

**STATE MODEL SYLLABUS FOR UNDER  
GRADUATE  
COURSE IN GEOLOGY  
(Bachelor of Arts/Science Examination)**

UNDER  
CHOICE BASED CREDIT SYSTEM

## GEOLOGY

Semester		CORE COURSE (14)	Ability Enhancement Compulsory Course (AECC) (2)	Ability Enhancement Elective Course (SEC) (2) (Skill Based)	Discipline Specific Elective: DSE (4)	Elective: Generic (GE) (4)
I	CC 1	General geology and Quaternary geology	English Communication/ Odia/ Hindi			<b>GE-I</b> General geology and Mineralogy
	CCII	Tectonics and Remote sensing				
II	CCIII	Crystallography and Mineralogy	Environmental Science			<b>GE-II</b> Petrology and Historical geology
	CCIV	Optics and Geochemistry				
III	CCV	Igneous petrology		SEC I		<b>GE-III</b> Structure and engineering geology
	CCVI	Sedimentary petrology				
	CCVII	Metamorphic petrology				
IV	CCVIII	Palaeontology		SEC II		<b>GE- IV</b> Applied geology
	CCIX	Stratigraphy				
	CCX	Structural geology				
V	CCXI	Processes of formation and Mineral economics			<b>DSE-I</b> Fuel Geology	
	CCXII	Economic geology			<b>DSE-II</b> Climate Change and Disaster Management	
VI	CCXIII	Groundwater and Engineering geology			<b>DSE-III</b> Earth and Climate	
	CC XIV	Mining and Environmental geology			<b>DSE-IV</b> Project Work / <b>Evolution of life through time</b>	

## **GEOLOGY- Honours**

Core course – 14 papers,  
 Discipline Specific Elective – 4 paper,  
 SEC (out of the various options provided)  
 Generic Elective for Non-Geology students – 4 papers. In case University offers 2 subjects as GE, then papers 1 and 2 will be the GE paper.

Marks per paper – Mid term : 15 marks, End term : 60 marks, Practical: 25 Total – 100 marks  
 Credit per paper – 6, Teaching hours per paper – 40 hours + 20 Practical

### **CC – 1: GENERAL GEOLOGY AND QUATERNARY GEOLOGY**

#### **Unit - 1: Earth as a planet**

Geology - its perspective, scope and subdivisions; General characteristics and origin of the Universe, Solar System and its planets. The terrestrial and jovian planets. Meteorites and Asteroids. Earth in the solar system - origin, size, shape, mass, density, rotational and revolution parameters and its age.

#### **Unit II: Internal structure of the Earth**

Seismology and internal structure of the earth; Formation of core, mantle, crust; Convection in Earth's core and its magnetic field. Radioactivity and age of the earth.

Volcanoes: Types, products and distribution. Earthquakes - intensity, causes, earthquake belts and distribution. Oceanic current system and effect of Coriolis force; Concept of eustasy; Land-air-sea interaction. Atmospheric circulation, Weather and climatic changes; Earth's heat budget

#### **Unit - 3: Geomorphology**

Weathering and Erosion, Mass wasting; Geological works of river, glacier, wind, underground water, ocean and landforms produced by them. Wave erosion and beach processes.

#### **Unit - 4: Quaternary geology**

Scope, climate change, eustatic movement and other geological phenomena during Quaternary; Landforms and deposits with special reference to India; Neotectonics; Glaciation and its causes; Sea-level change during Quaternary.

**Practical:** Study of geomorphic forms and drainage patterns. Study of contour patterns and drawing of profiles. Study of major ocean currents of the World. Laboratory records and viva voce.

**Text Book:** Duff, P.M.D., & Duff, D. (Eds.). (1993). Holmes' principles of physical geology. Taylor & Francis.

#### **Suggested Readings:**

1. Emiliani, C. (1992). Planet earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press.
2. Gross, M. G. (1977). Oceanography: A view of the earth.
3. Invitation to Oceanography (2009) Paul R. Pinet Jones & Barlett Learning
4. Trujilo, A. and Thurman, H. (2012) Essentials of Oceanography, 12<sup>th</sup> Edition, Pearson

### **CC-2: TECTONICS AND REMOTE SENSING**

#### **Unit - 1: Earth movement**

Tectonic movements – Epeirogeny and orogeny; Isostasy – concept and theories; Geosynclines; Mountain building theories; Origin of oceans, continents, mountains and rift valleys

#### **Unit - 2: Plate tectonics**

Plate tectonics – concept and types of plate margins; Continental drift – evidences and causes; Sea-

floor spreading; Mid-oceanic ridge, trenches, transform faults; Island arc.

### **Unit - 3: Photogeology and Remote Sensing**

Principles of aerial photography; Types and acquisition of aerial photographs; Scale and resolution; Principles of stereoscopy, relief, displacement, vertical exaggeration and distortion, Photo-elements and interpretation. Application of aerial photography in mineral exploration, ground water exploration and geomorphology.

Principles of remote sensing, Electromagnetic radiation, Scale, Platforms, Photo mosaic and FCC. Sensors and scanners, Satellites and their characteristics, Data formats-Raster and Vector. Digital Image Processing, Image errors, Rectification and restoration, Image Enhancement, Filtering, Image Rationing, Image classification and accuracy assessment. Application of remote sensing in mineral exploration, ground water exploration and geomorphology.

**Unit - 4: Marine geology** Relief of ocean floor; Marine sediments and their classification; Marine resources; Submarine canyons, Sea mounts and guyots; Coral reef.

**Practical:** Study of aerial photographs and uses of stereoscopes. Aerial Photo interpretation of various aeolian, glacial, fluvial and marinel and forms from aerial photographs. Study of maps of plates, earthquake belts, hot spots, trenches, triple junctions and volcanic belts. Laboratory records and viva voice.

**Text Book:** Jensen, J.R., 1996. Introductory Digital Image Processing: A Remote Sensing Perspective, Springer- Verlag.

#### **Suggested Readings:**

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

## **CC-3: Crystallography and Mineralogy**

### **Unit - 1: Crystallography**

Crystalline and non-crystalline substances, Crystals - definition, characteristics, intercepts, parameters, indices and forms. Symmetry elements and classification of crystals in to six systems. Hermann-Mauguin symbol; Holohedrim, hemihedrim hemi morphism and enantiomorphism. Study of axial relationship, symmetry elements and forms present in  $4/m\bar{3}2/m$ ,  $43m$ ,  $2/m\bar{3}$ ,  $4/m2/m2/m$ ,  $6/m2/m2/m$ ,  $32/m$ ,  $2/m2/m2/m$ ,  $2/m$  and 1 classes. Fundamentals of stereographic projection of crystals.

Zone and zonal laws, Twinning.

### **Unit - 2: Physical and chemical mineralogy**

Scope of mineralogy; chemical bonding and compound formation. Definition and classification of minerals. Physical properties of minerals, Silicate structure and its classification.

### **Unit - 3: Silicate minerals**

Study of atomic structure, chemistry, physical, optical properties and uses of minerals of Olivine, Feldspar, Pyroxene, Amphibole, Garnet and Mica groups.

### **Unit - 4: Descriptive mineralogy**

Isomorphism, polymorphism and pseudo morphism; Chemical composition, physical and optical properties and uses of agate, amphibole, anatase, andalusite, anhydrite, apatite, aragonite, augite, barite, beryl, biotite, calcite, chlorite, corundum, diamond, diopside, dolomite, enstatite, epidote,

fluorite, garnet, gypsum, halite, hornblende, hypersthene, kyanite, magnesite, microcline, monazite, muscovite, olivine, orthoclase, plagioclase, quartz, rutile, sanidine, serpentine, sillimanite, sphene, staurolite, talc, topaz, topaz, tourmaline, and zircon.

