SYLLABUS
FOR THE SESSION
2013-2014

B.Sc. (HONS.) GEOLOGY
AND
M.Sc. (APPLIED GEOLOGY)

DEPARTMENT OF GEOLOGY
ALIGARH MUSLIM UNIVERSITY
ALIGARH
# Course Structure of B.Sc. (Hons.)

## Session 2013-2014

### FIRST YEAR

<table>
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<th>Paper/Code No.</th>
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<td>B 3</td>
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<td>B 4</td>
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<td>B 6</td>
<td>Structural Geology</td>
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<td>B 7</td>
<td>Natural Environment ( including elements of Remote sensing, Hydrogeology and Engineering Geology)</td>
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<td>B 8</td>
<td>Energy Resources and Mineral Exploration</td>
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PART-I
Syllabus of B.Sc. (Hons.)
Session 2013-2014
Paper-I Introduction to Geology-I

Unit-I
Geology and its perspective.
Earth in the solar system: origin, size, shape, mass, density, rotational and revolution parameters.
Formation of core, mantle, crust, hydrosphere, atmosphere and biosphere and elemental abundance in each constituent.
Convection in the earth’s core and production of its magnetic field.
Radioactivity and age of the Earth.
Elementary ideas of various geotectonic units namely shield, craton, platform, orogenic belt, mid-oceanic ridge, ocean island arc, deep sea trenches and their examples.
Elementary ideas about seafloor spreading, plate tectonics, and continental drift.

Unit-II
Wilson cycle and origin of mountains.
Earthquake: seismic waves, measurement and causes of earthquakes, and earthquake belts.
Volcanoes: type and distribution.
Generation of oceanic currents, surface currents and global ocean conveyor system.
Wave erosion and beach processes. Coastal landforms.
Ocean as a thermostat for the earth’s surface heat balance.
Atmospheric circulation.

Unit-III
Earth’s heat budget weather and global climatic changes.
Rock weathering: type, controlling factors and products of weathering.
Soil formation, soil profile and soil types.
Important erosional and depositional landforms produced by running water: waterfalls, rapids, meanders, oxbow lakes, floodplains, levees, alluvial fans, stream terraces and deltas. Youth, mature and old stages of river systems. Stream patterns.
Sediments erosion, transport, deposition and resultant landforms produced by:
Wind-pedestal rocks, hamadas, bajadas, earth pillars, blow holes, dunes and loess.
Glaciers- cirque, U-shaped valley, hanging valleys, moraines, boulder terrains, drumlins, Kames, eskers, till and varves.
Glacial periods: cause of glacial ages and glacio-eustasy.

Unit-IV
Study of outcrops, identification of bedding, data measurement, effects of topography, outlier and inlier.
Unconformity-origin and types. Onlap and offlap.
Simple deformational structures: Folds-parts of folds, various types in vertical sections, block diagrams and in geological plans.
Faults-parts of faults and common types in vertical sections, in block diagrams and in geological plan.
Joints and their types.

Unit-V
Elementary ideas about crystal structure.
Concept of lattice: planar, space
Morphological characters of crystal: faces, edges, solid angle, interfacial angle, zone and forms.
Crystallographic axes and axial angles.
Parameters and indices: system of Weiss and Miller, crystal symmetry and operations, points group symmetry.
Herman-Maugin system of symmetry.
Laws of crystallography.
Classification of crystals into seven systems and description of symmetry elements of their normal classes

Unit-VI
Types of chemical bonding and compound formation.
Mineral: physical properties (form, colour, lusture, strak, cleavage, fracture, hardness, specific gravity) and chemical composition.
Silicate structure and their classification.
Petrological microscope: its parts and functioning.
Principles and optical mineralogy: reflection, refraction, refractive index, twinkling, birefringence, relief, pleochroism, interference colours, extinction angle, twinkling.
Introductory knowledge of conoscopy

**Books Recommended:**
4. Mineralogy, Concept Description and Determinations-L.G. Berry.
Paper-II Introduction to Geology-II

Unit-I
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-II
Sediments: origin, transportation, deposition and lithification.
Statistical measure: basic ideas about grain size, sorting, skewness, kurtosis and roundness.
Basic concept of size and nomenclature of sediments. 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.

Unit-III
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-IV
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.

Unit-V
Different methods of stratigraphic correlation.
Physiographic subdivisions of Indian subcontinent-their physical, structural and geological features.
Brief account of constituent cratons of Indian shield.
Brief account of geographical distribution of Palaeozoic, Mesozoic and Cenozoic rocks of India.

Unit-VI
Introduction to common rock forming, ore forming and industrial minerals.
Radioactive minerals, Fuel minerals. Formation and types of mineral deposits, rock association.
Basic ideas about the method of mineral exploration, mining, conservation and utilization of natural resources in ancient India.
Application of statistics, trigonometry, algebra and calculus to the study of geology.
Use of computer in geological studies: construction of travel time curve for two-layer system, determination of velocities, depth to bed rock from seismic surveys.
Derivation of the equation to find out age of rocks and minerals from radio-active decay principle.
Determination of altitude of a horizon from topographic map and from bore hole data.
Trigonometric solutions of faults problems.
Measures of central tendency (mean, median and mode), dispersion (mean deviation, standard deviation), correlation co-efficient, least square regression curve.
Computer hardware, software, acquaintance with package used in solving geological problems.
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
Practical

BL 1

(a) Study of important geomorphological models. Reading topographical maps. Use of Clinometer and Brunton Compass. Laboratory exercise on structural geology problems: Completion of outcrops, drawing and interpretation of cross-sections through elementary representative geological structures. Study of elements of symmetry of at least one representative crystal from normal classes of seven crystal systems. Study of physical properties of minerals and rocks in hand specimen. Study of the optical characters of important minerals using polarizing microscope.

