

# Qualifying Examination Syllabus (B.Sc.) For M. Sc. Geology Entrance Examination (SPPU)

## Unit 1

### Mineralogy

#### Introduction:

Definition, branches and scope of mineralogy.  
Importance and conservation of minerals.

#### Formation of minerals:

Introduction and description of geological processes of mineral formation;

- a. Crystallization from melt.
- b. Crystallization from Solution. ( Evaporation and precipitation)
- c. Crystallization from Vapour. ( Sublimation)
- d. Metamorphic processes.
- e. Alteration and related weathering. (oxidation and supergene enrichment)

#### Utility of Minerals in Industries:

Ceramic, Refractory, Pharmaceutical, Paint, Glass, Cement, Fertilizer, Oil Industry, Electrical and Electronics.

#### Crystallography

- a. Definition and conditions conducive for the formation of crystals.
- b. Crystal morphology – faces, forms, edges, solid angles, interfacial angle and its measurement by contact Goniometer, law of constancy of interfacial angle.
- c. Symmetry of crystals – Plane, axis and center of symmetry, crystallographic and geometrical symmetry. Crystallographic axes, lettering and order of crystallographic axes, parameters, axial ratio, indices, parameter system of Weiss, index system of Miller, Law of rational indices.
- d. Study of following crystallographic systems with respect to their elements of symmetry, crystallographic axes and their forms with indices.
  - i. Orthorhombic (Type: Barytes)
  - ii. Tetragonal (Type: Zircon)
  - iii. Cubic (Type: Galena)
  - iv. Hexagonal (Type: Beryl)
  - v. Monoclinic (Type: Gypsum)
  - vi. Triclinic (Type: Axinite)

#### CRYSTALLOGRAPHY:

- A) Definition of a Crystal, External and Internal Imperfections in Crystals, Growth of crystals in Cavities, Etch figures and Solution Pits.
- B) Study of Holohedral, Hemihedral and Hemimorphic forms of crystals with suitable examples
  - I) Study of Cubic system (Type- Pyrite and Type Tetrahedrite) Comparative study of three types of Cubic system.
  - ii) Study of Hexagonal system (Type- Calcite, Type- Quartz, & Type- Tourmaline), Comparative study of four Types of Hexagonal system.
- D) Twinning in crystals: Definition, Causes terms related to Twinning, Types of Twins and Laws of Twinning in the different crystal systems.

## Physical properties of minerals

- a. Colour, streak, lustre, cleavage, fracture, hardness, form, magnetism, electrical property, radioactivity, specific gravity & luminescence. (Phosphorescence and Fluorescence)
- b. Methods of determining specific gravity – Chemical balance, Walker's steelyard, Jolly's spring balance, pycnometer, heavy liquids.

## Optical mineralogy

- a. Nature of light – ordinary and plane polarized light.
- b. Double refraction of light. (with the help of calcite crystal)
- c. Nicol's prism and polaroids.
- d. Petrological microscope.
- e. Introduction to optical properties:–
  - In plane polarized light: Colour, form, cleavage, cracks, relief, twinkling, pleochroism.
  - In between Crossed Nicols:

Isotropism, anisotropism, extinction positions (straight, oblique and symmetrical), extinction angle, interference colours, twinning, cross hatching.

## Optics

- i) Isotropism and Anisotropism in minerals
- ii) Phenomenon of Extinction, Extinction Position in minerals of different Crystal System with respect to Vibration Direction and Optic Orientation.
- iii) Phenomenon of Interference Colours and Newton's Scale of Interference Colours.
- iv) Twinning (simple, multiple, cross hatching) & Zoning in Minerals

## Gemstones

- i) Introduction (Three basic attributes of Gemstones, Beauty, Durability and Rarity)
- ii) Scope and Importance
- iii) Study of the following gemstones with respect to their Physical Properties (Crystal System, Hardness and Sp Gravity), Optical Properties (Colour, Luster, Singly Refracting / Doubly Refracting and Refractive Index) and Indian geographical occurrences.

- a) Diamond
- b) Corundum (Ruby, Sapphire)
- c) Beryl (Aquamarine, Emerald)
- d) Silica (Rock crystal, Amethyst, Citrine, Tiger's eye, Opal)
- e) Tourmaline
- f) Topaz
- g) Garnet (Almandine)

## Crystal Chemistry

- A. Atoms and Ions.
- B. Bonding forces in crystals:- Ionic, Covalent, Vander Waal's and Metallic bond, crystals with more than one type of bonds.
- C. Major element constituents of minerals.
- D. Geochemical affinity & geochemical classification of elements.
- E. Geometrical and electrical stability of minerals. (concept of relative size of ions, radius ratio, co-ordination number & ionic substitution)

E. Isomorphism, polymorphism, pseudomorphism.

G. Silicate structures

## **DESCRIPTIVE MINERALOGY**

### **Mineral Kingdom:**

A. Crystalline and Non-Crystalline minerals.

B. Classification of minerals based on Chemical Composition and Silicate Structure.

C. Study of the following mineral groups with respect to Silicate Structure, Chemical Composition, Physical and Optical properties and Paragenesis.

i. Olivine (Olivine)

ii. Pyroxene (Augite + Hypersthene)

iii. Amphibole (Hornblende + Actinolite)

iv. Mica (Muscovite, Biotite)

v. Feldspar (Orthoclase, Microcline, Plagioclase)

vi. Silica (Quartz) vii. Felspathoid. (Sanidine, Leucite, Hauyene-Nosean)

### **Mineral Optics:**

Refractive index & methods of comparing R.I of minerals: Becke line, shadow method & immersion method

a) Relief of minerals

b) Uniaxial & biaxial minerals, indicatrices

c) Vibration direction & optic orientation

d) Pleochroism & absorption

e) Accessory plates: Quartz wedge, Mica plate & Gypsum plate

f) Compensation & Determination of interference colours

g) Sign of minerals

h) Sign of elongation of uniaxial minerals where C axis is known

### **Mineral Chemistry:**

a) Isomorphism

b) Polymorphism

c) Pseudomorphism

### **Descriptive Mineralogy-I**

**Study of the following mineral groups (silicates) with reference to their silicate structure, chemical & optical characters, paragenesis & alteration products**

a) Olivine group

b) Garnet group

c) Aluminosilicates: Sillimanite, Kyanite & Andalusite

d) Pyroxene group

e) Amphibole group

f) Mica group

### **Descriptive Mineralogy-II**

**Study of the following mineral groups (silicates) with reference to their silicate structure, chemical & optical characters, paragenesis & alteration products**

a) Chlorite group

b) Clay group

c) Felspar group

d) Zeolite group

**Study of following non metallic mineral deposits with reference to their mineralogy, properties, occurrences & uses**

Refractory minerals : Fire clay, Kyanite, Chromite, Graphite, Magnesite, Dolomite

- a) Precious & Semiprecious stones

**Descriptive Mineralogy-III**

**Study of following non-silicates with reference to their crystal structure, chemical composition, physical properties & uses**

- a) Oxides & Hydroxide : Corundum, Hematite, Ilmenite, Rutile & Limonite
- b) Sulphides : Pyrite, Sphalerite, Galena
- c) Sulphates : Gypsum & Baryte
- d) Carbonates : Calcite, Aragonite, Rhodochrosite, Siderite
- e) Phosphates : Apatite & Monazite
- i) Halides : Fluorite & Halite is known

**Mineral forming processes -I**

A) Introduction: a) Definition of ore minerals, gangue, tenor, overburden, country rock, syngenetic & epigenetic deposits. b) Classification of economically important metalliferous & non metalliferous mineral deposits.

