A.C.-10.05.2025
Appendix-31

Department of Geology

University of Delhi

2-year M.Sc (National Education Policy) Course framework

Postgraduate Curricular Framework 2024 (based of NEP 2020)

1st year of PG curricular structure for 2-year PG programmes (3 +2)

Semester	DSC	DSE	2 credit course	Dissertation/Academic Project/Entrepreneurship	Total Credit
Semester - I	DSC 1 Structural Geology & Tectonics (3 0 1) DSC -2 Igneous Petrology (3 0 1) DSC-3 Mineralogy (3 0 1) **(12 credit)**	DSE-1 Earth Surface Processes/ Tectonic Geomorphology (3 0 1) DSE-2 Stratigraphic principles and applications/ Geology of India (3 0 1) Or DSE-1 Earth Surface Processes/ Tectonic Geomorphology (3 0 1) GE-I Earth Energy Resources/ History of Life (3 1 0) **(8 credits)**	Skill based course/workshop/specialized laboratory/ Hands of learning Thematic Geological Mapping (1 0 1) **(2 credits)**	Nil	**22**
Semester-II	DSC-4 Metamorphic Petrology (3 0 1) DSC -5 Micropaleonology and Paleooceanography (3 0 1) DSC-6	DSE-3 Geological application of Remote Sensing and GIS/ Introduction to Numerical Methods and Modelling in Earth Sciences (3 0 1) DSE-4	Skill based course/workshop/specialized laboratory/ Hands of learning Geological sample collection, processing and analytical techniques (1 0 1)	Nil	**22**

	Sedimentary Geology (3 0 1) **(12 credits)**	Vertebrate and Invertebrate Paleontology/Geochemistry (3 0 1) Or DSE-2 Stratigraphic principles and applications/ Geology of India (3 0 1) GE-II Applied Mineralogy/ Earth: The planet with a difference (3 1 0) **(8 credits)**	**(2 credit)**		

NEP M.Sc (Geology) Programme

Programme -Specific Outcomes (PSOs)

Core Courses:

DSC 1 Structural Geology &Tectonics

Due to the dynamic instability of the lithosphere, continuous and discontinuous deformation takes place within the rocks in solid or semi-solid state, at different scales, which manifests in a variety of complex structures in these rocks. The present course will teach the student how to unravel the underlying deformation processes and mechanisms through an accurate geometric and kinematic analysis of these natural structures.

DSC 2 Igneous Petrology

The course is intended to emphasize on how the final appearance of characteristics of igneous rocks is controlled by chemical and physical properties of magmas and their surroundings. 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.

DSC 3 Mineralogy

The course is intended to 1) Identify common rock-forming minerals in hand specimen and in thin section using diagnostic physical, optical, and chemical properties (2) infer about the formation environment of a silicate mineral (3) ability to understand the information that minerals can provide about Earth processes and Earth history (4) understanding of basic techniques of mineral characterization.

DSC 4 Metamorphic Petrology

Dynamic nature of lithosphere leads to solid state transformations of rocks which hold clue to the past processes which are not possible to reconstruct by other means. This course aims to enable students to identify critical data as well as provide theoretical basis for interpreting this data for past geodynamic processes, especially the orogenic events

DSC 5 Micropaleontology and Paleoceanography

Micropaleontology, the science of microfossils and nannofossils has become very important due to its significance in deciphering paleoclimate and its use in oceanographic studies. Nearly seventy percent of the Earth's surface is covered with oceans and the floor of the ocean is covered by a thick layer of sediments mostly consisting of microfossils, known as biogenic ooze. The micropaleontological study helps to decipher past ocean circulation which controlsthe heat budget of the earth, monsoon variability and El Nino Southern Oscillation. The Oceanic multiple microfossil biostratigraphy providesrelative ages of the events that occurred in the geological past. Microfossils are one of the most important proxy indicators for studying paleoclimate and paleoceanography and are also extensively used in Oil Exploration, paleoenvironmental and climate change studies. Recently the micropaleontological studies have opened new insights in the field of astrobiology and origin of life

DSC 6 Sedimentary Geology

Sedimentary rocks are storehouse of many basic necessities of modern civilization viz. water, hydrocarbon etc. Major objective of the course is to make students understand fundamentals of sedimentary processes and their products, formation and filling history of sedimentary basins in different tectonic backdrop. Nuances of both clastic and chemical sedimentation processes will be covered.

Department Specific Elective (DSE) Courses

DSE 1

Earth Surface Processes

The course "Earth Surface Processes" is intended to provide a holistic approach to study the surficial features and the processes with emphasis on links and feedbacks between its Department of Geology, University of Delhi components. The subject will serve as a dynamic and physical based account of the processes at planet's surface with an integrated approach involving the principles of geomorphology and sedimentology.

Tectonic Geomorphology

The course 'Tectonic Geomorphology' is intended to inculcate among students the concepts of tectonics and its role in making different physiography on the earth surface. The physical process involved in making hills, slopes, valleys etc.

DSE 2

Stratigraphic Principles and Applications

The course is intended to familiarise the student with stratigraphic principles and nomenclature, major stratigraphic units, methods of stratigraphic correlation, depositional environments and tectonostratigraphic framework of various lithostratigraphic units of India spanning Archaean to Holocene, and mass extinction boundaries.

Geology of India

This course is designed to provide students an idea how the Indian plate evolved through geological time. The course will cover different Indian cratons, their amalgamation history besides understanding on different intrusive and extrusive events in Indian peninsula. Various lithostratigraphic units spanning from Archean to Holocene will be discussed

DSE 3

Geological Application of Remote Sensing & GIS

The main aim of this course is to 1) learn about the principles of Remote Sensing, Photogeology, GIS, and GPS, 2) learn Remote Sensing and GIS techniques, and 3) learn application of Remote Sensing and GIS in different fields with emphasis on geology.

Introduction to Numerical Methods and Modelling in Earth Sciences

The aim of this course is to provide a gentle introduction to numerical methods relevant to Earth Sciences, to refresh foundational mathematical skills for modelling Earth system processes, to introduce the basics of geostatistics and spatial data handling and to build confidence among students in applying quantitative reasoning to geological problems.

DSE 4

Vertebrate and Invertebrate Paleontology

The principal objective of the course is to impart knowledge on the life forms of the geological past, their diversity dynamics and evolution. It is also aimed at acquainting the student with evolutionary transitions and functional adaptations in different groups of animals and plants, and relevance of fossils in relative dating of rocks and reconstructing past ecosystems. Major bio-events and mass extinctions during the geological past will be discussed in detail. The students will be able to comprehend to process the paleontological specimens.

Geochemistry

This course will discuss different geochemical principles that guide elemental distribution in the lithosphere, asthenosphere, cryosphere and hydrosphere. Major, Minor, Trace and REE geochemistry will be discussed

General Elective (GE) courses

GE 1

Earth Energy Resource

This course is designed to introduce students to different types of conventional and unconventional, renewable energy resources. Concerns of climatic deterioration and role of human interference will be discussed. Discussion will be done for a carbon neutral Earth system and road ahead

History of Life

The objective of the course is to make the student aware about the early form of life and evolution of life through geological time, evolution from simple prokaryotic to complex multicellular life forms, and the role of geological processes and climatic events in shaping the evolution of life on the Earth.

GE 2

Applied Mineralogy

The aim of this course to convey importance of different minerals in our day to day life, our societal development and medicinal need. The course will aim at making understanding of the students about importance of natural minerals and their sustainable use

Earth: The planet with a difference

The course will try to convey to the students the uniqueness of the earth in the Solar planetary system. Attempt will also be made to make students understand how the earth acts as a heat engine and sustain life.

Skill based course/ workshop/Specialized laboratory/ Hands of learning Courses

Thematic Geological Mapping (Sem 1)

The course is intended to familiarize students with exposure of rocks, basic techniques of field work, introduction to concepts of geological mapping, hand-on training of mapping in any geological province of interest.

Geological sample collection, processing and analytical techniques (Sem 2)

The course is intended to expose students to any economic deposit, familiarize them about host rock and economic mineral relationship, variable geometry of ore bodies, planning of exploration and exploitation, Opencast and/or underground Mine sections.

Teaching-Learning Process

1. Classroom teachings

2. Seminars, Interactive sessions and Group Discissions

3. Practical classes and Hands-on training in field

Semester -I

Discipline-Specific Core (DSC) Courses:

DSC -1

Course Title and Code	Total Credit	Credit distribution in course	
Structural Geology & Tectonics	4	Lecture	Practical
		3	1

Lecture (45 Hours)
Course Objective:

This course focuses on the deformation of rocks in solid and/or semi-solid states due to the dynamic instability of the lithosphere, leading to the formation of complex structures at various scales. Students will learn to analyze these structures using geometric and kinematic principles to unravel the underlying deformation mechanisms and the possible tectonic history. Emphasis is placed on the development, classification, and interpretation of geological structures through advanced analytical techniques.

Learning Outcome:

1. Precise geometric characterization of structures present in naturally deformed rocks.
2. Collection of orientation data from geological structures, representation through appropriate diagrams, and quantitative analysis.
3. Fundamental understanding of rock rheology and its influence on the deformation behavior of rocks.
4. Examination of deformation mechanisms across micro-, meso-, and macroscopic scales.
5. The strength and dynamic behaviour of the lithosphere at the plate-scale.

Contents:

Unit I:

Introduction and significance of rock mechanics and rheology:

Stress and strain analysis in 2D and 3D space, and their geological implications; Application of Mohr diagrams in structural analysis; Stress-strain compatibility; Rock deformation under various stress regimes and their geological importance; Concept of continuous and discontinuous media; Grain-scale deformation mechanism; Mechanics of rock deformation in the brittle field: fracture initiation, propagation and their significance; Coloumb´s criterion, Griffith's theory for fracturing in rocks.

Unit II:

Geological structures under the ductile regime:

A) Folds: Morphological and genetic classification of folds; Mechanics of buckle folding in single-layer and multi-layer systems; Analysis of superposed folding in 3D, and in 2D outcrop patterns; Strain distribution in a folded layer and its significance;
B) Foliation and Lineation: Origin and kinematic analysis of different types of planar and linear structures in rocks and their relationship with the strain ellipsoid; Mechanism of cleavage formation; Evolution and kinematic significance of axial plane cleavage and transected cleavage in folds; Importance of cleavage-bedding intersection in a folded terrain.