(b) Study of megascopic and microscopic characters of important rock-forming minerals. Study of morphological characters of phyla included in the theory syllabus. Preparation and study of stratigraphic maps.

Geological Field Training: Students will be required to carry out field work in a suitable geological area to study the elementary aspects of field geology and submit a report thereon.
PART - II
Paper-III: Earth’s Processes and Resources

Unit-I
Factors controlling mineral availability.
Global mineral reserves and resources.
Renewable and non-renewable energy resources.
Coal: origin, raw materials and end products, types of coal.
Oil and Gas: source material, geological environment of formation, migration and accumulation.
Nuclear fuels: the nuclear fuel cycle, sources of uranium.
Hydroelectric power. Energy from the sun, wind, hot springs and sea waves.
Distribution of mineral deposits in space and time.

Unit-II
Rock forming minerals: Systematic classification of minerals, Chemical composition and physical properties of the following classes of minerals.
Silicates, carbonates, oxides, sulfides, sulfates, halides.

Unit-III
Ore forming minerals: metallic and non-metallic minerals.
Processes of ore formation.
Ore deposits related to magmatic activity.
Hydrothermal and skarn deposits.
Ore deposits formed by sedimentation. Weathering products and Residual deposits.
Ore deposits formed by oxidation & supersgene enrichment.
Ore deposits formed by replacement and biochemical activity, evaporation and metamorphism, colloidal deposition.

Unit-IV
Global tectonic and metallogeny through geological time.
Geological setting, mineralogical characteristics and Indian distribution of metallic mineral deposits of iron and manganese, chromium, copper, lead and zink, gold, and aluminum.

Unit-V
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.

Unit-VI
Methods of mineral exploration.
Physiographics, mineralogical, stratigraphic, lithologic and structural guides to ore.
Methods of mineral exploitation-open pit and underground mining.
Mineral processing and beneficiation: methods of size reduction, screening and separation.
Environmental implications of exploration of mineral resources.

Books Recommended:
2. Ore Deposits-Parks and Mc diarmid.
3. India’s Mineral Resources-Krishnaswami.
5. Ore Petrology-Evans.
7. Mining Geology-Arogyaswami.
Paper-IV: Palaeobiology and Stratigraphy

Unit-I
Methods of fossil identification, description and illustration.
Taxonomic categories and code of systematic nomenclature.
Variation in fossil assemblage and its causes.
Application of palaeontologic studies in organic evolution, biostratigraphy, palaeoecology, palaeogeography, and palaeoclimatology.
Microfossils: definition, significance and a brief account of important groups.

Unit-II
Brachiopoda: Morphology and geological distribution.
Echinoidea Morphology and geological distribution.
Trilobita: Morphology and geological distribution.
Pelecypoda: Morphology and geological distribution.
Gastropoda: Morphology and geological distribution.
Cephalopoda: Morphology and geological distribution.
Rugose Corals Morphology and geological distribution.

Unit-III
Origin of vertebrates and landmarks in vertebrate evolution.
Major groups of vertebrates: pisces, amphibians, reptiles, aves and mammals-their brief description of geological distribution. Evolutionary history of Equidae.
Palaeobotany: Broad classification of plant kingdom.
Morphology, classification and geological range of important Lr. Gondwana flora.
Morphology, classification and geological range of important Upp. Gondwana flora.

Unit-IV
Stratigraphy and its various branches.

Unit-V
Classification, geographic distribution, lithologic characteristics, fossil content and economic importance of Various geological divisions of Peninsular Shield: Cratons – Dharwar, Baster, Singhbhum, Bundelkhand, Aravalli, and Marwar.
Mobile belts: Eastern Ghats, Pandyan and Satpura.
Archean Basement Complex: Peninsular Gneiss of Karanata, Banded Gneissic Complex of Rajasthan, Older Metamorphics of Eastern India.
Greenschist belts of Karnataka: Sargurs (enclaves), Nuggihalli, Holenarsipur and Chitradurga Belts.
Aravalli Supergroup, Dungargarah Supergroup, Iron Ore Group.
Delhi Supergroup, Vindhyan Supergroup, Cudappah Supergroup.

Unit-VI
Classification, geographic distribution, lithologic characteristics, fossil content and economic importance of Haimanta System, Muth Quartzite, Permo-Carboniferous System of Spiti. Gondwana Supergroup, Triassic of Spiti, Jurassic of Kutch, Cretaceous of south east coast of India and Deccan Traps.
Dharamshala, Dagshi and Kasauali Formations, Siwalik system. Karewa Group of Western Himalaya and Evolution of Himalayas.
Books Recommended:
1. Invertebrate Palaeontology-Woods.
2. The Elements of Palaeontology-Black
3. Introduction to Paleobotany-Arnold.
4. Essential of Paleobotany-Shukla and Misra.
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.
Practical

BL2

(a) Study of physical and optical properties of additional rock minerals (other than those covered under paper II). Study of physical properties of ore forming minerals in hand specimen. Preparation of maps showing distribution of important ores and other economic minerals in India. Study of metallogenic maps.

(b) 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.

