

UNIVERSITY OF NORTH BENGAL



ENLIGHTENMENT TO PERFECTION

Syllabus for B.Sc. (Honours) in Geology

**Six Semester Course Under
Choice Based Credit System
2018 - 2019**

1.1. Credit distribution across courses:

Course Type	Total Papers	Credits	
		Theory + Practical	Theory*
Discipline Specific Core Compulsory Courses	14	14x4 = 56 14x2 = 28	14x5 = 70 14x1 = 14
Discipline Specific Electives	4	4x4 = 16 4x2 = 8	4x5 = 20 4x1 = 4
Generic Electives	4	4x4 = 16 4x2 = 8	4x5 = 20 4x1 = 4
Ability Enhancement Compulsory Courses	2	2x2 = 4	2x2 = 4
Skill Enhancement Courses	2	2x2 = 4	2x2 = 4
Totals	26	140	140

* Tutorials of 1 Credit will be conducted in case there is no practical component

1.2. CBCS Syllabus Structure for Geology - B.Sc. (Hons.)

B.Sc. 1st Year Semester – I:

Course Type	Course Code	Course Name	Credit Point
Core Theory	Core/TH/01	Earth System Science	4
Core Practical	Core/PR/01	Earth System Science Lab	2
Core Theory	Core/TH/02	Mineral Science	4
Core Practical	Core/PR/02	Mineral Science Lab	2
Ability Enhancement Compulsory Course	AECC/01	Environmental Sciences (ENVS)	2
Generic Elective Theory	GE/TH/01	TBD*	4
Generic Elective Practical	GE/PR/01	TBD*	2
			Total credit = 20

TBD: To be chosen by the student from **General Elective** courses offered by other departments.

*Mathematics should be one of the “COMPULSORY” general elective for Geology (H) Students.

B.Sc. 1st Year Semester – II:

Course Type	Course Code	Course Name	Credit Point
Core Theory	Core/TH/03	Elements of Geochemistry	4
Core Practical	Core/PR/03	Elements of Geochemistry Lab	2
Core Theory	Core/TH/04	Structural Geology	4
Core Practical	Core/PR/04	Structural Geology Lab	2
Ability Enhancement Compulsory Course	AECC/02	Compulsory Language	2
Generic Elective Theory	GE/TH/02	TBD*	4
Generic Elective Practical	GE/PR/02	TBD*	2
			Total credit = 20

TBD: To be chosen by the student from **General Elective** courses offered by other departments.

*Mathematics should be one of the “COMPULSORY” general elective for Geology (H) Students.

B. Sc. 2nd Year Semester – III:

Course Type	Course Code	Course Name	Credit Point
Core Theory	Core/TH/05	Igneous Petrology	4
Core Practical	Core/PR/05	Igneous Petrology Lab	2
Core Theory	Core/TH/06	Sedimentology	4
Core Practical	Core/PR/06	Sedimentology Lab	2
Core Theory	Core/TH/07	Palaeontology	4
Core Practical	Core/PR/07	Palaeontology Lab	2
Generic Elective Theory	GE/TH/03	TBD*	4
Generic Elective Practical	GE/PR/03	TBD*	2
Skill Enhancement course	SEC I	Field Geology	2
			Total credit = 26

TBD: To be chosen by the student from **General Elective** courses offered by other departments.

*Mathematics should be one of the “COMPULSORY” general elective for Geology (H) Students.

B. Sc. 2nd Year Semester – IV:

Course Type	Course Code	Course Name	Credit Point
Core Theory	Core/TH/08	Metamorphic Petrology	4
Core Practical	Core/PR/08	Metamorphic Petrology Lab	2
Core Theory	Core/TH/09	Principles of Stratigraphy and Indian Stratigraphy	4
Core Practical	Core/PR/09	Principles of Stratigraphy and Indian Stratigraphy Lab	2
Core Theory	Core/TH/10	Hydrogeology	4
Core Practical	Core/PR/10	Hydrogeology Lab	2
Generic Elective Theory	GE/TH/04	TBD*	4
Generic Elective Practical	GE/PR/04	TBD*	2
Skill Enhancement Course	SEC II	Field Geology	2
			Total credit = 26

TBD: To be chosen by the student from **General Elective** courses offered by other departments.

*Mathematics should be one of the “COMPULSORY” general elective for Geology (H) Students.

B.Sc. 3rd Year Semester – V:

Course Type	Course Code	Course Name	Credit Point
Core Theory	Core/TH/11	Economic Geology	4
Core Practical	Core/PR/11	Economic Geology Lab	2
Core Theory	Core/TH/12	Engineering Geology	4
Core Practical	Core/PR/12	Engineering Geology Lab	2
Department Specific Elective	DSE I	DSE - I	4+2 = 6 Or 5+1 = 6
Department Specific Elective	DSE II	DSE - II	4+2 = 6 Or 5+1 = 6
			Total credit = 24

DSE: To be chosen by the student from **DSE** courses offered by the department.

B.Sc. 3rd Year Semester – VI:

Course Type	Course Code	Course Name	Credit Point
Core Theory	Core/TH/13	Geomorphology	4
Core Practical	Core/PR/13	Geomorphology Lab and/or Field Studies	2
Core Theory	Core/TH/14	Remote Sensing and GIS	4
Core Practical	Core/PR/14	Remote Sensing and GIS Lab	2
Department Specific Elective	DSE III	DSE - III	4 + 2 = 6 Or 5+1 = 6
Department Specific Elective	DSE IV	DSE - IV	4 + 2 = 6 Or 5+1 = 6
		Total credit = 24	

DSE: To be chosen by the student from **DSE** courses offered by the department.

Grand Total of Credit Points in 3 years B. Sc. Course (in six semesters): 140

2. LIST OF COURSES OFFERED UNDER CBCS GEOLOGY (HONS.)

A. DISCIPLINE SPECIFIC CORE COMPULSORY COURSES:

Core/Geol/01: Earth System Science

Core/ Geol/02: Mineral Science

Core/ Geol/03: Elements of Geochemistry

Core/ Geol/04: Structural Geology

Core/ Geol/05: Igneous Petrology

Core/ Geol/06: Sedimentology

Core/ Geol/07: Palaeontology

Core/ Geol/08: Metamorphic Petrology

Core/ Geol/09: Principles of Stratigraphy and Indian Stratigraphy

Core/ Geol/10: Hydrogeology

Core/ Geol/11: Economic Geology

Core/ Geol/12: Engineering Geology

Core/ Geol/13: Geomorphology

Core/ Geol/14: Remote Sensing and GIS

B. CHOICES FOR DISCIPLINE SPECIFIC ELECTIVE COURSES:

For UG SEM V: Any two of the following:

DSE/Geol/1: Exploration Geology

DSE/Geol/2: Earth and Climate

DSE/Geol/3: Fuel Geology

DSE/Geol/4: River Science

For UG SEM VI: Any two of the following:

DSE/Geol/5: Evolution of Life through Time

DSE/Geol/6: Oceanography

DSE/Geol/7: Introduction to Geophysics

DSE/ Geol/8: Physics and chemistry of earth

C. SKILL ENHANCEMENT COURSES: Any two of the following in SEM III and IV

SEC/Geol/01: Field Geology I

SEC/Geol/02: Field Geology II

SEC/Geol/03: Field Geology III

SEC/Geol/04: Field Geology IV

SEC/Geol/05: Field Geology V

SEC/Geol/06: Field Geology VI

SEC/Geol/07: Field Geology VII

3. DISCIPLINE SPECIFIC CORE COMPULSORY COURSES SYLLABUS

3.1 Core/Geol/TH/01 – Earth System Science

Unit 1: Earth as a planet

Holistic understanding of dynamic planet 'Earth' through Astronomy, Geology, Meteorology and Oceanography. Introduction to various branches of Earth Sciences. General characteristics and origin of the Universe, Solar System and its planets. The terrestrial and jovian planets. Meteorites and Asteroids. Earth in the solar system - origin, size, shape, mass, density, rotational and revolution parameters and its age.

