K. J. SOMAIYA COLLEGE OF SCIENCE AND COMMERCE,

VIDYAVIHAR, MUMBAI 400 077

AUTONOMOUS- AFFILIATED TO UNIVERSITY OF MUMBAI

Scheme of Course Structure (Faculty of Science) 2020-2021

Syllabus for **T.Y. B.Sc.**

Program: **B.Sc.**

Course: **Geology**

(Choice based Credit System System with effect from

the academic year 2020–2021)

Preamble

1) Understanding the fundamentals of Stratigraphy, stratigraphic succession and stratigraphic correlation for different geological formations of India
2) To understand the evolution and occurrence of igneous, sedimentary and metamorphic rocks and their specific textures and structures which help in identification of the rocks and their formation histories
3) To develop the ability to identify and understand the structure of different geological structures like folds, faults, joint planes; their identification on field. To learn about the implication of geology in civil projects
4) To develop skills for preparation of topographical maps, geological maps and identification of geomorphic forms to help in mapping. Also to learn about groundwater movement and prospecting
5) To know about the science of remote sensing and its application in various fields such as geologic and geomorphic investigation, navigation, communication and disaster management
6) To understand the fundamental process involved in formation of the Earth, abundance of elements and their isotopes; formation and interaction of the lithosphere, atmosphere and biosphere and their interaction with climate through geological time

Syllabus – T.Y.B.Sc. Geology

Semester V	Course Number	Course Title	Course code	Credits	Hours	Periods (50 min)	Unit/ Module	Lectures (50 min)
	1	Precambrian Stratigraphy	20US5GEPS1	2	30	36	3	12
	2	Igneous Petrology- evolution of igneous rock	20US5GEIP2	2	30	36	3	12
	3	Structural Geology	20US5GEST3	2	30	36	3	12
	4	Sedimentary Geology	20US5GESD4	2	30	36	3	12
DSE	1	Element of Geochemistry	20US5GEGC1	2	30	36	3	12
	2	RS-GIS	20US5GERS2	2	30	36	3	12
	3	EXPLORATION GEOLOGY	20US5GEEG3	2	30	36	3	12
SEC		Field Geology I: Economic Geology and Mining methods	20US5GEFG	2	30			

Semester VI								
	1	Phanerozoic Stratigraphy	20US6GEPS1	2	30	36	3	12
	2	Igneous Petrology- textures and structures	20US6GEIP2	2	30	36	3	12
	3	Metamorphic Petrology	20US6GEMP3	2	30	36	3	12
	4	Engineering Geology	20US6GEEN4	2	30	36	3	12
DSE	1	Earth and Climate	20US6GEEC1	2	30	36	3	12
	2	Urban Geology	20US6GEUG2	2	30	36	3	12
	3	Evolution of life through time	20US6GEET3	2	30	36	3	12
SEC		Field Geology-II	20US6GEFG	2	30			

SEMESTER V

Course: STRATIGRAPHY AND GEOLOGY OF INDIA – PRECAMBRIAN

Course Outcome: To understand, history of earth and Indian subcontinent during its formation about 4.0 Ga.

Course Specific Outcome: Students will have a brief idea about tectonic elements of continent and ocean; they will understand evolution of peninsular and extra peninsular India during Archean period and Proterozoic sedimentary basin evolution and mineralization.

Number of lectures: 12 per unit/module

Unit **Stratigraphy and Geology of India – Precambrian**

I **Learning Objective:**

To define tectonic elements of continent and ocean. Describe tectonic division of India.

Learning Outcome:

1. Understand craton, folded mountain belt.
2. Describe geology of different cratons of India.

Earth's Crustal Structure, Tectonic divisions of India and Precambrian Basement of Indian Peninsula:

Tectonic Elements of Continents, Tectonic Elements of Oceans. Tectonic Divisions of India.

II **Learning Objective:**

Comprehensive knowledge on Precambrian sedimentary basin.

Learning Outcome:

1. Describe about Proterozoic sedimentary basins of India and its mineralization.
2. Explain sedimentary environment of different formation.

Precambrian: Dharwar Province, Central Indian Province Singhbhum Orissa Province, Aravalli Bundelkhand Province.

Precambrian of the Tethyan Basement.

Precambrian of the Lesser Himalaya.

III Learning Objective:

Discuss stratigraphic formation of Tethyan basement

Learning Outcome:

Understand different lithology deposits of Tethyan and lesser Himalaya.

Proterozoic History Basement Cover Transition.

Proterozoic Succession:

Lower Purana Succession and Upper Purana Succession.

Recommended Books and References

1. Krishnan, M. S. (1982) Geology of India and Burma, CBS Publishers, Delhi

2. Doyle, P. & Bennett, M. R. (1996) Unlocking the Stratigraphic Record. John Wiley

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

4. Valdiya, K. S. (2010) The making of India, Macmillan India Pvt. Ltd.

Course: IGNEOUS PETROLOGY – Evolution of Igneous Rocks

Course Outcome:

Comprehend the interior structure of Earth and role of magma in formation of different types of igneous rocks.

Course Specific Outcome:

1. State the composition of Earth and establish its evolution with geological time.
2. Outline several factors affecting the genesis of magma, its differentiation and generation of igneous rock types.

Number of lectures: 12 per unit/module

Unit **Igneous Petrology – Evolution of Igneous Rocks**

I **Learning Objective:**

1. Discuss the formation and composition of Earth and seismic variation within the Earth.
2. Describe several mechanisms of evolution and differentiation of magma.

Learning Outcome:

1. Acquainted with different divisions of Earth present and its significance.
2. Assess the role of plate tectonics, temperature, pressure and fluids in generation of magma.

The Interior of the Earth: Evidence of the Earth's Composition and Mineralogy: Seismic data, Meteorites, Xenoliths. Mantle Petrology; Low Velocity Zone, Pressure and Temperature variations with Depth. Magma generation and plate tectonics.

The Evolution of Magmas: Differentiation: Fractional Crystallization and Other Differentiation Mechanisms. Magmatic Mixing and Assimilation. Melting of the mantle, generation of Basaltic magma from a Chemically Uniform Mantle.

