Course structure
&
Syllabus

Under Choice Based Credit System (CBCS)

M.Sc. (Applied Geology)
2018-19

DEPARTMENT OF GEOLOGY
ALIGARH MUSLIM UNIVERSITY
ALIGARH

Syllabus – M.Sc. (Applied Geology)

Session 2018-19

Choice Based Credit System (CBCS)

Semester I

Type of Course	Course No.	Course Title	Marks distribution			Credit	Contact Hours		
			Sessional	End Semester	Total		L	T	P
Core	M1	Ore Geology and Mining Geology	30	70	100	4	4	1	0
Core	M2	Mineralogy, Instrumentation and Analytical Techniques	30	70	100	4	4	1	0
Core	M3	Structural Geology	30	70	100	2	2	0	0
Core	M4	Geotectonics	30	70	100	2	2	0	0
Core	M5	Hydrogeology	30	70	100	2	2	0	0
Core	ML1	Lab work: Ore Geology and Mining Geology, Structural Geology and Survey	Continuous evaluation - 30	70	100	2	0	1	2
Core	ML2	Lab Work: Mineralogy, Instrumentation and Analytical Techniques, Geotectonics and Hydrogeology	Continuous evaluation - 30	70	100	2	0	1	2
Elective (DC)	ME 1	Choose one of the following	30	70	100	4	4	1	0
		a) Coal Petrology							
		b) Oceanography							
		c) Watershed Management							
AE (DC)	MAE1	Field Geology/Industrial/ Laboratory Training	30	70	100	2			
Total						24			

Semester II

Type of Course	Course No.	Course Title	Marks distribution			Credit	Contact Hours		
			Sessional	End Semester	Total		L	T	P
Core	M6	Paleobiology and Indian Stratigraphy	30	70	100	4	4	1	0
Core	M7	Metamorphic Petrology	30	70	100	2	2	1	0
Core	M8	Remote Sensing in Geosciences	30	70	100	4	4	1	0
Core	M9	Geophysical Exploration	30	70	100	4	4	1	0
Core	M10	Well Hydraulics and Water Chemistry	30	70	100	2	2	0	0
Elective (DC)	ME2	Choose one of the following	30	70	100	4	4	1	0
		a) Geodynamic Processes and Crustal Evolution							
		b) Global Climate Change							
		c) Medical Geology							
AE (DC)	MAE2	Lab work: Paleobiology and Indian Stratigraphy, Metamorphic Petrology and Geophysical Exploration	Continuous evaluation - 30	70	100	2	0	1	2
AE (DC)	MAE3	Lab work: Remote Sensing in Geosciences, and Well Hydraulics & Water Chemistry	Continuous evaluation - 30	70	100	2	0	1	2
Total						24			

Semester III

Type of Course	Course No.	Course Title	Marks distribution			Credit	Contact Hours		
			Sessional	End Semester	Total		L	T	P
Core	M11	Fuel Geology	30	70	100	4	2	1	0
Core	M12	Engineering Geology	30	70	100	2	2	0	0
Core	M14	Geochemistry and Radiogenic Isotopes	30	70	100	2	2	0	0
Core	M15	Sedimentology	30	70	100	2	2	0	0
Core	M16	Environmental Geology	30	70	100	2	2	0	0
Core	ML3	Lab work: Fuel Geology, Engineering Geology and Sedimentology	Continuous evaluation -40	60	100	2	0	1	2
Core	ML4	Lab work: Geochemistry and Radiogenic Isotopes, Environmental Geology, Computer Applications	Continuous evaluation - 30	70	100	2	0	1	2
Elective (DC)	ME3	Choose one of the following:	30	70	100	4	4	1	0
		a) Applied Remote Sensing							
		b) Advanced Ore Geology							
		c) Advanced Hydrogeology							
		d) Petroleum Exploration							
		e) Rock Deformation and Structural Analysis							
AE(DC)	MAE4	Field Geology/ Industrial/ Laboratory Training	Continuous evaluation - 30	70	100	4			
						24			

Semester IV

Type of course	Course No.	Course Title	Marks distribution			Credit	Contact Hours		
			Sessional	End Semester	Total		L	T	P
Core	M17	Geochemistry and Stable Isotopes	30	70	100	2	2	0	0
Core	M18	Applied Sedimentation	30	70	100	2	2	0	0
Core	M19	Environmental Pollution and Natural Hazards	30	70	100	2	2	0	0
Core	M20	Applied Geomorphology	30	70	100	4	4	1	0
Core	M21	Planetary Geology	30	70	100	2	2	0	0
Core	ML5	Lab work: Geochemistry and Stable Isotopes, Applied Sedimentation and Computer Applications	Continuous evaluation - 30	70	100	2	0	1	2
Core	ML6	Lab work: Environmental Pollution & Natural Hazards, Applied Geomorphology and Planetary Geology	Continuous evaluation - 30	70	100	2	0	1	2
Elective (DC)	ME4	Choose one of the following:	30	70	100	4	4	1	0
		a) Exploration Geochemistry							
		b) Sedimentary Environments and Sedimentary Basins							
		c) Impact of Geology on Environment							
		d) Engineering Geology and Geotechnics							
		e) Glaciology							
Open Elective	OE(AE)	Choose one of the following:	30	70	100	4	4	1	0
		a) Global Change							
		b) Earth Systems							
Total						24			

L = Lecture period, T = Tutorial, P = Practical Period

Syllabus – M.Sc. (Applied Geology)
Session 2018-19
Semester I

Paper M1: Ore Geology and Mining Geology

Core Credit: 4, Period: 56

UNIT 1:

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 2:

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 3:

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 4:

Application of rock mechanics in mining.

Planning, exploration and exploratory mining of surface and underground mineral deposits involving diamond drilling, shaft sinking, drifting, cross cutting, winzing, stoping, room and pillaring, 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:

1. Ore Microscopy and Ore Petrography – J.R. Craig and D.J. Vauhan, 1994. John Wiley and Sons, 434pp.
2. Ore Geology and Industrial Minerals – A.M. Evans, 2013. John Wiley and Sons, 400pp
3. Metal deposits in relation to plate tectonics – F.J. Sawkins, 2013. Springer Science & Business Media, 461pp.
4. Ore Petrology – R.L. Stanton, 1972. McGraw-Hill, 713pp.
5. Economic Geology and Geotectonics – D.H. Tarling, 1981. John Wiley and Sons, 213pp.
6. Geochemistry of Hydrothermal Ore Deposits – H.L. Barnes (Ed), 1979. John Wiley and Sons, 798pp.
7. Time and Strata Bound Ore Deposits – D.D. Klemm and H.J. Schneider, 2012. Springer Science & Business Media, 446pp.
8. The Geology of Ore Deposits – J.M. Guilbert and C.F Park, Jr, 2007. Waveland Press, 985pp.
9. Ore genesis – A Holistic Approach – A. Mookherjee, 1999. Allied Publishers, 657pp.
10. Mining Geology II Ed. – H.E. McKinstry, 1962. Asia Publishing House,
11. Elements of Mining 3rd Ed. - R.S. Lewis and G.B. Clarke, 1964. John Wiley and Sons, New York,

12. Courses in Mining Geology – R.N.P. Arogyaswami, 1973. Oxford and IBH Pub. Co., 916p.
13. Mineral Deposits and Earth Evolution – I. McDonald, et al (Eds), 2005. The Geological Society, London, 269pp.
14. Hydrothermal Mineral Deposits: Principles and Fundamental Concepts for the Exploration Geologist – F. Piranjo, 2012. Springer Science & Business Media, 709pp.

Paper M2: Mineralogy, Instrumentation and Analytical Techniques

Core Credit: 4, Period: 56

UNIT 1:

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

UNIT 2:

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

UNIT 3:

Chemical composition, crystal structure and mode of occurrence of following groups of non-silicate minerals.
Native elements: Gold, Silver, Copper, Platinum, Iron, Sulfides- Cu, Fe, Pb, and Zn sulfides.
Sulfosalts-Ag, Cu and Pb sulfosalts , Oxides-simple and multiple oxides excluding SiO_2
Hydroxides- Brucite, Gibbsite, Goethite, Limonite, Psilomelane, Carbonates-Calcite, Magnesite, Rhodochrosite, Dolomite, Siderite
Mineral assemblages- Assemblages and phase rule, Assemblages and rock types
Gem and Semi-precious minerals – identification, diagnostic properties, classification, important deposits of India

UNIT 4:

Powdering methods, tools, contaminations
Concepts in analytical Chemistry-Terms & definitions, Units of measurement, accuracy and precision.
Statistical tests of reliability. Detection limits. Contamination (analytical), Calibration of Instruments.
X-rays: Nature, generation and spectra of X-ray, Diffraction, Bragg's law,
X – rays and Crystal structure
X-ray Diffractrometry , X-ray diffractrometer (XRD) :Principle, parts, operation
X-rays and Petrochemistry
XRF (wave length dispersive and Energy Dispersive): Principle, parts and function
Rock digestion through acid treatment, Rock digestion through fusion with alkali salts, Soil samples digestion, Water samples.
Conventional analytical methods and Instruments:
Classical, Photometric, Flame photometric and Titration (EDTA)
Rapid methods and Instruments:
Determination of ferrous iron, Determination of water & CO_2.
Optical spectrometry- Principles, Nature of light, Absorption and emission of light
Instrumentation for optical spectrometry, Monochromaters, 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:

1. Deer, W.A., Howie, R.A. and Zussman, J., 1996: The Rock forming Minerals-Longman
2. Klein, C. and Hurlbut, Jr. C.S., 1993: Manual of Mineralogy-John Wiley
3. Putnis, Andrew, 1992: Introduction to Mineral Sciences-Cambridge University Press
4. Spear, F.S. 1993: Mineralogical Phase Equilibria and Pressure-Temperature-Time paths-Mineralogical 5.Society of America Publ.
5. Phillips, Wm, R. and Griffen, D.T., 1996: Optical Mineralogy-CBS Edition
6. Hutchinson, C.S., 1974: Laboratory Handbook of Petrographic Techniques-John Wiley

Paper M3: Structural Geology

Core Credit: 2, Period: 28

UNIT 1:

Dynamic analysis. Concept of stress analysis. Computing axial stress. Stress vector and its computation. Computation of total state of stress. The Mohr stress diagram. Role of confining pressure temperature, time, solutions in rock deformation. Microstructural behavior of rocks.

