

**Structure and Detailed Syllabus**  
**of the Undergraduate Course (B.Sc.) in Geology under CBCS**  
**Department of Geology**  
**Presidency University**



**PRESIDENCY UNIVERSITY**  
**KOLKATA**



**Department of Geology**  
**(Faculty of Natural and Mathematical Sciences)**  
**Presidency University**  
**Hindoo College (1817-1855), Presidency College (1855-2010)**  
**86/1, College Street, Kolkata - 700 073**  
**West Bengal, India**

## Content

Topic	Page No.
<b>A. Semester-wise Course Structure and Module Compositions</b>	<b>3</b>
<b>B. Detailed Syllabus and Suggested Reading List for respective Modules</b>	<b>5 - 59</b>
Earth System Science	6
Mineral Science	8
Essentials of Geology	10
Elements of Geochemistry	13
Structural Geology	14
Rocks & Minerals	16
Sedimentology	18
Igneous Petrology	19
Palaeontology	21
Fossils & their Applications	23
Field Work 1	24
Metamorphic Petrology	26
Principles of Stratigraphy and Precambrian Stratigraphy of India	28
Phanerozoic Stratigraphy of India	30
Global Tectonics & Supercontinent Cycles	31
Field Work 2	33
Economic Geology	35
Hydrogeology	37
Fuel Geology	39
Environmental Geochemistry	41
Earth and Climate	43
Tectonics	45
Oceanography and Marine Science	47
Engineering Geology	49
Geomorphology and Remote Sensing & GIS	50
Introduction to Geophysics	52
Exploration Geology	54
Evolution of Life through Time	56
River Science	58
Field Work 3	60

Semester-wise Modules of the Undergraduate Course in Geology (Major) under CBCS  
Department of Geology, Presidency University, Kolkata

Semester	Course Type			
	Core Course	Department Specific Elective	Generic Elective	Skill Enhancement Course
First	Earth System Science		Essentials of Geology	
	Mineral Science			
Second	Elements of Geochemistry		Rocks & Minerals	
	Structural Geology			
Third	Sedimentology		Fossils & their Applications	Field Work 1
	Igneous Petrology			
	Palaeontology			
Fourth	Metamorphic Petrology		Global Tectonics and Supercontinent Cycles	Field Work 2
	Principles of Stratigraphy and Precambrian Stratigraphy of India			
	Phanerozoic Stratigraphy of India			
Fifth	Economic Geology	Fuel Geology/ Environmental Geochemistry/ Earth and Climate		
	Hydrogeology	Tectonics/ Oceanography and Marine Science		
Sixth	Engineering Geology	Introduction to Geophysics/ Exploration Geology		Field Work 3
	Geomorphology and Remote Sensing & GIS	Evolution of Life through Time/ River Science		

**Academic Session:** Each Semester shall contain at least 16 Teaching Weeks

Odd Semesters: Semesters One and Three - July to December

Even Semesters: Semesters Two and Four - January to June

## Credit Allocation and Marks Distribution for the Undergraduate Course in Geology (Major) under CBCS

### Department of Geology, Presidency University, Kolkata

Semester	Course Type	Paper Code	Course Name	Credits				Marks			
				Theory	Practical	Tutorial	Total	Theory	Practical	Tutorial	Total
First	Core Course	GEOL01C1	Earth System Science	4	2		6	70	30		100
First	Core Course	GEOL01C2	Mineral Science	4	2		6	70	30		100
First	Generic Elective	GEOL01GE1	Essentials of Geology	4	2		6	70	30		100
Second	Core Course	GEOL02C3	Elements of Geochemistry	4	2		6	70	30		100
Second	Core Course	GEOL02C4	Structural Geology	4	2		6	70	30		100
Second	Generic Elective	GEOL02GE2	Rocks & Minerals	4	2		6	70	30		100
Third	Core Course	GEOL03C5	Sedimentology	4	2		6	70	30		100
Third	Core Course	GEOL03C6	Igneous Petrology	4	2		6	70	30		100
Third	Core Course	GEOL03C7	Palaeontology	4	2		6	70	30		100
Third	Generic Elective	GEOL03GE3	Fossils & their Applications	5		1	6	80		20	100
Third	Skill Enhancement Course	GEOL03SEC1	Fieldwork - 1	4			4	100			100
Fourth	Core Course	GEOL04C8	Metamorphic Petrology	4	2		6	70	30		100
Fourth	Core Course	GEOL04C9	Principles of Stratigraphy and Precambrian Stratigraphy of India	5		1	6	80		20	100
Fourth	Core Course	GEOL04C10	Phanerozoic Stratigraphy of India	5		1	6	80		20	100
Fourth	Generic Elective	GEOL04GE4	Global Tectonics and Supercontinent Cycles	4	2		6	70	30		100
Fourth	Skill Enhancement Course	GEOL04SEC2	Fieldwork - 2	4			4	100			100
Fifth	Core Course	GEOL05C11	Economic Geology	4	2		6	70	30		100
Fifth	Core Course	GEOL05C12	Hydrogeology	4	2		6	70	30		100
Fifth	Department Specific Elective	GEOL05DSE1A/B/C	Fuel Geology/ Environmental Geochemistry/ Earth and Climate	4/ 5	2	1	6	70/ 80	30	20	100
Fifth	Department Specific Elective	GEOL05DSE2A/B	Tectonics/ Oceanography and Marine Science	4/ 5	2	1	6	70/ 80	30	20	100
Sixth	Core Course	GEOL06C13	Engineering Geology	4	2		6	70	30		100
Sixth	Core Course	GEOL06C14	Geomorphology and Remote Sensing & GIS	4	2		6	70	30		100
Sixth	Department Specific Elective	GEOL06DSE3A/B	Introduction to Geophysics/ Exploration Geology	4	2		6	70	30		100
Sixth	Department Specific Elective	GEOL06DSE4A/B	Evolution of Life through Time/ River Science	4	2		6	70	30		100
Sixth	Skill Enhancement Course	GEOL06SEC3	Fieldwork - 3	4			4	100			100
Totals:				103/ 105	38/ 34	3/ 5	144	1870/ 1890	570/ 510	60/ 100	2500

**B.Sc. 1<sup>st</sup> Year Sem-I**

### **GEOL01C1: Earth System Science**

Credits - 6: (Theory- 04, Practical- 02)

#### **Theory**

Credit : 4

Contact Hours per Week : 4

**Unit 1: Earth as a planet:** Introduction to various branches of Earth Science; General characteristics and origin of the Universe, Solar System and its planets; Meteorites and Asteroids; Cosmic abundance of elements; Origin of Earth-atmosphere, ocean, and life.

**Unit 2: Solid Earth:** Seismic waves and internal constitution of the Earth; Concept of isostasy; Earth's magnetic field; Geothermal gradient and internal heat of the Earth.

**Unit 3: Plate Tectonics:** Concept of plate tectonics, sea-floor spreading and continental drift; Plate boundaries; Earthquake and earthquake belts; Volcanoes- types, products and their distribution.

**Unit 4: Hydrosphere and Atmosphere:** Atmospheric circulations; Oceanic currents, tides and waves. Climate System and the Changing Climate from rock record; Concepts of eustasy.