II **Learning Objective:**

1. Demonstrate the importance of Phase Equilibrium and Phase Rule.
2. Compare one component and two component systems and its petrogenetic significance.

Learning Outcome:

1. Define the basic principle governing systems in thermodynamic equilibrium.
2. Discuss the role of temperature and pressure on crystallization of magma.

The Phase Rule and System with One and two Component Systems: Melting Behavior of Natural Magmas, Phase Equilibrium and The Phase Rule, One Component Systems, Two Component (Binary Systems) and Its Petrogenetic Significance. Binary Systems with Complete Solid Solution, Binary Eutectic Systems, Binary Peritectic Systems, the Alkali

Feldspar System.

III Learning Objective:

1. Illustrate the crystallization and melting relationships in multi component systems.
2. The effects of pressure variation and different fluids on the melting and crystallization of magma.

Learning Outcome:

1. Comment on the petrogenetic significance and igneous textures associated with multi component systems.

System with More Than Two Components. Ternary Systems:- Ternary Eutectic Systems, Ternary Systems with Solid Solution Reaction Series, The effect of fluids on Melting Behaviour. The effects of Pressure on the Melting and Crystallization of Magma.

Recommended books and references:

1. Best M.G. Igneous and Metamorphic Petrology, Blackwell Publications

2. Blatt H., Tracy R.J. and Owens B.E. (2006), Petrology – Igneous, sedimentary and Metamorphic rocks (3 rd Edition), W.H. Freeman and Company, New York.

3. Bose M.K. (1997), Igneous Petrology. The World Press Pvt. Ltd. 568 p.

4. Bowen N.L. (1928), The evolution of Igneous Rocks. Princeton Univ. Press. N.J. 332 p.

5. Collinson J.D and Thompson D.B (1989), Sedimentary Structures (2nd Edition), Unwin Hyman Ltd, Sydney.

6. Ehlers, E.G. and H. Blatt (1982), Petrology, Igneous, Sedimentary and Metamorphic, W.H Freeman, San Francisco.

7. Hatch F.H., Wells A.K and Wells M.K. (1984), Petrology of the igneous rocks. CBS Publishers, 551 p.

8. Turner F.J and Verhoogen J. (1960), Igneous and Metamorphic Petrology, Mc Graw- Hill.

9. Tyrrel G.W. (1998), The Principles of Petrology, B.I. Publications Pvt. Ltd.

10. Winter J. D. (2001), an Introduction to Igneous and Metamorphic Petrology, Prentice Hall, 697p

Course: STRUCTURAL GEOLOGY

Course Outcome: To understand the basic concepts of structural geology

Course Specific Outcome: Students will be able to understand, comprehend, assess, analyse different structures and develop core competencies to apply this knowledge in field and practical problems. This course will greatly enhance their skills in structural mapping.

Number of lectures: 12 per unit/module

Unit	Structural Geology

I

Learning Objective:

To get a thorough understanding and definitions of the fundamental concepts of structural geology.

Learning Outcome:

1. Define structural geology and understand its significance
2. Analyse the topographic, structural features and understand structural maps
3. Understand, analyse and assess the effect of stress and strain in rocks and field

Structure and Topography: Effects of topography on structural features, Topographic and structural maps; Importance representative factors of the map, Concept of dip and strike; Outcrop patterns of different structures

Concept of deformation/Rock Rheology: Elastic (Hookean) Behavior, Permanent Deformation – Ductility Controlling Factors

Stress: Definition, Stress on a Plane, Stress at a Point, Mohr Construction, Mohr's Hypothesis, Stress Ellipsoid

Strain: Definitions, Strain Ellipsoid, Simple and Pure Shear, Measurement of Strain in Rocks, Strain Markers, Flinn Diagram

II **Learning Objective:**

To get comprehensive understanding of brittle deformations.

Learning Outcome:

1. Understand and illustrate the mechanism for the formation of Joints and Faults
2. Classify the type of fault based on geometry and genetics
3. Understand, analyse and illustrate the effect of faulting on the outcrops

Study of Structures – (Joints): Joints, fractures and Shear Fractures, Formation of a Fracture Griffith Theory, Joints and Fracture Mechanics, Joints in Plutons

Study of Structures – (Faults): Geometric and genetic classification and terminology, Criteria for Faulting; Brittle versus Ductile Faults, Introduction to Shear Zones, Brittle shear zone, Shear – Sense Indicators

Effects of faulting on the outcrops : Outcrop patterns, Geologic/geomorphic criteria for recognition of faults and fault plane solutions

III **Learning Objective:**

To get comprehensive understanding of ductile deformations.

Learning Outcome:

1. Classify the type of folds
2. Understand, analyse and illustrate the complex folding patterns
3. Understand and illustrate the mechanism for the formation of folds

Study of Structures – (Folds): Fold Geometry and Classifications, Classifications based on Interlimb angle, Ramsay standard classification

Fundamentals of Parallel Folds and Similar Folds. Ductile shear zones.

Complex Folds: Occurrence and Recognition, Fold Interference Patterns, Fold Mechanisms and accompanying phenomena, ptygmatic folding, chevron folding, Deformation mechanism in folds

S-L Tectonites (lineations, foliations)

Recommended books and references:

1. Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley

2. Billings, M. P. (1987) Structural Geology, 4th edition, Prentice-Hall.

3. Park, R. G. (2004) Foundations of Structural Geology. Chapman & Hall.

4. Pollard, D. D. (2005) Fundamental of Structural Geology. Cambridge University Press.

5. Ragan, D. M. (2009) Structural Geology: an introduction to geometrical techniques (4th Ed). Cambridge University Press (For Practical)

6. Fossen, H. (2016). Structural geology. Cambridge University Press.

Course: SEDIMENTARY PETROLOGY

Course Outcome:

Identify the sedimentary rocks and the process of their formation

Course Specific Outcome:

Explain the process of formation of different types of sedimentary rocks

Number of lectures: 12 per unit/module

Unit **Sedimentary Petrology**

I **Learning Objective:**

Understanding the process of formation of various sedimentary rocks and structures.

