Parvatibai Chowgule College of Arts and Science
(Autonomous)

Accredited by NAAC with Grade 'A+'
Best Affiliated College-Goa University Silver Jubilee Year Award

DEPARTMENT OF GEOLOGY

SYLLABUS FOR FOUR YEAR UNDERGRADUATE DEGREE HONOURS PROGRAMME IN GEOLOGY

(Implemented from Academic Year 2023-2024 onwards)

Annexure B

COURSE STRUCTURE

SEMESTER	MAJOR (4 credits/course)	MINOR/ VOCATIONAL (4 credits/course)	MDC (3credits/course)	SEC (3 credits/course)
I	**UG-GEL-101:** Fundamentals ofGeology		**UG-GEL-MDC1:** Natural Hazard Management **UG-GEL-MDC2:** Historical Geology	**UG-GEL-SEC1:** Exploratory Drilling and Drillhole Data Management
II	**UG-GEL-102:** Earth Dynamics and Tectonism			**UG-GEL-SEC2:** Field Techniques for Geological Mapping
III	**UG-GEL-201:** Optical Mineralogy **UG-GEL-202:** Stratigraphy and Paleontology		**UG-GEL-MDC3:** Physical Geology	**UG-GEL-SEC3:** Gemmology
IV	**UG-GEL-203:** Mineralogy **UG-GEL-204:** Ore Genesis **UG-GEL-205:** Geotectonics **UG-GEL-206:** Sedimentary Petrology	**UG-GEL-VOC1:** Occupational Health and Safety		
V	**UG-GEL-301:** Magma Evolution and Igneous Rock Formation **UG-GEL-302:** Metamorphic Petrology **UG-GEL-303:** Precambrian Stratigraphy of India	**UG-GEL-VOC2:** Groundwater Exploration Techniques		
VI	**UG-GEL-304:** Phanerozoic Stratigraphy of India	**UG-GEL-VOC3:** Petroleum Exploration and Techniques		

	UG-GEL-305: Rock Mechanics and Structures			
	UG-GEL-306: Surveying and Field Geology			
	UG-GEL-PRJ: Minor Project			
VII	**UG-GEL-401:** Geochemistry			
	UG-GEL-402: Engineering Geology and Geotechnology			
	UG-GEL-403: Rock Microstructures and Deformation			
	UG-GEL-404: Geophysical Exploration and Mining Methods			
VIII	**UG-GEL-405:** Remote Sensing and Digital Image Processing			
	UG-GEL-406: Advanced Igneous Petrology			
	UG-GEL-407: Geological Field Training			
	UG-GEL-408: Ocean Sciences			

SEMESTER I

DISCIPLINE SPECIFIC CORE COURSE

Course Title : **FUNDAMENTALS OF GEOLOGY**
Course Code : **UG-GEL-101**
Credits : **04**
Marks : **75**
Duration : **45 hours**

Course Objectives

Mineralogy is the science of minerals whereas petrology is the science of rocks. Both basic and essential fundamentals of Geology shall be covered under this course. As minerals are building blocks of earth's material the course is designed to understand the basic concepts in mineralogy and their chemistry. Further, the students will study crystallography in understanding the morphology, symmetry, and the normal crystal classes. With respect to petrology the course will help the students to exhibit an improved understanding of fundamental petrologic processes and common rock types. In practicals, students learn to identify, describe, and classify minerals and rocks using hand specimens.

Course Learning Outcomes

Upon completion of the course, the student will be able to:

CLO1 Explain what is a mineral and its formation, Link how the internal atomic structure of minerals affects the external development of a crystal in terms of crystal symmetry, crystal system and crystal forms.

CLO2 Explain the processes involved in the formation, identify the forms, textures, structures of igneous rocks.

CLO3 Explain the processes involved in the formation of sedimentary and metamorphic rocks, identify their textures, structures and classify them.