Unit III:

Geological structures under the brittle and/or semi-brittle regime:
A) Faults and Joints: Mechanics of faulting; Anderson's theory of faulting and its limitations; Complex geometry of normal, strike-slip and thrust faults with natural examples; Geometry and mechanism of development of fault-related folds; Introduction to the techniques of Cross-Section Balancing and its applications; Concept of fault zone weakening; fault reactivation and its significance;
Geometric analyses of joints – importance of tectonic, columnar, hydraulic and release joints; Mechanical aspect of fracturing and joint formation; Joints with relation to folds and faults.
B) Shear Zone: Geometric characters of ductile and brittle-ductile shear zones; Analysis of strain in shear zones; Fault/shear zone rocks: cataclasite, gouge, breccia, mylonite, pseudotachylyte; Kinematic significance of asymmetric structures in mylnites; Shear sense indicators; Vorticity and flow behavior of rock in shear zones; Large scale shear zones and their importance in continental crustal evolution.

Unit IV:

Large-scale deformation of the lithosphere:

Thermo-mechanical structure and brittle-plastic transition of the crust; Seismic behaviour of the continental and oceanic lithosphere; Plate convergence and large-scale orogenic deformation: transpressional and transtensional tectonics; Basement-cover relationships in orogenic belts; Heat flow, dehydration and weakening of rocks in subduction zone and rift systems; Indian and overseas examples.

Practical Exercises (30 Hours)

1. Analysis and interpretation of geological maps of various complexities.
2. Stereographic projection techniques for different planar and linear structures and their geological significance.
3. Structural problems related to borehole data, used in mineral exploration.
4. Stress analysis using Mohr's circle; Paleo-stress analysis using fault-slip data.
5. R_f/ϕ method, Fry method, and Wellman method for strain estimation in deformed rocks.

Suggested Readings:

1. Fossen, H., 2010. Structural Geology. Cambridge University Press. London.
2. Ghosh, S.K., 1993. Structural Geology: Fundamentals, and modern developments, Pergamon Press.
3. Davis, G.H. and Reynolds, S. J., 2011. Structural geology of rocks and regions.
4. Passhier, C. and Trouw, RAJ, 2005. Microtectonics. Springer, Berlin.
5. Ramsay, J.G and Huber, M.I., 1983. Techniques of Modern Structural Geology: Vol. I & II. Academic Press.
6. Twiss, R. J. & Moores, E. M., 1992. Structural Geology, W. H. Freeman & Co. Ltd.
7. Van der Pluijm, B.A. and Marshak, S., 2004. Earth structure: an introduction to structural geology and tectonics, W.W. Norton & Co. Ltd.
8. Turcotte, D. and Schubert, G., 2014. Geodynamics. Cambridge University Press.
9. Leyson, P.R. and Lisle, R.J., 2004. Stereographic projection techniques in structural geology, Cambridge University Press.
10. Rowland, S.M., Duebendorier, E. and Schiefelbein, I.M., 2007. Structural analysis and synthesis: a laboratory course in structural geology, Blackwell Pub.
11. Lisle, R.J., 2004. Geological structures and maps: A practical guide. Cardiff University.

DSC -2

Course Title and Code	**Total Credit**	**Credit distribution in course**	
Igneous Petrology	**4**	**Lecture**	**Practical**
		03	**01**

Lectures (45 Hrs.)

Course Objectives

The primary objective of the study is to understand how the chemical and physical properties of magmas and their environments influence the final appearance and characteristics of igneous rocks. Additionally, by examining these rocks, the study aims to deduce tectono-magmatic settings through geological context**.**

Learning outcomes

Upon completing the course, students should be able to:

(1) Identify igneous rocks using petrographic, mineralogical, and geochemical indices.
(2) Understand the process of melt generation through the partial melting of the mantle.
(3) Identify the tectonic environment of basaltic rocks using various discriminant diagrams.

Contents

Unit- I

Igneous petrology and its scope, Origin of the Solar system and the Earth, Differentiation of the Earth, Major structural units of the Earth, Pressure and temperature variations with depth within the Earth, Heat Sources in the Earth's Interior, Heat transfer through the Earth's interior, Heat Flux from the Earth, Mantle Convection: whole mantle convection model and two-layer mantle convection model, Plate Tectonic and associated Igneous rocks.

Classification and Nomenclature of Igneous Rocks, IUGS classification of plutonic, and volcanic rocks, Total alkali vs silica diagram for volcanic rocks, Mode and Norm, CIPW Norm Calculation, Nucleation, Growth, and Diffusion in crystals, Textures of Igneous Rocks, Twinning, Secondary reactions and replacement in igneous rocks: Seritization, Symplectite and Myrmekite, Igneous structures, Physical properties of magma, Effect of magma composition, temperature and pressure on viscosity

Unit- II

Laws of thermodynamics, Thermodynamic variables: Intensive and Extensive variables, Gibbs free energy, enthalpy, entropy, Gibbs Free Energy for a Phase with Pressure and Temperature, Clapeyron equation. Phase rule, Phase and component, One-component systems: H_2O system and SiO_2 system, the lever rule, Two-component systems: Binary System with Solid Solution, Binary Eutectic System, Binary Peritectic System, The Alkali Feldspar System, Three-component (ternary) systems: Ternary Eutectic Systems, Ternary Peritectic Systems, Ternary Systems with Solid Solution, Effects of pressure on melting behaviour, Effects of fluids on melting behaviour.

Unit- III

Analytical principles and methods: XRF, Mass spectrometer, ICP-MS, EMPA, SEM, geo-standards, accuracy and precision, major, minor and trace elements, Variation Diagrams: Bivariate, Triangular Plots and normalized multi-element plot, Magma series, Goldschmidt's rules, Chemical Fractionation, compatible and incompatible elements, Partition coefficient, Bulk Partition coefficient, magma evolution models (Batch melting, Incremental Batch melting, Equilibrium Crystallization, Rayleigh fractionation, Rayleigh fractional melting), Palaeotectonic setting indicators, Stable and radiogenic isotopes, mass fractionation, radiogenic decay, isochron technique, Rb-Sr, Sm-Nd and U-Pb-Th systems,

Unit- IV

Petrology of the Mantle, Stability of aluminous-lherzolite, Mantle melting and generation of basaltic melt, Characteristics of Tholeiitic and Alkaline Basalts, Primary, parental and derivative magma, Magma diversity: Magmatic Differentiation, Magma Mixing, and Assimilation, Mantle reservoirs, Magma generation and igneous rocks associated with various plate tectonic settings, Granitoid rocks and crustal melting.

Practical Exercises (30 Hrs)

1. Study of igneous rocks in hand specimens and under the petrological microscope.
2. CIPW Norm calculations.
3. Identifying the minerals using mineral chemistry.
4. Plotting variation diagrams using geochemical data.
5. Numerical on bulk partition coefficient, equilibrium crystallization, fractional crystallization

Suggested readings

(1) Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
(2) Wilson, M. (1989) Igneous Petrogenesis, Springer-Verlag Berlin Heidelberg.
(3) Frost, B. R. and Frost, C. D., (2013) Essentials of Igneous and Metamorphic Petrology Cambridge University Press.
(4) Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
(5) Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.
(6) Sen, G. (2014) Petrology Principles and Practice, Springer-Verlag Berlin Heidelberg Bose M.K. (1997). Igneous Petrology.

DSC -3

Course Title and Code	**Total Credit**	**Credit distribution in course**	
Mineralogy	**4**	**Lecture**	**Practical**
		03	**01**

Lectures (45 Hrs)

Course Objectives:

To understand (1) the characteristics of major rock-forming mineral groups (2) crystal symmetry, crystallography, and atomic structure (3) formation environments and associations of rock-forming minerals (4) techniques of mineral characterization.

Learning Outcomes:

(1) Identify common rock-forming minerals in hand specimens and thin sections using diagnostic physical, optical, and chemical properties

(2) learning about crystallography and to infer the environment of formation of minerals

(3) minerals as a tool to understand Earth processes, Earth's Interior and Earth history

(4) understanding of basic techniques of mineral characterization.

Contents:

Unit- I:

Periodicity and symmetry concept**.** Close-packed structures. Hexagonal close-packing, cubic close-packing and body-centred structure, Structure types based on close-packing, Minerals with structures based on close packing, structures built from polyhedra.

Unit- II:

Detailed mineralogy from Silicates: olivine, pyroxene, amphibole, mica, feldspar, silica, garnet covering crystal structure and different structural sites of cations/anions, crystal chemistry involving atomic substitutions (simple, coupled) and solid solutions between different mineral end members, petrogenetic significance and occurrences in rocks.

Unit- III:

Concept of Optical indicatrix, isotropic minerals, anisotropic minerals; Mineral colour and pleochroism, Interference phenomena, Interference figures.

Unit- IV:

Introduction to X-ray diffraction, SEM, and EPMA in mineral characterization.

Practical Exercises (30 Hrs)

(1) Study of Crystal Structures and Symmetry in Minerals : To analyze the periodicity and symmetry of mineral crystal structures using crystallographic models and digital visualization tools. Emphasis is placed on understanding lattice types, unit cell geometry, and symmetry elements relevant to mineral classification.

(2) Optical Properties of Minerals under Polarizing Microscope: To identify isotropic and anisotropic minerals and investigate their optical properties, including pleochroism, birefringence, extinction angles, and interference figures, using a polarizing microscope. This practical enhances skills in optical mineral identification and textural interpretation.

(3) Introduction to Mineral Characterization Techniques: To understand the principles and geological applications of modern mineral characterization techniques such as X-ray Diffraction (XRD) and Electron Probe Micro-Analyzer (EPMA). The focus is on data acquisition, phase identification, and microchemical analysis of minerals.

(4) Calculation and Interpretation of Mineral Chemical Formulas: To compute ideal and structural chemical formulas of minerals from oxide weight percentage data. The exercise involves converting oxides to cation proportions, normalising to a fixed number of oxygens, and assigning cations to crystallographic sites following crystal chemical constraints.