**Practical:** Study and identification of crystal models as mentioned in theory. Megascopic identification of rock forming minerals as mentioned in theory, Laboratory records and viva voce.

Suggested Books :

1. Optical Mineralogy – The non-opaque minerals, W. R. Phillips and D. T. Griffen (2004), CBS Pub. & Dist., New Delhi
2. Rutley's Elements of Mineralogy(27<sup>th</sup> Edition) Revised by C.D. Gribble
3. Practical approach to crystallography and mineralogy, R. N. Hota (2011), CBS Pub. & Dist., New Delhi

## CC – 4: Optics and Geochemistry

### Unit - 1: Nature of light

Nature of light rays and their propagation, internal reflection, double refraction, interference and polarization. Nicol Prism and polaroids. Petrological microscope - parts and their functions. Preparation of thin section of minerals and rocks.

### Unit - 2: Mineral optics

Behaviour of light in thin section and production of interference colours. Order of interference colour, twinkling, Optic axis, Uniaxial and biaxial minerals. Isotropism and anisotropism, Extinction and extinction angle. Pleochroism, pleochroic scheme, Birefringence; Outline of study of optical characters of minerals in thin sections.

### Unit - 3: Concept of geochemistry

Chemical bonding, states of matter and atomic environment of elements. Cosmic abundance of elements; composition of planets and meteorites. Structure and composition of earth. Conservation of mass, isotopic and elemental fractionation. Concept of radiogenic isotopes in geochronology and isotopic tracers.

### Unit - 4: Cosmic abundance of elements

Geochemical classification of elements, Primary geochemical differentiation; Atomic substitution. Advection and diffusion; Chromatography; Elements of marine chemistry; Mineral reactions- diagenesis and hydrothermal reactions. Distribution of elements in solar system; Chemical differentiation and composition of the Earth; General concepts about geochemical cycles and mass balance; Geo-chemical behavior of major elements.

**Practical:** Microscopic identification of rock forming minerals; Measurement of extinction angle; sign of elongation and order of interference colour. Laboratory records, Field report and viva voce.

**Text Book:**

1. Dexter Perkins (2002) Mineralogy, Prentice-Hall of India, New Delhi.

**Suggested readings:**

1. 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.
2. Kerr, P. F. (1959). Optical Mineralogy. McGraw-Hill.
3. Verma, P.K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt. Ltd.
4. Deer, W.A., Howie, R.A., & Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman.
5. Hota, R. N. (2017) Practical approach to crystallography and mineralogy, CBS Publishers and Distributors, New Delhi

## CC – 5: Igneous petrology

### Unit - 1: Concepts of Igneous petrology

Introduction to petrology: Heat flow, geothermal gradients through time. origin and nature of magma; Magma generation in crust and mantle, their emplacement and evolution. Magmatism in the oceanic domains (MORB, OIB); Crystallization behavior of unicomponent magma; bicomponent magma showing solid solution and eutectic relationships.

### Unit-2: Forms of Igneous Rocks

Introduction, Forms, Texture, Mega-and micro-structures of igneous rocks. Mode of occurrence of igneous rocks

### Unit-3: Diversity of Igneous rocks

Bowen's reaction series and its implications. Differentiation of magma and diversity of igneous rocks. Introduction to Di-Ab-Anternary system; Classification of igneous rocks. Preliminary idea on assimilation processes. Magmatism along the plate margins (Island arcs/continental arcs).

### Unit - 5: Igneous petrography

Petrogenesis of Felsic and Mafic igneous rocks; Petrographic notes on Basalt, Dolerite, Gabbro, Granite, Pegmatite, Syenite, Dunite, Diorite, Peridotite, Carbonatite, Anorthosite and Kimberlite and their occurrences in India..

**Practical:** Mega scopic and microscopic identification of important igneous rocks. Laboratory records and viva voce.

#### Text Book:

1. Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.

#### Suggested readings:

1. Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
2. Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Rout ledge.
3. Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks.
4. McGraw-Hill Science Engineering.
5. Mc Birney, A. R. (1984). Igneous Petrology. San Francisco (Freeman, Cooper & Company) and Oxford (Oxford Univ. Press),
6. Myron G. Best (2001). Igneous and Metamorphic Petrology,
7. K.G.Cox,J.D.Bell.(1979).The Interpretation of Igneous Rocks.
8. Bose M.K. (1997). Igneous Petrology.
9. G W Tyrrell. (1926). Principles of Petrology. Springer
10. Hota,R.N.(2017)Practical approach to petrology, CBS Publishers and Distributors, New Delhi

## CC – 6: Sedimentary petrology

### Unit - 1: Origin of sediments

Introduction, formation of sediments and sedimentary rocks. Elementary idea on sedimentary environments. Compaction, cementation and diagenesis

### Unit - 2: Sedimentary textures, structures and environment

Texture and fabric of sedimentary rocks. Fluid flow, sediment transport and sedimentary structures: Types of fluids, Laminar vs. turbulent flow, Particle entrainment, transport and deposition. Elementary idea on sedimentary facies and environment.

**Unit - 3: Sedimentary provenance and basins**

Classification of sedimentary rocks; sandstone and limestone; Palaeocurrent, Heavy minerals and Provenance. Sedimentary basins of India.

**Unit - 4: Sedimentary Petrography**

Petrographic notes on sandstones, conglomerate, shale, limestone and breccia and their occurrences in India. Dolomite and dolomitisation

**Practical:** Megascopic and microscopic identification of sedimentary rocks. Exercises on sedimentary structures, Paleocurrent analysis; Laboratory records and viva voce.

**Text Book:** Nichols, G. (2009) Sedimentology and Stratigraphy Second Edition. Wiley Blackwell

**Suggested readings:**

1. Prothero, D.R., & Schwab, F. (2004). Sedimentary geology. Macmillan.
2. Tucker, M. E. (2006) Sedimentary Petrology, Blackwell Publishing.
3. Collinson, J. D. & Thompson, D. B. (1988) Sedimentary structures, Unwin- Hyman, London.
4. Hota, R.N. (2017) Practical approach to petrology, CBS Publishers and Distributors, New Delhi

**CC-7: Metamorphic petrology****Unit - 1: Metamorphism: controls and types**

Introduction, Definition of metamorphism. Factors controlling metamorphism: Agents and types of metamorphism, ACF and AKF diagrams.

**Unit - 2: Metamorphic facies and grades**

Index minerals, Metamorphic zones and grades. Concept of metamorphic facies; Mineralogical phase rule of closed and open system; Structure and textures of metamorphic rocks.

**Unit - 3: Metamorphism and Tectonism**

Relationship between metamorphism and deformation; Metamorphic mineral reactions (prograde and retrograde); Migmatites and their origin; Metasomatism and role of fluids in metamorphism. Classification of metamorphic rocks; Metamorphic differentiation.

**Unit - 4: Metamorphic Petrography**

Petrographic notes on important rock types like schists, gneisses, marble, quartzite, slate, phyllites, khondalite and charnockite, eclogites and their occurrences in India.,

**Practical:** Megascopic and microscopic identification of metamorphic rocks. Laboratory records and viva voce.

**Text Book:** Yardley, B. W., & Yardley, B. W. D. (1989). An introduction to metamorphic petrology. Longman Earth Science Series.

**Suggested Readings:**

1. Philpotts, A., & Ague, J. (2009). *Principles of igneous and metamorphic petrology*. Cambridge University Press.
2. Winter, J.D. (2014). *Principles of igneous and metamorphic petrology*. Pearson.
3. Rollinson, H. R. (2014). *Using geochemical data: evaluation, presentation, interpretation*. Routledge.
4. Raymond, L. A. (2002). *Petrology: the study of igneous, sedimentary, and metamorphic rocks*. McGraw-Hill Science Engineering.
5. Hota, R.N. (2017) Practical approach to petrology, CBS Publishers and Distributors, New Delhi

**CC - 8: Palaeontology****Unit - 1: Fossilization and fossil record**

Fossil-definition and conditions of fossilization; Mode of preservation and geological significance of

fossils.