CLO4 Identify rock- forming minerals in hand specimen using their physical properties and classify minerals into crystal systems based on crystal symmetry.

CLO5 Classify andidentify the different igneous, sedimentary and metamorphic textures and structures based on hand specimens.

Module I **(15 hours)**

Elemental and Major oxide composition of the earth's crust; Ionic Radius; Radius Ratio; Co-ordination Number; Types of Co-ordinations.

Minerals: Definition; rock-forming minerals, and ore minerals.

Crystal: External Morphology, Space lattice and Unit cell.

Crystallographic Axes

Crystal Systems: Cubic; Tetragonal; Hexagonal; Orthorhombic; Monoclinic and Triclinic

Symmetry in Crystals: Axis, Plane, Centre

Common physical properties of minerals (in brief):

Colour; Streak; Diaphaneity; Cleavage and Fracture; Form; Hardness; Specific Gravity

Silicate structures:

Sorosilicate;Cyclosilicates;Nesosilicates;Inosilicate;Phyllosilicates; Tectosilicate

Introduction to rock-forming mineral groups:

Olivine; Pyroxene; Amphibole; Mica; Feldspar; Silica.

Module II **(15 hours)**

Rocks and Rock cycle

Magma and Lava: Definition;Formation;Composition.

Physical Properties:Temperature;Density; Viscosity;Pressure.

Bowen's Reaction Series

Mode of occurrences of Igneous rocks: Intrusive and Extrusive Forms

Intrusive Concordant Forms - Hypabyssal: Sills, Laccoliths, Lopoliths; Phacoliths.

Intrusive Discordant Forms – Plutonic: Batholiths (stocks, bosses); roof pendants.Hypabyssal – Dykes:Arcuate, Radiating Ring dykes,Cone sheets and Volcanic necks.

Extrusive Forms: Central and Fissure type of eruptions

Multiple and Composite intrusions.

Structures of Igneous rocks: Megastructures and Mesostructures

Textures of Igneous rocks based on Crystallinity, Granularity, and Mutual relationship.

Classification: Based on Mode of Occurrence and Colour Index

Module III **(15 hours)**

Weathering: Types – Biological, Chemical and Physical and products.

Erosion, Transportation and Deposition

Diagenesis and Lithification

Sedimentary structures: Primary

Textures: Clastic and Non clastic

Classification based on Grain size

Metamorphism and Metasomatism

Factors controlling metamorphism: Temperature, Pressure, Chemically Active Fluids,

Protolith: Types

Types of metamorphism: Local -Cataclastic and Contact and Regional - Dynamothermal

Metamorphic textures and structures: Foliated and Non-foliated.

Nomenclature of metamorphic rocks

Practical: 1 credit **(30 hours)**

Maximum Marks: 25

1. Identifying and determining the crystal symmetry, class, system in the normal class of the six systems.
2. Identification and study of minerals w.r.t their physical properties, occurrence, chemical composition.
3. Megascopic study of Igneous, Sedimentary and Metamorphic rocks.

List of books recommended for reference

Mandatory Reading

- Perkins, D., (2015), Mineralogy, Pearson Education Limited.

- Lutgens, F. K., Tarbuck, E. J., & Tasa, D. G. (2014). Essentials of Geology. Pearson Higher Ed.
- Marshak, S., (2013) Essentials of Geology. New York: W.W. Norton.
- Dana, J.D & Ford, W. E., (2010). Dana's Manual of Mineralogy. J. Wiley & Sons.
- Deer, W.A., Howie, R.A. and Zussman, J. (1992) An Introduction to the Rock-Forming Minerals. 2nd Edition, Prentice Hall, Harlow
- Klein, C. and Dutrow, B., (2007). The Manual of Mineral Science, John Wiley & Sons, Inc.
- Winter, J D., (2014). Principles of Igneous and Metamorphic Petrology, Pearson Education Limited.
- Boggs S., (2009) Petrology of Sedimentary rocks (2nd edition), Cambridge University Press.
- Prothero, D. R., and Schwab, F.; (2004) Sedimentary Geology. Macmillan.
- Best, M., (2003). Igneous and Metamorphic Petrology, Blackwell Publishing.
- Tucker E.M. (2001) Sedimentary Petrology (3rd Edition), Blackwell Science Ltd.
- Pettijohn F.J., (1984) Sedimentary Rocks (3rd Edition), CBS Publishers, New Delhi.