Learning Outcome :

1. Classify different sedimentary rocks.
2. Be acquainted with the different types of primary and deformational structures found in a sedimentary rock
3. Identify the energy conditions during which a sedimentary structure was formed in any sedimentary rock.

Origin and Transport of sedimentary materials: Origin, Transportation, and deposition of sediments. Sedimentary textures: Laboratory Techniques, Grain Size, Udden-Wentworth

Size Scale, Phi Scale, Grain Size Measurement, Roundness and Shape, Grain to Grain relationship, permeability and porosity.

Sedimentary structures: Stratification and bedforms: Laminated bedding, Graded bedding, Ripples, Dunes, Antidunes, cross-stratification. Convolute bedding and Lamination, Flame structure, Dish and Pillar structures, Scour and fill Structures. Bedding-Plane Marking: Groove Cast, Striation, bounce, brush, prod, and roll marks Flute Cast, Load Cast, Tracks, Trails, Burrows and Mudcracks.

II **Learning Objective:**

Discuss origin of the clastic sedimentary rocks

Learning Outcome:

1. Students will be able to identify and classify the clastic sedimentary rocks.
2. Be acquainted with the significance of grain size and mineralogy in understanding the provenance

Clastic sedimentary rocks: Classification of sedimentary rocks, Sandstone: Framework minerals, Cement, Matrix, Classification of Sandstone, Sandstone Maturity. Conglomerate: Particle Composition, Classification, Origin and occurrence of Conglomerates. SHALES: Composition, Classification, Origin and Occurrence of Shales. Diagenesis and Provenance of Siliciclastic rocks.

III **Learning Objective:**

Discuss origin of the non-clastic sedimentary rocks

Learning Outcome:

1. Students will be able to identify and classify the non-clastic sedimentary rocks.
2. Attain knowledge of the genesis of various types of non-clastic rocks

Non-clastic Sedimentary Rocks: Limestones and Dolomites: chemistry and Mineralogy,

Limestone texture, Dolomite texture, classification of carbonate rocks, Other Types of Sedimentary Rocks: Evaporites, Kinds of Evaporites and Origin of Evaporite deposits. Cherts: Phanerozoic Marine Cherts; Phanerozoic Nonmarine Cherts; Precambrian Cherts. Phosphate Rocks: Origin of Phosphorites. Bedded Iron Deposits: Oolitic Iron Formations; Bedded Iron Formations.

Recommended books and references:

1. Pettijohn F.J. (1984), Sedimentary Rocks (3 rd Edition), CBS Publishers and Distributors, New Delhi

2. Sengupta S.M. (2007), Introduction to Sedimentology (2 nd Edition), CBS Publishers and Distributors, New Delhi.

3. Collinson, J. D. & Thompson, D. B. (1988) Sedimentary structures, Unwin- Hyman, London.

4. Nichols, G. (2009) Sedimentology and Stratigraphy Second Edition. Wiley Blackwell

5. Tucker, M. E. (2006) Sedimenary Petrology, Blackwell Publishing.

6. Boggs Jr, S. (2014). Principles of sedimentology and stratigraphy. Pearson Education.

Course: GEOCHEMISTRY

Course Outcome:

Comprehend the geochemistry of solar system and solid Earth

Course Specific Outcome:

Geochemical classification of elements and its isotopic types

Number of lectures: 12 per unit/module

Unit **Geochemistry**

I **Learning Objective:**

Get introduced to geochemical properties of elements

Learning Outcomes:

Learn the basics of periodic table and bonding states of elements

Concepts of geochemistry

Introduction to properties of elements: The periodic table, Chemical bonding, states of matter and atomic environment of elements, Geochemical classification of elements

II **Learning Objective:**

Discuss the composition of layered Earth and isotopic and elemental abundance

Learning Outcome:

Study of nuclides and radioactivity in different reservoirs of Earth

Layered structure of Earth and geochemistry

Composition of different Earth reservoirs and the nuclides and radioactivity, Conservation of mass, isotopic and elemental fractionation, Concept of radiogenic isotopes in geochronology and isotopic tracers

III **Learning Objective:**

Analyse the geochemical variation in solid Earth and behaviour of important silicate elements

Learning Outcome:

1. Describe the process of formation of solar system
2. Study the composition of Earth using meteorites

Geochemistry of solid Earth

The solid Earth – geochemical variability of magma and its products.

The Earth in the solar system, the formation of solar system, Composition of the bulk silicate Earth, Meteorites, Geochemical behaviour of selected elements like Si, Al, K, Na etc.

Recommended Books and references:

1. Mason, B. (1986) Principles of Geochemistry. 3rd Edition, Wiley New York.

2. Rollinson, H. (2007) Using geochemical data – evaluation, presentation and interpretation. 2nd Edition. Publisher Longman Scientific & Technical.

3. Walther, J. V. (2009). Essentials of geochemistry. Jones & Bartlett Publishers.

4. Albarède, F. (2003). Geochemistry: an introduction. Cambridge University Press.

5. Faure, Gunter and Teresa M. Mensing (2004). Isotopes: Principles and Applications, Wiley India Pvt. Ltd

Course: REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM

Course Outcome:

To understand the basic concepts used in remote sensing and GIS

Course Specific Outcome:

To analyse the suitability of a dataset for different applications related to remote sensing and GIS

Number of lectures: 12 per unit/module

Unit **Remote Sensing and Geographic Information System**

I **Learning Objective:**

To understand the basic principles of electromagnetic radiation and study the basic principles used in remote sensing techniques

Learning Outcome:

1. Understand the energy interactions in the atmosphere and with the different earth surface features
2. Analyse the spectral responses from different earth surface features

Energy Sources and Radiation Principles

Energy interactions in the Atmosphere: Scattering, Absorption

Spectral Reflectance of Vegetation, Soil and Water, Spectral response patterns, Atmospheric Influences on Spectral Response Patterns.