### **Unit - 2: Invertebrate Palaeontology**

Morphology and geological history of Trilobita, Brachiopoda, Pelecypoda, Cephalopoda, Gastropoda, Echinoidea, Coral and Graptolite.

### **Unit - 3: Vertebrates Palaeontology**

Origin of vertebrates and major steps in vertebrate evolution. Mesozoic reptiles with special reference to origin diversity and extinction of dinosaurs; Siwalik fauna Evolution of horse and intercontinental migrations. Human evolution.

### **Unit - 4: Palaeobotany**

Scope of paleobotany, taxonomy of plants, Gondwana flora and their significance. Separation of spores and pollens and mounting for study. Utility of palynological studies in different fields.

**Practical:** Identification of important invertebrate and plant fossils; Drawing and labeling of fossils; Arrangement of fossils in chronological order; Laboratory records and viva voce.

**TextBook:** Clarkson, E.N.K. (2012) Invertebrate paleontology and evolution 4th Edition, Blackwell Publishing.

#### **Suggested readings**

1. Raup, D.M., Stanley, S.M., Freeman, W.H. (1971) Principles of Paleontology
2. Benton, M. (2009). Vertebrate paleontology. John Wiley & Sons.
3. Shukla, A.C. & Misra, S.P. (1975). Essentials of paleobotany. Vikas Publisher
4. Armstrong, H. A., & Brasier, M.D. (2005) Microfossils. Blackwell Publishing.

## **CC – 9: Stratigraphy**

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

Principles of Stratigraphy, Stratigraphic units; Stratigraphic correlation, Standard stratigraphic time scale and Indian equivalences; Geomorphic and tectonic divisions of India.

### **Unit - 2: Code of stratigraphic nomenclature**

Indian code of stratigraphic nomenclature. Concepts of Stratotypes. Global Stratotype Section and Point (GSSP). Brief introduction to the concepts of lithostratigraphy, biostratigraphy, chrono stratigraphy, seismic stratigraphy, chemo stratigraphy, Magneto stratigraphy, Sequence stratigraphy

### **Unit - 3: Precambrian stratigraphy**

Precambrian stratigraphy of Karnataka, Odisha, Jharkhand, Rajasthan, Madhya Pradesh and Maharashtra. Stratigraphy of Cuddapah and Vindyanbasins.

### **Unit - 4: Paleozoic, Mesozoic and Cenozoic stratigraphy of India**

Gondwana rocks with special emphasis on fossils, climate and economic importance. Triassic of Spiti, Jurassic of Kutch and Cretaceous of Trichinopoly. Deccan traps and Tertiary of Assam. Siwalik rocks.

**Practical:** Drawing of stratigraphic units in outline map of India and Odisha; Identification and interpretation of stratigraphic assemblages; Laboratory records and viva voce.

#### **TextBook:**

1. Ramakrishnan, M. and Vaidyanadhan, R. (2008) Geology of India Volumes 1 & 2, Geological society of India, Bangalore.

#### **Suggested readings:**



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

## **CC – 10: Structural geology**

### **Unit - 1: Rock deformation**

Introduction, Attitude of beds; V's rule; Deformation, concept of stress and strain; Strain ellipses of different types and their geological significances. Effects of topography on structural features, Topographic and structural maps; Importance representative factors of the map. Outlier, Inlier, Nappe, Klippe and Window.

### **Unit - 2: Folds**

Fold morphology; Geometric and genetic classification of folds; Introduction to the mechanics of folding; Buckling, Bending, Flexural slip and flow folding; recognition in field and map, causes of folding. Top and bottom criteria of deformed strata.

### **Unit - 3: Faults and joints**

Fault- classification, mechanism, significance, recognition in the field and map, general effects of faulting on outcrops. Joints - geometry, classification and significance.

### **Unit - 4: Unconformities, Foliation and lineation**

Unconformity - types, significance, recognition in the field and map, difference between fault and unconformity. Foliation - types and relation with major structures, Lineation - types and relation with major structures; Salt domes and diapirs.

**Practical:** Interpretation of structure, stratigraphy and geologic history from maps; Drawing of sections; Completion of outcrops; Three point problems; Thickness and depth problems; Laboratory records, field report and viva voce.

**Text Book:** Davis, G. R. (1984) *Structural Geology of Rocks and Region*. John Wiley

#### **Suggested readings:**

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

## **CC–11 Processes of formation and Mineral economics**

### **Unit-1: Magmatic and hydrothermal processes**

Process of formation of ore bodies: Magmatic concentration, Hydrothermal processes, Wall rock alteration and Paragenesis, Zoning.

### **Unit - 2: Secondary processes**

Process of formation of ore bodies: Residual and mechanical concentration, Oxidation and Supergene enrichment. Process of formation of ore bodies: Sedimentation, Evaporation, Metamorphism.

### **Unit - 3: Energy Resources and mineral economics**

Origin, occurrence, distribution and uses of coal and petroleum; Atomic minerals.

**Unit - 4: Mineral economics**

Strategic, essential and critical minerals. Sustainable developments of minerals; Conservation of mineral resources.

**Practical:** Megascopic study of strategic, critical and essential minerals. Laboratory records and viva voce.

**CC – 12: Economic geology****Unit - 1: Ores and gangues**

Ores, gangue minerals; tenor and grade; Resources and reserves, Metallogenetic epoch and provinces of India. Controls of ore localization, Classification of mineral deposits; Metallogenic epochs and provinces; Oredistricts.

**Unit - 2: Mineral Exploration**

Exploration and exploitation techniques; Geological, Geophysical and Geochemical Explorations, Geological mapping at different scales, drilling, borehole logs.

**Unit - 3: Metallic minerals**

Mineralogy, mode of occurrence, origin, Indian distribution and uses of ores of Fe, Mn, Al, Cr, Cu, Pb and Zn ores. Important ore deposits of India

**Unit - 4: Industrial minerals**

Mineralogy, mode of occurrence, origin, Indian distribution and uses of Mica, Asbestos, Kyanite, Sillimanite, Graphite, Baryte, Serpentine and Magnesite and Limestone.

**Practical:** Mega scopic identification and uses of important metallic and non-metallic minerals; Distribution of important ores and other economic minerals in India. Laboratory records and viva voce.

**Text Book:** Bateman, A.M. and Jensen, M.L. (1990) Economic Mineral Deposits. John Wiley.

**Suggested readings:**

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

**CC-13 Ground water and Engineering geology****Unit - 1: Water bearing characteristics**

Hydrological cycle, vertical zonation of ground water, Properties of water bearing formations - porosity, permeability, specific yield, specific retention, storativity. Aquifer types - Confined and unconfined aquifers, aquitard, aquiclude, aquifuge. Darcy's law.

**Unit - 2: Groundwater exploration and quality**

Ground Water exploration - types of wells, groundwater provinces of India and Odisha. Sea-water intrusion, Quality of ground water and its use in domestic, agriculture and industries; Ground water pollution.

**Unit - 3: Engineering properties of materials and geology of dams**

Introduction, engineering properties of rocks and soils, Types of dams; Geological considerations of Dam and reservoir site selection.

**Unit - 4: Geology of tunnel and bridge**

Geological considerations of tunnel alignment, bridge site selection. Earthquake resistant

structures, Soil - classification, erosion and conservation.

**Practical:** Problems related to groundwater and engineering properties of rocks. Laboratory records and viva voce.

## **CC – 14 Mining and Environmental geology**

### **Unit - 1: Mining**

Terminology in mining, opencast and Under ground mining methods, Drilling, Surveying; Sampling; Assaying and ore reserve estimation

### **Unit - 2: Disaster Management**

Natural disasters and their management–Earthquake, Landslide, Flood, Tsunami and Cyclone.