Geological Field Training: Geological mapping and visit to economic mineral deposits in some appropriate area followed by laboratory processing of rock samples, ores and fossils collected during the field work and preparation of report thereon.
PART - III
Paper-V- Igneous Petrology and Dynamics of the Earth

Unit-I
Mantle petrology: mineralogy and chemistry.
Physical properties of magma, volatile contents.
Magmatic processes: fractional crystallization, magma mixing, crystal setting, liquid immiscibility, assimilation, differentation.
Trace elements and their significance in igneous petrology.
Classification of igneous rocks, basis of IUGS classification.

Unit-II
Basic principles of equilibrium thermodynamics.
Concept of system, phase and component.
Chemical potential and phase rule.
Phase equilibria of the following two and three component silicate systems:
Binary system-Albite-Anorthite, Diopside-anorthite, Nepheline-silica.
Ternary systems-Albite-Anorthite-Diopside, Nepheline-Kalsilite-silica.

Unit-III
Rock association in time and space.
Concept of Rock Series.
General characteristics of the following Precambrian igneous rock assemblages:
(a) Komatiites (b) Anorthosites (c) Tonalite-trondhjemite-granodiorite (TTG)
Mineralogical characteristics and origin of the following rock types:
(I) Granite, granodiorite, diorite, rhyolite, (II) Basalt, dolerite, gabbro
(III)Syenite, nepheline-syenite, trachyte, (IV) Peridotites.

Unit-IV
Internal structure constitution and chemical composition of various layers of the earth.
Geochemical evolution of the earth.
Geophysical conditions of the earth: gravity, magnetism, heat flow.
Application of geophysics in understanding the dynamics of the earth.
Concept and theories of isostasy.
Movements of the earth’s crust: orogenic and epeirogenic phases.

Unit-V
Continental drift and its evidences.
Magnetic anomaly patterns in the ocean basins and sea-floor spreading.
Origin, significance and distribution of divergent margins, mid-oceanic ridges.
Island arcs and trenches.
Plate tectonics theory-the mechanism of plate tectonics.
Nature and types of plate margins.
Geometry and driving mechanism of plate motion.

Unit-VI
Evolution of continents and oceans.
Tectonics of continental rifts, continental margins, shelves, marginal basins and intracratonic basins.
Relationship of magmatism, metamorphism and metallogeny with orogeny.
Neotectonics: Active fault systems.
Indicators of recent tectonic activity.
Geomorphological indicators.
Drainage changes.
Recurrent seismicity.
Causes of natural and man-made geohazards and their prevention.

Books Recommended:
1. Principles of igneous and Metamorphic Petrology-Philpots
3. Igneous and metamorphic petrology-Best.
4. Plate Tectonics and Crustal evaluation-Condie.
5. Aspects of Tectonics-Valdiya.
Paper-VI-Structural Geology

Unit-I
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, mechanics of plastic deformation.

Unit-II
Unconformities, their types and recognition in the fields and on geological maps. Geological significance of unconformities. Criteria for distinguishing faults from unconformities. Evaporite (Salt domes) and serpentinite diapers, sedimentary vents and mud lumps.

Unit-III
Description and nomenclature of folds.
Geometric and genetic classification of folds.
Recognition and interpretation of folds in field and geological maps. Synforms and antiforms.
Minor folds and their relations to major folds. Drag folds-Origin, geometry and significance.
Mechanics and causes of folding.

Unit-IV
Description and classification of faults.
Normal faults, horst and graben, rifts, strike-slip-faults.
Reverse faults, thrusts, thrusts and overthrusts. Nappe, Klippe, Window.
Effects of faults on outcrop.
Criteria for recognition of faults, in the field and on geological maps.

Unit-V
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.

Unit-VI
Joints, their classification and significance.
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.
Laboratory methods of geological mapping. Methods of analysis of simple structural data.
Stereographic projections and its use in structural analysis.

Books Recommended:
2. Structural Geology of Rocks and Regions-Davis
Paper-VII-Natural Environment (including Elements of Remote Sensing, Hydrogeology and Engineering Geology)

Unit-I
Definition of Environmental Geology. The interdisciplinary approach to environmental geology.
Fundamental Concept: The earth as closed system, limitation of earth resources, uniformitariasm, understanding hazardous earth processes.
Environmental changes due to influence of human dominated activities over nature dominated system:
Concept of natural ecosystems on the earth and their mutual relations and interactions (atmosphere, hydrosphere, lithosphere and biosphere): dynamic interaction among system cycling and recycling.
Cycles in earth system: carbon energy cycle, biogeochemical cycle, rock cycle, geochemical cycle

Unit-II
Soil: process of soil formation, classification of soil, soil degradation and mitigation.
Hazardous earth process: shifting of river courses and their impact on soil erosion.
Landslides: slope stability, causes of land slides, prevention and mitigation.
Floods: causes, impact and mitigation.
Earthquakes: causes, impact and mitigation.

Unit-III
Environmental and Geological consideration in site selection of dams, and tunnels.
Dams: foundation materials, structures causes of failure, seismicity, hydrology.
Tunnels: geology, structures, seepage problem, role of water table and seismicity.

Unit-IV
Basics of remote sensing, EMR, platforms, sensors. Types of aerial photographs, Framing and scanning systems.
Types of satellites and images. Spatial, spectral and temporal resolution. Sensors and their characteristics on board IRS, Landsat and SPOT satellites
EMR interaction with atmosphere and earth surface spectral signatures of soil, water and vegetation

Unit-V
Elements of image interpretation (photographic and geotechnical). Basic drainage pattern and their recognition on images/aerial photos. Identification and characteristics of common rock types on aerial photographs.
Application of remote sensing techniques in natural hazards. Examples from India.
Application of remote sensing in geological and geomorphological mapping.