**Unit 5: Rock types and Soils:** Igneous, Sedimentary and Metamorphic rocks; Weathering and Erosion; Soil formation.

**Unit 6: Understanding Stratigraphic records:** Stratigraphy and nature of stratigraphic records; Fundamental laws of stratigraphy: laws of superposition and faunal succession; Concepts of neptunism, plutonism, uniformitarianism, and catastrophism; Absolute and relative time in Geology. Concept of radiometric dating. Radiometric dating of rocks and minerals: U-Pb, Rb- Sr, Sm-Nd, C-14 methods. Geological time scale; Fossil record and Mass Extinction.

**Unit 7: Natural Resources:** Mineral resources; hydrocarbon; Renewable energy resources.

#### **Practical**

Credit : 2

Contact Hours per Week : 4

Study of major geomorphic features and their relationships with outcrops in topographic sheets.

Study of distribution of major stratigraphic units on the map of India.

Study of minerals in hand specimen - Silicates: olivine, garnet, andalusite, sillimanite, kyanite, staurolite, beryl, tourmaline, pyroxene, tremolite, hornblende-actinolite, serpentine, talc, muscovite, biotite, quartz, feldspar, nepheline, zeolite, asbestos, quartz

**DEPARTMENT OF GEOLOGY**  
**PRESIDENCY UNIVERSITY**

Other minerals: pyrite, chalcopyrite, galena, sphalerite, barite and gypsum, magnetite, haematite, pyrolusite, psilomelane, corundum, ilmenite, chromite, bauxite; fluorite, calcite, dolomite, apatite, graphite.

Study of common sedimentary, igneous and metamorphic rocks in hand specimens – sandstone, shale, limestone, conglomerate, chert, BIF, granite, basalt, gabbro, dolerite, pegmatite, peridotite, anorthosite, nepheline syenite, rhyolite, slate, phyllite, schist, gneiss, and granulite

**Suggested Reference Books :**

- Grotzinger, J., Jordan, T.H., Press, F., Siever, R. (2007): Understanding Earth. W.H. Freeman & Co., New York, 5<sup>th</sup> Ed.
- Emiliani, C. (1992): Planet Earth: Cosmology, Geology, and the Evolution of Life and Environment. Cambridge University Press. Published in USA.
- 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.
- Duff, P. M. D., & Duff, D. (Eds.). (1993). *Holmes' principles of physical geology*. Taylor & Francis.
- Gross, M. G. (1977). Oceanography: A view of the earth.

## GEOL01C2: Mineral Science

Credits - 6: (Theory- 04, Practical- 02)

### Theory

Credit : 4

Contact Hours per Week : 4

**Unit 1: Crystallography:** Crystal--Concept of crystalline matter; Interfacial angle and external morphology in relation to internal structures; Crystal parameters and indices; form and zone. Stereographic projection of crystal faces. Crystal symmetry, classification of crystals into systems and point groups. International symbol of point groups

**Unit 2: Atomic arrangements and Mineralogical structure:** Atomic arrangements: Unit cell, CCP, FCC and HCP; Ionic radius and coordination, Pauling's rules. Solid Solution, Polymorphism, Pseudomorphism; Twinning.

**Unit 3: Rock forming minerals:** Minerals - definition and classification, physical and chemical properties; Chemical classification of minerals; Internal structure, classification and Composition of common rock-forming minerals (silicates); Derivation of structural formulae based on composition.

**Unit 4: Optical Mineralogy:** Nature of light- Concept of visible electro-magnetic spectrum and optical behavior of minerals-- isotropic, uniaxial and bi-axial crystals; Double refraction; polarization, Nicol Prism; indicatrix; Introduction to petrological microscope; Refractive index and birefringence, interference phenomena, extinction, Michael Levy chart of interference colours, pleochroism, extinction. Interference phenomenon in convergent light, interference figures, and use of interference figures for determination of optic sign.

### Practical

Credit : 2

Contact Hours per Week : 4

Study of the symmetry of crystals. Stereographic projection of crystals.

Introduction to optical microscope in laboratory studies.

Study of optical properties of common rock-forming minerals: quartz, orthoclase, microcline, plagioclase, perthite, nepheline, olivine, orthopyroxene, clinopyroxene, hornblende, staurolite, garnet, muscovite, biotite, calcite, tourmaline, sillimanite, kyanite, andalusite



**Suggested Reference Books:**

- 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
- Verma, P. K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt Ltd.
- Nesse, W.D., 2000, Introduction to Mineralogy, Oxford University Press, New York, 442 p.

## **GEOL01GE1: Essentials of Geology**

Credits - 6: (Theory- 04, Practical- 02)

### **Theory**

Credit : 4

Contact Hours per Week : 4

### **Unit 1**

Introduction to geology: scope, sub-disciplines and relationship with other branches of sciences.

### **Unit 2**

Earth in the solar system, origin.

Earth's size, shape, mass, density, rotational and evolutionary parameters.

Solar System- Introduction to various planets - Terrestrial Planets, Jovian Planets.

### **Unit 3: Solid Earth, Hydrosphere, Atmosphere and Biosphere**

Mechanical layering of the Earth: lithosphere, asthenosphere, mantle and core.

Earthquake and earthquake belts: seismic waves and internal constitution of the Earth.

Volcanoes and volcanism, distribution of volcanoes.

Concept of isostasy.

Formation of core, mantle, crust, atmosphere, hydrosphere and biosphere.

Convection in Earth's core and production of its magnetic field.

Geothermal gradient and internal heat of the Earth.

### **Unit: 4. Rocks, Mineral and fossils**

Definition. General character. Usefulness.

### **Unit 5: Plate Tectonics**

Fundamental Earth process: plate tectonics.

Plates and plate boundaries.

Origin of oceans, continents, mountains and rift valleys.

### **Unit 6: Earth's Surface Processes**

Weathering and Erosion.

Landforms in deserts, glaciated region and river valleys.

### **Unit 7:**

Age of the earth; radioactivity and its application in determining the age of the Earth.

## Practical

Credit : 2

Contact Hours per Week : 4

Study of topographic sheets and description of physiographic features of an area.

Study of geological maps with simple outcrop patterns.

Study of distribution of major lithostratigraphic units on the map of India.

### Suggested Reference Books:

- Holmes' Principles of Physical Geology. (1992). Chapman and Hall.
- 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. Prentice Hall.

# B.Sc. 1<sup>st</sup> Year Sem-II

### **GEOL02C3: Elements of Geochemistry**

Credits - 6: (Theory- 04, Practical- 02)

#### **Theory**

Credit : 4

Contact Hours per Week : 4

**Unit 1: Basic Concepts:** Introduction to properties of elements: Meteorite-classification and significance; Chemical bonding; Cosmic abundance of element; Geochemical classification of elements.

**Unit 2: Layered Structure of Earth and Geochemistry:** Composition of the bulk silicate Earth; Composition of core; Composition of mantle: depleted mantle and enriched mantle; Composition of crust: Continental and Oceanic.

**Unit 3: Element transport:** Advection and diffusion; Aqueous geochemistry- basic concepts and application in geological processes like Weathering, diagenesis & hydrothermal system; Eh, pH relation; Elements of marine chemistry; Geochemical behavior of elements.