### **Unit - 3: Resource management**

Renewable and non-renewable resources; Conservation of mineral resources; Impact of mining on environment; Fundamentals of environmental impact assessment.

### **Unit - 4: Environmental Geology**

Management of solid wastes including mining wastes; Fly ash, Radioactive wastes; Environmental protection- Legislative measures in India; Fluorosis problems and arsenic poisoning in India – Causes and remedial measures.

**Practical:** Borehole problems, assay and ore reserve estimation. Laboratory records, Field report and viva voce.

#### **Text Book:**

1. Smith, K., 1992. Environmental Hazards. Routledge, London.
2. Valdiya, K. S. (1987) Environmental geology, Tata McGraw Hill, New Delhi

#### **Suggested reading:**

1. Bell, F.G., 1999. Geological Hazards, Routledge, London.
2. Bryant, E., 1985. Natural Hazards, Cambridge University Press.
3. Subramaniam, V., 2001. Textbook in Environmental Science, Narosa International

## **DISCIPLINE SPECIFIC ELECTIVE**

### **DSE I: FUEL GEOLOGY**

#### **Unit 1: Coal**

Definition and origin of coal; Classification of coal. Fundamentals of Coal Petrology - Introduction to lithotypes. Proximate and ultimate analysis

#### **Unit 2: Coal as a fuel**

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

#### **Unit 3: Petroleum**

Chemical composition and physical properties of crude petroleum. Origin of petroleum; Maturation of kerogen; Biogenic and Thermal effect

#### **Unit 4: Petroleum Reservoirs and Traps**

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

## **PRACTICALS**

1. Study of hand specimens of coal

2. Reserve estimation of coal
3. Section correlation and identification of hydrocarbon prospect
4. Panel and Fence diagrams

**Text Book:**

1. Chandra D. (2007). Chandra's Textbook on applied coal petrology. Jijnasa Publishing House.

**SUGGESTED READINGS:**

1. Shelly R.C. (2014). Elements of Petroleum geology: Third Edition, Academic Press
2. Bjorlykke, K. (1989). Sedimentology and petroleum geology. Springer-Verlag.
3. Bastia, R., & Radhakrishna, M. (2012). Basin evolution and petroleum prospectivity of the continental margins of India (Vol. 59). Newnes.

**DSE- 2 CLIMATE CHANGE AND DISASTER MANAGEMENT****Unit 1: Natural disasters and their management**

Drought, Flood, Cyclone, Tornado, Thunder storm; Earthquake, Land slide, Tsunami, Inundation of Coastlines

**Unit 2: Elements of Climatology**

Thermal Structure & Composition of Atmosphere; Elements of Climate and weather

**Unit 3: World Weather Circulation**

Jet stream and its influence on world weather; Air Mass, their classification and influence on world weather; Fronts (Front classification).

**Unit 4: Climate Change**

Glacial periods, sea-level rise, effects of sea level rise, Rise of carbon dioxide in the atmosphere, green house gases, green house effect and global warming, Desertification

**Practical:** Tutorials and Seminar

**Text Book:** Bell, F.G., 1999. Geological Hazards, Routledge, London.

**Suggested readings:**

1. Bryant, E., 1985. Natural Hazards, Cambridge University Press.
2. Smith, K., 1992. Environmental Hazards. Routledge, London

**DSE- 3 EARTH AND CLIMATE****Unit- 1: Climate system**

Forcing and Responses Components of the climate system, Climate forcing, Climate controlling factors, Climate system response, response rates and interactions within the climate system Feedbacks in climate system. Response of biosphere to Earth's climate; Climate Change: natural vs. anthropogenic effects; Humans and climate change; Future perspectives; Brief introduction to archives of climate change; Archive based climate change data from the Indian continent

**Unit - 2: Heat budget of Earth and Monsoons**

Incoming solar radiation, receipt and storage of heat; Heat transformation; Earth's heat budget. Interactions amongst various sources of earth's heat; Mechanism of monsoon; Factors associated with monsoonal intensity; Effects of monsoon

**Unit - 3: Atmosphere - Hydrosphere**

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

**Unit - 4: Glacial Periods**

Milankovitch cycles and variability in the climate; Glacial-interglacial stages; The Last Glacial

maximum (LGM); Pleistocene Glacial-Inter glacial cycles  
Younger Dryas; Marine isotope stages

**Practical**

1. Study of distribution of major climatic regimes of India on map
2. Distribution of major wind patterns on World map
3. Preparation of paleo geographic maps (distribution of land and sea) of India during specific geological time intervals

**Text Book:** Rudiman, W.F., 2001. Earth's climate: past and future. Edition 2, Freeman Publisher.

**Suggested readings:**

1. Rohli, R.V., and Vega, A.J., 2007. Climatology. Jones and Bartlett
2. Lutgens, F., Tarbuck, E., and Tasa, D., 2009. The Atmosphere: An Introduction to Meteorology. Pearson Publisher
3. Aguado, E., and Burt, J., 2009. Understanding weather

**DSE–4 Project/ EVOLUTION OF LIFE THROUGH TIME**

**Unit I: Origin of life**

Possible life sustaining sites in the solar system

Archaean life: Earth's oldest life, Transition from Archean to Proterozoic, the oxygen revolution and radiation of life

Precambrian macrofossils–The garden of Ediacara, The Snow Ball Earth Hypothesis

**Unit II: Life through ages**

Fossils and chemical remains of ancient life.

Geological Time Scale with emphasis on major bio events. Biogeochemical cycles

Abundance and diversity of microbes, extremeophiles

Microbes □ mineral interactions, microbial mats

**Unit III: Life in Paleozoic**

The Cambrian Explosion. Bio 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 IV: Life in Mesozoic and Cenozoic**

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

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

**PRACTICAL**

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

**SUGGESTED READINGS:**

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

**PROJECT WORK (6 Credits): Full marks 100****Preamble of Project Work**

Geology is essentially a field science and a part of the knowledge is gained from study of exposures in the field. The project work has been envisaged to give the students an actual feel of working condition in the field. He/she can have hands on experience in locating himself in the field, study different types of rocks, their texture, structure and interrelationship, find out attitudes of beds, differentiate various geological structures, stratigraphy etc. In the field, the student can acquaint himself with different exploration procedures including drilling and logging of cores. Visit to different opencast and underground mines can provide comprehensive account on occurrence of mineral deposits in nature, requisites of different mining conditions, mineral engineering and ore-dressing practices. The student can receive hands on experience in cutting edge technologies like XRD, Ion chromatography, FESEM-EDAX, XRF from visit to different technological laboratories. Finally, from visit to different mineral-based plants and industries the student can gain knowledge on various extraction processes.

In view of the above, the student can take up project work on any of the above aspects under the supervision of a teacher, in which the theoretical knowledge can be substantially augmented.

**Field study should be treated as the project work.**

Each year the students should go for field study commensurate with the theory subjects under the guidance of one or more teachers. They should map an area and study the petrographic and structural aspect of the rocks. Further they may visit mines, mineral/ rock based industries, engineering projects and areas of palaeontological importance.

**Generic Elective****GE-I: General geology and Mineralogy****Unit-1: General geology and geomorphology**

Scope and subdivisions of Geology; Origin, age and interior of the Earth; Earthquake and volcanoes. Weathering and erosion; Geological work of river, wind, glacier and underground water.

**Unit-2: Crystallography**

Crystalline and non-crystalline substances; Symmetry elements, parameters and indices; Classification of crystals into six systems. Symmetry elements and forms of normal classes of isometric, tetragonal and orthorhombic systems.