Magmatic Concentration:

- a) Early magmatic deposits
- b) Late magmatic deposits

C) Hydrothermal processes:

- a) Principles of hydrothermal processes, characters of solutions, types of openings in rocks, factors affecting deposition from hydrothermal solution, wall rock alterations.
- b) Types of hydrothermal deposits 1. Cavity filling deposits:
  - Processes & characteristic features
  - Types of cavity filling deposits: Fissure veins & its types (in brief), stock work, saddle reefs, ladder veins, pitches and flats, breccias filling deposits, solution cavity fillings, pore space fillings & vesicular fillings. Metasomatic replacement: Definition, Criteria of replacement & resulting mineral deposits

Oxidation & Supergene enrichment:

- a. Oxidation & solution in the zone of oxidation
- b. Gossans & Cappings, the role of iron in gossans, indigenous & transported limonite, false gossans & gossans as guides to the hidden deposits.
- c. Ore deposition in the zone of oxidation & their method of precipitation
- d. Supergene Sulphide Enrichment:
  - 1. Requirements for supergene enrichment
  - 2. Factors influencing supergene enrichment
  - 3. Recognition of supergene enrichment

**Mineral forming processes -II**

A) Evaporation, Residual concentration & Mechanical concentration: a. Evaporation:

- 1. Process of mineral formation by evaporation
- 2. Evaporation deposits: Brief account of deposits of oceanic water, lake water, ground water & hot springs
- b. Residual concentration (residual deposits):
  - 1. Conditions favouring of residual deposits

2. Brief account of residual deposits: Bauxite, clay & iron formation
- c. Mechanical concentration (placer deposits):
  1. Principles involved in the process of mechanical concentration
  2. Study of placer deposits: Eluvial, Alluvial, Beach & Aeolia
- B) Study of following metallic deposits with reference to mineralogy, properties, uses & their geological & geographical distribution
  - a. Precious metals: Gold, Silver.
  - b. Non-ferrous metals: Copper, Lead, Zinc & Aluminium
  - c. Iron & Ferro alloy metals – Iron, Manganese, Nickel & Chromium
- C) Study of following non-metallic deposits with reference to mineralogy, properties, uses & their geological & geographical distribution
 

Muscovite, Gypsum, Baryte, Calcite/Dolomite, Asbestos, Fluorsopar, Wollastonite, Kyanite, Coal.
- D) Radioactive minerals:**
  - a. Study of Uranium & Thorium deposits of India with reference to mineralogy, mode of occurrence, properties, uses & their geological & geographical distribution
- E) Introduction to Geophysical and Geochemical methods for mineral exploration F) Environmental and social issues related to mineral resource extraction
- Study of Ocean floor
  - A) Physiographic divisions of oceans (the Continental Shelf, the Continental Slope, the Deep Sea Plain & the Oceanic Deeps)
  - B) Ocean floor rocks - Ultramafic rocks, Gabbroic rocks & Basalts Marine sediments.
  - C) Origin, structure and evolution of Indian Ocean shelf and margins (estuaries, deltas, tidal flats)
  - D) Applications of Geophysical Techniques for Exploration of the Sea Floor (Introduction, Explosion seismology, Reflections: echosounding and seismic-profiling)

## Petrology

### Definition and major divisions

- a. Definition of petrology, lithology, petrography, petrogenesis.
- b. Major divisions and diagnostic characteristic of rocks : igneous, Sedimentary and metamorphic.
- c. Rock cycle.

### Igneous Petrology

#### Magma

- a. Magma and its composition.
- b. Formation of crystals and glass.

#### Forms of Igneous bodies

- a. Intrusive: Concordant and discordant intrusions
  1. Concordant: sill, laccolith, lopolith.
  2. Discordant: dyke and veins, batholith.
- b. Extrusive: lava flows

#### Textures and Structures

- a. Textures: Definition and factors controlling textures: Equigranular (granitic), Inequigranular (porphyritic), glassy
- b. Structures: Vesicular, amygdaloidal, blocky, pillow, flow and columnar.

### Classification of Igneous Rocks

Basis of Classification: Depth of formation, silica percentage, Type of feldspar content and colour index. Tabular classification.

## **IGNEOUS PETROLOGY:**

Physico-chemical constitution of Magma.

- a) Temperature
- b) Pressure
- c) Viscosity
- d) Volatiles

### **Crystallization of Magma.**

- a) i) Unicomponent Magma ii) Factors controlling grain size of igneous rocks
- b) Bicomponent Magma i) Eutectic crystallization ii) Solid solutions (Plagioclase series)

Textures and Microstructures:

- a) Definition, factors determining the texture of rocks
- b) Study of following texture with respect to characters examples and genesis - Poikilitic, Ophitic, Subophitic, Intergranular, Intersertal, Directive, Intergrowth (Graphic)
- c) Study of following structures / micro structures with respect to characters, examples and genesis- Orbicular, Spherulitic, Perlitic, Expansion Cracks and Reaction Rims.

### **Characteristics and generation of magmas in the interior of the earth**

#### **Characteristics and generation of magmas**

- a) The physico-chemical nature of magma – density, viscosity, chemical constituents and temperature-pressure.
- b) Role of magma in geological processes: melting of rocks and generation of magmas temperature- pressure conditions and volatile constituents. Generation of magmas in different tectonic settings.

**Types of magma:** Primary and derivative

#### **Crystallization of magmas**

- a) Binary magma with an incongruent melting compounds: Leucite – silica system
- b) Ternary system: Albite-Anorthite-Diopside system.
- c) Reaction series and its importance

### **Magmatic evolution**

#### **Magmatic Differentiation**

- a) Crystal fractionation: Forsterite - Fayalite, Forsterite - Silica systems.  
Separation mechanisms: Gravitational settling, flow differentiation, flow crystallisation, filter pressing, selective nucleation, gas streaming, gravitational liquid separation.
- b) Liquid immiscibility in silicate – silicate and silicate – water systems.
- c) Liquid fractionation : Thermal diffusion and gravitational diffusion.

#### **Contamination :**

Assimilation by melting, without melting and equilibration of xenoliths, incorporation of the equilibrated foreign matter, contaminated granites. Significance of contamination.

#### **Zone Melting**

**Mixing of magmas :** Similar and dissimilar magmas

#### **Role of volatile constituents in differentiation of magma**

#### **Textures, Structures and Classification of Igneous rocks**

##### **A) textures/structures in igneous rocks & their significance**

**B) Textures :** Granitic, porphyritic, glomero-porphyritic, poikilitic, ophitic & sub-ophitic, inter-granular, inter-sertal, cumulate, glassy, corona/ reaction rim, myrmeketic,

**Structures** : Ropy, vesicular, amygdaloidal, columnar, graphic, Orbicular, expansion cracks, flow,

**Classification of igneous rocks**

- a) Complexity in classification
- b) Types of classification,
  - i) Shand's classification
  - ii) CIPW classification
  - iii) IUGS (plutonic, volcanic) classifications

**Petrographic Provinces, Rock Kindreds and Description of Igneous Rocks**

**Concept of tectono-magmatic association**

**Petrographic Provinces & Rock Kindreds**

**Description of rock types**

Description of rock types with regard to their characteristics, composition, Origin and occurrence in relation to their tectonic setting:

- i) Peridotite clan rocks
- ii) Basalt
- iii) Anorthosite
- iv) Andesite
- v) Granite
- vi) Pegmatite
- vii) Aplite

**Sedimentary Petrology**

Sediments, sedimentation, sedimentary environment (definition and types) and formation of sedimentary rocks - Weathering (mechanical and chemical), erosion, denudation, transportation, deposition, compaction, cementation and lithification

**Textures and structures of sedimentary rocks:**

- A. Clastic and non-clastic textures.
- B. Structures: Lamination, bedding (concordant and discordant), graded bedding and ripple marks.

**(A) Derivation of sediments.**

- i. Sources of sediments
- ii. Mineral composition of clastic / detrital sediments
- iii. Concept of matrix and cement and its effect on porosity and permeability 5

**B) Transportation of Detrital/ Clastic sediments:**

- i. Modes of Transportation (Including phases of traction)
- ii. Definition of Competence, Capacity and Load of transporting Medium
- iii. Progressive changes in sediments during transport with respect to size, shape and mineral composition.

**C) Diagenesis:** Outline of following diagenetic processes:- Cementation, Authigenesis, Diagenetic Metasomatism, Diagenetic Differentiation and Intrastratal Solution.

**D) Primary Sedimentary Structures:** Description of following primary structures with respect to their origin and environmental significance:- Lamination, Bedding, Cross Bedding, Graded Bedding, Ripple Marks, Mud-Cracks.

## **Introduction to Sedimentary Petrology**

### **A) Introduction:**

- a) Introduction to terms Sedimentology and Sedimentary Petrology
- b) Branches of Sedimentology
- c) Methodology: Field & Laboratory studies (in brief)
- d) Application of Sedimentology in prospecting of hydrocarbons & sedimentary ores (Placer, Syngenetic & Epigenetic)

### **B) Role of weathering in sedimentation:**

- a) Surface processes of rock weathering
- b) Chemistry of the weathering processes & mobility of oxides
- c) Mineral stability series

### **C) Dispersal of sediments:**

- a) Dynamics of transportation
- b) Concept of dispersal based on: size, roundness & sphericity, mineral composition & processes ( Selective abrasion, Selective sorting & progressive dilution)

## **Texture & Structures of Sedimentary Rocks**

- a) Definition of texture & factors controlling textures of sedimentary rocks
- b) Concept of shape & size classification
- c) Classification of sedimentary aggregates
- d) Grade scales (Udden, Wentworth, Krumbein & Phi scale)
- e) Mechanical / Sieve analysis: procedures & format for plotting & interpretation in brief.
- f) Inorganic primary sedimentary structures & their significance (a brief mention of their varieties):
  - 1. Bedding
  - 2. Lamination
  - 3 Cross bedding
  - 4 Graded bedding
  - 5 Ripple marks
  - 6. Chemical structures: stylolites, concretions, nodules
  - 7. Penecontemporaneous sedimentary Structures: Load-cast, flute-cast, mud-cracks, ball & pillow, clastic dykes, slump folds, Dewatering fold
- g) Study of organic sedimentary structures (in brief)

## **Provenance, Classification of Sedimentary Rocks And Sedimentary Basins**

### **Concept of provenance:**

- a) Introduction
- b) Based on petrography, light & heavy mineral suites

### **Classification of sandstones & limestones:**

- a) Dott's Classification of sandstones
- b) Dunham's classification of limestones

### **Sedimentary basins & control on sedimentation:**

- a) Sedimentary basins their formation & classification (Kingston et al).
- b) Climatic control.

