# M.SC. GEOLOGY PROGRAMME

## CURRICULUM STRUCTURE

(Academic Year 2020-21 Onwards)

## Department of Geology

School of Earth Sciences

Central University of Tamil Nadu

**Department of Geology**
**M.Sc., Geology**

**VISION:** To spread the geological knowledge to the students and to make them masters. And to do advanced research in geoscientific studies.

The branch of Geology is one of the vital disciplines for comprehensive, holistic and Sustainable Development for the nation. The Department of Geology has created to achieve this ambitions/goal.

**MISSION**:

The Geoscientific studies are made independently and inter-dependably with other disciplines**.**

- Natural Resources Inventory and Management

Mineral, Water, Hydrocarbon and Geothermal Resources inventory and mapping. Creation of natural resources-based development plans for the nation.

- Water Management

Specific Studies to bring out village wise / taluk wise / region-wise or geologic boundary line-wise water management plans including surface water potential, water quality pollution due to rock - water interaction and anthropogeny, rejuvenation of defunct water bodies inventory and modelling of Groundwater, Artificial recharge etc.

- Nuclear waste management:

Type of radioactive waste, immobilization of nuclear waste and safe disposal in the geological repository. Long-term performances of nuclear waste glass containments in geological repository.

- Green-house gases control:

CO2 sequestration by injection into deep geological formations and mineral carbonation. Geological storage of the CO2, hydrodynamic trapping, solubility trapping and mineral sequestration processes.

- Geo-energy Management

Geo-Energy Resources like Oil and Gas, Coal, radioactive and geothermal resources studies in terms of inventory, mapping & Planning.

- Geological Ecosystem-based development plans

Creation of development plans based on geomorphic provinces like river systems and coastal systems, arid systems or glacial system.

- Natural Disaster Vulnerability Mapping and Management Models

Earthquakes, Landslides, Floods, Tsunami and other disasters predictive and preventive development plans for the nation.

- Creation of Spatial Decision Support Systems for the development of the nation.

**General Information**

The branch of Geology is one of the premier sciences as it deals with all the planet earth, its dynamics and the related natural resources like metals, minerals, oil, and other conventional energy resources: water resources: an ecosystem of the earth: and the natural disaster vulnerability of the earth.

The prosperity of any nation or country depends on natural resources and disaster vulnerability. Hence, the geology acquires its importance.

**The Program:**

The M.Sc., Geology program covers a full spectrum of branches necessary for developmental planning of the earth such as the origin of the earth, the interior of the earth, the endogenic and exogenic dynamic processes that are operative since 3500 million years to until the date, etc.

**Employment opportunities**

The branch is high demand in national agencies like GSI, ONGC, Atomic Mineral Division, Oil India Ltd., Oil industry development board, Indian Space Research Organisation (ISRO), PRL, Private oil companies, seabed mining agencies, State and Central Groundwater board/ authorities. Urban development board, Rural Development organisations, GIS Industries, Academic Institutions and International and National NGO's.

**Eligibility**

A pass in B.Sc., in Geology/ Applied Geology or its equivalent.

**Central University of Tamilnadu**

**OBE ELEMENTS**

Name: **Geology**

Academic Programme offered: M. Sc., Geology

OBE Elements for **M. Sc., Geology**

## Programme Educational Objectives (PEO)

**PEO 1:** To provide knowledge in geology and their applications.

**PEO 2:** To develop analytical and logical aptitude amongst students to adapt quickly to new work environments, assimilate further information and problem-solving ability.

**PEO 3:** To provide exposure to new technologies to the students and motivate them to take new challenges.

**PEO 4:** To inculcate self-learning, discipline and leadership qualities to introduce them to a holistic approach of working in a team according to the codes of professional practice.

**PEO 5:** High level of technical competence in research that generates, communicates and applies new knowledge for the betterment of society.

## Programme Outcome (PO)

The POs are statements that describe what the students graduating from any of the educational programmes should be able to do.

**PO 1:** Become professional in the subject of Geology and apply the principles of the same to the needs of the Employer / Institution /Enterprise/ Society.

**PO 2:** Gain Analytical skills in the field/area of Geology

**PO 3:** Understand and appreciate professional ethics, community living and Nation Building initiatives

**PO4:** Able to identify, analyse, interpret geological data in multiple perspectives

**PO5:** Able to use skills and modern technical tools in the field of Geology

**PO6:** Able to work as an individual and as teams with cross-culture perspective with a

potentially become leader with practical communication skills.

**PO7:** Identify, formulate, research literature and analyse complex problems reaching substantiated conclusions

## PROGRAMME SPECIFIC OUTCOME (PSO)

**PSO**s are Statements that describe what the graduates of a specific educational Programme should be able to do.

**PSO 1:** Apply the knowledge of Geology in the multidisciplinary domains.

**PSO 2:** Solve the complex problems in the field of geology with an understanding of the societal, legal and cultural impacts of the solution

**PSO3:** Use research-based knowledge and research methods, including analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

**PSO4:** Understand the impact of Geology in societal and environmental contexts, and Describe the knowledge of, and need for sustainable development

**PSO5:** Communicate effectively with the scientific community and with the society such that, being able to comprehend, write useful reports and make clear documentation, make effective presentations.

## SCHEME OF EXAMINATIONS

| Semester | Courses | | Credits | | | | Assessment | |
|---|---|---|---|---|---|---|---|---|
| | Code | Title | L | T | P | Total | CIA | ESE |
| | **First Year** | | | | | | | |
| I | GLYCC01 | Physical Geology & Geomorphology | 3 | | | 3 | 40 | 60 |
| I | GLYCC02 | Structural Geology and tectonics | 3 | | | 3 | 40 | 60 |
| I | GLYCC03 | Crystallography, Mineral Optics And Mineralogy | 4 | | | 4 | 40 | 60 |
| I | GLYCC04 | Geochemistry | 3 | | | 3 | 40 | 60 |
| I | GLYCP01 | Structural Geology | | | 2 | 2 | 60 | 40 |
| I | GLYCP02 | Crystallography, mineral optics, Mineralogy & Geochemistry | | | 3 | 3 | 60 | 40 |
| I | GE | Generic Elective + | | | | | | |
| | | | **Total** | | | **18** | **600** | |
| II | GLYCC05 | Stratigraphy | 3 | | | 3 | 40 | 60 |
| II | GLYCC06 | Igneous and Metamorphic Petrology | 4 | | | 4 | 40 | 60 |
| II | GLYCC07 | Sedimentology | 3 | | | 3 | 40 | 60 |
| II | GLYCC08 | Palaeontology | 4 | | | 4 | | |
| II | GLYCP03 | Igneous and metamorphic petrology | | | 2 | 2 | 60 | 40 |
| II | GLYCP04 | Sedimentology & Palaeontology | | | 2 | 2 | 60 | 40 |
| II | GE | Generic Elective+ | | | | | | |
| | | | **Total** | | | **18** | **600** | |
| | **Second Year** | | | | | | | |
| III | GLYCC09 | Economic Geology | 4 | | | 4 | 40 | 60 |
| III | GLYCC10 | Hydrogeology and Engineering geology | 4 | | | 4 | 40 | 60 |
| III | GLYCC11 | Computer Geology and Geostatistics | 4 | | | 4 | 40 | 60 |
| III | GLYCP05 | Economic Geology | 2 | | | 2 | 40 | 60 |
| III | GLYCP06 | Hydrogeology | | | 2 | 2 | 40 | 60 |
| III | GLYCP07 | Geological Field Study | | | 2 | 2 | 40 | 60 |
| | | | **Total** | | | **18** | **600** | |
| IV | GLYCC12 | Exploration Geology | 3 | | | 3 | 200 | |
| IV | GLYCC13 | Remote Sensing and GIS | 4 | | | 4 | 100 | |
| IV | GLYCP08 | Remote Sensing and GIS | 2 | | | 2 | 100 | |
| IV | GLYCC14 | Dissertation | | | | 6 | 200 | |
| IV | DSE | 1. Oceanography & Marine Geology<br>2. Mining geology<br>3. Fuel Geology<br>4. Environmental Geology<br>5. MOOC/ SWAYAM /NPTL Course | | | | 3 | 100 | |
| | | | **Total** | | | **18** | **700** | |
| | | | **Grand Total** | | | **72 +** | **2500 +** | |

| | |
|---|---|
| CC: Core Course | CP: Core Practical |
| DSE: Discipline Specific Elective | GE: Generic Elective |
| MOOC: Massive Open Online Course | + Students will opt from other departments |

# Semester I

**Credits: 3** **Course Code: GLY CC01**

# PHYSICAL GEOLOGY AND GEOMORPHOLOGY

**Learning Outcomes**

*At the end of this course, the student will be able to,*

1. *Explain the Origin, Age and Interior of the Earth, Earthquakes, Isostasy, Continental Drift and Plate Tectonics.*
2. *Describe the Fundamental concepts of Geomorphology, Weathering, Soil processes and Karst Topography, Speleology, morphogenesis and morphography; Morphometric analysis, Morphochronology and Neotectonics.*
3. *Discuss the geological structures formed by the Tectonic activities and the geological work done by a river and glacial processes.*
4. *Describe the coastal process along the shoreline on the surface of the earth and the geological work done by the wind.*
5. *Explain the volcanic processes acting on the surface of the earth and its resultant surface morphology; geomorphology of India and Application of Geomorphology in various studies.*

**Unit I: Solar System; Origin of the Earth:** Nebular Hypothesis, Planetesimal Hypothesis, Gaseous Tidal Hypothesis. Binary star Hypothesis. **Age of the Earth;** Direct and Indirect Methods. **Interior of the Earth. The Atmosphere, Hydrosphere, Lithosphere and their Constituents. Geological Process;** Endogenic Process and Exogenic Process. **Earthquakes**: Seismic waves, Origin, Classification and Causes of Earthquake, Earthquake Intensity Scale; Isostasy, Continental Drift, Paleomagnetism, Plates and plate boundaries, Principles of Plate Tectonics, Convection current hypothesis, Sea Floor spreading, polar wandering and reversal of earth's magnetic field, Orogeny and Epeirogeny.

**Unit II: Fundamental Concepts of Geomorphology; Geomorphic Processes:** Exogenetic and Endogenetic processes. **Weathering:** Physical weathering, Chemical Weathering, Biological Weathering. **Soil Processes:** Soil Profile, Climate and Soil Formation, Soil Types. **Mass Wasting:** Soil Creep and Solifluction, Earth and Mud Flows and Slides**.** Karst Topography and speleology, slope and catchment erosion processes. An elementary idea about morphogenesis and morphography; Morphometric analysis; Morphochronology, Neotectonics.

