### Department of Geology
A.M.U., Aligarh

Programme: M.Sc. (Applied Geology), Semester System (Total Four Semesters)
Session 2017-2018

#### Fourth Semester

<table>
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<th>Type of course</th>
<th>Course No.</th>
<th>Course Title</th>
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<td>Core</td>
<td>M16</td>
<td>Geochemistry and Stable Isotopes</td>
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<td>Continuous evaluation - 40</td>
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<td>b) Exploration Geochemistry - II</td>
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<td>c) Sedimentary Environments and Sedimentary Basins- II</td>
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<td>d) Micropalontology – II</td>
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<td>e) Advance Ore Geology – II</td>
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<td>f) Advance Hydrogeology – II</td>
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<td>g) Impact of Geology on Environment – II</td>
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<td>h) Petroleum Exploration – II</td>
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<td>i) Gemology – II</td>
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<td>j) Engineering Geology and Geotechnics-II</td>
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<td>k) Rock Deformation and Structural Analysis-II</td>
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<td>b) Earth Systems</td>
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| Total         | Grand Total ( I^th+II^th+III^th+IV^th) Semesters | 24 96 |

L = Lecture period, T = Tutorial, P = Practical Period
Semester - IV
Core Credit 2, Period - 28

Paper M 16: Geochemistry and Stable Isotopes

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

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

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

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

Books Recommended:
Paper M 17: Applied Sedimentation

Unit-I
Textural and mineralogical maturity of clastic rocks.

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

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

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

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

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

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

Unit-IV

Books Recommended:
2. Keller, E.A., 1978: Environmental Geology-Bell and Howell, USA
8. Vulnerability, threats and analysis-Case Studies from India, TERI, The Energy & Resources Institute, New Delhi.
ML 5: LAB WORK  Exercise related to Geochemistry, and Computer Applications

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

ML 6: LAB WORK  Exercise related to Applied Sedimentation and Environmental Geology

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

ML 7: LAB WORK

Project Oriented Dissertation (To be allotted after second semester exam or at the beginning of third semester)

ML 8: LAB WORK

Presentation and Viva-Voce on Project Oriented Dissertation.
Elective (Discipline Centric) ME 4   Credit – 4, Period - 56

a. Advance Remote Sensing in Geosciences – II

Unit-I

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

Unit- III
Digital image processing. Various image processing softwares their environments and working principles of data interpretation. Digital image processing techniques: data formats, enhancement, filtering, preparation of false colour composite image, unsupervised and supervised classification, preparation of training sets, extraction of information, HIS, PCA and vegetation indices and their utility in image interpretation.

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

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

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

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

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

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

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

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

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

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

**Unit –IV**

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

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

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

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

Books Recommended
e. Advance Ore Geology- II

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

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

**Unit-III**
Quantitative methods in ore microscopy-Reflectance and microindentation hardness.
Methods of fluid inclusion studies and their applications.
Textures formed due to cooling.
Textures formed due to deformation and annealing.
Transformation Textures.
Applications of textural characteristics to ore dressing.

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

**Books recommended:**
   and books given in Paper I.
f. Advanced Hydrogeology-II

Unit-I

Unit – II

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

Unit-IV

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

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

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

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

**Unit-IV**

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

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

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

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

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

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

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

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

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

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

Books Recommended:
j. Engineering Geology and Geotechniques-II

**Unit-I**

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

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

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

**Book Recommended:**
1. Environmental and engineering geophysics—P.V. Sharma.
5. Rock Mechanics—W. Wittke
k. Rock Deformation and Structural Analysis-II

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

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

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

Unit-IV

Books recommended:

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

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

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

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

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

Readings:
Field Techniques in Glaciology and Glacial Geomorphology by Bryn Hubbard and Neil F. Glasser, willey International
Holmes' Principles of Physical Geology Paperback 1993, P. McL. D. Duff and Arthur Holmes
Himalayan Glaciers, 1999, Syed Iqbal Hasnain, Allied Publishers
Himalayan Glaciers, 1999, Naseeuddin Ahmad and Sarwar Rais, Allied Publishers
Snow and Glacier Hydrology, 2000, P. Singh, Vijay P. Singh
The Preamble: Planet Earth is undergoing a constant change through an ever increasing resource consumption, population growth, urban sprawl development, technological advancement and consequent disturbance of the natural systems. Human intervention has been changing the global climate and environment in an unprecedented manner over Earth’s history. The greatest question for society in the 21st century is whether these changes to Earth’s life-support systems sustainable?

This course, Global Change is aimed at providing a broad understanding of complex issues involved in global change and global sustainability. It investigates the causes and potential impacts of global changes using a combination of traditional lecture-based and modern web-based teaching methodologies. The course draws on the fundamental principles of science to establish the sustainability of human activity on Earth. It surveys the evolution and interaction of physical, chemical, and biological processes; how past changes on Earth help us predict the future. After the course, students will become better equipped to contribute to the debates on global environmental change, resource management and societal adaptation strategies. They should be able to discern sound science from biased claims and will have a foundation for making informed decisions about sustainable practices in their own lives. The course content is also expected to provide opportunities to students to conduct research on topics of interest in their disciplines accruing from an understanding of the Earth systems.

(a) Global Change

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

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

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

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

BOOKS RECOMMENDED:


(b) Earth Systems

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

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

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

Unit 4

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