B.Sc. (Honours) in Geology
Under the Framework of Honours School System
PREAMBLE

The Centre of Advanced Study in Geology was established in the Panjab University in 1958. The Centre was soon recognized for its contribution by the University Grant Commission (UGC), which raised its status to that of the Centre of Advanced Study (CAS) in Palaeontology and Himalayan Geology in the year 1963. The Centre has continued to get funding under SAP-CAS programme of the UGC. The Centre has also received funding from the Department of Science and Technology, Government of India under COSSIST (1984-1989) and FIST (2002-2007) for improving the infrastructure in research and teaching.

Now the Centre has been renewed as Centre of Advanced Study under Special Assistance Programme of the UGC for a period of 5 years (1-4-2012 to 31-3-2017) in Phase-VII with the financial assistance of Rs. 148 Lacs in the following thrust areas: Palaeontology - Stratigraphy; Petrology; Hydrogeology & Environmental Geology.

The centre has received national and international honours and distinctions for seminal scientific contributions. The centre is endowed with well-equipped student-faculty interfaced laboratories, such as Scanning Electron Microscopy, Optical Microscopy, Sample Preparation Laboratory, and comfortable academic working environs. Besides, an internationally famous museum, a pride of the centre, is the mainstay for school children and lay public, where all and sundry are served hands-on activity for observing and understanding various aspects of earth sciences.

The Centre strives to maintain high standards of teaching by making its students not only aware of various geological problems, but also to study Geology as a quantitative science. The core subjects are taught at undergraduate levels, while interdisciplinary and modern courses are covered in the postgraduate level. The curriculum pertaining to B.Sc. (Honours) (3 Year course & 6 Semesters) in the subject of Geology under Honours School Framework has been upgraded as per provision of the UGC module for CHOICE BASED CREDIT SYSTEM and demand of the academic environment.
### COURSE STRUCTURE

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<td>GEO-C1: Earth System Science</td>
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<td>C2</td>
<td>GEO-C2: Mineral Science</td>
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<tr>
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<td>English</td>
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- **C**: Core Courses; **GE**: General Elective; **AECC**: Ability Enhancement Compulsory Courses; **SEC**: Skill Enhancement Courses; **DSE**: Discipline Specific Elective

*: GE subjects are to be selected by the students from the pool of GE Subjects offered by various Departments of the University.
**GENERIC ELECTIVE SUBJECTS (Offered by Geology Department) for students of other departments**
1. GEO-GE1: Essentials of Geology
2. GEO-GE2: Rocks and Minerals
3. GEO-GE3: Structural Geology
4. GEO-GE4: Fossils & their Applications
5. GEO-GE5: Stratigraphy
6. GEO-GE6: Hydrogeology

**SKILL ENHANCEMENT COURSES (any one per semester in semesters 3-4)**
1. GEO-SEC1: Field Geology 1 – Basic Field Training
2. GEO-SEC2a: Field Geology 2 – Geological Mapping
3. GEO-SEC2b: Field Geology 3 – Himalayan Geology Field
4. GEO-SEC2c: Field Geology 4 – Stratigraphy and Paleontology Related Field
5. GEO-SEC2d: Field Geology 5 – Precambrian Geology Field

**DISCIPLINE SPECIFIC ELECTIVE (any two per semester in semesters 5-6)**
1. GEO-DSE1: Earth and Climate
2. GEO-DSE2: Evolution of Life Through Time
3. GEO-DSE3: Introduction to Geophysics
4. GEO-DSE4: Fuel Geology
5. GEO-DSE5: River Science
6. GEO-DSE6: Urban Geology

Courses under these will be offered only if a minimum of 10 students opt for the same

**Pattern of End-Semester question paper**

The theory question paper for the end-semester examination will have nine questions, with 20 marks reserved for first question, which is compulsory. Further, the latter would comprise of 10 short answer questions, without any choice, covering the whole syllabus. The remaining 4 questions carrying 15 marks each, are to be attempted from the 4 Units. Each unit would comprise of two questions.

**Pattern of Mid-Term question paper**

The question paper for the mid-term examination will have two questions, each being comprised of four parts with equal marks. Five parts have to be attempted, selecting at least two parts from each question.
B.Sc. (Hons.) Course in Geology

I Year

Semester I and II
Outlines of Tests, Syllabi and Courses of Reading for B.Sc. (Honours: under the Framework of Honours School System) I Year in Geology (Choice Based Credit System) Examinations 2017-2018, 2018-19 and 2019-20

**I Semester Examination**

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<tr>
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<th>Course</th>
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**Paper I: EARTH SYSTEM SCIENCE - (Course No. GEO-C1)**

Total Marks: [100 (Mid-Semester Test M.M. 20, End-Semester Exam. M.M. 80)]

Total Lectures: 60

**Credits: 4**

*Objective: This basic fundamental course aims to understand various conceptual aspects of Earth’s evolution and its constitution. It is also aimed to study a brief account of plate tectonic processes, about hydrosphere and atmosphere and also to understand fundamentals of stratigraphy including the geological time scale.*

**UNIT 1: Earth as a planet (15 hrs)**


**UNIT 2: Plate tectonics (15 hrs)**

UNIT 3: Hydrosphere and atmosphere (15 hrs)


UNIT 4: Understanding the past from stratigraphic records (15 hrs)


SUGGESTED READING


Paper II: MINERAL SCIENCE - (Course No. GEO-C2)

Total Marks: [100 (Mid-Semester Test M.M. 20, End-Semester Exam. M.M. 80)]

Total Lectures: 60                        Credits: 4

Objective: This course aims to understand the basic concepts of crystals and crystal systems, and the characteristics and properties of various crystal systems. This course also introduces the general physical and optical characteristics of minerals with an aim to carry out a detailed study of physical & optical properties and chemical compositions of some important rock-forming silicate minerals and some non-silicates.
UNIT 1: Crystallography (15 hrs)

Elementary ideas about crystal morphology: Forms and morphology of crystals; Open and closed forms, Zone and Zone axes, Like and unlike faces, Interfacial angle and its measurements; Law of constancy of interfacial angle; Crystal parameters and indices: Weiss and Miller’s systems of notation; Law of rational indices.