UNIT 2:

Kinematic analysis. Concept of Kinematic analysis and strain. Ground rules for strain analysis. Computing changes in line lengths, changes in angles between lines, Shear strain. Strain ellipse and its calculation. Calculating the variations in strain. The Mohr circle strain diagram. The strain ellipsoid and its application. Finite and infinitesimal strain.

UNIT 3:

Fold shape classifications and projection techniques of fold orientations. Mechanism of single layer and multilayer folds and associated structures. Flexure folds and flow folds.

UNIT 4:

Fault and its classifications .Normal fault systems, Thrust systems. Strike slip fault systems. Fault orientation in relations to stress and strain axes.

Books recommended:

1. Structural analysis of metamorphic Tectonics-Turner and Weiss.
2. Structural Geology of Rocks and Regions-Davis.
3. Folding and Fracturing of Rocks-Ramsay.
4. An Outline of Structural Geology-Rubbs, Mears and William.
5. A Manual of Problems in Structural Geology-Gokhle

Paper M4: Geotectonics

Core Credit: 2, Period: 28

UNIT 1:

Historical perspective of the theory of plate tectonics: Continental drift, Sea-floor spreading and the birth of plate tectonics, Impact of plate tectonics. The framework of plate tectonics: plates and plate margins, Distribution of earthquakes, Relative and absolute plate motions, Hotspots, Polar wander.

UNIT 2:

Sea-floor spreading, Marine magnetic anomalies, geomagnetic reversals, Magnetostratigraphy, Dating the sea-dloor.

Oceanic ridges: Ridge topography, structure of the upper mantle beneath ridges, Heat-flow and hydrothermal circulation, transform faults and oceanic fracture zones.

UNIT 3:

Continental rifts and rifted margins: general features, rock assemblages, rift development and volcanic activity along rifts, transition from rift to rifted margin, The Wilson Cycle. Continental Transform and strike slip faults.

UNIT 4:

Subduction zones: Oceanic trenches, Morphology of island arc systems, rock assemblages, Structure deciphered from earthquakes, Volcanic and plutonic activity, High pressure Metamorphism, Gravity anomalies of subduction zones.

Orogenic belts: Ocean-continent convergence, Compressional sedimentary basins, Continent-Continent collision, arc-continent collision, suture zones.

Books Recommended:

1. Plate tectonics and crustal evolution - K.C.Condie
2. Aspects of Tectonics- K.S.Valdiya
3. Global Tectonics- Kearey and Vine

Paper M5: Hydrogeology

Core Credit: 2, Period: 28

UNIT 1:

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

Hydrologic properties of rocks: porosity, permeability, specific yield, specific retention, hydraulic conductivity, transmissivity, storage coefficient and methods of their measurements. Hydrographs. Springs and their type. Concept of drainage basins and groundwater basins.

UNIT 2:

Hydraulic properties of aquifer and aquitard and their controlling factors, transmissivity, storavity 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 3:

Concepts of water table and potentiometric surfaces; Water table contour maps, hydrostratigraphic units of India. Artificial recharge of ground water, rain water harvesting. Water balance methods, water level fluctuations: causative factors and their measurement, Problem of over exploitation. Conjunctive use of surface and groundwater. Groundwater legislation.

UNIT 4:

Surface and subsurface geophysical and geological methods of ground water exploration.

Hydro geomorphic and lineament mapping using various remote sensing techniques.

Surface geophysical methods: resistivity, seismic, gravity and magnetic methods. Well logging for delineation of aquifers and estimation of water quality, electrical resistivity and SP, radiation logging, Gamma, Gamma Gamma, Neutron Caliper and temperature logging

Books Recommended:

1.Todd, D.K., 1980: Groundwater Hydrology-John Wiley
2.Davies, S.N. & De Wiest, R.J.M., 1966: Hydrogeology-John Wiley
3.Freeze, R.A. & Cherry, J.A., 1979: Ground Water-Prentice Hall
4.Fetter, C.W., 1990: Applied Hydrogeology-Merill Publishing
5.Raghunath, N.M., 1982: Ground Water-Wiley Eastern
6.Karanth, K.R., 1987: Groundwater Assessment-Development and Management-Tata McGraw Hall
7.Alley, W.M., 1993: Regional Ground Water Quality-VNR, New York

Practical ML1: Exercise related to Ore Geology & Mining Geology, Structural Geology and Survey

Core Credit: 2, Period: 36

(a) **Ore Geology and Mining Geology**: Observation of various physical and optical properties of common oxide and sulfide ore minerals using reflected light microscopy. Assessment of ore and gangue minerals in ore samples. Systematic identification of ore minerals. Identification, description and classification of ore mineral textures in the context of mineral beneficiation and ore genesis. Preparation of polished blocks of ore minerals.

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.

(b) **Structural Geology**: 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.

(c) **Survey**: Basic methods of GPS data collection, uploading the data to a computer, and making simple maps of collected data using GIS software. Surveying of point, line and area features using a handheld GPS receiver. Repeated measurements of point locations for assessment of accuracy. Transfer of GPS data to ArcGIS of any other appropriate GIS application software. Georeferencing maps and satellite images. Transference of GPS data onto maps and satellite images. Use of GPS-based coordinates to find pre-determined locations.

Practical ML2: Exercises related to Mineralogy, Instrumentation and Analytical Techniques, Geotectonics and Hydrogeology

Core Credit: 2, Period: 36

(a) **Mineralogy, Instrumentation and Analytical Techniques**: Microscopic study of rock forming minerals using optical accessories. Exercises on thin section and polished section making, etching and staining. 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.

(b) **Geotectonics**: Understanding and Diagrammatic presentation of the following:
APW paths and their tectonic implications, supercontinent assembly; P-T-t paths in relation to geodynamics; Calculation of rate and vector of plate motion: absolute and relative motion; Plate motion on transform and transcurrent faults, types of transform margins; Delineation of modern-day plate margins and vector of plate motion; Present-day hotspots: oceanic and continental; Different stages of Wilson cycle; Magnetic anomalies: ocean floor spreading; Mariana and Cordilleran type margins; Thermal structure and gravity anomaly patterns of shield, MOR, trench, arc, continental rift; Accretionary orogens, collision orogens: tectonic division of Himalayan collision orogeny

(c) **Hydrogeology**: Presentation of rainfall data-arithmetic mean, isohytal and Thiessen Polygon methods . Analyses of hydrograph and estimation of infiltration capacity, Exercises related to porosity, Estimation of permeability by grain size and laboratory methods, Preparation and interpretation of water table contour maps, calculation of hydraulic gradient, Three point problem to determine groundwater movement. Chemical analyses of water.

Paper ME1(a): Coal Petrology

Elective (Discipline Centric) Credit: 4, Period: 56

UNIT 1:

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

UNIT 2:

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

UNIT 3:

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

UNIT 4:

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

Books recommended

1. Taylor, G.H., Teichmuller, M., Davis, A., Diessel, C.F.K., Littke, R. and Robert, P., 1998: Organic
2. Petrology-Gebruder Borntraeger, Stuttgart
3. Chandra, D., Singh, R.M. and Singh, M.P., 2000: Textbook of Coal (Indian Context)-Tara Book Agency, Varanasi.
4. Singh, M.P., (Ed.), 1998: Coal and Organic Petrology-Hindustan Publ. Corp., New Delhi
5. Stach, E., Mackowsky, M.T.H., Taylor, G.H., Chandra, D., Teichmuller, M. and Teichmuller, R., 1982: 7.Stach's Text Book of Coal Petrology- Gebruder Borntraeger, Stuttgart

Paper ME1(b): Oceanography

Elective (Discipline Centric) Credit: 4, Period: 56

UNIT 1:

Topography of the ocean floor. Sea-floor features – Shelf, slope, rise, basin, oceanic ridges, seamounts, trenches and island arcs.

Physical and chemical properties of sea-water and their spatial variations.

Residence time of elements in sea-water. Major water masses of the world's oceans.

Ocean currents, waves and tides. Important current systems.

UNIT 2:

Thermohaline circulation and the oceanic conveyor belt.

Structure and chemical composition of the atmosphere, lapse rate and stability, scale height, geopotential height, greenhouse gases and global warming. Waves in atmospheric and oceanic systems. Ocean-atmosphere coupling.

UNIT 3:

Atmospheric turbulence and boundary layer. Cloud formation and precipitation processes, air- sea interactions on different space and time scales. Insolation and heat budget, radiation balance, general circulation of the atmosphere and ocean. Climatic and sea level changes on different time scales.

UNIT 4:

Coupled ocean-atmosphere system, El Nino Southern Oscillation (ENSO). General weather systems of India, - Monsoon system, cyclone and jet stream, Western disturbances and severe local convective systems, distribution of precipitation over India.

Marine and atmospheric pollution, ozone depletion.

Biological productivity in the oceans.