**Unit - 3: Mineralogy**

Minerals: definition and classification; Study of physical and chemical characters of rock forming minerals like quartz, feldspar, hypersthene, diopside, augite, hornblende, muscovite, biotite, garnet, olivine, sillimanite, kyanite, tourmaline, topaz, epidote, calcite, apatite, fluorite, talc, gypsum and corundum.

**Unit - 4: Optical Mineralogy**

Nature of light rays; Polarization, Double refraction, Isotropism, Anisotropism, Nicol prism, Petrological microscope; Behaviour of light in thin section; Birefringence; pleochroism, extinction angle and interference colours.

**Practical:** Identification of crystal models with respect to axis, symmetry and forms; Megascopic and microscopic identification of minerals mentioned in theory. Laboratory record and viva voce.

**Text Book:** Mukherjee, P. K., Text Book of Geology, World Press

**GE-II: Petrology and Historical geology****Unit-1: Igneous and metamorphic petrology**

Forms and texture of igneous rocks; Bowen's reaction series; Classification of igneous rocks; Magmatic differentiation; Petrography of granite, syenite, peridotite, anorthosite, gabbro, dolerite and basalt. Metamorphism: definition, agents, types. Petrography of schists, gneisses, marble, charnockite and khondalite.

**Unit - 2: Sedimentary Petrology**

Formation of sedimentary rocks; Texture, structure and classification of sedimentary rocks. Petrography of conglomerate, breccia, sandstone, shale and limestone.

**Unit - 3: Palaeontology**

Fossilisation and uses of fossils; Morphology and geologic history of trilobite, brachiopod, pelecypod, gastropod, cephalopod. Gondwana flora.

**Unit - 4: Stratigraphy**

Definition and scope of stratigraphy. Stratigraphic units and correlation. Physiographic division of Indian subcontinent. Stratigraphy of type areas of Archaeans, Cuddapah, Vindhyan, Triassic, Jurassic, Cretaceous and Gondwanas.

**Practical:** Megascopic and microscopic identification of igneous, sedimentary and metamorphic rocks as mentioned in theory. Morphological study of invertebrate and plant fossils mentioned in theory; drawing and labeling of fossils. Laboratory record and viva voce.

**Text Book:** Mukherjee, P. K. Text Book of Geology, World Press

**GE-III Structure and engineering geology****Unit-1: Structural Geology and geotectonics**

Strike and dip; Fold: geometry, classification, recognition and causes of folding; Fault: geometry,

classification and recognition. V's rule. Unconformity: definition, types, significance and classification. Elementary idea about foliation and lineation.

Orogeny and epeiorogeny; Plate tectonics, continental drift; Isostasy; mid oceanic ridge, geosynclines.

#### **Unit - 2: Groundwater**

Hydrologic cycle; vertical distribution of groundwater; porosity and permeability; types of aquifers; Darcy's law. Quality of groundwater and its use; groundwater provinces of India.

#### **Unit - 3: Engineering Geology**

Engineering properties of rocks; Geological and geotechnical studies of dam, reservoir and tunnel. Earthquake resistant structures.

#### **Unit - 4: Environmental Geology**

Renewable and non-renewable resources; Conservation of mineral resources; Impact of mining on environment; Management of solid wastes including mining wastes.

**Practical:** Interpretation of structure, stratigraphy and geologic history from maps; Drawing of sections; Completion of outcrops; Identification of building stones and their uses. Laboratory records and viva voce.

#### **Text Book:**

1. Mukherjee, P. K. ( 1997) Text Book of Geology, World Press, Kolkata
2. Sinha,R.K.andSharma,N.L(1980)Mineral Economics, Oxford and IBH, NewDelhi

### **GE-IV Applied geology**

#### **Unit - 1: Ore Genesis**

Ore mineral, gangue, tenor and grade; Processes of formation of mineral deposits: Magmatic, Hydrothermal, Mechanical and residual concentration, oxidation and supergene sulphide enrichment.

#### **Unit - 2: Prospecting**

Geological, geophysical and geochemical prospecting methods; Controls of ore localization; Metalogenic epoch and provinces; Ore reserve estimation.

#### **Unit - 3: Mining and Resource Evaluation**

Open cast and underground mining methods; sampling methods and ore reserve estimation; Origin, occurrence, distribution and uses of coal and petroleum.

#### **Unit - 4: Mineral Resource**

Mineralogy, mode of occurrence, distribution and uses of ores of Fe, Mn, Cr, Cu and Al.

Mineralogy, mode of occurrence, origin, Indian distribution and uses of Mica and Asbestos.

**Practical:** Mega scopic identification and uses of important metallic and non-metallic minerals mentioned in theory; Laboratory records and viva voce.

#### **Text Book:**

1. Sen,A.K.and Guha,P.K.(2006)A hand book of economic geology, Modern Book Agency, Kolkata
2. Sinha, R. K. and Sharma, N. L (1980) Mineral Economics, Oxford and IBH, New Delhi



**GEOLOGY -PASS**

Semester	Course	Course name
<b>I</b>	DSC-I DSC-I Practical	General geology and mineralogy
<b>II</b>	DSC-II DSC-II Practical	Petrology and historical ecology
<b>III</b>	DSC-III DSC-III Practical	Structure and engineering geology
<b>IV</b>	DSC-IV DSC-IV Practical	Applied geology
<b>V</b>	DSE-I DSE-I Practical	Fuel geology
<b>VI</b>	DSE-II DSE-II Practical	Climate change and disaster management

**DISCIPLINE SPECIFIC CORE**  
**DSC-I General geology and Mineralogy**

**Unit-1: General geology and geomorphology**

Scope and subdivisions of Geology; Origin, age and interior of the Earth; Earthquake and volcanoes. Weathering and erosion; Geological work of river, wind, glacier and underground water.

**Unit-2: Crystallography**

Crystalline and non-crystalline substances; Symmetry elements, parameters and indices; Classification of crystals into six systems. Symmetry elements and forms of normal classes of isometric, tetragonal and orthorhombic systems.

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Minerals: definition and classification; Study of physical and chemical characters of rock forming minerals like quartz, feldspar, hypersthene, diopside, augite, hornblende, muscovite, biotite, garnet, olivine, sillimanite, kyanite, tourmaline, topaz, epidote, calcite, apatite, fluorite, talc, gypsum and corundum.

**Unit - 4: Optical Mineralogy**

Nature of light rays; Polarization, Double refraction, Isotropism, Anisotropism, Nicol prism, Petrological microscope; Behaviour of light in thin section; Birefringence; pleochroism, extinction angle and interference colours.

**Practical:** Identification of crystal models with respect to axis, symmetry and forms; Megascopic and microscopical identification of minerals mentioned in theory. Laboratory record and viva voce.

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**DSC-II Petrology and Historical ecology**

**Unit-1: Igneous and metamorphic petrology**

Forms and texture of igneous rocks; Bowen's reaction series; Classification of igneous rocks; Magmatic differentiation; Petrography of granite, syenite, peridotite, anorthosite, gabbro, dolerite and basalt. Metamorphism: definition, agents, types. Petrography of schists, gneisses, marble, charnockite and khondalite.

**Unit - 2: Sedimentary Petrology**

Formation of sedimentary rocks; Texture, structure and classification of sedimentary rocks. Petrography of conglomerate, breccia, sandstone, shale and limestone.

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Definition and scope of stratigraphy. Stratigraphic units and correlation. Physiographic division of Indian subcontinent. Stratigraphy of type areas of Archaeans, Cuddapah, Vindhyan, Triassic, Jurassic, Cretaceous and Gondwanas.

**Practical:** Megascopic and microscopical identification of igneous, sedimentary and metamorphic rocks as mentioned in theory. Morphological study of invertebrate and plant fossils mentioned in theory; drawing and labeling of fossils. Laboratory record and viva voce.