**Unit 4: Geochemistry of solid Earth:** Geochemical behavior of elements during magmatic crystallization, partial melting; Concept of partition coefficient (Kd), compatible and incompatible elements; REE-essential characters, behavior and importance;

**Unit 5: Isotope geology:** Isotopic and elemental fractionation; Radiogenic and stable isotopes in Earth materials.

#### **Practical**

Credit : 2

Contact Hours per Week : 4

Geochemical variation diagrams and its interpretations: bivariate and trivariate plots to delineate the control of different compositional variables: Harker variation diagram, AFM diagram, MgO diagram. Chemical variation diagrams based on major, trace and REE: the alkali-lime index, iron enrichment index, aluminum saturation index and alkalinity index diagrams.

#### **Suggested Reference Books :**

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

## **GEOL02C4: Structural Geology**

Credits - 6: (Theory- 04, Practical- 02)

### **Theory**

Credit : 4

Contact Hours per Week : 4

### **Unit 1: Basic Structural Elements**

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. Concept of Stress: normal stress, shear stress, stress ellipse concept, principal axes of stress, planes of maximum shear stress, Mohr circle of stress. Concept of strain: Longitudinal and shear strain, principal axes of strain, strain ellipse concept, Homogenous and inhomogeneous strain, Rotational and irrotational strain in rocks. Strain ellipsoids of different types and their geological significance. Flinn and Ramsay's diagram.

Concept of brittle and ductile deformation, Factors controlling deformation behaviour of rocks.

### **Unit 3: Folds**

Fold morphology; Geometric classification of folds; elementary idea on mechanism of folding-buckling, bending, flexural slip and flow folding, Relation of foliation and lineation with folds.

### **Unit 4: Foliation and Lineation**

Morphological features of foliations and lineations. Tectonic significance of foliation and lineation, Brief idea of origin of foliation.

### **Unit 5: Fractures and faults**

Classification of fractures, Faults and Joints, Relation of Joints to Folds.

Fault zone terminology, Geometric classification of faults. Anderson dynamic analysis of faulting.

Effects of faulting on the outcrops.

Criteria for recognition of faults. Fault plane solution.

Basic idea of shear zone and shear sense indicators.

## Practical

Credit : 2

Contact Hours per Week : 4

Basic idea of topographic maps, Topographic sheets of various scales. Interpretation of topographic maps. Interpretation of geological maps with unconformity, fault, fold and igneous bodies. Construction of structural cross section.

Stereographic projections of planes and lines

True dip and apparent dip problems, 3-point problems, fold problems, fault problems and their solutions through graphical methods and stereographic projection methods.

### Suggested Reference Books:

- Davis, H.G, Reynolds, S.J, Kluth, C. F. (2011), Structural Geology of Rocks and Region, John Wiley
- Ragan, D. M. (2009) Structural Geology: an introduction to geometrical techniques (4<sup>th</sup>. Ed.) Cambridge University Press (For Practical)
- Twiss, R. J. and Moores, E. M (2007) Structural Geology, Second Edition. W. H. Freeman and Company.
- Fossen, H (2010), Structural Geology, Cambridge University Press.
- Marshak, S and Mitra G. (1988) Basic Methods in Structural Geology, Prentice Hall.
- Ben A. van der Pluijm and Stephen Marshak (2004) Earth Structure: An Introduction to Structural Geology and Tectonics (Second Edition) 2nd Edition

## **GEOL02GE2: Rocks and Minerals**

Credits - 6: (Theory- 04, Practical- 02)

### **Theory**

Credit : 4

Contact Hours per Week : 4

### **Unit 1**

Minerals: definitions. Physical properties of minerals. Chemical classification of minerals.  
Internal structure of minerals.  
Atomic structure of silicate minerals.

### **Unit 2**

Mineralogical composition of common crustal rocks. Mineralogical Composition of mantle.

### **Unit 3**

Rocks: Definitions and types, processes of formation of Igneous rocks, sedimentary rocks and metamorphic rocks.  
Classification of Igneous rocks (Hatch and Wells and IUGS), sedimentary rocks (Folk) and metamorphic rocks.  
Concept of grade in metamorphic rocks.  
Brief idea about the plate tectonic settings of the common rock types.

### **Practical**

Credit : 2

Contact Hours per Week : 4

Study of physical properties of common rock forming minerals – quartz, feldspar, mica, calcite.  
Study of common sedimentary, igneous and metamorphic rocks in hand samples – granite, basalt, dolerite, sandstone, limestone, schist, gneiss

### **Suggested Reference Books:**

- Cornelis Klein and Anthony Philpotts (2013), Earth Materials- Introduction to Mineralogy and Petrology, Cambridge University Press.
- John Grotzinger and Thomas H. Jordan, (2010), Understanding Earth. 6th Edition, W.H. Freeman and company, New York.



# B. Sc. 2<sup>nd</sup> Year Sem-III

### **GEOL03C5: Sedimentology**

Credits - 6: (Theory- 04, Practical- 02)

#### **Theory**

Credit : 4

Contact Hours per Week : 4

**Unit 1: Origin of sediments Weathering and sedimentary flux:** Physical and chemical weathering, soils and paleosols.

**Unit 2: Sediment granulometry:** Grain-size scale, particle size analysis and connotations; particle shape and fabric.

**Unit 3: Sedimentary textures, structures and environment:** Sediment transport mechanism--types of flow (Newtonian and Non-Newtonian), 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, bedform stability diagram. Sediment-gravity flow—types and deposits; Sedimentary structure- Primary, penecontemporaneous deformation and biogenic structures

Paleocurrent analysis: data acquisition, methodology, different palaeocurrent patterns

**Unit 4: Sedimentary rocks:** Components and classification(s) of conglomerates, sandstones, carbonate rocks and iron formations. General outline of controls on deposition of sandstones and carbonate rocks.

**Unit 5: Diagenesis:** Concepts of diagenesis, processes and stages of diagenesis, dolomites and dolomitisation

#### **Practical**

Credit : 2

Contact Hours per Week : 4

Exercises on sedimentary structures in hand specimens; Particle size distribution & statistical treatment, Palaeocurrent analysis, Petrography of clastic and non-clastic rocks through thin sections.

#### **Suggested Reference Books :**

- 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
- Folk, R.L. (1980) Petrology of Sedimentary Rocks. Hemphill Publishing Company, Austin, 184 p

- Pettijohn FJ, 1970, Sedimentary rocks, New York: Harper & Row, 628p.

## **GEOL03C6: Igneous Petrology**

Credits - 6: (Theory- 04, Practical- 02)

### **Theory**

Credit : 4

Contact Hours per Week : 4

**Unit 1: Introduction to Igneous Petrology:** Magma generation in the crust and upper mantle. Physical properties of magma - temperature, viscosity, density and volatile content. Modes of emplacement of igneous rocks: volcanic, hypabyssal, plutonic.

**Unit 2: Forms of Igneous rock bodies:** Mode of occurrence of igneous rocks. Forms of igneous rocks.

**Unit 3: Texture and Microstructure of Igneous rocks:** Crystallinity, granularity, shapes and mutual relations of grains; nucleation and growth of minerals in magma; Description of the following textures and microstructures with their occurrence in different rocks - panidiomorphic, hypidiomorphic, allotriomorphic, porphyritic, vitrophyric, poikilitic, ophitic, sub-ophitic, intergranular, intersertal, pilotaxitic, trachytic, graphic, granophyric, rapakivi, orbicular, corona, perthitic, myrmekitic, variolitic, speherulitic and spinifex.