Books Recommended:

1. Robert H. Stewart (2008). Introduction to Physical Oceanography. Texas A & M University. 345p.
2. Tom Garrison (2012). Essentials of Oceanography, Sixth Edition. Brooks/Cole Publishers, Belmont. 435p.
3. John H. Steele, Steve A. Thorpe and Karl K. Turekian (Eds) (2009). Elements of Physical Oceanography. Elsevier, Heidelberg. 647p.
4. Garrison, T.S. (1999). Essentials of Oceanography. Wadsworth Publishing Co., California.
5. Pinet, P.R. (1992). Oceanography – An Introduction to the Planet Oceanus. West Publishing Co., Minnesota.
6. Pipkin, B.W and Trent D.D. (2000). Geology and the Environment. Brooks/Cole Publishers, California.

Paper ME1(c): Watershed Management

Elective (Discipline Centric) Credit: 4, Period: 56

UNIT 1:

Concept of watershed and water divide. Watershed characteristics- climatic and physiographic. Strategies for watershed management. Major Indian river basins- surface and groundwater resource potential. Terrain Parameters of watersheds and their role in water resources. Watershed delineation using DEM. Morphometric analysis of watersheds: linear, shape, relief and areal parameters.

UNIT 2:

Soil erosion and its treatment in watershed. Management of natural drainage in watershed. Management of arable and non-arable lands. Hydrologic components of watershed- precipitation, infiltration, evapotranspiration, run off. Sediment yield index-assessment methods Watershed characterisation and prioritization based on morphometric parameters. Case studies and examples from India.

UNIT 3:

Flood damage monitoring and mitigation. Ridge to valley approach. Participatory rural appraisal (PRA) in watershed management. Integrated watershed management programmes- national and regional. Case studies and examples. Remote sensing and GIS applications in monitoring, evaluation and assessment of watershed resources.

UNIT 4:

Water harvesting structures. Techniques of water harvesting- indigenous and engineering methods. Interlinking of rivers-prospects and challenges. Location and planning of water harvesting structures in watersheds using remote sensing and GIS. Case studies and examples from India.

Suggested Books:

1. Watershed management: Madan Mohan Das and Mimi Das Saikia, PHI publications.
2. Watershed management guidebook www.ierstahoe.com/pdf/research/watershed_management_guidebook.pdf
3. Watershed management: JVS Murty, New Age international
4. Watershed management – balancing sustainability and environmental change: Robert J Naiman, Springer Publications.

Field Training MAE1: Field Geology/Industrial/Laboratory Training

Elective (Discipline Centric) Credit: 2

Field visit to places of geological interest. Geological and structural mapping.

Semester - II

Paper M6: Paleobiology and Indian Stratigraphy

Core Credit: 4, Period: 56

UNIT 1:

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 2:

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 3:

Precambrian stratigraphy of India.

Crustal evolution and cratonizing history of Aravalli craton: lithostratigraphy and geochronology of TTG gneisses and granitoids. Contrasts between BGC-I and BGC-II.

Aravalli Supergroup: basement, age and lithostratigraphy.

North Delhi Fold Belt and South Delhi Fold Belt: Contrasts, age and lithostratigraphy.

Bundelkhand craton : lithology and radiometric ages of TTG gneisses, granitoids and mafic dyke swarms.

Singhbhum craton : Older Metamorphic Group, Iron Ore group, Singhbhum Granite, Newer Dolerite,

Chhotonagpur terrain.

Bastar craton : Gneisses and granitoids, Spracrustal sequences, Mafic dyke swarms.

Dharwar Craton: lithological and age contrasts between Western Dharwar Craton and Eastern Dharwar Craton, Gnreenstone belts, Closepet granite.

Mobile belts : Eastern Ghat Mobile Belt, Central Indian Tectonic Zone.

UNIT 4:

Basin configuration, stratigraphy and sedimentary evolution of the following basins. Vindhyan, Chattisgarh and Cuddappah.

Paleogeographic and paleoclimatic conditions prevailing in Indian subcontinent during Paleozoic, Mesozoic and Cenozoic eras. Igneous activity in Indian subcontinent in relation to break up of Gondwanaland. Mountain building activities in Indian subcontinent during Cenozoic Era.

Archean-Proterozoic; Proterozoic-Cambrian,

Permian- Triassic and Cretaceous-Tertiary boundary problems in Indian subcontinent.

Books Recommended:

1.Clarkson, E.N.K., 1998: Invertebrate Palaeontology and Evolution.IV Ed.-Blackwell

2.Stearn, C.W. & Carroll, R.L, 1989: Palaeontology-the Record of Life-John Wiley

3. Principles of Paleontology by David M. Raup and Steven M. Stanley. CBS Publishers and Distributers.

4. Evolution of Vertebrates by E.H. Colbert. Wiely Eastern Ltd.

5.Pomerol, C., 1982: The Cenozoic Era: Tertiary and Quaternary-Ellis Harwood Ltd.

Paper M7: Metamorphic Petrology

Core Credit: 2, Period: 28

UNIT 1:

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.

UNIT 2:

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, glaucophane-lawsonite (blueschist), eclogite.

UNIT 3:

Nature of metamorphic reactions and pressure-temperature. Conditions of metamorphism. Isoreactiongrad, Schreinmakers rule and construction of petrogenetic grids. Graphical representation: ACF, AKF, AFM. Metamorphic differentiation. Anatexis and origin of migmatites. Regional metamorphism and paired metamorphic belts.

UNIT 4:

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:

1. Turner, F.J., 1990: Metamorphic Petrology, McGraw Hill, New York
2. Yardley, B.W. 1989: An Introduction to Metamorphic Petrology-Longman,
3. Bucher, K. and Frey, M.1994: Petrogenesis of Metamorphic Rocks-Springer Verlag
4. Philipotts, A., 1992: Igneous and Metamorphic Petrology-Prentice Hall
5. Best, M.G., 1986: Igneous Petrology-CBS Publ.
6. Kretz, R., 1994: Metamorphic Crystallization-John Wiley
7. Bose, M.K., 1997: Igneous Petrology-World Press
8. Perchuk, L.L. and Kushiro, I.1991: Physical Chemistry of Magmas-Springer Verlag

Paper M8: Remote Sensing in Geosciences

Core Credit: 4, Period: 56

UNIT 1:

Spectral Characteristics of solar radiation. Transmittance of the atmosphere. Spectral reflectance of land covers: soil, water and vegetation

RS Satellite characteristics-orbits and swaths. Sensors used in remote sensing.

Types of satellite remote sensing data used in earth system studies. Image interpretation and analysis. Applications of Remote Sensing techniques in geological investigations-Mapping lithology, lineaments and minerals.

UNIT 2:

Photogrammetry: Applications and recent advances. Aerial photographs and their geometry. Errors in aerial photographs and their correction, swing, tilt, pitch, yaw. Ortho photographs. Classification of aerial photographs and aerial mosaics. Types of Photomosaic. Stereoscopes: mirror and pocket stereoscope. Photogrammetric techniques. Concept of digital photography.

Parallaxes: parallax bar, Parallax formula, height and slope determination. Scale determination of aerial photographs on uniform and variable terrain.

UNIT 3:

Elements of image interpretation (photographic and geotechnical). Characteristics of common igneous, sedimentary, and metamorphic rocks on aerial photographs and satellite images. Geomorphic processes and resulting landforms. Characteristics of common landforms on satellite images and aerial photographs Principles of GIS: functions, data structure and formats. Integration of spatial and non-spatial data in GIS. Applications of GIS in geosciences. Concept of Digital Elevation Model (DEM) and its applications in morphometric analysis.

UNIT 4:

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

Books Recommended:

1. Millor, V.C., 1961 Photogeology. Mc Graw Hill
2. Sabbins, F.F.,1985 Remote Sensing-Principles and Applications. Freeman
3. Moffitt, F.H. and Mikhail, E.M., 1980 Photogrammetry-Harper and Row
4. Lillesand, T.M. and Kieffer, R.W., 1987: Remote Sensing and Image Interpretation-John wiley
5. Pandey, S.N., 1987: Principles and Applications of Photogeology-Wiley Eastern
6. Thornbury, W.D. Principles of Geomorphology
7. Craig, R.G. and Craft, J.L Applied Geomorphology
8. Fundamentals of GIS – M. Demers
9. Encyclopedia of Applied Geology - Finkiel
10. Remote Sensing of Environment by A.R. Jensen
11. Fundamentals of Remote Sensing by George Joseph
12. Geomorphology by Bloom
13. www.isro.org, www.nrsc.gov.in

Paper M9: Geophysical Exploration

Core Credit: 4, Period: 56

UNIT 1:

Variations of gravity over the earth's surface. Measurements of earth's gravity field – Relative gravity and gravity gradients. Density of common rocks and minerals. Gravity survey practice. Reduction of gravity data – Derivation of free-air and Bouguer gravity anomaly maps. Interpretation of gravity maps. Gravity signatures of mineral deposits. Recent development in gravity surveys.

UNIT 2:

The geomagnetic field and its variations. Rock magnetism. Magnetic anomalies. Magnetic surveying instruments – Fluxgate magnetometer, Proton magnetometer, Optically pumped magnetometer, Magnetic gradiometers. Magnetic survey practice – Ground and airborne surveys. Reduction of Magnetic data – Temporal and regional variations in field strength, Elevation and terrain effects. Interpretation of magnetic anomalies. Applications of magnetic surveying.

UNIT 3:

Resistivity methods: Basic principles, Various types of electrode configurations. Field procedures:Profiling and Sounding. Applications of electrical methods in groundwater prospecting and civil engineering problems.

Description of borehole environment, Brief outline of various well-logging techniques. Principles of electrical logging and its applications in petroleum, groundwater and mineral exploration.