II Learning Objective:

To learn the different characteristics of a scanning system and get introduced to various scanning systems in use

Learning Outcome:

1. Learn about the types of data characteristics that are used in remote sensing, their characteristics and interaction with one another
2. Analyse the different digital formats used to save datasets

The four types of resolution, digital data formats

Scanners and their Operating principles. Along and Across-track scanning

Satellite Sensor and Scanner Systems: Multispectral and Hyper spectral Sensing. Thermal scanning. Thermal Radiation principles.

III Learning Objective:

To understand the basic principles of landform identification and factors controlling a geographical information system

Learning Outcome:

1. Become conversant with the use of aerial photography for measurements using photogrammetry methods
2. Learn the use of aerial photos and satellite imageries in landform evaluation
3. Understand the basics of a GIS system and its governing data models

Fundamentals of Visual Image Interpretation. Principles of Landform Identification and Evaluation.

Type of aerial photos, determination of photo scales, aerial photos, types of parallax, flight procedures

Components of GIS system, hardware and software requirements of a GIS system

Coordinate system, Raster and Vector GIS models and analysis

Recommended books and references:

1. Demers, M.N., 1997. Fundamentals of Geographic Information System, John Wiley & sons. Inc.

2. Hoffmann-Wellenhof, B., Lichtenegger, H. and Collins, J., 2001. GPS: Theory & Practice, Springer Wien New York.

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

4. Lillesand, T. M. & Kiefer, R.W., 2007. Remote Sensing and Image Interpretation, Wiley.

5. Richards, J.A. and Jia, X., 1999. Remote Sensing Digital Image Analysis, Springer-Verlag.

Course: EXPLORATION GEOLOGY

Course Outcome:

To understand the basic concepts used in mineral exploration

Course Specific Outcome:

To classify various mineral deposit and processes of mineral reserves.

Number of lectures: 12 per unit/module

Unit-I Mineral Resources

Learning Objective:

To understand the basic principles of economic Geology and identification of mineral reserves

Learning Outcome:

1. Understand the various processes that form the mineral reserves
2. Classify the various types of mineral deposits

Mineral Resources

Resource reserve definitions, Mineral resources in industries – historical perspective and present, A brief overview of classification of mineral deposits with respect to processes of formation in relation to exploration strategies.

Unit II: Prospecting and Exploration

Learning Objective:

To learn the different Principles of mineral exploration and mineral Prospecting

Learning Outcome:

1. Understand the various principles of mineral exploration
2. Get acquainted with various processes of mineral exploration

Prospecting and Exploration,

Principles of mineral exploration, Prospecting and exploration- conceptualization, methodology and

stages, Sampling, subsurface sampling including pitting, trenching and drilling, Geochemical exploration.

Unit III: Drilling and Logging

Learning Objective:

To understand the core and non-core drilling methods

Learning Outcome:

Understand the various Core and non-core drilling methods

Drilling and Logging

Core and non-core drilling

Planning of bore holes and location of boreholes on ground

Core-logging

SUGGESTED READINGS:

1. Clark, G.B. 1967. Elements of Mining. 3rd Ed. John Wiley & Sons.

2. Arogyaswami, R.P.N. 1996 Courses in Mining Geology. 4th Ed. Oxford-IBH.

3. Moon, C.J., Whateley, M.K.G., Evans, A.M., 2006, Introduction to Mineral Exploration,

Blackwell Publishing.

Course: Field Geology-I (Economic geology and Mining methods)

Module I

Unit 1: Visit to any mineral deposit

Unit 2: Mode of occurrence of ore, Ore mineralogy

Unit 3: Ore-Host rock interrelation

Unit 4: Ore formation process

Unit 5: Basic techniques of surveying, concept of outcrop mapping

Module 2

Unit 1: Visit to underground or open cast mine

Unit 2: Practical experience of mining methods

Unit 3: Underground mapping/ Bench mapping

Unit 4: Isopach and Isochore maps.

Course code **PRACTICALS**

20US5GEP1 **Stratigraphy and Geology of India, Maharashtra and Mumbai**

1. Standard Geological Time Scale
2. Diagrammatic examples of Lithostratigraphic boundaries and classification
3. Study of fold and fault characteristics from Geological maps with geological history of the area in chronological order
4. Problems on radiometric dating

20US5GEP1 **Igneous Petrology**

Megascopic Structures and Textures Identification of Igneous Rocks: Equigranular: Hypidiomorphic, Panidomorphic. (Orthophyric), Allotriomorphic (Aplitic), Aphanitic Inequigranular: Porphyritic, Glomeroporphyritic, Ophitic/ Subophitic, Poikilitic, Intergranular, Intersertal Directive: Banded (Fluidal), Trachytic Intergrowth: Graphic/Micrographic, Perthitic, Granophyric

Igneous Mega-Structures Vesicular/ Amygdaloidal Lava, Blockery/ Clinkery Lava, Ropy Lava Surface, Columnar Joint Block, Flow Banding, Intrusive Contacts and Xenoliths

Study of the Texture, Mineral composition, Mode of occurrence, and Association of the following Rock Types. Granite, Rhyolite, Pegmatite, Aplite, Quartz porphyry Pitchstone, Obsidian Syenite (Hornblende / Biotite), Trachyte, Feldspar porphyry Nepheline Syenite

20US5GEP2 **Structural Geology**

Profiles and cross sections of

1. Geological maps showing various structural features: Sills,

Dykes, two series of dipping beds. (4 maps)

2. Patterns of dipping strata (folds/faults/unconformity) (3 maps)

Structural Problems

1. Three-Point problems.

2. Thickness and depth of strata

Stereographic Projection

1. Plotting a line that lies in a plane, poles to plane

2. Determining the angle between two lines

3. Strike and Dip from apparent dips

4. Attitude of intersection of two planes

5. π and ß diagrams

20US5GEP2 Sedimentary Petrology

Megascopic and Microscopic Structures and Textures.

Sedimentary Textures.