Study of Elements of crystal symmetry and aspects of crystal structures. Classification of crystals into six systems and principles of classification into 32 classes. Study of holohedral class of cubic, tetragonal, orthorhombic, monoclinic, triclinic and hexagonal crystal systems, and hemihedral classes of cubic and hexagonal crystal systems.

UNIT 2: Physical and optical characters of Minerals (15 hrs)

Minerals-definition and classification, physical characters of minerals: habit, colour, streak, cleavage, fracture, lustre, hardness and specific gravity; Nature of light and principles of optical mineralogy: polarized light and crossed polarized light; reflection, critical angle, total reflection, refraction and Snell’s law; optical properties of minerals: isotropic and anisotropic minerals, refractive index, relief, colour, pleochroism, birefringence and retardation, interference colours, extinction and its measurement.

UNIT 3: Rock forming mineral groups/minerals-I (15 hrs)


UNIT 4: Rock forming mineral groups/minerals-II (15 hrs)

Physical and chemical composition of following common rock-forming minerals/groups of minerals: Nesosilicates –titanite, staurolite and chloritoid, Sorosilicates – epidote; Cyclosilicates –beryl, tourmaline and cordierite; Inosilicates – pyroxene group and amphibole group; Phyllosilicates– mica group, talc, serpentine and chlorite; apatite, calcite, barite, fluorite and corundum. Optical Identification of common rock-forming minerals: Nesosilicates, Sorosilicates, Cyclosilicates, Inosilicates and Phyllosilicates.

SUGGESTED READING

Practical I: EARTH SYSTEM SCIENCE - (Course No. GEO-C1P)

Total Marks: [50 (Continuous Assessment M.M. 10, End-Semester Exam. M.M. 40)]

Total Lectures: 60

1. Study of topographic sheets: features and scales.
2. Physiographic description of an area.
3. Study of major geomorphic features.
4. Distribution of lithostratigraphic units.
5. Major oceanic currents of the world.

Practical II: MINERAL SCIENCE - (Course No. GEO-C2P)

Total Marks: [50 (Continuous Assessment M.M. 10, End-Semester Exam. M.M. 40)]

Total Lectures: 60

1. Clinographic projections and study of element of symmetry of the following crystal modals: Cube, Octahedron, Rhombdodecahedron; Tetrahexahedron, Trisoctahedron and Trapezohedron; Zircon, Barite, Gypsum, Hornblende, Beryl, Calcite, Pyritohedron and Tetrahedron.

2. Study of physical properties of mineral group/minerals in hand specimen: Feldspar group, feldspathoid group and silica group. olivine group, garnet group, aluminium silicate group, titanite, staurolite, beryl and tourmaline; pyroxene group and amphibole group; mica group, talc, serpentine and chlorite; apatite, calcite, barite, fluoride and corundum.

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

II Semester Examination

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Practical: Core Course

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Total Credits & Marks  

12 \hspace{1cm} 300
Paper I: ELEMENTS OF GEOCHEMISTRY - (Course No. GEO-C3)

Total Marks: [100 (Mid-Semester Test M.M. 20, End-Semester Exam. M.M. 80)]

Total Lectures: 60 Credits: 4

Objective: The aim of this course is to provide elementary idea about concepts of geochemistry, beginning with basic concepts of chemistry, geochemical classification of elements, rules of substitution and types of various elements. An overview of the structure of Earth and use of isotopes in geochronology is also provided. The course also aims to provide basics of aqueous geochemistry and solid earth.

UNIT 1: Concepts of geochemistry (15 hrs)

Matter and its nature, elements and the periodic table of elements: periods and groups, atomic number, atomic mass and isotopes, ions, molecules and chemical bonding; states of matter, thermal energy and temperature, heat and heat transfer.

Geochemical classification of elements; Goldschmidt’s rules of substitution and their modification ; Types of elements: transition elements, large-ion lithophile elements, high-field strength elements, incompatible and compatible elements, mobile and immobile elements.

UNIT 2: Layered structure of Earth and geochemistry (15 hrs)

Differentiation of the earth, Composition of different layers of Earth; the nuclides and physics of the nucleus; radioactivity: radioactive decay; the law of radioactive decay; Concept of radiogenic isotopes in geochronology and isotopic tracers; Decay schemes of Rb-Sr method, Sm-Nd method, U-Th-Pb method.

UNIT 3: Element transport (15 hrs)


Chromatography: Techniques by physical state of mobile phase; Chromatographic bed shape and separation mechanism.

Aqueous geochemistry: basic concepts and speciation in solutions, Eh, pH relations and mineral solubility.


Chemical control on Diagenesis, Metamorphism and Hydrothermal reactions.

UNIT 4: Geochemistry of solid Earth (15 hrs)

Cosmic elemental abundances; Composition of the bulk silicate Earth: major and minor elements in the crust.

Analytical methods and results, sources of error, precision and accuracy. The solid Earth – geochemical variability of magma and its products: composition of magma, volatiles in magma, variation diagrams: bivariate and triangular plots; Rare earth elements (REE) diagrams; Spider diagrams. Meteorites.