UNIT 4:

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

Books Recommended:

1. Lowrie, W. (2007). Fundamentals of Geophysics (Second Ed.) Cambridge University Press, 381p.
2. Keary, P., Brooks, M. and Hill, I. (2002). An introduction to Geophysical Exploration (Third Ed.), Balckwell Science, Oxford. 262p.
3. Lowe, C. Thomas, M.D. and Morris, W.A. (Eds.) (1999). Geophysics in Mineral Exploration: Fundamentals and Case Histories. Geological Association of Canada, Ontario. 175p.
4. Dentith, M. and Mudge, S. (2014). Geophysics for the Mineral Exploration Geoscientist. Cambridge University Press, New York. 438p.

Paper M10: Well Hydraulics and Water Chemistry

Core Credit: 2, Period: 28

UNIT 1:

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 2:

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 3:

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 4:

Representations of hydrochemical data, Piper Trilinear diagram, Ground water facies analysis quality criteria for different uses, drinking, irrigation and industrial uses, Use of Water quality in mineral assessment. Ground Water contaminants and pollutants. Dispersion of pollutants.Evaluation of pollution potential and monitoring of ground water quality.

Hydrochemical provinces of India.

Problem of arsenic and fluoride, radioisotopes in hydrogeological studies.

Books Recommended:

1. Todd, D.K., 1980: Groundwater Hydrology-John Wiley
2. Davies, S.N. & De Wiest, R.J.M., 1966: Hydrogeology-John Wiley
3. Freeze, R.A. & Cherry, J.A., 1979: Ground Water-Prentice Hall
4. Fetter, C.W., 1990: Applied Hydrogeology-Merill Publishing
5. Raghunath, N.M., 1982: Ground Water-Wiley Eastern
6. Karanth, K.R., 1987: Groundwater Assessment-Development and Management-Tata McGraw Hall
7. Alley, W.M., 1993: Regional Ground Water Quality-VNR, New York
8. Subramaniam, V., 2000: Water-Kingston Publ. London.

Paper ME2(a): Geodynamic Processes and Crustal Evolution

Elective (Discipline Centric) Credit: 4, Period: 56

UNIT 1:

Condensation of the Solar System: Evidence from astronomical observations, Cosmochemistry, meteorites. Chondrites and achondrites, Early Earth Systems, Nature of early Geological records, Archaean geological records, Geodynamic processes of Archaean Greenstone belts, Archaean granitegneiss terrains, oldest terrestrial material.

UNIT 2:

Earth differentiation-the first earth system. Constraints on core formation: thermal constraints, geochemical constrants. Accretion history of the Earth. Evolution of the Earth's mantle: evidence from seismology, mantle xenoliths. Mantle convection, mantle plumes. Archaean mantle models: evidence from Archaean basalts, komatiites, boninites.

UNIT 3:

Origin of the continental crust: Crustal growth at destructive plate boundaries, arc magma sources, Conditions of slab melting processes. Crustal growth through intraplate magmatism, Crustal growth through time. Geochemical evidence for the secular evolution of the continental crust. Formation of TTGs, adakites, sanukitoids. Accretionary orogens.

UNIT 4:

Origin of Earth's atmosphere and oceans. The rise of atmospheric oxygen: evidence from redox-sensitive detrital sediments, Fe-mobility in paleosols. Geological evidence for an early Co2-rich atmosphere: Archaean weathering profiles. Controls on CO2 drawdown. Proxies for the nature of early oceans: Archaean limestones, BIF.

Books Recommended:

1. Plate Tectonics and Crustal evaluation-Condie.
2. Aspects of Tectonics-Valdiya.
3. Global Tectonics-Kearey and Vine.

Paper ME2(b): Global Climate Change

Elective (Discipline Centric) Credit: 4, Period: 56

UNIT 1:

Components of Earth Systems – Atmosphere, hydrosphere, lithosphere and biosphere. Parameters of climate regime. Arid, semi-arid, polar, humid and sub-humid climatic regimes. Thronwaite system of climate classification.

UNIT 2:

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

UNIT 3:

Earth's climate and its components. Change of climatic regimes in the earth's history. Global climatic changes- causes, effects and adaptation measures. Impact of climate change on water resources, agriculture, forests and land use/land cover. Case studies and examples.

UNIT 4:

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

Suggested books:

1. Kent Condie-Earth as an Evolving Planetary System-Academic Press (2004).
2. Lee R. Kump,James F. Kasting,Robert G. Crane-The Earth System-Pearson (2009).
3. Trewartha, G.T. , & Horn, L.A. , Introduction to climate, International Studies, 1990.
4. Hussain, Majid., Fundamentals of Physical Geography, Rawat Pub., Jaipur, 2001.

Paper ME2(c): Medical Geology

Elective (Discipline Centric) Credit: 4, Period: 56

UNIT 1:

Definitions: Medical Geology, Ecological Health, Total/One Health. Environmental Epidemiology. History, evolution, and future prospects of medical geology. Geologic materials and processes and their role in human and ecological health. Relationship between public health and geologic processes.

UNIT 2:

Environmental geochemistry: natural and anthropogenic sources of chemical elements and compounds in the environment. Weathering and its control in mobilization of natural elements and compounds. Environmental Biology: Biological function, uptake and body response to elements. Geologic materials and nutrition. Case studies illustrating health and environmental impacts from heavy metals.

UNIT 3:

Principles of toxicology. Disease and well-being. Environmental and behavioural diseases. Disease burden: morbidity and mortality. Major human diseases and mortality in modern time: Top ten killers and their significance. Climate change impacts on human and ecological health and its mitigation. Case histories of vector- and water-borne diseases.

UNIT 4:

Effects of combustion of coal and other fuel materials, dust, heavy metals, volatile organic compounds, and pesticides on human and ecological health. Medical geology data source (maintained by WHO, CDC, USEPA, and others) and its use in medical geology research. GIS applications in human and environmental health. A guided class project on medical geology using available research tools will be conducted during the semester. A final report and team PowerPoint class presentation are required.

Suggested Books:

1. Essentials of Medical Geology, 2nd revised edition, 2013. Olle Selinus (Editor), Springer, 805 p.
2. Earth Materials and Health: Research Priorities for Earth Science and Public Health, 2007. Catherine Skinner (Chair), U.S. National Academy of Sciences. National Academies Press, Washington, DC; 188 p.

Practical MAE2: Lab work related to Paleobiology & Indian Stratigraphy, Metamorphic Petrology and Geophysical Exploration

Ability Enhancement (Discipline Centric) Credit: 2, Period: 36

Exercise related to:

a) **Paleobiology & Indian Stratigraphy**: 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. Exercises on stratigraphic classification and correlation. Exercises on interpretation of seismic records for staratigraphy study of palaeogeographic maps of all geological periods

b) **Metamorphic Petrology**: 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.

c) **Geophysical Exploration**: Study of gravimeter, magnetometer and seismographs. Resistivity survey. Interpretation of underground structure on the basis of seismic data.

Practical MAE3: Lab work related to Remote Sensing in Geosciences and Well Hydraulics & Water Chemistry

Ability Enhancement (Discipline Centric) Credit: 2, Period: 36

Exercise related to

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

Display and inspection of multispectral data in individual bands and various FCCs. Calculating image statistics. Combining separate image bands into a single multispectral image file. Subsetting image data. Querying spectral reflectance and geographic coordinates of pixels in georeferenced images. Image enhancement for increased interpretability of land cover features-linear contrast stretch. Classifying imagery using supervised and unsupervised methods. Ground truth verification using GPS navigation. Integrating ground truth with results of classification. Viewing satellite imagery in 3D. Mapping structural, geological and geomorphological features using satellite imagery.

(a) **Well Hydraulics and Water Chemistry**:

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.

Semester III

Paper M11: Fuel Geology

Core Credit: 4, Period: 56

UNIT 1:

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 2:

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 3:

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 4:

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:

1. Taylor, G.H., Teichmuller, M., Davis, A., Diessel, C.F.K., Littke, R. and Robert, P., 1998:
2. Organic Petrology-Gebruder Borntraeger, Stuttgart
3. Chandra, D., Singh, R.M. and Singh, M.P., 2000: Textbook of Coal (Indian Context)-Tara Book Agency, Varanasi.
4. Singh, M.P., (Ed.), 1998: Coal and Organic Petrology-Hindustan Publ. Corp., New Delhi

5. Stach, E., Mackowsky, M.T.H., Taylor, G.H., Chandra, D., Teichmuller, M. and Teichmuller, R., 1982: Stach's Text Book of Coal Petrology- Gebruder Borntraeger, Stuttgart
6. Holson, G.D. and Tiratsoo, E.N., 1985: Introduction to Petroleum Geology-Gulf Publ. Houston, Texas
7. Tissot, B.P. and Welte, D.H., 1984: Petroleum Formation and Occurrence-Springer Verlag
8. Selley, R.C., 1998: Elements of Petroleum Geology-Academic Press
9. Durrance, E.M., 1986: Radioactivity in Geology. Principles and Application-Ellis Hoorwool
10. Dahlkamp, F.J., 1993: Uranium Ore Depostis-Springer Verlag
11. Boyle, R.W., 1982: Geochemical Prospecting for Thorium and Uranium Deposits-Elsevier

Paper M12: Engineering Geology

Core Credit: 2, Period: 28

UNIT 1:

Development of Engineering Geology, Important Geo-engineering failures. Engineering Geology vs Geology, Role of engineering geology in civil construction and mining industry, various stages of engineering geological investigation for civil engineering projects. Surface and sub-surface investigations for site selection. Geological causes for mishaps and failures of engineering structures. Engineering properties of rocks, rock discontinuities.

UNIT 2:

RQD, engineering classification of rock mass.

Terzaghi's rock mass classification, coates, C-factor, Q-system and geochemical classification.