Supplementary Reading

- Lutgens, F. K., Tarbuck, E. J., & Tasa, D. G. (2014). Essentials of Geology. Pearson Higher Ed.
- Johnson, O. (2004). Minerals of the World: Ole Johnson. Princeton University Press.
- Read, H. H., (1988). Rutley'sElements of Mineralogy, CBS Publications.
- Battey, M H. (1971), Mineralogy for students, Oliver & Boyd

MULTI DISCIPLINARY COURSES (MDC)

Course Title : **NATURAL HAZARDS AND MANAGEMENT**
Course Code : **UG-GEL-MDC1**
Credits : **03**
Marks : **50**
Duration : **30 hours**

Course Objectives

The course is designed with an aim to give the student an understanding about: various natural hazards; stages in management aimed at avoiding and /or reducing loss to life and property

Course Learning Outcomes

Upon completion of the course, the student will be able to:

CLO1 Understand the causes, effects, and mitigation measures for natural hazards such as droughts, floods, cyclones, tsunami, landslides & subsidence, Earthquake, salinity hazards, coastal erosion.

CLO2 Understand the framework and roles of various bodies under the National disaster management plan of India.

CLO3 Prepare a simple disaster management plan for a building/unit.

Module I **(15 hours)**

- Classification of hazards: Natural and Man-made disasters
- Floods: causes and effects, prediction, Cloud burst/Flash floods, remedial measures
- Cyclones: Structures, origin, effects, prediction, path tracking and early warning systems.
- Earthquakes: Causes, Magnitude and intensity, Recording, effects andpreparedness, Earthquake Zonation Map; Prediction.
- Tsunamis: relation of Tsunamis to tectonics; Damage due to tsunamis, Co-ordinated approach to early warning of tsunamis.

Module II **(15 hours)**

- Landslides and Avalanches: Classification of mass wasting, mechanics, causes of landslides and stabilizing methods of slopes; civil engineering measures.
- Subsidence: Causes, slow and brisk types
- Salinity hazards: Inland and Coastal
- Coastal erosion and mitigatory measures
- Droughts: Types, causes, mitigation
- Forest Fires: Causes and Management
- Disaster Management Cycle
- National Disaster Management

Practical : **1 credit**
Marks : **25** **(30 hours)**

- Earthquake Zonation Map and Locating Epicenter
- Visit to local beach and documenting features of coastal erosion.
- Analysis of satellite imagery to document areas prone to erosion.

- Prepare a model disaster management plan for Parvatibai Chowgule College of Arts and Science Autonomous Margao based of NDMA guidelines for school disaster management plan.

List of books recommended for reference

- Hess, D., (2012) Mc Knight's Physical Geography, PHI learning, Pvt Ltd, New Delhi.
- Paul, K, B., (2011) Environmental Hazards and Disasters: Context, Perspectives and Management, Wiley-Blackwell, West Sussex.
- Keller, E. A., 2011) Environmental Geology, Santa Barbara Prentice Hall.
- Sethi, V. K., (2009) Disaster Management, Essential Books PW, New Delhi.
- Joshi M.V., (2004) Environmental Disaster, Causes, Impacts and Remedies, Adhyayan Publishers.
- Krynine, D. and Judd W., (1998) Principles of Engineering Geology and Geotectonics, McGraw Hill.
- Holmes, A., edited by Duff P.M.D., (1993) 4th edition, Physical Geology, E.L.B.S Publications.
- Valdiya K.S., (1987) Environmental Geology: Indian Context, Tata-McGraw Hill