SUGGESTED READING

Paper II: STRUCTURAL GEOLOGY - (Course No. GEO-C4)

Total Marks: [100 (Mid-Semester Test M.M. 20, End-Semester Exam. M.M. 80)]

Total Lectures: 60 Credits: 4

Objective: This course introduces the fundamentals of structural geology with an objective to study in detail the structures related to processes of fracturing. The main aim of this course is to appraise the structures related to deformation and tectonics.

UNIT 1: Structure and Topography (15 hrs)

Effects of topography on structural features; Topographic and structural maps; Important representative factors of the map; Concept of dip and strike; Stratum contour, clinometer compass and Brunton compass, bearing and back bearing. Stereographic projection and its use in structural geology. Thickness and width of outcrops, outlier, inlier. Unconformities: significance, onlap, offlap, types and recognition of unconformities.

UNIT 2: Stress and strain in rocks; Foliation and lineation (15 hrs)

Concept of rock deformation: stress and strain in rocks, strain ellipses of different types and their geological significance. Factors controlling behaviour of rocks; Methods of determination of top and bottom of beds.

Description (definition and types) and origin of foliation: axial plane cleavage and its significance; its relationship with bedding. Description (definition and types) and origin of lineation and relationship with the major structures.

UNIT 3: Folds (15 hrs)

Fold morphology; Geometric and genetic classification of folds; Introduction to mechanics of folding: buckling, bending, flexural slip and flow folding. Causes of folding.

UNIT 4: Joints and faults (15 hrs)

Joints: general characteristics, joint sets, joint system, major joints and their relation with other structure; use of Rose diagram and stereographic projection; joint intensity.


SUGGESTED READING


**Practical I: ELEMENT OF GEOCHEMISTRY** - (Course No. GEO-C3P)

**Total Marks:** [50 (Continuous Assessment M.M. 10, End-Semester Exam. M.M. 40)]

**Total Lectures:** 60  
**Credits:** 2

1. Types of geochemical data analysis and interpretation of common geochemical plots.
2. Geochemical variation diagrams, rare earth elements (REE) and spider diagrams and their interpretations.

**Practical II: STRUCTURAL GEOLOGY** - (Course No. GEO-C4P)

**Total Marks:** [50 (Continuous Assessment M.M. 10, End-Semester Exam. M.M. 40)]

**Total Lectures:** 60  
**Credits:** 2

1. Basic idea of topographic contours; Topographic sheets of various scales.
2. Introduction to geological maps: Lithological and Structural maps.
3. Structural contouring and 3-point problems of dip and strike.
4. Drawing profile sections and interpretation of geological maps of different complexities. Completion of outcrops.
5. Exercises of stereographic and orthographic projections of mesoscopic structural data (planer, linear, folded, etc.).

I Semester Examination

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Total Credits & Marks 12 300

Paper I: ESSENTIALS OF GEOLOGY - (Course No. GEO-GE1)

Total Marks: [100 (Mid-Semester Test M.M. 20, End-Semester Exam. M.M. 80)]

Total Lectures: 60 Credits: 4

Objective: The aim of this course is to introduce the subject of geology along with its various branches and also to provide an introduction to some basic concepts in geology, such as about age of Earth, internal structure of Earth and various internal and external processes, which modify the landscapes and relief of the earth.

UNIT 1: Introduction to earth and planetary sciences (15 hrs)


UNIT 2: Internal structure and rock-air-water interactions (15 hrs)

UNIT 3: Earth history (15 hrs)


UNIT 4: Evolution of Earth’s landscape and origins (15 hrs)


SUGGESTED READING


Paper II: MINERALS AND ROCKS - (Course No. GEO-GE2)

Total Marks: [100 (Mid-Semester Test M.M. 20, End-Semester Exam. M.M. 80)]

Total Lectures: 60 Credits: 4

Objective: This course introduces the general physical characteristics of minerals with an aim to carry out a detailed study of physical properties and chemical compositions of some important rock-forming silicate minerals and some non-silicates. The course also introduces the fundamentals of petrology in order to have broad idea of forms, textures and classification of igneous, metamorphic and sedimentary rocks.

UNIT 1: Physical characters of minerals (15 hrs)


UNIT 2: Rock forming mineral groups/minerals-I (15 hrs)

Physical properties, chemical composition, occurrence and uses of following minerals/groups of minerals: Nesosilicates – titanite, staurolite and chloritoid. Sorosilicates – epidote; Cyclosilicates – beryl, tourmaline and cordierite; Inosilicates – pyroxene group and amphibole group; Phyllosilicates – mica group, talc, serpentine and chlorite; apatite, calcite, barite, fluorite and corundum.
UNIT 3: Introduction to Igneous Petrology (15 hrs)

Introduction to petrology. Igneous petrology: introduction to magma; igneous environments; forms and structures of extrusive and intrusive igneous rocks; igneous textures; classification (mineralogical including IUGS and chemical) and nomenclature of igneous rocks; and petrography of common igneous rocks.

UNIT 4: Introduction to Sedimentary & Metamorphic Petrology (15 hrs)

Sedimentary petrology: formation of sediments; types and formation of sedimentary rocks (siliciclastic, biochemical, organic and chemical); sedimentary structures; and diagenesis. Metamorphic petrology: definition of metamorphism; limits and types of metamorphism; metamorphic agents; types of metamorphic protoliths; textures and structures; and classification and names of metamorphic rocks.

SUGGESTED READING


Practical I: ESSENTIALS OF GEOLOGY - (Course No. GEO-GE1P)

Total Marks: [50 (Continuous Assessment M.M. 10, End-Semester Exam. M.M. 40)]

Total Lectures: 60 Credits: 2

1. Major geomorphic features and relationship with outcrops.
2. Topographic sheets and scales.
3. Study of topographic maps of selected areas.