Unit-VI
Introduction to hydrogeology. Hydrologic cycle and its component.
Rock properties affecting groundwater. Vertical distribution of ground water.
Classification of aquifers.
Darcy’s Law and its validity. Permeability and methods of its measurement.
Ground water provinces of India. Concepts of watershed management.
Groundwater pollution, waste disposal, Impact of mining activity.

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
Paper-VIII-Energy Resources and Mineral Exploration

Unit-I
Introduction to fossil fuels
Petrology of coal
Peat, lignite, bituminous and anthracite coal.
Origin of Coal.
Gondwana and Tertiary coalfields of India.
Geothermal energy provinces in India.

Unit-II
Origin, migration and entrapment of natural hydrocarbons.
Source and reservoir rocks.
Structural, stratigraphic and mixed oil traps.
Hydrocarbon exploration techniques-geological and geophysical methods.
Onshore and off-shore distribution of petroliferous basins in India.

Unit-III
Radioactive minerals: mineralogy, geochemistry, origin and distribution of uranium and thorium deposits in India.
Detection and measurement of radioactivity.
Methods of prospecting for radioactive minerals.
Radioactive well logging.
Nuclear waste disposal: problems and solutions.

Unit-IV
Surface and subsurface methods of mineral exploration.
Application of remote sensing techniques in mineral exploration.
Geophysical methods of mineral exploration-airborne versus ground surveys.
Gravity, electrical, magnetic and seismic methods.

Unit-V
Prospecting for economic minerals.
Methods of drilling, sampling, assaying and reserve estimation.
Fundamentals of geobotanical and Geochemical methods of exploration.
Bore-hole logging and deviation testing.

Unit-VI
Principles of mineral economics.
Strategic, critical and essential minerals.
Mineral production in India.
Changing pattern of mineral consumption.
National mineral policy of India including hydrocarbon
Mineral concession rules.
Mineral resources of the sea and law of sea.

Books Recommended:
2. Text Book of Coal-Chandra, Singh and Singh.
3. Petroleum formation and occurrence-Tisot and Welte.
4. Radioactivity in Geology-Principles and Application-Durrance.
5. Courses in Mining Geology-Arogyaswami.
8. Techniques in Mineral exploration-Readman.
Paper-IX-Sedimentary and Metamorphic Petrology

Unit-I
Significance of grain size distribution in relation to environments.
Particle size of detrital rocks-grade scale in mm and phi scales.
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.
Basic ideas about depositional environments and their classification.
Dynamics of eolian and fluvial environments: Laminar and turbulent flows and flow regimes.

Unit-II
Morphology and occurrence of bedding plane structures, internal structures, soft sediment deformational structures, biogenic structures and significance of ichno fossils.
Processes of sediment deposition: aqueous, Aeolian, glacial and gravitational (turbidity, mud flow and debris flow). Diagenesis of terrigenous and chemical sediments.
Heavy minerals and their geological significance.

Unit-III
Petrography and geological significance of diamicrite and tillite.
Concept of maturity from mineralogy of sands and textural attributes.
Shale, types, their bedding characteristics and mineralogy.
Classification and origin of carbonates with special reference of Folk’s classification.
Tectonics and sedimentation. Cratonic and plateform basins and facies.
Geosyncline basins and facies. Krynine’s cycle.

Unit-IV
Metamorphic processes and a detailed account of agents and their role in metamorphism.
Nucleation. Chemical equilibrium in metamorphic rocks.
Types of metamorphism-contact, regional, cataclastic and metasomatism.
Textures and structures of metamorphic rocks and their significance.

Unit-V
Barrovian zones of regional metamorphism and principles of isograd mapping.
Rosenbusch’s zones of thermal metamorphism, contact aureole.
Concept of metamorphic facies and facies series.
Low pressure and medium to high pressure facies (field relation and mineralogy).
Metamorphism in relation to plate tectonics. Paired metamorphic belts.

Unit-VI
Cataclastic metamorphism and its products. Contact metamorphism of mafic, pelitic and carbonate rocks. Regional metamorphism of mafic, pelitic rocks.
Metasomatism: types mass transfer and products, anatexis and granitisation.
P-T-t diagrams and projective analysis.
Petrology, origin and distribution (in India) of charnockites, khondalites, granulites and eclogites.
Books Recommended:
1. Sedimentary Rocks-Pettijohn
2. Palaeo current and Basin Analysis-Potter and Pettijohn.
5. Petrology of Metamorphic Rocks-Mason.
Paper-X-Applied Geology

Unit-I

Unit-II

Unit-III

Unit-IV

Unit-V

Unit-VI
Description and identification of gem material: Apatite, bery (aquamarine, emerald etc.), corundum (ruby, sapphire), chrysoberyl (alexandrite), Calcite, diamond, diopside, epidote, feldspar (moonstone, labradorite etc.), garnet (almandine, pyrope, spessarite, grossular, andradite etc.), opal, quartz (crystalline, chaledony), spinel, kyanite, sillimanite, topaz, tourmaline, turquoise, malachite, lapis lazuli, zoisite, zircon, amber, coral, jet and pearl. Gemstone cuts: basic and simple style of cut.

Books Recommended:
2. Environmental Sciences-Miller.
5. Geochemical Exploration-Bjorklund.
8. Fundamentals of GIS- M. Demers
9. Datum Map Projection and Coordinate System – Survey of India (lecture notes)
10. Lecture notes on remote sensing GIS and map protection (reference Copy)
11. Remote sensing and Geographic Information System by A.M. Chandra
Practical

BL3

(a) Microscopic study of major igneous rocks. Model mineralogy of some Plutonic and hypabassal rocks and their nomenclature using Streckeisen’s approach. Study of sections across continental margins, island arcs and plate tectonics models. Study of geohazard maps and introduction to basic geophysical instruments used for understanding the dynamics of the Earth.