**Text Book:** Mukherjee, P. K. ( ) Text Book of Geology, World Press

### **DSC-III Structure and engineering geology**

#### **Unit-1: Structural Geology and geotectonics**

Strike and dip; Fold: geometry, classification, recognition and causes of folding; Fault: geometry, classification and recognition. V's rule. Unconformity: definition, types, significance and classification. Elementary idea about foliation and lineation.

Orogeny and epeirogeny; Plate tectonics, continental drift; Isostasy; mid oceanic ridge, geosynclines.

#### **Unit - 2: Groundwater**

Hydrologic cycle; vertical distribution of groundwater; porosity and permeability; types of aquifers; Darcy's law. Quality of groundwater and its use; groundwater provinces of India.

#### **Unit - 3: Engineering Geology**

Engineering properties of rocks; Geological and geotechnical studies of dam, reservoir and tunnel. Earthquake resistant structures.

#### **Unit - 4: Environmental Geology**

Renewable and non-renewable resources; Conservation of mineral resources; Impact of mining on environment; Management of solid wastes including mining wastes.

**Practical:** Interpretation of structure, stratigraphy and geologic history from maps; Drawing of sections; Completion of outcrops; Identification of building stones and their uses. Laboratory records and vivavoce.

#### **Text Book:**

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2. Sinha,R.K. and Sharma,N.L.(1980)Mineral Economics, Oxford and IBH, NewDelhi

### **DSC-IV Applied geology**

#### **Unit - 1: Ore Genesis**

Ore mineral, gangue, tenor and grade; Processes of formation of mineral deposits: Magmatic, Hydrothermal, Mechanical and residual concentration, oxidation and supergene sulphide enrichment.

#### **Unit - 2: Prospecting**

Geological, geophysical and geochemical prospecting methods; Controls of ore localization; Metalogenic epoch and provinces; Ore reserve estimation.

#### **Unit - 3: Mining and Resource Evaluation**

Open cast and underground mining methods; sampling methods and ore reserve estimation; Origin, occurrence, distribution and uses of coal and petroleum.

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Mineralogy, mode of occurrence, distribution and uses of ores of Fe,Mn,Cr,Cuand Aloses. Mineralogy, mode of occurrence, origin, Indian distribution and uses of Mica and Asbestos.

**Practical:** Mega scopic identification and uses of important metallic and non-metallic minerals mentioned in theory; Laboratory records and viva voice.

#### **Text Book:**

1. Sen,A.K.andGuha,P.K.(2006)A hand book of economic geology, Modern Book Agency, Kolkata
2. Sinha, R. K. and Sharma, N. L (1980) Mineral Economics, Oxford and IBH, New Delhi

## DISCIPLINE SPECIFIC ELECTIVE

### DSE – I: FUEL GEOLOGY

#### **Unit 1: Coal**

Definition and origin of coal; Classification of coal. Fundamentals of Coal Petrology - Introduction to lithotypes. Proximate and ultimate analysis

#### **Unit 2: Coal as a fuel**

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

#### **Unit 3: Petroleum**

Chemical composition and physical properties of crude petroleum. Origin of petroleum; Maturation of kerogen; Biogenic and Thermal effect

#### **Unit 4: Petroleum Reservoirs and Traps**

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

#### **PRACTICALS**

1. Study of hand specimens of coal
2. Reserve estimation of coal
3. Section correlation and identification of hydrocarbon prospect
4. Panel and Fence diagrams

**Text Book:** Chandra D. (2007). Chandra's Textbook on applied coal petrology. Jijnasa Publishing House.

#### **SUGGESTED READINGS:**

1. ShellyR.C.(2014).Elements of Petrol eumgeology: Third Edition, Academic Press
2. Bjorlykke,K.(1989). Sedimentology and petroleum geology. Springer-Verlag.
3. Bastia, R.,& Radhakrishna, M.(2012).Basin evolution and petroleum prospectivity of the continental margins of India (Vol. 59).Newnes.

**DSE-II: CLIMATE CHANGE AND DISASTER MANAGEMENT****Unit 1: Natural disasters and their management**

Drought, Flood, Cyclone, Tornado, Thunder storm; Earthquake, Land slide, Tsunami, Inundation of Coastlines

**Unit 2: Elements of Climatology**

Thermal Structure & Composition of Atmosphere; Elements of Climate and weather

**Unit 3: World Weather Circulation**

Jet stream and its influence on world weather; Air Mass, their classification and influence on world weather; Fronts (Front classification).

**Unit 4: Climate Change**

Glacial periods, sea-level rise, effects of sea level rise, Rise of carbon dioxide in the atmosphere, green house gases, green house effect and global warming, Desertification

**Practical:** Tutorials and Seminar

**Text Book:** Bell, F.G., 1999. Geological Hazards, Rout ledge, London.

**Suggested readings:**

1. Bryant, E., 1985. Natural Hazards, Cambridge University Press.
2. Smith, K., 1992. Environmental Hazards. Routledge, London

**SKILL ENHANCEMENT COURSE****SEC-1 Basics of Computer**

**UNIT-1:Introduction:** Introduction to computer system, uses, types. Data Representation: Number systems and character representation, binary arithmetic. Human Computer Interface: Types of software, Operating system as user interface, utility programs.

**UNIT-2:Devices: Input and output devices (with connections and practical demo), keyboard, mouse, joystick, scanner, OCR, OMR, bar code reader, web camera, monitor, printer, plotter.** Memory: Primary, secondary, auxiliary memory, RAM, ROM, cache memory, hard disks, optical disks

**UNIT-3:Computer Organisation and Architecture: C.P.U., registers, system bus, main memory unit, cache memory, Inside a computer, SMPS, Motherboard, Ports and Interfaces, expansion cards, ribbon cables, memory chips, processors.**

**Reference Books:**

1. Goel, Computer Fundamentals, Pearson Education, 2010.
2. P. Aksoy, L. DeNardis, Introduction to Information Technology, Cengage Learning, 2006
3. P. K.Sinha, P. Sinha, Fundamentals of Computers, BPB Publishers, 2007.

**SEC - II FIELD GEOLOGY - 1**

(Basic field raining)

**Unit I:** Orientation of Topographic sheet in field, marking location in toposheet, Bearing (Front and back). Concepts of map reading

**Unit II:** Identification of rock types in field; structures and texture of rocks, use of hand lens

**Unit III:** Basic field measurement techniques: Bedding dip and strike. Reading contours and topography.

**SEC III FIELD GEOLOGY –2**

(Geological Mapping)

**Unit I:** Geological mapping, stratigraphic correlation

**Unit II:** Primary (scalars and vectors) and secondary structures (linear and planar)

**Unit III:** Trend, plunge, Rake/Pitch, Stereo plots of linear and planar structure

**SEC-IV FIELD GEOLOGY-3**

(Economic Geology field)

**Unit I:** Visit to any mineral deposit or Mines

**Unit II:** Mode occurrence of ore, Ore mineralogy

**Unit III:** Mining Methods, Ore formation process

**SEC-V Renewable energy and Energy harvesting**

Unit-1: Fossil fuels and Alternate Sources of energy: Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity.

**Unit – 2: Solar energy:** Solar energy, its importance, storage of solar energy, solar pond, non plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.

**Unit-3: Wind and Geothermal energy:** Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid

interconnection topologies. Geothermal Resources, Geothermal Technologies.

**Unit-4: Ocean and hydro energy:** Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass. Hydropower resources, hydropower technologies, environmental impact of hydro power sources.

#### **SEC-VI Groundwater management:**

##### **Unit - 1: Concept of Groundwater**

Hydrological cycle, vertical zonation of ground water, Properties of water bearing formations - porosity, permeability, specific yield, specific retention, storativity.

##### **Unit - 2: Aquifer characteristics**

Aquifer types- Confined and unconfined aquifers, aquitard, aquiclude, aquifuse. Darcy's law.