Practical II: MINERALS AND ROCKS - (Course No. GEO-GE2P)

Total Marks: [50 (Continuous Assessment M.M. 10, End-Semester Exam. M.M. 40)]

Total Lectures: 60 Credits: 2

1. Study of various physical properties of minerals. Study of the following minerals in hand specimen: olivine, garnet, kyanite, andalusite, sillimanite, orthoclase, plagioclase, sodalite, quartz and its varieties, titanite, staurolite, beryl, tourmaline, hypersthene, diopside, augite, anthophyllite, tremolite, actinolite, hornblende, muscovite, biotite, lepidolite, phlogopite, talc, chlorite, serpentine, asbestos, apatite, calcite, barite, fluorite and corundum.

2. IUGS classification of igneous rocks.

3. Magascopic study of the following igneous, metamorphic and sedimentary rocks: Igneous rocks: granite, pegmatite, syenite, diorite, granodiorite, gabbro, rhyolite, dacite, trachyte, andesite and basalt. Metamorphic
II Semester Examination

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Paper I: STRUCTURAL GEOLOGY - (Course No. GEO-GE3)

Total Marks: [100 (Mid-Semester Test M.M. 20, End-Semester Exam. M.M. 80)]

Total Lectures: 60  
Credits: 4

Objective: This course introduces the fundamentals of structural geology with an objective to study in detail the structures related to processes of fracturing. The main aim of this course is to appraise the structures related to deformation and tectonics.

UNIT 1: Structure and Topography (15 hrs)

Effects of topography on structural features; Topographic and structural maps; Important representative factors of the map; Concept of dip and strike; Stratum contour, clinometer compass and Brunton compass, bearing and back bearing. Stereographic projection and its use in structural geology. Thickness and width of outcrops, outlier, inlier. Unconformities: significance, onlap, offlap, types and recognition of unconformities.

UNIT 2: Stress and strain in rocks; Foliation and lineation (15 hrs)

Concept of rock deformation: stress and strain in rocks, strain ellipses of different types and their geological significance. Factors controlling behaviour of rocks; Methods of determination of top and bottom of beds.

Description (definition and types) and origin of foliation: axial plane cleavage and its significance; its relationship with bedding. Description (definition and types) and origin of lineation and relationship with the major structures.
UNIT 3: Folds (15 hrs)

Fold morphology; Geometric and genetic classification of folds; Introduction to mechanics of folding: buckling, bending, flexural slip and flow folding. Causes of folding.

UNIT 4: Joints and faults (15 hrs)

Joints: general characteristics, joint sets, joint system, major joints and their relation with other structure; use of Rose diagram and stereographic projection; joint intensity.


SUGGESTED READING


Paper II: FOSSILS AND THEIR APPLICATIONS - (Course No. GEO-GE4)

Total Marks: [100 (Mid-Semester Test M.M. 20, End-Semester Exam. M.M. 80)]

Total Lectures: 60 Credits: 4

Objective: This basic fundamental course aims to understand various conceptual aspects of Earth’s evolution and its constitution. It is also aimed to study a brief account of plate tectonic processes, about hydrosphere and atmosphere and also to understand fundamentals of stratigraphy including the geological time scale.

UNIT 1: Introduction to fossils (15 hrs)

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

UNIT 2: Species concept (15 hrs)

Definition of species, species problem in paleontology, speciation, methods of description and naming of fossils, code of systematic nomenclature

UNIT 3: Introduction to various fossil groups (15 hrs)

Brief introduction of important fossils groups: invertebrate, vertebrate, microfossils, spore, pollens and plant fossils. Important age-diagnostic fossiliferous horizons of India
UNIT 4: Economic and academic application of fossils (15 hrs)


SUGGESTED READING


Practical I: STRUCTURAL GEOLOGY - (Course No. GEO-GE3P)

Total Marks: [50 (Continuous Assessment M.M. 10, End-Semester Exam. M.M. 40)]

Total Lectures: 60 Credits: 2

1. Basic idea of topographic contours; Topographic sheets of various scales.
2. Introduction to geological maps: Lithological and Structural maps;
3. Structural contouring and 3-point problems of dip and strike.
4. Drawing profile sections and interpretation of geological maps of different complexities. Completion of outcrops.
5. Exercises of stereographic and orthographic projections of mesoscopic structural data (planer, linear, folded, etc.).

Practical II: FOSSILS AND THEIR APPLICATIONS - (Course No. GEO-GE4P)

Total Marks: [50 (Continuous Assessment M.M. 10, End-Semester Exam. M.M. 40)]

Total Lectures: 60 Credits: 2

1. Study of fossils showing various modes of fossilization.
2. Identification of representative genera of the Phyla: Mollusca: Pelecypoda, Gastropoda and Cephalopoda; Brachiopoda, Arthropoda, Corals and Echinodermata.
3. Distribution of age diagnostic fossils in India
B.Sc. (Hons.) Course in Geology

II Year

Semester III and IV
### III Semester Examination

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#### Theory: Core Course

**Paper I: IGNEOUS PETROLOGY - (Course No. GEO-C5)**

Total Marks: [100 (Mid-Semester Test M.M. 20, End-Semester Exam. M.M. 80)]

Total Lectures: 60

Credits: 4

*Objectives: This course aims to understand forms, textures and structures of igneous rocks. It is also aimed to study crystallisation behaviour of magmas, various processes of magmatic differentiation, and petrogenesis and tectonic settings of important igneous rocks.*