Unit 2: The Solid Earth

The Earth as a Layered Planet, Mechanical Layering of the Earth; Layers of Different Composition and Physical State; Earth's Magnetic Field Convection in Earth's core and production of its magnetic field.

Unit 3: Plate Tectonics

Concept of plate tectonics, sea-floor spreading and continental drift. Geodynamic elements of Earth- Mid Oceanic Ridges, trenches, transform faults and island arcs. Origin of oceans, continents, mountains and rift valleys. Earthquake and earthquake belts. Volcanoes- types, products and their distribution.

Unit 4: Hydrosphere, Atmosphere and Biosphere

Origin of Hydrosphere, Atmosphere and Biosphere; Oceanic current system and effect of Coriolis force, Concepts of eustasy, Land-air-sea interaction, Wave erosion and beach processes, Atmospheric circulation, Weather and climatic changes, Earth's heat budget.

Unit 5: Introduction to the concept of time in geological studies

Nature of stratigraphic records. Standard stratigraphic time scale and introduction to the concept of time in geological studies. Introduction to geochronological methods and their application in geological studies. History of development in concepts of uniformitarianism, catastrophism and neptunism. Laws of superposition and faunal succession.

Unit 6: Cosmic abundance of elements

Distribution of elements in solar system and in Earth. Chemical differentiation and composition of the Earth. General concepts about geochemical cycles and mass balance. Properties of elements. Geochemical behavior of major elements. Mass conservation of elements and isotopic fractionation.

Unit 7: Life on Earth

A Planetary Perspective on Life, The Habitable Planet, The Biosphere, Biogeochemical Cycles and Biological Evolution, Extinctions and the Biosphere

3.2 Core /Geol/PR/01 – Earth System Science Lab

Practical:

1. Study of major geomorphic features and their relationships with outcrops through physiographic models.
2. Detailed study of topographic sheets and preparation of physiographic description of an area.
3. Study of soil profile of any specific area.
4. Study of distribution of major lithostratigraphic units on the map of India.
5. Distribution of cratons, mobile belts and major sedimentary basins in India.
6. Study of major ocean currents of the World
7. Study of major rocks types in hand specimen.
8. Study of distribution of major dams on map of India and their impact on river systems

SUGGESTED READINGS:

- Skinner, B.J., Porter, S.C., Botkin, D.B. (1999): The Blue Planet – An Introduction to Earth System Science. John Wiley & Sons, Inc. New York. P.552
- Mathez, E.A. and Webster, J.D. (2004): The Earth machine – The Science of a Dynamic Planet. Columbia University Press, New York. P.335
- Grotzinger, J., Jordan, T.H., Press, F., Siever, R. (2007): Understanding Earth. W.H. Freeman & Co., New York, 5th Ed.
- Emiliani, C. (1992): Planet Earth: Cosmology, Geology, and the Evolution of Life and Environment. Cambridge University Press. Published in USA.
- Holmes, A., Principles of Physical Geology, 1992, Chapman and Hall
- Condie, K.C. Plate Tectonics and Crustal Evolution, Pergamon Press, 1989
- Duff, P. M. D., & Duff, D. (Eds.). (1993). *Holmes' principles of physical geology*. Taylor & Francis.
- Emiliani, C. (1992). *Planet earth: cosmology, geology, and the evolution of life and environment*. Cambridge University Press.
- Gross, M. G. (1977). Oceanography: A view of the earth.

3.3 Core/ Geol/TH/02 – Mineral Science

Unit 1: Crystallography

Elementary ideas about crystal morphology in relation to internal structures. Crystal parameters and indices. Crystal symmetry and classification of crystals into six systems and 32 point groups, Crystal symmetry and projections, Stereographic projections of symmetry elements and forms

Unit 2: Crystal Chemistry and Structure

Elements of crystal chemistry and aspects of crystal structures, Atomic arrangements: Unit cell, CCP, FCC and HCP, Ionic radius and coordination, Pauling's rules. Solid Solution, Polymorphism, Pseudomorphism, Atomic structure of silicate minerals

Unit 3: Rock forming minerals

Minerals - definition and classification, physical and chemical properties. Silicate and non-silicate structures, Composition of common rock-forming minerals

Unit 4: Properties of minerals under microscope

Basic properties of light, Principles of optical mineralogy, Introduction to the petrological microscope and identification of common rock-forming minerals

3.4 Core/ Geol/PR/02 – Mineral Science Lab

Practical:

Observation and documentation on symmetry of crystals

Study of physical properties of minerals in hand specimen

Silicates: Olivine, Garnet, Andalusite, Sillimanite, Kyanite, Staurolite, Beryl, Tourmaline, Augite, Actinolite, Tremolite, Hornblende, Serpentine, Talc, Muscovite, Biotite, Phlogopite, Quartz, Orthoclase, Plagioclase, Microcline, Nepheline, Sodalite, Zeolite

Quartz varieties: Chert, Flint, Chalcedony, Agate, Jasper, Amethyst, Rose quartz, Smoky quartz.

Native Metals/non-metals, Sulfides, Oxides- Copper, Sulfur, Graphite, Pyrite, Corundum, Magnetite, Hydroxides, Halides, Carbonates, Sulfates, Phosphates, Psilomelane, Fluorite, Calcite, Malachite, Gypsum, Apatite.

Study of some key silicate minerals under optical microscope and their characteristic properties

Suggested Readings:

- Klein, C., Dutrow, B., Dwight, J., & Klein, C. (2007). The 23rd Edition of the Manual of Mineral Science (after James D. Dana). J. Wiley & Sons.
- Deer, W. A., Howie, R. A., & Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman.
- Nesse, W. D. (2011). Introduction to Optical Mineralogy (Fourth Edition). Oxford University Press.
- Putnis, A. (1992): Introduction to Mineral Sciences. Cambridge University Press.
- Whalstrom, E.E. (1969): Optical Crystallography. John Wiley & Sons

3.5 Core/ Geol/TH/03 – Elements of Geochemistry

Unit 1: Concepts of geochemistry

Introduction to properties of elements, Cosmic nucleosynthesis. H burning, CNO cycle, p-s process, Chemical bonding, Geochemical classification of elements. Gibbs free energy, Boltzmann's distribution law and fractionation.