(b) Exercises on structural geology problems. Stereographic projections of structural data. Geometrical problems on folds and faults. Drawing and the interpretation of profile sections across the geological maps.


(d) Hydrogeology: drawing of hydrogeological cycle, depth to water table map, measurement and presentation of rainfall data-arithmetic mean, isohyetal map, isocones and other methods of representation of chemical data. Preparation and interpretation of water table maps. Identification and uses of water on the basis of quality (drinking, irrigation and industrial purpose).

BL4

a) Hand specimen study of different types of coals, selected radioactive minerals and their host rocks. Exercises in showing distribution of various mineral deposits, fuel resources and hydrocarbon resources on map of India. Laboratory exercises in solving exploration related problems. Data representation & analysis of field resources.

b) Study of important primary sedimentary structures in hand specimens. Microscope study of sedimentary textures, mineralogy and diagenetic features in sedimentary rocks. Microscopic study textures and mineralogy of metamorphic rocks. Laboratory exercises in graphic plots for petrochemistry and interpretation of paragenetic diagrams.


BL5

Geological Field Training: 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 fieldwork.

BL 6

Comprehensive Viva
SYLLABUS
for the session
2013-2014

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

Department of Geology
Aligarh Muslim University
Aligarh
# Course Structure - Semester System

**M.Sc. (Applied Geology)**

**w.e.f. Session 2013-2014**

<table>
<thead>
<tr>
<th>Paper</th>
<th>Title</th>
<th>Max.Marks</th>
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<td><strong>M.Sc. Applied Geology Part – I</strong></td>
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<tr>
<td>I (M1)</td>
<td>Ore Geology and Mining Geology</td>
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<tr>
<td>II (M2)</td>
<td>Structural Geology and Tectonics</td>
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<tr>
<td>III (M3)</td>
<td>Mineralogy, Instrumentation and Analytical Techniques</td>
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<td>IV (M4)</td>
<td>Hydrogeology - I</td>
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<td><strong>Lab. Work</strong></td>
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<td>I (ML1)</td>
<td>Ore Geology, Mining Geology, Structural Geology and Survey</td>
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<td>II (ML2)</td>
<td>Mineralogy, Instrumentation and Analytical Techniques Hydrogeology</td>
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<td>V (M 5)</td>
<td>Paleobiology and Stratigraphy</td>
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<td>VI (M 6)</td>
<td>Igneous and Metamorphic Petrology</td>
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<td>VII (M 7)</td>
<td>Remote Sensing in Geology and Geomorphology</td>
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<td>VIII (M8)</td>
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<td>Paleobiology, Stratigraphy, Igneous and Metamorphic Petrology</td>
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<td>V (ML5)</td>
<td>Remote Sensing in Geology, Geomorphology, Hydrogeology</td>
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<td>X (M10) Geophysical Exploration and Engineering Geology</td>
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<td>XI (M11) Geochemistry- I</td>
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<td>XII (M12) Sedimentology - I</td>
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<td>XIII (M13) Environmental Geology- I</td>
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<td>XIV (M14) Special Paper – I ( Optional amongst the following)</td>
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<td>3. Sedimentary Environments and Sedimentary Basins- I</td>
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<td>4. Micropalentology – I</td>
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<td>5. Advance Ore Geology – I</td>
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<td>7. Impact of Geology on Environment – I</td>
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<td>8. Petroleum Exploration – I</td>
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<td>9. Gemmology – I</td>
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<td>10. Engineering Geology and Geotechniques – I</td>
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<td>11. Rock Deformation and Structural Analysis-I</td>
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<td>VIII (ML8) Geochemistry, Sedimentology, Environmental Geology</td>
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<td>XVII (M17) Environmental Geology- II</td>
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<td>3. Sedimentary Environments and Sedimentary Basins- II</td>
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<td>7. Impact of Geology on Environment – II</td>
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<td>XIX (M19) Project Oriented Dissertation <em>(To be allotted after second semester exam or at the beginning of third semester)</em></td>
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<td>IX (ML9) Geochemistry, and Computer Applications</td>
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<td>X (ML10) Sedimentology and Environmental Geology</td>
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Syllabus of M.Sc.-Applied Geology for the session
2013-2014

Semester System
M.Sc. App. Geology – Part -I
SEMESTER-I

Paper-I 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
Geothermometry of ore deposits.
Fluid inclusion in ores: Principles, assumptions, limitations and applications.
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, stopping, room and pillar mining, top-slicing, sub-level caving and block caving.
Cycles of surface and underground mining operations.
Exploration for placer deposits.
Open pit mining. Ocean bottom mining.
Types of drilling methods.
Mining hazards: mine inundation, fire and rock burst.
Books Recommended:
2. Evans, A.M., 1993: Ore Geology and Industrial Minerals-Blackwell
3. Sawkins, F.J., 1984: Metal deposits in relation to plate tectonics-Springer Verlag
Springer Verlag
Paper-II Structural Geology and Tectonics

Unit-I
Mechanical principles and properties of rocks and their controlling factors. (confining pressure, temperature, time, pore fluid pressure etc). Concept of stress. Two dimensional stress analyses.
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.
Description of componental, parts of folds.
Mechanics of folding and buckling. Flexure fold; flexural slip folds, flexural flow folds, passive folds. Distribution of strains in folds.