**UNIT 1: Concepts of igneous petrology (15 hrs)**

Introduction to petrology; Generation of melts (melting of mantle and factors controlling melting of mantle); Heat flow, geothermal gradients through time and space; Composition of magma, volatiles in magma; Properties of magma: viscosity & density; Rise of magma; Convection in magma; Forms and structures of extrusive and intrusive igneous rocks; Igneous textures; Classification (mineralogical including IUGS and chemical) and nomenclature.
UNIT 2: Phase diagrams and magma diversification (15 hrs)

Basic principles of thermodynamics: system, equilibrium, phase, component, entropy, chemical potential, phase rule and variance. One component system (SiO$_2$ system); Binary systems (solid solution: Albite-Anorthite and Forsterite-Fayalite systems; eutectic: Diopside-Anorthite system; peritectic: Forsterite-Silica system; solid solution and eutectic: Alkali feldspar system); Ternary systems (eutectic: Anorthite-Diopside-Forsterite system; solid solution and eutectic: Diopside-Albite-Anorthite system). Magmatic processes of magma diversification: differentiation, fractional crystallisation, liquid immiscibility, magma mixing and assimilation.

UNIT 3: Petrogenesis and tectonic setting-I (15 hrs)

Classification, petrography, chemistry, tectonic setting and petrogenesis of: Layered mafic intrusions; Komatites; Ophiolites; Mid-ocean ridge basalt (MORB); Ocean island basalt (OIB); Continental flood basalt (CFB).

UNIT 4: Petrogenesis and tectonic setting-II (15 hrs)

Classification, petrography, chemistry, tectonic setting and petrogenesis of: Island arc magmatism; Continental arc magmatism; Granitoid rocks; Continental rift magmas: Alkaline magmatism, Carbonatites, Lamprophyres, Kimberlites; Lamproites; Anorthosites.

SUGGESTED READING


PAPER II: SEDIMENTARY PETROLOGY - (Course No. GEO-C6)

Total Marks: [100 (Mid-Semester Test M.M. 20, End-Semester Exam. M.M. 80)]

Total Lectures: 60 Credits: 4

Objectives: The course contents are focused on major origin of sediments, sediment geometry, and understanding of textural and structural fabrics in relation to environments of deposition. Origin and classification of siliciclastic and carbonate rocks along with processes of diagenesis would also be dealt with.

UNIT 1: Origin of sediments (15 hrs)

Weathering processes and products: physical and chemical weathering; soil origin and profiles; Palaeosols.

UNIT 2: Sediment granulometry (15 hrs)

Grain size scale; particle size distribution; Environmental connotation; Particle shape and fabric.
UNIT 3: Sedimentary textures, structures and environment (15 hrs)

Fluid flow, sediment transport: types of fluids, laminar vs. turbulent flow; Particle entrainment, transport and deposition; Paleocurrent analysis-collection, presentation, interpretation and paleocurrents for different sedimentary environments; Sedimentary structures-primary, inorganic and syn-sedimentary structures.

UNIT 4: Varieties of sedimentary rocks (15 hrs)

Genesis and classification of sedimentary rocks; Siliciclastic rocks: conglomerates, sandstones, mudrocks; Carbonate rocks, controls of carbonate deposition; Components and classification of limestone, dolomite and dolomitisation; Diagenesis: concepts and processes.

SUGGESTED READINGS


Paper III: PALAEONTOLOGY- (Course No. GEO-C7)

Total Marks: [100 (Mid Semester Test M.M. 20, End Semester Exam. M.M. 80)]

Total Lectures: 60 Credits: 4

Objectives: The currently taught course is related to processes and patterns of fossilization, morphology, biostratigraphy and palaeobiogeographic significance of invertebrates, vertebrates and palaeobotanical groups along with introduction of ichnology.

UNIT 1: Fossilization and fossil record (15 hrs)

Fossilization process and fossil record. Modes of preservation. Applications of fossils in biostratigraphy, palaeoenvironments, palaeoecology, palaeobiography and palaeoclimatology. Species concept and taxonomy with reference to paleontology and evolution.

UNIT 2: Invertebrates (15 hrs)

Brief introduction to: Bivalvia, Gastropoda, Brachiopoda, Cephalopoda, Trilobites, with their biostratigraphic and palaeobiogeographic significance.
UNIT 3: Vertebrates (15 hrs)
Origin of vertebrates and major steps in vertebrate evolution. Mesozoic reptiles, dinosaurian evolution and extinction patterns. Evolution of horse and humans.

UNIT 4: Introduction to palaeobotany, Gondwana flora (15 hrs)
Introduction to palaeobotany, Morphology of Gondwana flora, with Indian examples. Introduction to ichnology.

SUGGESTED READING

Practical I: IGNEOUS PETROLOGY - (Course No. GEO-C5P)
Total Marks: [50 (Continuous Assessment M.M. 10, End-Semester Exam. M.M. 40)]
Total Lectures: 60
Credits: 2
1. IUGS classification of igneous rocks.
2. Texture, mineral composition, and order of crystallisation of the following rock types involving handspecimens and thin section study: Granite and its varieties; Syenite and nepheline syenite; Diorite, Gabbro and Dolerite; Anorthosite; Dunite; Peridotite; Pyroxenite; Rhyolite and its varieties, Andesite, Dacite, Trachyte; Basalt and its varieties; Lamprophyre and its varieties.

Practical II: SEDIMENTARY PETROLOGY - (Course No. GEO-C6P)
Total Marks: [50 (Continuous Assessment M.M. 10, End-Semester Exam. M.M. 40)]
Total Lectures: 60
Credits: 2
1. Exercises on sedimentary structures.
3. Paleocurrent analysis.
4. Petrography of clastic and non-clastic rocks through hand specimens and thin sections.