Online resources

https://ndma.gov.in/Governance/Guidelines

Course Title : **HISTORICAL GEOLOGY**
Course Code : **UG-GEL-MDC2**
Credits : **03**
Marks : **50**
Duration : **30 hours**

Course Objectives

The Objective of this course is to provide the students with a glimpse the Earth's past. The course includes introduction to techniques of radiometric dating and fossils correlation, that help us to understand the geological history of an area. Further through this course the students will be aware of Geoheritage sites and will be able to explain its significance.

Course Learning Outcomes

Upon completion of the course, the student will be able to :
CLO1 Explain the geological time scale and how fossils help us infer the geological past.
CLO2 Explain significance of Geoheritage sites and the need for its conservation.
CLO3 Identify fossil casts, moulds, and impressions.

Module I **(15 hours)**

Scope andSignificance of Historical Geology
Origin of the Earth
Age of the Earth: Absolute and Relative age.
Radiometric Dating
Geological Time scale
Life through the geological time scale
Mass Extinctions.
Fossils: Mega- Micro-Ichnofossils
Conditions for fossilization; Favourable environments for fossilization.
Modes of fossilization: Petrification, Carbonization, Natural moulds, and casts

Module III **(15 hours)**

Earth Heritage Conservation
Need for Conservation of sites
Conservation & community participation
Case studies: Geoheritage sites (any four)

- Cretaceous Formations of Trichinopoly District, Tamil Nadu
- Pillow lavas near Mardihalli, Chitradurga District, Karnataka
- Peninsular Gneiss, Lalbagh Botanical Garden, Bengaluru, Karnataka
- Columnar Basalt, Coconut Island (St. Mary's Island), Udupi District, Karnataka
- Lonar Lake, Buldhana District, Maharashtra
- Stromatolite Park, Jhamarkotra, Udaipur District, Rajasthan
- National Fossil Wood Park, SathanurPerambalur District, Tamil Nadu

Practical: 1 credit **(30 hours)**

Maximum Marks: 25

- Plot Geoheritage sites/ fossil locations on outline maps of India.
- Study of fossils/casts/shells w.r.t their morphology and geological age.
  Phylum: Mollusca , Brachiopoda, Arthropoda (Trilobites) and Plant fossils

List of books recommended for reference

Mandatory Reading

- Indian National Trust for Art and Cultural Heritage. (2016). A Monograph on National Geoheritage Monuments of India.
- Wicander, R., & Monroe, J. S. (2010). Historical Geology- Evolution of Earth and Life Through Time. Belmont: Brooks/Cole, Cengage Learning.
- Doyle, P. (1996). Understanding Fossils: An Introduction to Invertebrate Palaeontology. England: John Wiley & Sons Ltd.
- Black. R M., (1989). The Elements of Palaeontology, Cambridge University Press.
- Koregave, M A., Fundamentals of Invertebrate Palaeontology, Book World Enterprises.
- Spencer, E, (1962) W, Basic concepts of Historical Geology, Oxford & IBH Publishing Co.

SKILL ENHANCEMENT COURSE (SEC)

Course Title : **EXPLORATORYDRILLING AND DRILLHOLE DATA MANAGEMENT**
Course Code : **UG-GEL-SEC1**
Credits : **03**
Marks : **50**
Duration : **30 hours**

Course Objectives

Drilling is the ultimate test to all geological interpretations made during the prospecting phase. Invariably, it is an essential task that needs to be taken up to complete any exploration project related to ground water, oil & gas or mineral prospecting. The objective of this course is to provide the students an understanding of the various processes involved in a drilling project and the role of a geologist in it. The course focuses on developing skills pertaining to drillhole data management using Ms Excel.