(Clastic) Rudaceous, (Conglomeratic/ Brecciatic), Arenaceous (Gritty/Sandy), Argillaceous

Sedimentary Structures:

Stratification, Current Bedding, Graded Bedding, Ripple Marks, Rain Imprints, Concretions/Secretions

Identification of Sedimentary Rocks :

Conglomerate, Breccia, Grit , Sandstone, Shale, Limestone,

Fossiliferous Limestone , Oolitic Limestone, Laterite

20US5GEP3 Elements of Geochemistry

1. Types of geochemical data analysis and interpretation; of common

geochemical plots.
2. Geochemical analysis of geological materials.
3. Geochemical variation diagrams and its interpretations.

20US5GEP3 RS-GIS

Aerial Photo interpretation, identification of sedimentary, igneous and metamorphic rocks

Landform Identification and Evaluation from imageries and various aeolian, glacial, fluvial and marine landforms

Introduction to different remote sensing software

Creating a FCC from raw data analysis of satellite data in different bands and interpretation of various objects on the basis of their spectral signatures.

20US5GEEG3 EXPLORATION GEOLOGY

1. Identification of anomaly

2. Concept of weighted average in anomaly detection

3. Geological cross-section

4. Evaluation of sampling data

SEMESTER VI

Course: STRATIGRAPHY AND GEOLOGY OF INDIA – PHANEROZOIC

Course Outcome:

Understand the origin and development of different Phanerozoic stratigraphic formations of India and problems associated with stratigraphic boundaries.

Course Specific Outcome:

List the age, lithology, fossil content and economic minerals present in different succession of India.

Number of lectures: 12 per unit/module

Unit **Stratigraphy and Geology of India – PHANEROZOIC**

I **Learning objective:**

1. Discuss the tectonic history of Palaeozoic period and evolution of different life forms during the same.
2. Categorise different Palaeozoic formations of India with respect to their age, lithology, fossil content and important economic minerals.

Learning outcome:

1. Identify different Palaeozoic succession of India.
2. Comment on their stratigraphic significance and its correlation with different formations present all over India.

Palaeozoic History: Tectonic History, Palaeozoic Life, Precambrian Cambrian Boundary, Marine Palaeozoic Formations of India, Tethyan Regions, Lesser Himalayan Regions

Gondwana Sequence of India: Sedimentation and Palaeoclimates, Lower Gondwana Sequence, Talchir Formations, Marine Intercalations Bap and Badhaura Formations, Damuda Group, Lower Gondwana of Eastern Himalayas, Upper Gondwana Sequence, Damodar Valley Basin, Satpura Basin, Rajmahal Hills, Mahanadi-Son Valley Basin, Pranhita-Godavari Basin

II **Learning objective:**

1. Discuss the tectonic history of Mesozoic period and evolution of different life forms during the same.
2. Categorise different Mesozoic formations of India with respect to their age, lithology, fossil content and important economic minerals.

Learning outcome:

1. Identify different Mesozoic succession of India.
2. Comment on their stratigraphic significance and its correlation with different formations present all over India.

Mesozoic History: Tectonic History, History of Mesozoic Life, Marine Forms, Land Forms, Permian Triassic Boundary, Marine Mesozoic Formations of India, Tethyan Himalaya, Lesser Himalaya (Krol Belt), Indian Peninsula

Geology of Maharashtra: Geology of the State, Geological and Geographical distributions of minerals

III **Learning objective:**

1. Discuss the tectonic history of Cenozoic period and evolution of different life forms during the same.
2. Categorise different Cenozoic formations of India with respect to their age, lithology, fossil content and important economic minerals.

Learning outcome:

1. Identify different Cenozoic succession of India.
2. Comment on their stratigraphic significance and its correlation with different formations present all over India.

Cenozoic History: Tectonic History, History of Cenozoic Life, Boundary Problems, Indian Cenozoic Formations, Himalayan Palaeogene Succession, Himalayan Neogene Succession, Indus Belt, Deccan Traps, Assam–Arakan Region, Cauveri and Godavari Basins

Recommended books and references:

1. Krishnan, M. S. (1982) Geology of India and Burma, CBS Publishers, Delhi

2. Doyle, P. & Bennett, M. R. (1996) Unlocking the Stratigraphic Record. John Wiley

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

4. Valdiya, K. S. (2010) The making of India, Macmillan India Pvt. Ltd.

Course: IGNEOUS TEXTURES AND STRUCTURES

Course Outcome:

Understand petrogenesis of different igneous rocks and classification of igneous rock

Course Specific Outcome:

IUGS classification of igneous rock, petrography and petrogenesis of rocks from different plate boundary.

Number of lectures: 12 per unit/module

Unit **Igneous texture and structures**

I **Learning Objective:**

Discuss igneous textures and its importance in magma behaviour.

Learning Outcome:

Understand the primary igneous textures.

Define textures of volcanic and pyroclastic rocks. Textures of Igneous rocks: Primary Textures (Crystal/Melt Interactions), Rates of Nucleation, Growth and Diffusion Nucleation at preferred sites, Compositional Zoning Crystallization sequence Magmatic Reaction and Resorption, Cumulate Textures, Volcanic textures and Pyroclastic textures.

II **Learning Objective:**

Discuss field relationships of extrusive and intrusive igneous rocks.

Learning Outcome:

1. Differentiate between extrusive and intrusive rocks
2. Define different volcanic landforms.
3. Discuss contact relationships of plutons and time of intrusion.

Igneous structures and Field Relationship Extrusive or volcanic, Processes, Products and Landforms: Properties of Magma and Eruptive Style, Central vent Landforms, Fissure Eruptions, lava flow features, pyroclastic deposits, Intrusive, or Plutonic, Processes and Bodies: Tabular Intrusive Bodies, Non-Tabular Intrusive Bodies, Contact Relationships of Plutons, time of intrusions.

III **Learning Objective:**

Discuss the nomenclature of magmatic and volcanic rocks

Learning Outcome:

Name the different igneous rocks and understand their petrogenesis process

Classification and Nomenclature of Magmatic Rocks Introduction, Compostional terms, IUGS classification, Phaneritic Rocks, felsic, mafic and Ultra-mafics, Aphanitic rocks, Pyroclastic rocks.