Unit 2: Layered structure of Earth

Composition of different Earth reservoirs and the nuclides and radioactivity; The Rb-Sr, Pb-Pb, Sm-Nd, Re-Os isotopic systematic; Concept of radiogenic isotopes in geochronology and isotopic tracers. DM, EM, HIMU. Conservation of mass and elemental fractionation. Stable isotope.

Unit 3: Geochemistry of Earth as planet

The solid Earth – geochemical variability of magma and its products. The Earth in the solar system, the formation of solar system, water in Earth, formation of moon; Composition of the bulk silicate Earth; Meteorites (chondrite and achondrite),

Unit 4: Element transport

Advection and diffusion; Chromatography; Aqueous geochemistry- basic concepts and speciation in solutions, Eh, pH relations; Elements of marine chemistry; Diagenesis and hydrothermal alteration.

Unit 5: Analytical Instruments, Data Acquisition and Interpretation

Zircon, Monazite and garnet in geochronology, Application of EPMA, XRF, ICPMS. BSE and CL imaging.

3.6 Core/ Geol/PR/03 – Elements of Geochemistry Lab

Practical

Geochemical analysis of geological materials; Geochemical variation diagrams and its interpretations: Bivariate and trivariate plots to delineate the control of different compositional variable, Chemical variation diagrams based on major elements.

Suggested reading:

1. Mason, B. (1986) Principles of Geochemistry. 3rd Edition, Wiley New York.
2. Rollinson, H. (2007) Using geochemical data – evaluation, presentation and interpretation. 2nd Edition. Publisher Longman Scientific & Technical.
3. Walther, J. V. (2009). Essentials of geochemistry. Jones & Bartlett Publishers.
4. Albarède, F. (2003). Geochemistry: an introduction. Cambridge University Press.
5. Faure, Gunter and Teresa M. Mensing (2004). Isotopes: Principles and Applications, Wiley India Pvt. Ltd

3.7 Core/ Geol/TH/04 - Structural Geology

Unit 1: Structure and Topography

Diastrophic and non- diastrophic structures, Structural elements: planar and linear structures, concept of strike and dip, trend and plunge, rake/pitch Application of primary sedimentary and igneous structure in structural geology. Unconformity and its types; recognition of Unconformity, Concept of scale of observation of structures, Topographic maps. Outcrop patterns of different structures

Unit 2: Stress and strain in rocks

Concept of rock deformation: Stress and Strain in rocks, Strain ellipses of different types and their geological significance. Rheology and its Application to rock deformation.

Unit 3: Folds

Fold morphology; Geometric and genetic classification of folds; Introduction to the mechanics of folding; Buckling, Bending, Flexural slip and flow folding

Unit 4: Foliation and lineation

Description and origin of foliations: axial plane cleavage and its tectonic significance
Description and origin of lineation and relationship with the major structures

Unit 5: Fractures and faults

Geometric and genetic classification of fractures and faults; Effects of faulting on the outcrops
Geologic/geomorphic criteria for recognition of faults and fault plane solutions

3.8 Core/ Geol/PR/04 – Structural Geology Lab

Practical:

Basic idea of topographic contours, Topographic sheets of various scales.
Introduction to Geological maps: Lithological and Structural maps
Structural contouring and 3-point problems of dip and strike
Drawing profile sections and interpretation of geological maps of different complexities
Exercises of stereographic projections of mesoscopic structural data (planar, linear, folded etc.)

Suggested reading:

1. Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley
2. Billings, M. P. (1987) Structural Geology, 4th edition, Prentice-Hall.
3. Park, R. G. (2004) Foundations of Structural Geology. Chapman & Hall.
4. Pollard, D. D. (2005) Fundamental of Structural Geology. Cambridge University Press.
5. Ragan, D. M. (2009) Structural Geology: an introduction to geometrical techniques (4th Ed). Cambridge University Press (For Practical)
6. Lahee F. H. (1962) Field Geology. McGraw Hill

7. Ghosh, S.K. (1993) Fundamentals and Modern Developments of Structural Geology. Pergamon Press
8. Ramsay, J. G. (1967). Folding and Fracturing of Rocks. Mc-Graw Hill, New York
9. Twiss, J.R. and Moores, M.E. (2006). Structural Geology. W.H. Freeman and Company, New York

3.9. Core/ Geol/TH/05 - Igneous Petrology

Unit 1: Introduction

Principal modes of magma formation in the crust and upper mantle; physical properties of magma -temperature, viscosity, density and volatile content; formation and types of igneous rocks: volcanic, hypabyssal, plutonic. Geothermal gradient through geological time.

Unit 2: Forms, Textures and Structures

Classification of igneous rocks; Textures and structures of igneous rocks; Mode of occurrence of Igneous rocks

Unit 3: Phase diagrams and petrogenesis

Binary and Ternary Phase diagrams in understanding crystal-melt equilibrium in basaltic and granitic magmas; Magma generation, their emplacement and evolution

Unit 4: Magmatic Processes and Magmatism in different tectonic settings

Magmatic processes: crystal settling in magma, magma convection, crystal mush theory, igneous cumulates, liquid immiscibility, diffusion processes – Soret effect, magmatic assimilation and assimilation and fractional crystallization (AFC), mixing of magmas, trace element fractionation by magmas, Magmatism in the oceanic domains (MORB, OIB), Magmatism along the subduction zones: island arcs and continental arcs, Magmatism along continental rifts, Continental flood basalts and large igneous provinces, Special Precambrian associations & Meteorite-impact-generated rocks

Unit 5: Petrogenesis of Igneous rocks

Petrogenesis of Felsic and Mafic igneous rocks; Komatiites, Granitoides, Basalt, Gabbros, Alkaline rocks, kimberlites and lamproites.

3.10 Core/ Geol/PR/05 – Igneous Petrology Lab

Practical:

Study of important igneous rocks in hand specimens and thin sections, Norm calculation. Visual estimation of modes from thin sections, Plotting of mode in IUGS classification of plutonic rocks

Suggested reading:

- Philpotts, A. & Ague, J. (2009): Principles of igneous and metamorphic petrology. Cambridge University Press.
- Winter, J.D. (2014): Principles of igneous and metamorphic petrology. Pearson.
- Rollinson, H.R. (2014): Using geochemical data: evaluation, presentation, interpretation. Routledge.
- Raymond, L.A. (2002): Petrology: the study of igneous, sedimentary and metamorphic rocks. McGraw-Hill Science Engineering.
- Best, M.G. (2001): Igneous and Metamorphic Petrology.
- Cox, K.G., Bell, J.D. (1979): The Interpretation of Igneous Rocks. Springer/Chapman & Hall.
- Bose, M.K. (1997): Igneous Petrology.
- Frost, B.R. & Frost, C.D. (2014): Essentials of igneous and metamorphic petrology. Cambridge University Press.
- G W Tyrrell. (1926). Principles of Petrology. Springer

3.11 Core/ Geol/TH/06 -Sedimentology**Unit 1: Introduction to Sedimentology**

Outline of sedimentation process: Definition of sediment; origin of sediments: mechanical and chemical sediments; source rock or provenance

Unit 2: Sedimentary textures

Grain size: concept and size scale, particle size distribution, particle shape and fabric

