

MINUTES OF THE MEETING OF THE BOARD OF STUDIES IN GEOLOGY

HELD ON 30th SEPTEMBER, 2023 at

Parvatibai Chowgule College of Arts & Science

(Autonomous)

Margao - Goa

Vide Chowgule College Notice BOS/2023-24/133(C)/724 dated 14 September 2023 a virtual meeting of this Board of Studies (BoS) was convened on September 30, 2023 at 2.30 p.m. in Block A, Parvatibai Chowgule College of Arts and Science (Autonomous), Margao-Goa. Since the number of members present represented the quorum, the BoS began its proceedings.

Minutes are presented in the format.

Members present in person:

1. Dr Meghana S Devli - Chairperson
2. Mrs Swati S Ghadi – Member Secretary
3. Shri. Sachit Kuttikar– Member
4. Ms Siddhi Shirodkar - Member

The following members of the Board of Studies attended the meeting online via Google meet.

1. Dr Hrishikesh Samant – Nominee of the Vice Chancellor of Goa University
2. Dr Makarand Kale – Academic Council Nominee
3. Shri Brahmanand Sawant – Postgraduate Meritorious Alumnus

Members absent with intimation:

1. Shri Harish S Nadkarni – Member
2. Dr. Prakash Narashimha – Academic Council Nominee

Members absent without intimation:

1. Shri Smitesh S Talawadkar – Representative from Corporate Sector

Proceedings:

The members of the Board of Studies (BoS) were welcomed by the Chairperson Dr Meghana S Devli. Ms Siddhi Shirodkar was inducted as a member of the Board. The minutes of the previous meeting held on April 15, 2023 were read out by the Member Secretary and were approved. The Chairperson introduced and explained the agenda for this meeting and the Board transacted the following business:

Agenda :

1. To approve the UG syllabus for Semester III and IV under NEP 2020
2. To approve the syllabus of Multidisciplinary, Skill Enhancement, Vocational Education and Training under NEP 2020.
3. A.O.B.

AGENDA 1:

1. To approve the UG syllabus for Semester III and IV under NEP 2020

The syllabus for the Discipline Specific Core courses, UG-GEL-201: Optical Mineralogy; UG-GEL-202: Stratigraphy and Paleontology to be offered at Semester III and UG-GEL-203: Mineralogy; UG-GEL-204: Ore Genesis; UG-GEL-205: Geotectonics; UG-GEL-206: Sedimentary Petrology to be offered at Semester IV was discussed, deliberated, and approved by the members of the board (Annexure A)

AGENDA 2:

2. To approve the syllabus of Multidisciplinary, Skill Enhancement, Vocational Education & Training under NEP 2020.

Syllabi for the Multidisciplinary course (MDC) and Skill Enhancement course (SEC) to be offered at semester III was discussed, deliberated, and approved by the members of the board (Annexure A):

- | | |
|-----------------|------------------|
| I. UG-GEL-MDC3 | Physical Geology |
| II. UG-GEL-SEC3 | Gemmology |

Syllabi for the Vocational Course (VOC) which is to be offered at Semester IV was discussed, deliberated, and approved by the members of the board (Annexure A):

- III. UG-GEL-VOC1: Occupational Health and Safety

AGENDA 3:

3. Any other Business (A.O.B) with the permission of the Chair. Nil

PART A:

The BoS passed the resolutions as follows:

1. Resolution was passed to approve the syllabi for Discipline Specific Courses to be offered at Semester III and IV under the approved new Programme structure and passed a resolution to incorporate it for the batch of students enrolled under NEP 2020 (Annexure A).
2. Resolution was passed to approve the syllabi for Multi-Disciplinary Courses and Skill Enhancement Courses to be offered at Semester III and a Vocational Course (VOC) to be offered at Semester IV under the approved new Programme structure and passed a resolution to incorporate it for the batch of students enrolled under NEP 2020 (Annexure A).

PART B:

Important points/recommendations of BoS that require consideration/approval of Academic Council:

1. To seek approval for the syllabi for Discipline Specific Courses to be offered at Semester III and IV under the approved new Programme structure and passed a resolution to incorporate it for the batch of students enrolled under NEP 2020 (Annexure A).
2. To seek approval for the syllabi for Multi-Disciplinary Courses and Skill Enhancement Courses to be offered at Semester III and a Vocational Course (VOC) to be offered at Semester IV under the approved new Programme structure and passed a resolution to incorporate it for the batch of students enrolled under NEP 2020 (Annexure A).

