

Savitribai Phule Pune University

Three Year B. Sc. Degree Course in

GEOLOGY

T.Y.B.Sc. Syllabus

(To be implemented from Academic Year 2015-16)

**Equivalences for the Old Courses with New Courses in Geology
T.Y.B.Sc. Geology**

Papers in Old Course	Equivalent papers in New Course
GL331: Mineralogy	GL331: Mineralogy
GL332: Igneous Petrology	GL332: Igneous Petrology
GL333: Sedimentary Petrology	GL333: Sedimentary Petrology
GL334: Structural Geology	GL334: Structural Geology
GL335: Precambrian Stratigraphy of India	GL335: Precambrian Stratigraphy of India
GL336: Applied Geology I (Field Geology & Remote Sensing)	GL336: Applied Geology I (Geomorphology, Remote-Sensing, GIS and Field Geology)
GL341: Metamorphic Petrology	GL341: Metamorphic Petrology
GL342: Environmental Geology	GL342: Environmental Geology
GL343: Economic Geology	GL343: Economic Geology
GL344: Geotectonics	GL344: Geotectonics
GL345: Phanerozoic Stratigraphy of India & Palaeontology	GL345: Phanerozoic Stratigraphy of India & Palaeontology
GL346: Applied Geology II (Prospecting, Engineering Geology & Hydrogeology)	GL346: Applied Geology II (Prospecting, Engineering Geology & Hydrogeology)
Practicals- GL 347: Mineralogy & Petrology	GL 347: Mineralogy & Petrology
GL348: Structural Geology, Economic Geology, Paleontology & Indian Stratigraphy	GL348: Structural Geology, Economic Geology, Paleontology & Indian Stratigraphy
GL349: Applied Geology (Remote Sensing, Geohydrology, Geophysical Prospecting, Field Geology & Environmental Geology)	GL349: Applied Geology (Remote Sensing, Geohydrology, Geophysical Prospecting, Field Geology & Environmental Geology)

GL-331 : Mineralogy

Unit I) Mineral Optics & Mineral Chemistry

12 Lectures

A) Mineral Optics:

(9 Lectures)

- a) Refractive index & methods of comparing R.I of minerals: Becke line, shadow method & immersion method
- b) Relief of minerals
- c) Uniaxial & biaxial minerals, indicatrices
- d) Vibration direction & optic orientation
- e) Pleochroism & absorption
- f) Accessory plates: Quartz wedge, Mica plate & Gypsum plate
- g) Compensation & Determination of interference colours
- h) Sign of minerals
- i) Sign of elongation of uniaxial minerals where C axis is known

B) Mineral Chemistry:

(3 Lectures)

- a) Isomorphism
- b) Polymorphism
- c) Pseudomorphism

Unit II) Descriptive Mineralogy-I

12 Lectures

A) 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

Unit III) Descriptive Mineralogy-II

12 Lectures

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

(8 Lectures)

- a) Chlorite group
- b) Clay group
- c) Felspar group
- d) Zeolite group

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

(4 Lectures)

- a) Refractory minerals : Fire clay, Kyanite, Chromite, Graphite, Magnesite, Dolomite
- b) Precious & Semiprecious stones

Unit IV) Descriptive Mineralogy-III

12 Lectures

**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
- f) Halides : Fluorite & Halite

REFERENCE BOOKS -

- 1) Rutley's Elements of Mineralogy by H.H. Read.
- 2) Mineralogy by Berry & Mason
- 3) Mineralogy by Dexter Perkins
- 4) An Introduction to the rock forming minerals by Deer, Howie, Zussman
- 5) Manual of Mineralogy by Kleine & Hurlbut C.S.
- 6) Optical Mineralogy by Kerr P.F.
- 7) Optical Mineralogy by Whalstrom E.E.
- 8) Optical Mineralogy & Non opaque minerals by Philip W.R. & Griffen check
D.T.
- 9) Dana's textbook of Mineralogy by William E. Ford.
- 10) Optical Mineralogy by S.Ray and PRJ Naidu

GL 332 - Igneous Petrology

UNIT I) Characteristics and generation of magmas in the interior of the earth **12 Lectures**

A) Characteristics and generation of magmas (6 Lectures)

- 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.

B) Types of magma: Primary and derivative (1 Lecture)

C) Crystallization of magmas (5 Lectures)

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

UNIT II) Magmatic evolution **12 Lectures**

A) Magmatic Differentiation (6 Lecture)

- a) Crystal fractionation: Forsterite - Fayalite, Forsterite - Silica systems.
- i) 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.