Course Learning Outcomes

Upon completion of the course, the student will be able to:
CLO1 Explain the stages of an exploratory drilling program.
CLO2 Explain the processes involved in collection of drillhole data.
CLO3 Create Excel tables for managing drilling data and construct a dummy drillhole database in MS Excel

Module I **(15 hours)**

Introduction to Drilling: Purpose and Types of drilling
Planning a drilling Programme
Outline of a drilling contract
Defining job responsibility: Driller and the geologist
Drill site hazards: Environment and Safety
Site preparation
Measures needed to abandon drilling site

Module II **(15 hours)**

Drill hole data Management
Daily drilling report
Survey data- drill hole location and drillhole deviation
Geological data- Geological map, Borehole logging, sampling data
Quality Assurance and Quality Control (QAQC)
Management of drill hole data in excel: Types of files (mandatory and optional files)

Practical : 1 credit **(30 hours)**
Marks : 25

- Excel Tables for managing and reporting of drilling data
- Creating digital borehole logs
- Constructing and analysis of QAQC data: scatter plots and control charts
- Creating a drillhole plan and cross sections manually
- Create a drillhole database in MS Excel
- Importing the database into QGIS and viewing the drillholes in 3-D. (demonstration)

List of books recommended for reference

- Abzalov, M. (2016). Applied Mining Geology. Switzerland: Springer International Publishing.
- Marjoribanks, R. (2010). Geological Methods in Mineral Exploration and mining (Second Edition ed.). New York: Springer Heidelberg Dordrecht London.
- Charles J. Moon, M. K. (2005). Introduction to Mineral Exploration. Oxford, UK: Blackwell Publishing.

SEMESTER II

DISCIPLINE SPECIFIC CORE

Course Title : **EARTH'S DYNAMICS AND TECTONICS**
Course Code : **UG-GEL-102**
Credits : **03**
Marks : **75**
Duration : **45 hours**

Course Objectives

This is a core branch of earth science which deals with basic concepts of natural internal forces shaping the earth. Earth's Dynamics and Tectonics aims at acquainting the student with these forces as well as the geological structures resulting from the action of these forces on rocks. The course also aims at providing an understanding of the processes in action on the earth's surface and their impact on man and his institutions.

Course Learning Outcomes

Upon completion of the course, the student will be able to:

CLO1 Explain the origin and nature of the earth, the internal layering, the earth's Gravity and magnetic field.
CLO2 Differentiate between the different types of forces operating in the lithosphere, responses to these forces and relate them to geological hazards.
CLO3 Explain the formation of structural features likes fold, faults, joints and unconformities.
CLO4 Read and interpret geological maps and draw geological cross – sections.
CLO5 Derive graphical solution to structural problems

Module I **(15 hours)**

Origin of the universe (Big Bang Theory); Origin of Solar System (Nebular Concept);Formation of a layered Earth.
Size and shape of the Earth.
Internal structure of the Earth: Geosphere;Asthenosphere; Lithosphere;Hydrosphere;Biosphere, Atmosphere (anoxic to oxic conditions) wrt to earth dynamics.
Earth's Gravity: Acceleration due to gravity; Change with latitude and altitude.
Earth's Magnetism: Earth as a magnet; Lines of force, Source of Earth's Magnetic field, Declination
and Inclination, Geomagnetic axis, and Geographic axis.

Module II **(15 hours)**

Introduction to Plate Tectonics:Continental Drift Theory; Sea Floor Spreading; Types of Plates.
Concept of Isostacy
Lithostatic or Confining Pressure, Differential forces: tension; compression; couple.
Concept of Stress and Strain: Stages of Deformation: Elastic, Plastic and Rupture.
Brittle and Ductile substances.
Introduction to geological hazards: exogenous (floods, drought and cyclones) and endogenous (volcanic hazards, earthquakes and tsunamis, mass wasting)

Module III **(15 hours)**

Map and Scales

Stratification, Strike and Dip (True and Apparent dip); Strike and dip symbols.