The Chairman thanked the members of the Board of Studies in Geology for their valuable contribution and active participation in the meeting.

The meeting ended with a vote of thanks to the Chair.

The foregoing minutes of the meeting were circulated by the Chairman, Board of Studies in Geology after the conclusion of the BoS meeting.

The following members of the Board of Studies were present in person for the meeting:

1. Dr Meghana S Devli - Chairperson
2. Mrs Swati S Ghadi – Member Secretary
3. Shri. Sachit Kuttikar– Member
4. Ms Siddhi Shirodkar - Member

The following members of the Board of Studies attended the meeting online via video conferencing

Link:

Meeting link : meet.google.com/edn-yifo-qnj

By phone

(US) +1 475-299-8933

PIN: 317847482

1. Dr Hrishikesh Samant – Nominee of the Vice Chancellor of Goa University
2. Dr Makarand Kale – Academic Council Nominee
3. Shri Brahmanand Sawant – Postgraduate Meritorious Alumnus

Members absent with intimation:

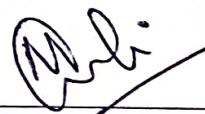
1. Shri Harish S Nadkarni – Member
2. Dr. Prakash Narashimha – Academic Council Nominee

Members absent without intimation:

1. Shri Smitesh S Talawadkar – Representative from Corporate Sector



Ms Swati S Ghadi
(Member Secretary)



Dr Meghana S Devli
(Chairperson, Board of Studies, Geology)

Date: 05 October 2023.

PART C: The remarks of the Dean of Academics:

- The minutes are in order.
- The minutes may be placed before the Academic Council with remark, if any.
- Important points of the minutes which need clear policy decision of the Academic Council to be recorded.

Date: 05-10-2023

Signature of the Dean of Academics:



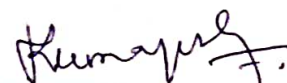
Dr Meghana S Devli

PART D: The remarks of the Member Secretary of the Academic Council:

- The minutes are in order.
- The minutes may be placed before the Academic Council with remark, if any.
- Important points of the minutes which need clear policy decision of the Academic Council to be recorded.

Date: 16/10/23

Signature of the Member Secretary,
Academic Council



Mr. V. C. Kumaresh



**Parvatibai Chowgule College of Arts and Science
(Autonomous)**

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

**SYLLABUS FOR SEMESTER III AND IV FOR
UNDERGRADUATE DEGREE HONOURS
PROGRAMME IN GEOLOGY**

(Implemented Academic Year 2024-2025)

ANNEXURE A
COURSE STRUCTURE

SEMESTER	DISCIPLINE SPECIFIC CORES (4 credits/course)	MINOR/ VOCATIONAL (4 credits/course)	MULTIDISCIPLIN ARY COURSES (3credits/course)	SKILL ENHANCEMENT COURSES (3 credits/course)
I	UG-GEL-101: Fundamentals of Geology		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-305: Rock Mechanics and Structures UG-GEL-306: Surveying and Field Geology UG-GEL-PRJ: Minor Project	UG-GEL-VOC3: Petroleum Exploration and Techniques		
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 III

DISCIPLINE SPECIFIC CORES

Course Title : OPTICAL MINERALOGY
Course Code : UG-GEL-201
Credits : 4 (45 contact hours theory + 30 hours practical)
Marks : 100

Course Objectives

The objective of the course is to provide the basics of geoscientific studies in Optical Mineralogy involving optical properties of minerals in plane polarized light, in between crossed polars and convergent light. Further, it will strengthen their knowledge in understanding of optical indicatrices and determination of optic sign of minerals.

Course Learning Outcomes

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

- CLO1** Explain basic concepts in optical mineralogy and relate them to study of minerals in Plane Polarised Light (PPL)
- CLO2** Explain basic concepts in optical mineralogy and relate them to study of minerals Between Crossed Polars (BXP).
- CLO3** Distinguish Uniaxial and Biaxial Indicatrix and study behavior of minerals under convergent light.
- CLO4** Identify major rock-forming minerals in microsections and detecting optic sign for Uniaxial and Biaxial Minerals using Interference Figures, Determine Anorthite content of Plagioclase and calculate Optic Axial Angle.