Unit 3: Basic hydraulics and Sedimentary structures

Fluid flow: Types of fluids, Laminar and turbulent flow, subcritical, critical and supercritical flows; concept of mean flow velocity, unit discharge and bed shear stress; flow profile and flow separation; particle entrainment, transport and deposition, Mass flow: types, mechanisms and controlling factors, process-product relationship, Penecontemporaneous deformation: mechanisms and controlling factors, Sedimentary structure: Primary and penecontemporaneous structures, Bedform stability diagram, Paleocurrent analysis: Data acquisition, methodology, different palaeocurrent patterns

Unit 4: Sedimentary rocks

Siliciclastic rocks: Components and classification(s) of conglomerates, sandstones & mudstones, Tectonic control on sandstone composition, Carbonate rocks; controlling factors of carbonate deposition; components and classifications of limestone; dolomite and dolomitisation

Unit 5: Diagenesis

Concepts of diagenesis, Stages of diagenesis: diagenetic changes in sand and carbonate deposits, lithification

3.12 Core/ Geol/PR/06 – Sedimentology Lab

Practical:

Identification of sedimentary structures, Particle size distribution and statistical analysis, Paleocurrent analysis, Petrographic study of clastic and non-clastic rocks through hand specimens and thin sections

Suggested reading:

- Prothero, D. R., & Schwab, F. (2004). *Sedimentary geology*. Macmillan
- Tucker, M. E. (2006). *Sedimentary Petrology*, Blackwell Publishing
- Collinson, J. D. & Thompson, D. B. (1988). *Sedimentary structures*, Unwin- Hyman, London
- Nichols, G. (2009). *Sedimentology and Stratigraphy Second Edition*. Wiley Blackwell
- Allen, J.R.L., 1985. *Principles of Physical Sedimentology*. George Allen and Unwin, London

3.13 Core/ Geol/TH/07 - Paleontology

Unit 1: Fossilization and fossil record

Nature and importance of fossil record; Fossilization processes and modes of preservation

Unit 2: Taxonomy and Species concept

Species concept with special reference to paleontology, Taxonomic hierarchy Theory of organic evolution interpreted from fossil record

Unit 3: Invertebrates

Brief introduction to important invertebrate groups (Bivalvia, Gastropoda, Brachiopoda) and their biostratigraphic significance.

Significance of ammonites in Mesozoic biostratigraphy and their paleobiogeographic implications Functional adaptation in trilobites and ammonoids.

Unit 4: Vertebrates

Origin of vertebrates and major steps in vertebrate evolution.

Mesozoic reptiles with special reference to origin diversity and extinction of dinosaurs

Evolution of horse and intercontinental migrations. Human evolution.

Unit 5. Introduction to Paleobotany, Gondwana Flora

Introduction to Ichnology.

Unit 6: Application of fossils in Stratigraphy

Biozones, index fossils, correlation

Role of fossils in sequence stratigraphy

Fossils and paleoenvironmental analysis

Fossils and paleobiogeography, biogeographic provinces, dispersals and barriers

Paleoecology – fossils as a window to the evolution of ecosystems

3.14 Core/ Geol/PR/07 – Paleontology Lab

Practical:

Study of fossils showing various modes of preservation

Study of diagnostic morphological characters, systematic position, stratigraphic position and age of various invertebrate, vertebrate and plant fossils

Suggested reading:

1. Raup, D. M., Stanley, S. M., Freeman, W. H. (1971) Principles of Paleontology
2. Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution 4th Edition by Blackwell Publishing.
3. Benton, M. (2009). Vertebrate paleontology. John Wiley & Sons.
4. Shukla, A. C., & Misra, S. P. (1975). Essentials of paleobotany. Vikas Publisher
5. Armstrong, H. A., & Brasier, M.D. (2005) Microfossils. Blackwell Publishing.

3.15 Core/ Geol/TH/08 - Metamorphic Petrology

Unit 1: Metamorphism: controls and types.

Definition of metamorphism. Factors controlling Metamorphism, Types of metamorphism. The causes of variation, crustal heat flow and geothermal gradient, Concept of P-T-t paths

Unit 2: Metamorphic Facies and grades

Index minerals, Chemographic projections, Metamorphic zones and isograds, Concept of Metamorphic facies and grade

Unit 3: Phase rule and texture

Mineralogical phase rule of closed and open system; Textures of metamorphic rocks; Principles of geothermobarometry and textural identification

Unit 4: Metamorphism and tectonism

Metamorphism and Tectonism; Relationship between metamorphism and deformation
Metamorphic mineral reactions, prograde and retrograde metamorphism

Unit 5: Metamorphic rock Association

Migmatites, Granulites, Blueschists, Eclogites, Paired metamorphic belt. Ultra High Pressure and Ultra High Temperature assemblage.

3.16 Core/ Geol/PR/08 – Metamorphic Petrology Lab

Practical:

Hand specimen study of metamorphic rocks, Textural and mineralogical study of metamorphic rocks in thin sections, Graphical plots of metamorphic mineral assemblages using chemographic diagrams

Suggested reading:

- Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
- Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
- Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.
- Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
- Yardley, B. W. D. (1989). An introduction to metamorphic petrology. Longman Scientific and Technical, London.
- Spear F. S. 1993. Metamorphic phase equilibria and Pressure-Temperature-Time paths. Mineralogical Society of America. Monograph 799

3.17 Core/ Geol/TH/09 - Principles of Stratigraphy and Indian Stratigraphy

Unit 1: Principles of stratigraphy

Fundamentals of litho-, bio- and chrono-stratigraphy; Introduction to concepts of dynamic stratigraphy (chemostratigraphy, seismic stratigraphy, sequence stratigraphy)

Unit 2: Code of stratigraphic nomenclature

International Stratigraphic Code – development of a standardized stratigraphic nomenclature.

Concepts of Stratotypes. Global Stratotype Section and Point (GSSP).

Brief introduction to the concepts of lithostratigraphy, biostratigraphy, chronostratigraphy, seismic stratigraphy, chemostratigraphy, Magnetostratigraphy, Sequence stratigraphy and their subdivisions with Indian examples.

Unit 3: Principles of stratigraphic analysis Facies concept in stratigraphy

Walther's Law of Facies. Concept of paleogeographic reconstruction

Unit 4: Physiographic and tectonic subdivisions of India

Brief introduction to the physiographic and tectonic subdivisions of India.

Introduction to Indian Shield

Introduction to Proterozoic basins of India.

Geology of Vindhyan and Cudappah basins of India

Unit 5: Phanerozoic Stratigraphy of India

Paleozoic Succession of Kashmir and its correlatives from Spiti and Zaskar Stratigraphy
Structure and hydrocarbon potential of Gondwana basins.

Mesozoic stratigraphy of India: Triassic successions of Spiti, Jurassic of Kutch, Cretaceous successions of Cauvery basins; Cenozoic stratigraphy of India: Kutch basin, Siwalik successions: Assam, Andaman and Arakan basins.