**Unit 4: Classification of Igneous Rocks:** Bases of classification of igneous rocks: mineralogical, textural, chemical, chemico-mineralogical and associational. Norm and mode. Standard classification schemes – Niggli, Hatch and Wells and IUGS. TAS diagram for volcanic rocks; Composition and texture of important igneous rocks: granitoids, pegmatite, syenite, monzonite, diorite, norite, gabbro, anthrothosite, dolerite, pyroxenites, peridotite, lamprophyres, carbonatite, rhyolite, andesite, dacite, basalt, komatiite.

**Unit 5: Phase Diagrams:** Phase rule and its application to eutectic, peritectic and solid solution system. Phase equilibria in the following binary and ternary systems, and their petrogenetic significance: diopside – anorthite, forsterite – silica, albite – anorthite, albite – orthoclase, diopside – albite – anorthite, forsterite – diopside – silica and nepheline - kalsilite – silica.

**Unit 6: Diversification of igneous rock and chemical evolution of magma:** Bowen's reaction Series and its application, Magmatic differentiation- fractional crystallization, partial melting, assimilation and their role in magmatic differentiation. Bi-variate and tri-variate chemical variation diagram, idea about Mg.no., Fe-no., D.I. alkali-lime index, Petrgraphic Province

**Unit 7: Petrogenesis of Igneous Rocks:** Petrogenesis and tectonic setting of felsic and mafic igneous rocks: granitoids, basalt, gabbros, anorthosite, alkaline rocks, kimberlites.

## Practical

Credit : 2

Contact Hours per Week : 4

Study of important igneous rocks in thin sections: granite, granodiorite, diorite, syenite, nepheline syenite, gabbro, anorthosite, ultramafic rock, basalt, andesite, dolerite, rhyolite, dacite.

Norm calculation for silica undersaturated and silica oversaturated rocks

Plotting of modal data in IUGS classification diagram for plutonic rocks (Streckeisen diagram).

### Suggested Reference Books:

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

### **GEOL03C7: Palaeontology**

Credits - 6: (Theory- 04, Practical- 02)

#### **Theory**

Credit : 4

Contact Hours per Week : 4

**Unit 1: Fossil and Fossilization:** Palaeontology – scope and different disciplines; Fossilization – conditions, processes (Taphonomy) and modes; Fossil lagerstätten, soft part preservation.

**Unit 2: Taxonomy and Species concept:** Species concept with special reference to palaeontology; Taxonomic hierarchy; Binomial nomenclature; Principles of organic evolution – speciation, micro- and macroevolution, theories of evolution.

**Unit 3: Invertebrate Palaeontology:** Brief introduction to important invertebrate groups (e.g., Trilobita, Mollusca) and their biostratigraphic significance

**Unit 4: Micropalaeontology:** Brief introduction to important microfossil groups (e.g., Foraminiferida) and their biostratigraphic significance

**Unit 4: Introduction to Vertebrate Palaeontology:** Origin of vertebrates and major steps in vertebrate evolution; Evolution of horse; Human evolution.

**Unit 5: Introduction to Paleobotany:** Major steps in plant evolution, Gondwana Flora

**Unit 6: Introduction to Ichnology:** Scope, major types and importance

#### **Unit 7: Application of fossils:**

A. Biostratigraphy - Biozones, index fossils, correlation

B. Palaeobiogeography – Disjunct distribution: dispersals and vicariance; barriers to dispersals

C. Paleoecology – biotic interactions, abiotic controlling factors

#### **Practical**

Credit : 2

Contact Hours per Week : 4

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 Reference Books :**

- Foote, M. and Miller, I.A. (2007) Principles of Paleontology. 3<sup>rd</sup> Edition by W. H. Freeman and company
- Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution. 4th Edition by Blackwell Publishing.
- Benton, M. (2009). Vertebrate paleontology. John Wiley & Sons. 4th Edition.
- Shukla, A. C., & Misra, S. P. (1975). Essentials of paleobotany. Vikas Publisher
- Armstrong, H. A., & Brasier, M.D. (2005) Microfossils. Blackwell Publishing.

### **GEOL03GE3: Fossils and their Applications**

Credits - 6: (Theory- 05, Tutorial- 01)

#### **Theory**

Credit : 5

Contact Hours per Week : 5

#### **Unit 1: Introduction to Fossils**

Definition of fossil, fossilization processes (taphonomy), taphonomic attributes and its implications, modes of fossil preservation, role of fossils in development of geological time scale.

#### **Unit 2: Species concept**

Definition of species, species problem in paleontology, speciation, code of systematic nomenclature.

#### **Unit 3: Introduction to various fossils groups**

Brief introduction of important fossils groups: invertebrate, vertebrate, microfossils, spore, pollens, plant fossils, and trace fossils.

#### **Unit 4: Application of fossils**

Application of fossils in the study of biostratigraphy, paleoecology, paleobiogeography and paleoclimate.

#### **Unit 6: Economic importance of fossils**

Micropaleontology in hydrocarbon exploration; Spores and pollens as indicators of thermal maturity of hydrocarbon reservoirs.

#### **Tutorial**

Credit : 1

Contact Hours per Week : 1

Problems and topics on preservation and application of fossils

#### **Suggested Reference Books:**

- Schoch, R.M. 1989. Stratigraphy, Principles and Methods. VanNostrand Reinhold.
- Clarkson, E.N.K. 1998. Invertebrate Paleontology and Evolution George Allen and Unwin
- Prothero, D.R. 1998. Bringing fossils to life - An introduction to Paleobiology, McGraw Hill.
- Benton, M.J. 2005. Vertebrate paleontology (3rd edition). Blackwell Scientific, Oxford.
- Colbert's Evolution of the Vertebrates: A History of the Backboned Animals Through Time, Edwin H. Colbert, Michael Morales, Eli C. Minkoff, John Wiley and Sons, 1991

**GEOL03SEC1: Field Work 1**

Credit : 4

Identification of different rock types, structural features/lithological features/fossils

Use of topographic sheet, Clinometer/ Brunton compass/GPS

Collection of samples

Techniques of measurement of orientation data in field.

Scientific report writing



# B. Sc. 2<sup>nd</sup> Year Sem-IV

## **GEOL04C8: Metamorphic Petrology**

Credits - 6: (Theory- 04, Practical- 02)

### **Theory**

Credit : 4

Contact Hours per Week : 4

### **Unit 1: Metamorphism: controls and types**

Definition of metamorphism. Factors controlling metamorphism, Types of metamorphism – contact, regional, fault zone metamorphism, impact metamorphism  
Metamorphic rock as a system, Fundamentals of geochemical thermodynamics

### **Unit 2: Metamorphic Facies and Grades**

Index minerals, metamorphic zones and isograds.  
Concept of metamorphic facies and grade  
Mineralogical phase rule of closed and open system  
Composition-paragenesis diagrams. ACF, AKF and AFM diagrams  
Concept of metamorphic P-T-t path

### **Unit 3: Metamorphism and deformation**

Structure and textures of metamorphic rocks  
Relationship between metamorphism and deformation.

### **Unit 4: Metamorphic reactions**

Types of metamorphic reactions  
Kinetics of metamorphic reactions  
Progressive and retrogressive metamorphism  
Progressive metamorphism of pelitic, basic and carbonate rocks

### **Unit 5: Migmatites and their origin**

Metasomatism and role of fluids in metamorphism.  
Brief idea of crustal anatexis, migmatites and its origin.

