’ Principles of Physical Geology Paperback 1993, P. McL. D. Duff and Arthur Holmes
Himalayan Glaciers, 1999, Syed Iqbal Hasnain, Allied Publishers
Himalayan Glaciers, 1999, Naseeuddin Ahmad and Sarwar Rais, Allied Publishers
Snow and Glacier Hydrology, 2000, P. Singh, Vijay P. Singh
Open Elective (Ability Enhancement) OE  

Credit – 4, Period- 56

(a) Global Change

Unit I

Global change: An overview; Time dimension of global change; Big bang and fundamental laws; Evolution of the solar system; Age and evolution of the Earth; Earth’s energy balance; Changing Earth-Sun relationship; Factors that make Earth a habitable planet; Major components of the Earth’s climate system; Evolution of the Earth’s atmosphere, greenhouse gases and climate; Ozone in the Atmosphere – Aspect related to the dynamics of atmospheric ozone;

Unit II

Earth’s magnetic field - Changing geomagnetic field and its environmental effects; The dynamics of Earth’s hydrosphere; Atmosphere-hydrosphere interactions; Water cycle and global energy transfer; Ocean observation in relation to global change; Sea level changes and global climate change; Sensitivity of inland surface waters to global change; Water cycle information for decision making; Monitoring terrestrial snow and ice for global change studies.

Unit III

Land-Cover and Land-Use Dynamics – Land-use and land-cover mapping, Land-use Land-cover change and climate; The biosphere – processes of evolution and natural selection; Evidence of natural selection; Biogenic processes and changing atmospheric composition; Agricultural practices and global change; Lithosphere and Plate tectonics; Terrestrial impacts and their role in global change; Global deforestation; Human impacts on global change;

Unit IV

Biomass Burning – Role of fire in global change analysis; Fire monitoring and burn area mapping; International Efforts on global Change Research; Global observing systems; NASA Earth observing agenda; Review of NASA EO Missions; Role of the European Space Agency in global change observations; International collaborative programmes; Monitoring networks and databases.

BOOKS RECOMMENDED:

(b) Earth Systems

Unit 1
Origin of earth, Formation of solar system, Cosmic abundance and nucleosynthesis, Meteorites, Interior of earth (major divisions and discontinuities), Movements of earth (Plate tectonic theory, Isostasy, Sea floor spreading), Supercontinents and Continental drift theory, Fossils: Important landmarks of evolution of life, Major extinction events and their causes

Unit 2
Physical processes inside the earth, magmatism: mechanism and causes, Earthquakes at plate margins, Stable Continental Region (SCR) Earthquakes, Mountain building activities, gravity and magnetic properties of earth, Magnetic polarity reversals, Radioisotopes and age determination, Formation of various rock types (Igneous, sedimentary and Metamorphic)

Unit 3
Economic resources of earth, mineral deposits and exploration, ore forming processes, Geophysical techniques and prospecting (Well Logging instrument and techniques), Geology of fuels (Coal and Petroleum), Hydrocarbons, Radioactive minerals

Unit 4

Books Recommended:
5. Fundamentals of Historical Geology and Stratigraphy of India-Ravindra Kumar.
7. Igneous and Metamorphic petrology-Best.
12. Radioactivity in Geology-Principles and Application-Durrance.