Module I

(15 hours)

Introduction: Nature of light, Polarized light, Refractive Index, Critical angle and Total Internal reflection, Wave Surface, Double Refraction.

Parts and working of a Polarizing / Petrological microscope

Properties of minerals in Plane Polarised Light (PPL): Colour, Form, Cleavage/Cracks; Relief, Twinkling; Pleochroism, Pleochroic halos.

Alteration, Inclusions.

Module II

(15 hours)

Optical characters of minerals: Isotropism and Anisotropism

Properties of minerals Between Crossed Polars (BXP): Interference colours: Formation, Newton's Scale, Anomalous interference colours;

Extinction and Extinction types.

Twinning and Zoning

Module III

(15 hours)

Optical accessories: Quartz Wedge, Gypsum plate, Mica plate

Uniaxial indicatrix

Biaxial indicatrix

Convergent Light: Principle

Uniaxial Interference Figure

Biaxial Interference Figure

Optic Sign of Uniaxial and Biaxial Minerals

2V and 2E (Measurement of True and Apparent Optic Axial Angle)

Practical: 1 credit

(30 hours)

Maximum Marks: 25

1. Identification of common rock forming minerals based on optical properties
2. Determination of Optic sign for Uniaxial and Biaxial Minerals
3. Determination of An-content using extinction angles
4. Determining 2V using Mallards Method.

List of books recommended for reference

Mandatory Reading

- Perkins, D., (2015). Mineralogy. Pearson New International Edition
- Nesse, D. W., (2012), Introduction to Optical Mineralogy, Oxford University Press.
- Kerr, P., (1977), Optical Mineralogy, McGraw Hill Publishers.
- MacKenzie, W. S and Guilford, C., Atlas of Rock forming minerals in thin section_

Supplementary reading

- Cornelis, K and Cornelis, H. (1993). Manual of Mineralogy, John Wiley and Sons Ltd.

Course Title : STRATIGRAPHY AND PALEONTOLOGY

Course Code : UG-GEL-201

Credits : 4 (45 contact hours theory + 30 hours practical)

Marks : 100

Course Objectives

Stratigraphy and Paleontology, the two branches of Geology work together to unearth the secrets of age from rocks of the earth's crust. Stratigraphers study the composition and arrangement of layered or stratified rocks. Paleontologists study the remains of plants and animals which have been preserved in the earth's crust by natural processes. With these objectives in mind, it becomes pertinent to understand the basic concepts of Stratigraphy and Paleontology.

Course Learning Outcomes

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

CLO1 Explain principles of Stratigraphy, concept of Facies, correlation, and measurements of geologic time.

CLO2 Describe types of fossils, conditions, and modes for fossilization, how fossils can be used to locate economic deposits

CLO3 Describe and explain morphology of the hard parts of body fossils belonging to the different phyla and their geological time

CLO4 Read maps, solve problems on bearings and handle clinometer compass.

CLO5 Describe and identify fossils/casts/shells w.r.t their morphology and geological age.

Module I

(15 hours)

Principles of stratigraphy: Uniformitarianism, Original horizontality, Order of superposition, Faunal succession, Cross-cutting relationship, Inclusions.

Principles of stratigraphic analysis, Facies concept in stratigraphy

Walther's Law of Facies.

Age of the earth: radiometric dating; Principles.

Measurement of geologic time:

Time Units: Eon-Era-Period-Epoch-Age

Lithostratigraphic/ Rock Units: Group-Formation-Member-Bed

Chrono-/ Time stratigraphic units: Erathem-System-Series-Stage

Biostratigraphy and Biozones

Standard Stratigraphic Scale.

Correlation and methods of Correlation:

Paleontological Criteria: Index/ Zone fossils

Lithological Similarity: Marker/ Key bed

Structural relations: Tectonic criteria

Brief account of the Geological Formations of Goa.

Module II

(15 hours)

Fossils: Mega- Micro-Ichnofossils

Conditions for fossilization; Favorable environments for fossilization.