Improvements of properties of rock mass: grouting, gnuting, rock bolting, cable anchorage.

Active faults, features of active faults, Earthquakes and seismicity, seismic zones of India, Paleoseismic indicators.

UNIT 3:

Engineering properties of soil, Atterberg limits, cohesive and noncohesive soils. Soil classification: textural classification, unified soil classification systems, American Association of State Highway and Transport Officials (AASHTO) classification system. Quick clay, quick sand, thixotrophy, soil liquefaction, Physical characters of building stone, metal and concrete aggregates, size and gradation, shape, surface fearures and coating of aggregates.

Alkali aggregate reactions, artificial aggregate.

UNIT 4:

Mass movements with special emphasis on landslides and causes of hill slope instability.

Geological consideration for evaluation of dams and reservoir sites, dam foundation rock problems.

Geotechnical evaluation of tunnel alignments and transportation routes, methods of tunneling, classification of ground for tunneling purposes, various types of support. Geotechnical investigations for bridges and coastal barriers. Case history of the following engineering projects:

(a) Sardar Sarovar hydroelectric project

(b) Tehri hydroelectric projec**t**

Books Recommended:

1. Sharma, P.V. (1986)-Geophysical Methods in Geology-elsevier
2. Sharma, P.V. (1997)-Environmental and Engineering Geophysics-Cambridge University Press.
3. Vogelsang, D. (1995)-Environmental Geophysics-A Practical Guide-Springer Verlag.
4. Dobrin, M.B. (1976)-Introduction to Geophysical Prospecting-McGraw Hill
5. Parasnis, D.S. (1975)-Principles of Applied Geophysics-Chapman and Hall
6. Stanislave, M. (1984)-Introduction to Applied Geophysics-Reidel Publ.
7. Krynine, D.H. and Judd. W.R. (1998)-Principles of Engineering Geology-CBS Edition.

Paper M14: Geochemistry and Radiogenic Isotopes

Core Credit: 2, Period: 28

UNIT 1:

Cosmic abundances of elements, nucleosynthesis, meteorites.

Periodic Table: Atomic structure, physical and chemical properties of different element groups.

Geochemical classification of elements: major elements, trace elements, transition elements, Compatible and incompatible elements, HFSE, LILE, LFSE, PGE, REE.

Special properties of alkali elements (AE), alkaline earth (AEE), transition (TE) and rare earth elements (REE).

UNIT 2:

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 3:

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 4:

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:

1. 1.Mason, B. and Moore, C.B., 1991: Introduction to Geochemistry-Wiley Eastern
2. 2.Krauskopf, K.B., 1967: Introduction to Geochemistry-McGraw Hill
3. 3.Faure, G., 1986: Principles of Isotope Geology-John Wiley
4. 4.Hoefs, J., 1980: Stable isotope Geochemistry –Springer Verlag
5. 5.Marshal, C.P. and Fairbridge, R.W., 1999: Encyclopaedia of Geochemistry-Kluwer Academic
6. 6.Govett, G.J.S. (Ed.), 1983: Handbook of Exploration Geochemistry-Elsevier
7. 7.Nordstrorm, D.K. and Munoz, J.L., 1986: Geochemical Thermodynamics-Blackwell
8. 8.Henderson, P., 1987: Inorganic Geochemistry-Pergamon Press

Paper M15: Sedimentology

Core Credit: 2, Period: 28

UNIT 1:
Earth surface systems: Liberation and flux of sediments.
Fundamentals of fluids laminar and turbulent flow.
Reynodls number, Froude number, velocity profiles and bed roughness.
Flow regimes- Idealized sequence of structures in lower and upper flow regimes. Hyulstroms diagram.
Particle transport by sediment gravity flow. Boumas ideal sequence.

UNIT 2:
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 3:
Classification of sedimentary environments.
Facies Models of alluvial-fluvial, lacustrine, desert-aeolian and glacial sedimentary systems.
Shallow coastal clastics, Marine and continental evaporates

UNIT 4:
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:

1. Allen, J.R.L., 1985: Principles of Physical Sedimentation-George Allen & Unwin
2. Allen, P., 1997: Earth Surface Processes-Blackwell
3. Nichols, G., 1999: Sedimentology and Stratigraphy-Blackwell
4. Reading, H.G., 1996: Sedimentary Environment-Blackwell
5. Davis, R.A. Jr., 1992: Depositional System-Prentice Hall
6. Einsele, G., 1992: Sedimentary Basins-Springer Verlag
7. Relneck, H.E. and Singh, I.B., 1980: Depositional Sedimentary Environments-Springer Verlag
8. Miall , A.D., 2000: Principles of Sedimentary Basin Analysis-Springer Verlag
9. Pettijohn, F.J., Potter, P.E. and Siever, R., 1990: Sand and Sandstone-Springer Verlag
10. Bhattacharya, A. and Chakraborti, C., 2000: Analysis of Sedimentary Successions-Oxford-IBH
11. Boggs Sam Jr., 1995: Principles of Sedimentary and Stratigraphy-Prentice Hall

Paper M16: Environmental Geology

Core Credit: 2, Period: 28

UNIT 1:

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 2:

Thermal inversion, suspended particulate matter, heavy metals, carbon mono oxide, sulfur dioxide, nitrogen oxide, volatile organic compounds, ground level ozone, natural sources, smog and tropospheric ozone.

Impact of circulation in atmosphere and oceans on climate, rainfall and agriculture, wind system, global circulation, Coriolis effect

Thermal interactions between oceans and atmosphere, advective and convective processess, Heat budget of ocean, ocean ecosystem, ocean currents, general pattern of oceanic circulation.

UNIT 3:

Structure and evolution of atmosphere, chemical evolution of atmosphere. Role of volcanism and recent atmospheric changes. Recent major volcanic eruptions and their effects on the atmosphere. Global warming : causes and effects. Global climatic changes: causes, impacts, assessment and adaptation measures. UNFCCC: role and mandate. Climate change impacts on water resources, agriculture and land use /land cover. Examples and case studies. GIS applications in climate change studies.

UNIT 4:

Nitrogen oxide and ozone layer, cycling of carbon, records of paleotemperature in ice cores of glaciers, palaeo-temperature changes during the glacial ages, glacial ages, last ice age, causes of glaciation, Limestone deposits and climate change.

Cenozoic climate extremes, evolution of life especially the impact on human evolution.

Books Recommended:

1. Valdiya, K.S., 1987: Environmental Geology-Indian Context-Tata McGraw Hill
2. Keller, E.A., 1978: Environmental Geology-Bell and Howell, USA
3. Bryant, E., 1985: Natural Hazards-Cambridge University Press
4. Patwardhan, A.M., 1999: The Dynamic Earth System-Prentice Hall
5. Subramaniam, V., 2001: Textbook in Environmental Science-Narosa International
6. Bell, F.G., 1999: Geological Hazards-Routledge, London
7. Smith, K., 1992: Environmental Hazards-Routledge, London

Practical ML3: Lab work related to Fuel Geology, Engineering Geology and Sedimentology

Core Credit: 2, Period: 36

(a) **Fuel Geology**: Maps and exercises related to coal geology, Study of geological maps and sections of important oilfields of India, Exercises and maps related to petroleum geology, Study of geological sections of U-Th bearing rocks of the country, Megascopic study of some uranium and thorium bearing minerals and rocks.

(b) **Engineering Geology**: Study of properties of common rocks with reference to their utility in engineering projects, Study of maps and models of important engineering structures as dam sites and tunnels, Interpretation of geological maps for landslide problems.

(c) **Sedimentology**: 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.

Practical ML4: Lab work related to Geochemistry and Radiogenic Isotopes, Environmental Geology and Computer Applications

Core Credit: 2, Period: 36

(a) **Geochemistry and Radiogenic Isotopes**: Rock/Soil/sediments/water analysis. Calculation of mineral formulae from concentration of various oxides in minerals.

(b) **Environmental Geology**: 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.

(c) **Computer Applications**: Computer applications in geological and environmental studies using satellite imageries, digital elevation data, virtual globes and different software packages:

i. Land cover change detection using GIS and reflectance imageries.
ii. Mapping urban sprawl around a moderately sized urban agglomeration and assessing its implications.
iii. Preparing landslide inventory maps using Virtual Globes.
iv. Geological mapping using reflectance imagery as a base map.

Paper ME3(a): Applied Remote Sensing

Elective (Discipline Centric) Credit: 4, Period: 56

UNIT 1:

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

UNIT 2:

Application of remote sensing in drought monitoring and assessment- hydrological drought, agricultural drought and meteorological drought. CAPE and CADA missions of Indian government. Sediment yield index- role of remote sensing and GIS. Case studies and examples. RS and GIS applications for site selection of dams, water harvesting structures and waste disposal. Examples and case studies.

UNIT 3:

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. Hydrogeomorphic mapping for ground water potential zones.

UNIT 4:

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:

1. Sabbins, F.F.,1985 Remote Sensing-Principles and Applications. Freeman
2. Lillesand, T.M. and Kieffer, R.W., 1987: Remote Sensing and Image Interpretation- John wiley
1. Fundamentals of GIS – M. Demers
2. Encyclopedia of Applied Geology – Finkiel
3. Remote Sensing and Geographical Information System-M.Anji Reddy.
4. Remote sensing and Geographic Information System by A.M. Chandra
3. Remote Sensing of Environment by A.R. Jensen
4. Fundamentals of Remote Sensing by George Joseph

Paper ME3(b): Advanced Ore Geology

Elective (Discipline Centric) Credit: 4, Period: 56

UNIT 1:

Ore deposits related to chemical sedimentation: Sedimentary base-metal deposits and other chemical precipitates, Sedimentary iron deposits, Sedimentary manganese deposits, Phosphate deposits, Evaporites, Manganese nodules.
Ore deposits related to clastic sedimentation: Placer deposits.
Ore deposits Related to Weathering: Nickel laterite deposits, Manganese deposits, Bauxite deposits, Supergene sulfide enrichment.