##### **Unit - 3: Quality of Groundwater**

Physical and Chemical Quality of ground water and its use in domestic, agriculture and industries; Ground water pollution.

##### **Unit - 4: Groundwater exploration and harvesting**

Ground Water exploration - types of wells, Sea-water intrusion, Groundwater hazard due to Arsenic and Fluoride and their mitigation Groundwater basin, Water table fluctuation, Artificial recharge of groundwater, Rainwater Harvesting

#### **SEC-VII Disaster management:**

##### **Unit-1 Understanding disaster**

Concept and definitions of different terms of disaster, classification of disasters- natural, manmade; difference between disaster and hazard- atmospheric and geo- hazards, Disaster risk, Vulnerability

**Unit-2** General characteristics and problem areas of different atmospheric hazards: Flood, cyclone, drought, heat wave, lightning. Earthquake, Tsunami, volcanoes, Landslide

##### **Unit-3 Concepts of disaster management**

Pre disaster, post disaster management, real time management, Warning system, Public Communication system, Relief operation, rescue operation

##### **Unit-4 Disaster risk mitigation**

Hazard mapping and forecasting. Preparedness for damage mitigation and coping with disasters. Evacuation strategy, Capacity building for disaster/damage mitigation

#### **Reference Books**

- Bureau's Higher Secondary Geology (Part – I) (2009) The Odisha State Bureau of Textbook Preparation and Production, Pustak Bhawan, Bhubaneswar
- Bureau's Higher Secondary Geology (Part – II) (2011) The Odisha State Bureau of Textbook Preparation and Production, Pustak Bhawan, Bhubaneswar
- A. Das gupta (2005) An introduction to Palaeontology, World Press, Kolkata
- A. Das gupta (2006) An introduction to Earth Science, World Press, Kolkata
- A. Holmes - Principles of Physical Geology
- A. K. Jain (2014) An introduction to structural geology, Geological Society of India, Bangalore
- A. K. Roy (2009) Introduction to Geological maps and structures, World Press, Kolkata
- A. K. Sen and P. K. Guha (2006) A Hand Book of Economic Geology, Modern Book Agency, Kolkata
- A. M. Bateman & Jansen - Economic Mineral Deposit
- A. M. Evans (1993) Ore geology and industrial minerals, A.K. Sen - Laboratory Manual of Geology
- B. Mason and C.B. Moore (1982) Principles of Geochemistry, Wiley Eastern, New Delhi
- B. S. Sathya Narayan Swami (1985) Engineering Geology Laboratory Manual, Urasia Publ. House,

New Delhi

Berry and Mason - Mineralogy

Bhaskar Rao - Metamorphic Petrology

Brain Mason - Geochemistry

C. S. Hurlbut and C. Klein (1977) Manual of Mineralogy, John Wiley & Sons, New York.

C. W. Fetter (2007) Applied Hydro geology, CBS Pub. & Dist., New Delhi

D. Chandra and R. M. Singh (2003) Petroleum – Indian Context, Tara Book Agency, Varanasi

D. Chandra, R. M. Singh and M. P. Singh (2000) Text Book of Coal – Indian Context, Tara Book Agency, Varanasi

D. G. A. Whitten and J. R. V. Brooks (1972) Penguin Books Ltd., London

D. K. Banerjee (1992) Mineral resources of India, World Press, Kolkata

D. K. Todd (1980) Groundwater hydrology; John Wiley & Sons, New York

D. M. Raup and S. M. Stanley (2004) Principles of palaeontology, CBS Pub. & Dist., New Delhi

D. R. Prothero and F. Schwab (1999) Sedimentary Geology, W. H. Freeman & Co., New York

Dobrin - Geophysical Prospecting

E. Flint (1964) Essentials of Crystallography, Mir Publ., Moscow

E. N. K. Clarkson (1998) Invertebrate palaeontology and evolution, Wiley India

E. S. Dana and W. E. Ford (1977) A text book of mineralogy, Asia Publ. House, Kolkata  
Keller – Environmental Geology

F. H. Lahee (1987) Field Geology, CBS Pub. & Dist., New Delhi

F. J. Pettijohn (1984) Sedimentary rocks, CBS Pub. & Dist., New Delhi

F. J. Turner and J. Verhoogen (1987) Igneous and Metamorphic petrology, CBS Pub. & Dist.,  
New Delhi

G. Nichols (2001) Sedimentology and Stratigraphy, Blackwell Science, London

G. W. Tyrrel (1980) Principles of Petrology, B.I. Publication, New Delhi

G. B. Mohapatra (2010) Text book of Geology; CBS Pub. & Dist., New Delhi

G. B. Mohapatra (2010) Textbook of Physical Geology; CBS Pub. & Dist., New Delhi  
Geology and Mineral Resources of Odisha (2006), SGAT, Bhubaneswar

H. H. Read (1984) Rutley's Element of Mineralogy, CBS Pub. & Dist., New Delhi

H. M. Raghunath (1987) Ground Water, New Age International, New Delhi

H. Williams, F. C. Turner and C. M. Gilbert (1985) Petrography – An introduction to the study of  
rocks in thin section, CBS Pub. & Dist., New Delhi

H. Woods (1985) Invertebrate Palaeontology, CBS Pub. & Dist., New Delhi

J. A. Steers (1979) The Unstable Earth, Kalyani Publisher, New Delhi

J. D. Collinson and D. B. Thompson (1994) Sedimentary structures, CBS Pub. & Dist., New Delhi

K. M. Bangar (2013) Principles of Engineering Geology, Standard Publ. & Dist., Delhi

K. S. Valdiya (1987) Environmental Geology, Tata McGraw Hill, New Delhi

K. V. G. K. Gokhale and T. C. Rao (1973) Ore deposits of India, Thomson Press, Delhi  
Krynire & Judd - Principles of Engineering Geology