Modes of fossilization: Petrification, Carbonization, Natural moulds and casts

Frozen and mummified fossils.

Uses of fossils in locating coal and petroleum deposits.

Module III

(15 hours)

Binomial Nomenclature of Organisms and Taxonomy

Morphology of the hard parts and geological time range of the following:

Phylum: Arthropoda- Class: Trilobita

Phylum: Mollusca- Class: Pelecypoda; Gastropoda and Cephalopoda- Nautiloidea; Ammonoidea; Belemnoida

Phylum: Brachiopoda

Phylum: Echinodermata- Class: Echinoidea

Practical: 1 credit

Maximum Marks: 25

- Drawing cross-section and description of structural maps involving two series (Horizontal and Inclined)
- Study of fossils/casts/shells w.r.t their morphology and geological age.
- Preparation of lithologs from field data

List of books recommended for reference

- Dana, J.D., (2010), Manual of Geology, Anmol Publications.
- Monroe, J and Wicander, R., (1994). The Changing Earth: Exploring Geology and Evolution, Brooks/Cole
- Black, R M., (1989). The Elements of Palaeontology, Cambridge University Press.
- Doyle, P. (1996). Understanding Fossils: An Introduction to Invertebrate Palaeontology. England: John Wiley & Sons Ltd.
- Spencer, E, W, Basic concepts of Historical Geology, Oxford & IBH Publishing Co.
- Koregave, M A., Fundamentals of Invertebrate Palaeontology, Book World Enterprises.

MULTIDISCIPLINARY COURSE

Course Title : PHYSICAL GEOLOGY

Course Code : UG-GEL-MDC3

Credits : 3 (30 contact hours theory + 30 hours practical)

Marks : 75

Course Objectives

The natural agencies like wind, rivers, glaciers have been moulding and remoulding the surface of the earth over millions of years. This course aims at the understanding of the processes and the physical forces responsible in developing the surficial features and highlighting the role of these natural agencies in grading and degrading the land surface.

Course Learning Outcomes

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

CLO1 Explain the processes of weathering, erosion, transportation, deposition, and how these geological processes create desert landforms.

CLO2 Identify and explain formation of various landforms created by geological action of streams, underground water, glaciers and the sea.

CLO3 Assign stream order as per Strahler's Method, hypsometric curve and preparation of long and cross sections of river profiles from SOI Toposheet.

Module I

(15 Hours)

Weathering and erosion

Earth Systems Affecting Weathering

Types of weathering: Mechanical, Chemical and Biological

Factors Affecting rate of Weathering.

Weathering versus Erosion

Transportation and deposition

Laminar and Turbulent Flow

Agents of Transportation – Wind, Water, Glaciers, Gravity

Modes of transportation – Bed Load (sliding, rolling, saltation), Suspension, dissolved load

Factors Affecting Depositions

Action of Wind

Generation of Winds,

Characteristics of Desert.

Problems Associated with Desertification.

Desert Landforms:

Depositional: sand dunes, Sand Seas/Ergs, Playa, sabkha

Erosional: Grooves, Ventifacts & Yardangs mushroom rock, Inselbergs, Mesas, and Buttes,

Desert Pavement

Module II

(15 Hours)

Drainage Basin and River System – Drainage Patterns

Geological Action of Rivers

Erosion by River

Process of Stream Erosion – Removal of Regolith, Downcutting, Headward Erosion.

Erosional Feature in Upper Course - Steep Valleys, Gorges, Interlocking Spurs, Potholes, Waterfall and Rapid

Erosional Features in Middle and Lower Course – Meander, Ox Bow Lake, Hogbacks, Cuestas

Depositional Landforms by River

Floodplains – Meanders, Point Bars, Natural Levees, Backswamps, Braided Stream, Deltas

Alluvial Valleys – Step Terraces

Alluvial Fans

Deposition by Groundwater

Speleothems – Stalactites, Stalagmites

Types of glaciers and Glacial Budget

Ablation – Melting, Evaporation, Calving

Action of Sea Waves

Erosional and depositional features of the coast.