## **Sedimentary Environments & Facies**

- A) Sedimentary environments: Depositional & Erosional
- B) Physical & Chemical parameters of depositional sedimentary environments
- C) Classification of depositional sedimentary environments



D) Concept of sedimentary facies: Definition, nomenclature & types of Sedimentary facies, Walther's Law of Facies.

### **Metamorphic Petrology**

- A) Definition of metamorphism, agents of metamorphism, kinds of metamorphism, characteristics of different types of metamorphism
- B) Tabular classification giving original rock, predominant agent of metamorphism, type of metamorphism and their metamorphic product of the following rocks: Slate Quartzite, Marble, Hornblende schist, Mica schist, Hornblende gneiss.
- C) Structures in metamorphic rocks: maculose, slaty cleavage, granulose, schistose, gneissose
- A) Metamorphism and Metamorphic minerals:
  - a) Salient features of metamorphism as a process
  - b) Difference between Metamorphism, Weathering, Diagenesis and Metasomatism
  - c) Metamorphic minerals- Stress and anti-stress minerals, Idioblastic and Xenoblastic crystals.
- B) Metamorphism and Metamorphic Products: Definition, general characteristics, textures/structures and mineral transformation involved during –
  - a) Regional Metamorphism of
    - i) Argillaceous rocks
    - ii) Quartzofeldspathic rocks
    - iii) Basic igneous rocks
  - b) Cataclasis and its products- Crush Breccia, Crush Conglomerate, Cataclasite
  - c) Thermal Metamorphism of
    - i) Pure and impure limestones
    - ii) Arenaceous rocks

### **Introduction to Metamorphism:**

Introduction, Definition & Characteristics.

- A) Domain of metamorphism
- B) Metamorphic recrystallization as distinct from igneous crystallization
- C) The concept of metamorphic facies: Diagrammatic representation of pressure temperature conditions (with depth) of the different facies of contact, regional & Plutonic metamorphism
- D) Introduction to mineralogical phase rule- system, component and phase
- F) Introduction to phase diagrams of metamorphic rocks- ACF, A'KF and AFM diagrams

### **Types of metamorphism I**

#### **A) Thermal Metamorphism**

- a) Definition & General characteristics of the sub types of thermal metamorphism
- b) Factors controlling Thermal metamorphism
- c) Attainment of Chemical equilibrium
- d) Chemically active fluids in heat dominant metamorphism
- a) Aureoles of Thermal metamorphism
- b) Effects of thermal metamorphism on :
  - i) Igneous rocks (Intermediate & basic)

- ii) Aluminous & ferruginous deposits
- iii) Non – calcareous argillaceous sediments

**B) Dynamic/ Cataclastic metamorphism:**

- a) Definition & General characteristics
- b) Rock deformation involved
- c) Stress & metamorphic chemical reactions
- d) Stress & solubility of minerals
- e) Mechanics of the formation of slaty cleavages
- f) Strain & solution effects in the crystalline rocks
- g) Mineralogical changes in cleaved & crystallized rocks.

**Types of metamorphism II**

**A) Regional Metamorphism & its products**

Definition & general characteristics of the sub types of regional metamorphism

- a) Depth zones & characteristic minerals
- b) Diagrammatic representation of the conditions controlling metamorphism
- c) Barrovian zones of regional metamorphism.
- d) Development of textures & structures of regionally metamorphosed rocks
- e) Crystal growth under stress
- f) Effects of regional metamorphism:
  - i. Argillaceous (Non – calcareous) sediments – (Barrovian zones)
  - ii. Ferruginous & aluminous sediments
  - iii. Calcareous sediments
  - iv. Igneous ( acidic & basic)

**B) Plutonic metamorphism**

- a) Definition & General characteristics
- b) Formation of Granulites, Charnockites & Eclogites

**C) Pneumatolysis / Metasomatism**

- a) Definition & General characteristics of the various types of metasomatism
- c) Pneumatolytic processes – Tourmalinisation, Greissening, Scapolitisation, Autometasomatism

**Metamorphic texture & structure**

- A) Residual structures & textures.
- B) Metamorphic reconstitution (Limit set to diffusion)
- C) Characteristics of crystal growth in the solid state.
- D) Significance of inclusions in metamorphic crystals
- E) Forces of crystallization & the concept of the crystalloblastic series
- F) Common habits of metamorphic crystals.
- G) Diagnostic structures of thermally metamorphosed rocks.
- H) Diagnostic structures of cataclastically metamorphosed rocks
- I) Diagnostic structures of regionally metamorphosed rocks & their development- foliations, schistosity, gneissosity & cleavage
- J) Textures & structures formed due to metasomatism

**Unit 2**

## **Structural Geology**

### **Introduction and definition.**

Planar features and their measurements, Clinometer compass (construction and uses)

Folds: Definition, parts of fold, anticline, syncline, symmetrical, asymmetrical.

Faults: Definition terms associated with fault, normal fault, reverse fault, step fault, horst and graben.

Joints: Definition, general characteristics, sheet joints, columnar joints.

Unconformities: Definition and types (disconformity, angular unconformity, nonconformity)

### **Definition and its relation with other branches of geology**

ii) Tectonic and Non-tectonic structures.

iii) Scale of tectonic structures (Micro, Meso, Macro & Regional)

#### **B. PLANAR/LINEAR STRUCTURES, OUTLIER/INLIER**

i) Attitude of planar feature - Strike and Dip

ii) True & Apparent Dip, True & Apparent thickness, True & Apparent Width of Outcrop and Vertical Thickness of planar feature.

iii) Attitude of Linear Feature, Bearing, Plunge and Rake of Linear Feature in given Planar Feature.

iv) Outlier and Inlier- Definition & Formation. v) Brunton Compass & its uses.

### **FOLDS:**

i) Introduction: Definition, causes and parts of folds: - axis, axial plane, limb, hinge, crystal line, crystal plane, trough line and trough plane.

ii) Definition, causes and characters of the following types of folds: - anticline, syncline, anticlinorium, synclinorium, symmetrical, asymmetrical, overturned, recumbent, isoclinal, chevron, box, fan, monocline, homocline, Structural terrace, open, close, drag, plunging and nonplunging, doubly plunging, dome and basin. Decollement, diapir, disharmonic, suprataneous.

iii) Concepts of fold systems and refolding

iv) Method to determine the depth of folding- Principle, assumptions, merits and limitations.

v) Recognition of folds by direct observation, plotting attitude of beds on map, topographic studies, drilling and mining data.

vi) Methods of representation of folds

### **FAULTS :**

i) Definition of fault as a Planar zone, terms associated with Faults / fault zones

ii) Movements along faults- absolute, relative, apparent, translational and rotational

iii) Slips, separations, shift along faults

iv) Effects of faulting on disrupted strata

v) Geometric classification of faults

vi) Genetic classification of faults

vii) Recognition of faults in the field

### **JOINTS:**

i) Definition and general characteristics of joints

ii) Rupturing under tension, compression, couple and torsion

iii) Geometric and genetic classification of joints with examples

### **UNCONFORMITY:**

- i) Definition, stages in development of unconformities,
  - ii) Structural classification of unconformities, Recognition of unconformity in the field.
  - iii) Distinguishing unconformable contacts from intrusive contacts and faults.
- LANDFORMS ASSOCIATED WITH TECTONIC STRUCTURES  
 DETERMINATION OF TOP OF BED WITH THE HELP OF PRIMARY STRUCTURES  
 (SEDIMENTARY & IGNEOUS) AND INTERPRETATION OF MAJOR STRUCTURES WITH  
 WHICH THEY ARE ASSOCIATED.