Stratigraphy and structure of Krishna-Godavari basin, Cauvery basin, Bombay offshore basin, Kutch and Saurashtra basins and their potential for hydrocarbon exploration

Unit 6: Volcanic provinces of India

Deccan, Rajmahal, Sylhet Trap

Unit 7: Stratigraphic boundaries

Important Stratigraphic boundaries in India - Precambrian-Cambrian boundary, Permian-Triassic boundary, and Cretaceous-Tertiary boundary

3.18 Core/ Geol/PR/09 – Principles of Stratigraphy and Indian Stratigraphy Lab

Practical:

Study of geological map of India and identification of major stratigraphic units, Study of rocks in hand specimens from known Indian stratigraphic horizons, Drawing various paleogeographic maps of Precambrian time, Study of different Proterozoic supercontinent reconstructions.

Suggested reading:

1. Krishnan, M. S. (1982) Geology of India and Burma, CBS Publishers, Delhi
2. Doyle, P. & Bennett, M. R. (1996) Unlocking the Stratigraphic Record. John Wiley
3. Ramakrishnan, M. & Vaidyanadhan, R. (2008) Geology of India Volumes 1 & 2, Geological society of India, Bangalore.
4. Valdiya, K. S. (2010) The making of India, Macmillan India Pvt. Ltd.

3.19 Core/ Geol/TH/10 – Hydrogeology

Unit 1: Introduction and basic concepts

Scope of hydrogeology and its societal relevance

Hydrologic cycle: precipitation, evapo-transpiration, run-off, infiltration and subsurface movement of water.

Rock properties affecting groundwater, Vertical distribution of subsurface water
Types of aquifer, aquifer parameters, anisotropy and heterogeneity of aquifers

Unit 2: Groundwater flow

Darcy's law and its validity
Intrinsic permeability and hydraulic conductivity
Groundwater flow rates and flow direction
Laminar and turbulent groundwater flow

Unit 3: Well hydraulics and Groundwater exploration

Basic Concepts (drawdown; specific capacity etc)
Elementary concepts related to equilibrium and non-equilibrium conditions for water flow to a well in confined and unconfined aquifers.
Surface-based groundwater exploration methods
Introduction to subsurface borehole logging methods

Unit 4: Groundwater chemistry

Physical and chemical properties of water and water quality
Introduction to methods of interpreting groundwater quality data using standard graphical plots
Sea water intrusion in coastal aquifers

Unit 5: Groundwater management

Surface and subsurface water interaction
Groundwater level fluctuations
Basic concepts of water balance studies, issues related to groundwater resources development and management
Rainwater harvesting and artificial recharge of groundwater

3.20 Core/Geol/PR/10 – Hydrogeology Lab

Practical:

Preparation and interpretation of water level contour maps and depth to water level maps
Study, preparation and analysis of hydrographs for differing groundwater conditions
Water potential zones of India (map study).
Graphical representation of chemical quality data and water classification (C-S and Trilinear diagrams)
Simple numerical problems related to: determination of permeability in field and laboratory, Groundwater flow, Well hydraulics etc.

Suggested reading:

1. Todd, D. K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.
2. Davis, S. N. and De Weist, R.J.M. 1966. Hydrogeology, John Wiley & Sons Inc., N.Y.
3. Karanth K.R., 1987, Groundwater: Assessment, Development and management, Tata McGrawHill Pub. Co. Ltd.

3.21 Core/Geol/TH/11 - Economic Geology**Unit 1 Earths Geochemical differentiations and ore deposits; Ores and gangues**

Ores, gangue minerals, tenor, grade and lodes

Resources and reserves- Economic and Academic definitions

Unit 2: Mineral deposits and Classical concepts of Ore formation

Mineral occurrence, Mineral deposit and Ore deposit

Unit 3: Structure and texture of ore deposits

Concordant and discordant ore bodies

Endogenous processes: Magmatic concentration, skarns, greisens, and hydrothermal deposits

Exogenous processes: weathering products and residual deposits, oxidation and supergene enrichment, placer deposits,

Unit 4: Mineral exploration

Exploration and exploitation techniques. Remote Sensing, Geophysical and Geochemical Explorations. Geological mapping at different scales, drilling, borehole logs and transverse sections

Unit 5: Mineral Economics

Assessment of grade, reserve estimation

Unit 6: Metallic and Nonmetallic ores

Metallogenic provinces and epochs. Important deposits of India. Non-metallic and industrial rocks and minerals in India. Introduction to gemstones.

3.22 Core/Geol/PR/11 – Economic Geology Lab**Practical:**

Megascopic identification; Study of microscopic properties of ore forming minerals;

Preparation of maps; Distribution of important ores and other economic minerals in India.

Suggested reading:

1. Guilbert, J.M. and Park Jr., C.F. (1986) The Geology of Ore deposits. Freeman & Co.
2. Bateman, A.M. and Jensen, M.L. (1990) Economic Mineral Deposits. John Wiley.
3. Evans, A.M. (1993) Ore Geology and Industrial minerals. Wiley
4. Laurence Robb. (2005) Introduction to ore forming processes. Wiley.
5. Gokhale, K.V.G.K. and Rao, T.C. (1978) Ore deposits of India their distribution and processing, Tata-McGraw Hill, New Delhi.
6. Deb, S. (1980) Industrial minerals and rocks of India. Allied Publishers.
7. Sarkar, S.C. and Gupta, A. (2014) Crustal Evolution and Metallogeny in India. Cambridge Publications.

3.23 Core/Geol/TH/12 - Engineering Geology**Unit 1: Introduction**

Engineering Geology, Role of Engineering geologists in planning, design and construction of major man-made structural features

Unit 2: Site investigation and characterization**Unit 3: Foundation treatment**

Grouting, Rock Bolting and other support mechanisms

Unit 4: Intact Rock and Rock Mass properties

Rock aggregates; Significance as Construction Material

Unit 5: Rock Quality Assessment

Concept, Mechanism and Significance of:

- a. Rock Structure Rating (RSR)
- b. Rock Mass Rating (RMR)
- c. Tunneling Quality Index (Q)

Unit 6: Geology and Engineering Construction

Geological, Geotechnical and Environmental considerations for Dams and Reservoirs and tunnels

Unit 7: Natural Disasters and Engineering Geology

Landslides Causes, Factors and corrective/Preventive measures
Earthquake: Causes, Factors and corrective/Preventive measures

Unit 8: Case histories related to Indian Civil Engineering Projects

3.24 Core/Geol/PR/12 – Engineering Geology Lab

Practical:

Computation of reservoir area, catchment area, reservoir capacity and reservoir life; Merits, demerits & remedial measures based upon geological cross sections of project sites; Computation of Index properties of rocks; Computation of RQD, RSR, RMR and ‘Q’

Suggested reading:

1. Krynin, D.P. and Judd W.R. 1957. Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).
2. Johnson, R.B. and De Graf, J.V. 1988. Principles of Engineering Geology, John Wiley.
3. Goodman, R.E., 1993. Engineering Geology: Rock in Engineering constructions. John Wiley & Sons, N.Y.
4. Waltham, T., 2009. Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.
5. Bell: F.G-, 2006. Basic Environmental and Engineering Geology Whittles Publishing.
6. Bell, .F.G, 2007. *Engineering Geology*, Butterworth-Heineman

3.25 Core/Geol/TH/13 – Geomorphology

Unit 1: Introduction to Geomorphology

Endogenic and Exogenic processes

Unit 2:

Geoid, Topography, Hypsometry, Global Hypsometry, Major Morphological features Large Scale Topography - Ocean basins, Plate tectonics overview, Large scale mountain ranges (with emphasis on Himalaya).