**Unit III: Tectonic Geomorphology:** Topography on Domal and Folded Structures, Topography upon Faulted Structures. **Fluvial Geomorphology:** Stream Erosion, Stream Transportation and Deposition, Features of Stream Erosion, Depositional Landforms, Drainage Systems, Types of Streams and Stages of Valley Development. Climate change and the geomorphic response of fluvial systems of arid and humid regions. **Glacial Geomorphology:** Types of Glaciers, Movement of Glaciers, Glacial Erosion, Transport by Glaciers, Glacial Deposits.

**Unit IV: Coastal Geomorphology:** Shorelines; Classification of Coast and shoreline; Johnson's Classification of shores, Shepard's Classification of the coast, Davies Classification. Shoreline Erosional Features, Transportation by Sea, Deposition by Sea. Features of Ocean basin floor

(Mid Ocean Ridge, Deep Ocean Trenches, Abyssal Plains, Sea Mounts). Coral Reefs. **Geomorphic response** to tectonics, sea level/base-level change, anthropogenic effects. **Aeolian Geomorphology:** Wind Erosion, Erosional Features, Wind Transport, Wind Deposits. Types of Sand Dunes. Loess.

**Unit V: Volcanic Geomorphology:** Types of Eruption, Features of Lava fields, Features Associated with Volcanoes; Ash Showers, Volcanic Mudflows or Lahars, Plug Domes. **Depression Forms:** Craters, Calderas, Volcanic Tectonic Depression. **Volcanic Plateaus and Plains. Geomorphology of India:** Peninsular, Extra Peninsular, Indo Gangetic Plain. **Application of Geomorphology** in Mineral Prospecting, Civil Engineering, Military purposes, Hydrogeology and Environmental studies.

**References**

1. Alka Gautam (2009), Geomorphology, First edition: Sharada Pustak Bhawan
2. Allen Cox (1973), Plate Tectonics, Freeman and Company.
3. Radhakrishnan. V (1987), Physical Geology, VV.P. Publishers.
4. Savindra Singh, (2012) Geomorphology, Fifth Edition: Pyayag Pustak Bhawan.
5. Thornbury, W.D., (2002) Principles of Geomorphology, John Wiley and Sons, 2nd Edition, New York.
6. Small, R.J. 1978: Study of Landforms: A Textbook of geomorphology (2nd Edition), Cambridge University Press.
7. Sharma, H.S. 1990: Indian Geomorphology. Concept Publishing Co. New Delhi.
8. Holmes, A. 1992: Holmes Principles of Physical Geology Edited by P. McL. D. Duff. Chapman and Hall, London.
9. Condie, Kent. C. 1989. Plate Tectonics and Crustal Evolution. 3rd Edition. Butterworth-Heinemann Ltd.
10. Windley B. 1995: The Evolving Continents. 3rd Edition Wiley-Blackwell.
11. Davies, G.F. 1999: Dynamic Earth: Plates, Plumes and Mantle Convection. Cambridge University Press.
12. Keller, E.A and Pinter, N 2001: Active Tectonics. 2nd Edition. Pearson Publications.
13. Kearey P, Klepeis, K A and Vine, F.J 2009: Global Tectonics 3rd Edition. Wiley-Blackwell.
14. Burbank D W and Anderson R S 2016: Tectonic Geomorphology. Wiley India.
15. Bloom, A. (2005) Geomorphology. Pearson. New Delhi.
16. Gupta, R.P (2003) Remote Sensing Geology, Springer - Verlag - New York, London.
17. Hamilton, E. I. (1965) Applied Geomorphology. Academic Press.
18. Holmes, A. (1965) Principles of Physical Geology. Ronald.
19. Jha, V.C. (2001) Geomorphology and Remote Sensing, ACB Publications.
20. Sharma, H. S. (1990) Indian Geomorphology. Concept Publishing Co., New Delhi.

**Credits: 3** **Course Code: GLY CC02**

## STRUCTURAL GEOLOGY AND TECTONICS

**Learning Outcomes**

On completion of Course, the students should be able to

1. Predict the concept of stress forces acting in the earth's and its resultant structural changes. The Geometry, Types and Mechanism of Faulting and Folding.
2. Explain the concept of strain and its effects on Geometry.
3. Assess the theory of plate tectonics and describe how the outer part of the earth broken into large fragments (plates) that are always in motion relative to each other.

**Unit I: Mechanical principles;** Properties of rocks and their controlling factors; Concept of Stress; Two-dimensional stress analyses, Theories of Rock failure.

**Causes and dynamics of faulting**; Strike-slip faults, Normal faults, Thrust Faults, Thin-skinned deformation, Decollement;

Mechanics of folding and Buckling, Fold development and distribution of strain in folds; Superposed folding patterns

**Unit II: Concept of Strain;** Two-dimensional strain analyses; Types of strain ellipses and ellipsoids- their properties and geological significance; Strain markers and methods of strain measurements in naturally deformed rocks; Brittle and ductile shear zones; Geometry and products of shear zones; Mylonites and cataclastic.

Planarand linear fabrics in deformed rocks, their origin and significance; Stereographic and equal-area projections for presenting different types of fabrics, and π and β diagrams. Geometrical analysis of simple and complex structures on macroscopic scale Basic idea about petrofabrics and use of Universal stage

**Unit III: Introduction to geotectonics**; Continental drift, seafloor spreading and convection current hypotheses; Paleomagnetism, polar wandering and reversal of earth's magnetic field; Geomagnetic time scale; Principal Geotectonic features: Features of the Ocean, Continent and Continental margins

**Plates and plate boundaries**; Principles of Plate Tectonics; Force Balance and Mantle Plume models of plate movements; Orogeny and Epeirogeny; Anatomy of orogenic Belts; Geodynamic Evolution of Himalaya

**References**

1. Turner, F.J. and Weiss, L.E. (1963): Structural analysis of Metamorphic Tectonites McGraw Hill.
2. Ramsay, J.G. (1967): Folding and fracturing of rocks. McGraw Hill.
   Hobbs, B.E., Means, W.D. and Williams, P.F. (1976): An outline of Structural Geology. John Wiley and Sons. New York.
3. Ghosh, S.K. (1993): Structural Geology: Fundamentals and Modern Developments. Pergamon Press.
4. Ramsay, J.G. and Huber, M.I. (1983): Techniques of Modern Structural Geology. Vol. I. Strain Analysis. Academic Press.
5. Ramsay, J.G. and Huber, M.I. (1987): Techniques of Modern Structural Geology. Vol. II. Folds and Fractures. Academic Press.
6. Pollard DD and Fletcher RC ( 2005): Fundamentals of Structural Geology Cambridge University Press

7. Twiss, R.J. and Moores, E.M. (2006): Structural Geology Second Edition, W. H. Freeman
8. Ragan, D.M (2009): Structural Geology: An Introduction to Geometrical Techniques, 3rd Edition, Wiley Publications
9. Ragan, D.M, 2009: Structural Geology, An Introduction to Geometrical Techniques (Fourth Edition), Cambridge University Press
10. Fossen, H. 2010: Structural Geology, Cambridge University Press:
11. Marshak S and Mitra, G (1988): Basic Methods of Structural Geology, Printice Hall.
12. Lisle, R.J.2004: Geological Structures and Maps: A Practical Guide, Third E. Elsevier
13. Lisle R.J. and Leyshon, P.R (2004): Stereographic Projection Techniques for Geologists and Civil Engineers, 2 edition, Cambridge University Press;
14. Rowland, S.M. Duebendorfer, E.M. and Schiefelbein, I.M. (2007) Structural Analysis and Synthesis: A Laboratory Course in Structural Geology 3 edition, Wiley-Blackwell

**Credits: 4** **Course Code: GLY CC03**

# CRYSTALLOGRAPHY, MINERAL OPTICS AND MINERALOGY

**Learning Outcomes**

At the end of the course, the students will be able to

1. Describe the characteristics of Nesosilicates, sorosilicate and Ring Silicates.
2. Explain the characteristics of Inosilicates, Phyllosilicates, Tectosilicates.
3. Assess Optical mineralogy in detail from Mineral Preparation to Optical characteristics identification.

**Unit I: Structural classification of silicates**.

A detailed study of the vital silicate mineral groups (listed below) concerning general and structural formulae, atomic classification structure, polymorphs/structural states, chemistry including the substitution of elements/solid solution and experimental work on pressure-temperature stability of the minerals, modes of occurrence and alterations.

***Nesosilicates***: Olivine group, Garnet group, Aluminosilicate Group (Kyanite, Andalusite and Sillimanite).

***Sorosilicate***: Epidote group,

***Ring Silicates*****:** Tourmaline –Benitoite- Beryl.

**Unit II: *Inosilicates*:** Pyroxene group- Amphibole group and Wollastonite,

***Phyllosilicates:*** Mica group- Chlorite group,

***Tectosilicates*****:** Quartz -Feldspar group- Feldspathoid group- Zeolite and Scapolite groups, Cordierite.

**Unit III: Mineral optics**

**Mineral Preparation for Microscopic study;** Types of Preparation, Materials for Thin Section, The Mineral Slice and Cutting. **Plane polarised and cross-polarised light; Isotropic and Anisotropic minerals;** Behavior of minerals in cross-polarised light- Birefringence – Uniaxial minerals. **Uniaxial and Biaxial Indicatrices; Optical accessories like mica, gypsum and quartz plates – Determination of Optic sign**: uniaxial and biaxial minerals- Absorption of light by minerals – Scheme of pleochroism, crystal orientation, 2V and 2E.

**Unit VI: Crystallography**

32 crystals classes and description of the different normal classes.

Different types of crystal projections – spherical and stereographic and their uses.

Twinning and Twin Laws: common types of twins and their examples in minerals.

Space Lattice and Symmetry of internal structures – 14 Bravais Lattice. Introduction to space group Historical development of X-ray Crystallography Bragg's Law and its derivation. X-rays in mineral science. Application of Electron Micro Probe analyses and Scanning electron Microscopy in mineral sciences.

**Credits: 3** **Course Code: GLY CC04**

# GEOCHEMISTRY

**Learning Outcomes**

At the end of the course, the students will be able to

1. Describe the chemical composition characteristics of the universe,
2. Discuss the classification of Geochemistry, Trace and REE and sampling procedures.
3. Explain the geochemistry of water and sediments.

**Unit I:** Earth System Science and various reservoirs. Introduction to the chemical composition and properties of atmosphere, lithosphere, hydrosphere and biosphere. Geochemical cycles. Concept of biogeochemical cycle.