### **Structural Geology.**

#### **Fundamental Principles of Rock Deformation**

#### **Objectives and applications of Structural Geology.**

#### **Rock Deformation- Definition, Concept & fundamental principles**

- a) Force: Definition, representation, types (balanced & unbalanced) & unit of force.
- b) Confining / Hydrostatic pressure & differential forces.
- c) Stress & Strain-Definition and concept.
- d) Stress-Strain diagram with reference to following :
- e) Elastic & Plastic deformation
- f) Brittle & Ductile substance
- g) Rupture strength, Ultimate strength & Fundamental strength.
- h) Factors controlling rock deformation: Confining pressure, temperature, time, solution, anisotropy & inhomogeneity of rocks.
- i) Rheology (definition & concept).

#### **Mechanics of Plastic deformation:**

- a) Definition & examples of plastic deformation
- b) Mechanisms of plastic deformation: Intergranular & intragranular movements, recrystallization with & without change in shape, Reckie's principle.

#### **Concept & Mechanics of folding: (Based on internal processes operative within the rock) Study of the following genetic styles of folding:**

- a) Flexure / Flexure-slip folding
- b) Flow / Incompetent folding
- c) Shear / Slip folding
- d) Folds due to vertical movements

#### **Introduction to Dip Isogons and Ramsay's classification**

#### **Introduction to Flutey's Classification**

#### **Introduction to Analytical techniques- pi & beta diagrams**

#### **Mechanics of Rupturing & Faulting:**

##### **A) Mechanics of Rupturing**

- a) Concept of mechanics of rupturing
- b) Two genetic types of fractures-tension & shear fractures
- c) Rupturing under differential forces
- d) Stress & Strain ellipsoid – Concept & their relation with rupture

**B) Mechanics of faulting:**

- a) Concept of mechanics of faulting
- b) Faulting along tension & shear fractures
- c) Direction of displacement along shear fractures`
- d) Mechanics of gravity, thrust & strike slip faults
- e) Introduction to Analytical Techniques – Orthographic Projections
- f) Ultimate causes of folding & faulting

**Foliations & Lineations:**

**A) Foliations**

- a) Definition, types & examples of foliations
- b) Map symbols to express attitude of foliations & rock cleavages
- c) Types of cleavages & schistosity (Secondary foliations):
  - i) Slaty cleavages / schistosity
  - ii) Fracture cleavages
  - iii) Slip cleavages
  - iv) Bedding cleavages
- d) Origin of slaty cleavages / schistosity:
  - i) Slaty cleavages as flow cleavages
  - ii) Slaty cleavages as shear cleavages
- e) Origin of fracture cleavages, slip cleavages & bedding cleavages
- f) Cleavage banding & Segregation banding
- g) Introduction to Superimpose Deformation

**B) Lineations:**

- a) Definition, types & examples of lineations (Primary & Secondary)
- b) Types of secondary lineations & their origin:
  - i) Linear parallelism of stretched pebbles / prismatic minerals / elliptical mica plates
  - ii) Intersecting planar features
  - iii) Cenulations
  - v) Slicken-sides
  - vi) Boudins or Boudinage structures
  - vii) Rodings
  - viii) Axes of folds
  - ix) Mullion structure
- c) Map symbols to express attitude of lineations
- d) Lineations in relation to major structures

## **Geotectonics**

### **Introduction to Geodynamics**

#### **A) Evolution & formation of the solar system & earth & its physical properties**

- a) Formation and evolution of solar system
- b) Meteorites- Types, Origin

#### **B) Interior of the Earth:**

- a) Direct & indirect observations in exploration of Earth's interior
  - i) The variable interior- evidences:
  - ii) Seismic waves & Earth's interior:- Types of seismic waves & their characteristics,
  - iii) Seismic wave velocity & depth curve to indicate layered structure of the Earth
- b) Physical-chemical characteristics of the different layers of the Interior of the earth
  - i) Composition, physical properties & characteristics of three spherical zones of the Earth namely crust, mantle (including LVZ) & core
  - ii) Concept of Lithosphere, Asthenosphere & Mesosphere
  - iii) Concept & types of discontinuities –Conrad, Moho, Guttenberg & Lehman's Discontinuity
  - iv) Introduction to Convection Currents & mantle dynamics

### **Global tectonics I – Geomagnetism & Introduction to Plate Tectonics**

#### **A) Introduction to Palaeomagnetism**

- a) Earth's Magnetic field & Geodynamo
- b) Remnant magnetisation – TRM, DRM, CRM, VRM.
- c) Concept of Polar wandering & its application in plate – tectonics, Apparent & True Polar wandering paths ( with example)
- c) Magnetic anomalies & sea floor Spreading- Mechanics & applications
- e) Magnetic reversal & geomagnetic time scale.

#### **B) Plate Tectonics**

- a) Historical background of the plate tectonics theory, Plate tectonics as a unifying theory
- b) Introduction to Wilson's cycle & Concept of plate tectonics
- c) Characteristics of lithospheric plates
- d) Concept of plate margin & plate boundary
- e) Migration & motion of the plate boundaries
- f) Present motion of world's large plates

### **Global tectonics II- Plate Tectonics II**

#### **A) Three plate boundaries- (Divergent, Convergent & Transform faults-description examples).**

##### **a) Divergent plate boundary**

- i) Divergent boundary as a constructive plate boundary & source of new oceanic crust

- ii) Concept of a rift valley & mid-oceanic ridges
- iii) Structural environment at divergent plate boundary
- iv) Examples of divergent plate boundary
- b) Convergent boundary as a destructive plate boundary :**
  - Description & examples of the following types of convergent plate boundaries:
  - i) Oceanic-oceanic subduction.
  - ii) Oceanic-continental subduction
  - iii) Continent-continent collision- case study of Alpine- Himalyan Orogeny
  - iv) Concept of trench, subduction zone, Benioff zone & Ophiolite suites
- c) Transform fault boundary**
  - i) Transform fault boundary as conservative plate boundary-
  - ii) Distinction between Transform & Transcurrent faults
  - iii) Examples of Transform fault boundary
- d) Assumptions & problems in plate tectonics**
- e) Concept of triple junctions with their examples**
- f) Basin tectonics – Introduction to fore arc, back arc, foreland & rift basins .**
- g) Concept of hot plumes & hot spots with examples**
- h) Overview of Phanerozoic Tectonics- Spatial and Temporal evolution of palaeo supercontinents to present continents.**

## **Global Tectonics III- Origin of Mountains and Introduction to Archaean and Neotectonics**

### **A) Origin of mountains**

- c) Plate tectonic model
- d) Deformation of sedimentary basins,
- e) Plutonism & metamorphism
- d) Orogenies in space & time

### **C) Introduction to Archaean Tectonics**

- a) Early crustal evolution of the earth and Introduction to concepts of Cratons, Shields, Platform, Mobile belt with suitable Indian examples.
- b) Difference between Orogenic Belts and Mobile Belts

### **E) Introduction to Neotectonics**

### **D) Brief overview of Tectonic Evolution of India**

#### **Unit 3**

#### **Stratigraphy**

- A)** Introduction, definition, principles of stratigraphy, development of stratigraphic concepts, importance of stratigraphy. ii) Stratigraphic classification & Nomenclature, study of stratigraphic elements, lithostratigraphy and its units, chronostratigraphy and its units, biostratigraphy and its units. Inter-relationship between lithostratigraphic, chronostratigraphic and biostratigraphic units. iii) Methods of collecting stratigraphic data ( stratigraphic procedures on outcrop and subsurface

- B)**
  - i) Stratification : processes, Controlling stratification-physical, chemical and biological. Vertical succession, alternations, varves, cycles (symmetrical and asymmetrical)
  - ii) Unconformity: definition, importance in stratigraphy environmental classification and stratigraphic evidence of unconformities.
  - iii) Correlation: definition and evidence for correlation-physical and palaeontological.

**Palaeontology Systematic position, morphology of hard parts, geological and geographical distribution of the following:**

**A) Phylum Mollusca:**

- I. Class Lamellibranchia or Bivalvia: Morphology of hard parts of the shell, ornamentation and types of hinge lines.
- II. Class Gastropoda: Morphology of hard parts of the shell and forms of the gastropod shell.
- III. Class Cephalopoda: Morphology of hard parts of Nautilus, Ammonoids, Belemnites and type of suture lines.  
Comparison between Nautilus and Ammonoids.

**B) Phylum Brachiopoda**

- Morphology of hard parts of Class Articulata and Inarticulata.  
Types of brachial skeleton.  
Comparison between Lamellibranchs and Brachiopods.

**C) Phylum Echinodermata**

- Class Echinoidea: Morphology of hard parts of Regularia. Variation in the apical disc in echinoids.

**D) Phylum Arthropoda**

- Class Trilobita – Morphology of hard parts of Trilobites.

**E) Phylum Coelenterata**

- Class Anthozoa- Madreporaria, polyp, medusa, types of septa.