Practical: 1 Credit

1. Basin Morphometry Perimeter Calculation using rotameter
2. Area Calculation – Square Grid/Planimeter/Area using triangles
3. Stream Ordering (Strahler's Method)
4. Hypsometric Curve
5. Long Profile and Cross Profile of River – Upper Course, Middle Course, Lower Course of river from SOI Toposheet.
6. Field visit to nearby area to understand and describe the various physical geology features.

List of books recommended for reference

- Monroe, S. J and R. Wicander., 2014. The Changing Earth: Exploring Geology and Evolution. Brooks Cole Publishers.
- Mathur, S. M., 2012. Physical Geology of India. National Book Trust
- Carlson, D.H., Plummer, C.C., McGary, D., 2008. Physical Geology: Earth revealed. Higher Education.
- McConnell, D., Steer, D., Knight, C., Owens, K., Park, L., 2008. The Good Earth – Introduction to Earth Science. Higher Education.
- Monroe, J.S., Wicander, R., Hazlett, R., 2007. Physical geology – Exploring the Earth (6th Ed.) Thomson Brooks/Cole.
- King, C.A.M., 2006: Techniques in Geomorphology, Edward Arnold, London

SKILL ENHANCEMENT COURSE

Course Title : GEMMOLOGY

Course Code : UG-GEL-SEC3

Credits : 3 (30 contact hours theory + 30 hours practical)

Marks : 75

Course Objectives

To introduce students to the scientific identification of gemstones.

Course Learning Outcomes

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

CLO1 Decide on the factors deciding cost of a gemstone, explain the causes of colours in gemstones.

CLO2 Explain how gemstones are synthesized, explain how gemstones are enhanced from low-grade to saleable quality, and explain the styles of cuts preferred for different gemstones.

CLO3 Identify gemstones based on visual observations, by using a dichroscope, polariscope, refractometer, spectroscope, ultraviolet lamp, gemmological microscope and determining Specific Gravity by hydrostatic method.

Module I

(15 hours)

Introduction to Gemmology
Association of Gemstones with rocks
Factors deciding the cost of a gemstone
Causes of colour in gemstones
International grading of diamonds
Composites

Module II

(15 hours)

Enhancement of gemstones
Treatments of gemstones
Synthesis of gemstones
Need for Faceting
Styles of cut
Diamond Cutting

Practical: 1 credit

(30 hours)

Visual observation of gemstones: Colour changing Sapphire, Colour changing Alexandrite, Opal, Sunstone, Star Garnet, Star Ruby, Diamond, Spectrolite, Lapis Lazuli, Chrysoberyl cats' eye, Tigers eyes, Aquamarine Cats eye, sillimanite Cats eye, Labradorite, Moss Agate, Amber,

Study of Natural crystals: Garnet, Emerald, Spinel, Tourmaline, Gypsum, Magnetite, Aquamarine, Ruby

Dichroscope for identifying gemstones: Andalusite, Tsavorite Garnet, Chrome Tourmaline, Green Tourmaline, Pink Tourmaline, Alexandrite, Sapphire, Natural Ruby, Synthetic Ruby, Tanzanite, Kyanite, Iolite.

Polariscope for identifying gemstones: Rose Quartz, Lemon Quartz, Rock crystal, Aquamarine, Iolite, Alexandrite, Scapolite.

Determination of Specific Gravity by Hydrostatic Method

Spectroscope in gemstone identification: Cubic Zirconia (American Diamond), Zircon, Diamond, Synthetic Ruby, Natural Ruby, Synthetic Sapphire, Natural Sapphire.

Refractometer in gemstone identification: Aquamarine, Tourmaline, Quartz (Uniaxial), Iolite, Kyanite (Biaxial)

Ultra Violet lamp in gemstone identification: Synthetic and Natural Ruby, Synthetic and Natural Sapphire, Zircon, Cubic Zirconia, Colour Changing Sapphire.

Gemmological Microscope in gemstone identification: Tourmaline, Sillimanite, Emerald, Kyanite, Spectrolite

List of books recommended for reference:

- Fernandes S. and Choudhary G., (2010) Understanding Rough Gemstones, Indian Institute of Jewellery.
- Karanth, R V; (2000) Gem and Gem deposits of India, Geological Society of India.
- Read, P. G., (1991). Gemmology, Butterworth-Heinemann Ltd.
- Webster, R., edited by Anderson, B, W., (1983) Gems: Their Sources, Descriptions and Identification, Butterworth-Heinemann Ltd.
- Sinkankas, J., (1969) Mineralogy: A First Course, Van Nostrand Reinhold Company.