Suggestive Readings:

1. Putnis A. Introduction to mineral Sciences, Cambridge publication, 1992
2. Cornelis Klein and Barbara Dutrow, The Manual of Mineral Science, Wiley Publication 2007
3. Nesse W. D., Introduction to Optical mineralogy.2008, Oxford University Press.
4. Deer W. A., Howie. R. A. and Zussman, J., An introduction to the rock-forming minerals, ELBS publication I962-1963

Discipline-Specific Elective (DSE) Courses:

DSE -1

Course Title and Code	Total Credit	Credit distribution in course	
		Lecture	Practical
Earth Surface Processes	04	03	01

Lecture (45 Hrs)

Course Objectives:

The course offers a thorough framework for understanding the physical basis of various surficial processes essential for investigating and interpreting the role of different forcing factors in environmental change.

Learning Outcome:

Upon completion of this course, learners are expected to:

(1) Acquire an understanding of the earth's basic properties and the interaction of different energy sources with the Earth system.
(2) Apply the basic principles of physics, chemistry, and biology to understand the process of soil formation and erosion and how the regional climate and tectonics can impact this.
(3) Explain how fluid mechanics works in the entrainment, transportation and deposition of sediments in different environments.
(4) Apply geomorphology, sedimentology and fluid mechanics principles to understand the transportation depositional processes of the fluvial, aeolian, glacial, coastal and marine regimes.
(5) Understand how the changes in the climate impact the earth's surface process and how to investigate them.

Contents:

Unit I:

Introduction to Earth Surface System. Earth's energy balance, hydrological cycle, carbon cycles, heat transfer, topography and bathymetry.

Unit II:

Earth's critical zone, weathering and formation of soils, sediment routing systems, sediment and solute in drainage basins, importance and impact of climate change and tectonics on sediment yield and transport.

Unit III:

Fluid and sediment dynamics and transport: Natural substances, settling of grains, types of flows and boundary separation layers, sediment continuity, modes of sediment transport, bedforms and stratification.

Unit IV:

Sediment transport and deposition associated with fluvial, aeolian, glacial, coastal and marine regimes.

Impact of environmental changes on Earth Surface processes. Climate forcings and feedbacks. Quaternary climate and climate proxies, Marine Isotopic Stage, Global warming and impacts. Dating techniques.

Practical Exercises (30 Hrs):

1. Numerical exercises on isostasy
2. Exercises related to hillslope processes and sediment routing.
3. Exercises related to settling of sediments
4. Hydrology exercises
5. Sediment flux exercises
6. Identifying landforms from a contour map
7. River profile construction (Hack Profile, calculation of stream gradient and steepness index).
8. Exercises related to the use of statistics in fluvial geomorphology
9. Exercises on the rate of uplift and incision.

Suggestive Readings:

1. Allen, P. A., 2009, Earth Surface Processes. Wiley
2. Bridge, J., and Demicco, R., Earth Surface Processes and Landforms and Sediment Deposit.
3. Bloom, A.L., 1998. Geomorphology: A Systematic Analysis of Late Cenozoic Landforms, Pearson Education
4. Summerfield, M.A., 1991. Global Geomorphology, Prentice Hall.
5. Pelletier, J.D. 2008. Quantitative Modelling of Earth Surface Processes Cambridge University Press.
6. Allen, J.R.L. 1992. Principles of Physical sedimentology, Chapman & Hall, London, U.K.

DSE 1

Course Title and Code	**Total Credit**	**Credit distribution in course**	
Tectonic Geomorphology	**04**	**Lecture**	**Practical**
		03	**01**

Course Objectives:

- To understand the fundamental concepts and mechanisms of tectonic deformation and landscape evolution.
- To identify geomorphic indicators of active and ancient tectonics.
- To equip students with modern tools and techniques for tectonic geomorphological analysis.
- To develop the ability to analyze topographic, geophysical, and remote sensing data to study tectonic processes.

Learning Outcomes

Upon successful completion of this course, students will be able to:

1. Explain the principles and processes of tectonic geomorphology.
2. Identify and interpret landforms and geomorphic indicators.
3. Apply quantitative techniques such as morphometric indices, knickpoint and hypsometric analysis etc.
4. Use remote sensing and GIS tools for analyzing tectonically influenced landforms and landscapes.
5. Design and conduct field-based or analytical projects relevant to tectonic geomorphology.

Lectures (45 Hrs)

Unit I

Introduction to Tectonic Geomorphology

- Definition and scope; historical development;
- Relationship with other earth sciences (tectonics, geomorphology, seismology)
- Scales of tectonic deformation: regional to local
- Concept of neotectonics and active tectonics

Unit II

Tectonic Landforms and Processes

- Uplift, subsidence, and tilting
- Faults, folds, domes, and warping
- Tectonic geomorphology of mountain fronts, fault scarps, and basins
- Geomorphic expression of different tectonic regimes (compressional, extensional, strike-slip)

Unit III

Geomorphic Markers and Quantitative Techniques

- River terraces, alluvial fans, knickpoints, and deflected streams
- Drainage anomalies: stream capture, drainage basins asymmetry, etc.
- Morphometric indices

– Concept of geomorphic response time and transient landscapes

Unit IV

Tools, Techniques & Case Studies

– Remote sensing and aerial photo interpretation
– Digital Elevation Models (DEM) and their derivatives
– GIS and spatial analysis in tectonic geomorphology
– Dating techniques: Radiocarbon, OSL, cosmogenic nuclides, U-series
– Active tectonics and earthquake hazard assessment
– Fluvial response to tectonic forcing
– Himalayan tectonics and morphotectonics
– Case studies from Indian and global examples

Practical Exercises (30 Hrs)

- Identification of tectonic landforms: fault scarps, terraces, fans, lineaments
- Mapping drainage anomalies and geomorphic features
- Basin delineation and extraction from topographic maps or DEMs
- Calculation of tectonic geomorphic indices (HI, SL, AF, etc.)
- Extraction and interpretation of longitudinal stream profiles and knickpoints
- Chi-plot and Ksn mapping using software like LSDTopoTools or TopoToolbox
- Exercises on integrating field data with remote sensing and geochronology
- Case study analysis: reconstructing tectonic history from landforms

Suggested Readings:

1. **Burbank, D.W. & Anderson, R.S. (2012)** – *Tectonic Geomorphology* (2nd Ed.), Wiley-Blackwell
2. **Keller, E.A. & Pinter, N. (2002)** – *Active Tectonics: Earthquakes, Uplift and Landscape*, Prentice Hall
3. **Schumm et al. (2000)** – *Alluvial Rivers and Active Tectonics*. Cambridge University Press
4. Recent and important research papers from journals.

DSE -2 Stratigraphic principles and applications

Course Title and Code	**Total Credit**	**Credit distribution in course**	
Stratigraphic principles and applications	**4**	**Lecture**	**Practical**
		03	**01**

Lectures (45 Hrs)

Course Objectives:

The course is intended to familiarise the student with stratigraphic principles and nomenclature, major stratigraphic disciplines and units, methods of stratigraphic correlation, Major global events through the 4.5 Ga geological history of the Earth. Depositional environments and tectonostratigraphic framework of various lithostratigraphic units of India spanning from Archaean to Holocene, and mass extinction boundaries. Supercontinent amalgamation and fragmentation history and signatures in stratigraphic record. Periods of Glaciation in the Earth history.

Learning Outcomes

On successful completion of the course, the student will be able to:

(1) Understand basic principles of stratigraphy, different types of stratigraphic units and how they are categorised and correlated

(2) Know the crustal evolution during the Precambrian in peninsular India geological history of different cratons (Aravalli-Bundelkhand, Bastar, Singhbhum, Eastern and Western Dharwar, Southern granulite) and how the hydrosphere, biosphere responded to the Precambrian-Cambrian boundary events.

(3) Appreciate how plate tectonic movements separated India from contiguous landmasses and shaped the depositional basins of the Indian Phanerozoic, and what were their effects on climate and life.

(4) Learn about large igneous provinces and their role in mass extinction events and important mass extinction boundary sections.

(5) Gain knowledge on stratigraphy and sedimentation in India – Asian continental collision zone and Himalayan foreland basin.

Contents:

Unit I

Principles of stratigraphy and correlation, Facies Concept in Stratigraphy, Walther's Law. Basic concepts of sequence stratigraphy, magneto-, seismic and chemo-stratigraphy. Methods of measurements of Geological Time Scale. Recent advances in refinement of Geological Time Scale. International Stratigraphic Code and development of a standardised stratigraphic nomenclature. Concepts of Stratotypes, Global Stratotype Section and Point (GSSP).

Unit II

Precambrian and its subdivisions. Plate tectonics during the Precambrian. Tectonostratigraphic framework of Dharwar craton, an overview of Bastar, Singhbhum, Bundelkhand and Aravalli cratons, Eastern Ghat mobile belt, Central Indian Tectonic Zone; Proterozoic sedimentary basins of India; Precambrian biota and its stratigraphic significance.

Unit III

Major plate movements during Phanerozoic. Subdivisions of Phanerozoic up to Stage level. Stratigraphic and tectonic framework of Palaeozoic rocks of the Tethys basin with special reference to Kashmir, Spiti, Kumaon and their correlatives in Salt Range and peninsular India. Criteria for recognising major stratigraphic boundaries of Phanerozoic and their GSSPs. Permianl-Triassic boundary sections of India

Unit IV

(A) Mesozoic Rocks of the Tethys Basin; Stratigraphy of rift basins; Gondwana Basins of India, tectonic set-up, depositional history, its fauna and flora, economic importance and climate; Pericratonic Jurassic sedimentary basins of western India; Evolution of Cretaceous sedimentary basins of Cauvery Basin and Narmada Valley; Deccan Volcanic Province; Cretaceous-Palaeogene boundary sections of India.

(B) Palaeogene and Neogene stratigraphy of Kachchh. Stratigraphy of the Himalayan foreland basin (Subathu, Murree/Dagshai-Kasauli , Siwalik) and recent advances. Indus Basin sediments of the Indus Tsangpo Suture Zone. Cenozoic deposits of Andaman Islands, continental Quaternary deposits and their significance.

Practical Exercises (30 Hrs)

1. Study of geological map of India and identification of major stratigraphic units.

2. Identification and delineation of lithotectonic units on map of India.

3. Exercises in preparation of charts to evaluate inter-regional correlations.

4. Drawing various palaeogeographic maps of the Phanerozoic time

5. Study of different Proterozoic supercontinent reconstructions.

Suggestive Readings:

1. Doyle, P. and Bennett, M.R., 1996. *Unlocking the Stratigraphic Record,* John Willey.

2. Krishnan, M.S., 1982. *Geology of India and Burma,* C.B.S.Publishers, Delhi

3. Naqvi, S.M. 2005. *Geology and Evolution of the Indian Plate: From Hadean to Holocene-4 Ga to* 4 *Ka.*

Capital Pub., New Delhi.