Concept of equilibrium. Entropy, enthalpy, Gibbs free energy and laws of thermodynamics. Chemical kinetics in geoscience and its applications: disequilibrium textures, the kinetics of radioactive decay, and diffusion. Meteorites, their classification, mineralogy and origin.

**Unit II:** Geochemical classification of elements. Element partitioning in mineral/rocks formation and concept of distribution coefficient. The utility of trace elements in the petrogenesis of rocks. Interpretation of REE patterns.

Sampling procedures and introduction to important analytical techniques used in geochemistry. Stable isotope geochemistry of carbon and oxygen and its applications to Geology.

Radiogenic isotopes. Decay scheme of K-Ar, U-Pb, Rb-Sr and Sm-Nd. Radiometric dating of single minerals and whole rocks. Petrogenetic implications of Sm-Nd, Rb-Sr systems.

**Unit III:** A brief introduction to the geochemistry of natural waters. Introduction to sedimentary geochemistry. Geochemical processes involved in rock weathering and soil formation. Mineral stability in Eh-Ph diagrams.

Principles of ionic substitution in minerals. Crystal structure of some simple compounds – AX structures (NaCl, CsCl, ZnS, NiAs), AX2 structure (Fluorite, Rutile). A brief idea about some other compounds such as A2X3 (Corundum), ABX3 (Calcite, Ilmenite) and AB2X4 (Spinel).

**Reference:**

1. Albarede, F. (2009): Geochemistry an Introduction, Cambridge Univ. Press, (2nd) 330p
2. Beus, A. A. and Grigorian, S. V. (1977): Geochemical Exploration Methods for Mineral Deposits, Applied Publication, University of California, 287p.
3. Brownlow, A. H. (1979): Geochemistry, Englewood Cliffs and London Prentice Hall, 498p.
4. Deckin, A. P.(2005): Radiogenic Isotope Geology, Cambridge University Press, 492p (II Ed)
5. Hawkes, H. E. & Webb, J. S. (1962): Geochemistry in Mineral Exploration, Harper & Row.
6. Krauskopf, K. B. and Bird, D. K.(1995): Geochemistry, McGraw Hill, New York,640p

Suggested Reading:

7. Levinson, A.A. (1980): Introduction to Exploration Geochemistry, (2nd Ed) App. Pub., 924p.
8. Mason, B. and Moore, C. B. (1982): Principles of Geochemistry, Wiley Eastern Ltd., 344p.
9. Fairbridge, R. W. (1972): Encyclopedia of Geochemistry and Environmental Sciences, Von Nostrand Reinhold Co, 1321p.

**Credits: 2** **Course Code: GLY CP01**

# STRUCTURAL GEOLOGY

**Learning Outcomes**

At the end of the course, the students will be able to

1. Prepare the structural map of the area,
2. Estimation of Paleostress,
3. Understanding the different tectonic settings of the area,
4. Describe the geometrical and kinematical evolution of the area.

**Contents**

Preparation and interpretation of Geological maps and sections.

Structural problems based on orthographic and stereographic projections concerning economic deposit.

Recording and plotting of the field data

Study of the hand specimen of deformed structures

Strain estimation from the data already collected from the field.

Study of dip-isogons from the fold profiles.

**Credits: 3** **Course Code: GLY CP02**

**CRYSTALLOGRAPHY & MINERALOGY, GEOCHEMISTRY**

**Learning Outcomes**

At the end of the course, the students will be able to

**1:** Identify the rock-forming minerals

**2:** Explain the optical mineralogical characteristics.

**3:** Discuss the Goniometers and symmetry characteristics of 32 classes.

**4:** explain the geochemical studies.

**5:** Analyze the rock/mineral or water samples.

## Mineralogy

Identification of rock-forming minerals in hand specimens.

## Optical Mineralogy

Determination of length fast and length-slow characters of minerals.

Scheme of pleochroism and absorption of a given mineral in thin section.

Determination of extinction angle and composition of plagioclase.

Study of interference figures of uniaxial and biaxial crystals, determination of optic signs.

## Crystallography

Goniometer and its use in measuring the interfacial angle of crystals and calculation of the axial ratio.

Representation of symmetry elements of crystals belonging to 32 classes of symmetry and study of their stereograms.

## Geochemistry:

Methods of geochemical sampling. Chemical elements in the earth's crust; pathfinders and common geochemical associations of elements. Methods of geochemical analysis: preparations of samples; decomposition and separation of elements; A relative study of commonly used methods of estimation. Methods of quick analysis as used in geochemistry; spot test paper, colourimetry, chromatography.

# Semester II

**Credits: 3** **Course Code: GLY CC05**

## STRATIGRAPHY

**Learning Outcomes**

On completion of Course, the students should be able to

1: Evaluate the principles of advanced Stratigraphy and details of Geological Time scale.

2: Identify Indian stratigraphic systems of Archean, Dharwar, Cuddapah, Kurnool, Vindhyan and Aravalli systems, The Paleozoic Group, The Tertiary Group

3: Describe the detailed insight into the Geological Time events of Gondwana, Triassic, Jurassic and Cretaceous.

4: Assess the detailed significance of the Siwalik, Pleistocene, Holocene, Himalayas, and Eocene systems.

5: Analyze the age and boundary problems of various ages.

**Unit I: Stratigraphy:** Principles and Classification of Stratigraphy– Litho-, Bio-, chrono-, Magnetostratigraphy and their Applications– **Elements of** stratigraphy, Allo-, Pedo-, Chemo- and Seismic Stratigraphy. Basic ideas of ***Sequence stratigraphy*** and Quaternary Stratigraphy. Bouma sequence – Geological Time Scale and Indian Time Scale, Paleogeography and life of each period. ***Correlation***: Physical and paleontological correlation method – Homotaxic, Contemporaneity and Syntaxis, Lateral variation and facies– code of stratigraphic nomenclature. Stratotypes and its requirements.

**Unit II:** ***Indian Stratigraphy*****:** Stratigraphic Distribution, Geological Succession, Structure, Tectonics and **Economic Importance of the following**; – Archaean system –Cuddapah system – Kurnool system – Vindhyan system – ***Aravalli system of India***, Dharwar system– Sargur Supergroup, Sakoli Group – Sausar Group – Iron ore Group of Bihar and Orissa – Bundelkhand Group – Banded Gneiss complex, The Paleozoic Group.

**Distribution - Classification - Structure - Correlation - Sedimentation - Fossils - Paleogeography and Economic importance** of Cambrian to Lower Carboniferous systems-Gondwana Group, Triassic of Spiti, Jurassic of Kutch, Cretaceous of Trichinopoly and the marine Cretaceous system

**Unit III: Distribution: Structure, Lithology, Climate, Fossils and Origin of** - Siwalik system, Pleistocene-Holocene system, Quaternary glaciations, Rise of Himalayas - Eocene, Oligocene and Lower Miocene systems.

***Deccan Traps***: Temporal and spatial distribution of Deccan volcano-sedimentary sequiences, Deccan Traps stratigraphy, Infra/inter-trappeans Distribution - Bagh and Lameta Beds, – Origin-Economic importance - Economic importance.

**Boundary and Age Problems**- K-T boundary problem, Precambrian – Cambrian boundary problem, Permian - Triassic boundary problem, Age of Saline Series, Age of Deccan traps, World stratigraphy**:** Brief description of the principle, stratigraphic units of the world in type area. Stratigraphic importance in economic reserve identification techniques.

**References:**

1. Doyle, P. and Bennett, M.R., 1996. Unlocking the Stratigraphic Record, John Willey.
2. Dunbar, C.O. and Rodgers, J., 1957. Principles of Stratigraphy. JohnWiley & Sons.
3. Krishnan, M.S., 1982. Geology of India and Burma, C.B.S.Publishers, Delhi

4. Naqvi, S.M., 2005. Geology and Evolution of the Indian Plate: FromHadean to Holocene-4 Ga to 4 Ka. Capital Pub., New Delhi.
5. Naqvi, S.M. and Rogers, J.J.W., 1987. Precambrian Geology of India.Oxford University Press.
6. Pascoe, E.H., 1968. A Manual of the Geology of India & Burma (Vols.IN), Govt. of India Press, Delhi.
7. Pomerol, C., 1982. The Cenozoic Era? Tertiary and Quaternary. Ellis Harwood Ltd., Halsted Press.
8. Schoch, R.M., 1989. Stratigraphy: Principles and Methods, Van Nostrand Reinhold, New York.

**Credits: 4** **Course Code: GLY CC06**

**IGNEOUS AND METAMORPHIC PETROLOGY**

Preamble: Igneous petrology in the field of geology, the objective of the study to gain an appreciation for how the final appearance of characteristics of igneous rocks is controlled by chemical and physical properties of magmas and their surroundings.

**Course Learning Outcomes:**

(List of outcomes in terms of leanings which student will be able to acquire due to this course)
Study of igneous rocks is a key component of geology curriculum (because these rocks not only abundant throughout the crust of the Earth, but, dominate some crustal and upper mantle environments) that provides understanding of melt generation and crystallization mechanisms, diverse rock types and their link to tectonic settings.

**Contents:**
(Unit-wise details of course contents)

**Unit I: Introduction:**

*(A) Fundamentals:*

Igneous petrology and its scope, differentiation of the Earth, major structural units of the Earth, energy and mantle heat engine, gravity, pressure and geobaric gradient, viscosity of melts chemical diffusion, heat diffusion, nucleation and crystal growth, vesiculation and fragmentation of magma, igneous rock series.

*(B) Thermodynamics and kinetics:*

First law of thermodynamics, enthalpy, entropy, second and third law of thermodynamics, stability (phase) diagrams, thermodynamics of solutions, fugacity and activity, equilibrium constant, silica activity, silica buffers and silica saturation and, alumina saturation. Fe-Ti oxide buffers.

*(C) Crystal-melt equilibria in magmaic systems:*

Phase relations in binary systems, feldspar-melt equilibria, anhydrous olivine and pyroxene crystal-melt equlibria, crystal-melt equilibria in basalt magma systems, haplo-granite system. geobarometers and geothermometers.

**Unit II**: **Composition and classification of magmatic rocks**

*A) Composition of magmatic rocks*

Analytical principles and procedures: XRF, ICP-MS, EPMA and SEM-EDS, sampling, analyses, geo-standards, accuracy and precision, mineral and glass compositions, major, minor and trace elements and relative abundances, oxidation states and volatile, FeO, $Fe_2O_3$ and Total Fe, Mg #, mole conversions, mineral formulae calculations, chemical compositions and variation diagrams

*(b) Classification of magmatic rocks:*

Classification of magmatic rocks - based on fabric, field relations, mineralogical and modal, and whole rock compositions, IUGS classification of plutonic, hypabyssal and volcanic rocks, Irvine-Baragar classification of volcanic rocks, classification of basalt, igneous rock names, chemical discriminants of rock types. MELT programme.