Unit-II
Joint description, morphology, genetic and geometric classification.
Terminology of foliation. Classification and genesis of axial plane foliation, crenulation foliation, bedding foliation (transposition foliation) fracture cleavage (spaced cleavage). Significance of foliation in geology
Description of lineations in deformed rocks, their origin and significance.

Unit - III
Plate Tectonics: Recent advances, pros and cons.
Dynamic evolution of continental and oceanic crust.
Principal tectonics features of the earth: oceans basins, structure of continental crust, Precambrian shields, Archean terrane, Proterozoic terrane, Phanerozoic terrane, Continental rifts and modern continental margins, continental platforms, orogenic belts. Tectonics of Precambrian orogenic belts of India: early Proterozoic mobile belts and middle Proterozoic mobile belts of Indian shield

Unit - IV
Formation of mountain roots.
Anatomy of orogenic belts: outer foredeep or foreland basin, foreland fold and thrust belt, crystalline core zone, high angle fault zone.
Metamorphism and tectonics.
Plume Tectonics.

Books Recommended:
Paper-III- 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)
Determinative mineralogy - RI(Beckeline, oblique illumination, immersion), axiality,
optic sign, 2V and plagioclase composition by microscope
Description and function of microscopic aids- compensation plates and wedges,
Spindle stage, Universal stage.
Sample - Definition, field samples (rock, soil, sediment, water), sampling methods.
Sample preparation-laboratory sample.
Selection and screening criterion (physical, optical, biological), Preparation of
specimen, Types of specimen
Thin Section Studies-Etching technique
Staining techniques particularly for feldspars, carbonates, dolomite,
paragonite and quartz
Model analysis and techniques, Calibration of eyepiece micrometer, areas selection
and point counting
Polished Section Studies-Reflectance (specular and diffusive) and reflectance
spectrometry
Birefringence and reflection pleochroism, Colour of opaques, Microhardness and
determination
Knowledge of some common photographic Cameras
Scanning and Transmission Electron Microscope (SEM & TEM) :Principle, parts,
function and application. Diffraction and imaging
Electron Probe Microanalyser (EPMA) :Principle, parts, operation and application
Principles, instruments and geological applications of Cathodeluminescence and
thermoluminescence

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
   (c) 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
SiO2
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 and tools-Conventional (Steel Mortar, Agate Mortar etc.), Modern (Autopulverizer)

Contaminations ( precautious and measures)

Concept in analytical Chemistry-Terms & definitions, Units of measurement., Accuracy and precision.

Statistical tests of reliability. Detection limits. Contamination (analytical)

Calibration of Instruments, Elements and analytical techniques, Presentation of geochemical data

X-rays: Nature, generation and spectra of X-ray, Diffraction, Bragg’s law,

X-rays and Crystal structure and Mineral chemistry

X-ray Diffractometry, X-ray diffractometer (XRD): Principle, parts, operation

Mineral composition with particular reference to feldspar, orthopyroxene and clay minerals

X-rays and Petrochemistry

XRF (wave length dispersive and Energy Dispersive): Principle, parts and function

Preparation of sample for geochemical analyses

Rock digestion through acid treatment, Rock digestion through fusion with alkali salts, Soil samples digestion, Water samples – Selection of water quality variables and collection of samples, Preservation techniques

Number of samples, Storage before analysis

Conventional analytical methods and Instruments:

Classical, Photometric, Flame photometric and Titration (EDTA)

Rapid methods and Instruments:

Determination of ferrous iron, Determination of water & CO2, Determination of Fluorine and Chlorine

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:

Paper-IV Hydrogeology-I

Unit-I
Hydrologic cycle and its components
Ground water origin, types, importance, occurrence, renewable and non-renewable ground water resources. Surface movement and vertical distribution of groundwater
Hydrologic properties of rocks: porosity, permeability, specific yield, specific retention, hydraulic conductivity, transmissivity, storage coefficient and methods of their measurements Hydrographs.

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
Water table contour maps, hydrostratigraphic units of India. Artificial recharge of ground water, rain water harvesting. Water balance methods, water level fluctuations: causitive factors and their measurement, Problem of over exploitation.
Ground water legislation.

Unit-IV
Surface and subsurface geophysical and geological methods of ground water exploration.
Hydrogeomorphic mapping using various remote sensing techniques.
Surface geophysical methods: resistivity, seismic, gravity and magentic 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
LAB WORK

I (ML1)
Ore Geology
(a) Megascopic study of structures and fabrics of different ores and their associations. Mineralogical and textural studies of common ore minerals under ore-microscope and petrological study of other industrial and non-metallic minerals. Exercises in the determination of relative hardness of common ore minerals.

Mining Geology
(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.

Structural Geology
(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. Study of large scale tectonic features of the Earth.

Survey
(d) Various methods and instruments of surveying including plane table, prismatic and theodolite and Telescopic Aledade.

II (ML2)
(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
(c) Delineation of hydrological boundaries on water-table contour maps and estimation of permeability Analysis of hydrographs and estimation of infiltration capacity. Chemical analysis of water.

III (ML3) Field Geology –1
SEMESTER - II
M.Sc. Applied Geology – PART – I
SEMESTER- II
Paper-V Paleobiology and 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
Controls on the development of stratigraphic records. Lithostratigraphy, Codes units, correlation and contacts. Biostratigraphphy- units, biogeographical acme zone provinces, controlling factors, zonation and their time significance.
Geochronology. Chronostratigraphy : code and units.
Basic principles of pedostratigraphy, quantitative stratigraphy, seismic stratigraphy and sequence Stratigraphy, magnetostratigraphy, cyclostratigraphy, event Stratigraphy.
Tectonic evolution of the following cratonic blocks.
Dharwar, Aravalli-Bundelkhand, Singhbhum and Bhandara- Bastar.