Practical III: PALAEONTOLOGY - (Course No. GEO-C7P)
Total Marks: [50 (Continuous Assessment M.M. 10, End-Semester Exam. M.M. 40)]
Total Lectures: 60
Credits: 2
1. Study of fossils showing various modes of preservation
2. Study of diagnostic morphological characters, systematic position, stratigraphic position and age of various invertebrate, vertebrate and plant fossils.
Skill Enhancement Course: Field Geology 1: Basic Field Training - (Course No. GEO-SEC1)

Total Marks: [50 (Field Work M.M. 25, Field Report M.M. 25)]  

Credits: 2

UNIT 1: Orientation of Topographic sheet in field; marking location in toposheet; Bearing (Front and back); Concepts of map reading, distance, height and pace approximation.

UNIT 2: Identification of rock types in field; Structures and texture of rocks; Use of hand lens.

UNIT 3: Basic field measurement techniques: Bedding dip and strike, Litholog measurement.

UNIT 4: Reading contours and topography; Traverse mapping.

Note: The duration of field work would be of eight days (two credits). It is mandatory for the students to maintain a systematic field diary and also to submit a well illustrated field report based on the field work. A candidate who does not attend the field work or fails to get pass marks in it will have to do the Field Work by joining the field tour of the same class in a subsequent year as per University rules.

IV Semester Examination

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Practical: Core Course

|       | GEO-C8P  | Metamorphic Petrology                      | 2      | 10                | 40                       | 50          |
|       | GEO-C9P  | Stratigraphic Principles & Indian Stratigraphy | 2      | 10                | 40                       | 50          |
|       | GEO-C10P | Hydrogeology                               | 2      | 10                | 40                       | 50          |

Skill Enhancement Course

|       | GEO-SEC2 | Field Geology 2/3/4/5                      | 2      | Field Work        | 25                       | 50          |
|       |          |                                            |        | Field Report      | 25                       |             |

Total Credits & Marks  

|       | 20      | 500               |

B.Sc. (Hons.) Geology
Objective: The aim of this course is to understand textures and structures of metamorphic rocks along with applications and details of metamorphic concepts and processes.

UNIT 1: Metamorphism: controls and types (15 hrs)
Definition of metamorphism; factors controlling metamorphism; limits and types of metamorphism; types of metamorphic protoliths; textures and structures of metamorphic rocks; classification and names of metamorphic rocks; Phase rule and its applications; The concept of equilibrium and its application to metamorphic rocks;

UNIT 2: Metamorphic facies and grade (15 hrs)
Index minerals; Chemographic projections; Metamorphic zones and isograds; Concept of metamorphic facies and grades; Metamorphic facies series; Concept of paired metamorphic belts; Metamorphism of argillaceous, arenaceous, mafic and calcareous rocks.

UNIT 3: Metamorphism and tectonism (15 hrs)
Regional orogenic metamorphic textures: tectonites, foliation and lineations; Deformation versus metamorphic mineral growth: textures of pre-kinematic, syn-kinematic and post-kinematic crystals and their S characteristics; Analysis of polydeformed and polymetamorphosed rocks; Textures of contact metamorphism: granoblastic polygonal, deccusate, nodular, skeletal; High strain metamorphic textures, cataclasis and mylonitisation; Replacement textures and reaction rims; Pressure-Temperature-Time (P-T-t) models for metamorphism.

UNIT 4: Metamorphic rock associations (15 hrs)
Khondalites, Charnockites, Blue schists, Eclogites, UHT and UHP; Migmatites and their origin; Geothermometry and Geobarometry; Experimental Petrology: Methods and techniques; Application of experimental petrology to anatexis and formation of granitic magmas; Metamorphic fluids and metasomatic processes and mechanism of metasomatism.

SUGGESTED READING
Paper II: STRATIGRAPHIC PRINCIPLES AND INDIAN STRATIGRAPHY - (Course No. GEO-C9)

Total Marks: [100 (Mid-Semester Test M.M. 20, End-Semester Exam. M.M. 80)]

Total Lectures: 60  
Credits: 4

Objective: This course provides an understanding of principles of stratigraphy and brief introduction of Indian stratigraphic successions.

UNIT 1: Principles of stratigraphy (15 hrs)


UNIT 2: Code of stratigraphic nomenclature (15 hrs)


UNIT 3: Phanerozoic stratigraphy of India (15 hrs)

Tethyan Paleozoic succession. Mesozoic stratigraphy of India: Triassic successions of Spiti; Jurassic succession of Kutch; Cretaceous successions of Cauvery basin. Palaeogene and Siwalik stratigraphy.

UNIT 4: Stratigraphic boundaries (15 hrs)


SUGGESTED READINGS


Paper III: HYDROGEOLOGY - (Course No. GEO-C10)

Total Marks: [100 (Mid-Semester Test M.M. 20, End-Semester Exam. M.M. 80)]

Total Lectures: 60  
Credits: 4

Objective: The main emphasis of this course is on the basic concepts of hydrogeology along with principles of occurrence, chemistry movement, development and management of groundwater resources.

UNIT 1: Introduction and basic concepts (15 hrs)

Scope of hydrogeology and its societal relevance; Origin, occurrence and distribution of water, Types of water; Hydrologic cycle: precipitation, evapo-transpiration, run-off, infiltration and subsurface movement of water;
Water balance; Rock properties affecting groundwater; Vertical distribution of subsurface water, Types of aquifer, anisotropy and heterogeneity of aquifers.