*(c) Igneous structures and fabric related to magmatic rocks*

Mega, minor and microstructures associated with igneous rocks, Kinetic paths and fabric of magmatic rocks.

**Unit III**:

*(A) Mantle Melting and the Generation of Basaltic Magma:*

Melt composition, mantle material, partial melting of the peridotite mantle and magma generation, alkaline magma generation, magma generation in continental crust, differentiation (open and closed systems) and assimilation, hybrid magmas, magma storage, ascent and emplacement, field relations of intrusions

*(B) Trace elements and isotopes:*

Trace elements behavior, geochemical characteristics of primary magma, palaeotectonic setting indicators, chemical fractionation, partition coefficient and trace element compatibility, rare earth elements and batch melting models, , magma evolution models (batch melting, incremental batch melting, fractional crystallization, Rayleigh fractionation),

Stable and radiogenic isotopes, mass fractionation, radiogenic decay, isotopes as petrogenetic indicators, K-Ar system, isochron technique, Sr-Rb, U-Pb-Th and Sm-Nd systems, model ages, interpretation of chronological data, isotope reservoirs.

**Unit IV**: **Petrotectonic associations:**

Idea of consanguinity, rock suites and their distribution in time and space

*Igneous rocks of oceanic regions:*

Oceanic spreading ridges and related basaltic rocks, mantle plumes and oceanic island volcanic rocks, plume heads and flood basalt plateau lavas, arc magmatism, oceanic island arcs.

*Other associations*:

Igneous rocks associated with convergent plate boundaries, continental flood basalt and large igneous provinces, large layered igneous complexes, continental alkaline rocks, ultra-alkaline and silica poor alkaline rocks, alkaline cratonic associations, ophiolite, granites and granites, continental rift associations.

**Suggested Readings:**

1. Shrivastava, J. P. 2009 Igneous Rocks National Science Digital Library, CSIR, New Delhi http://hdl.handle.net/123456789/1034
2. Cox, K. G., Bell, J. D. and Pankhurst, R. J. 1979 Interpretations of igneous rocks. George Allen and Unwin, London.
3. Wilson, M. 1989 Igneous Petrogenesis. London Unwin Hyman.
4. Blatt, H. Tracy, R. J. and Owens, B. E. 2006 Petrology. W. H. Freeman and Company.
5. Ragland, P. C. 1989 Basic analytical Petrology. Oxford University Press.
6. Anthony R. Philpotts and Ague, J. J. 2009 Principles of Igneous and Metamorphic Petrology. Cambridge
7. Winter, J. D. 2001 Igneous and Metamorphic Petrology. Prentice Hall
8. Best, M. G. 2013 Igneous and Metamorphic Petrology. Wiley Blackwell
9. White, W. M. Isotope Geochemistry. Wiley Blackwell
10. Faure, G. and Mensing, T. M. 2009 Isotope principles and Applications.
11. Riddle Chris (Ed) Analysis of Materials. Marcel Dekker, Inc.
12. Rollinson, H. R. 1993 Using Geochemical Data: Evaluation, Presentation, Interpretation
13 Shrivastava, J. P. (2017) 16 Video lectures on Igneous textures: process and pathways, and Deccan volcanism (available on IGNOU website).

**III** Closed and Open Systems, Nature of Metamorphic Reactions, Isograds and Reaction Isograds, Schrienemakers Rule and Construction of Petrogenetic Grids. Application of mineral chemistry and isotope geology in metamorphic petrology.

Quantitative Geothermobarometry: P-T evolution paths of metamorphic rocks.

Overview of different types of metamorphism; Concept and Classification of Metamorphic Facies and Facies Series; Textures and structures in relation to deformation and metamorphism in regional terrains; Dynamic metamorphism Processes and kinetics of thrust and fault rocks;

Metamorphism of pelites, mafic, ultramafic and calcareous rocks; Hi PIT ratio metamorphism, Metasomatism.

**IV** Metamorphic Differentiation, Anatexis and Origin of Migmatites in the light of experimental studies

Exhumation and Uplift rates, Erosion, Geodynamics and the Geomorphology of Metamorphic Terrains

Geochronology/Dating methods (Fission-Track) and isotope studies in metamorphism, Diffusion and Kinetics of metamorphic reactions.

**Reference:**

1. Best, M.G, 2002. Igneous Petrology, 2nd Edition, Blackwell Publishers
2. Bose, M.K., 1997. Igneous Petrology, World Press, Kolkata.
3. Cox, K.G, Bell, J.D. and Pankhurst, R.J., 1993. The Interpretation of Igneous Rocks. Chapman & Hall, London.
4. Hall, A., 1997. Igneous Petrology, Longman.
5. LeMaitre, R.W., 2002. Igneous Rocks. A Classification and Glossary of Terms, Cambridge University Press.
6. McBirney, 1994. Igneous Petrology, CBS Publishers, Delhi.
7. Phillpotts, A.R., 1994. Principles of Igneous and Metamorphic Petrology, Prentice Hall of India.
8. Philpotts, A.R., Petrography of Igneous and metamorphic rocks under the microscope, Prentice-Hall.
9. Vernon; R. H., 2004. A Practical Guide to Rock Microstructure,Cambridge University Press.
10. Winter, J.D., 200 I. An Introduction to Igneous and Metamorphic Petrology, Prentice-Hall.
11. Yardley, B.W., 1989. An Introduction to Metamorphic Petrology,Longman.
12. Bard 1986. Microtextures of Igneous and Metamorphic Rocks. Reidel, Dordrecht.
13. Best, M.G., 2003. Igneous and Metamorphic Petrology, Blackwell Science.
14. Bucher, K. and Frey, M., 1994. Petrogenesis of Metamorphic Rocks, Springer Verlag.
15. Fry, N., 1985. Field Description of Metamorphic Rocks, New York, Geological Society of London Handbook Series.
16. Mason, R., 1990. Petrology of Metamorphic Rocks, Springer, London.
17. Miyashiro, A., 1994. Metamorphic Petrology, Oxford University Press.
18. Shelley 1993. Igneous and Metamorphic Rocks Under the Microscope. Chapman and Hall.
19. Vernon, R. H., 2004. A Practical Guide to Rock Microstructure, Cambridge University Press.
20. Winter, 1.D., 2001. An Introduction to Igneous and MetamorphicPetrology, Prentice-Hall.
21. Yardley, B.W.D., 1989. An Introduction to Metamorphic Petrology, Longman Earth Science Series.
22. Yardley et al., 1990. Atlas of Metamorphic Rocks and their Textures.Longmans.
23. Chandra, D., Singh, R.M. and Singh, M.P., 2000. Textbook of Coal (Indian context), Tara Book Agency, Varanasi.
24. Holson, GD. and Tiratso, E.N., 1985. Introduction to Petroleum Geology, Gulf Publishing, Houston, Texas.
25. Leverson, AI., 1970. Geology of Petroleum, Freeman and Co.
26. North, F.K., 1985. Petroleum Geology. Alien Unwin.
27. Scott, AC., 1987. Coal and Coal-bearing Strata: Recent Advances, The geological Society of London, Publication no. Blackwell Scientific Publications.
28. Selley, R.C., 1998. Elements of Petroleum Geology, Academic Press.
29. Singh, M.P., 1998. Coal and Organic Petrology. Hindustan Publishing Corporation, New Delhi.
30. Stach, E., Makowsky, M~Th., Taylor, GH., Chandra, D., Teichumullelr, M. and Teichmuller R., 1982. Textbook of Coal Petrology, Gebruder Bomtraeger, Stuttgart.

**Credits: 3** **Course Code: GLY CC07**

## SEDIMENTOLOGY

**Learning Outcomes**

At the end of the course, the students will be able to

1: Explain the Sedimentary Processes, weathering and description and classification of sedimentary rocks.

2: Identify the Sedimentary texture and Siliciclastic rocks

3: Explain the Non-siliciclastic rocks and environments, Paleoenvironment analysis and Basin Analysis.

**Unit I: Sedimentary Processes and Products:**

Introduction to basic concepts: Developments in sedimentology, description and classification of sedimentary rocks, sedimentary environments and facies, earth's sedimentary shell.

Weathering and sedimentary flux: Physical and chemical weathering, submarine weathering, soils and paleosols.

Fluid flow, sediment transport and sedimentary structures: Types of fluids, Laminar vs turbulent flow, Reynolds number, Froude Number, Boundary layer effect, Particle entrainment, transport and deposition, sediment gravity flows, Concept of flow regimes and bedforms.

**Unit II: Siliciclastic sediments and environments**:

Sedimentary texture: Grain size scale, particle size distribution, statistical treatment of particle size data, particle shape and fabric Sedimentary structures: Primary and secondary sedimentary structures,Paleocurrent analysis.

Siliciclastic rocks: Conglomerates, sandstones, mudrocks (texture, composition, classification and origin and occurrence), diagenetic processes and histories, terrestrial, coastal and marine sedimentary environments; lithification and diagenesis of siliciclastic rocks

**Unit III: Non-siliciclastic rocks and environments**:

Carbonate rocks, controls of carbonate deposition, components and classification of limestone, dolomite and dolomitization, carbonate sedimentary environments, Chert and siliceous sediments, phosphorites, carbonaceous sediments, iron-rich sediments and evaporates; lithification and diagenesis of carbonate rocks, chert and siliceous sediments.

**Paleoenvironment analysis**:

Application of radioactive and stable isotopes in the reconstruction of paleoenvironments

Basin Analysis:

Sedimentary basins and their classification, basin analysis (maps, cross-sections, petrofacies, geological history, applications)

Tectonics and Sedimentation:

Sedimentation in orogenic belts and cratons, plate tectonics and sedimentation (sedimentation-divergent margins, convergent margins, transform margins) secular changes in the sedimentary record.

**Reference:**

1. Allen, P.A., 1997. Earth Surface Processes, Blackwell publishing.
2. Collinson, J.D. and Thompson, D.B., 1988. Sedimentary Structures, Unwin-Hyman, London.
3. Hsu, K.J., 2004. Physics of Sedimentology, Springer Verlag, Berlin.
4. Leeder, M.R., 1982. Sedimentology: Process and Product. George Alien &Unwin, London, 344p.
5. Lindholm, R.C., 1987. A Practical Approach to Sedimentology, Allcn ane Unwin, London.
6. Pettijohn, F.J., 1975. Sedimentary Rocks, Harper and Row Publ. New Delhi.