Unit – IV
Basin configuration, stratigraphy and sedimentary evolution of the following basins. Vindhyan, Chattisgarh and Cuddapah.
Paleogeographic and palaeoclimatic conditions prevailing in Indian subcontinent during Paleozioc, 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.
Completeness / incompleteness of stratigraphic records; preservation and net rates of accumulation in various basinal settings

Books Recommended:
Paper-VI- Igneous and Metamorphic Petrology

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

Unit-II
Phase equilibrium of the following silicate systems, its relation to magma genesis and crystallization in the light of modern experimental work:
Single Systems-Silica, Carbon.
Binary Systems-Albite-Anorthite, Diopside-Anorthite.
Ternary Systems-Nepheline-Kalsilite-Silica, Fosterite-Anorthite-Silica, Diopside-Forsterite-Silica.
Quaternary system: Diopside-Nepheline-Forsterite-Silica.
Crystallization of magmas-nucleation and growth of crystals, quench crystals.
Physico-chemical interpretation of igneous textures including spinifex, rapakivi, mixed crystals, intergrowths, reaction rims.
Petrogenesis of the following igneous rock types:
Ultramafic (Peridotite and Picrite, Komatiite), Basalts, Andesites, Granites, Syenite, Carbonatite, Anorthosite

Unit-III
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, glaucoephane-lawsonite (blue-schist), eclogite.

Unit-IV
Isoreaction grad, Schreinmakers rule and construction of petrogenetic grids.
Graphical representation: ACF, AKF, AFM.
Metamorphic differentiation.
Anatexis and origin of migmatites in the light of experimental studies.
Regional metamorphism and paired metamorphic belts.
Metamorphism and Tectonics.
Metamorphic facies series. P-T-t paths and their implications.
Ultra high temperature, ultra-high pressure and ocean-floor metamorphism.
Partial melting during granulite metamorphism.
Chemical zoning and its relation to tectonism.
Books Recommended:
Paper-VII Remote Sensing in Geology and Geomorphology

Unit-I
Spectral Characteristics of solar radiation.
Transmittance of the atmosphere.
Spectral reflectance of land covers.
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: and applications recent advances.
Aerial photographs and their geometry. Errors in aerial photographs and their correction, swing, tilt, ortho photographs. Classification of aerial photographs and aerial mosaics. Photomosaics and its types.
Stereoscopes: mirror and pocket stereoscope. Photogrammetric techniques
Parallaxes: parallaxe bar, Prallax formula, height and slope determination.
Scale determination of photographs on uniform and variable terrain.

Unit-III
Geological studies: image characters and their relations with ground objects based on recognition elements (photographic and geotechnical elements). Convergence of evidence in interpretations of lithology (igneous sedimentary and metamorphic rocks)
Interpretation of topography and tectonic features and evaluation of ground water potential.

Unit-IV
Digital processing techniques, 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. Principles and 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-VIII Hydrogeology-II

Unit – I
Methods of pumping test and analysis of test data.
Evaluation of aquifer parameters using Theim, Theis, Jacob’s and Walton equations.
Flow Net Analyses. 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
IV (ML4)
(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.

V (ML5)
Remote sensing and GIS
(a) Delineation of gulley erosion and drainage pattern. Photointerpretation and identification of major lithounits in 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, landuse and land cover mapping using IRS data. Mapping of geomorphological features in remote sensing data.
(c) Viewing satellite imagery in 3D. Mapping structural, geological and geomorphological features using satellite imagery.

Geomorphology
(b) 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

Hydrogeology
(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.

VI (ML6) Field Geology –2
M.Sc. Applied Geology – Part II

Paper-IX-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, wellsite 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-X-Geophysical Exploration and Engineering Geology

Unit-I

Unit-II
Role of engineering geology in civil construction and mining industry, various stages of engineering geological investigation for civil engineering projects. Engineering properties of rocks, rock discontinuities, features of active faults. RQD, engineering classification of rock mass. Terzaghi’s rock mass classification, coates, C-factor, Q-system and geomechanical classification. Improvements of properties of rock mass: grouting, gnuting, rock bolting, cable anchorage. Earthquakes and seismicity, seismic zones of India, aseismic design of building.

Unit – III
Unit – IV
Mass movements with special emphasis on landslides and causes of hill slope instability.
Geological causes for mishaps and failures of engineering structures.
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:
Paper-XI-Geochemistry - I

Unit-I
Origin and abundance of elements in the solar system and in the Earth, and its constituents. Nucleosynthesis, Meteorites.
Atomic structures and properties of elements in the periodic table. Special properties of transition and rare earth elements.
Geochemical classification of elements, major elements trace elements, compatible, incompatible, HFSE, LILE, Low field strength elements, PGE.

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- XII Sedimentology- I

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.
Hylstroms 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-XIII 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
processes, 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 in geological sequence.
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
Unit-I
Types and geometry of aerial photograph, tilt and relief distortion, elements of photogrammetry, digital photogrammetry, types of mosaics and its uses, scale variation on aerial photographs, vertical exaggeration, height and slope rectification of aerial photographs.

Unit-II
Aerial photo-interpretation techniques, recognition of photo-elements and terrain elements like tone, texture, pattern, size, shape, terrain elements like drainage pattern, density, type, landform characteristics, erosion behaviour of rocks and soil material, vegetation characteristics, landuse and land cover classification.