Outcrop patterns of Horizontal, Inclined,and vertical strata on various types of grounds (horizontal ground, valley, and spur).

Folds: Terminology; Causes.

Types of Folds:Symmetrical; Asymmetrical;Overturned;Recumbent; Isoclinal;Fan;Chevron; Monocline;Structural terrace;Plunging and Non-plunging.

Outcrop pattern of folds on horizontal ground, valley, and spur. Significance

Faults: Definition and terminology;Geometric classification;Significance; Horst and Graben; Criteria for identification in field.

Joints: Geometric classification;Map symbols; Columnar joints and sheet structure;Significance.

Unconformities: Stages of development;Types, Significance; Outliers and Inliers; Overlap and Offlap; Criteria for identification in field.

Practical: 1 credit **(30 hours)**

Maximum Marks: 25

1. Drawing cross-section and description of structural maps involving single series (Horizontal and Inclined).
2. Graphical solution to structural problems based on Strike and Dip.

List of books recommended for reference

Mandatory reading

- Travis, H., (2012) Living with Earth, Phi Learning Pvt. Ltd., New Delhi.
- Press, Siever, Grotzinger and Jordan., (2003) Understanding the Earth (4th edition).
- Charles C. Plummer and David McGeary., (2001) Physical Geology, (4th edition), Wm C. Brown Publishers.
- Monroe and Wicander., (2001) The Changing Earth: Exploring Geology and Evolution (3rd edition).
- Jain, A K ., (2014) An Introduction to Structural Geology, Geological Society of India.
- Holmes, (1978) Principles of Physical Geology edited by P.McL.D.Duff (ELBS).
- Hills, E. S.,(1972) Elements of Structural Geology, Methuen.

Supplementary Reading

- Zumberge J.H. & Nelson C.A., (1963) Elements of Geology (3rd edition), John Wiley & Sons, New York.

SKILL ENHANCEMENT COURSE (SEC)

Course Title : **FIELD TECHNIQUES FOR GEOLOGICAL MAPPING**
Course Code : **UG-GEL-SEC2**
Credits : **03**
Marks : **50**
Duration : **30 hours**

Course Objectives:
Earth materials and structures can be studied better when seen with related features, this is where field study becomes an important part of learning geology. The objective of this course is to offer the students a basic knowledge of performing a field study. This includes understanding map basics, getting acquainted with the geological equipment, making field observations, and recording it in a systematic manner.

Course Learning Outcomes
Upon completion of the course, the student will be able to:
CLO1 Read a geological map and toposheet
CLO2 Use a clinometer compass
CLO3 Make field observations and record them systematically

Module I **(15 hours)**
Field Geology in General: Aims and Objectives
Outcrop and exposure
Topography and features
Toposheets: Toposheet Indexing and Scale
Reading a Geological Map and Scale
Maintaining a Field diary
Reconnaissance studies: field equipment and their utility in the field
Compass: Clinometer working and use

Module II **(15 hours)**
Bearings: Whole Circle Bearings (WCB), Quadrantal Bearings (QB).
Measuring distances
Map Symbols- Attitude of the bed, Structural features.
Observations done in field.
Collecting Rock samples in field.
Surveying
PreparingGeological Field Report.

Practical : **1 credit** **(30 hours)**
Marks : **25**
Plane Table Survey
Geological Field Work and Report Writing

List of books recommended for reference:

- Lisle R., Brabham P and Barnes J., (2011) Basic Geological Mapping (Geological Field Guide), Wiley Blackwell.
- Gokhale, N W., (2001) A Guide to Field Geology, CBS Publishers & Distributors.

- Lambert, D A., (1998) Field Guide to Geology, Facts on File Inc.
- Compton, R R., (1985) Geology in the Field, John Wiley & Sons, Inc.
- Compton, R R., (1962) Manual of Field Geology, John Wiley & Sons, Inc.