### **Unit 6: Metamorphic rock associations and plate tectonic settings**

Regional occurrence and tectonic significance of metamorphic rocks: Metamorphism along convergent plate margins, in continent-continent collisions, in rifting terrains and sea floor metamorphism.

## Practical

Credit : 2

Contact Hours per Week : 4

Textural and mineralogical study of metamorphic rocks in thin sections: varieties of schists, amphibolite, charnockite, khondalite, mafic granulite.

Graphical plots of metamorphic mineral assemblages using chemographic diagrams

### Suggested Reference Books :

- 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.
- 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

## **GEOL04C9: Principles of Stratigraphy and Precambrian Stratigraphy of India**

Credits - 6: (Theory- 05, Tutorial- 01)

### **Theory**

Credit : 5

Contact Hours per Week : 5

### **Unit 1: Principles of stratigraphy**

Fundamentals of stratigraphy –definition and significance, stratigraphic units- lithostratigraphy, biostratigraphy and chronostratigraphy; International Stratigraphic Code; Stratotypes. Global Stratotype Section and Point (GSSP) ; type section; Principles of stratigraphic correlation ; elementary ideas on chemostratigraphy, magnetostratigraphy, sequence stratigraphy, paleogeographic reconstruction

Facies concept in stratigraphy, Walther's Law

### **Unit 2: Introduction to Precambrian Stratigraphy**

Divisions of Precambrian time scale, Characteristics and status of Archaean and Proterozoic Eons in global perspective, Archaean-Proterozoic boundary.

### **Unit 3: Physiographic and Tectonic subdivisions of India**

Brief Introduction to the physiographic and tectonic subdivisions of India.

Introduction to Indian shield, craton

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

Introduction to Indian Precambrian belts.

Introduction to Proterozoic basins of India

### **Unit 4: Geologic evolution of important Precambrian terrains in India**

Geologic evolution with emphasis on sedimentation, lithology, magmatism, structure, metamorphism and geochronology of: Singhbhum, Dharwar, Rajasthan, Central India and Eastern Ghats.

Vindhyan and Cudappah basins of India.

### **Tutorial**

Credit : 1

Contact Hours per Week : 1

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

Major features of palaeogeographic maps – Precambrian

**Suggested Reference Books :**

- Krishnan, M.S. (1982) Geology of India and Burma, CBS Publishers, Delhi
- Doyle P. and Bennett, M.R. (1996), Unlocking the Stratigraphic Record. John Wiley
- Ramakrishnan, M. and Vaidyanadhan, R. (2008), Geology of India Volumes 1 and 2, Geological Society of India, Bangalore,
- Valdiya K.S. (2010). The making of India, Macmillan India Pvt. Ltd.
- Nichols, G. (2009). Sedimentology and Stratigraphy Second Edition. Wiley Blackwell
- Code of International Stratigraphy Commission.

## GEOL04C10: Phanerozoic Stratigraphy of India

Credits - 6: (Theory- 05, Tutorial- 01)

### Theory

Credit : 5

Contact Hours per Week : 5

**Unit 1: Introduction:** Definition; Important stratigraphic boundaries during Phanerozoic time in India - a. Precambrian-Cambrian boundary, b. Permian-Triassic boundary, and c. Cretaceous-Tertiary boundary.

**Unit 2: Important Phanerozoic successions in India:** Important Palaeozoic and Mesozoic successions in India with emphasis on succession, lithology, flora and fauna, correlation and palaeoenvironment of the following:

Gondwana succession of Peninsular India

Successions of extra-peninsular India, with special reference to Kashmir and Spiti valley:

Mesozoics of peninsular India with special reference to Kutch and Cauvery basins

Cenozoics successions of Kutch basin, Siwalik succession, Assam and Bengal basins.

**Unit 3: Stratigraphy and Structure:** Stratigraphy and structure of Assam-Arakan basins, Cauvery basin, Bombay offshore basin and Kutch basins and their potential for hydrocarbon exploration.

### Unit 4: Deccan Traps and Intertrappeans

**Unit 5: Quaternary Geology:** Definition; Principles of subdivision of Quaternary succession in India.

**Unit 6:** Study of geological map of India and identification of major Phanerozoic stratigraphic units; Stratigraphic correlation of Phanerozoic stratigraphic units in geological map of India.

### Tutorial

Credit : 1

Contact Hours per Week : 1

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

Major features of palaeogeographic maps – Phanerozoic

### Suggested Reference Books :

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

**GEOL04GE4: Global Tectonics and Supercontinent cycles**

Credits - 6: (Theory- 04, Practical- 02)

**Theory**

Credit : 4

Contact Hours per Week : 4

**Unit 1**

Tectonics – definitions and scope; Crustal types and their properties; active and passive continental margins.

**Unit 2**

Constitution of the Earth: Evidences from Seismic studies.

Earthquakes, intensity and magnitude, elastic rebound theory, focus and epicenter, seismograms. Global earthquake belts. Seismic zones of India.

**Unit 3**

Gravity and gravity anomaly on Earth, Bouguer and free-air anomaly. Concept of isostasy and compensation, hypotheses of Airy, and Pratt.

**Unit 4**

Volcanoes and volcanism, eruptive styles.

**Unit 5**

Rock deformation and deformation structures.

**Unit 6**

Continental drift hypothesis; Seafloor spreading hypothesis; Palaeomagnetism and polarity reversals.

Plate tectonics: Definition of plates; Plate motion – absolute and relative; driving forces and evidences. Plate boundaries and orogeny.

Wilson Cycle; Supercontinent and Supercontinent Cycle.

## Practical

Credit : 2

Contact Hours per Week : 4

Drawing of block diagrams depicting tectonic features.

Interpretation of maps showing tectonic elements on planar and uneven topography.

Construction of structural cross sections.

Fault plane solutions.

### Suggested Reference Books:

- Kearey, P., Klepeis, K.A., and Vine, F.J., 2009, Global Tectonics, 3<sup>rd</sup> Edn., Wiley-Blackwell, Oxford, 482 p. [Earlier edition of this book with Keary and Vine as authors is also useful]
- Condie, K.C., 1997, Plate tectonics and crustal evolution, 4<sup>th</sup> Edn., Butterworth-Heinemann, Oxford, 294 p.
- Press, F., Siever, R., Grotzinger, J. and Jordan, T.H., 2004, Understanding Earth, 4<sup>th</sup> Edn., W.H. Freeman, 567 p.
- Skinner, B.J., Porter, S.C. and Park, J., 2003, The Dynamic Earth: An Introduction to Physical Geology [With CDROM], John Wiley & Sons, 631 p.
- Tarbuck, E.J. and Lutgens, F.K., 2006, Earth Science, 11<sup>th</sup> Edn., Pearson Prentice Hall, New Jersey, 726 p.



**GEOL04SEC2: Field Work 2**

Credit : 4

Lithological and structural mapping, in large and small scale, in a deformed terrain.

Petrographic and microstructural analysis of rock samples.

Processing of structural data and Report writing.