B) Contamination : (3 Lecture)

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

C) Zone Melting (1 Lecture)

D) Mixing of magmas : Similar and dissimilar magmas (1 Lecture)

E) Role of volatile constituents in differentiation of magma (1 Lecture)

UNIT III) Textures, Structures and Classification of Igneous rocks **12 Lectures**

A) textures/structures in igneous rocks & their significance (7 Lectures)

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

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

B) Classification of igneous rocks (5 Lectures)

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

UNIT IV) Petrographic Provinces, Rock Kindreds and Description of Igneous Rocks

12 Lectures

A) Concept of tectono-magmatic association (2 Lectures)

B) Petrographic Provinces & Rock Kindreds (4 Lectures)

C) Description of rock types (6 Lectures)

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

REFERENCE BOOKS -

- 1) Igneous Petrology : Anthony Hall
- 2) Igneous rocks : McBirney
- 3) Igneous and Metamorphic Petrology : Myron Best
- 4) Principles of Petrology : GW Tyrrell.
- 5) Igneous, metamorphic and sedimentary Rocks : Elher and Blatt
- 6) Igneous and metamorphic Petrology : Turner and Verhoogen
- 7) Principles of Igneous & metamorphic Petrology : Philpotts and Ague
- 8) Petrology of the Igneous rocks : Hatch, Wells and Wells
- 9) Petrography and Petrology : Grout
- 10) Igneous Petrology : Barker D. S.
- 11) Igneous and Metamorphic petrology : Raymond Loren
- 12) Principles of Igneous and Metamorphic Petrology: John D. Winter
- 13) Petrology by Blatt, Tray and Owens

GL – 333: Sedimentary Petrology

UNIT I) Introduction to Sedimentary Petrology **12 Lectures**
(3 Lectures)

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: **(5 Lectures)**

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

C) Dispersal of sediments: **(4 Lectures)**

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

UNIT II) Texture & Structures of Sedimentary Rocks **12 Lectures**

- 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 folds
- g) Study of organic sedimentary structures (in brief)

UNIT III) Provenance, Classification of Sedimentary Rocks And Sedimentary Basins **12 Lectures**
(3 Lectures)

A) Concept of provenance:

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

B) Classification of sandstones & limestones: **(3 Lectures)**

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

C) Sedimentary basins & control on sedimentation: **(6 Lectures)**

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

UNIT-IV: Sedimentary Environments & Facies **12 Lectures**

- 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.

REFERENCE BOOKS -

- 1) Igneous, Metamorphic & Sedimentary petrology by Ehler & Blatt
- 2) Sedimentary Petrology by Pettijohn
- 3) Introduction to Sedimentology by Sengupta
- 4) Stratigraphy & Sedimentation by Krumbein & Sloss
- 5) Applied Sedimentology by R.K. Sukhatankar
- 6) Sand & Sandstones by Pettijohn, Potter & Siever.
- 7) Sedimentary basins and Environments by Reineck and Singh
- 8) Petrology of Sedimentary Rocks by S.J.Boggs (1992)
- 9) Sedimentary Petrology: an Introduction to the Origin Sedimentary Rocks by M.E.Tucker (2001)
- 10) Sedimentary Environment, Processes and Facies by Harold Reading
- 11) Sedimentary Basin, Budget and Facies, by Gerhard Einsele, (1995)
- 12) Sedimentary Structures by Collinson and Thompson

GL 334: Structural Geology.

Unit I) Fundamental Principles of Rock Deformation	12 Lectures
A) Objectives and applications of Structural Geology.	(2 Lectures)
B) Rock Deformation- Definition, Concept & fundamental principles	(7 Lectures)
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).	
C) Mechanics of Plastic deformation:	(3 Lectures)
a) Definition & examples of plastic deformation	
b) Mechanisms of plastic deformation: Intergranular & intragranular movements, recrystallization with & without change in shape, Reckie's principle.	
Unit II) Concept & Mechanics of folding:	12 Lectures
(Based on internal processes operative within the rock)	
A) Study of the following genetic styles of folding:	(8 Lectures)
a) Flexure / Flexure-slip folding	
b) Flow / Incompetent folding	
c) Shear / Slip folding	
d) Folds due to vertical movements	
B) Introduction to Dip Isogons and Ramsay's classification	(1 Lecture)
C) Introduction to Flutey's Classification	(1 Lecture)
D) Introduction to Analytical techniques- pi & beta diagrams	(2 Lectures)
Unit III) Mechanics of Rupturing & Faulting:	12 Lectures
A) Mechanics of Rupturing	(3 Lectures)
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:	(9 Lectures).
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	
Unit IV) Foliations & Lineations:	12 Lectures
A) Foliations	(6 Lectures)
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:

(6 Lectures)

- 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
 - iv) Slicken-sides
 - v) Boudins or Boudinage structures
 - vi) Rodings
 - vii) Axes of folds
 - viii) Mullion structure
- c) Map symbols to express attitude of lineations
- d) Lineations in relation to major structures