7. Prothoreo and Schwab, 2004. Sedimentary Geology, Freernam, New York, 557p
8. Miall, A.D., 1999. Principles of Sedimentary Basin Analysis 3rd Fd Springer Verlag, New York.
9. Nichols, G., 1999. Sedimentology and Stratigraphy, Blackwell publishing.
10. Sam Boggs, 1995. Principles of Sedimentology and Stratigraphy, Print ice Hall, New Jersey.
11. Tucker, M.E., 2006. Sedimentary Petrology. Blackwell Publishing.

**Credits: 4** **Course Code: GLY CC08**

**PALAEONTOLOGY**

**Learning Outcomes**

At the end of the course, the students will be able to

1: Understand modern systematics, the evolution of Microfossils, Ammonoids, Trilobites and Brachiopods.

2: Explain the Micropaleontology basics and applied aspects of interpretation of paleo history.

3: Identify and Explain about Calcareous micro and nono fossils and its application.

4. Siliceous and Phosphatic Microfossils and application of Microfossils in hydrocarbon exploration.

**Unit I:** Modern systematics, concept and kind of type specimens, species, speciation and adaptive radiation. Ichnofossils - modes of preservation, classifications and ichnofacies.

Micro- and macro-evolution, types of heterochrony in evolutionary lineages, application to biochronology with Indian examples. Evolutionary trends and geological history of Ammonoidea and Trilobita.

Classification of Brachiopoda and Bivalvia. Approaches to palaeoecological and palaeoenvironmental studies based on benthic communities, trace fossils and taphonomic record with Indian examples.

Distribution, migration and dispersal of organisms applied to palaeobiogeography and plate-tectonics with Indian examples.

**Unit II: Micropaleontology**

Definition and scope of the subject; Relationship of micropaleontology with ocean sciences; Modern field and laboratory techniques in the study of microfossils (collection, sampling and processing techniques, scanning electron microscopy and mass spectrometry); A brief account of the concepts and methods for the development of micropaleontological indicators useful in reconstruction of history of past, environmental changes and biostratigraphic correlation.

**Unit III: Types of Microfossils.** Calcareous Microfossils: (i) Foraminifera - Planktic foraminifera, their modern biogeography, an outline of morphology, significance in Cenozoic oceanic biostratigraphy and paleoceanographic, paleoclimatic interpretations; Benthic foraminifera - their brief morphology and application in bottom water paleoceanography and paleobathymetric reconstructions; Larger foraminifera, their outline of morphology and application in Indian stratigraphy;

(ii) Calcareous nannofossils - outline of morphology, modern biogeography and their application in oceanic biostratigraphy and paleoceanographic, paleoclimatic reconstructions; (iii) Ostracoda - outline of morphology and wall structure, their significance in environmental studies and oceanic biostratigraphy; (iv) Pteropods - a brief introduction, application of pteropods in reconstruction of the Quaternary oceanography and climate; A brief introduction of calpionellids and calcareous algae.

**Unit VI:** Siliceous Microfossils: Radiolaria, diatoms and silicoflagellate - outline of morphology, modern biogeography, their environmental significance and application in biostratigraphy.

Phosphatic Microfossils: Conodonts - outline of morphology, paleoecology, geological significance and biological affinities; Stratigraphic significance of conodonts with special reference to India. Introduction to Organic walled microfossils and their biostratigraphic and palaeoenvironmental significance.

Application of Micropaleontology in hydrocarbon exploration. Geochemical study of microfossil tests (stable isotopes and elemental composition) and its application in paleoceanography and

palaeoclimatology and tracing the history of marine pollution. Determination and correlation of paleofacies by microfossils; Interpretation of seafloor tectonism from micropaleontological evidence.

**Reference:**

1. Boardman, R.S., Cheethan, A.M. and Rowell, A.J. (1988): Fossil Invertebrates, Blackwell. Clarksons, E.N.K. (1998): Invertebrate Paleontology and Evolution, Allen and Unwin, London.
2. Dobzhansky, Ayala, Stebbins and Valentine (1977): Evolution, Freeman.
3. Horowitz, A.S. and Potter, E.D. (1971): Introductory Petrography of Fossils, Springer Verlag. Mayr, E. (1971): Population, Species and Evolution, Harvard.
4. Prothero, D.R. (2004): Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.), McGraw Hill. Raup, D.M. and Stanley, S.M. (1985): Principles of Paleontology ,CBS Publ.
5. Smith, A.B. (1994): Systematics and Fossil Record – Documenting Evolutionary Patterns, Blackwell.
6. Strean, C.W. and Carroll, R.L. (1989): Paleontology – the record of life, John Wiley.
7. *P. K. Saraswati and M. S. Srinivasan (2016): Micropaleontology: Principles and Applications, Springer.*
8. *Arnold (2002): Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett), Oxford*
9. *B. U. Haq and A. Boersma (1998). Introduction to Marine Micropaleontology, Elsevier.*
10. *P. R. Pinet (1992): Oceanography: An introduction to the Planet Oceanus, West Pub,Co*
11. *Bignot, G., Grahm and Trottman (1985): Elements of Micropaleontology, London.*
12. *David Tolmazin (1985): Elements of Dyanamic Oceanography, Allen and Unwin*
13. *Grant Gross, M. (1977): Oceanography; A view of the Earth, Prentice-Hall.*
14. *John Houghton (1997): Global Warming, Cambridge Univ. Press.*
15. *Jones, T.P. and Rowe, T.P. (1999): Fossil plants and spores, Modern Techniques, Geological Soc. Of London.*

**Credits: 02** **Course Code: GLY CP03**

**IGNEOUS AND METAMORPHIC PETROLOGY**

**Learning Outcomes**

At the end of the course, the students will be able to

1: Identify the Igneous rocks and also its microscopic characteristics

2. Explain the identification characteristics of metamorphic rocks with microscopic characteristics.

**Igneous Petrology**

**Unit V: Practical**

- Study of igneous rocks in hand specimens and under the perological microscope
- Whole rock analysis of igneous rocks using XRF
- Norm calculations and application of GEOSOFTWARE.
- Mineral formulae calculations
- MELT programme
- $Ar^{40}$-$Ar^{39}$ age calculations using the ArArCALC software.

Model age calculations

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**Metamorphic Petrology**

- Identification of Minerals, reactants and products in Hand specimen and thin sections
- Metapelites, Metabasic and calcareous rocks
- Deciphering deformational and metamorphic history in thin sections
- Hands-on Analytical Techniques SEM-EPMA, XRF, XRD etc.
- Mineral analyses and projections (Practical/homework)
- Mineral Analyses and the AFM Projection
- Mineral Formula calculation: step-by-step instructions for the recalculation of a mineral analysis from weight per cent into cations per formula unit, using computer programmes e.g. formula.xls
- P-T calculations from EPMA data - Computer programs

**Credits: 02** **Course Code: GLY CP04**

**SEDIMENTOLOGY AND PALEONTOLOGY**

**Learning Outcomes**

At the end of the course, the students will be able to

1: Explain the sedimentary structures and grain size analysis, heavy mineral studies

2. Identify all the invertebrate fossils

3. Explain the separation of microfossils, identification of fossils and its application.

**Sedimentology**

- Exercises on sedimentary structures and their paleoenvironmental significance
- Particle size distribution and statistical treatment
- Heavy mineral analysis and provenance, paleocurrent analysis.
- Exercises based on vertical sedimentary sequences of different terrestrial, coastal and marine environments, petrography of clastic and non-clastic rocks.

**Invertebrate Paleontology**

Study of the morphological characters of some important invertebrate fossils belonging to Brachiopoda, Bivalvia, Gastropoda, Ammonoidea, Trilobita, Echinoidea and corals; Determination of valves and dental formula of heterodont bivalves; Shell petrography of bivalves and brachiopods; Study of an assorted group of trace fossils; Study of ammonoid suture pattern, coiling, whorl section and ontogenic variation; Measurements of dimensional parameters and preparation of elementary bivariate growth curves and scatter plots.

**Micropaleontology**

Techniques of separation of microfossils from matrix; Types of microfossils - calcareous, siliceous, phosphatic and organic-walled microfossils; SEM applications in micropaleontology; Study of surface ultrastructures of foraminifera; Study of important planktic foraminifera useful in surface water, paleoceanography and oceanic biostratigraphy; Study of larger benthic foraminifera useful in Indian stratigraphy with special reference to Cenozoic petroliferous basins of India; Important palynomorphs of Cretaceous and Paleogene age.

Depth biotopes and estimation of palelodepth of the ocean using benthic foraminiferal assemblages; Identification of modern and ancient surface water mass with the help of planktic foraminiferal assemblages; Identification of benthic foraminifera characteristic of Low oxygen environment; Identification of Planktic foraminifera characteristic of warm and mixed layer, thermocline and deep surface water of the modern oceans; Study of modern surface water, mass assemblages of planktic foraminifera from Indian ocean, Atlantic ocean and Pacific ocean.

# Semester III

**Credits: 04** **Course Code: GLY CC09**

## ECONOMIC GEOLOGY

**Learning Outcomes**

At the end of the course, the students will be able to

1: Explain the ore Geology and exploration methods.

2. Discuss the Salient Metallic mineral groups.

3. Assess the Mineral Exploration Techniques and Sampling and surface mining methods.

4. Formulate the Scientific questions the Underground mining methods.

**Unit I:** Historical background to the development of Ore Geology. Field and laboratory studies of ores: Brief Survey of Geological, Geochemical, Geophysical Exploration, Remote Sensing, Sampling methods. Distribution, morphology and disposition of Orebodies. Physical characteristics, optical properties, ore microscopy, Structure of ore minerals, Experimental ore petrology, fluid inclusion, trace element and isotope studies in the ore.

Ore Minerals, Their texture and structure, development in open space and polycrystalline aggregates. Process of formation and transformation of ores. Endogenous: magmatic, pegmatitic, contact metasomatic (skarn, greisen, and hydrothermal ore generation- emphasis on critical aspects and physicochemical conditions. Exogenous: residual, chemical weathering and mechanical weathering accumulation; sedimentary including bacteriogenic and submarine exhalative, emphasis on chemical and biochemical factor. Transformation: Metamorphic and Metamorphosed.

**Unit II:** Petrological ore association-consideration with reference to distinct ore types, classical occurrences and details of Indian Ore Deposits.

1. Ore associated with ultramafic and related mafic plutonic rocks.Sudbury -type Fe -Ni -Cu sulphides, apatite rich and Ti -v bearing magnetites. Fe-Ti oxides and anorthosites

2. Ores associated with felsic plutonic rock: porphyry deposit of Cu, Mo Greisen and skarn deposit of Wand Sn Various Pegmatoid deposit.