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 – Finkiel
9. Remote sensing and Geographic Information System by A.M. Chandra
Special paper 2. Applied Geochemistry - I

**Unit-I**
Historical background and developments.
Geochemical cycle, planning-oriented surveys.
Geochemical data analysis—evaluation of quality of data, presentation and statistical treatment of data. Interpretation of data
Advanced analytical methods—AAS, XRF, ICP-ES, ICP-MS, NAA, IDMS, SSMS, Ion microprobe, EPMA.

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

**Unit-III**
Geochemistry of petroleum—paraffins, napthenes, aromatics, heterocompounds.
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:**

Unit – I
Siliciclastic 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:
Special paper 4. 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
Special paper 5. Advance Ore Geology – I

Unit – I
Ore-genesis and detailed study of all principal ore mineral groups, their textures and structures.

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.
Textures of ore minerals and their significance.
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:
and books given in Paper I.
Special Paper 6. 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:
Special paper 7. **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
Special Paper 8. Petroleum Exploration- I

Unit-I
Physico-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
Special Paper 9. Gemmology-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 chatoancy, 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:
Special Paper 10 Engineering Geology and Geotechniques-I

Unit-I

Unit – II
Seismic Survey-Reflaction 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 geotectonical applications.

Unit-III

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
Special Paper 11. Rock Deformation and Structural Analysis-I

Unit-1:


Unit-2:


Unit-3:

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-4:

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
LAB WORK

VII (ML7)
(a) Maps and exercises related to coal geology
(b) Study of geological maps and sections of important oilfields of India.
Excercises and maps related to petroleum geology
(c) Study of geological sections of U-Th bearing rocks of the country.
Megascopic study of some uranium and thorium bearing minerals and rocks.
(d) Study of gravimeter, magnetometer and seismographs. Resistivity survey.
Interpretation of underground structure on the basis of seismic data.
(e) 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.
(f) Computer applications in petrology, geochemistry, hydrogeology, structural
analysis and other branches of geology using different software packages

VIII (ML8)
(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.
(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,
M.Sc. App. Geology - Part - II
SEMESTER - IV
Paper-XV Geochemistry- II

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 co-efficients.
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:
Paper- XVI Sedimentology-II

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: intraplatten 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:
Paper-XVII Environmental Geology - II

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 hazardad, 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.
Special paper 1. Advance Remote Sensing in Geosciences – II

Unit-I

Unit-II
Terrain classification, terrain mapping, applications of remote sensing techniques in study of geomorphology, soil types mapping, hydrogeology, engineering geology, land use and land cover mapping, forest types, their distribution and relationship of vegetation to rock types. Watershed characterization and mapping. Groundwater targeting in various terrains. Case studies from India.

Unit-III
Digital image processing. Various image processing softwares their environments and working principles of data interpretation. 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
Special paper 2. Applied 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
Thermoluminescence 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:
Special paper: 3. Sedimentary Environment and Sedimentary Basins-II

Unit –I
Sedimentary cycles, rhythms and cyclothsms. 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:
Special paper 4. 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
Radiolaria: morphology of hard parts and outline classification
Ecology and biostratigraphy of radiolaria

Unit-IV
Palynology: branches and application in various disciplines
Palynofossils: morphology of spores and pollens
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
Special paper: 5. Advance Ore Geology- II

Unit-I
Detailed study of ore deposits formed as chemical precipitates, syngentic clastic beds and by weathering. Significance of stratiform and strata-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.

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

Books recommended:
Special Paper 6. Advanced Hydrogeology-II

Unit-I

Unit – II

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

Books Recommended:
Special paper 7. 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 phenomena.

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
Special Paper 8. Petroleum Exploration-II

Unit-I
Rig and their components
Elements of well drilling-cable tool drilling, rotary drilling, directional drilling, dyne 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
Special Paper 9. Gemmology-II

Unit-I
Synthetic, Composite and limitation Gemstones; methods of synthesis, stones synthesized, identification techniques, characteristics, manufactures and trade name. Gem Enhancement methods and their identification: colourless/coloured impregnation, heat treatment, coating irradiation, Diffusion treatment Foiling and Laser drilling.

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, Jadeite, lolite, Lapis Lazuli, Opal, Peridot, Sillimanite Quartz group, Spinel, Tanzanite Topaz, Tourmaline Turquiose, 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: Brilliant (with proportion for diamond) Cabochons, mixed, rose, step (Emerald) cut, Scissors or cross cut etc. Importance of Orientation and Valuation.

Books Recommended:
**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
Special Paper 11. Rock Deformation and Structural Analysis-II

Unit-1:

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

Unit-2:

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-3:

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

Unit-4:


Books recommended:

2. Structural Geology of Rocks and Regions-Davis.
5. A Manual of Problems in Structural Geology-Gokhle
LAB WORK

IX (ML 9)
(a) Calculation of weathering indices in soil and sediments. Presentation of analytical data.
(b) Computer applications

X (ML –10)
(a) Exercises related to analysis and interpretation of depositional sedimentary environments using actual case histories from the Indian stratigraphic records. Determination of porosity in clastic and carbonate rock. Staining and mineral identification in carbonate rocks. Petrography of clastic and chemical sedimentary rocks. Detailed study of diagenetic features in thin sections. Microscopic study of heavy minerals. Exercises on mineralogical and geochemical data plots for environmental interpretations
(b) Evaluation of environmental impact of air pollution groundwater, landslides, deforestation, cultivation and building construction in specified areas

XI Viva –Voce on Paper XIX (M-19)