REFERENCE BOOKS –

- 1) Structural Geology : M.P.Billings
- 2) Techniques of Modern Structural Geology : Ramsay and Huber
- 3) Structural Geology : De Sitter
- 4) Structural Geology : Ramsay
- 5) Structural Geology for Petroleum Geologists : Russel
- 6) Folding and fracturing of rocks : Ramsay J G
- 7) Structural and Tectonic Principles: Badgley
- 8) Analysis of metamorphic tectonites : Turner and Weiss
- 9) Introduction to Geology : Sander
- 10) Structural Geology : Dennis
- 11) Modern Structural Geology (Vol. 1 and 2) : Ramsay and Huber
- 12) Analysis of Geological structural : Price N.J. and Cosgrove
- 13) Mechanics in Structural Geology : Bayly B.
- 14) Structural Geology : Fundamentals of Modern Developments : S.K.Ghosh
- 15) Structural Geology of rocks and region : Davis, Reynolds, & Kluth
- 16) An outline of Structural Geology : Hobbs B E, Means W.D & Williams P. F.
- 17) Structure and Tectonics : Badgley P C
- 18) Tectonics : Moore & Twiss

GL – 335: Precambrian Stratigraphy of India

Unit I) Introduction to Indian and World Precambrian History **12 Lectures**

- 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

Unit II) Precambrian rocks of Peninsular India **12 Lectures**

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

Unit III) The Precambrian Mobile belts and Precambrians of the Extra-Peninsula:

12 lectures

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

Unit IV) The Proterozoic rocks of India:

12 lectures

- A)** a) The Archaean – Proterozoic boundary.
b) Proterozoic history in brief, changes in marine and terrestrial environments, tectonic zonation in platform 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.

REFERENCE BOOKS -

- 1) Singhum - Orissa Iron Ore Craton : Geological Society of India –Special Publication
By Sinha Roy
- 2) Geology of Karnataka: Geological Society of India – Special Publication
By Radhakrishna B.P.
- 3) Geological of Maharashtra- Geological Society of India – Special Publication
By G.G. Deshpande
- 4) Purana Basins of India: Geological Society of India – Special Publication
- 5) Geology of Western and Central India: Geological Society of India – Special Publication
- 6) Stratigraphy of Lesser Himalaya- By K.S. Valdiya
- 7) A Geological Time Scale- By Brian Harland et. al.
- 8) Stratigraphy of India and Burma- By M.S. Krishnan
- 9) Fundamentals of Historical Geology and Stratigraphy of India- By Ravindra Kumar
- 10) Geology of India Vol 1 &2. Ramkrishna-Vaidhyanathan- Geological Society of India
Special Publication
- 11) The Making of India: Geodynamic Evolution- by K.S. Valdiya
- 12) Geological Evolution of the Indian Plate (From Haedean to Holocene -4Ga to 4Ka)- by
Naqvi, S.M., 2005.

GL: 336- Applied Geology I
(Geomorphology, Remote-Sensing, GIS and Field Geology)

- Unit I) Geomorphology and Principles of Remote Sensing** **12 lectures**
- A) Geomorphology**
- a) Introduction to Geomorphic Concepts **(2 Lectures)**
 - b) Landforms: Role Of Lithology, Endogenous And Exogenous Processes, Climatic And Tectonic Forces **(1 Lecture)**
 - 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 **(3 Lectures)**
- B) Principles of Remote Sensing**
- a) Definition, Types of Remote sensing Systems (Active & Passive), Elements of passive Remote sensing system (data acquisition & data analysis) **(2 Lectures)**
 - b) Energy source and radiation principles (EM wave, Wave theory, EM spectrum, particle theory, Stefan-Boltzman's law, Emissivity, Black, white & grey bodies) **(2 Lectures)**
 - 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. **(2 Lectures)**
- Unit II) Photogeology** **12 lectures**
- A) Aerial Photography** **(2 Lectures)**
- 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** **(3 Lectures)**
- 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.
- C) Photo recognition Elements** **(3 Lectures)**
- 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** **(4 Lectures)**
- Photo characters of Sedimentary, igneous and metamorphic rocks. Interpretation of geologic structures (folds & faults), Interpretation of photo-lineament maps.
- Unit III) Satellites, Satellite data and Applications of Remote Sensing** **12 lectures**
- A) Introduction to Satellites, Sensors & their applications** **(6 Lectures)**
- 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)** **(3 Lectures)**

- 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 (2 Lectures)**
- D) Applications of Remote sensing in studying the natural resources like minerals, ground water, soil, forests & in geo-technical investigations (1 Lecture)**

Unit IV) GIS, GPS and Field Geology 12 lectures

- A) GPS, GIS and its applications (3 Lectures)**
 - a) GPS - What is GPS? Working of GPS.
 - b) GIS- What is GIS, Components of GIS, Data base management systems, Raster and vector data
 - c) Applications of remotely sensed data using GPS & GIS

- B) Field Geology (9 Lectures)**
 - a) Literature review
 - 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