# B.Sc. 3<sup>rd</sup> Year Sem-V

### **GEOL05C11: Economic Geology**

Credits - 6: (Theory- 04, Practical- 02)

#### **Theory**

Credit : 4

Contact Hours per Week : 4

#### **Unit 1: Introduction to ore geology:**

Basic concepts of Ores, gangue minerals, tenor, grade, resources and reserves.  
Morphology of ore bodies  
Review of concepts of ore genesis process

#### **Unit 2: Ore-forming processes**

Orthomagmatic processes  
Sedimentary processes  
Hydrothermal  
Supergene and Residual enrichment processes  
Metamorphic processes

#### **Unit 3: Plate Tectonics and ore deposits**

Role of plate tectonics in ore mineralization.  
Metallogeny through ages

#### **Unit 4: Metallic and Non-metallic ores of India**

Metallic ores  
Non-metallic and industrial rocks and minerals  
Atomic minerals  
Gem & Gemstones

#### **Unit 5: Mineral exploration and exploitation**

Ore grade and Reserve, assessment of grade, reserve estimation  
Exploration and exploitation techniques  
Aspects of Geological mapping for interpretation of mineral exploration

#### **Practical**

Credit : 2

Contact Hours per Week : 4

Hand specimen study of important ores  
Study of microscopic properties of ore minerals.

**Suggested Reference Books:**

1. Evans, A.M. (1993) Ore Geology and Industrial minerals. Wiley
2. Laurence Robb. (2005) Introduction to ore forming processes. Wiley.
3. Ridley, J. (2013): Ore Deposit Geology. Cambridge University Press, UK. P398.
4. Guilbert, J.M. and Park Jr., C.F. (1986) The Geology of Ore deposits. Freeman & Co.
5. Bateman, A.M. and Jensen, M.L. (1990) Economic Mineral Deposits. John Wiley.
6. Gokhale, K.V.G.K. and Rao, T.C. (1978) Ore deposits of India their distribution and processing, Tata-McGraw Hill, New Delhi.
7. Deb, S. (1980) Industrial minerals and rocks of India. Allied Publishers.
8. Sarkar, S.C. and Gupta, A. (2014) Crustal Evolution and Metallogeny in India. Cambridge Publications.
9. Mukherjee, A. (1999): Ore Genesis – A Holistic Approach. Allied Publishers Ltd., New Delhi, India. P657.
10. New Insights on Mineral Exploration Concepts and Guidelines (2018). Government of India Ministry of Mines, Geological Survey of India, Natural Resources Assessment, Nagpur Miscellaneous Publication No. 66 (ISSN 0579 4706).
11. S.K. Halder (2013): Mineral explorations: principles and applications. Elsevier, P372.

## **GEOL05C12: Hydrogeology**

Credits - 6: (Theory- 04, Practical- 02)

### **Theory**

Credit : 4

Contact Hours per Week : 4

### **Unit 1: Introduction and basic concepts**

Scope of hydrogeology; Groundwater quality and its societal relevance.

Hydrologic cycle; Origin of groundwater, vertical distribution of subsurface water. Genetic classification of groundwater.

### **Unit 2: Aquifers and Groundwater flow**

Types of aquifer– unconfined, confined and semi-confined. Water table and piezometric surface.

Darcy's law; Reynold's Number. Groundwater velocity.

Intrinsic permeability and hydraulic conductivity, transmissivity.

Drawdown, specific capacity etc.

### **Unit 3: Groundwater chemistry**

Physical, chemical and bacteriological properties of water and water quality. Introduction to methods of interpreting groundwater quality data using standard graphical plots. Elementary concept on groundwater pollution: arsenic, fluoride and nitrate, sea water intrusion in coastal aquifers.

### **Unit 4: 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.

### **Unit 5: Indian Provinces**

Groundwater provinces in India and west Bengal

## Practical

Credit : 2

Contact Hours per Week : 4

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 Reference Books:

- Todd, D. K. and Larry, W.M. (2005). Groundwater Hydrology, 3<sup>rd</sup> Ed. John Wiley and Sons, N.Y.
- Davis, S. N. and De Weist, R. J. M. (1966). Hydrogeology. John Wiley and Sons Inc., New York.
- Karanth K.R. (1987). Groundwater: Assessment, Development and management. Tata McGraw- Hill Pub. Co. Ltd.
- Raghunath H, M. (2007). Groundwater. 3<sup>rd</sup> Ed. New Age International Publishers, New

### **GEOL05DSE1A: Fuel Geology**

Credits - 6: (Theory- 04, Practical- 02)

#### **Theory**

Credit : 4

Contact Hours per Week : 4

#### **Unit 1: Energy resources**

Different sources of energy: Global and Indian scenario.

#### **Unit 2: 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 of coal.

Major coal basins of India.

#### **Unit 3: Coal as a fuel**

Concept of clean coal technology

Coal Bed Methane (CBM)

Underground coal gasification

Liquefaction of coal

#### **Unit 4: Petroleum**

Chemical composition and physical properties of crudes oil

Origin of and migration of petroleum

Kerogen: maturation of kerogen; biogenic and thermal effect

#### **Unit 5: Petroleum Reservoirs and Traps**

Reservoir rocks: general attributes and petrophysical properties

Cap rocks: definition, general properties

Hydrocarbon traps: definition, classification of hydrocarbon traps - structural, stratigraphic and combination trap.

Plate tectonics and global distribution of hydrocarbon reserves

Petroliferous basins of India

#### **Unit 6: Other fuels**

Nuclear Fuel

Gas Hydrate

Prospect of non-conventional fuel in India

## Practical

Credit : 2

Contact Hours per Week : 4

Study of hand specimens of coal

Section correlation and identification of hydrocarbon prospect

### Suggested Reference Books :

- Thomas L. (2013) Coal Geology: Second Edition, John Wiley & Sons, Ltd.
- Shelly R. C. (2014). Elements of Petroleum geology: Third Edition, Academic Press
- Bjorlykke, K. (1989). Sedimentology and petroleum geology. Springer-Verlag.
- Bastia, R., and Radhakrishna, M. (2012). Basin evolution and petroleum prospectively of the continental margins of India (Vol. 59). Newness.



**GEOL05DSE1B: Environmental Geochemistry**

Credits - 6: (Theory- 04, Practical- 02)

**Theory**

Credit : 4

Contact Hours per Week : 4

**Biogeochemical cycles and organic geochemistry**

Biogeochemical cycles of carbon, nitrogen, phosphorus and sulphur

Organic molecules in nature

Elemental tracers (C, N), molecular fossils

Organic contaminants: sources, sinks, remediation techniques

Stable isotope geochemistry

**Chemical Weathering and geochemistry of water, sediment and soil**

Chemical weathering and soil formation

Silicate weathering and global climate

Eh-pH diagrams: its use in determining mobility of element

**Lakes, Rivers, estuaries and Oceans**

Nutrient overloading and primary productivity

Oxygen depletion

Ocean acidification

**Human induced global environmental changes**

Acid rain

Urban sewage

Natural and anthropogenic distribution of heavy metals in ground and surface waters

**Practical**

Credit : 2

Contact Hours per Week : 4

Laboratory work will involve sampling, qualitative measurement of environmental parameters, and data analysis.