Unit 3: Surficial Processes and geomorphology

Weathering and associated landforms, Hill slopes Glacial, Periglacial processes and landforms, Fluvial processes and landforms, Aeolian Processes and landforms, Coastal Processes and landforms, Landforms associated with igneous activities

Unit 4: Endogenic- Exogenic interactions

Rates of uplift and denudation, Tectonics and drainage development, Sea-level change, Long-term landscape development

Unit 5: Overview of Indian Geomorphology, Extraterrestrial landforms

3.26 Core/ Geol/PR/13 – Geomorphology Lab and/or Field studies

Practical:

Reading topographic maps ,Concept of scale Preparation of a topographic profile , Preparation of longitudinal profile of a river; Preparing Hack Profile; Calculating Stream length gradient index,

Morphometry of a drainage basin, Calculating different morphometric parameters , Preparation of geomorphic map , Interpretation of geomorphic processes from the geomorphology of the area; Geological Field work.

Suggested reading:

1. Robert S. Anderson and Suzzane P. Anderson (2010): Geomorphology - The Mechanics and Chemistry of Landscapes. Cambridge University Press.
2. M.A. Summerfield (1991) Global Geomorphology. Wiley & Sons

3.27 Core/Geol/TH/14 – Remote Sensing and GIS

Unit 1: Photogeology

Types and acquisition of aerial photographs; Scale and resolution; Principles of stereoscopy, relief displacement, vertical exaggeration and distortion

Elements of air photo interpretation

Identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms

Unit 2: Remote Sensing

Concepts in Remote Sensing

Sensors and scanners

Satellites and their characteristics

Data formats- Raster and Vector

Unit 3: Digital Image Processing

Image Errors, Rectification and Restoration, FCC, Image Enhancement, Filtering, Image Rationing, Image classification and accuracy assessment. GIS integration and Case studies, examples.

Unit 4: GIS

Datum, Coordinate systems and Projection systems

Spatial data models and data editing

Introduction to DEM analysis

Unit 5: GPS:

Concepts of GPS

Integrating GPS data with GIS

Applications in the earth system sciences

3.28 Core/Geol/PR/14 – Remote Sensing and GIS Lab

Practical:

Aerial Photo interpretation, identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms

Introduction to DIP and GIS softwares. Digital Image Processing exercises including analysis of satellite data in different bands and interpretation of various objects on the basis of their spectral signatures Creating a FCC from raw data, Registration of satellite data with a toposheet of the area Enhancing the satellite images; Generating NDVI images and other image ratio and its interpretation

Classification of images. DEM analysis: generating slope map, aspect map and drainage network map and its applications

Suggested reading:

1. Demers, M.N., 1997. Fundamentals of Geographic Information System, John Wiley & sons. Inc.
2. Hoffmann-Wellenhof, B., Lichtenegger, H. and Collins, J., 2001. *GPS: Theory & Practice*, Springer Wien New York.
3. Jensen, J.R., 1996. Introductory Digital Image Processing: A Remote Sensing Perspective, Springer- Verlag.
4. Lillesand, T. M. & Kiefer, R.W., 2007. Remote Sensing and Image Interpretation, Wiley.
5. Richards, J.A. and Jia, X., 1999. Remote Sensing Digital Image Analysis, Springer-Verlag.

4. DEPARTMENT SPECIFIC ELECTIVE SUBJECTS SYLLABUS

4.1 DSE/Geol/TH/1 - Exploration Geology

Unit 1: Mineral Resources

Resource reserve definitions, Mineral resources in industries – historical perspective and present, A brief overview of classification of mineral deposits with respect to processes of formation in relation to exploration strategies.

Unit 2: Prospecting and Exploration

Principles of mineral exploration, Prospecting and exploration- conceptualization, methodology and stages, Sampling, subsurface sampling including pitting, trenching and drilling, Geochemical exploration.

Unit 3: Evaluation of data

Evaluation of sampling data, Mean, mode, median, standard deviation and variance

Unit 4: Drilling and Logging

Core and non-core drilling, Planning of bore holes and location of boreholes on ground
Core-logging

Unit 5: Reserve estimations and Errors

Principles of reserve estimation, density and bulk density. Factors affecting reliability of reserve estimation, Reserve estimation based on geometrical models (square, rectangular, triangular and polygon blocks) Regular and irregular grid patterns, statistics and error estimation

4.2 DSE/Geol/PR/1 – Exploration Geology Lab

Practical:

Identification of anomaly; Concept of weighted average in anomaly detection; Geological cross-section; Models of reserve estimation

Suggested reading:

1. Clark, G.B. 1967. Elements of Mining. 3rd Ed. John Wiley & Sons.
2. . Arogyaswami, R.P.N. 1996 Courses in Mining Geology. 4th Ed. Oxford-IBH.
3. Moon, C.J., Whateley, M.K.G., Evans, A.M., 2006, Introduction to Mineral Exploration, Blackwell Publishing

4.3 DSE/ Geol/TH/2 - Earth and Climate

Unit 1: Climate system: Forcing and Responses

Components of the climate system; Climate forcing, Climate controlling factors; Climate system response, response rates and interactions within the climate system; Feedbacks in climate system.

Unit 2: Heat budget of Earth

Incoming solar radiation, receipt and storage of heat; Heat transformation; Earth's heat budget. Interactions amongst various sources of earth's heat.

Unit 3: Atmosphere – Hydrosphere

Layering of atmosphere and atmospheric Circulation; Atmosphere and ocean interaction and its effect on climate; Heat transfer in ocean; Global oceanic conveyor belt and its control on earth's climate; Surface and deep circulation; Sea ice and glacial ice.

Unit 4: Response of biosphere to Earth's climate

Climate Change: natural vs. anthropogenic effects; Humans and climate change; Future perspectives; Brief introduction to archives of climate change; Archive based climate change data from the Indian continent.

Unit 5: Orbital cyclicality and climate

Milankovitch cycles and variability in the climate; Glacial-interglacial stages The Last Glacial maximum (LGM); Pleistocene Glacial-Interglacial cycles; Younger Dryas; Marine isotope stages.

Unit 6: Monsoon

Mechanism of monsoon; Monsoonal variation through time; Factors associated with monsoonal intensity; Effects of monsoon

4.4 DSE/ Geol/PR/2 - Earth and Climate Lab

Practical:

Study of distribution of major climatic regimes of India on map; Distribution of major wind patterns on World map; Preparation of paleogeographic maps (distribution of land and sea) of India during specific geological time intervals; Numerical exercises on interpretation of proxy records for paleoclimate.