REFERENCE BOOKS –

- 1) Manual of Field Geology : Compton R.J
- 2) Field Geology : Lahee
- 3) Remote Sensing and Image Interpretation : Kiefer & Lillesand
- 4) Principles and Applications of Photogeology : Pandey S.N.
- 5) Remote Sensing: Principles and Applications : Sabins F.F.
- 6) Remote Sensing & GIS : B. Bhatta
- 7) An Introduction to Geographical Information Systems : Ian Heywood e.tal.
- 8) Remote Sensing of the Environment. An earth resource perspective : by John R. Jenson (2003)
- 9) Introduction to Geographical Information Systems : Kang-tsung Chang (2002)
- 10) Geomorphology: Thornburry
- 11) Concepts of Geomorphology: Gupta and Kale
- 12) Photogeology: Gupta
- 13) Landforms and Tectonics: Olier

GL – 341: Metamorphic Petrology:

UNIT I) Introduction to Metamorphism: 12 Lectures

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

Unit II) Types of metamorphism I 12 Lectures

A) Thermal Metamorphism (6 Lectures)

- 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
- e) Aureoles of Thermal metamorphism
- f) Effects of thermal metamorphism on :
 - i) Igneous rocks (Intermediate & basic)
 - ii) Aluminous & ferruginous deposits
 - iii) Non – calcareous argillaceous sediments

B) Dynamic/ Cataclastic metamorphism: (6 Lectures)

- 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.

Unit III) Types of metamorphism II 12 Lectures

A) Regional Metamorphism & its products (7 Lectures)

- a) Definition & general characteristics of the sub types of regional metamorphism
- b) Depth zones & characteristic minerals
- c) Diagrammatic representation of the conditions controlling metamorphism
- d) Barrovian zones of regional metamorphism.
- e) Development of textures & structures of regionally metamorphosed rocks
- f) Crystal growth under stress
- g) 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 (2 Lectures)

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

C) Pneumatolysis / Metasomatism (3 Lectures)

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

UNIT IV) Metamorphic texture & structure

12 Lectures

- 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

REFERENCE BOOKS -

- 1) Igneous & Metamorphic petrology : by Myron Best
- 2) Principles of Petrology : by G.W. Tyrell
- 3) Igneous, Metamorphic & Sedimentary petrology : by Ehler & Blatt
- 4) Igneous & Metamorphic petrology : by Turner & Verhoogen.
- 5) Metamorphism : by Alfred Harker.
- 6) Principles of Igneous and Metamorphic Petrology: John D. Winter
- 7) Principles of metamorphic petrology by Vernon and Clarke, 2008
- 8) Petrology of metamorphic rocks, Roger Mason

GL-342: Environmental Geology

- Unit I) Concept, Objective and Scope of Environmental Geology: 12 lectures**
- A) Seven concepts, Objectives, and Scope of Environmental Geology; Physical, Biological, and Socio-geological Environment, Bio-geochemical cycles. (4 lectures)**
 - B) Deterioration of land surface: Dimensions of Erosion, processes, causes of accelerated erosion, remedial measures. (2 lectures)**
 - C) Desertification and degradation of land: meaning, extent, causes and preventive measures. (4 lectures)**
 - D) Soil conservation, badland topography, alkalinity and salinity of soils (2 lectures)**

Unit II) Natural Hazard and Mitigation: I 12 lectures

- A) Natural hazards:** Definition, type, Natural hazard zones and Impact assessment, Natural hazard zonation maps, Role of Geologists in disaster management plan
(2 lectures)
- B) Distinction between:** hazard and disaster (with examples), local and regional context, disaster profile of India
(1 lecture)
- C) 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
(3 lectures)
- D) 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
(3 lectures)
- E) 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
(3 lectures)

Unit III: Natural Hazard and Mitigation: II : 12 lectures

- A) Floods:** Introduction, definition, classification, causative factors, vulnerability, predictability (forecasting), mitigation measures, flood hazards in India
(3 lectures)
- B) Coastal hazards:** Introduction, causes and impacts of coastal erosion, tsunami, storms and their predictability and mitigation measures
(3 lectures)
- C) Mining hazards:** Types of mining hazards and restoration techniques
(3 lectures)
- D) Subsidence of land:** Causes of subsidence of land, prediction and mitigation measures
(3 lectures)

Unit IV: Crises, Conservation of natural resources and pollution: 12 lectures

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 **(2 lectures)**

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) **(3 lectures)**

b) **Soil Pollution:** Sources of soil pollution (use of pesticides, fertilizers, industrial domestic water, and their effects) **(2 lectures)**

c) **Air pollution:** Sources of air pollution, (aerosols, particulate matters in urban and industrial area), case histories: Chernobyl disaster and Bhopal gas disaster **(2 lectures)**

C) Solid waste disposal: Solid waste disposal methods (deep well disposal, ocean dumping, hazardous chemical wastes), its effects with geological perspective **(3 lectures)**

REFERENCE BOOKS -

1. Environmental Geology : By K.S. Valdiya
2. Environmental Geology : by E.A. Keller (Latest Edition)
3. Mining & Environment : by Bharat B. Dhar
4. Mineral Economics : by Sinha R.K.
5. Geology in Environmental planning : by A.D. Howard.