UNIT 2: Groundwater flow and well hydraulics (15 hrs)

Laminar and turbulent groundwater flow; Theory of groundwater flow- Darcy's law and its validity; Elementary concepts related to equilibrium and non-equilibrium conditions for water flow to a well in confined and unconfined aquifers; Aquifer parameters-transmissivity, storage coefficient, hydraulic conductivity, transmissivity, hydraulic resistance and likage factor; Intrinsic permeability and hydraulic conductivity; Groundwater flow rates and flow direction.

UNIT 3: Groundwater chemistry (15 hrs)

Physical and chemical properties of water; Quality criteria for different uses-Domestic, Irrigation and Industrial; Graphical presentation of groundwater quality data; Groundwater quality in different provinces in India; Groundwater contamination; natural (geogenic) and anthropogenic contaminants; Saline water intrusion in coastal aquifers.

Unit 4: Groundwater management (15 hrs)

Surface and subsurface water interaction, Conjunctive use of surface and groundwater; Groundwater legislation.; Groundwater level fluctuations; Basic concepts of water balance studies, issues related to groundwater resources development and management, artificial recharge of ground water- Concept of artificial recharge – recharge methods, relative merits; Applications of remote sensing in artificial recharge of ground water.

SUGGESTED READING


Practical I: METAMORPHIC PETROLOGY - (Course No. GEO-C8P)

Total Marks: [50 (Continuous Assessment M.M. 10, End-Semester Exam. M.M. 40)]

Total Lectures: 60 Credits: 2

1. Detailed megascopic and microscopic fabric study of rocks of different facies of metamorphism, viz. greenschist, amphibolite and granulite facies.
2. Graphic construction of ACF, AKF and AFM diagrams.
3. Estimation of pressure and temperature from important models of geothermobarometry.
4. Analysis of deformation versus metamorphic mineral growth: textures of pre-kinematic, syn-kinematic and post-kinematic crystals.
Practical II: STRATIGRAPHIC PRINCIPLES AND INDIAN STRATIGRAPHY - (Course No. GEO-C9P)

Total Marks: [50 (Continuous Assessment M.M. 10, End-Semester Exam. M.M. 40)]

Total Lectures: 60 Credits: 2

1. Study of geological map of India, and major stratigraphic basins.
2. Study of rocks in hand specimens from known Indian Precambrian and Phanerozoic stratigraphic horizons.

Practical III: HYDROGEOLOGY - (Course No. GEO-C10P)

Total Marks: [50 (Continuous Assessment M.M. 10, End-Semester Exam. M.M. 40)]

Total Lectures: 60 Credits: 2

1. Preparation and interpretation of water level contour maps and depth to water level maps.
2. Study, preparation and analysis of hydrographs for differing groundwater conditions.
3. Graphical representation of chemical quality data and water classification (Trilinear diagrams).
4. Simple numerical problems related to: determination of permeability in field and laboratory, groundwater flow, well hydraulics, etc.

Skill Enhancement Course: Field Geology 2: Geological Mapping - (Course No. GEO-SEC2)

Total Marks: [50 (Field Work M.M. 25, Field Report M.M. 25)] Credits: 2

UNIT 1: Geological mapping, stratigraphic correlation.

UNIT 2: Primary (scalars and vectors) and secondary structures (linear and planar).

UNIT 3: Trend, plunge, Rake/Pitch.

UNIT 4: Stereoplots of linear and planar structures, Orientation analyses.

Note: The duration of field work would be of eight days (two credits). It is mandatory for the students to maintain a systematic field diary and also to submit a well illustrated field report based on the field work. A candidate who does not attend the field work or fails to get pass marks in it will have to do the Field Work by joining the field tour of the same class in a subsequent year as per University rules.

OR

Skill Enhancement Course: Field Geology 3: Himalayan Geology Field - (Course No. GEO-SEC2)

Total Marks: [50 (Field Work M.M. 25, Field Report M.M. 25)] Credits: 2

Identification and characterization of major structural boundaries in Himalaya viz. MBT, MFT etc.
or
Field along any suitable transect of the Himalayan foreland.
or
Field transect in Siwalik.

or

Identification of the Himalayan and the pre-Himalayan elements.

Note: The duration of field work would be of eight days (two credits). It is mandatory for the students to maintain a systematic field diary and also to submit a well illustrated field report based on the field work. A candidate who does not attend the field work or fails to get pass marks in it will have to do the Field Work by joining the field tour of the same class in a subsequent year as per University rules.

OR

**Skill Enhancement Course: Field Geology 4: Stratigraphy & Palaeontology-related Field**
- (Course No. GEO-SEC2)

Total Marks: [50 (Field Work M.M. 25, Field Report M.M. 25)]

Credits: 2

UNIT 1: Field training along Phanerozoic basin of India.

UNIT 2: Documentation of stratigraphic details in the field.

UNIT 3: Collection of sedimentological, stratigraphic and paleontological details and their representation.

UNIT 4: Facies concept and its spatio-temporal relation (Walther’s Law) and concept of facies distribution at basinal-scale.
Fossils sampling techniques and their descriptions.

Note: The duration of field work would be of eight days (two credits). It is mandatory for the students to maintain a systematic field diary and also to submit a well illustrated field report based on the field work. A candidate who does not attend the field work or fails to get pass marks in it will have to do the Field Work by joining the field tour of the same class in a subsequent year as per University rules.

OR

**Skill Enhancement Course: Field Geology 5: Precambrian Geology Field** - (Course No. GEO-SEC2)

Total Marks: [50 (Field Work M.M. 25, Field Report M.M. 25)]

Credits: 2

UNIT 1: Field transect in any Precambrian terrain.