3. Ores associated with acid mafic volcanic rocks, including those in greenstone belts: Kabalda type, Kuroko type, Cyprus Types of ores

**Unit III:** 4. Stratabound ore deposit associated with nonvolcanic, Meta Sedimentary rocks, Kupferschiefer, Rhodesia -Katanga, Broken Hill

5. McArthur, Mississippi valley type, Witwatersrand type, Bog iron-manganese ores ironstone, Banded iron formation manganese ores orthoquartzite-c1ay association, Jaspilite and volcanic association, metamorphosed manganese ores. Colorado Plateau type U-V ores, Surficial deposits: Lateritoid and Karst deposit ofF e, Mn, AI, and Ni: Placer deposit of Gold, Tin, Tungsten, monazite. oxidation and supergene enrichment sulphide enrichment. Ocean floor deposit of Mn, Ni-Cu-Co.

Crustal evolution and metallogenesis. Discussion on Various environment of Ore formation.

**Unit IV** Petroleum

Introduction to Petroleum geology, Physical and chemical properties of petroleum, subsurface environment, generation and migration of petroleum, traps and seals, sedimentary basins, assessment of basin reserves and global reserves, reservoir characteristics, identification and demarcation of flow units, relationship between porosity, permeability and texture, Correlation of well log parameters with seismic properties, bulk properties and pore fluid conditions. Oil and gas fields of India.

**Coal**

Definition, the origin of coal. Stratigraphy of coal measures. Fundamentals of coal petrology, peat, lignite, bituminous and anthracite coal. Microscopic constituents of coal. Industrial application of coal petrology. Indian coal deposits.

**Mineral Economics**

Importance of Minerals in National Economy. The basic pattern of Mineral economy and changing mineral requirements, Concepts of strategic Minerals and their supplies in time of peace and war material in various important industries, the problem relating to their marketing. developing substitute to cover the internal shortage, production cost & its relation to mineral in short supply. internal controls (monopolies and cartel), trade restriction and production incentives. Concession rules, world resources and production of important mineral. Importance of steel &Fuels in Modem Economy. Impact of atomic Energy over conventional fuels.

Conservation of non-renewable & associated Renewable resources.

**References:**

1. Barnes, H.L., 1979. Geochemistry of Hydrothermal Ore Deposits, John Wiley.
2. Evans, A.M., 1993. Ore Geology and Industrial Minerals, Blackwell.
3. Guilbert, J.M. and Park, Jr. c.F., 1986. The Geology of Ore Deposits. Freeman.
4. Klemm, D.D. and Schneider, H.J., 1977. TIme and Strata Bound Ore Deposits. Springer Verlag.
5. Mookherjee, A, 2000. Ore Genesis - A Holistic Approach. Allied Publisher.
6. Ramdohr, P., 1969. The Ore Minerals and their Intergrowths. Pergamon Press.
7. Stanton, R.L., 1972. Ore Petrology, McGraw Hill.
8. Wolf, K.H., 1976-1981. Hand Book of Stratabouond and Stratiform Ore Deposits. Elsevier.

**Credits: 4** **Course Code: GLY CC10**

**HYDROGEOLOGY AND ENGINEERING GEOLOGY**

**Learning Outcomes**

At the end of the course, the students will be able to

1: Explain the origin and occurrence, distribution and types of groundwater

2: Describe the properties darcy law, Pumping test and quality characteristics of groundwater

3: understand about Groundwater Basins, Recharge and Management studies

4: Explain Engineering properties of rocks and major engineering structures

**Unit I: Hydrological Properties of Rocks:** Porosity, Permeability, Specific Yield and Specific Retention, Base Flow, Transmissivity and Storage Coefficient - Hydraulic Conductivity – **Groundwater and genetic types-** Meteoric, Juvenile and Connate**. Groundwater Distribution (subsurface**): Zone of Aeration, Capillary fringe, Zone of Saturation and Water Table- **Aquifers**: Types - unconfined, confined, leaky and perched aquifers - **Ground Water Flow Equations**: Steady, Unsteady and Radial Flow –

**Unit II: Darcy's Law:** Validity of Darcy's Law - **Pumping Tests**: Definition, Methodology, Data Collection, and Interpretation by Theis, Cooper-Jacob's methods. Drilling Methods for Groundwater Bore Wells.

**Physical Parameters of Groundwater Quality** - Analysis of Major and Minor Elements in groundwater using APHA standards - **Outline of Water Quality Standards and Guidelines**: WHO, BIS and ICAR - Water Quality Parameters for Drinking, Agriculture, and Industrial Uses - **Graphical Representation and Interpretation of Water Quality Data:** WILCOX, USSL, GIBBS plot, Piper Trilinear, Donean and Durov diagrams - **Coastal Aquifers**: Ghyben-Herzberg relation and Saline Water Intrusion.

**Unit III: Groundwater Basins**: Drainage and Basin Morphometry - Problems due to over-exploitation of groundwater. **Groundwater recharge:** natural and artificial methods, Artificial recharge techniques - **Groundwater Management – Watershed:** definition, watershed management **- Rainwater harvesting**: definition, methods, and design of harvesting structures - ***Outline of methods of groundwater exploration*** - Groundwater provinces of India and Tamil Nadu.

**Unit IV: Engineering properties of rocks**: Rocks as materials for construction – Rocks as sites for construction - Specific Gravity, Porosity, Absorption, Strength of rocks, compressive strength, tensile strength. Poisson's ratio and their measurement - Soil profile, soil particles, soil structure, plasticity & swelling - Decorative stones & Building Stones.

**Dams and Reservoirs:** Classification & types Problems & failures of dams - A brief account on Major Indian Dams - **Tunnels:** Classification & nomenclature, Geological survey prior to tunnelling - **Landslides**: Types & causes, Preventive measures, Road network & related problems & preventive measures, Ghats road alignment.

**Reference:**

1. David Keith Todd, Larry W. Mays, (2013) Groundwater Hydrology, Wiley son's publication.
2. Fetter, C. W, (2007) Applied Hydrology, CBS Publications.

3. Herman Bouwer, (2014) Groundwater Hydrology, McGraw hill education private limited.
4. Raghunath, H.M., (2003) Groundwater, New age international publications.
5. Bankar K.M., Principles of Engineering Geology, Edition: 2014, Published by Nem Chand Jain for Standard Publishers Distributors
6. Deman, MCJ. Smith G.S and Verstappen, H. T. (1986), Remote Sensing for resources development and environmental management, A. A. Ballkema Publishers, Totterdam, Netherlands.
7. Gurugnanam, B (2009) Essentials of Hydrogeology, NIPA publications, New Delhi.
8. Ramakrishnan. S. (1998) Groundwater, CBS Publishers & Distributors.
9. Parbin Singh, Engineering and General Geology, Eight Revised Edition, Published by S.K. Kataria & Sons.

**Credits: 4** **Course Code: GLY CC10**

**COMPUTER GEOLOGY AND GEOSTATISTICS**

**Learning Outcomes**

At the end of the course, the students will be able to

**1:** Describe the principles of computer, statistical analysis using the computer, MATLAB, and computer programming.

**2:** Use the Geological software and explain the application of this software in geology.

3. Explain the principles of Geostatistics

4. Apply Geostatistics in geological data interpretation

**Unit I:** Introduction to computer hardware. Statistical analysis using various statistical software including Excel, Origin and SPSS. Introduction to MATLAB, Writing codes in MATLAB, applications in geosciences. Computer programming. Writing small codes in FORTRAN or C language.

**Unit II: Geological Software and its application:** Aquachem, Rockworks, Petro plot, Stereonet, Igpet, IPI2WIN, Surfer, Petrograph, Tri plot, SPSS, Statistical, Origin. Mobile Android Geological Softwares; Field Move Clino, Smart Geology -Mineral Guide, Petrologic, Geological time scale, Strike and dip, Rocklogger, ArcGIS, Geo Area.

**Unit III: Geostatistics:** Meaning, Definition, and History of Geostatistics, **Spatial data**- Definition and Characteristics Types: Point pattern, continuous surfaces, Area with counts and aggregate rates, Terms in Spatial Analysis - **Definitions of** i. Spatial dependence, Stationery and Isotropy, Anisotropy, Region of stationary, Spatial correlation, Autocorrelation, Correlogram.

**Unit IV: Exploratory spatial data analysis:** ESDA/EDA - Meaning of Exploratory spatial data analysis (ESDA) and Exploratory data analysis (EDA). **Concepts of data distribution in space** - Data – i. Sampling, ii. Heterogeneity, iii. Dependency, Univariate description. Frequency tables, Histogram, Cumulative frequency table, Normal probability plots. Summary / Descriptive statistics, Bivariate description - Scatter plot, correlation, covariance, correlation coefficient, linear regression.

References:

1. Merriam D.F., (Ed.) 2000. Computer Methods in the Geosciences, Elsevier.
2. Chapman, S.J., 2008 Fortran for Scientists and Engineers (3rd Edn.) McGraw-Hill.
3. Sancheti. D. C. and Kapoor, V. K. (1992) Statistics Theory, Methods and Application. Sultan Chand & Sons publishers P.5.1 to 5.47
4. Isaaks, E. H. and Srivastava, R.M., (1989) An Introduction to Applied Geostatistics, Oxford University Press,
5. Davis, J. C., (2002) Statistics and data analysis in geology, third edition, John Wiley & Sons, Singapore.
6. Using ArcGIS Geostatistical Analyst. (2001) GIS by ESRI.
7. Kitanidis P.K., (1997) Introduction to Geostatistics, Applications in Hydrogeology, Cambridge University Press.
8. Sharma, D. D, (2009), Geostatistics with applications in Earth sciences Jointly published with Capital Publishing Company.
9. Simon W., (2000) Houlding Geostatistics: Modeling and Spatial Analysis, Springer: Har/CdrEdition (8 June 2000), CD-ROM: 161 pages, 2000.
10. Cressie, N.A.C. (1993) Statistics for Spatial Data, New York: John Wiley & Sons, Inc.