**Suggested Reference Books:**

- T.E. Gredel and P.J. Crutzen (1995): Atmosphere, Climate, and Change (New York: Freeman, 1995).
- E.A. Keller (2010): Environmental Geology (9th Edition). Pearson
- Fergusson J.E. 1990. The heavy elements: chemistry, environmental impact and health effects. Pergamon Press Inc.
- Adriano D.C. 2001. Trace elements in the terrestrial environment. 2nd ed. Springer-Verlag.
- Drever J.I. 1998. The geochemistry of natural waters: surface and groundwater environments, 3rd ed. Chapters 6, 8. Prentice Hall, Upper Saddle River.
- Killops S.D., Killops V.J. 2005. An introduction to organic geochemistry. 2nd ed. Blackwell Publishing, Malaysia.
- Millero F., Sohn M. 1992. Chemical oceanography. Chapter 8. Organic compounds. CRC Press, Boca Raton.
- Thurman E.M. 1985. Organic geochemistry of natural waters. Martinus Nijhoff/ Dr W. Junk Publishers, Dordrecht.

## **GEOL05DSE1C: Earth and Climate**

Credits - 6: (Theory- 05, Tutorial- 01)

### **Theory**

Credit : 5

Contact Hours per Week : 5

### **Unit 1: Climate system: Forcing and Responses**

Components of the climate system.

Climate forcing, Climate controlling factors, Responses and Feedbacks.

### **Unit 2: Heat budget of Earth**

Insolation and Earth's heat budget.

### **Unit 3: Atmosphere – Hydrosphere**

Atmosphere and ocean interaction and its effect on climate.

Global oceanic conveyor belt and its control on earth's climate.

Sea ice and glacial ice.

### **Unit 4: Response of biosphere to Earth's climate**

Climate change: natural vs. anthropogenic effects.

Archives of climate change and paleoclimate

### **Unit 5: Orbital cyclicity and climate**

Milankovitch cycles and variability in the climate.

Glacial-interglacial stages.

The last glacial maximum (LGM).

Pleistocene Glacial-Interglacial cycles.

Younger Dryas.

Application of stable Isotopes.

### **Unit 6: Monsoon**

Mechanism of monsoon.

Monsoonal variation through time.

Factors associated with monsoonal intensity.

### **Tutorial**

Credit : 1

Contact Hours per Week : 1

Numerical exercises on interpretation of proxy records for paleoclimate

**Suggested Reference Books:**

- Rudiman, W.F., 2001. Earth's climate: past and future. Edition 2, Freeman Publisher.
- Rohli, R.V., and Vega, A.J., 2007. Climatology. Jones and Barlatt
- Lutgens, F., Tarbuck, E., and Tasa, D., 2009. The Atmosphere: An Introduction to Meteorology. Pearson Publisher
- Aguado, E., and Burt, J., 2009. Understanding weather and Climate. 5th Edition, Pearson Publisher
- Dorothy Merritts, Kirsten Menking and Andrew deWet, 2014. Environmental Geology: An Earth Systems Science Approach. Edition 2, W.H.Freeman and Co Ltd

## **GEOL05DSE2A: Tectonics**

Credits - 6: (Theory- 04, Practical- 02)

### **Theory**

Credit : 4

Contact Hours per Week : 4

### **Unit 1: Introduction**

Continents and oceans, Continental and oceanic crust, Concept of Lithosphere and asthenosphere, Physical character of lithosphere and asthenosphere.

Earthquakes and internal structure of the earth.

Concept of plate. Plate tectonic system

Concept of Hot spot and plumes.

### **Unit 2: Historical Perspective: Continental Drift and Sea Floor spreading**

Wegener's continental drift hypothesis and its evidences. Continental position in the past.

Sea-Floor spreading theory and its evidences.

Magnetic time scale. Palaeomagnetism and motion of plates

### **Unit 3: Plate and Plate boundaries**

Plates: physical character of plates. Macro and micro plates

Plate boundaries: types, character, identification of boundaries, Motion along plate boundaries. Triple junction, Kinematics of plate motion, Rate of plate motion.

Volcanic arcs, island arcs, trenches, accretionary prisms, oceanic ridges, transform faults, Magmatism in oceanic ridges and in subduction zones.

### **Unit 4: Plate Tectonics: Past and Present**

Plate tectonics model and its evidences. Distribution of plates in the Earth. Reconstruction of plates. Supercontinent, supercontinents and their break up and assembly. Assembly and break up of Pangaea. Wilson cycle

Driving Mechanisms of plates, Plate tectonics and mantle convection.

### **Practical**

Credit : 2

Contact Hours per Week : 4

Study of Tectonic maps of India

Stability analysis of plate boundaries

Fault slip analysis

Earthquake focal mechanism solutions

**Suggested Reference Books :**

- Kearey, P., Klepeis, K.A. and Vine, F.J. (2009) Global Tectonics. Third edition. Wiley-Blackwell, Oxford.
- Condie K.C. (1997), Plate Tectonics and Crustal Evolution. Fourth Edition, Butterworth Heinemann.
- Moores E.M. and Twiss, R.. J. (1995) Tectonics . W.H. Freeman, New York.

## **GEOL05DSE2B: Oceanography & Marine Science**

Credits - 6: (Theory- 05, Tutorial- 01)

### **Theory**

Credit : 5

Contact Hours per Week : 5

### **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 in Ocean

Animals of the Pelagic Environment and Life

Animals of the Benthic environment and Life

### **Tutorial**

Credit : 1

Contact Hours per Week : 1

Topics on different aspects and characteristics

### **Suggested Reference Books**

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

# B.Sc. 3<sup>rd</sup> Year Sem-VI



### **GEOL06C13: Engineering Geology**

Credits - 6: (Theory- 04, Practical- 02)

#### **Theory**

Credit : 4

Contact Hours per Week : 4

#### **Unit 1: Introduction**

Role of geologists in planning, design and construction of structural features

#### **Unit 2: Rock aggregates and Rock Quality Designation (RQD)**

Foundation treatment; Grouting, Rock Bolting and other support mechanisms

Rock aggregates; Significance as Construction Material

Concept and Significance of RQD

#### **Unit 3: Geological Investigation for site selection of major structures**

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

#### **Unit 4: Natural hazards management**

Landslides: Causes, Factors and corrective/Preventive measures

Earthquakes: Causes, Factors and corrective/Preventive measures. Mitigating the damage caused by Earthquake

#### **Practical**

Credit : 2

Contact Hours per Week : 4

Computation of Index properties of rocks.

Computation of RQD

#### **Suggested Reference Books :**

- Krynin, D.P. and Judd W.R. (1957). Principles of Engineering Geology and Geotechnique. McGraw Hill (CBS Publ).
- Johnson, R.B. and De Graf, J.V. (1988). Principles of Engineering Geology, John Wiley.
- Goodman, R.E. (1993). Engineering Geology: Rock in Engineering constructions. John Wiley and Sons, New York.
- Waltham, T. (2009). Foundations of Engineering Geology (3rd Edn.). Taylor and Francis.
- Bell: F.G. (2006). Basic Environmental and Engineering Geology. Whittles Publishing.
- Bell, F.G (2007). Engineering Geology. Butterworth-Heineman. Todd, D. K. and Larry, W.M. (2005).

## GEOL06C14: Geomorphology and Remote Sensing & GIS

Credits - 6: (Theory- 04, Practical- 02)

### Theory

Credit : 4

Contact Hours per Week : 4

**Unit 1: Introduction:** Introduction to geomorphology; relationship between the landforms and the properties of earth material and different kind of processes; Endogenic and exogenic processes.

**Unit 2: Major morphological features of the earth surface;** Large scale topography - plate tectonics overview, large scale mountain ranges (with emphasis on Himalayas).