**F) Origin and evolution of life over geological time.**

**G) Uses and Importance of fossils**

- i) Concepts of organic evolution. (Definition, Evidence of evolution, Macro & Micro evolution, Darwinism, Lamarckism & Mutation)
- ii) Evolutionary trends in Ammonoids and Trilobites
- iii) Introduction to Micropalaeontology
- iv) Definition, different types of microfossils, their size range and composition.
- v) Different branches of Micropalaeontology. Uses of microfossils

**A) Field and Laboratory Techniques**

- (i) Field techniques for collection of microfossils (sampling methods)
- (ii) Laboratory techniques for separation- Mechanical and chemicals methods, Recovery of microfossils from shale and limestone. Separation of microfossils from coal (maceration), Preservation and Illustration.

**C) Study of the following microfossils: (with respect to their morphology, environmental and paleo-ecological significance)**

- (i) Foraminifers
- (ii) Ostracods
- (iii) Pollens and Spores



(iv) Diatoms, Dinoflagellates, Radiolarian

## **Stratigraphy of India**

### **Introduction to Indian and World Precambrian History**

- A)** Physiographic / Tectonic divisions of India and their comparisons
- B)** a) Definition of Tectonic Elements of continents (cratons, shield, folded mountain belts) and oceans (mid oceanic ridges, trenches and transform faults)
  - b) Cratons of India and associated Proterozoic basins
  - c) General review of Indian Stratigraphy & Classification of the Indian litho-stratigraphic units, according to the Geological time scale.
  - d) Earlier and current classification of Precambrian formations of India by- Sir T. H. Holland, Sarkar et al(1976) and Ramkrishna and Vaidhyanathan (ICS, 2014)
- C)** a) World Precambrian history in brief
  - b) Cratons and mobile belts of the World

### **Precambrian rocks of Peninsular India**

Brief account of their distribution, Geographical location, classification lithological succession, structure and economic importance, with a broad stratigraphic correlation.

- a) The Dharwar Craton:** General Stratigraphy of Dharwar craton (in tabular form), distinction between older and younger Greenstone belts: Sargur Supergroup, Peninsular Gneisses, Dharwar Supergroup, Clospet Granite, Chamundi Granite.
- b) The Singhbhum – Odisha Iron Ore Craton:** General Stratigraphy of the region (in tabular form) Older Metamorphic Group (OMG), Iron Ore Group (IOG), Singhbhum Granite, Singhbhum Group, Extrusive and intrusive phases in the craton.
- c) The Central Indian Craton/ Bastar Craton:** General Stratigraphy of the region (in tabular form). Sakoli Group and Dongargarh Supergroup.
- d) Aravalli Craton:** General Stratigraphy in the Bhilwara Supergroup (Mangalwar Complex Sandmata Complex, Hindoli Group), Aravalli Supergroup
- e) Bundelkhand Craton:** Supracrustal and gneisses, Bundelkhand Granite and mafic dyke swarm

### **The Precambrian Mobile belts and Precambrians of the Extra-Peninsula:**

#### **A) The Precambrian mobile belts**

- a) The Eastern Ghat mobile belt: Description and distribution of the Chalk Hills, Anorthosites of Salem, Sitampundi Complex, Khondalites and Kodurites.
- b) The Satpura mobile belt/ CITZ (Central Indian Tectonic Zone): Constituents and extent, N-S tabular cross section of CITZ, lithostratigraphy in brief of Mahakoshal belt/Group, Betul belt and Sausar belt/Group

#### **B) The Precambrians of the Extra-Peninsula:**

- a) The Tectonic sub-divisions of the Himalayas
- b) Precambrians of the Western and Central Lesser Himalayas
- c) Precambrians of the Western and Central Tethyan Himalayas

### **The Proterozoic rocks of India:**

- A)** a) The Archaean – Proterozoic boundary.  
 b) Proterozoic history in brief, changes in marine and terrestrial environments, tectonic zonation in platformal and geosynclinal basins
- B)** Classification, Succession, lithology, fossils and economic importance of:
- a) The Delhi Supergroup:
  - b) Cuddapah Supergroup
  - c) The Vindhyan Supergroup:
  - d) The Kaladgi Supergroup.
  - e) The Chhattisgarh Supergroup.

**Introduction to Phanerozoic Stratigraphy:**

**A) Precambrian – Cambrian boundary**

**B) Study of following Geological systems with reference to their type area, broad lithology, fossils content:**

Cambrian, Ordovician, Silurian, Devonian, Carboniferous, Permian, Triassic, Jurassic, Cretaceous & Tertiary

**The Paleozoic and Mesozoic Formations of Peninsular India:**

**A) Palaeozoic Formations of Peninsular India**

- a) A brief history of the Paleozoic Formations,
- b) Gondwana Supergroup:
  - i. Geographical distribution,
  - ii. Stratigraphic classification- bipartite and tripartite,
  - iii. Lithology,
  - iv. Age,
  - v. Palaeoclimatic conditions,
  - vi. Flora,
  - vii. Fauna,
  - viii. Igneous activity,
  - ix. Marine intercalations,
  - x. Economic importance.

**B) The Mesozoic Formations of Peninsular India:**

- a) A brief history of the Mesozoic formations.
- b) Jurassic of Kachchh
- c) Cretaceous of Narmada Valley/ Bagh beds.
- d) Cretaceous of Cauvery basin.

**Cenozoic Formations of Peninsular India and Geology of Maharashtra**

**A) The Deccan Volcanic Province :**

Distribution, extent, age, structure, mode of eruption and occurrence, Petrological characters and variations, Lithostratigraphic classification, Infra trappeans and Intertrappean beds.

**B) The Cenozoic Formations of Peninsular India:**

- a) Tertiary of Assam
- b) Tertiary of the K-G basin
- c) Tertiary formations along the West Coast.

**C) Laterites: Definition, Origin, Types and distribution.**

## **D) The Geology and Stratigraphy of Maharashtra**

### **The Phanerozoic Stratigraphy of Extra-Peninsular India and Palaeontology:**

#### **A) The Phanerozoic Stratigraphy of Extra-Peninsular India:**

Classification, lithological succession and fossil content of the:

- a) Spiti area b) Siwaliks c) Karewas

#### **B) Palaeontology:**

- a) Morphology, Classification & distribution of Graptolites.
- b) Mass extinction, causes, evidence, five major mass extinctions.
- c) Palaeobotany: Definition, Conditions and different modes of preservation of plants through the geological ages.
- d) Study of following genera with respect to their classification, generic definition, characteristic and distribution – Ptillophyllum, Glossopteris, Gangamopteris, Vertebraria, Elatocladus, Equisetales, Cladophlebis, Brachyphyllum and Gleichenites.

## **Economic Geology**

### **Basics of Economic Geology & Primary processes of formation of mineral Deposits:**

#### **Introduction:**

- a) Definition of ore minerals, gangue, tenor, overburden, country rock, syngenetic & epigenetic deposits
- b) Classification of economically important metalliferous & non metalliferous mineral deposits
- c) Processes of formation of mineral deposits
  - a) **Magmatic Concentration:**
  - b) Early magmatic deposits
  - c) Late magmatic deposits

#### **Hydrothermal processes:**

Principles of hydrothermal processes, characters of solutions, types of openings in rocks, factors affecting deposition from hydrothermal solution, wall rock alternations.

- a) Types of hydrothermal deposits (Cavity filling & Metasomatic replacements)  
Cavity filling deposits:
  - i) Processes & characteristic features
  - ii) Types of cavity filling deposits: Fissure veins & its types (in brief), stock work, saddle reefs, ladder veins, pitches and flats, breccias filling deposits, solution cavity fillings, pore space fillings & vesicular fillings
- b) Metasomatic replacement: Definition, Criteria of replacement & resulting mineral deposits

#### **Secondary processes of formation of mineral deposits:**

##### **A) Oxidation & Supergene enrichment:**

- a) Oxidation & solution in the zone of oxidation

- b) Gossans & Cappings, the role of iron in gossans, indigenous & transported limonite, false gossans & gossans as guides to the hidden deposits.
- c) Ore deposition in the zone of oxidation & their method of precipitation
- d) Supergene Sulphide Enrichment:
  - i) Requirements for supergene enrichment
  - ii) Factors influencing supergene enrichment
  - iii) Recognition of supergene enrichment

**B) Evaporation, Residual concentration & Mechanical concentration:**

a) **Evaporation:**

- i) Process of mineral formation by evaporation
- ii) Evaporation deposits: Brief account of deposits of oceanic water, lake water, ground water & hot springs

b) **Residual concentration (residual deposits):**

- i) Conditions favouring of residual deposits
- ii) Brief account of residual deposits: Bauxite, clay & iron formation

c) **Mechanical concentration (placer deposits)**

- i) Principles involved in the process of mechanical concentration
- ii) Study of placer deposits: Eluvial, Alluvial, Beach & Aeolian