Subduction –Related Activity: Island Arc Volcanic Rocks and Magma Series, The Ophiolite Suite; Calcalkaline and Tholeiite Groups; Petrogenesis of Island Arc Magmas, Plutonic Rocks – Batholiths related to subduction zones. Petrogenesis of Mid-Oceanic Volcanism, Gabbroic Layered Intrusions; Anorthosites; Nephelinites; Carbonatites, Kimberlites and related Rocks.

Recommended books and references:

1. Best M.G. Igneous and Metamorphic Petrology, Blackwell Publications

2. Blatt H., Tracy R.J. and Owens B.E. (2006), Petrology – Igneous, sedimentary and Metamorphic rocks (3 rd Edition), W.H. Freeman and Company, New York.

3. Bose M.K. (1997), Igneous Petrology. The World Press Pvt. Ltd. 568 p.

4. Hatch F.H., Wells A.K and Wells M.K. (1984), Petrology of the igneous rocks.CBS Publishers, 551 p.

5. Turner F.J and Verhoogen J. (1960), Igneous and Metamorphic Petrology, Mc Graw- Hill.

6. Tyrrel G.W. (1998), The Principles of Petrology, B.I. Publications Pvt. Ltd.

7. Winter J. D. (2001), an Introduction to Igneous and Metamorphic Petrology, Prentice Hall, 697p.

Course: METAMORPHIC PETROLOGY

Course Outcome:

To understand the basic concepts of metamorphic petrology

Course Specific Outcome:

To classify, analyse, interpret the metamorphic rocks, textures and mineral assemblages.

Number of lectures: 12 per unit/module

Unit	Metamorphic Petrology

I **Learning Objective:**

To get comprehensive understanding of the concept of Metamorphism and its types.

Learning Outcome:

1. Define and explain the process of metamorphism and understand the role and significance of the agents of metamorphism.
2. Comprehend and illustrate the types of metamorphism and its varied effects.

Introduction to Metamorphic Petrology: Definition of Metamorphism, factors of Metamorphism, agents of Metamorphism: Temperature, Pressure and Fluids.

Types of Metamorphism: Contact Metamorphism, Regional Metamorphism, Fault zone and Impact Metamorphism. Progressive nature of Metamorphism, Types of Protolith

II **Learning Objective:**

To get acquainted with the classification of metamorphic rocks, textures and

structures.

Learning Outcome:

1. Classify the metamorphic rocks
2. Analyse and Interpret the metamorphic textures
3. Analyse and interpret and give inferences based on the time deformation relationships

Classification of Metamorphic Rocks: Foliated and Lineated Rocks, Non-Foliated and Non-Lineated rocks , High strained rocks

Structure and textures of Metamorphic Rocks: Texture of contact metamorphism, High-Strain metamorphic texture, Regional Metamorphic texture.

Time, Temperature and Deformational Relationships: Porphyroblasts and Tectonism: Pretectonic, Syntectonic and Post-Tectonic Porphyroblasts; Polymetamorphism.

III **Learning Objective:**

To comprehensively understand the concept of metamorphic facies

Learning Outcome:

1. Identify the metamorphic facies and protoliths of a metamorphic rock
2. Explain and Illustrate the concept of metamorphic facies on PT diagram
3. Correlate the concept of metamorphism and plate tectonics

Metamorphic facies and grades: Concept of metamorphic facies and grade Facies series, Index minerals, Chemographic projections, Metamorphic zones and isograde.

Mineral Variation related to Initial Rock Composition: Metamorphism of Mafic rocks, Pelitic Sediments, Carbonate, Ultrabasic rocks.

Metamorphic Rocks and Global Tectonics: Metamorphism at Time of Formation of Paired Belts

Course: ENGINEERING GEOLOGY

Course Outcome:

Identify the geological sites and rocks for building any engineering structure.

Course Specific Outcome:

Evaluate the suitability of a geological formation for the construction of an engineering structure.

Number of lectures: 12 per unit/module

Unit **Engineering Geology**

I **Learning Objective:**

1. Discuss physical/chemical engineering properties of rocks.
2. Explain the properties of aggregates.

Learning Outcome:

1. Students will be able to state the suitability of rock for various engineering constructions.
2. Can plan and select the rock properties needed for specific construction purpose.

Engineering Properties of Rocks: Specific Gravity, Porosity, Absorption, Compressive Strength, Tensile Strength, Elasticity of Rocks, Residual Stress and Shear Stress in Rocks. Rocks as Construction Materials: Types of Rocks used in construction, How are they obtained in nature, Use of Rocks as facing stone. Factors influencing Engineering usefulness of Rocks.

Use of Rocks as aggregates: Use of rock as an aggregate in different types of constructions, sources of different grades of aggregates. Properties of Aggregates Shape, Size, Surface Texture, Roundness, Coating, Cement aggregate reaction, Thermal effects on aggregate. Highway aggregate, Rail – road ballast Runway aggregate

II **Learning Objective:**

1. Describe the geological considerations for tunnel construction

2. List the various causes of landslides and ways for its prevention.

Learning Outcome:

1. Be able to differentiate between favourable and unfavourable geological conditions for tunnel construction.
2. Students will be able to classify the landslides
3. Be acquainted with the various reasons for the occurrence of landslides.

Geological and Geotechnical investigations for Civil Engineering Projects: Tunnels: Terminology, Geological conditions for tunnel sites, Tunnels in folded rocks and bedded rocks. Influence of divisional planes, Effects of faults Crushed zones, Tunnels near slopes, Role of Groundwater in tunneling. Landslides: Causes and Types of Landslides Prevention of landslides, Influence of divisional planes Effects of faults, Crushed zones.

III **Learning Objective:**

Describe the geological considerations for dam and reservoir construction

Learning Outcome:

1. Be able to differentiate between favourable and unfavourable geological conditions for dam and reservoir construction.
2. Identify the various types of dams

Reservoir Studies: Types of spillways. Geological conditions for the selection of reservoir site Terminology associated with reservoir Locations of all the Hydro – electric projects in India.