UNIT 2:

Ore deposit types and their primary expressions:
Dispersion around magmatic deposits, contact metasomatic (skarn) deposits, hydrothermal deposits, exhalative deposits, marine-sedimentary deposits, metamorphic deposits, residual & supergene deposits and placer deposits

UNIT 3:

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.
Textures formed due to exsolution.
Textures formed due to precipitation from colloids.
Textures formed due to deformation.

UNIT 4:

Ore deposits in a global tectonic context: Patterns in the distribution of mineral deposits, Continental growth rates, Crustal evolution and metallogenesis, Metallogeny through time, Plate tectonics and ore deposits.
Mineralization through Geological time.
Mineral deposits at terrestrial impact structures.

Books Recommended:

1. Introduction to Ore Forming Processes – Lawrence Robb, 2005, Blackwell Publishing Company, Victoria, 373pp.
2. Mineral Deposits and Earth Evolution – I. McDonald, A.J. Boyce, I.B. Butler, R.J. Herrington and D.A. Polys (Eds), 2005, The Geological Society of London. 269pp.
3. Metals and Society – An Introduction to Economic Geology - Nicholas Arndt and Clément Ganino, 2012, Springer, Heidelberg, 160pp.
4. Ore Deposit Types and their Primary Expressions – K K.G. McQueen, CRC LEME, Australian National University, Canberra, ACT 0200 and School of REHS, University of Canberra, ACT 2601. 14p.
5. The Geology of Ore Deposits – John M. Guilbert and Charles F. Park, Jr., 2007, Waveland Press Inc., Illinois, 984pp.
6. Ore Microscopy and Ore Petrography – J.R. Craig and D.J. Vauhan, 1994. John Wiley and Sons, 434pp.
7. Metal deposits in relation to plate tectonics – F.J. Sawkins, 2013. Springer Science & Business Media, 461pp.
8. Ore Petrology – R.L. Stanton, 1972. McGraw-Hill, 713pp.
9. Economic Geology and Geotectonics – D.H. Tarling, 1981. John Wiley and Sons, 213pp.
10. Ore genesis – A Holistic Approach – A. Mookherjee, 1999. Allied Publishers, 657pp.
11. Hydrothermal Mineral Deposits: Principles and Fundamental Concepts for the Exploration Geologist – F. Piranjo, 2012. Springer Science & Business Media, 709pp.

Paper ME3(c): Advanced Hydrogeology

Elective (Discipline Centric) Credit: 4, Period: 56

UNIT 1:

Hydrographic analyses: hydrograph separation, baseflow recession, storm hydrograph. Gaining and losing streams. Water balance: groundwater recharge, discharge and balance, estimation of recharge components, estimation of groundwater discharge, water balance-case histories. Occurrence of groundwater in various geological formations. Spring (including thermal): type, origin and movement of water.

UNIT 2:

Principle of groundwater flow: mechanical energy, hydraulic head, force potential and hydraulic head, Darcy Law in terms of force potential.

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.

UNIT 3:

Groundwater contamination: septic tank and cesspools, landfills, chemical spills and leaking underground tanks, mining and other sources of groundwater contamination. Bacteriological analyses of drinking water: faecal coliform bacteria. Trace elements: source, trace element and health hazards. Isotope hydrology: tritium, radiocarbon dating of groundwater, stable isotope of oxygen and hydrogen and other isotope. Fossil water and its significance.

UNIT 4:

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

Books Recommended:

1. Chow, V.T., 1988: Advances in Hydroscience-McGraw Hill
2. Walton, W.C., 1988: Ground Water Resource Evolution-McGraw Hill
3. Black, W. and Others (Ed.), 1989: Hydrogeology-Geol. Soc. Of America Publ.
4. Mahajan, G., 1990: Evolution and Development of Ground Water-D.K. Publisher
5. Singhal, B.B.S., 1986: Engineering Geosciences-Savita Prakashan

Paper ME3(d): Petroleum Exploration

Elective (Discipline Centric) Credit: 4, Period: 56

UNIT 1:
Origin of Petroleum: Organic and Inorganic
Production and preservation of organic matter and formation of Kerogen
Petroleum migration
Petroleum System and Basin Modeling
Physical and chemical properties of petroleum

UNIT 2:
Geophysical methods of petroleum exploration: Magnetic, Gravity, and Seismic surveys, 4-D Seismic survey
Application of remote sensing in petroleum exploration
Reservoirs: Types and characters
Reservoir continuity
Traps and seals: Structural, Stratigraphic, diapric

UNIT 3:
Application of microfossils in Petroleum Exploration
Sampling procedures and processing of microfossils in commercial laboratories
Biosteering: method and application
Types and hydrocarbon potential of organic reefs
Application of logs in petrophysics and facies analysis

UNIT 4:
Drilling rigs and their components
Types of drilling: Cabe tool, Rotary, Directional, Horizontal
Hydrocarbon reserve calculation and production methods, Enhanced Recovery methods
Non-conventional Petroleum Resources; Tar Sand, Oil Shale, Shale Gas, CBM, Gas Hydrate
Prospects and probabilities of hydrocarbon, Prospect Appraisal: Geologic and Economic aspects, assessment of Basin and Global reserves

Books Recommended

1. Richard C. Selly: Elements of Petroleum Geology. 2nd Edition. Academic Press
2. F. K. North: Petroleum Geology. Allen and Unwin
3. B. P. Tissot and D. H. Welte: Petroleum Formation and Occurrence. 2nd Revised and Enlarged Edition. Springer-Verlag.

Paper ME3(e): Rock Deformation & Structural Analysis

Elective (Discipline Centric) Credit: 4, Period: 56

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:

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.

UNIT 4:

Types of cleavage and lineation. Geometric relationship of cleavage to folding. Strain significance of cleavage. Tectonites and their significance. Descriptive and geometric analysis of tectonites.

Books recommended

1. Structural analysis of metamorphic Tectonics-Turner and Weiss.
2. Structural Geology of Rocks and Regions-Davis.
3. Folding and Fracturing of Rocks-Ramsay.
4. An Outline of Structural Geology-Hubbs, Mears and William.
5. A Manual of Problems in Structural Geology-Gokhle

Field Training MAE4: Field Geology/Industrial/Laboratory Training

Ability Enhancement (Discipline Centric) Credit: 4

Visit to areas of geological interest, Visit to important underground and open cast mines.

Semester IV

Paper M17: Geochemistry and Stable Isotopes

Core Credit: 2, Period: 28

UNIT 1:

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 2:

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 3:

Laws of thermodynamics, concept of free energy, activity, fugacity and equilibrium constant, thermodynamics of ideal, non-ideal and dilute solutions. Principles of ionic, substitution in minerals, element partitioning in mineral/rock formation.

Concept of simple distribution co-efficient and exchange reaction distribution coefficients.

Elements partitioning in mineral assemblages and its use in P-T estimation.

UNIT 4:

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:

1. Mason, B. and Moore, C.B., 1991: Introduction to Geochemistry-Wiley Eastern
2. Krauskopf, K.B., 1967: Introduction to Geochemistry-McGraw Hill
3. Faure, G., 1986: Principles of Isotope Geology-John Wiley
4. Hoefs, J., 1980: Stable isotope Geochemistry –Springer Verlag
5. Marshal, C.P. and Fairbridge, R.W., 1999: Encyclopaedia of Geochemistry-Kluwer Academic
6. Govett, G.J.S. (Ed.), 1983: Handbook of Exploration Geochemistry-Elsevier
7. Nordstrorm, D.K. and Munoz, J.L., 1986: Geochemical Thermodynamics-Blackwell
8. Henderson, P., 1987: Inorganic Geochemistry-Pergamon Press

Paper M18: Applied Sedimentation

Core Credit: 2, Period: 28

UNIT 1:

Textural and mineralogical maturity of clastic rocks.

Sandstone classification.Volcaniclastic: on-land and marine.

Diagenesis and fluid flow: diagenesis of mudstones, sandstones and carbonate rocks: changes in mineralogy, fabric and chemistry. Classification of conglomerate. Chert: occurrence and petrographic characteristics.

UNIT 2:

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

UNIT 3:

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 4:

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:

1. Allen, J.R.L., 1985: Principles of Physical Sedimentation-George Allen & Unwin
2. Allen, P., 1997: Earth Surface Processes-Blackwell
3. Nichols, G., 1999: Sedimentology and Stratigraphy-Blackwell
4. Reading, H.G., 1996: Sedimentary Environment-Blackwell
5. Davis, R.A. Jr., 1992: Depositional System-Prentice Hall
6. Einsele, G., 1992: Sedimentary Basins-Springer Verlag
7. Relneck, H.E. and Singh, I.B., 1980: Depositional Sedimentary Environments-Springer Verlag
8. Prothero, D.R. and Schwab, F., 1996: Sedimentary Geology-Freeman
9. Miall , A.D., 2000: Principles of Sedimentary Basin Analysis-Springer Verlag
10. Pettijohn, F.J., Potter, P.E. and Siever, R., 1990: Sand and Sandstone-Springer Verlag
11. Biatt, H., Murray, G.V. and Middleton, R.C., 1980: Origin of Sedimentary rocks
12. Bhattacharya, A. and Chakraborti, C., 2000: Analysis of Sedimentary Successions-Oxford-IBH
13. Boggs Sam Jr., 1995: Principles of Sedimentary and Stratigraphy-Prentice Hall
14. Sengupta, S., 1997: Introduction to Sedimentology-Oxford-IBH

Paper M19: Environmental Pollution and Natural Hazards

Core Credit: 2, Period: 28

UNIT 1:

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 2:

Water logging, problems of water logging due to indiscrete construction of canals, reservoirs, dams, water logging problem in India, Floods, causes of floods, flood hazarad, 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 4:

Natural hazards: Concepts of environmental security. Neotectonics and seismic hazards assessment. Seismicity in India and significance of seismic hazard maps. Distribution, magnitude, intensity and geological effects of earthquakes. Sea level rise: impacts and risks. Desertification: causes, impact and assessment. Wasteland classification: mapping and reclamation. Application of remote sensing & GIS in natural hazards. Examples & case studies.