**Unit 3: Surficial processes and geomorphology;** weathering and associated landforms; Landforms produced by glacial, periglacial processes, fluvial processes, aeolian processes, coastal processes; Landforms associated with igneous activities. Geomorphic expressions of active structure.

**Unit 4: Photogeology:** Types and acquisition of aerial photographs; scale and resolution; principles of stereoscopy, relief displacement, vertical exaggeration and distortion; Elements of air photo interpretation;

**Unit 5: Remote Sensing:** Concepts in Remote Sensing; Sensors and scanners; Satellites and their characteristics; Data formats- Raster and Vector.

**Unit 6: Digital Image Processing:** Image errors; rectification and restoration; FCC; image enhancement, filtering, image rationing; Image classification and accuracy assessment; GIS integration and case studies - Indian examples.

**Unit 8: GIS and GPS:** Datum, Coordinate systems and projection systems; Spatial data models and data editing; Introduction to DEM analysis; Concepts of GPS; Integrating GPS data with GIS; Applications of GPS in earth system sciences.

### Practical

Credit : 2

Contact Hours per Week : 4

Reading topographic maps.

Preparation of a topographic profile.

Aerial photo interpretation.

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.

Registration of satellite data with a toposheet of the area.

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

**Suggested Reference Books:**

- Robert S. Anderson and Suzanne P. Anderson (2010). *Geomorphology - The Mechanics and Chemistry of Landscapes*. Cambridge University Press.
- M.A. Summerfield (1991). *Global Geomorphology*. Wiley and Sons.
- R G Huggett. *Fundamentals of Geomorphology* (3rd ed). Routledge.
- Demers, M.N. (1997). *Fundamentals of Geographic Information System*, John Wiley and sons. Inc.
- Hoffmann-Wellenhof, B., Lichtenegger, H. and Collins, J. (2001). *GPS: Theory and Practice*, Springer Wien, New York.
- Jensen, J.R. (1996). *Introductory Digital Image Processing: A Remote Sensing Perspective*. Springer-Verlag.
- Lillesand, T. M. and Kiefer, R.W. (2007). *Remote Sensing and Image Interpretation*. Wiley.
- Richards, J.A. and Jia, X. (1999). *Remote Sensing Digital Image Analysis*. Springer-Verlag.

### **GEOL06DSE3A: Introduction to Geophysics**

Credits - 6: (Theory- 04, Practical- 02)

#### **Theory**

Credit : 4

Contact Hours per Week : 4

#### **Unit 1: Geology and Geophysics**

What is geophysics?

Interrelationship between geology and geophysics.

#### **Unit 2: Geophysical methods**

Different types of geophysical methods - gravity, magnetic, electrical and seismic; principles of different methods. Applications of different methods. Elements of well logging.

Geophysical field operations

#### **Unit 3: Application of Geophysical methods**

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

Geological interpretation of geophysical data.

Planning and execution of geophysical surveys

#### **Unit 4: Geophysical anomalies**

Regional and residual (local) anomalies, factors controlling anomaly

#### **Practical**

Credit : 2

Contact Hours per Week : 4

Anomaly and background- graphical method

Study and interpretation of seismic reflector geometry

Gravity anomaly: problems on gravity anomaly

**Suggested Reference Books:**

- Ramachandra Rao, M.B. Prasaranga (1975). Outlines of Geophysical Prospecting - A manual for geologists, University of Mysore, Mysore, 1975.
- Bhimasarikaram V.L.S. (1990). An Outline on Exploration Geophysics, Association of Exploration Geophysicists, Osmania University, Hyderabad.
- Dobrin, M.B. (1984). An introduction to Geophysical Prospecting. McGraw-Hill, New Delhi.
- Telford, W. M., Geldart, L. P., and Sheriff, R. E. (1990). Applied geophysics (Vol. 1). Cambridge university press.
- Lowrie, W. (2007). Fundamentals of geophysics. Cambridge University Press.
- Mussett, A. E. and Khan, M. A. (2000). Looking into the Earth. Cambridge University Press.

### **GEOL06DSE3B: Exploration Geology**

Credits - 6: (Theory- 04, Practical- 02)

#### **Theory**

Credit : 4

Contact Hours per Week : 4

#### **Unit: 1 Mineral Resources**

Unit 1: Resource: definition. Mineral resources in industries – present day scenario, classification of mineral deposits; Exploration strategies.

#### **Unit: 2 Prospecting and Exploration**

Principles of mineral exploration

Prospecting and exploration: concepts, methodologies and stages, sampling techniques.

Core and non-core drilling methods.

Geochemical exploration.

Outline of exploration techniques for different resources.

#### **Unit: 3 Evaluation of data**

Evaluation of sampling data: standard deviations and variances.

#### **Unit: 4 Reserve estimations and Errors**

Principles of reserve estimation, factors affecting reliability of reserve estimation; reserve estimation based on geometrical models.

Regular and irregular grid patterns

Statistics and error estimation

#### **Practical**

Credit : 2

Contact Hours per Week : 4

Identification of anomaly: gravity and magnetic

Concept of weighted average in anomaly detection

Geological cross-section

Models of reserve estimation

**Suggested Reference Books:**

- Clark, G.B. (1967). Elements of Mining. 3rd Ed. John Wiley and Sons.)
- Arogyaswami, R.P.N. (1996). Courses in Mining Geology. 4th Ed. Oxford-IBH.
- Moon, C.J., Whateley, M.K.G. and Evans, A.M. (2006). Introduction to Mineral Exploration, Blackwell Publishing.
- Haldar, S.K., 2013. Mineral Exploration – Principles and Applications. Elsevier Publication.

## **GEOL06DSE4A: Evolution of Life through Time**

Credits - 6: (Theory- 04, Practical- 02)

### **Theory**

Credit : 4

Contact Hours per Week : 4

### **Unit 1: Life in the Precambrian**

Archean Life: chemical remains of ancient life and other evidences; Transition from Archean to Proterozoic, the oxygen revolution and radiation of life

Precambrian macrofossils – The garden of Ediacara.

Geological Time Scale with emphasis on major bio-events.

### **Unit 2: Paleozoic Life**

The Cambrian Explosion.

Biom mineralization 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 3: 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 4: 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

### **Unit 5: The age of humans**

Hominid dispersals and climate setting

Human intervention and environment

### **Practical**

Credit : 2

Contact Hours per Week : 4

Study of fossils from different stratigraphic levels from the Phanerozoic of India

Exercises related to Biostratigraphy, and palaeoecological and palaeobiogeographical reconstruction



**Suggested Reference Books :**

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

**GEOL06DSE4B: River Science**

Credits - 6: (Theory- 04, Practical- 02)

**Theory**

Credit : 4

Contact Hours per Week : 4

**Unit 1: Stream hydrology**

Basic stream hydrology

Physical properties of water, sediment and channel flow

River discharge, River hydrographs (UH, IUH, SUH, GIUH) and its application in hydrological 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

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

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.

## Practical

Credit : 2

Contact Hours per Week : 4

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

### Suggested Reference Books:

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

**GEOL06SEC3: Field Work 3**

Credit : 4

Visit to Economic Deposits/Mines

Study of sedimentary successions in rock record and recent analogue.

Visit to fossiliferous sedimentary terrains.

Report writing.