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

6. Schoch,R.M., 1989. *Stratigraphy: Principles and Methods,* Van Nostrand Reinhold, New York.

7. Vaidyanathan, R & Ramakrishnan, M. 2008. *Geology of India,* Geological Society of India.

8. K.S.Valdiya, 2016. The Making of India: Geodynamic Evolution, Springer.

DSE -2

Course Title and Code	Total Credit	Credit distribution in course	
Geology of India	4	Lecture	Practical
		03	01

Lectures (45 Hrs)
Course Objectives

The course is designed to expose the students to different Physiographic and Tectonic subdivisions of Indian craton; their evolution through time. The course will discuss how the present geometry of Indian peninsula developed; what are geological histories of cratons and their mobile belts. Further the course elaborate the evolution of Indian craton through the Phanerozoic time.

Learning Outcomes

On completion of this course, the students will learn

1. Evolutionary history of cratons; their stitching and formation of Peninsula
2. Position of Indian peninsula in different Supercontinents and their signatures
3. Evolution of the Indian plate through the Phanerozoic time
4. Built up history of mighty Himalayas in the backdrop of Indian plate geodynamics

Contents:

Unit I

Physiographic and tectonic subdivisions of India; brief outline of regional geology and tectonic revolution of cratons and mobile belts in peninsular India; geology of Proterozoic sedimentary basins. Supercontinents and participation of Indian peninsula in different Supercontinents

Unit II

Palaeozoic succession of Kashmir and its correlatives from Spiti and Zanskar; stratigraphy and structure of Gondwana basins of peninsular India and correlatives from the Himalayan region, economic importance of Gondwana basins; marine Mesozoic formations with reference to the Triassic deposits of the Himalayan region and Jurassic rocks of Kutch and Jaisalmer basins of peninsular region; important marine incursions into peninsular India during Late Palaeozoic and Cretaceous periods; hydrocarbon potential of Gondwana and Cretaceous shallow marine sequences of India

Unit III

Distribution and age of Mesozoic volcanic provinces. Sedimentation and evolution of Himalayan foreland basin; Palaeogene succession of the Himalayan belt, life and palaeogeography in the context of India and Asia collision

Unit IV

Recent advances in the stratigraphic and faunal studies of the Siwalik Group; stratigraphy and structure of Krishna-Godavari basin, Cauvery basin, Bombay offshore basin, and Kutch and Saurashtra basins and their potential for hydrocarbon exploration; stratigraphic boundary problems with special reference to *Pc/T, P/T, and' K/T* boundaries in India.

Practical Exercises (30 Hrs)

1. Identification of major stratigraphic units in geological map of India.

2. Delineation of lithotectonic units on map of India.

3. Exercises in preparation of charts to evaluate inter-regional correlations.

4. Palaeogeographic maps of India for the Phanerozoic time

5. Proterozoic supercontinent reconstructions in the backdrop of Indian sub-continent

Suggested Readings:

1. Krishnan, M.S. 1982. Geology ofIndia and Burma, CBS Publishers, Delhi

2. Pascoe, E.H. 1968. A manual of the Geology of India and Burma (Vol.IIV), Govt. Of India Press, Delhi.

3. Schoch, R.M. 1989. Stratigraphy, Principles and Methods.Van Nostrand Reinhold. . .

4. Doyle, P. & Bennett, M.R. 1996. Unlocking the Stratigraphic Record. John Wiley

5. Ramakrishnan, M. &Vaidyanadhan, R. 2008. Geology of India Volumes 1 & 2, geological society of India, Bangalore.

6. Valdiya, K.S. 2010. The making oflndia, Macmillan India Pvt. Ltd.

General Elective (GE) Courses

GE 1

Course Title and Code	**Total Credit**	**Credit distribution in course**	
Earth Energy Resources	**4**	**Lecture**	**Tutorials**
		03	**01**

Lectures (45 Hrs)

Course objective:

This course is designed to give students idea on different types of Earth energy resource. In the light of present climatic deterioration and protocols, the present course will discuss different renewable energy resource and their role.

Learning Outcomes:

After this course students will be able to understand

(1) How energy gets sequestered and converted in the Earth system
(2) How different renewable energy resource operate
(3) The goal of Govt of India and the task ahead to achieve that goal

Contents:

Unit I

Definition of Energy: Primary and Secondary Energy. Difference between Energy, Power and Electricity.

Renewable and Non-Renewable Sources of Energy. The concept and significance of Renewablity:

Social, Economic, Political and Environmental Dimension of Energy.

Unit II

Major Types and Sources of Energy

Resources of Natural Oil and Gas, Coal and Nuclear Minerals.

Potential of Hydroelectric Power, Solar Energy, Wind, Wave and Biomass Based Power and Energy

Energy Sources and Power Generation: Thermal, Nuclear, Hydroelectric, Solar, Wind and Wave;

General Principles.

Unit III

Relative Merits and Demerits including, Conversion Efficiency, Generation Cost and Environmental Impact: Concepts of Open and Combined Cycles, Co-generation: Clean Coal Initiatives;

Unit IV

Current Scenario and Future Prospects of Carbon Sequestration, Coal Gasification and CBM.

Current Scenario and Future Prospects of Solar Power, Hydrogen Power and Fuel Cells.

Tutorials (15 Hrs)

1. Problems related to stratigraphic and tectonic hydrocarbon traps

2. Problem on deviation drilling

2. Preparation of working model for Solar and Wind energy

3. Numerical related to conversion efficiency in solar and wind systems

Suggested Readings

1. Energy after Rio: Prospects and Challenges by AKN Reddy , RH Williams and T.B. Johanson

ISBN: 92-1-12670-1

2. Energy and the Environment by Fowler , J.M 1975 Wiley

3. Global Energy Perspectives by Nebojsa Nakicenovic (Ed.) 1998

4. Energy Resources and Systems: Fundamentals and Non-Renewable Resources by Tushar K.Ghosh and M.A. Prelas 2009 Springer

5.Introduction to Wind Energy Systems: Hermann-Josef Wagner and Jyotirmay Mathur Third Ed. 2018 Springer

6. Renewable Energy: Bent Sorensen Academic Press Vth Edition 2017

7. World Energy resources: C.E.Brown Springer Nature 2002

GE 1

Course Title and Code	Total Credit	Credit distribution in course	
History of life	4	Lecture	Tutorial
		03	01

Lectures (45 hours)

Course Objectives

The objective of the course is to make the student aware about the early form of life and evolution of life through geological time, evolution from simple prokaryotic to complex multicellular life forms, and the role of geological processes and climatic events in shaping the evolution of life on the Earth.

Learning outcomes

On completion of the course, the student will be able to learn widely accepted

(1) 'Theory of origin of life'; how life evolved and recorded as fossil, fossilization processes operate in nature. How early planetary conditions led to the origin and evolution of early life?

(2) The student will also be able to understand mass-extinction events, their causes and how life re-established after mass-extinction.

(3) How various geological and climatic events influenced the evolution of life and how life reciprocated the geological processes?

Contents:

UNIT – I

Life through Time: Theory of origin of life**,** Taphonomy: fossilization processes and modes of fossil preservation, exceptional preservation; Geological Time Scale with emphasis on major biotic-events.

UNIT – II

Geobiology: Biosphere as a system, processes and products; Biogeochemical cycles; Abundance and diversity of microbes, extremophiles; Microbes-mineral interactions, microbial mats. Origin of life; possible life sustaining sites in the solar system.

UNIT – III

Life during Precambrian: Earth's oldest life, the oxygen revolution and radiation of life- The Garden of Edicara and the evolution of metazoan life.

UNIT – IV

Life during Palaeozoic: The Cambrian explosion of life; Biomineralisation and the fossil record.

Palaeozoic marine life; Origin and progression of vertebrates; Early adaptations of plants to terrestrial life.

Life during Mesozoic: Life after the (P/T) mass-extinction, life in the Jurassic seas; Origin of mammals; Rise and fall of dinosaurs; Origin of birds; and spread of flowering plants.

Life during Cenozoic: Radiation of placental mammals following K/Pg mass-extinction; Evolution of modern grasslands and co-evolution of hoofed grazers; Palaeocene-Eocene Thermal Maximum (PETM) deep time analogue for modern greenhouse state; Back to water – Evolution of Whales; The age of humans; Hominid dispersals and climate setting.

Tutorials (15 hours)

Students in different batches or groups will be given exercises to prepare shorts reports about the life evolution and extinction through different geological times on Earth.

Recommended readings:

1. Stanley, S.M. & Luczaj, J.A. (2014). Earth System History (4th Edition), W.H.Freeman (Macmillan). **(Unit-III).**
2. Cowen, R. (2000). History of Life. Wiley-Blackwell. **(Unit-III).**
3. Benton, M.J. & Harper, D.A.T. (2016). Introduction to Paleobiology and the fossil record. Wiley. **(Unit-I) & (Unit-III).**
4. Canfield, D.E. & Konhauser, K.O. (2012). Fundamentals of Geobiology, Blackwell. **(Unit-II).**
5. Lumine, J.I. (1999). Earth-Evolution of a Habitable World, Cambridge University Press. **(Unit-III).**
6. Lieberman, B.S. & Kaesler, R. (2010). Prehitoric Life-Evolution and the Fossil Record, Wiley- Blackwell. **(Unit-IV) & (Unit-V).**
7. Cowen, R. (2000). History of Life. Wiley-Blackwell. **(Unit-IV) & (Unit-V).**
8. Cockell, C., Corfield, R., Edwards, N. & Harris, N. (2007). An Introduction to the Earth-Life System Cambridge University Press. **(Unit-II)**

Skill Development Course:

(2 Credit)

Course Title and Code	**Total Credit**	**Credit distribution in course**	
Thematic Geological Mapping	**2**	**Lecture**	**Practical**
		01	**01**

Lectures (15 Hrs)

Course Objectives

This course will allow students to know the most challenging task of a geologist i.e. Geological mapping. Students will get hands-on knowledge on different types of rocks, their natural affinity and occurrence patterns. How to identify a rock and broadly define its composition? How to identify and measure lithological and/or structural details of rocks at the outcrop/hand-specimen scale? How to plot the data on a base map/toposheet to create a lithological and/or structural map of the terrain? Additionally, students will understand topographic sheet, geological map, lithological boundary tracing, basement- coven relation as well as high-resolution transect mapping.