L. R. A. Narayan (1999) Remote sensing and its application, University Publ., Hyderabad  
Levorsen – Petroleum Geology

M. C. Dash and P. C. Mishra (2001) Man and Environment, MacMillan, Kolkata

M. G. Best (1986) Igneous and metamorphic petrology, CBS Pub. & Dist., New Delhi

M. K. Bose (2010) Igneous petrology, World Press, Kolkata

M. P. Billings ( ) Structural Geology

M. P. Billings (1972) Structural Geology, Prantice-Hall of India, New Delhi

M. Ramakrishnan and R. Vaidyanadhan (2008) Geology of India (Vol. I & II), Geological Society  
of India, Bangalore

M. S. Krishnan (1982) Geology of India and Berma, CBS Pub. & Dist., New Delhi

N. K. N. Aiyengar and K. N. Prasad (1996) An introduction to Invertebrate paleontology, Vikas Publ.  
House, New Delhi

N. W. Gokhale (1994), Manual of Geological Maps, CBS Pub. & Dist., New Delhi

N. W. Gokhale (1996) Exercises on Geological maps and dip-strike problems, CBS Pub. & Dist., New Delhi

N. W. Gokhale (2000) A manual of problems in structural geology, CBS Pub. & Dist., New Delhi

N. W. Gokhale (2001) A guide to field geology, CBS Pub. & Dist., New Delhi



- P. C. Jain and M. S. Anantharaman (2005) Palaeontology; Vishal Pub. Co., Jalandhar
- P. F. Kerr (1964) Optical mineralogy, Tata McGraw Hill, New Delhi
- P. J. R. Reddy (2013) A text book of Hydrology, University Science Press, New Delhi
- P.K. Mukherjee (1997) A Text Book of Geology, World Press, Kolkata
- R. C. Moore, C. G. Iallicker and A. G. Fischer ( 2004) Invertebrate fossils, CBS Pub. & Dist., New Delhi
- R. K. Sinha and N. L. Sharma (1980) Mineral Economics, Oxford & IBH, New Delhi
- R. Lindholm (1987) A Practical Approach to Sedimentology, Allen and Unwin, London
- R.N.Hota(2017)Practicalapproachtocrystallographyandmineralogy;CBSPub.&Dist.,New Delhi
- R. N. Hota (2017) Practical approach to petrology; CBS Pub. & Dist., New Delhi
- R. N. P. Arogyaswami (1980) Courses in mining geology, Oxford and IBH, New Delhi
- R. R. Shrock and W. H. Twenhofel (1953) CBS Pub. & Dist., New Delhi
- R. S. Sharma and A. Sharma (2014) Crystallography and Mineralogy, Geological Society of India, Bangalore
- Ravindra Kumar (1986) Fundamentals of Historical Geology & Stratigraphy of India, Wiley Eastern, New Delhi
- S. Deb(1980)IndustrialmineralsandrocksofIndia,AlliedPubl.,Mumbai
- S. K. Donovan (1992) The process of Fossilization, CBS Pub. & Dist., New Delhi
- S. K. Shah (2013) Elements of Palaeontology, Geological Society of India, Bangalore
- S. K. Tiwari ( 2004) Stratigraphy, Micropalaeontology and Palaeobotany, Kalyani Publ., New Delhi
- S. Krishnaswami (1972) India's Mineral resources, Oxford and IBH, New Delhi
- S. M. Mathur (2001) Guide to field geology, Prantice-Hall of India, New Delhi
- S. M. Naqvi (2005) Geology and evolution of the Indian plate, Capital Publ. Co. New Delhi
- S. N. Pandey (1987) Principles and applications of photogeology, Wiley Eastern, New Delhi
- S. Ray - Text Book of Geology
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- Sharma and Ram - Introduction to India's Economic Minerals
- Shephard - Submarine Geology
- U. Prasad (2000) Economic Geology, CBS Pub. & Dist., New Delhi
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- W. A. Deer, R. A. Howie and J. Zuzman (1979) An introduction to the rock forming minerals, ELBS and Longman
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- W. G. Morrison (2004) A dictionary of Geology, CBS Pub. & Dist., New Delhi
- W. R. Phillips and D. T. Griffen (2004) Optical Mineralogy – The non-opaque minerals, CBS Pub. & Dist., New Delhi
- Winchell - Optical Mineralogy

**Laboratory Instruments / Mineral and Rock specimens**

1. Petrological microscope @ 01 for each 02 students
2. Geomorphic models of River, wind, glacier, underground water and ocean
3. Megascopic minerals and slides of minerals: agate, amphibole, anatase, andalusite, anhydrite, apatite, aragonite, augite, barite, beryl, biotite, calcite, chlorite, corundum, diamond, diopside, dolomite, enstatite, epidote, fluorite, garnet, gypsum, halite, hornblende, hypersthene, kyanite, magnesite, microcline, monazite, muscovite, olivine, orthoclase, plagioclase, quartz, rutile, sanidine, serpentine, sillimanite, sphene, staurolite, talc, topaz, topaz, tourmaline, and zircon.
4. Aerial photographs, stereoscopes and imageries
5. Forms present in  $4/m\bar{3}2/m$ ,  $\bar{4}3m$ ,  $2/m\bar{3}$ ,  $4/m2/m2/m$ ,  $6/m2/m2/m$ ,  $\bar{3}2/m$ ,  $2/m2/m2/m$ ,  $2/m$  and  $\bar{1}$  classes and combinations there of.
6. Megascopic rocks and slides of Basalt, Dolerite, Gabbro, Granite, Pegmatite, Syenite, Dunite, Diorite, Peridotite, Carbonatite, Anorthosite and Kimberlite, sandstones, conglomerate, shale, limestone and breccias, schists, gneisses, marble, quartzite, slate, phyllites, khondalite and charnockite, eclogites,
7. Fossils of class / phyla of Trilobita, Brachiopoda, Pelecypada, Cephalopoda, Gastropoda, Echinoidea, Coral and Graptolite, Siwalik fauna, plant fossils
8. Megascopic specimens of ores of Fe, Mn, Al, Cr, Cu, Pb and Zn ores.
9. Megascopic specimens of Mica, Asbestos, Kyanite, Sillimanite, Graphite, Baryte, Serpentinite and Magnesite and Limestone.

**Geology – Teacher training- 21 days**

1. Neotectonics; Glaciation and its causes; Sea-level change during Quaternary
2. Digital Image Processing, Image errors, Rectification and restoration, Image Enhancement, Filtering, Image Rationing, Image classification and accuracy assessment.
3. Hermann-Mauguin symbol
4. Preparation of thin section of minerals and rocks.
5. Conservation of mass, isotopic and elemental fractionation. Concept of radiogenic isotopes in geochronology and isotopic tracers. Chromatography
6. Palaeocurrent and Provenance
7. ACF and AKF diagrams
8. Mesozoic reptiles with special reference to origin diversity and extinction of dinosaurs; Siwalik fauna. Separation of spores and pollens and mounting for study.
9. Concepts of Stratotypes. Global Stratotype Section and Point (GSSP). Lithostratigraphy, biostratigraphy, chronostratigraphy, seismic stratigraphy, chemostratigraphy, Magnetostratigraphy, Sequence stratigraphy
10. Coal Bed Methane (CBM): global and Indian scenario; Underground coal gasification; Coal liquefaction, Maturation of kerogen
  
11. Thermal Structure & Composition of Atmosphere; Elements of Climate and weather
12. Jet stream and its influence on world weather; Air Mass, their classification and influence on world weather; Fronts (Front classification).
13. Forcing and Responses Components of the climate system, Climate forcing, Climate controlling factors, Climate system response, response rates and interactions within the climate system Feedbacks in climate system. Response of biosphere to Earth's climate; Climate Change: natural vs. anthropogenic effects.
14. Heat transformation; Earth's heat budget. Interactions amongst various sources of earth's heat; Mechanism of monsoon; Factors associated with monsoonal intensity.
15. Layering of atmosphere and atmospheric Circulation; Atmosphere and ocean interaction and its effect on climate; Heat transfer in ocean; Global oceanic conveyor belt and its control on earth's climate; Surface and deep circulation.
16. Milankovitch cycles and variability in the climate; Glacial-interglacial stages; The Last Glacial maximum (LGM); Pleistocene Glacial-Interglacial cycles, Younger Dryas; Marine isotope stages.  
 Possible life sustaining sites in the solar system, Archaean life: Earth's oldest life, Transition from Archean to Proterozoic, the oxygen revolution and radiation of life  
 Precambrian macrofossils – The garden of Ediacara,  
 The Snow Ball Earth Hypothesis  
 The Cambrian Explosion. Biomineralization and skeletalization  
 Origin of vertebrates and radiation of fishes  
 Origin of tetrapods - Life out of water  
 Early land plants and impact of land vegetation  
 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  
 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.
17. Developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity.
18. Solar energy, its importance, storage of solar energy, solar pond, non plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.
19. Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies. Geothermal Resources, Geothermal Technologies.

20. Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass. Hydropower resources, hydropower technologies, environmental impact of hydro power sources.
21. Artificial recharge of groundwater, Rainwater Harvesting.
22. Ecosystem- Structure and function of ecosystem (Abiotic and Biotic factors); Energy flow in an ecosystem. Environmental Problems: global warming and Climate change, ozone layer depletion. Deforestation, acid rain; impacts of environmental disturbances.
23. Energy resources: Renewable and non-renewable energy sources. Biodiversity patterns and global biodiversity hot spots, India as a mega-biodiversity nation; Endangered and endemic species of India, Threats to biodiversity, Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.
24. Environmental pollution: Air, water, soil and noise pollution, Nuclear hazards and human health risks, Solid waste management: Control measures of urban and industrial waste.
25. Environment Protection Act and International agreements: Montreal and Kyoto protocols and Convention on Biological Diversity (CBD).