**Metallic & Radioactive deposits of India**

**A) Study of following metallic deposits with reference to mineralogy, properties, uses & their geological & geographical distribution**

Non-ferrous metals : Copper, Lead, Zinc & Aluminium

- i) Iron & Ferro alloy metals – Iron, Manganese, Nickel & Chromium
- ii) Polymetallic Nodules

**B) Plate tectonics & mineral deposits:**

Mineral deposits associated with different plate boundaries

**C) Radioactive minerals:**

Study of Uranium & Thorium deposits of India with reference to mineralogy, mode of occurrence, properties, uses & their geological & geographical distribution

**Fossil Fuels:**

**A) Petroleum & Natural Gas:** Origin & Entrapment, Types of traps, Formation of oil & gas pools, Surface indicators, description of oil fields in India (Cambay, Assam, Bombay High & Krishna Godavari Basins)

**B) Coal:** Origin, mode of occurrence, types of coal, Important Indian occurrences.

**Petroleum Geology I**

- a. Origin of petroleum
- b. Kerogen: Source Material and Formation, Composition and Distribution
- c. Petroleum Chemical composition and physical properties of crudes oil

**Oil Well Drilling**

- A) Introduction to Oil Well Drilling,
  - a. Types oil wells and geotechnical order

- b. Methods of Oil well drilling: Cable tool drilling and rotary drilling
  - B) Components of rotary drilling system
    - a. Monitoring of drilling process Concept of Subsurface pressure
    - b. Types of Drilling Rigs, Controlled Directional Rotary Drilling and Horizontal Drilling
  - c. Drilling Mud
  - d. Introduction, Techniques and Applications of Coring in Petroleum Geology
    - Formation Evaluation
      - A) Formation Evaluation: Wire line logs, Basic Principles, tools of SP, gamma ray, Neutron, Density, Caliper, Dipmeter, Temperature and Sonic Logs and their interpretation.
      - B) Mud logging: Principle, techniques and tools of mud logging.
    - Interpretation of gas, drilling and mud parameters. MWD (Measurement While Drilling)/LWD (Logging While Drilling). Principle and tools of MWD/LWD, data analysis and interpretation,
    - d. Occurrence of petroleum, nature of source rock
    - e. Reservoir fluids: Water, oil and gas
    - f. Origin, migration and accumulation of oil and natural gas Petroleum Geology II
      - A) Study of Reservoir and Traps
      - B) Petroliferous Basins of India
        - Bombay basin; Krishna-Godavari basin, Assam basin, Cauvery basin and Rajasthan basin
        - C) Petroliferous Basins of World
          - A)** Spraberry (USA), Greater Burgan (Kuwait,) and Carabobo 1 (Venezuela)
- Introduction to coal bed methane, Shale gas & Gas hydrates
- Mineral exploration**
- Introduction of mining:
  - Geology in mining industry,
  - Definition of ore minerals
  - Gangue, Tenor, Overburden, Country rock, and Grade, Float ores and In situ ores, Gossan
- Mineral exploration:
  - a. Introduction to mineral exploration, Surface and sub-surface exploration methods.
  - b. prospecting for economic minerals – drilling, sampling and assaying,
  - c. Geophysical techniques
  - d. Geomorphological and remote sensing techniques
  - e. Geobotanical and geochemical methods
- C) Mining terminology
  - Pits, Trenches and Boreholes, core drilling, Core drill sampling, core splitting, logging, storage, sludge
- D) Types of mining
  - Surface and underground mining
  - Equipment and accessories for mining
  - Calculation of Specific gravity, Porosity, Bulk density, compression factor
- Mineral exploration A) Sampling:
  - Sampling Principle, Methods, Size and quantity, Reduction, Errors, Sampling practices in open-cast mining

B) Categories of reserves, estimation of reserves, cross-sectional method, Area of influence method, triangular method and weighted volume estimate method

C) Classification of mining methods:

- a. Open cast mining,
- b. Underground mining,
- c. Coal mining methods

Factors influencing choice of mining method

D) Mining Acts and Regulations in India and Conservation of mineral resources Physical Oceanography A) Physical oceanography (Introduction, Pressure, temperature, density) B) Ocean salinity (Definition, Salinity Variations, Surface Salinity Variation, Salinity Variation with Depth, Processes Affecting Seawater Salinity) C) Ocean currents (Introduction, Origin of surface currents, Main Components of Ocean Surface Circulation, Indian Ocean Circulation) D) El-Nino-La Nino effect relation between climate and ocean in the Indian context Credit II: Oceanic Processes and Coastal Regulatory Zones A) Sea level changes (Introduction, Processes Affecting Sea Level, Past Sea Level Changes & Effects) B) The Coast: Beach (Definition, movement of sand on beach, Features Exist Along Erosional and Depositional Shores); Coastal erosion (Introduction, Causes, Types of coasts) and conservation methods C) Coastal Regulatory Zones (Introduction, Classification & Prohibited activities within CRZ & Regulation of permissible activities in CRZ )

## **Environmental Geology**

### **Concept, Objective and Scope of Environmental Geology:**

**A) Seven concepts, Objectives, and Scope of Environmental Geology; Physical, Biological, and Socio-geological Environment, Bio-geochemical cycles.**

Deterioration of land surface: Dimensions of Erosion, processes, causes of accelerated erosion, remedial measures.

Desertification and degradation of land: meaning, extent, causes and preventive measures.

Soil conservation, badland topography, alkalinity and salinity of soils

### **B) Natural Hazard and Mitigation: I**

- i) **Natural hazards:** Definition, type, Natural hazard zones and Impact assessment, Natural hazard zonation maps, Role of Geologists in disaster management plan
- ii) **Distinction between:** hazard and disaster (with examples), local and regional context, disaster profile of India
- iii) **Earthquakes:** Introduction, general characteristics, effects of disaster on human life and habitation, origin and severity of earthquakes, precursors (instrumental and natural), vulnerability, seismic zones of India, Impact assessment and mitigation measures
- iv) **Volcanoes:** Introduction, types of volcanic activity and their origin, distribution, hazards, effects (lava flows, pyroclastic activity, toxic gases, mud flows, fires), Prediction and mitigation measures

- v) **Mass movement:** Introduction, causes and types of mass movements, Identification of landslides zones, control measures, avalanches and their causes, mitigation and concept of safety factor

### **Natural Hazard and Mitigation: II :**

**Floods:** Introduction, definition, classification, causative factors, vulnerability, predictability (forecasting), mitigation measures, flood hazards in India

**Coastal hazards:** Introduction, causes and impacts of coastal erosion, tsunami, storms and their predictability and mitigation measures

**Mining hazards:** Types of mining hazards and restoration techniques

**Subsidence of land:** Causes of subsidence of land, prediction and mitigation measures

### **Crises, Conservation of natural resources and pollution:**

A) Classification and types of natural resources (renewable and non-renewable, conservation and development of natural resources, Crises faced by mankind with regards to conventional and non-conventional energy resources

#### **B) Pollution:**

a) **Water Pollution:** Sources of water pollution (natural and man-made), Case histories related to water pollution: Minamata disease (Japan), Arsenic poisoning (West Bengal), and Fluorosis (Bhandara)

b) **Soil Pollution:** Sources of soil pollution (use of pesticides, fertilizers, industrial domestic water, and their effects

c) **Air pollution:** Sources of air pollution, (aerosols, particulate matters in urban and industrial area), case histories: Chernobyl disaster and Bhopal gas disaster

**Solid waste disposal:** Solid waste disposal methods (deep well disposal, ocean dumping, hazardous chemical wastes), its effects with geological perspective

## **Applied Geology (Geomorphology, Remote-Sensing, GIS and Field Geology)**

### **Geomorphology and Principles of Remote Sensing**

#### **A) Geomorphology**

a) Introduction to Geomorphic Concepts

b) Landforms: Role Of Lithology, Endogenous And Exogenous Processes, Climatic And Tectonic Forces

c) Study Of Different Landforms Like: Mesa, Butte, Cuesta, Hogback, Ridge and valley topography, Tor topography, Badland topography, Karstic topography-sinkholes, disappearing streams, Sand dunes, Moraines, River terraces, Alluvial fans

#### **B) Principles of Remote Sensing**

a) Definition, Types of Remote sensing Systems (Active & Passive), Elements of passive Remote sensing system (data acquisition & data analysis)

b) Energy source and radiation principles (EM wave, Wave theory, EM spectrum, particle theory, Stefan-Boltzman's law, Emissivity, Black, white & grey bodies)

- c) Energy interactions in the atmosphere (Scattering, absorption, atmospheric windows & related sensing systems); Energy interactions with the earth (principles of the Conservation of energy, specular & diffused reflectors), Spectral reflectance of vegetation, soil & water; Data acquisition & interpretation.