GL-343 : Economic Geology

Unit I) Basics of Economic Geology & Primary processes of formation of mineral deposits: 12 Lectures

A) Introduction: (2 Lectures)

- 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

B) Magmatic Concentration: (3 Lectures)

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

C) Hydrothermal processes: (7 Lectures)

- 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 (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
- c) Metasomatic replacement: Definition, Criteria of replacement & resulting mineral deposits

Unit II) Secondary processes of formation of mineral deposits: 12 Lectures

A) Oxidation & Supergene enrichment: (6 Lectures)

- 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: (6 Lectures)

- 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

Unit III) Metallic & Radioactive deposits of India

12 Lectures

A) Study of following metallic deposits with reference to mineralogy, properties, uses & their geological & geographical distribution (8 Lectures)

- i) Precious metals : Gold, Silver.
- ii) Non-ferrous metals : Copper, Lead, Zinc & Aluminium
- iii) Iron & Ferro alloy metals – Iron, Manganese, Nickel & Chromium
- iv) Polymetallic Nodules

B) Plate tectonics & mineral deposits: (1 Lecture)

Mineral deposits associated with different plate boundaries

C) Radioactive minerals: (3 Lectures)

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

Unit IV] Fossil Fuels:

12 Lectures

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) (6 Lectures)

B) Coal: Origin, mode of occurrence, types of coal, Important Indian occurrences. (4 Lectures)

C) Introduction to coal bed methane, Shale gas & Gas hydrates. (2 Lectures)

REFERENCE BOOKS-

- | | |
|---|------------------------------|
| 1. Economic mineral deposits | :by Bateman |
| 2. Ore deposits of India | :by Gokhale & Rao |
| 3. India's Mineral Resources | :by Krishnaswami |
| 4. India's Minerals | :by D.N Wadia |
| 5. Industrial Minerals | :by Deb. |
| 6. Geology Of the industrial rocks & minerals | :by Rober L.Bates |
| 7. Economic Geology | :by Umeshwar Prasad |
| 8. Geology of Petroleum | :by A.I. Levorsen |
| 9. Economic mineral deposits of India | :by Umate (IBM) |
| 10. Elements of Petroleum geology | :by R.C. Selly (2002) |
| 11. Economic Ore Deposits | :by Park & Mc-dermitt (1997) |

GL: 344-Geotectonics

Unit I) Introduction to Geodynamics 12 Lectures

A) Evolution & formation of the solar system & earth & its physical properties (2 Lectures)

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

B) Interior of the Earth: (10 Lectures)

- 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, 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

Unit II) Global tectonics I – Geomagnetism & Introduction to Plate Tectonics

12 Lectures

A) Introduction to Palaeomagnetism (5 Lectures)

- 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)
- d) Magnetic anomalies & sea floor Spreading- Mechanics & applications
- e) Magnetic reversal & geomagnetic time scale.

B) Plate Tectonics (7 Lectures)

- 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

Unit III) Global tectonics II- Plate Tectonics II

12 Lectures

A) Three plate boundaries- (Divergent, Convergent & Transform faults-description & examples). (7 Lectures)

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 (1 Lecture)**
- e) Concept of triple junctions with their examples (1 Lecture)**
- f) Basin tectonics – Introduction to fore arc, back arc, foreland & rift basins. (1 Lecture)**
- g) Concept of hot plumes & hot spots with examples (1 Lecture)**
- h) Overview of Phanerozoic Tectonics- Spatial and Temporal evolution of palaeo supercontinents to present continents. (1 Lecture)**

Unit IV) Global Tectonics III- Origin of Mountains and Introduction to Archaean and Neotectonics 12 Lectures

- A) Origin of mountains (4 Lectures)**
 - a) Plate tectonic model
 - b) Deformation of sedimentary basins,
 - c) Plutonism & metamorphism
 - d) Orogenies in space & time
- B) Introduction to Archaean Tectonics (4 Lectures)**
 - 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
- C) Introduction to Neotectonics (2 Lectures)**
- D) Brief overview of Tectonic Evolution of India (2 Lectures)**

REFERENCE BOOKS -

1. General Geology : V. Radhakrishnan
2. Plate tectonics and Crustal evolution : Condie
3. Aspects of Tectonics : Valdiya K. S.
4. Tectonics : Moore and Twiss
5. Introducing Tectonics, Rock Structures and Mountain Belts by Graham Park
6. Geotectonics : V. V. Belousov
7. Physical Geology : Arthur Holmes
8. Global Tectonics : Keray P and Vine F.J
9. Our evolving planet : Bergen, Alma Mater Fortag
10. Dynamic Himalaya : Valdiya K. S.
11. Geomorphology and Global Tectonics : Summerfield M. A.
12. Cratons and Fold belts of India: Ram S. Sharma
13. Global Tectonics: Kerry, Klepeis, Vine
14. Planetary Tectonics- Edited by Thomas R. Watters and Richard A. Schultz
15. Plate Tectonics: Continental Drift and Mountain Building by Frisch, Meschede and Blackey
16. Paleomagnetism: Continents and Oceans by McElhinny and McFadden
17. Essentials of Paleomagnetism by Lisa Tauxe, 2010
18. PALEOMAGNETISM: Magnetic Domains to Geologic Terranes By Robert F. Butler, (1992)