Books Recommended:

1. Valdiya, K.S., 1987: Environmental Geology-Indian Context-Tata McGraw Hill
2. Keller, E.A., 1978: Environmental Geology-Bell and Howell, USA
3. Bryant, E., 1985: Natural Hazards-Cambridge University Press
4. Patwardhan, A.M., 1999: The Dynamic Earth System-Prentice Hall
5. Subramaniam, V., 2001: Textbook in Environmental Science-Narosa International
6. Bell, F.G., 1999: Geological Hazards-Routledge, London
7. Smith, K., 1992: Environmental Hazards-Routledge, London
8. Vulnerability, threats and analysis-Case Studies from India, TERI, The Energy & Resources Institute, New Delhi.

Paper M20: Applied Geomorphology

Core Credit: 4, Period: 56

UNIT 1:

Fundamental Geomorphic concepts, landscape evolution, relationship between form and process, geomorphic features produced by faulting, tectonic geomorphology, tectonic geomorphology and faulting, landforms of strike-slip, normal and reverse faulting. Endogenic and exogenic processes. Weathering-Types and associated landforms. Soil- factors in soil formation, soil profile, major soil types/groups of India. Mass wasting and its geomorphic significance. Major geomorphic units of India.

UNIT 2:

Introduction, Hypsometric Curve and Hypsometric Integral, drainage basin asymmetry, stream length-gradient index (SL), mountain-front sinuosity (Smf), ratio of valley-floor width to valley height (Vf), alluvial fans and tectonic activity at mountain fronts. Introduction, bedrock rivers, alluvial rivers, and river grade, coseismic modification of river systems, fluvial responses to tectonic modification, aggradation and degradation, changes in drainage and stream pattern, responses of bedrock channels, changes in longitudinal profile, fluvial terraces, other responses to longitudinal deformation, responses to lateral tilting, models of tectonic adjustment

UNIT 3:

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

UNIT 4:

Arid geomorphologic cycle. Characteristics of arid and semi arid regions. Landforms formed by wind- pedestal rock, dunes, loess, bajada, salina, blow holes, pediments, inselberg, ruware, yardang, ventifacts etc. Landforms formed in sedimentary and igneous rocks. Glacial landforms- arte, cirque, moraines, hanging valleys, drumlins, etc. Coastal processes and resulting landforms. Applied geomorphology: civil engineering, environmental studies, groundwater targeting etc.

Books Recommended:

1. Principles of Geomorphology by Willium D Thornbury, CBS Publishers and distributers
2. Geomorphology by Arthur L Bloom, PHI Publishers
3. Burbank D. W. and Anderson R. S. (2011). Tectonic Geomorphology, Blackwell Publishing, Oxford, 274 p.
4. Gardiner V. (1990). Drainage basin morphometry. In: Goudie AS (ed) Geomorphological techniques. Unwin Hyman, London, pp 71–81.
5. Keller E. (1986). Investigation of active tectonics: use of surficial earth processes. In: Wallace, R.E. (Ed.), Active Tectonics. Studies in Geophysics. Nat. Acad. Press, Washington, DC, p136-147.
6. Keller E. and Pinter N. (2000). Active Tectonics: Earthquakes, Uplift and Landscape, Prentice Hall, New Jersey.
7. Valdiya, K.S. (2010). The Making of India-Geodynamic Evolution. Macmillan Publishers India Ltd., New Delhi, p 816.
8. Wohl, E. (2013). Mountain Rivers Revisited. American Geophysical Union. ISBN: 978-0-87590-323-1.
9. Ron Cook, Andrew Warren and Andrew Goudie (1993): Desert Geomorphology. University College London Press. ISBN: 81-7314-003-0

Paper M21: Planetary Geology

Core Credit: 2, Period: 28

UNIT 1:

General characteristics and origin of the Universe, Solar System and its planets. The terrestrial and Jovian planets. Earth in the solar system, Observation and exploration of the terrestrial planets – Mercury, Venus, Earth and Mars. Basic planetary data of Terrestrial planets – Atmospheres, surfaces and interiors, magnetic fields and magnetospheres.

UNIT 2:

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

UNIT 3:

Geological processes affecting the solid surfaces of planets – Meteorite Impacts, Magmatism, Tectonics and Gradation. Small bodies of the inner solar system: Asteroids and meteorites. Asteroid types, Orbital groupings of asteroids, Geological processes on asteroids, Zonation of asteroid belt, Evolution of asteroids, Types of meteorites.

UNIT 4:

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

Books Recommended:

1. *New Views of the Solar System*. Compton's by Britanica, Encyclopædia Britannica, Inc. (2013) ISBN: 978-1-62513-039-6
2. *Introduction to planetary science: The geological perspective.* Gunter, F. and Teresa, M. M. Springer, the Netherlands (2007). ISBN: 13 978-1-4020-5544-7.
3. *Earth as an Evolving Planetary System*. Kondi, K.C. Elsevier, Amsterdam. 2016. ISBN: 978-0-12-803689-1.
4. Planetary Tectonics. Watters, T.R. and Schultz, R.A. Cambridge University Press. 2010. ISBN 978-0-521-76573-2.
5. *Planetary Surface Processes*. Melosh, S.J. Cambridge University Press. 2011. ISBN: 978-0-521-51418-7.
6. *Advances in Geosciences: Planetaty Science (Volume 3*). Bhardwaj A. (Ed). 2006. World Scientific Publishing C. Pte. Ltd. Singapore. ISBN: 981-256-983-8.
7. *Interiors of Planets.* Cook, A.H. Cambridge University Press, London. 1980. ISBN: 978-0-521-23214-2.
8. Dynamics of Small Bodies of the Solar System. Steves, B.A. and Roy, A.E. Springer-Science + Business Media, B.V. ISBN: 978-90-481-5133-2.
9. *The Origin and Evolution of the Solar System*. Woolfson, M.M. Institute of Physics Publishing, Bristol. 2000. ISBN: 0 7503 0457 X.
10. *New Frontiers in the Solar System - An Integrated Exploration Strategy*. Space Studies Board (Division of Engineering and Physical Sciences), The National Academies Press, Washington, D.C. 2003. ISBN: 0-309-08495-4.
11. The four major categories of geological processes that shape the solid-surface planets. Dawes, R. https://commons.wvc.edu/rdawes/ASTR217/Plan_Geol_Lecture.htm Accessed 15.08.2018.

Practical ML5: Lab Exercises related to Geochemistry and Stable Isotopes, Applied Sedimentation and Computer Applications

Core Credit: 2, Period: 36

(a) **Geochemistry and Stable Isotopes**: Calculation of weathering indices in soil and sediments .Presentation of analytical data.

(b) **Applied Sedimentation**: 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.

(c) **Computer Applications**: Exercises in basin morphometry using digital elevation data and GIS software. Calculation of Relief Ratio (R_r), Channel sinuosity (C_s), Bifurcation Ratio (R_b), Asymmetry factor (A_f), Drainage density (D_d), Basin elongation ratio (R_e), Basin Shape (B_s), Hypsometric integral (HI), Valley floor width-to-height ratio (V_f), Stream-length gradient index (SL)

Practical ML6: Lab Exercise related to Environmental Pollution & Natural Hazards, Applied Geomorphology and Planetary Geology

Core Credit: 2, Period: 36

a) **Environmental Pollution and Natural Hazards**: Evaluation of environmental impact of air pollution groundwater, landslides, deforestation, cultivation and building construction in specified areas.

b) **Applied Geomorphology**: Mapping and delineation of geomorphic landforma (fluvial and eolian) on satellite images and aerial photographs. Identification and mapping of soil/water erosion areas on FCC data. Drainage basin analysis: Computation of shape, aerial and relief parameters of drainage basins. Hydrogeomorphic mapping using IRS/LANDSAT satellite data. Prioritization of watersheds on the basis of morphometric parameters.

c) **Planetary Geology**: Examination and comparison of global-scale surface landforms of terrestrial planets. Study of major geological processes – Impact craters, Magmatism, Tectonics and Gradation – that shape the surfaces of planets and moons using images acquired from orbit. Photogeologic mapping of the Moon and Mars.

Paper ME4(a): Exploration Geochemistry

Elective (Discipline Centric) Credit: 4, Period: 56

UNIT 1:
Geochemical data analysis- evaluation of quality of data,
Precision and accuracy, presentation and statistical treatment of data.
Interpretation of data
Distribution of elements, primary dispersion, secondary dispersion.
Abundance, distribution, and migration of ore forming elements
Use of isotopes in geochemical exploration

UNIT 2:
Evolution and geochemical characteristics of the regolith,
Factors controlling the mobility and form of elements in various environments
Selection of appropriate sampling and analytical method.
Geochemical exploration methods-lithogeochemical, hydrogeochemical, atmogeochemistry.
Soil survey, pedochemical methods, overburden geochemistry.
Drainage survey, stream sediment survey-bed sediments, flood plain geochemistry, lake sediments.
Geobotanical survey, biogeochemical survey.