## **Photogeology**

### **A) Aerial Photography**

- a) Classification of aerial photographs on the basis of Camera axis
- b) Film and filter combination, lens -system, types of cameras, high and low sun angle photography, digital cameras

### **B) Planning of Aerial photography**

Time of photography, Acquiring stereographic photography, Discrepancies in aerial photographs (tip, tilt, drift, crab, gap) and their effects.

- a) Geometric characteristics of Aerial photos, marginal information on Aerial photos, Scale of Aerial photos, ground and photographic resolution of Aerial photos, Vertical exaggeration and relief displacement in Aerial photos.
- b) Mirror and pocket stereoscopes.

### **C) Photo recognition Elements**

Tone, texture, pattern, shape, size, site, shadow, associations. Basic drainage patterns and their geological significance. Advantages and limitations of Aerial photos.

### **D) Photo-geological interpretations**

Photo characters of Sedimentary, igneous and metamorphic rocks. Interpretation of geologic structures (folds & faults), Interpretation of photo-lineament maps.

## **Satellites, Satellite data and Applications of Remote Sensing**

### **A) Introduction to Satellites, Sensors & their applications**

Brief history, Types of Satellites (Orbital Characteristics, Sensors and applications with reference to latest IRS & LANDSAT: LANDSAT 7 and 8, IRS satellites (Oceansat, Cartosat, Resourcesat, SARAL)

### **B) Scanners - Hyperspectral Scanners, Active Remote Sensing Systems -RADAR and LIDAR (Principles & applications)**

### **C) Image characteristics & Spectral responses of various features like Lithology, geologic structures, geomorphic features, vegetation (cultivated, forest), land use, water bodies (shallow, deep, clear, polluted), Utility (traffic, telecom, power, settlement etc.) & soils**

### **D) Applications of Remote sensing in studying the natural resources like minerals, ground water, soil, forests & in geo-technical investigations**

## **GIS, GPS and Field Geology**

- a) GPS, GIS and its applications
- b) GPS - What is GPS? Working of GPS.



- c) GIS- What is GIS, Components of GIS, Data base management systems, Raster and vector data
- d) Applications of remotely sensed data using GPS & GIS

## **B) Field Geology**

- b) Toposheets and other tools for base map preparation
- c) Aims, objectives of fieldwork, reconnaissance survey
- d) Study of rock outcrops
- e) Determination of attitude of beds, Field correlation
- f) Recording observations in Igneous, Sedimentary and Metamorphic terrain
- g) Instruments used in the field and their proper utilization
- h) Sketching the field area, collection of selective rock/mineral samples, preparing sketches, taking photographs
- i) Traverse mapping
- j) Preparation of field report

### **Interpretation of geological maps and data**

- a. Reconnaissance study of areas having igneous and metamorphic and sedimentary rocks.
- b. Locating oneself on topographic map, Identification, discrimination and tracing of different type of contacts,
- c. Geological mapping of a small area, collection, identification and labelling of rock and mineral specimens.

#### Principles of Remote sensing and Aerial photography

A) Definition, Types of Remote sensing Systems (Active & Passive), Elements of passive Remote sensing system (data acquisition & data analysis)

B) Energy source and radiation principles (EM wave, Wave theory, EM spectrum, particle theory, Stefan-Boltzman's law, Emissivity, Black, white & grey bodies)

C) Energy interactions in the atmosphere (Scattering, absorption, atmospheric windows & related sensing systems); Energy interactions with the earth (principles of the Conservation of energy, specular & diffused reflectors), Spectral reflectance of vegetation, soil & water; Data acquisition & interpretation.

#### D) Aerial Photography

- a. Classification of aerial photographs on the basis of Camera axis
- b. Film and filter combination, lens -system, types of cameras, high and low sun angle photography, digital cameras

#### E) Planning of Aerial photography

- a. Time of photography, Acquiring stereographic photography, Discrepancies in aerial photographs (tip, tilt, drift, crab, gap) and their effects.
- b. Geometric characteristics of Aerial photos, marginal information on Aerial photos, Scale of Aerial photos, ground and photographic resolution of Aerial photos, Vertical exaggeration and relief displacement in Aerial photos.
- c. Mirror and pocket stereoscopes.

#### Interpretation and application of Remote sensing data

A) Photo Recognition Elements

Tone, texture, pattern, shape, size, site, shadow, associations. Basic drainage patterns and their geological significance. Advantages and limitations of Aerial photos.

**B) Photo-geological interpretations**

Photo characters of Sedimentary, igneous and metamorphic rocks. Interpretation of geologic structures (folds & faults), Interpretation of photo-lineament maps.

**C) Introduction to Satellites, Sensors & their applications:**

Brief history, Types of Satellites (Orbital Characteristics, Sensors and applications with reference to latest IRS & LANDSAT:

LANDSAT 7 and 8, IRS satellites (Oceansat, Cartosat, Resourcesat, SARAL)

**D) Scanners:**

Hyperspectral Scanners, Active Remote Sensing Systems RADAR and LIDAR (Principles & applications)

**E) Image characteristics & Spectral responses of various features:** Lithology, geologic structures, geomorphic features, vegetation (cultivated, forest), land use, water bodies (shallow, deep, clear, polluted), Utility (traffic, telecom, power, settlement etc.) & soils.

**F) Applications of Remote sensing:**

In studying the natural resources like minerals, ground water, soil, forests & in geo-technical investigations.

## **Engineering Properties Of Construction Material**

**A) Introduction:**

Significance of geology in Civil engineering, knowledge of geomorphology, petrology, mineralogy, stratigraphy, photo geology and structural geology as applied to Civil engineering projects.

**B) Engineering properties of rocks:** Specific gravity, porosity, sorption, strength of rocks (Compressive, shear & tensile), elasticity of rocks, residual and shear stresses in rocks. Hardness test and Impact test for aggregates in brief.

**C) Rocks as Construction Material:** How are they obtained in nature? Use of rocks as facing stone. Factors influencing engineering usefulness of the rocks.

**D) Use of rocks as an aggregate:** Use of rocks as an aggregate in different types of constructions, source of different grades of aggregates, Properties of aggregates (shape, size, surface texture, roundness and coatings), cement aggregates reaction, thermal effects on aggregates. Types of aggregates (Highway, railway ballast and runway).

## **Geological And Geotechnical Investigations For Civil Engineering Projects**

**A) Tunnels:**

Terminology, geological conditions for tunnel sites, tunnel in bedded rocks and folded rocks, influence of divisional planes, effects of faults and crushed zones. Tunnels in the

vicinity of slopes. Role of groundwater in tunnelling. Tunnels in the Deccan Traps. Names and locations of at least six very important tunnels in India, Case study: Jawahar Tunnel

**B) Dams and Reservoirs:**

Geological conditions for the selection of dam and reservoir sites, terminology associated with dams. Types of dams (Gravity, buttress, arch and earthen), types of spillways. Location with type of all the important dams and hydroelectric projects in India.

Case study: Sardar Sarovar Dam

**C) Road and Railways**

**Geohydrology**

**A) Introduction:**

- a) Definition- Hydrology, Geo-hydrology, Hydrogeology.
- b) Scope & groundwater development in India.
- c) Vertical distribution of groundwater, Origin & rock properties affecting groundwater (porosity, permeability, their types & effects)

**B) Aquifers, Darcy's law, Groundwater distribution & fluctuations:**

- a) Geologic formations as aquifers.
- b) Types of aquifers (Confined, Unconfined, and Perched).
- c) Groundwater movement (Darcy's law).
- d) Groundwater fluctuations due to seasonal changes, stream-flow changes, evapo-transpiration changes.
- d) Springs (cold & hot), conditions for formation of springs.
- f) Factors controlling groundwater distribution (topography, climate, structural, geological, proximity of tanks, rivers etc.)

**C) Groundwater recharge methods:**

- a) Introduction to artificial recharge methods.
- b) Types of recharge methods: -
  - i) Water spreading methods (Flooding, Basin, Ditch & furrow, Natural channel, Irrigation).
  - ii) Recharge through Pits & Shafts, Recharge through wells.
  - iii) Rain water harvesting.
  - iv) Groundwater recharge methods in Maharashtra (bore-blast & jacket-well techniques).