Dams and types of Dams: Terminology associated with Dams, Geological conditions for the selection of dam site, Types of dams, Locations of all the important dams in India

Recommended books and references:

1. Legget F.R. and Hatheway A.W. (1988), Geology and Engineering., 3 rd ed. McGraw-Hill.

2. Narayanswami S.B.S. (2000), Engineering Geology, Dhanpat Rai & Co, India.
3. Gupte R.B. (1992), A Textbook of Engineering Geology.2 nd ed. Pune Vidyarthi Griha Prakashan.
4. Krynine D.P. And Judd W.R (2003), Principles of Engineering Geology and Geotechniques, CBS Publishers.
5. Wahlstrom E.E. (1974), Dams, Dam Foundations and Reservoir Sites. Elsevier Scientific.
6. Dunn I.S., Anderson L.R and Kiefer F.W. (1980), Fundamentals of Geotechnical Analysis, John Wiley.
7. Maslov N.N. (1987), Basic Engineering Geology and Soil Mechanics. Mir Publishers.
8. Gokhale K.V.G.K and Rao D.M. (1981), Experiments in Engineering Geology. Tata McGraw-Hill.

Course: EARTH AND CLIMATE

Course Outcome:

Learn the causes of climate change and its influence on the biome.

Course Specific Outcome:

Assess the interaction between Earth's climate and its atmosphere, biosphere and hydrosphere.

Number of lectures: 12 per unit/module

Unit **Earth and Climate**

I **Learning Objective:**

Get acquainted with the components of Earth's climate and its controlling factors

Learning Outcome:

1. Recognise the interaction within the climate system
2. Understand the responses of climate because of celestial movements

Climate system and Orbital cyclicity

Forcing and Responses. Components of the climate system. Climate forcing, Climate controlling factors. Climate system response, response rates and interactions within the climate system. Feedbacks in climate system

Milankovitch cycles and variability in the climate. Glacial-interglacial stages. The Last Glacial maximum (LGM). Pleistocene Glacial-Interglacial cycles. Younger Dryas. Marine isotope stages, changes in sea level

II Learning Objective:

Discuss the sources of Earth's heat and their effect on climate

Learning Outcome:

1. Differentiate between the incoming and emitted sources of heat of the Earth
2. Measure the anthropogenic effects on climate

Heat budget of Earth

Incoming solar radiation, receipt and storage of heat

Heat transformation

Earth's heat budget. Interactions amongst various sources of earth's heat

Climate Change: natural vs. anthropogenic effects

Humans and climate change, sea level variations

Brief introduction to archives of climate change, importance from the Indian perspective

III Learning Objective:

Comprehend the different layers of the atmosphere, circulation of ocean currents and its effect on Monsoon

Learning Outcome:

1. Illustrate the intermingling of atmospheric and oceanic currents
2. Understand the phenomenon of monsoon and the effects of its variation

Atmosphere - Hydrosphere and Monsoon

Layering of atmosphere and atmospheric Circulation

Atmosphere and ocean interaction and its effect on climate

Heat transfer in ocean

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

Surface and deep circulation

Monsoon:

Mechanism of monsoon. Monsoonal variation through time. Factors associated with monsoonal intensity. Effects of monsoon

Recommended books and references:

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

2. Rohli, R.V., and Vega, A.J., 2007. Climatology. Jones and Barlatt

3. Lutgens, F., Tarbuck, E., and Tasa, D., 2009. The Atmosphere: An Introduction to Meteorology.

   Pearson Publisher

4. Aguado, E., and Burt, J., 2009. Understanding weather.

Course: URBAN GEOLOGY

Course Outcome:

Significance of geological aspects in urban development

Course Specific Outcome:

Sources and remediation of pollutants and waste disposal in urban region

Number of lectures: 12 per unit/module

Unit **Urban Geology**

I **Learning Objective:**

Evaluate the applications of geology in urban areas

Learning Outcome:

To understand the importance of geology in an urban setting

Geology and Society

Necessity of Geology in Urban life. Geology in Urban Constructions, Geotechnical feature and mapping for subsurface in Metropolitan areas, Building materials, Excavation and cutting in urban areas, Impact of sea level changes in coastal region

II **Learning Objective:**

Comprehend the sources of contamination of soil and water and their treatment

Learning Outcome:

To understand the geological implication of soil and water pollution

Geology, Urban Agriculture and Urban water

Soil studies, Chemistry and geochemistry of soil in relation to ground water and fertilizer. Effect of pollutants on vegetable contamination

Water lagging in built-up areas, Source of water, Standards for various uses of water. Sources of contamination. Waste waters: Sources and its disinfection and treatment, Groundwater surveys and resource development.

III Learning Objective:

1. Identify the types of wastes and their disposal sites
2. Get introduced to basics of GIS and its application in urban development

Learning Outcome:

Assess the suitability of waste disposal sites using geological mapping and GIS

Urban wastes and Treatment and GIS in Urban Geology

Geotechnical characterization for waste sites, Domestic waste,

Industrial waste, Mine drainage, Power production waste, Radioactive waste, Need for special purpose mapping for selection of waste disposal sites.

GIS- An introduction, Application in Urban development, Application in land use, Application in GW Exploration

Recommended books and references:

1. Huggenberger, P. and Eptin, J. 2011 Urban Geology: Process-Oriented Concepts for Adaptive and Integrated Resource Management. Springer

2. Lollino, G. et al. (Ed.), Engineering Geology for Society and Territory. Springer.

EVOLUTION OF LIFE THROUGH TIME

Course Outcome:

Understand how the life evolved with the evolution of Earth

Course Specific Outcome:

Understand and get acquainted with the changes that are taking place since the origin of planet earth

Number of lectures: 12 per unit/module

Unit I: Life through ages

Learning Objective:

Evaluate the applications of fossils in understanding of earth processes.