UNIT 3:
Geochemical prospecting
Radon as a geochemical exploration tool-generation, migration, radon measuring methods, applications in exploration
Quaternary dating methods
Fission tract plateau dating
Thermoluminiscence/OSL dating
Marine and Lacsturine sediments dating with ^{210}Pb

UNIT 4:
Geochemical background survey
Causes of geochemical anomalies
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

Books Recommended:

1. Pacal, Z. (ed), 1977: Geochemical Prospecting Methods-Ustrendi
2. Brooks, A.R., 1972 : Geobotany and Biogeochemistry in Mineral Exploration-Harper & Row
3. Rose, A.W., Hawkes, H.E. and Webb, J.A. 1979: Geochemistry in Mineral Exploration-Academic Press

Paper ME4(b): Sedimentary Environments and Sedimentary Basins

Elective (Discipline Centric) Credit: 4, Period: 56

UNIT 1:

Sedimentary cycles, rythms and cyclothems. Analysis of sedimentary facies and preparation of facies maps. Lithofacies, biofacies, dynamics and primary structures associated with the environments- alluvial fan, river plains, glaciers, deltas and estuaries.

UNIT 2:

Sedimentation pattern and depositional environment of selected undeformed sedimentary basins of India representing Precambrian, Phenerozoic and contemporary basins. Volacniclastics- formation and general characteristics, types of pyroclastics.

UNIT 3:

Sequence stratigraphy-historical perspective, concepts and principles, sequence stratigraphic tools, application to depositional system. 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 4:

Trace fossils- occurrence, association and petrographic characteristics, use of trace fossils, stromatolites,thrombolites and related structures in paleoenvironment analysis.

Books Recommended:

1. Allen, J.R.L., 1985: Principles of Physical Sedimentation-George Allen & Unwin
2. Allen, P., 1997: Earth Surface Processes-Blackwell
3. Nichols, G., 1999: Sedimentology and Stratigraphy-Blackwell
4. Reading, H.G., 1996: Sedimentary Environment-Blackwell
5. Davis, R.A. Jr., 1992: Depositional System-Prentice Hall
6. Einsele, G., 1992: Sedimentary Basins-Springer Verlag
7. Reineck, H.E. and Singh, I.B., 1980: Depositional Sedimentary Environments-Springer Verlag
8. Miall , A.D., 2000: Principles of Sedimentary Basin Analysis-Springer Verlag
9. Pettijohn, F.J., Potter, P.E. and Siever, R., 1990: Sand and Sandstone-Springer Verlag
10. Bhattacharya, A. and Chakraborti, C., 2000: Analysis of Sedimentary Successions-Oxford-IBH
11. Boggs Sam Jr., 1995: Principles of Sedimentary and Stratigraphy-Prentice Hall

Paper ME4(c): Impact of Geology on Environment

Elective (Discipline Centric) Credit: 4, Period: 56

UNIT 1:

Concept of Ecosystem; Ecology, Ecological perspective of Environment, Biotic communities, Biological Diversity. Values of Indian Biodiversity, Indian Biodiversity under serious threat. Concept of sustainable development-sustainable living and non-living resources.

Environmental priorities in India and sustainable development. The nature of earth resources.

UNIT 2:

Geotechnical consideration and Environmental implication of Roads and Canal construction, Dams and Reservoirs. Landslides and related phenomeno. Coastal hazards, Hazards on Indian coasts, Cyclones and their mitigation methods. 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 3:

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. 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 4:

Environmental laws, implementing the Environmental Laws. Indian Laws, Environmental Policy matters, pollution prevention and control. Environmental Impact Assessment. Hazardous substances management. Environment Education, Information and awareness.

Books Recommended:

1. Valdiya, K.S., 1987: Environmental Geology-Indian Context-Tata McGraw Hill
2. Keller, E.A., 1978: Environmental Geology-Bell and Howell, USA
3. Bryant, E., 1985: Natural Hazards-Cambridge University Press
4. Patwardhan, A.M., 1999: The Dynamic Earth System-Prentice Hall
5. Subramaniam, V., 2001: Textbook in Environmental Science-Narosa International
6. Bell, F.G., 1999: Geological Hazards-Routledge, London
7. Smith, K., 1992: Environmental Hazards-Routledge, London

Paper ME4(d): Engineering Geology and Geotechnics

Elective (Discipline Centric) Credit: 4, Period: 56

UNIT 1:

Site Investigation and exploration. Geotechnical Investigations-targets and techniques. Surface and sub-surface Investigations.

Geophysical techniques for near surface studies.

Seismicity- Active faults, Fractal distribution of faults and earthquakes, Induced seismicity,

Slope Stability-Stability analysis, stabilization, Reinforcement.

UNIT 2:

Discontinuities-Geometry, surface features, roughness, JRC, Rock Quality Indices, fracture frequency, C-factor, mass factor, velocity ratio, strength of discontinuity. Rock mass fabric-Geotechnical description and classification of rock masses. Classifications based on unconfined compressive strength, modulus ration, Rating concept, RMR, Total Rating, Rock mass quality classification. Rock mass reinforcement.

UNIT 3:

Soil- grading, consistency limits and their measurements, shear strength of soil.

Foundations for Buildings-Stress distribution, foundation failure, settlement, subsidence, Mitigation of subsidence.

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 4:

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

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
3. Fundamentals of Engineering Geology - F.G. Bell.
4. Engineering Geology and Geotechnics - F.G. Bell.
5. Rock Mechanics - W. Wittke
6. Rock Mechanics and Engineering - C. Jeger

Paper ME4(e): Glaciology

Elective (Discipline Centric) Credit: 4, Period: 56

UNIT 1:

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

UNIT 2:

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

UNIT 3:

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

UNIT 4:

Glacial Hydrolology and Hydrochemistry: Glacial hydrological system, meltwater process, mechanism of water discharge, characterstics of glacier runoff, diurnal and annual cycle, longterm variation, process of solute acquisition two component mixining model, chemical weathering process, meltwater character of Himalayan glacier, Application of isotopes in cryosphere studies.

Books Recommended

1. Field Techniques in Glaciology and Glacial Geomorphology by Bryn Hubbard and Neil F. Glasser, Wiley International.
2. The Physics of Glaciers, Fourth Edition Hardcover, 2010, Kurt M. Cuffey and W. S. B. Paterson
3. Holmes' Principles of Physical Geology Paperback 1993, P. McL. D. Duff and Arthur Holmes
4. Himalayan Glaciers, 1999, Syed Iqbal Hasnain, Allied Publishers Himalayan
5. Snow and Glacier Hydrology, 2000, P. Singh, Vijay P. Singh

Paper OE(AE)(a): Global Change

Open Elective (AE) Credit: 4, Period: 56

UNIT 1:

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

UNIT 2:

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

UNIT 3:

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

UNIT 4:

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

Books Recommended:

1. Emilio Chuvieco (2008) Earth Observation of Global Change. Springer Science
2. O'Neill B.C., Mackellar F.L. and Lutz W. (2001) Population and climate change. CambridgeUniversity
3. William L. Steffen and Susannah Eliott (2004). Global change and the earth system: a planet under pressure, International Geosphere-Biosphere Program (IGBP) Secretariat, 40 pages
4. Al Gore (2013), Six Drivers of Global Change, Random House, 554 pages.
5. David C Cuff and Andrew S Goudie (Eds) (2009). The Oxford Companion to Global Change. Oxford University Press, 683 pages.
6. Frank Biermann and Bernd Siebenhuner (Eds) (2009). Managers of Global Change: The Influence of International Environmental Bureaucracies. Massachusetts Institute of Technology,
7. Turner B.L., Clark W.C., Kates R.W., Richards J.F., Matthews J.T., and Meyers W.T. (1991). The Earth as transformed by human action: Globaland regional changes in Biosphere over the last 300 years. Cambridge University Press,New York
8. Parkinson C. L., Ward A., & King M. D. (Eds.) (2006).Earth science reference handbook.A guide to NASA's Earth science program and earth observing satellite missions. Washington, DC: National Aeronautics and Space Administration.

Paper OE(AE)(b): Earth Systems

Open Elective (AE) Credit: 4, Period: 56

UNIT 1:

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

UNIT 2:

Physical processes inside the earth, magmatism: mechanism and causes, Earthquakes at plate margins, Stable Continental Region (SCR) Earthquakes, Mountain building activities, gravity and magnetic properties of earth. Magnetic polarity reversals.

Radioisotopes and age determination, Formation of various rock types (Igneous, sedimentary and Metamorphic)

UNIT 3:

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

UNIT 4:

Natural Hazards (floods, landslides, earthquakes, tsunami)- Preventive/ precautionary measures. Nuclear waste disposal, Environment protection- legislative measures, Ground water chemistry, problems and management. Glacial and inter-glacial periods. Major Ocean currents and their effects. Composition and structure of atmosphere.

Books Recommended:

1. Physical Geology - S.Judson, M.E.Kauffman and L.D.Leet.
2. Physical Geology - Arthur Holmes.
3. Basic Concepts of Historical Geology - E.H. Spencer.
4. Structural Geology - M.P. Billings.
5. Fundamentals of Historical Geology and Stratigraphy of India - Ravindra Kumar.
6. Rutley's Elements of Mineralogy - H.H. Read.
7. Igneous and Metamorphic petrology-Best.
8. Sedimentary Rocks - Pettijohn.
9. Metamorphic Petrology - Turner.
10. Coal Petrology - Gebruder Borntraeger, Stuttgart.
11. Petroleum formation and occurrence - Tisot and Welte.
12. Radioactivity in Geology-Principles and Application - Durrance.
13. Mineral Economics - Husain.
14. Mineral Economics - Chatterjee.