**Basic concepts in Hydrogeology**

- A) Definitions- Hydrology, Geo-hydrology, Hydrogeology
- B) Water bearing properties of rocks –
  - a. Interstices and porosity, permeability, specific yield and specific retention, storativity, transmissivity and Hydraulic conductivity
  - b. Aquifers, Geologic formations as aquifers- Aquicludes, Aquitard and Aquifuge.
  - c. Vertical distribution of subsurface water-zone of saturation and zone of aeration.
  - d. Types of aquifers – unconfined, confined, Perched.
- C) Groundwater Flow-
  - a. Darcy's law and its validity

- b. Aquifer parameters-transmissivity, storage coefficient, hydraulic conductivity, Intrinsic permeability
- c. Groundwater flow rates and flow direction
- d. Laminar and turbulent groundwater flow

D) Field and laboratory methods used to characterize aquifer properties and hydrogeology of rocks

a) Field methods:

Pumping tests and slug test

- a. Principles – types of pumping tests, procedures,
- b. Determination of aquifer properties and well characteristics by Methods of Theim's equilibrium method.
  - a. Grain size Analysis method (GSA) consolidated and unconsolidated sediments
  - b. Permeameter method
- a) Well inventory

Water Well Construction – Selection of suitable site for well construction, Water well design criteria and specifications, maintenance of production wells and types of well.

b) Hydrogeology of rocks

Groundwater chemistry and Groundwater Resources of India      A) Groundwater chemistry:

- a. chemical standards for drinking, and irrigational water
- b. major ion and isotope analyses, chemical tracers in groundwater
- c. Physical and chemical properties of water and water quality.

BIS, WHO standard;

- d. Groundwater contamination; natural (geogenic) and anthropogenic contaminants;
- e. Saline water intrusion in coastal aquifers-Hymen Herzberg relation

B) Groundwater Resources i.e. aquifers of India

- a. Unconsolidated sedimentary
- b. Consolidated sedimentary
- c. Sedimentary Aquitards
- d. Folded metamorphic
- e. Jointed Crystalline
- f. Fractured Crystalline

C) Groundwater quality hotspots in India

- a. Hydrogeology in Maharashtra
- b. Groundwater quality hotspots in India- TDS, F, Ar, U, Fe

Geophysical Methods I      A) Gravity Method:

- a. Introduction, Principles, Types of Gravimeters, Concept of Bouguer
- b. Anomaly- Generalized interpretation of Gravity data- Case Study. B) Magnetic Method:
  - a. Introduction, Principles, Types of magnetometers- Magnetic anomalies and their interpretation.
  - b. Air borne surveys in Gravity and Magnetic Methods
  - c. Gravity and magnetics for the exploration of the minerals, oil /gas and groundwater
  - d. Processing and interpretation. C) Seismic Method:
    - a. Introduction and Principles
    - b. Seismic Reflection Method and Seismic Refraction Method
    - c. Seismic instruments and Field procedures

d. Processing of Seismic data and Case Study

## Prospecting And Mining Geology

### A) Objectives, stages & types of prospecting.

### B) Geological Prospecting:

- a) Geological Criteria: Climatic, Stratigraphic, Lithological, Structural, Geochemical, - Magmagenic and - Geomorphological.
- b) Physiographic Guides: Topographic expressions, Physiographic environment of the ore deposits, physiography in relation to oxidation & environment.
- c) Mineralogical Guides: Rock alteration, Target rings of mineral distribution, Significance of accessory & gangue minerals. iv) Stratigraphic & lithologic guides for Syngenetic & Epigenetic deposits, Fracture pattern as guides, Contacts & folds as guides

### C) Broad outline of geophysical prospecting:

Principles and applications of following geophysical methods along with their measured parameters, operative physical properties and names of the instruments used.

- i) Electrical (S.P. & Resistivity)
- ii) Magnetic
- iii) Gravity
- iv) Seismic refraction.

### Geophysical Methods II

#### A) Electrical Method:

Introduction, Principles and Anomalies B) Resistivity Method:

Introduction, Principles and Interpretation of resistivity data C) Self-potential Method:

Origin of self-potential instrumentation and field procedure D) Induced polarization Method:

Electrolytic and Electrode polarization- Instruments and field procedure E) Electromagnetic Method:

Principles, Instruments and Case Study.

### D) Mining Geology: Definition, Sampling, Mining methods – opencast and underground with two examples ( Mansar and Zawar underground Mine; Panna and Umred opencast Mine.

#### Mineral Resources

Mineral forming processes -I

- A) Introduction: a) Definition of ore minerals, gangue, tenor, overburden, country rock, syngenetic & epigenetic deposits.
  - b) Classification of economically important metalliferous & non metalliferous mineral deposits
- B) Magmatic Concentration: a) Early magmatic deposits b) Late magmatic deposits
- C) Hydrothermal processes: a) Principles of hydrothermal processes, characters of solutions, types of openings in rocks, factors affecting deposition from hydrothermal solution, wall rock alternations.

- b) Types of hydrothermal deposits
1. Cavity filling deposits:
    - Processes & characteristic features
    - Types of cavity filling deposits: Fissure veins & its types (in brief), stock work, saddle reefs, ladder veins, pitches and flats, breccias filling deposits, solution cavity fillings, pore space fillings & vesicular fillings
  2. Metasomatic replacement: Definition, Criteria of replacement & resulting mineral deposits

## Introduction to Engineering Geology

Significance of Geology in Engineering and Environment projects B) Rocks as Construction Material:

i. Building stone, Facing stone, and Foundation material. ii. Factors influencing engineering usefulness of the rocks (Durability of rock).

C) Engineering properties of rocks:

- i. Factors controlling the engineering properties of the rock. Specific gravity, porosity, sorption, strength of rocks (Compressive, shear & tensile), elasticity of rocks, residual and shear stresses in rocks.
- ii. Importance of weathering and clay formations. D) Use of rocks as an aggregate:
  - i. Use of rocks as an aggregate in different types of constructions, source of different grades of aggregates
  - ii. Types of aggregates
  - iii. Physical and Engineering properties of aggregates

Site investigations A) Study of foundation rocks:

- i. With reference to tunnelling, dams, reservoirs and bridges, ii. Scale factor and insitu measurements, Quantitative measurements of discontinuities B) Tunnels:
  - i. Types of tunnels and Site selection for tunnel construction
  - ii. Tunnelling in various terrains like tunnel in bedded rocks and folded rocks, influence of divisional planes, effects of faults and crushed zones.
  - iii. Tunnels in the vicinity of slopes
  - iv. Role of groundwater in tunnelling.
  - v. Tunnels in the Deccan Traps. Names and locations of at least six very important tunnels in India, Case study: Jawahar Tunnel
- C) Dams and Reservoirs:
  - i. Types of Dams and reservoirs
  - ii. Site selection for dam and reservoir construction
  - iii. Location with type of all the important dams and hydroelectric projects in India. Case study: Sardar Sarovar Dam
- D) Bridges:
  - i. Types of bridges and Site selection for bridge construction
  - ii. Names and locations of at least six very important bridges in India.

## Geotechnical Studies

- a. Drilling in geotechnical field and Drilling Equipments
- b. Rock Quality Designation (RQD) and Core Recovery (CR) Core logging and bore logging
- c. RMR(Rock Mass Rating) (Bienawiski, 1989)
- d. Types of foundations and Safe Bearing Capacity  
Laboratory and Field Geotechnical Tests
- a. Introduction to Piling Packer Permeability Test (P.P.T.), Standard Penetration Test and its types. (S.P.T.)
- b. Sieve analysis of Soil
- c. Specific Gravity by Pycnometer
- d. Determination of Field Density by Core cutter method and Sand Replacement method

- e. Determination of Consistency limit: Liquid Limit by Casagrande's Apparatus (Plastic Limit, Shrinkage Limit
- f. Direct Shear Test and Vane Shear Test, Triaxial Test, Determination of Compaction properties of Soil by standard proctor Test, Differential Free Swell Test
- Surveying and Levelling
- Surveying:
  - a. Definitions of Surveying and Levelling and Objectives of Survey
  - b. Measurement of horizontal and vertical angle by 1' Theodolite Measurement of distance, angle by using Total Station. B) Levelling:
    - a. Definitions of Terms used in Levelling, Characteristics of a Dumpy Level and a Levelling Staff, Bench Marks, Change Points
    - b. Levelling operations and steps in Levelling: Demonstration with an exercise in the field
    - c. Principles of Levelling: Simple and Differential, Reduction of Levels: The Collimation, and Rise and Fall systems of Computation
  - Concept of watershed, watershed characteristics
    - b. Importance of water resources in watershed, concept of watershed development in relation to water resources, salient features of development measures like contour bunding, gully plugs, stream bunds, percolation tank, subsurface dams, afforestation etc.
    - c. Significance of geology in watershed development
    - d. Assessment of water resources, i.e. surface water and ground water in a watershed: rainfall-runoff and ground water analysis
    - e. Role of NGO's and State Government in watershed development
  - Watershed Management
    - a. Concept of watershed management in relation to water resources.
    - b. Water balance equation for watershed, sustainability of water resources, conjunctive use of surface and groundwater resources.
    - c. Watershed Modelling
    - d. Drought assessment and management
    - e. Integrated watershed management

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