Learning Outcomes

After going through this course, students will get

(1) basic skills to carry out geological fieldwork in different terrains

(2) prepare a geological map with all aspects related to lithology, structures, deformation patterns., which is essential for basic understanding of geoscience and any detailed exploration activity.

Contents

Lectures (15 hours)

UNIT – I

Introduction to toposheets and Global Positioning Systems, their types and uses. Geology of different tectonic settings including lithotypes and structural patterns. Choosing a suitable geological terrain and traverse. Outcrop- and subsurface- data based mapping.

UNIT – II

Outcrop geology: Beds in deformed and undeformed terrains – rule of V. Identification of rock types, and their classification based on field criteria. Textural features of different rocks through field study and microscopy. Preparation of lithologs. Characterization of Synchronous and Diachronous features in outcrop-scale.

UNIT – III

Structural deformation features: Measurement of bedding strike, dip, fold axis trend, plunge, pitch etc. at the outcrop. Identification and structural measurement of a fold in the field. Geometric classification of a fold based on field data. Understanding the outcrop pattern of a fold in non-ideal sections

UNIT – IV

Faults: Distinguishing criteria of a fault in the field. Understanding the slip pattern of faults in an outcrop. Measuring the orientation of different planar and linear structures associated with a fault

Distinguishing characters of planar and linear structures in the outcrop scale. Overprinting nature of folds/ metamorphic foliations etc.

Practical Exercises (30 Hrs)

All the aforesaid techniques of measurement and identification will be demonstrated and practised in the field. The practical classes of this course will be conducted at a go through field visit (10 days) in a suitable geological terrain

Suggestive Readings:

1. Field Geology. McGraw Hill Billings, M. P. (1987).

2. Structural Geology, 4th edition, Prentice-Hall. Lisle, R.J., Brabham, P., Branes, J. 2011.

3. Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley

4. Park, R. G. (2004) Foundations of Structural Geology. Chapman & Hall.

Semester II

Discipline-specific Core (DSC) Courses:

DSC 4

Course Title and Code	Total Credit	Credit distribution in course	
Metamorphic Petrology	4	Lecture	Practical
		03	01

Lecture (45 Hrs)

Course Objectives:

Dynamic nature of lithosphere leads to solid state transformations of rocks which hold clue to the past processes which are not possible to reconstruct by other means. This course aims to enable students to identify critical data as well as provide theoretical basis for interpreting this data for past geodynamic processes, especially the orogenic events.

Learning Outcomes:

1. Identifying equilibrium mineral assemblages through textural and mineralogical observations
2. Plotting the quantitative as well as qualitative mineral and mineral assemblage data to interpret the discontinuous reactions and to infer the nature of continuous reactions
3. Learn the basics of Schreinemakers geometric plots for a set of reactions
4. Learn the basics of thermo-barometric calculations and how to estimate and interpret thermo-barometric data from natural rocks.

Contents

Unit I: Introduction- Significance of metamorphic petrology, Definition and limits of metamorphism, different types of metamorphism; Factors controlling metamorphic Processes, Protoliths, textures and structures of metamorphic rocks, Tectonic context of metamorphism

Unit II: Fundamentals of thermodynamics, Phase rules, metamorphic reactions and phase equilibria with solid solution and mixed volatile phases, geothermometry and geobarometry, Clausius-Clayperon equation, Schreinemakers rules, Concept of projections – ACF, AKF and AFM diagrams, Tie-line flip and rotations, continuous and discontinuous reactions, exchange vectors.

Unit III: Metamorphic grade, zones, facies and isograds, Metamorphic facies series, Concept of prograde and retrograde metamorphism, Metamorphism of pelites, mafic -ultra mafic rocks and siliceous dolomites, Granitisation and migmatites, UHT and UHP metamorphism, Metasomatism.

Unit IV: Geothermobarometry, Petrogenetic grid and pseudosections, Time scales of metamorphism, Metamorphic P-T-t paths and tectonic evolution, Metamorphic terrains of India.

Practical exercises (30 Hrs)

(1) **Identification and Description of Metamorphic Textures and Structures**: Examine key metamorphic textures (e.g., granoblastic, schistose, gneissose, porphyroblastic) and structures (e.g., foliation, lineation) in hand specimens and thin sections. Interpret protoliths and metamorphic conditions, and understand the relationship between mineral assemblages, deformation, and metamorphic grade.

(2) **Phase Diagrams and AFM/ACF Projections**: Analyse metamorphic mineral assemblages using ternary diagrams (AFM and ACF). Plot assemblages and interpret metamorphic reactions, including tie-line flips, and continuous versus discontinuous transitions, within the framework of phase equilibria.

(3) **Geothermo-barometry Calculations**: Estimate metamorphic pressure-temperature (P–T) conditions using mineral chemistry and calibrated thermobarometric equations to assess metamorphic grade and tectonic setting.

(4) **Interpretation of P–T–t Paths and Indian Metamorphic Terrains**: Reconstruct pressure-temperature-time (P–T–t) paths using mineral assemblages and geochronological data. Correlate these paths with tectonic settings and interpret the metamorphic evolution of major Indian terrains.

Suggestive Readings:

1. Bucher, K. and Grapes, R., 2010. *Petrogenesis of Metamorphic Rocks,* Springer.
2. Fry, N., 1985. *Field Description of Metamorphic Rocks,* New York, Geological Society of London Handbook Series.
3. Best, M.G., 2003. *Igneous and Metamorphic Petrology,* Blackwell Science.
4. Vernon, R. H., and Clarke G.L. 2008. *Principles of Metamorphic Petrology,* Cambridge University Press.
5. Winter, 1.D., 2001. *An Introduction to Igneous and MetamorphicPetrology,* Prentice Hall.
6. Yardley, B.W.D., 1997. *An Introduction to Metamorphic Petrology,* Longman Earth Science Series.
7. Spear, F.S., 1995, Metamorphic Phase Equilibria and Pressure-Temperature-Time paths, Mineralogical Society of America Monograph.

DSC- 5

Course Title and Code	**Total Credit**	**Credit distribution in course**	
Micropaleonology and Paleoceanography	**4**	**Lecture**	**Practical**
		3	**1**

Lecture (45 Hrs)

Course Objectives:

Micropaleontology, the science of microfossils and nannofossils, has become very important due to its significance in deciphering paleoclimate and its use in oceanographic studies. Nearly seventy percent of the Earth's surface is covered with oceans, and the ocean floor is covered by a thick layer of sediments, mainly consisting of microfossils, known as biogenic ooze. The micropaleontological study helps decipher past ocean circulation, which controls the earth's heat budget, monsoon variability, and El Nino Southern Oscillation. The Oceanic multiple microfossil biostratigraphy provides relative ages of the events that occurred in the geological past. Microfossils are one of the most important proxy indicators for studying paleoclimate and paleoceanography and are also extensively used in Oil Exploration, paleoenvironmental, and climate change studies. Recently, micropaleontological studies have opened new insights into the field of astrobiology and the origin of life.

Learning Outcomes:

1. to identify various types of microfossils and understand their geological applications.
2. to study microfossil groups important for oceanic biostratigraphy.
3. to comprehend the overall importance of microfossils in deciphering paleoceanographic and paleoclimatic changes in the geological past
4. to appreciate in detail the marine realm's physical, chemical, and geological aspects.
5. to understand the mechanism of surface and deep ocean circulation.
6. to learn the relationship between ocean current dynamics and its effect on the distribution of microorganisms and variability in the distribution of water mass sensitive microorganisms, which help decipher the cause and their effect in the geological records.
7. to comprehend the paleoceanographic condition through the geological records and their effect on paleoclimatic variability.
8. to learn the utility of microfossils in climate change and paleoenvironmental and oil exploration studies.

Contents

Unit I: Introduction to Marine Micropaleontology and paleoceanography.

Methods of exploring the Deep Ocean. Deep Sea Drilling Project (DSDP), Ocean Drilling Program (ODP), Integrated Ocean Drilling Program, Integrated Ocean Discovery Program (IODP), and Joint Global Ocean Flux Studies (JGOFS) and their major accomplishments. Sample processing techniques and ideas about equipment like mass spectrometers, scanning electron microscopes, and stereo-zoom binocular microscopes used for micropaleontological studies.

Unit II:

A. Calcareous Microfossils and their application in paleoceanography

(i) **Foraminifera**: Planktic Foraminifera, their modern biogeography, coiling, surface ultrastructure, outline of morphology. Benthic foraminifera, their brief morphology. Larger Foraminifera and their outline of morphology. Application in paleoceanography: Significance of planktic foraminifera in Cenozoic oceanic biostratigraphy, closing and opening of Ocean Gateways during Cenozoic and application in paleoceanographic and paleoclimatic interpretation. Application of benthic foraminifera in paleobathymetric reconstructions and bottom water paleoceanography. Benthic foraminifera as indicators of environmental change. Application of larger foraminifera in paleoclimatology and Indian stratigraphy.

(ii) **Calcareous nannofossils**: Outline of morphology, modern biogeography, Application in biostratigraphy & paleoceanography: Application of Calcareous nannofossils in surface water paleoceanographic reconstructions. Calcareous nannofossils and Paleoclimate.

- **(iii) Ostracoda:** Outline of morphology and wall structure. Application in paleoceanography: Significance of Ostracoda in Quaternary paleoceanographic and paleoclimatic studies. Environmental applications of Ostracoda including ancient and modern continental environments.
- **(iv) Pteropods, Calpionellids, and Calcareous Algae:** Brief Introduction of each group and their application in paleoceanography.