Suggested reading:

1. Rudiman, W.F., 2001. Earth's climate: past and future. Edition 2, Freeman Publisher.
2. Rohli, R.V., and Vega, A.J., 2007. Climatology. Jones and Barlett
3. Lutgens, F., Tarbuck, E., and Tasa, D., 2009. The Atmosphere: An Introduction to Meteorology. Pearson Publisher
4. Aguado, E., and Burt, J., 2009. Understanding weather

4.5 DSE/ Geol/TH/3 - Fuel Geology

Unit 1: Coal

Definition and origin of Coal; Basic classification of coal; Fundamentals of Coal Petrology - Introduction to lithotypes, microlithotypes and macerals in coal; Proximate and Ultimate analysis.

Unit 2: Coal as a fuel

Coal Bed Methane (CBM): global and Indian scenario; Underground coal gasification; Coal liquefaction.

Unit 3: Petroleum

Chemical composition and physical properties of crudes in nature; Origin of petroleum; Maturation of kerogen; Biogenic and Thermal effect.

Unit 4: Petroleum Reservoirs and Traps

Reservoir rocks: general attributes and petrophysical properties; Classification of reservoir rocks - clastic and chemical. Hydrocarbon traps: definition, anticlinal theory and trap theory; Classification of hydrocarbon traps - structural, stratigraphic and combination; Time of trap formation and time of hydrocarbon accumulation. Cap rocks - definition and general properties; Plate tectonics and global distribution of hydrocarbon reserves.

Unit 5: Other fuels

Gas Hydrate; Nuclear Fuel

4.6 DSE/ Geol/PR/3 - Fuel Geology Lab

Practical:

Study of hand specimens of coal; Reserve estimation of coal; Section correlation and identification of hydrocarbon prospect; Panel and Fence diagrams

Suggested reading:

1. Chandra D. (2007). Chandra's Textbook on applied coal petrology. Jijnasa Publishing House.
2. Shelly R. C. (2014). Elements of Petroleum geology: Third Edition, Academic Press
3. Bjorlykke, K. (1989). Sedimentology and petroleum geology. Springer-Verlag.
4. Bastia, R., & Radhakrishna, M. (2012). Basin evolution and petroleum prospectivity of the continental margins of India (Vol. 59). Newnes.

4.7 DSE/ Geol/TH/4 - River Science

Unit 1: Stream hydrology

Basic stream hydrology; Physical properties of water, sediment and channel flow; River discharge, River hydrographs (UH, IUH, SUH, GIUH) and their application in hydrological analysis; Flood frequency analysis.

Unit 2: River basin

Sediment source and catchment erosion processes; Sediment load and sediment yield; Sediment transport processes in rivers; Erosion and sedimentation processes in channel.

Unit 3: Drainage

Drainage network; Quantitative analysis of network organization – morphometry; Random Topology (RT) model and fractal analysis; Role of drainage network in flux transfer; Evolution of drainage network in geological time scale.

Unit 4: Rivers in time and space

River diversity in space, Patterns of alluvial rivers - braided, meandering and branching

channels, Dynamics of alluvial rivers; Channel patterns in stratigraphic sequences; Different classification approaches in fluvial geomorphology and its applications.

Unit 5: Channels and Landscapes

Bedrock channels, Bedrock incision process; River response to climate, tectonics and human disturbance; Bedrock channel processes and evolution of fluvial landscapes.

Unit 6: Fluvial hazards

Integrated approach to stream management; Introduction to river ecology.

4.8 DSE/ Geol/PR/4 - River Science Lab

Practical:

Stream power calculation; Longitudinal profile analysis; Hydrograph analysis and other related problems.

Suggested reading:

1. Davies, T. (2008) Fundamentals of hydrology. Routledge Publications.
2. Knighton, D. (1998) Fluvial forms and processes: A new perspective. Arnold Pubs.
3. Richards, K. (2004) Rivers: Forms and processes in alluvial channels. Balckburn Press.
4. Bryirely and Fryirs (2005) Geomorphology and river management. Blackwell Pub.,
5. Julien, P.Y. (2002) River Mechanics. Cambridge University Press.
6. Robert, A. (2003) River Processes: An introduction to fluvial dynamics. Arnold Publications.
7. Vanoni, V.A. (2006) Sedimentation Engineering. ASCE Manual, Published y American Society of Civil Engineering,
8. Tinkler, K.J., Wohl, E.E. (eds.) 1998. Rivers over rock. American Geophyscial Union Monogrpah, Washington, DC.

4.9 DSE/ Geol/TH/5 - Evolution of Life through Time

Unit 1: Life through ages

Fossils and chemical remains of ancient life; Geological Time Scale with emphasis on major bio-events. Fossilization processes and modes of fossil preservation. Exceptional preservation sites- age and fauna

Unit 2: Geobiology

Biosphere as a system, processes and products; Biogeochemical cycles; Abundance and diversity of microbes, extremophiles; Microbes-mineral interactions, microbial mats

Unit 3: Origin of life

Possible life sustaining sites in the solar system, life sustaining elements and isotope records
Archean life: Earth's oldest life, Transition from Archean to Proterozoic, the oxygen revolution

and radiation of life; Precambrian macrofossils – The garden of Ediacara; The Snow Ball Earth Hypothesis.

Unit 4: Paleozoic Life

The Cambrian Explosion. Biomineralization and skeletalization; Origin of vertebrates and radiation of fishes; Origin of tetrapods - Life out of water; Early land plants and impact of land vegetation.

Unit 5: Mesozoic Life

Life after the largest (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.

Unit 6: Cenozoic Life

Aftermath of end Cretaceous mass extinction – radiation of placental mammals; Evolution of modern grasslands and co-evolution of hoofed grazers; Rise of modern plants and vegetation; Back to water – Evolution of Whales.

Unit 7: The age of humans

Hominid dispersals and climate setting; Climate Change during the Phanerozoic - continental break-ups and collisions; Plate tectonics and its effects on climate and life; Effects of life on climate and geology.

4.10 DSE/ Geol/PR/5 - Evolution of Life through Time Lab

Practical:

Study of modes of fossil preservation; Study of fossils from different stratigraphic levels; Exercises related to major evolutionary trends in important groups of animals and plants

Suggested reading:

1. Stanley, S.M., 2008 Earth System History
2. Jonathan I. Lumine W.H.Freeman Earth-Evolution of a Habitable World, Cambridge University Press.
3. Canfield, D.E. & Konhauser, K.O., 2012 Fundamentals of Geobiology Blackwell
4. Cowen, R., 2000 History of Life, Blackwell

4.11 DSE/ Geol/TH/6 - Oceanography (Theory and Tutorial)

Unit 1: Fundamentals of Ocean

Concept of land and Ocean. Land-Ocean distribution; Marine Provinces; Plate Tectonics and Sea Floor spreading

Unit 2: Chemical and Physical aspects of Ocean

Ocean dynamics; Ocean Chemistry; Marine Sediments; Sea Water: Composition, Controls on sea water composition; Sea-Air Interaction

Unit 3: Waves, Tides and Coasts

Ocean Circulation; Waves and Water Dynamics; Ocean Energy; The Coast: Beaches and Shoreline; The Coastal Ocean - Migration for Coastal Erosion

Unit 4: Life in the Ocean

Marine Life and the Environment; Biologic Productivity and in Ocean; Animals of the Pelagic Environment and Life; Animals of the Benthic environment and Life

Suggested reading:

1. Introductory Oceanography by Harold V. Thurman, Mt. San Antonio College, Charles E. Merrill Publishing Company.
2. Oceanography for Beginners, by Pranab K. Banerjee, Allied Publishers Pvt. Limited
3. Coastal Hydraulics, by A. M. Muir and C. A. Fleming 1981, The MacMillan Press Ltd, London.