11. Duetsch, C.V. and Journel, A.G. (1992), GSLIB: Geostatistical Software Library and User's Guide, New York: Oxford University Press,
12. Hohn, M.E. (1988) Geostatistics and Petroleum Geology, New York: Van Nostrand Reinhold,

**Credits: 2** **Course Code: GLY CP05**

## ECONOMIC GEOLOGY

**Learning Outcomes**

At the end of the course, the students will be able to

1. Draw maps of resources and identify the important metallic and non-metallic minerals deposits.
2. Identify the minerals based on source rock, reservoir and traps, well logging and reserve estimation
3. Extract the information of petroliferous basins of India
4. Explain about Coal petrography

**Contents**

1. Drawing maps of the major and important mineral deposits of India.
2. Study of important metallic ores and industrial non-metallic minerals with reference to their distinguishing physical characters, association, form and structure. Preparation of polished ore-specimens. Ore: the microscopic study of the following minerals, their textural relationships and para-genesis of both metamorphosed and non metamorphosed ore.
3. Chalcopyrite; chalcosite; covellite; pentlandite; sphalerite; galena; pyrite; marcasite; arsenopyrite; melybdenite; stibnite; megnatite; ilmenite; goethite; psilomelane; pyrolusite; braunite; bixbyite;jacobsite; chromite; uraninite; pitchblende
4. Additional practical work exercises in comprehensive tests in mineral identification including physical, optical and associational characters
5. Exercises based on source rock, reservoir and traps, well logging and reserve estimation
6. Case studies of petroliferous basins of India
7. Coal petrography

**Credits: 2** **Course Code: GLY CP06**

**HYDROGEOLOGY**

**Learning Outcomes**

1: Demonstrate the rainfall and its assessment for hydrogeological studies.
2: Explain the water level data assessment.
3: Analyze the problems related to porosity and specific yield and retention.
4: Analyse the water sample for major element studies.
5: Execute the resistivity study in the field and assess the interpretation.

1. Rainfall - Arithmetic mean method Assessment.
2. Rainfall - Thiesson polygon method Assessment.
3. Rainfall – Isohyetal method Assessment.
4. Preparation of water level map and its interpretation
5. Problems - Porosity Specific and Specific yield / retention.
6. Major elements Analysis for water.
7. Graphical interpretation of water quality data.
8. Water Quality - Irrigation use Assessment.
9. Pumping test data interpretation.
10. Isohyetal map generation through surfer software.
11. Resistivity survey and the interpretation for lithology and water resources - Wenner method
12. Resistivity survey and the interpretation for lithology and water resources - Schlumberger method
13. Rock works software applications in Hydrogeology
14. Surfer software and its application in Hydrogeology

**Credits: 2** **Course Code: GLY CP07**

## GEOLOGICAL FIELD STUDY

Unit I: Introduction - Literatures and maps - Destruction of rocks - Physiography - Topographic expressions and relief - Inliers and outliers - requirements of the field - suggestions and precautions.

**Equipment and Supplies:** General, Geological Hammers, Pocket and Hand Lenses, Hydrochloric Acid, Streak Plate, Pocket Magnet, Pocket Knife, Measuring Tapes and Scales, Haversack or Rucksack, Mohs Scale of Hardness, Cold Chisel, Protractors, Pocket Calculator, Cameras, Care and Upkeep of Instruments.

**The compass and Clinometer:** The compass and its uses- Dip of the compass needle - Magnetic declination **- Clinometer:** Bearing and Reading directions - Measuring altitudes - Handling of the compass.

**Unit II: Topographic maps:** Base Maps, Scale of maps – Depiction of relief - Latitudes and Longitudes - Map grids - Measurement of mapped areas- Mounting and folding field maps- Marking on maps.

**Field documentation:** Field sketches and Drawings - Field photographs. **Basic field procedures:** Location - Soils and vegetation- measuring distances - Compass and tape traversing - Determination of slopes and gradients- Measuring difference in elevation - Field identification of rocks - Basic field observations.

**Geological Field study report preparation and submission (Minimum 15 days)**

**Reference**

1. Mathur, S. M., Guide to Field Geology. Prentice Hall India. New Delhi, 2001.
2. Compton, R. R., Geology in the Field, John Wiley & Sons Inc., New Delhi, 1985.
3. Gokhale, N.W., A Guide to Field Geology. CBS Publishers, New Delhi, 2001.
4. Coe, A. L. (ed)., Geological Field Techniques. Open University Press, Milton Keynes, UK, 2010.
5. Barnes, J. W., Basic Geological Mapping. John Wiley & Sons Inc., New Delhi, 2004.
6. Freeman, T., Procedures in Field Geology. John Wiley & Sons Inc., New Delhi, 1999
5. Lahee, F, Field Geology, CBS Publishers, New Delhi, 1987.

# Semester IV

**Credits: 34** **Course Code: GLY CC12**

**EXPLORATION GEOLOGY**

**Learning Outcomes**

At the end of the course, the students will be able to

1. Explain the Mineral exploration concept and field study.
2. Identify the minerals through geochemical methods of exploration
3. Describe the drilling methods and modelling and Explain the basics of Geophysical methods of exploration.

**Unit I:** Mineral Exploration Selection of minerals for explorations. Use of GIS and remote sensing in mineral exploration. Criteria and guides for mineral search. Stages of mineral exploration in India. Field observations and field types of equipment.
Geochemical exploration: mobility of elements and their primary & secondary dispersion. Geochemical approaches, mapping and sample material.

**Unit II:** Introduction to geobotanical and geophysical exploration methods. Use of geostatistics in exploration. Drilling: objectives of drilling, types of drilling for exploration and their advantages. Concept of Slice Plan/Bench Plan, the role of stripping boundary, Geological and mineable ore reserves, mineable waste and their calculation. Geological modelling for mineral exploration.

**Unit III:** Elementary knowledge of geophysical methods of exploration: Magnetic, Gravity and Seismic methods. Elementary knowledge of well drilling: cable-tool drilling, rotary drilling and various types of drilling units. Borehole model, Elementary knowledge of Wireline logs: Resistivity, SP, Gamma, Density, Sonic and Neutron logs. Application of logs in petrophysical analysis and facies analysis.

**References:**

1. Arogyaswami, R.P.N., 1996. Courses in Mining Geology, 4th Ed. OxfordffiH.

2. Bagchi, T.C., Sengupta, D.K. and Rao, S.Y.L.N., 1979. Elements of Prospecting and Exploration.

3. Banerjee, P.K. and Ghosh, S., 1997. Elements of prospecting for nonfuel mineral deposits, Allied Publishers Limited.

4. Sinha, R.K. and Sharma, N.L, 1993. An Introduction to Mineral Economics, Wiley Eastern.

**Credits: 4** **Course Code: GLY CC13**

## REMOTE SENSING AND GIS

**Learning Outcomes**

At the end of the course, the students will be able to

1. Understand basic concepts of electromagnetic radiation, its interaction with the earth's surface and atmosphere
2. Understand resolution properties to interpret, process and evaluate remotely sensed images
3. Explain about the GIS principles and applications.
4. Use basic analytical tool in GIS

**Unit I: Introduction to Remote Sensing:** Concepts, Components, Electro Magnetic Radiation & Spectrum, Theories of EMR; Types of Remote Sensing: Based on Energy source and Electro-Magnetic Spectrum.

Energy Interaction with Earth Surface & Atmosphere: Reflection, Absorption Transmission, Spectral Signature: Interaction with soil, water and vegetation and other features; Scattering: Rayleigh, Mie and Non-selective; Absorption, and Refraction; Atmospheric Windows.

**Unit II:** Platforms, Sensors, Orbits: Types of platform: Ground-Based, Airborne and Spaceborne; Types of sensors: Active and Passive, Satellite orbits, Resolution and its types: Spatial, Spectral, Radiometric, and Temporal; False Colour Composite; Natural Colour Composite; Vegetation Indices; Elements of Image Interpretation. Satellite Data Products: Landsat, MODIS, CartoSAT, ResourceSAT and SPOT.

**Unit III:** GIS: Definition and Applications; Components and Elements of GIS; Development of GIS technology; theoretical models and framework for GIS, representation of geographic data; coordinate systems, Scale, resolution, map projection.

Data Input, Storage and Editing: Nature of geographic data: Spatial and Attribute Data, Concept of vector and raster-based models; geodatabases, data input devices: Digitization; external databases; storage and manipulation of GIS databases, Data quality.

**Unit IV:** Basic Spatial Analysis: Spatial Queries, Map algebra, Neighbourhood analysis; Proximity analysis and buffers; Overlays Analysis – raster and vector-based overlay and their applications; Presentation of GIS output.

**References**

1. Anji Reddy, M. (2008): Textbook of Remote Sensing and Geographic Information System, B.S. Publication, Hyderabad
2. Campbell, J. (2002): Introduction to Remote Sensing, Taylor & Francis, London.
3. Curran, Paul J., 1985: Principles of Remote Sensing, Longman, London & New York.
4. Drury, S. A. (2001): Image Interpretation in Geology, Blackwell, Oxford
5. Jensen, J. R. (2005): Introductory Digital Image Processing, Prentice-Hall, New Jersey
6. Jensen, J.R., 2004: Remote Sensing of the Environment: An Earth Resource Perspective, Pearson Education.
7. Joseph, G. (2004): Fundamentals of Remote Sensing, Universities Press, Hyderabad, India
8. Lillesand, T. M., Kiefer, R. W. and Chipman, J. W. (2008): Remote Sensing and Image Interpretation, John Wiley & Sons, New Delhi
9. Sabins, Floyd F. Jr., 1997: Remote Sensing: Principles and Interpretation, W.H.Freeman, New York.
10. Singh, R.B. (ed.), 1991: Environmental Monitoring: Application of Remote Sensing and GIS, Geocarto Int. Centre, Hong Kong.

Singh, R.B. and Murai, S. (eds.), 1998: Space Informatics for Sustainable Development, Oxford & IBH Pub., New Delhi.

11. Burrough, P.A. and McDonnell, R.A., 1998 : Principles of Geographic Information systems, Oxford University Press, Oxford.
12. Chang, K-t., 2006: Introduction to Geographic Information Systems, Tata McGraw- Hill.
13. De Mers, Michael N., 1999: Fundamentals of Geographic Information Systems, John Wiley & Sons, NewYork.
14. Environmental Systems Research Institute (ESRI), 1997: Getting to know Arc View GIS, Cambridge: Geoinformation International.

15. Heywood, I. et al. 2004: An Introduction to Geographic Information Systems, Pearson Education.
16. Longley, P.A., Goodchild, M.F., Maguire, D.J. and Rhind, D.W., 2001, Geographic Information Systems and Science, Wiley, Chichester.
17. Maguire, D.J., M.F. Goodchild and D.W. Rhind, 1991: Geographic Information Systems, Longman Scientific and Technical, Harlow.
18. Sarkar, A. (2015) Practical geography: A systematic approach. Orient Black Swan Private Ltd., New Delhi
19. Singh R. B. and Murai S., 1998: Space-informatics for Sustainable Development, Oxford and IBH Pub.
20. Wolf P. R. and Dewitt B. A., 2000: Elements of Photogrammetry: With Applications in GIS, McGraw-Hill

**Credits: 2** **Course Code: GLY CP08**

**REMOTE SENSING AND GIS**

**Learning Outcomes**

At the end of the course, the students will be able to

1. Identify the satellite data for various applications
2. Analyse the satellite data
3. Analyse few GIS analytical tool for the preparation of thematic maps.