B. Siliceous, Phosphatic, and Organic Walled Microfossils.

- **(i) Radiolaria:** Outline of morphology. Modern biogeography. Application in paleoceanography.
- **(ii) Diatoms and silicoflagellates:** Brief knowledge of each group. (No morphological details).**:** Application in paleoceanography Application of Diatoms in interpreting ancient and modern lacustrine environments like Lake Eutrophication and lake Acidification. Diatoms and sea level changes. Diatoms and Sea ice cover during Quaternary. Diatoms and paleoceanography of Equatorial upwelling systems during Quaternary. Application of silicoflagellates in paleoclimatic interpretation. Importance of Siliceous microfossils in marine Geology and paleoceanography.
- **(iii) Brief Study of the Phosphatic Microfossils** like Conodonts. Outline of morphology, paleoecology, and zoological affinities. Environmental significance of Conodonts. Conodonts colour alteration index and its use. Stratigraphic significance of Conodonts with special reference to India.
- **(iv) Study of Organic Walled Microfossils** Brief knowledge of **Acritarchs** and **Dinoflagellates**. Application in environmental studies**.** Acritarchs in Indian Stratigraphy. Palynology**:** Outline of morphology of Pollens and Spores. Pollens and Spores in the marine realm. Environmental application of Pollen and Spores. Study of the application of Micropaleontology in hydrocarbon Exploration

Unit III:

- **(A) Physical & Chemical Oceanography:** Methods of measuring properties of seawater. Molecular structure of water. Temperature and salinity distribution on the surface of the ocean. Salt composition and residence time. Dissolved gases in seawater. Carbon dioxide and carbonate cycle. Composition of seawater – Classification of elements based on their distribution; major and minor constituents; behavior of elements; chemical exchanges across interfaces and residence times in seawater.
- **(B) Ocean circulation**: Surface circulation: mixed layer, thermocline and pycnocline, Coriolis force and Ekman Spiral, Upwelling, El Nino. Processes affecting biological productivity of ocean margin waters. The concept of thermohaline circulation in forming bottom waters. The Great Ocean Conveyor belt and its role in controlling the world's climate. Water masses of the world's oceans. Oxygen minimum layer in the ocean. Significant currents of the world's oceans.

Unit IV:

(A) Paleoceanography: Ocean Floor Morphology, Oceanic Crust, and Ocean Margins. Approaches to Paleoceanographic reconstructions. Paleoceanographic changes in Earth system history, including the impact of the oceans on climate change. Evolution of Oceans in the Cenozoic Era. Ocean Gateways of the Cenozoic and their role in controlling global climates. Sea level changes during Quaternary with special reference to India. Application of stable isotopes (Oxygen and Carbon) in Paleoceanography and Paleoclimatology. Paleoclimatic reconstructions from ice cores. Marine Stratigraphy, correlation, and chronology.

(B) Study about the ocean sediments and resources along with ocean pollution

- **(A) Deep-Sea Sediments and Processes:** Deep-sea sediments and their relation to oceanic processes such as solution, productivity, and dilution. Sediment distributions in time and space as related to tectonic models. Deep Sea hiatuses and their causes. Calcite and Aragonite Compensation depth and significance.
- **(B) Ocean Resources:** Ocean mineral resources, including polymetallic nodules. Marine Gas Hydrates and their economic potential.
- **(C) Marine Pollution:** Marine Pollution emphasizing geochemical aspects of the sources, transport, and fate of pollutants in the coastal marine environment and interpreting marine pollution with the help of microfossils during Quaternary.

Practical Exercises (30 Hrs):

1. Techniques of separation of microfossils from matrix
2. Types of microfossils: Calcareous, Siliceous, Phosphatic and organic-walled microfossils
3. Study of important planktic foraminifera useful in surface water paleoceanography and biostratigraphy
4. Study of larger benthic valuable foraminifera in Indian stratigraphy with special reference to Cenozoic petroliferous basins of India
5. Study of modern surface water mass assemblages of planktic foraminifera from Indian, Atlantic and Pacific Ocean
6. Depth biotopes and estimation of paleodepth of the ocean using benthic foraminiferal assemblages
7. Identification of benthic foraminifera characteristic of various deep sea environments
8. Identification of planktic foraminifera characteristic of Warm Mixed Layer, Thermocline and deep surface waters of the modern oceans
9. Identification of modern and ancient surface water mass with the help of planktic foraminifera
10. Exercises on the interpretation of oxygen and carbon isotopic record
11. Exercises on world ocean circulation
12. Exercises on Oceanic biostratigraphy

Suggested Readings:

1. Bignot, G., 1985. Elements of micropaleontology; Microfossils, their geolo gical and palaeobiological applications, Graham & Trotman, London, United Kingdom.
2. Braiser,M.D., 1980. Microfossils, Geogrge Allen and Unwin Publisher.
3. Fischer, G. and Wefer,G., 1999. Use of Proxies in Paleoceanography: Examples from the South Atlantic, Springer.
4. Gross,M.G., 1977. Oceanography: A view of the Earth, Prentice Hall.
5. Haq and Boersma, 1978. Introduction to Marine Micropaleontology, Elsevier.
6. Hasllett,S.K., 2002. Quaternary Environmental Micropalaeontology, Oxford University Press, New York.
7. Jones,R.W., 1996. Micropaleontology in Petroleum exploration, Clarendon Press Oxford.
8. Kennett and Srinivasan, 1983. Neogene Planktonic Foraminifera: A phylogenetic Atlas, Hutchinson Ross, USA.
9. Sinha, D.K., 2007. Micropaleontology: Application in Stratigraphy and

Paleoceanography, Alpha Science International, Oxford & Narosa Publishing House Pvt. Ltd. Delhi.
10. Tolmazin,D., 1985. Elements of Dynamic Oceanography, Allen and Unwin.
11. MicropaleontologyPrinciples and ApplicationsAuthors: Saraswati, Pratul Kumar, Srinivasan,
M.S. Springer, 2016

DSC 6

Course Title and Code	Total Credit	Credit distribution in course	
Sedimentary Geology	4	Lecture	Practical
		03	01

Lectures (45 Hrs) .

Course Objectives:

Sedimentary rocks are storehouse of many basic necessities of modern civilization viz. water, oil, gas, coal etc. Since the transition to a low-carbon economy is demand of the day, the importance of sedimentary petrology is being realised for the storage of CO_2 in sandstone reservoirs where injecting CO_2 often promotes geochemical reactions and diagenesis. Major objective of the course is to make students understand fundamentals of sedimentary processes and their products, formation and filling history of sedimentary basins in different tectonic backdrop. Nuances of both clastic and chemical sedimentation processes will be covered.

Learning Outcomes:

(1) To understand fundamentals of fluid flow, fluid- sediment interaction and formation of bedforms at various scales in different flow regime conditions
(2) To understand massflow processes and products
(3) To describe scales of sedimentary grain size measurement and statistical analysis of data to interpret provenance, transportation history or depositional environment
(4) To understand texture and structure of clastic sedimentary rocks; procedure and importance of paleocurrent analysis
(5) To comprehend concept of sedimentary environment and description of processes and products of different sedimentary environments viz. continental, marginal marine and marine
(6) To understand origin, mineralogy and signatures of diagenetic overprinting of chemical sedimentary rocks viz. carbonate, chert, phosphorite, Evaporite etc.
(7) To comprehend relationship between tectonics and sedimentary basin formation vis-a-vis their depositional motif.
(8) To understand role of Heavy minerals in provenance analysis, REE and trace elements for provenance interpretations, application of radio-isotopes for provenance interpretations
Contents:

Contents:

Unit I:

Fluid flow and sediment transport. 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.

Sedimentary textures, structures and Paleocurrent: Sedimentary texture: Grain size scale, particle size distribution, statistical treatment of particle size data, particle shape and fabric. Sediment texture and Petrophysics (porosity and Permeability)

Sedimentary structures: Primary (Depositional, Erosional, Penecontemporaneous deformational, biogenic) and post-depositional. Paleocurrent analysis (Scalar and Vector attributes); paleocurrent vs. paleoslope

Siliciclastic rocks: Conglomerates, sandstones, mudrocks (texture, composition, classification, origin and occurrence)

Unit II:

Paleoenvironment analysis: Concept of facies and facies association. Sedimentary Environments: Continental (Glacial, Fluvial, Eolian, Lacustrine), Marginal marine (Delta, Estuary, tidal, Chenier) and Marine (shelf, slope, deep marine).

Stratigraphic reservoirs (water/ hydrocarbon); Scales and Styles of geologic reservoir heterogeneity. Reservoir petrophysics

Application of radioactive and stable isotopes in reconstruction of paleoenvironment; Geochemical analysis for provenance and paleoclimatic study

Diagenesis and Lithification of siliciclastic rocks.

Non-siliciclastic rocks and environments: Carbonate rocks: controls on carbonate deposition, Carbonate Mineralogy, allochemical and orthochemical components. Classification of limestone

Diagenesis of carbonate sediments: Sea-floor, Meteoric (Vadose, Phreatic) and Deep burial diagenesis; Lithification

Carbonate sedimentary environments: Ramp, Rimmed Shelf and Isolated platform

Chert and siliceous sediments, Phosphorites, Evaporites (Saline Giants), Dolomite and dolomitization; Dolomite problem

Unit III:

Basin Analysis: Sedimentary basins and their classification, basin analysis (maps, cross sections, Isopach, petrofacies, geological history, applications); Concept of Geohistory analysis, concept of sequence stratigraphy

Unit IV:

Tectonics and Sedimentation: Geosynclines, Plate tectonics and sedimentation (sedimentation-divergent margins, convergent margins, transform margins), Basins in Orogenic belts. Secular changes in sedimentary record

Practical Exercises (30 Hrs)

1. Description of primary sedimentary structures from sketches and hand specimens.

2. Representation of grain size distribution data; Plotting of cumulative distribution curves, Determination of different statistical parameters. Interpretation of sediment source, sediment transport history and depositional environment

3. Plotting of paleocurrent (vector) data and interpretation. Paleocurrent vis-a-vis Paleoslope

4. Observation of common siliciclastic and carbonate sedimentary rocks under thin section. a. Siliciclastics: Quartz arenite, Arkose, Litharenite, Wackes etc. b. Sparites and Micrites

5. Exercises on sedimentary environment

Suggestive Readings:

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. Lindholm, R.C., 1987. A Practical Approach to Sedimentologv, AllcnaneUnwin, London.