GL – 345: Phanerozoic Stratigraphy of India and Palaeontology

Unit I) Introduction to Phanerozoic Stratigraphy: 12 Lectures

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

Unit II) The Paleozoic and Mesozoic Formations of Peninsular India: 12 Lectures

A) Palaeozoic Formations of Peninsular India

- a) A brief history of the Paleozoic Formations,
- b) Gondwana Supergroup: 1. Geographical distribution, 2. Stratigraphic classification- bipartite and tripartite, 3. Lithology, 4. Age, 5. Palaeoclimatic conditions, 6. Flora, 7. Fauna, 8. Igneous activity, 9. Marine intercalations, 10. 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.

Unit III) Cenozoic Formations of Peninsular India and Geology of Maharashtra

12 Lectures

A) The Deccan Volcanic Province : Distribution, extent, age, structure, mode of eruption and occurrence, Petrological characters and variations, Lithostratigraphic classification, Infra trapeans 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

Unit 4. The Phanerozoic Stratigraphy of Extra-Peninsular India and Palaeontology:

12 Lectures

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.

Study of following genera with respect to their classification, generic definition, characteristic and distribution – Ptillophylum, Glossopteris, Gangamopteris, Vertebraria, Elatocladus, Equisetales, Cladophlebis, Brachyphyllum and Gleichenites.

REFERENCE BOOKS -

- 1 Evolutionary trends in Invertebrates Swinnerton
- 2 Microfossils Brassier
- 3 Invertebrate Palaeontology Clarkson
- 4 Micropaleontology Daniel Jones
- 5 Paleobotany Arnold
- 6 Geology and Evolution of the Indian Plate S.M. Naqvi
- 7 Invertebrate Palaeontology M.A.Koregave
- 8 Geology of Maharashtra: Geological Society of India
Special Publication
G.G. Deshpande
- 9 Geology of Western & Central India: Geological Society of
India
Special Publication
- 10 Stratigraphy of Lesser Himalaya by K. S. Valdiya
- 11 A Geological Time Scale Brian Harland et.al
- 12 Stratigraphy of India and Burma M. S. Krishnan
- 13 Fundamentals of Historical Geology & Stratigraphy of India Ravindra Kumar
- 14 Geology of India Vol 1 &2. Ramkrishna-Vaidhyanathan: : Geological Society of India
Special Publication

GL: 346-Applied Geology II (Engineering Geology, Geohydrology & Prospecting)

UNIT I) Engineering Properties Of Construction Material

12 Lectures

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).

UNIT II) Geological And Geotechnical Investigations For Civil Engineering Projects

12 Lectures

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

Unit III: Geohydrology

12 Lectures

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.
- e) 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).

Unit IV) Prospecting And Mining Geology

12 Lectures

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.

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

REFERENCE BOOKS -

- 1) Principles of Geophysical Prospecting : M.B. Ramchandran
- 2) Geophysical Prospecting : Dobrin
- 3) Ground water Hydrology : Todd
- 4) Ground water : H.M. Raghunathan
- 5) Principles of Engineering Geology : Krynine & Judd
- 6) Engineering Geology : Parbin Singh
- 7) Fundamentals of Engineering Geology: R. S. Khurami
- 8) Mining Geology: Arogya Swami
- 9) Groundwater : Freeze and Cherry