Image interpretation and applications

Prepare a report consisting of five exercises on using any GIS Software on above-mentioned themes.

**Credits: 4** **Course Code: DSE01**

**OCEANOGRAPHY AND MARINE GEOLOGY**

**Learning Outcomes**

At the end of the course, the students will be able

1. To Understand they physical, biological and chemical oceanography
2. Describe marine geology, Classification of coast and its Minerals deposits
3. Describe the concept of Marine geology.
4. Analyze the marine environments using marine geological instruments.

**Unit I:** Introduction: Definition, nature, the scope of oceanography and relationship with other subjects, Historical development of oceanography, Historical development of oceanography in Bangladesh

**Unit II: Physical Oceanography:** Salinity, conductivity, temperature, density, light and pressure, etc. of seawater, **Waves:** definition, classification and different types of waves, origin of surface waves, forms and characteristics, growth and dissipation of wind waves, breakers and surfs, **Tides:** definition, classification, causes and types of tide, storm surges, seiches, and Tsunami, **Currents:** definition, classification, causes and types of current, major surface current system of the World Ocean, atmospheric circulation, global wind pattern, Ekman spiral, Ekman transport and upwelling. **Chemical Oceanography:** water molecule, dissolving the power of Seawater, the composition of seawater **Biological Oceanography:** Plankton, Nekton, Benthos **Geological Oceanography:** Marine sediments, types of sediment based on sources and origins, Ocean Management.

**Unit III: Marine Geology:** ***Introduction and scope of marine geology,*** Oceanic profile, oceanic features, beaches. **Classification of coast:** erosion and accretion. Waves, Currents and Tides. Coastal protection structures. **Classification of marine mineral deposits:** Origin and depositional system of marine resources. **Beach placers**: Shelf deposits, Deep Ocean phosphatic, Polymetallic nodules, Sulphate deposits, Hydrocarbon deposits.

Unit IV: **Seawater as a resource**: ***Ocean circulation, turbidity current***, submarine and sedimentation processes. **Oceanic sediments and microfossils**: Marine stratigraphy, correlation and chronology. **Tectonic history of the oceans-** Concept of sea-level changes. Seismic stratigraphy and sequence stratigraphy as applied to marine geology. Physical and chemical properties of seawater. Marine pollution, pathways, resilience time, pollutants in the marine environment. **Marine geological instruments**: - Methods of measuring properties of the sea. **Sediment samplers:** Van Veen grab, Peterson grab, La Fond & Dietz snapper, Phleger – corer sampler, Surficial sediment scoop, Sediment dredger.

Reference:

1. Pickard, GL 1963. Description of Physical Oceanography. Pergamon Press, London.
2. Yasso, WE 1965. Oceanography. Holt, Rinehert and Winston, Inc., New York.
3. King. CAN 1966. An Introduction to Oceanography. McGraw Hill Book Co, New York.
4. Pickard GL and WJ Emery, 4th enlarged, 1982. Descriptive Physical Oceanography. Pergamon Press, Oxford.
5. Weisberg, J and H Parish. 1974. Introduction to Oceanography. McGraw-Hill Kogakusha, Ltd., Tokyo.
6. Lal D.S, (2013). Climatology and Oceanography, Sharda Pustak Bhavan Publishers and Distributors.
7. Savindra Singh, (2014). Oceanography, Pravalika Publications' Army Corps of Engineers, (1995). Coastal Geology, University Press of the Pacific Honolulu, Hawaii

**Credits: 4** **Course Code: DSE02**

## MINING GEOLOGY

**Learning Outcomes**

At the end of the course, the students will be able

1. To Understand methods of mining processes
2. To Describe the methods of underground mining
3. To Describe the sampling methods and examination.
4. To Analyze Mining profits and excavation of Resources.

**UNIT I**

Intersecting loci and ring targets; guides to ore localization. Subsidence and the support of mine excavation; timber treatment; methods of breaking rocks; drilling blast holes; explosives used in mining; blasting practices; shaft sinking; mine drainage; ventilation; illumination

**UNIT II**

Alluvial, open- pit and underground mining methods; drifting; cross-cutting; winzing; stoping; room and pillaring; top-slicing; sub-level caving and block caving; ocean bottom mining, mine organization and operation; mine hazards.

**UNIT III**

Factors in evaluating a mineral deposit; mine examination; theory and methods of sampling; sampling calculations; recoverable values

**UNIT-IV**

Cost of mining; future costs and profits; life of mine; present value of mine and its determination by compound interest and Hoskold formula methods; amortisation; calculations pertaining to valuation of mines of uniform and non-uniform annual income; sale of mineral products; metal prices and mine valuation; valuation of prospects: developed mines and working mines; valuation report.

**Reference:**

1. Young, G.J.: - Elements of Mining
2. Lewis, R.A. and Clark, G.A:- Elements of Mining
3. Arogya swami : - Mining Geology
4. ckinstry, H.E.: - Mining Geology
5. Sheryanthov, L.: - Mining of Mineral deposits

**Credits: 4** **Course Code: DSE03**

## FUEL GEOLOGY

**Learning Outcomes**

At the end of the course, the students will be able to

1. Explain the Formation, properties, Migration and accumulation of Petroleum.
2. Describe prospects of oil and gas, drilling logging procedures, and Economic scenario.
3. Explain about Coal and its origin, occurrence and Classification of coal.
4. Explain about Chemical characterization, industrial and geological problems and purposes of Fuel
5. Describe prospecting and production of fuel and logging, sampling methods.

**UNIT I**

Petroleum- its composition and different fractions; origin, nature and migration (primary and secondary) Of oil and gas; transformation of organic matter into kerogene; surface and subsurface occurrence of petroleum and gas.

**UNIT II**

Characteristics of reservoir rocks and traps (structural, stratigraphic and correlation); Prospecting for oil and gas, drilling and logging procedures; oil-bearing basins of India; geology of the productive oil fields of India; the position of oil and natural gas in India; future prospects and the economic scenario.

**UNIT III**

Coal- Definition and origin of kerogen and coal; sedimentology of coal bearing strata; rank, grade and type of coal; Indian and International classifications of coal; macroscopic ingredients and microscopic constituents; the concept of maceral and microliths types.

**UNIT-IV**

Chemical characterization: proximate and ultimate analysis; coal petrology and its application in solving industrial and geological problems; preparation of coal for industrial purposes; coal carbonization (coke manufacture) coal gasification and coal hydrogenation Coal bed – methane: a new energy resource. Hydrocarbon evaluation,

**UNIT V**

Atomic fuel- Mode of occurrence and methods of prospecting and productive geological horizons in India; nuclear power stations of the country and future prospects; mud engineering, drilling fluid, gas sampling, mud logging , sample catching and its examination and interpretation

**Reference**

1. Levorsen A.I., (1985) Geology of Petroleum, CBS Publishers and Distributors, Delhi, Second Edition,
2. Larry Thomas (2012), Coal geology, Wiley India Pvt. Ltd.
3. listarir R. Brown, (1986) Interpretation of Three-Dimensional Seismic Data, American Association of Petroleum Geologists, USA.
4. Taylor, G.H., Teichmuiler, M., Davis, A., Diessel, C.F.K. and others: - Organic Petrology
5. Selley, R.C.: -Elements of Petroleum Geology
6. Chandra, D., Singh, R.M and Singh, M.P.: -Textbook of Coal
7. Singh, M.P.: - Coal and Organic Petrology
8. Stach, E, Macknowsty, M.T.H; Taylor, H.H and others: - Stach's Textbook of Coal Petrology
9. Durrance, E.M.: -Radioactivity in Geology: Principles and Applications

**Credits: 4** **Course Code: DSE04**

**ENVIRONMENTAL GEOLOGY**

**Learning Outcomes**

At the end of the Course, the students will be able to

1. Assess the basics of Environmental Geology and Natural Disaster Management
2. Explain the concept of Natural Disaster Management
3. Analyze the risk and mitigation of hazards.
4. Identify the remote sensing technology and GIS for natural disaster management.
5. Discuss the Natural Disaster Management through Geospatial technology

Unit I: **Environmental Geology:** Planet Earth, environment and its types, scope and importance of Environmental Geology, public awareness, **Natural Resources;** types of resources (based on origin, based on continual utility). **Natural Resources and Associated Problems**: Forest resources, Water resources, Flood, Drought, Mineral resources,

Unit II: **Energy Resources, Land resources, Ecosystem:** concept of an ecosystem, structure and function of an ecosystem, producers, consumers and decomposers, energy flow in the ecosystem, Ecological succession, food chains, food webs and ecological pyramids. **Causes, Effects and Control Measures of** Air Pollution, Soil Pollution, Marine Pollution, Noise Pollution, Thermal Pollution, Nuclear Hazards.

Unit III: ***Introduction to Disaster*****:** Concepts and Definitions. Disaster, Hazard, Risk, Vulnerability, Resilience. **Disaster: Classification, Causes and Impacts:** Natural Disaster: Beneath the Earth Surface: ***Earthquake*****, Tsunami,** ***Volcanic Eruptions***.

Unit IV: ***Natural Disaster*****:** On the Surface: Landslides, Avalanche. **Meteorological / Hydrological Disasters;** Flood, Droughts, Windstorms, Hailstorms, Tornadoes, **Health; Epidemics. Approaches to Disaster Risk Reduction:** Disaster Management Cycle, Phases of Disaster Cycle. Culture of Safety, Prevention, mitigation and Preparedness. Structural measures, Components of Disaster Relief. Four phases of Disaster Management.

**Reference**:

1. Jonathan Turk and Graham R. Thompson, Environmental Geoscience: Saunders College Division, 2000.
2. Savindra Singh., Environmental Geography, Prayag Pustak Bhawan, Allahabad, 2012
3. Chouhan, T.S.& Joshi, K.N., Applied Remote Sensing and Photo Interpretation, Vigyan Prakashan, 1996.
4. Edward A. Keller, Environmental Geology (8th Edition) Prentice Hall, 1999.
5. Misra., S. P & Pandey, S.N., Essential Environmental studies, 3rd Edition, Ane Books Pvt. Ltd, 2011.