4. Pettijohn, F.J., 1975. Sedimentary Rocks, Harper and Row Publ. New Delhi.

5. Prothoreo and Schwab, 2004. Sedimentary Geology, Freeman and

6. Tucker, M.E and Jones, S.J., 2023 Sedimentary Petrology John Wiley and Sons (Fourth Edition)

7. James, N.P. and Jones, B., 2016 Origin of carbonate sedimentary rocks. Wiley and Sons

Discipline-specific Elective (DSE) Courses:

DSE 3

Course Title and Code	**Total Credit**	**Credit distribution in course**	
		Lecture	**Practical**
Geological Applications of Remote Sensing and GIS	**4**	**03**	**01**

Lecture (45 Hrs)

Course Objectives

The objective of this course is to train the students with the geological applications of remote sensing and Geographic Information System (GIS). This course provides opportunity to students to gain knowledge on various remote sensing datasets and algorithms of data analysis and apply this in the field of geosciences.

Learning Outcomes

1. The students will understand the advanced concepts of remote sensing and GIS in the field of Geosciences.

2. The students will gain expertise in utilizing the Remote Sensing datasets for various geological applications using diverse techniques.
3. The students will be able to work with different datasets including Microwave and Hyperspectral and not limited to Optical datasets.

Contents:

Unit I: Introduction to remote sensing

Electromagnetic radiation principles, Sensors, Data formats, Concepts of GIS, Concepts of GPS (Global Positioning System).

Unit II: Digital image processing

Image resolutions, Image errors and corrections, Image classification (unsupervised and supervised), Image enhancement methods, Spatial and Temporal interpolation.

Unit III: Geological mapping

Mapping of geological features and landforms through aerial photographs, optical remote sensing and band transformations (band ratioing/ band indices/ PCA).

Unit IV: Applications in Natural Resource Management and Natural Hazard Mitigation

Groundwater potential zone mapping, Watershed delineation and application, Morphometric analysis, Total water storage analysis (GRACE), Hyperspectral remote sensing in Mineral mapping.

Susceptibility Mapping, Applications of SAR data (flood mapping/ landslide detection/ deformation analysis).

Practical Exercises (30 Hrs):

1. Introduction to software (QGIS/R), data procurement.
2. Image classification (unsupervised and supervised).
3. Image enhancement and Interpolation methods.
4. Feature extraction and mapping (optical remote sensing/aerial photographs).
5. Susceptibility mapping/groundwater potential zones.
6. Watershed delineation and analysis.
7. Morphometric analysis and interpretation.
8. SAR data analysis (Flood mapping/landslide detection).
9. SAR data for deformation analysis.
10. Mineral mapping using hyperspectral data.

Suggestive Readings:

1. Demers: M.N., 1997. Fundamentals of Geographic Information system, John Willey & sons. Inc.
2. Gupta, R. P., 2003. Remote Sensing Geology Springer
3. Hofmann-Wellenhof, B., Lichtenberger, H. and Collins J 2001. GPS. Theory & Practice, Springer Wien New York.
4. Jensen, J.R., 1997 Introductory Digital Image Processing: A Remote sensing perspective, Springer. Verlag.
5. Lillesand, T. M & Kiefer R W 2007 Interpretation of Remote Sensing and Image
6. Richards, JA., 1999. Remote Sensing Digital Image Analysis, An Introduction
7. Sabin, F. F., 2007 Remote Sensing: Principles, Interpretation, and Applications

8. Verbyla, D.L., 2002. Practical GIS Analysis, Taylor & Francis.

Course Title and Code	Total Credit	Credit distribution in course	
Introduction to Numerical Methods and Modelling in Earth Sciences	**4**	**Lecture**	**Practical**
		03	**01**

Lectures (45 Hrs)

Course Objectives:

- To provide a gentle introduction to numerical methods relevant to Earth Sciences.
- To refresh foundational mathematical skills for modelling Earth system processes.
- To introduce the basics of geostatistics and spatial data handling.
- To build confidence among students in applying quantitative reasoning to geological problems.

Learning Outcomes:

By the end of the course, students will be able to:

1. Use basic numerical techniques to solve geological problems.
2. Apply simple mathematical models to Earth science processes.
3. Understand and perform basic geostatistical analyses.
4. Use Excel or basic Python scripts for data visualization and numerical computation.
5. Interpret numerical and spatial outputs in the context of Earth systems.

Lectures (45 Hrs)

Unit 1

Refresher in Basic Mathematics: Mathematical Functions, graphs, and equations (linear, polynomial), Concepts of slope, area under a curve, rate of change. Examples: stream gradient, hypsometry, sediment accumulation

Unit 2.

Numerical Methods: Root finding: Bisection method; Interpolation: Linear and polynomial; Numerical differentiation and integration (using tables and Excel). Simple modelling of erosion rates, water balance, and decay equations.

Unit 3.

Introduction to Earth Systems' Modelling: Conceptual vs. numerical models, Model sensitivity and Uncertainty analysis. Examples: heat flow in rocks, sediment transport, groundwater recharge using equations to simulate basic Earth processes.

Unit 4

Geostatistics: Introduction to spatial data: point vs. gridded data; Descriptive statistics: mean, median, standard deviation; Probability concepts (Basic probability theory, Conditional probability Probability distributions); Spatial patterns: correlation, trend surfaces, regression; Basics of variogram and interpolation (inverse distance weighting, kriging).

Practical Exercises (30 Hrs):

1. Basic operations, formulas, graphing geological data (e.g., rainfall, temperature, sediment yield)
2. Solving simple problems using spreadsheets: root finding, slope analysis, interpolation
3. Create simple models for stream discharge, radioactive decay, or slope erosion using Excel
4. Introduction to modelling softwares (TopoToolbox, LSD TopoTools, MODFLOW)
5. Calculate mean, variance, and construct simple variograms manually

Suggested Readings and Tools:

1. Martin H Trauth (2010) *MATLAB recipes for Earth Sciences.* Springer
2. Jon D Pelletier (2008) *Quantitative Modeling of Earth Surface Processes.* Cambridge University Press
3. Turcotte, D.L., & Schubert, G. (2014). *Geodynamics*. Cambridge University Press
4. Gersten, J., & Smith, J. (2006). *Introduction to Numerical Methods for Earth Scientists*. Oxford University Press
5. Burrough, P.A., & McDonnell, R.A. (1998). *Principles of Geographical Information Systems*. Oxford University Press
6. John C. Davis (2002). Statistics and Data Analysis in Geology, 2nd ed. Wiley

DSE 4

Course Title and Code	**Total Credit**	**Credit distribution in course**	
Vertebrate & Invertebrate Paleontology	**4**	**Lecture**	**Practical**
		03	**01**

Lectures (45 Hrs)

Course Objectives

The principal objective of the course is to impart knowledge on the life forms of the geological past, their diversity dynamics and evolution. It is also aimed at acquainting the student with evolutionary transitions and functional adaptations in different groups of animals and plants, and relevance of fossils in relative dating of rocks and reconstructing past ecosystems. Major bio-events and mass extinctions during the geological past will be discussed in detail. The students will be able to comprehend to process the paleontological specimens.

Learning outcomes

On successful completion of the course, the student will be able to

(1) Appreciate how fossils get preserved in rocks, the nature of fossil record
(2) How fossils are named in a taxonomic framework. The student will gain knowledge on different invertebrate, vertebrate, and plant fossil groups, their palaeobiology, and the methodology used in relative dating of rocks
(3) Reconstruction of past climates, environments, and geography.

Contents

Unit -I

Introduction of Paleontology: Taphonomic processes and modes of preservation; nature and importance of fossil record. Taxonomic hierarchy; Speciation, species concept in palaeontology; Evolution and the fossil record; Modes of evolution, applications of biostratigraphy.

Unit-II

Invertebrate Paleontology: Brief introduction to important invertebrate groups (Bivalvia, Gastropoda, Brachiopoda, Graptolites, Trilobites) and their biostratigraphic significance. Significance of ammonites in Mesozoic biostratigraphy and their palaeobiogeographic implications. Functional adaptation in trilobites and ammonoids.

Unit -III

Vertebrate Paleontology: Origin of vertebrates and major steps in vertebrate evolution; Vertebrate evolution in the Palaeozoic Era; Mesozoic reptiles with special reference to origin diversity and extinction of dinosaurs, evolution in Proboscidea, Equidae and Hominidae.

Unit-IV

Paleobotany: Introduction to palaeobotany; fossil record of plants through time, fossil spores and pollen, Gondwana flora.
Ichnology: Introduction to ichnology; application of trace fossils in stratigraphy, fossils and paleobiogeography; fossils as a window to the evolution of ecosystems.

Practical Exercises (30 Hours)

1. Study of fossils showing various modes of fossilization.

2. Study of diagnostic morphological characters, systematic position, Stratigraphic position and age of various invertebrate, vertebrate and plant fossils

Suggested Readings

1. Clarkson, E.N.K.1998. Invertebrate Palaeontology and Evolution, George Allen & Unwin.

2. Raup, D.M. and Stanley, S. M. 1971. Principles of Palaeontology, W.H. Freeman and Company.

3. Benton, M. 1997. Basic Palaeontology: An introductory text, D.Harker, Addision Wisely Longman.

4. Prothero, D.R. 1998. Bringing fossils to life – An introduction to Palaeobiology, McGraw Hill.

5. Benton, M.J. 2005. Vertebrate palaeontology (3rd edition). Blackwell Scientific, Oxford.

6. Willis, K.J. & McElwain, J.C. 2002. The evolution of plants, Oxford University Press.

7. Brenchley, P. J., and Harper, D. A. T. 1998. Palaeoecology: Ecosystems,Environments and Evolution,by Chapman and Hall.

8. Foote, M. & Miller, A. I. (2006). Principles of Paleontology, third edition.

9. Shukla, A. C. & Mishra, S.P. (1982).Essentials of Palaeobotany.

10. Jones, R.W. (2011). Applications of Palaeontology - Techniques and Case Studies

DSE 4

Course Title and Code	Total Credit	Credit distribution in course	
Geochemistry	4	Lecture	Practical
		03	01

Lectures (45 Hrs)

Course Objectives:

The course aims to give an introduction in how chemical principles are used to explain the mechanisms that control the large geological systems such as the Earth's mantle, crust, ocean and atmosphere, and the formation of the solar system.

Learning Outcomes:

By attending this course student will be able

1. to understand evolution of the early Earth from proto-planetary material and its differentiation to present day state.

2. to describe the composition of the Earth's main geochemical reservoirs.

3. to explain element fractionation and how this can be used to understand geochemical processes.

4. to apply radiogenic and stable isotope signatures to trace the source of minerals, rocks and to date magmatic and metamorphic events.