GL – 347: Practical I
Mineralogy and Petrology

- Unit I) Mineralogy & Igneous Petrology** **5 Practicals**
- A) Mineralogy**
- a) Megascopic Mineralogy** **(1 Practical)**
Identification and the study of the following minerals with reference to physical properties and geological occurrence
Diopside, Mesolite, Andalusite, Albite, Phlogopite, Garnet, limonite, dolomite, halite, olivine, hornblende, augite, kaolinite **(any 10)**
- b) Microscopic mineralogy** **(1 Practical)**
Identification and the study of the following minerals with reference to optical properties:
Glaucophane, glauconite, staurolite, zircon, apatite, aegerine, hornblende, garnet, biotite, augite, plagioclase, microcline, olivine, chlorite **(any 10)**
- c) Mineral Optics** **(1 Practical)**
- a) Comparison of R.I of mineral / mounting medium using Becke line method
b) Study of accessory plates: Quartz wedge, gypsum and mica plate
c) Sign of elongation of minerals.
- B) Igneous Petrology**
- a) Description, genesis and significance of the following microscopic textures and structures** **(2 Practicals)**
Granitic, porphyritic (intergranular/ intersertal, poikilitic, ophitic and sub-ophitic), graphic, glassy, flow, serrate, vitrophyric, microlitic, spherulitic, orbicular, reaction rims, expansion cracks, spinifex, perlitic cracks, myrmekitic **(any 8)**
- Unit II) Igneous Petrology** **5 Practicals**
- A) Description, genesis and significance of the following megascopic textures and structures** **(1 Practical)**
Granitic, porphyritic, graphic, ropy, glassy, columnar, vesicular/ amygdaloidal.
- B) Megascopic igneous petrology** **(2 Practicals)**
Study of the following megascopic igneous rocks with regard to their texture, mineral composition, colour index, identification and classification:
Varieties of gabbro (anorthosite, troctolite, norite), felsites, peridotite, lamprophyre, serpentinite, varieties of basalt, carbonatite, granite, rhyolite. **(any 10)**
- C) Microscopic igneous petrology** **(2 Practicals)**
Study of the following megascopic igneous rocks with regard to their texture, mineral composition, identification and classification:
Norite, troctolite, anorthosite, peridotite lamprophyre, olivine basalt, granite, carbonatite, rhyolite, andesite **(any 8)**
- Unit III) Igneous Petrology & Sedimentology** **5 Practicals**
- A) Igneous Petrology** **(1 Practical)**
Problems related to CIPW Norm calculation for silica saturated igneous rocks
(3 problems)
- B) Sedimentology**
- a) Study of Megascopic sedimentary rocks** with regard to their texture / structure, mineral composition, identification, classification and sedimentological significance:
Laterite, bauxite, Conglomerate, breccias, grit, arkose, speckled sandstone, sandstone with dendritic markings, ferruginous and carbonaceous shale, limestone (Chemical and Organic), calc-tuffa. **(2 Practicals)**
- b) **Thin section study of the following sedimentary rocks:** Sandstone, arkose, greywacke, nummulitic and oolitic limestones, varieties of limestones with micrites and sparites. **(any 8)** **(1 Practical)**

c) Interpretation of the sedimentary structures giving their geological significance:

Sandstone showing parallel bedding, cross bedding, graded bedding, ripple marks, Mud / sun cracks, laminations, tracks and trails, Ball & Pillow, Flame, Load cast, Flute marks **(any 7)** **(1 Practical)**

Unit IV) Metamorphic Petrology

5 Practicals

A) Study of the following metamorphic megascopic rocks with regard to their texture / structure, mineral composition, colour, type of metamorphism, grade facies and the original rocks **(2 Practicals)**

Slate, phyllite, chlorite schist, mica(Biotite) schist, hornblende schist, staurolite schist, Kyanite schist, talc – tremolite schists, mica gneiss, hornblende gneiss, sillimanite gneiss, augen gneiss, eclogite, charnockite, fuschite quartzite, banded haematite quartzite, marbles (White, Pink, Black, Green and dolomite varieties), schorl, skarn. **(any 8)**

B) Study of the thin sections of the following metamorphic rocks with regard to their / structure, mineral composition, colour, type of metamorphism, grade, facies and the original rock **(2 Practicals)**

Chiastolite slate, chlorite schist, staurolite schist, kyanite schist, mica gneiss, sillimanite gneiss, augen gneiss, eclogite, charnockite, khondalite, banded haematite quartzite. **(any 8)**

C) Plotting of Chemical Composition of Metamorphic rocks on ACF diagrams. **(3 problems)** **(1 Practical)**

GL348: Practical II
Structural Geology, Economic Geology, Palaeontology & Indian Stratigraphy

Unit I) Geological maps: (At least 8 maps) 5 practicals
Description of topography & geology of the map. Drawing vertical section of the map along given direction.

(Note: Geological maps should contain different topographic patterns & all possible structural complexities like unconformity, vertical / inclined faults (strike /dip /oblique), vertical/ inclined dykes, lava flows, sills & symmetrical non-plunging folds.)

Unit II) Geological maps, Economic Geology & Precambrian Stratigraphy of India 5 practicals

A) Completion of outcrops: (At least 10 maps) (3 practicals)

Completion of an outcrop with the help of given topographic & lithological data

Note: One junction line may be partly shown or location of one junction line at three noncollinear

points may be given along with geologic / stratigraphic column. Such maps should also contain different topographic patterns & structural complexities like unconformity, vertical faults (strike /dip).

B) Economic Geology (1 practical)

a) Megascopic

Ore minerals- To study at least 10 selected ore minerals

Industrial minerals- - To study at least 10 selected industrial minerals.

b) Preparation of an ore mineral map of India for the following:

Fe, Mn, Cr, Cu, Pb, Zn & Al.