4.12 DSE/ Geol/TH/7 - Introduction to Geophysics**Unit 1: Geology and Geophysics**

Interrelationship between geology and geophysics, Role of geological and geophysical data in explaining geodynamical features of the earth.

Unit 2: General and Exploration geophysics

Different types of geophysical methods - gravity, magnetic, electrical and seismic; their principles and applications; Concepts and Usage of corrections in geophysical data

Unit 3: Geophysical field operations

Different types of surveys, grid and route surveys, profiling and sounding techniques
Scales of survey, Presentation of geophysical data

Unit 4: Application of Geophysical methods

Regional geophysics, oil and gas geophysics, ore geophysics, groundwater geophysics, engineering geophysics.

Unit 5: Geophysical anomalies

Correction to measured quantities, geophysical, anomaly, regional and residual (local) anomalies, factors, controlling anomaly, and depth of exploration

Unit 6: Integrated geophysical methods

Ambiguities in geophysical interpretation, planning and execution of geophysical surveys

4.13 DSE/ Geol/PR/7 - Introduction to Geophysics Lab

Practical:

Anomaly and background- Graphical method; Study and interpretation of seismic reflector geometry; Problems on gravity anomaly.

Suggested reading:

1. Outlines of Geophysical Prospecting - A manual for geologists by Ramachandra Rao, M.B., Prasaranga, University of Mysore, Mysore, 1975.
2. Exploration Geophysics - An Outline by Bhimasarikaram V.L.S., Association of Exploration Geophysicists, Osmania University, Hyderabad, 1990.
3. Dobrin, M.B. (1984) An introduction to Geophysical Prospecting. McGraw-Hill, New Delhi.
4. Telford, W. M., Geldart, L. P., & Sheriff, R. E. (1990). *Applied geophysics* (Vol. 1). Cambridge university press.
5. Lowrie, W. (2007). Fundamentals of geophysics. Cambridge University Press.

4.14 DSE/ Geol/TH/8 - Physics and Chemistry of Earth

Unit 1: Earth: surface features

Continents, continental margins, oceans

Unit 2: Earth's interior

Variation of physical quantities and seismic wave velocity inside the earth, major sub divisions and discontinuities.

Concepts of Isostasy; Airy and Pratt Model.

Core: Seismological and other geophysical constraints.

The geodynamo – convection in the mantle.

Unit 3: Elements of earth's magnetism

Secular variation and westward drift; Solar activity and magnetic disturbance.

Unit 4: Elements

Origin of elements/nucleosynthesis. Abundance of the elements in the solar system / planet earth; Geochemical classification of elements; Earth accretion and early differentiation; Isotopes and

their applications in understanding Earth processes. Stable isotopes: Stable isotope fractionation. Oxygen isotopes. Sublithospheric Mantle (Mineralogy/phase transitions)

Unit 5: Environmental geochemistry

Geological disposal of nuclear waste; Lead in environment and effect of lead on human health

4.15 DSE/ Geol/TH/8 - Physics and Chemistry of Earth Lab

Practical:

1. Projection of major elements on binary and triangular diagrams for rock classification
2. Projection of major element data on Harker's diagram to characterize magmatic differentiation
3. Study of trace elements through a) Projection of chondrite/primitive normalized trace elements to characterize sources b) Projection of trace elements on tectonic discrimination diagrams
4. Understanding Earth structure through behavior of seismic wave propagation
5. Problems on isostasy

Suggested reading:

1. Holmes, A., Principles of Physical Geology, 1992, Chapman and Hall
2. Condie, K.C. Plate Tectonics and Crustal Evolution, Pergamon 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

5. SKILL ENHANCEMENT COURSE

Any Two of the Following:

5.1 SEC/Geol/01 – Field Geology I

Introduction to Field Training Programme

Topographic sheet: Methods of naming. Features, scale. Map reading.

Use of topographic sheets in field. Marking location in topographic sheet using physical features and bearing.

Use of GPS in field.

Distance, height and pace approximation in field.

Identification of rock types.

Identification of primary and secondary structures in field.

Clinometer and Brunton compass: Use of the instruments in measuring geological data in field.

Techniques of measurement of orientation data in field.

Litholog measurement

Recording field data in maps and notebooks.
Procedures of Report writing.

5.2 SEC/Geol/02 - Geology II

Geological Field Mapping and Structural Geology Related Field

Preparation of a geological map of a small area with deformation and metamorphic features.
Stereographic plots of orientation data and their interpretation.
Identification of protolith composition of the deformed and metamorphosed rocks and reconstruction of geological evolution of the area in the form of a report.

5.3 SEC/Geol/03 – Field Geology III

Economic Geology field

Module I

Unit 1: Visit to any mineral deposit
Unit 2: Mode occurrence of ore, Ore mineralogy
Unit 3: Ore-Host rock interrelation
Unit 4: Ore formation process
Unit 5: Basic techniques of surveying, concept of outcrop mapping

Module 2

Unit 1: Visit to underground or open cast mine
Unit 2: Practical experience of mining methods
Unit 3: Underground mapping/ Bench mapping
Unit 4: Isopach and Isochore maps

5.4 SEC/Geol/04 – Field Geology IV

(Himalayan Geology field)

Identification and characterization of major structural boundaries in Himalaya viz. MBT, MFT etc. Or, Field along any suitable transect of Himalayan foreland, Or, Field transect in Siwalik, Or, Identification of Himalayan and pre-Himalayan elements

5.5 SEC/Geol/05 – Field Geology V

(Precambrian Geology field)

Field transect in any Precambrian terrain
Study of craton ensemble including basic intrusive suites
Precambrian sedimentary basin
Basement-Cover relation in: a. fold belts, b. sedimentary successions

5.6 SEC/Geol/06 – Field Geology VI

(Visit to Engineering Project sites)

Unit 1: Geological mapping of a project site (Dam sites, Tunnel alignments etc)

Unit 2: On site visit & to study various geotechnical aspects related to the project site.

Unit 3: Identification of geotechnical problems of a project site and remedial measures to be taken.

Unit 4: Identification of environmental problems of a project site and remedial measures to be taken.

Unit 5: Computation of rock mass Properties (RQD, RSR, RMR & Q) in the field.

Unit 6: Identification of potential suspected/probable sites of Natural Disaster and suggestions about corrective/preventive measures.

5.7 SEC/Geol/07 FIELD GEOLOGY –VII

(Stratigraphy and paleontology-related field)

Field training along Phanerozoic basin of India

Documentation of stratigraphic details in the field

Collection of sedimentological, stratigraphic and paleontological details and their representation

Facies concept and its spatio-temporal relation (Walther's Law) and concept of facies distribution at basinal-scale

Fossils sampling techniques and their descriptions.