5. to understand how chemical weathering of minerals and rocks control the composition of sediments/soil and natural water,

Contents

Unit- I

Earth in relation to Solar system and Universe, Nucleosynthesis, Meteorites, cosmic abundance of elements, Geochemical differentiation of primordial earth, chemical composition and properties of Earth's layers, Geochemical cycles.

Unit- II

Geochemical classification of elements, mineral partitioning coefficient; Behavior of major and trace elements in magmatic systems, handling and plotting of major and trace element data from igneous rocks, spider and REE diagrams, trace element modelling, discrimination diagrams, their use in understanding petrogenesis of rocks, Introduction to important analytical techniques used in geochemistry.

Unit- III

Radioactive decay schemes, principles and methods of radioactive dating, isochron calculation, model ages, interpretation of geochronological data, K-Ar, Ar-Ar, Rb-Sr, Sm-Nd, U-Th-Pb systems, isotopic reservoirs, Cosmogenic radionuclides, Fission Track and Radiocarbon methods of dating. Stable isotopes and their fractionation; principles of oxygen, carbon and sulphur isotope geochemistry and their application in Geology.

Unit- IV

Mineral stability in Eh-Ph diagrams; redox reactions, Mineral/mineral assemblages as sensors of ambient environments, a brief introduction to geochemistry of natural waters and sedimentary rocks; geochemical processes involved in weathering of minerals and rocks.

Practical Exercises (30 Hrs)

1. Calculation of Partition Coefficients (D-values): Perform calculations of mineral-melt partition coefficients using provided compositional data. Interpret the geochemical behaviour of major and trace elements during partial melting and fractional crystallization.
2. Major and Trace Element Data Processing and Interpretation: Utilize spreadsheet software or specialized geochemical programs to process, normalize, and graphically represent major and trace element data. Construct multi-element (spider) and rare earth element (REE) diagrams to interpret magmatic processes and petrogenetic trends.

3. Tectonic Discrimination Diagram Analysis: Generate AFM, TAS, and tectonic discrimination diagrams using geochemical data. Apply software tools (e.g., IgPet, GCDkit) to classify igneous rocks and interpret their tectonomagmatic settings.
4. Isochron Diagram Construction and Interpretation: Construct Rb-Sr or Sm-Nd isochron diagrams from isotopic data sets. Calculate the age and initial isotopic composition of geological samples to understand geochronological evolution.
5. Radiometric Dating and Decay Equation Applications: Solve numerical problems using decay equations for various radiometric systems (e.g., K-Ar, U-Pb, Rb-Sr). Understand the principles of radioactive decay and their application in absolute age determination.
6. Stable Isotope Fractionation and Environmental Interpretation: Plot $\delta^{18}O$ and $\delta^{13}C$ values for rock or water samples. Interpret isotopic variations in the context of geological processes such as diagenesis, hydrothermal alteration, and paleoclimatic changes.

Suggestive Readings:

Hugh R. Rollinson (1993) Using Geochemical Data: Evaluation, Presentation and Interpretation, Pearson Prentice Hall.

Alan P. Dickins (2005) Radiogenic Isotope Geology,. Cambridge University Press.

Kula C Misra (2012) Introduction to Geochemistry: Principles and Applications, Wiley-Blackwell.

Gunter Faure, 1998. Principles and applications of Geochemistry, Prentice Hall.

Claude Allegre, 2008. Isotope Geology, Cambridge University Press

Mason, B. and Moore, C.B., 1991. Introduction to Geochemistry, Wiley Eastern.

John V. Walther, 2010. Essentials of Geochemistry, Jones and 35 Bartlett Publication.

GE 2

Course Title and Code	**Total Credit**	**Credit distribution in course**	
Applied Mineralogy	**4**	**Lecture**	**Tutorial**
		03	**01**

Course Objectives:

This course aims to give an overview of the discipline of Applied geology aiming to enhance the understanding of practical aspects of mineralogical knowledge.

Learning Outcomes:

Upon successful completion of this course, students will be able to:

(1) Identify the industrial uses of key minerals and their economic significance.

(2) Assess the impact of mining and mineral industries on environmental systems.
(3) Analyse the mineralogical factors involved in health risks due to naturally occurring minerals (e.g., asbestos, arsenic).
(4) Evaluate the medicinal and toxicological properties of minerals and their physiological effects.

Lecture (45 Hrs)

Unit I:

Industrial Mineralogy: Mineral Processing, beneficiations and other related mineral usage, some characteristic details about Industrial aspects of Minerals

Unit II:

Environmental Mineralogy: Mineralogical effects causing Pollution and related Hazards, Health hazards from natural minerals, infrastructures of mineral industry and environmental factors, Mining and mineral industry

Unit III:

Concept of Geomedicine and Medicinal mineralogy: Geomedicine related to various elements and minerals, diseases caused by various minerals

Unit IV:

Gemstones and synthesis of minerals in laboratory, Common analytical methods in mineralogical studies.

Tutorial (15 Hrs):

Hands-on analytical skills for mineralogical studies: Analytical Data Interpretation: XRD or SEM-EDS spectra for a mineral sample will be provided and students will have to identify the mineral phases and discuss possible origin or use.

Case studies: A set of mineral-induced diseases (e.g., asbestosis, fluorosis) will be provided. Each student will build a short portfolio covering cause, geology of the region, its geographic location, mineral source, prevention.

Suggested Readings:

1. Applied Mineralogy: A Quantitative Approach by M.P. Jones
2. Essentials of Medical Geology: Impacts of the Natural Environment on Public Health" – Olle Selinus et al.
3. Mineral Exploration: Principles and Applications Swapan Kumar Haldar

GE 2

Course Title and Code	Total Credit	Credit distribution in course	
		Lecture	**Tutorial**
Earth: The planet with a difference	**4**	**03**	**01**

Lectures (45 Hrs)

Course objectives:

This course is designed to make students aware the dynamicity in the Earth system. How land and ocean distribution changed through geological history. How solar heat gets distributed in atmosphere and hydrosphere to sustain life. Trigger for extreme events.

Learning outcomes

After going through this course students will be able to comprehend

1. The origin of internal heat of the Earth and distribution of solar heat in the Earth system

2. Variation in land-sea distribution through the geological history and its trigger

3. Different air cycles and trigger for extreme events

4. Sequestration of Earth energy

Lecture (45 Hrs)

Unit I

Earth in the solar system. The fluid Earth, atmosphere, diverse ecosystem and stable climate. Nutrient cycle. Biosphere. Early atmosphere and Hydrosphere and its evolution through geological time.

Unit II

Earth as a heat engine. Distribution of solar energy. Air cycles. Internal energy.
Earth's materials: Rocks and Minerals. Concepts of Isostasy; Airy and Pratt Model.
Earth: surface features: Continents, continental margins, oceans
Supercontinents and Orogenic belts. Major orogenies in geological history

Unit III

Plate Tectonics; Distribution of land and ocean. Initiation of plate motion in early Earth. Lid Tectonics, Boring billion in the geological history

Unit IV

Elements of Earth's magnetism: Secular variation and westward drift. Solar activity and magnetic disturbance. Paleomagnetism. Sequestration of Earth energy; Extreme events

Tutorial (30 Hrs)

Hands-on experience of different types rocks and minerals. Exercises related to sea floor spreading and linear magnetic anomaly. Problems on Isostacy

Suggested Readings:

1. Holmes, A., Principles of Physical Geology, 1992, Chapman and Hall

2. Condie, K.C. Plate Tectonics and Crustal Evolution, Pargamon Press, 1989.

3. Krauskopf, K. B., & Dennis, K. Bird, 1995, Introduction to Geochemistry. McGraw-Hill

4. Faure, G. Principles and Applications of Geochemistry, 2/e (1998), Prentice Hall, 600 pp.

5. Anderson, G. M. (1996). Thermodynamics of natural systems. John Wiley & Sons Inc.

6. Steiner, E. (2008). The chemistry maths book. Oxford University Press.

7. Yates, P. (2007) Chemical calculations. 2nd Ed. CRC Press.

8. Condie, K.C. (2016) Earth as an evolving planetary system (3rd Edn.) Elsevier

Skill Development Course 2

Course Title and Code	**Total Credit**	**Credit distribution in course**	
Geological Sample collection, sample processing and analytical techniques	**2**	**Lecture**	**Practical**
		01	**01**

Course Objectives:

- To teach students in field-based and laboratory-based sampling techniques in geology.
- To equip students with practical skills in sample documentation, preservation, and preparation for various types of geological analysis.
- To develop a complete understanding of sampling bias, quality control, and contamination problems.

Learning Outcomes:

Successful course completion will enable students to:

1. Plan and carry out geological sample collection.
2. Field and subsurface sampling calls for different tools and methods.
3. Process and prepare samples for both descriptive and analytical research.
4. Maintain quality assurance.

Lectures (15 Hrs)

Unit 1

Principles of Geological Sampling

- Importance and scope of sampling in geological investigations
- Representative vs biased sampling; random vs systematic sampling
- Planning field campaigns; sample density; ethical considerations
- Documentation: notebooks, metadata, chain of custody

Unit 2

Field Sampling Techniques

- Rock sampling (igneous, sedimentary, metamorphic)
- Soil and sediment sampling (surface and subsurface)

- Fossil sampling and preservation
- Hydrogeological/geochemical sampling
- Use of field equipment: hammer, auger, core sampler, GPS

Unit 3

Laboratory Processing and Preparation

- Drying, crushing, sieving, and storage
- Jaw crusher, ball mill, and sieve shaker
- Sample preparation for:
    - Thin sections
    - Heavy mineral separation
    - Geochemical analysis (XRF, XRD, ICP-MS)
    - Grain size analysis
- Avoiding contamination and ensuring sample quality

Practical Exercises (30 Hrs)

1. Field Sampling **-** Collection of rock, soil, sediment
2. Field diagrams, GPS-based location marking, labelling
3. Field descriptions, and stratigraphic logging
4. Hands-on use of crushers, mills, and sieves
5. Demonstration of homogenisation and quartering
6. Demonstration of thin section production
7. Magnetic and heavy liquid mineral separation
8. Laboratory safety protocols
9. Sample storage, barcoding, and documentation

Suggested Readings:

1. Compton, R.R. (1985). *Geology in the Field.*
2. Manuals and SOPs of laboratory equipment