Learning Outcome:

To understand the Geological Time Scale and various bio-events.

Life through ages

Fossils and chemical remains of ancient life.

Geological Time Scale with emphasis on major bio-events.

Fossilization processes and modes of fossil preservation.

Exceptional preservation sites- age and fauna

Origin of life

Possible life sustaining sites in the solar system, life sustaining elements and isotope records

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

radiation of life

Precambrian macrofossils – The garden of Ediacara

The Snow Ball Earth Hypothesis.

Unit II:

Learning Objective:

Understand the geographical, biological and climatic changes that took place during the paleozoic and Mesozoic era.

Learning Outcome:

Identify the types of life forms present during paleozoic and Mesozoic life

Paleozoic Life

The Cambrian Explosion.

Biomineralization and skeletalization

Origin of vertebrates and radiation of fishes

Origin of tetrapods - Life out of water

Early land plants and impact of land vegetation

Mesozoic Life

Life after the largest (P/T) mass extinction, life in the Jurassic seas

Origin of mammals

Rise and fall of dinosaurs

Origin of birds; and spread of flowering plants

Unit III:

Learning Objective:

To understand the geological changes that took place during cenozoic life and the climate that was prevalent during the era.

Learning Outcome:

Identify the types of life forms present during Cenozoic time

Cenozoic Life

Aftermath of end Cretaceous mass extinction – radiation of placental mammals

Evolution of modern grasslands and co-evolution of hoofed grazers

Rise of modern plants and vegetation

Back to water – Evolution of Whales

The age of humans

Hominid dispersals and climate setting

Climate Change during the Phanerozoic - continental break-ups and collisions

Plate tectonics and its effects on climate and life

Effects of life on climate and geology.

Recommended books and references:

1. Stanley, S.M., 2008 Earth System History

2. Jonathan I. Lumine W.H.Freeman Earth-Evolution of a Habitable World, Cambridge University Press.

3. Canfield, D.E. & Konhauser, K.O., 2012 Fundamentals of Geobiology Blackwell

4. Cowen, R., 2000 History of Life, Blackwell

Course: FIELD GEOLOGY-II (Precambrian/Phanerozoic Geology field)

Field transect in any Precambrian/Phanerozoic terrain.

Study of craton ensemble including basic intrusive suites.

Precambrian/Phanerozoic sedimentary basin

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

Module 1

Structural mapping and contact mapping, Stride mapping

Using a toposheet to plan traverses and sampling locations on field

Identification of faults, folds, unconformities and joint sets

Isograd mapping in metamorphic terrain and lithology preparation in sedimentary terrain

Module 2

Use of field instruments: GPS, Brunton compass, Clinometer compass

Post-field analysis of data: rosette diagrams, stereonets, transect mapping

Course code **PRACTICALS**

20US6GEP1 **Stratigraphy and Geology of India, Maharashtra and Mumbai**

a. Study of common sedimentary, igneous and metamorphic rocks in Hand specimen from different stratigraphic horizons

b. Study of common fossil characteristics of a particular stratigraphic horizon

c. Stratigraphy of a geological section-fossils & radiometric age.

20US6GEP1 **Igneous Textures and Structures**

Microscopic Textures, Structures, Identification of Igneous Rocks. Diorite, Diorite porphyry, Andesite, Gabbro, Norite, Dolerite, Basalt (Vesicular/ Non-vesicular/Porphyritic, Amygdaloidal) Peridotite, Dunite; Anorthosite, Carbonatite

Igneous Micro-Structures Reaction: (a. Corona, b. Myrmekite), Xenolithic, Spherulitic, Perthitic

20US6GEP2 **Metamorphic Petrology**

Megascopic and Microscopic Structures and Textures Metamorphic Textures Idioblastic, Porphyroblastic, Granuloblastic, Xenoblastic

Metamorphic Structures Cataclastic, Slaty Cleavage, Maculose, Granulose, Schistose, Gneissose

Identification of Metamorphic Rocks Quartzite, Marble, Slate, Phyllite, Mica

Schist (with Staurolite/ Garnet), Actinolite/ Chlorite Schist, Mica- Gneiss, Hornblende Gneiss, Granulite, Eclogite, Serpentinite, Khondolite, Charnockite

20US6GEP2 Engineering Geology

Geological maps to demarcate and evaluate the suitability of sites for engineering projects such as Tunnels, Dams and Reservoir construction.

20US6GEP3 Earth And Climate

1. Study of distribution of major climatic regimes of India on map

2. Distribution of major wind patterns and oceanic currents on World map

3. Preparation of paleogeographic maps (distribution of land and sea) of India during specific geological time intervals

4. Numerical exercises on interpretation of proxy records for paleoclimate

20US6GEP3 Urban Geology

1. Map Reading

2. Ground water flow direction estimation

3. Case studies of Urban flood; Flood hydrographs

4. Case studies of urban planning

20US6GEET3 EVOLUTION OF LIFE THROUGH TIME

1. Study of modes of fossil preservation

2. Study of fossils from different stratigraphic levels

3.Exercises related to major evolutionary trends in important groups of animals and plants

SCHEME OF EXAMINATION:

SEMESTER V & SEMESTER VI
(I) INTERNAL: 40 MARKS PER PAPER

OPTION I
A) ASSIGNMENT/PRESENTATION: 15 MARKS
B) Continuous Assessment: 25 MARKS

OPTION II
BOOK REVIEW OR **PROJECT** (30 marks)
Report and presentation (10 marks)

(II) EXTERNAL: 60 MARKS PER PAPER
Pattern of Question Paper:
Instructions to Students:
NB.: All questions are compulsory
Illustrate your answers wherever necessary

Instructions to Paper setter:
The paper will be set for 60 marks.
Each question will carry 15 marks with internal options from within the unit and 100% choice, not exceeding 20 marks per question.
Q1 from all units (1 to 3)
Q2 from unit 1
Q3 from unit 2
Q4 from unit 3

PRACTICAL: MARKS 50 per combined practical

Laboratory Journal (5), Viva (5), Practical based on all the 3 units (40)