UNIT 2: Study of craton ensemble including basic intrusive suites.

UNIT 3: Precambrian sedimentary basin.

UNIT 4: Basement-Cover relation in: a. fold belts, b. sedimentary successions.

Note: The duration of field work would be of eight days (two credits). It is mandatory for the students to maintain a systematic field diary and also to submit a well illustrated field report based on the field work. A candidate who does not attend the field work or fails to get pass marks in it will have to do the Field Work by joining the field tour of the same class in a subsequent year as per University rules.

III Semester Examination

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STRATIGRAPHY - (Course No. GEO-GE5)

Total Marks: [100 (Mid-Semester Test M.M. 20, End-Semester Exam. M.M. 80)]

Total Lectures: 60

Credits: 4

Objective: The major role of this course is to understand and interpret earth history, both global as well as related to Indian context. Various concepts of stratigraphy, such as its fundamentals, classification and nomenclatural procedures and stratigraphic successions of India are highlighted to clarify and build geologic history of India in time and space.

UNIT 1: Principles of stratigraphy (15 hrs)


UNIT 2: Stratigraphic classification and stratigraphic nomenclature (15 hrs)

UNIT 3: Stratigraphy of India and Precambrian Successions (15 hrs)

An introduction to the overall stratigraphy of India: successions, fossils and ages from Precambrian to the Phanerozoic. Precambrian successions and correlative equivalents in Dharwar, south India, Singhbhum, central India, Aravalli Delhi belt. Precambrian basins in Himalayan regions of Kashmir, Kumaun, Himachal Pradesh and the northeast. Cuddapah (Kurnoo, Kaladgi and Bhima successions) and Vindhan Supergroups: lithostratigraphic successions, biotas and palaeoenvironmental significance.

UNIT 4: Phanerozoic Stratigraphy of India (15 hrs)

Paleozoic stratigraphy in Tethyan basins of Kashmir, Spiti and Ladakh with particular reference to biotas, palaeoenvironmental implications and biocorrelations. Palaeozoic stratigraphy of the Lesser Himalaya and peninsular India. Mesozoic stratigraphic successions in Peninsular India, with particular reference to Kachchh, Rajasthan, South India. Himalayan Mesozoic stratigraphy of Spiti area. Gondwana Supergroup: stratigraphic successions, biotas, ages, palaeogeography and palaeoclimates. Cenozoic successions of Foreland Basin (Siwalik Group and Palaeogene successions of Lesser Himalaya and Trans-Himalaya) and those of Peninsular India.

SUGGESTED READING


Practical: STRATIGRAPHY - (Course No. GEO-GE5P)

Total Marks: [50 (Continuous Assessment M.M. 10, End-Semester Exam. M.M. 40)]

Total Lectures: 60 Credits: 2

1. Study of geological map of India and identification of major stratigraphic units.
2. Study of rocks in hand specimens from known Indian stratigraphic horizons.
3. Drawing various paleogeographic maps of Precambrian and Phanerozoic times.
IV Semester Examination

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**HYDROGEOLOGY - (Course No. GEO-GE6)**

Total Marks: [100 (Mid-Semester Test M.M. 20, End-Semester Exam. M.M. 80)]

Total Lectures: 60

Credits: 4

Objective: The main emphasis of this course is on the basic concepts of hydrogeology along with principles of occurrence, chemistry movement, development and management of groundwater resources.

**UNIT 1: Introduction and basic concepts (15 hrs)**

Scope of hydrogeology and its societal relevance; Origin, occurrence and distribution of water, Types of water; Hydrologic cycle: precipitation, evapo-transpiration, run-off, infiltration and subsurface movement of water; Water balance; Rock properties affecting groundwater; Vertical distribution of subsurface water, Types of aquifer, anisotropy and heterogeneity of aquifers.

**UNIT 2: Groundwater flow and well hydraulics (15 hrs)**

Laminar and turbulent groundwater flow; Theory of groundwater flow- Darcy's law and its validity; Elementary concepts related to equilibrium and non-equilibrium conditions for water flow to a well in confined and unconfined aquifers; Aquifer parameters-transmissivity, storage coefficient, hydraulic conductivity, transmittivity, hydraulic resistance and likage factor; Intrinsic permeability and hydraulic conductivity; Groundwater flow rates and flow direction.

**UNIT 3: Groundwater chemistry (15 hrs)**

Physical and chemical properties of water; Quality criteria for different uses-Domestic, Irrigation and Industrial; Graphical presentation of groundwater quality data; Groundwater quality in different provinces in India; Groundwater contamination; natural (geogenic) and anthropogenic contaminants; Saline water intrusion in coastal aquifers.

**Unit 4: Groundwater management (15 hrs)**

Surface and subsurface water interaction, Conjunctive use of surface and groundwater; Groundwater legislation.; Groundwater level fluctuations; Basic concepts of water balance studies, issues related to
groundwater resources development and management, Artificial recharge of ground water- Concept of artificial recharge – recharge methods, relative merits; Applications of remote sensing in artificial recharge of ground water.

**SUGGESTED READING**


**Practical: HYDROGEOLOGY - (Course No. GEO-GE5P)**

**Total Marks: [50 (Continuous Assessment M.M. 10, End-Semester Exam. M.M. 40)]**

**Total Lectures: 60**

1. Preparation and interpretation of water level contour maps and depth to water level maps.
2. Study, preparation and analysis of hydrographs for differing groundwater conditions.
3. Graphical representation of chemical quality data and water classification (Trilinear diagrams).
4. Simple numerical problems related to: determination of permeability in field and laboratory, groundwater flow, well hydraulics, etc.