C) Precambrian Stratigraphy of India (1practical)

Preparation of maps showing geographical distribution of the following stratigraphic units of India:

- a. Dharwar Supergroup,
- b. Orissa – Singhbhum belt,
- c. Aravalli Supergroup
- d. Cuddapah Supergroup,
- e. Vindhyan Supergroup,

Unit III- Structural problems 5 practicals

A) Graphical problems-(To be solved by using method of descriptive geometry)

Type I)

Hill slope, attitude of the exposures of top & bottom of the bed on the hill slope along with true thickness of the bed given, finding out true dip direction, true dip amount & other geometrical parameters of the bed. With comment on normal or overturned bed.

Type II) Problems involving a single planar feature containing a linear feature:

a) Attitude of planar feature along with the bearing of a linear feature contained in it given, finding out plunge & rake of a linear feature in the given planar feature.

b) Attitude of a planar feature along with rake of a linear feature contained in it given, finding out bearing & plunge of the linear feature.

Type III)

Problems involving intersection of two planar features whose attitude readings are taken at the same elevation and to find out the bearing and plunge of the line of intersection and the

rake of the line of intersection in both the planar features.

Type IV)

Three point problems:-

Drill hole data for a hidden planar feature at three non-collinear points given in the form of

location, elevation & absolute depth of planar feature, finding out strike, true dip direction & true dip amount of the planar feature. Also determining one of the three parameters (location, elevation & absolute depth) where the other two parameters are known.

UNIT IV) Stereographic Problems, Phanerozoic stratigraphy of India & Palaeobotany
5 practicals

A) Stereographic Problems, (To be solved by using stereographic net)
(3 practicals)

Type I) Problems involving strike, true & apparent dip of a bed

a) Strike & true dip of the bed given, finding out apparent dip amount of the bed in the given apparent dip direction.

b) Strike & true dip of the bed given, finding out apparent dip directions for the given apparent dip amount.

c) Apparent dip amount of the bed in two different apparent dip directions given, finding out strike direction, true dip direction & true dip amount of the bed.

Type II) Problems involving a single planar feature containing a linear feature.

Types (a,b) are same as types (a,b) from the graphical problems respectively.

Type III) Problems involving two intersecting planar features- Same as type III from graphical problems.

Type IV) Stereographic projections of the following types of folds-

- i) Upright fold ii) Recumbent fold iii) Inverted fold iv) Reclined fold v) Inclined fold
- vi) Plunging fold

B) Phanerozoic Indian Stratigraphy:

Preparation of maps showing geographical distribution of the following stratigraphic units of India
(1 practical)

- a. Palaeozoic of Spiti
- b. Gondawana Supergroup,
- c. Jurassic of Kachchh, Cretaceous of Trichinopoly, Bagh Beds,
- d. Deccan Traps,
- e. Siwaliks,
- f. Tertiaries.

C) Palaeobotany:
(1 practical)

Generic definition, geological & geographic distribution of the following plant genera (any 5):

Glossopteris, Gangamopteris, Pterophyllum, Ptilophyllum, Vertebraria, Equisetales, Cladophlebis, Gleicherites, Elatocladus, Brachyphyllum

GL – 349: Practical – III
Remote Sensing, Geohydrology, Environmental Geology, Geophysical Prospecting & Field Geology:

- Unit I) Geomorphology and Satellite Imagery interpretation: 5 Practicals**
- A) Drainage Basin Analysis: Stream ordering by Strahler method and calculation of Bifurcation Ratio, Area of basin and stream frequency **(2 practicals)**
 - B) Visual interpretation of false colour composite (FCC) OR B/W satellite imageries: Identification of the lithology, structures, vegetation (Crops & forest cover), Land use and drainage patterns **(1 practical)**
 - C) Tracing of the drainage of an area with the on satellite imageries and identification of its type **(1 practical)**
 - D) Tracing of lineaments from satellite imageries and its analysis **(1 practical)**
- Unit II) Photogeology and Soil Analysis: 5 Practicals**
- A) Problems related to:
Scale of aerial photographs & relief displacement – Type A to D **(1 practical)**
 - B) Problems related to:
Scale of aerial photographs & relief displacement – Type E and mixed type **(1 practical)**
 - C) To identify geomorphology of an area from aerial photographs **(1 practical)**
 - D) Lithological & structural interpretation of aerial photographs **(1 practical)**
 - E) Textural classification of soil based on sand, silt and clay fractions **(1 practical)**
- Unit III) Engineering Geology and Hydrogeology 5 Practicals**
- A) Engineering problems in the form of maps with respect to tunnel and dam site- **(2 practicals)**
 - B) Preparation of hydrographs from given waterlevel data **(1 practical)**
 - C) Preparation of water table contour maps from given waterlevel data **(1 practical)**
 - D) To find Water Quality Index **(1 practical)**
- Unit IV) Environmental Geology, Prospecting and Field Geology 5 Practicals**
- A) Preparation of Hazard zonation maps for India and World **(1 practical)**
 - B) Problems related to Resistivity data (VES) for location of bore /dug well **(2 practicals)**
 - C) Field work for about two weeks, in an area of geological interest anywhere in India. Systematic collection of geological samples, data collection & preparation of geological field report **(2 practicals)**