SEMESTER IV

DISCIPLINE SPECIFIC CORE

Course Title : MINERALOGY

Course Code : UG-GEL-203

Credits : 4 (45 contact hours theory + 30 hours practical)

Marks : 100

Course Objectives

The course provides geoscientific study of mineralogy in understanding the structure, chemistry, optical and physical properties, stability relations and genesis of minerals.

Course Learning Outcomes

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

- CLO1** Explain the concept of Gibbs Phase Rule, geochemistry and collate structure, chemical composition with physical and optical properties of minerals of major silicate group of minerals, interpret stability relations of minerals using Phase diagrams of Olivine and Pyroxene group of minerals. Explain how minerals originate and associate with each other in a rock
- CLO2** Collate structure, chemical composition with physical and optical properties of minerals of major silicate group of minerals and interpret stability relations of minerals of Amphibole, Micas, and Feldspar Group of minerals. Explain how minerals originate and associate with each other in a rock
- CLO3** Collate structure, chemical composition with physical and optical properties of minerals of major silicate group of minerals and interpret stability relations of minerals of Feldspathoid and Silica group of minerals. Explain how minerals originate and associate with each other in a rock
- CLO4** Calculate end-members for olivine, pyroxene and feldspar group of minerals and determine the structural formula for the various silicate group of minerals.

Module I

(15 hours)

Introduction to mineral chemistry

Gibbs Phase Rule

Phase diagrams.

Whole rock chemistry (Major, Minor and Trace elements)

Concept of compatible and incompatible elements

Structure, mineral chemistry, paragenesis, and Phase diagrams of the following silicate group of minerals: Olivine group (Forsterite-Fayalite System); Pyroxene group (Diopside-Anorthite System);

Module II

(15 Hours)

Structure, mineral chemistry, paragenesis, and stability relations of the following silicate group of minerals: Amphibole Group; Mica Group; Feldspar group (Albite-Anorthite System; Orthoclase-Albite System);

Module III

(15 Hours)

Structure, mineral chemistry, paragenesis, and stability relations of the following silicate group of minerals: Feldspathoid group (Leucite-Silica System, Nepheline-Silica System; Silica Group.

Practical: 1 credit

(30 hours)

1. Calculation of end-members for olivine, pyroxene and feldspar group of minerals.
2. Calculation of Structural Formula for the common silicate group of minerals

List of books recommended for reference

- Deer, W. A, Howie, R. A and Zussman. J., (2013). An Introduction to Rock-Forming Minerals, Mineralogical Society.
- Ford, W. E., (2006). Dana's Textbook of Mineralogy (with extended treatise Crystallography and Physical Mineralogy). CBS Publishers, New Delhi.
- Griffen, D. T, Phillips, W. R and William, R. Phillips., (2004). Optical Mineralogy: The Nonopaque Minerals. CBS Publishers, New Delhi.
- Mason and Berry, (2004). Mineralogy, CBS Publishers, New Delhi.
- Faure, G (1998) Principles and Applications of Geochemistry. Prentice Hall
- White, W M (1997) Geochemistry, Wiley-Blackwell
- Krauskopf, K B and Bird, D K (1995) Introduction to Geochemistry. McGraw-Hill
- Mason, B and Moore, C., (1982). Principles of Geochemistry, John Wiley & Sons.

Course Title : ORE GENESIS
Course Code : UG-GEL-204
Credits : 4 (45 contact hours theory + 30 hours practical)
Marks : 100

Course Objectives

The course aims at understanding the various types of mineral deposits, classification, their mode of occurrence, geologic and geographical distribution and genesis. It primarily focuses on the processes of formation of ore deposits. Furthermore, it also aims at identification of economic minerals in hand specimens.

Course Learning Outcomes

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

- CLO1** Classify and differentiate the stages of ore-formation and ores, explain the igneous origin of ore minerals.
- CLO2** Explain the role of hydrothermal solutions and submarine volcanism forming ore-deposits. Also, describe sedimentation process in creating ore deposits.
- CLO3.** Describe various ore minerals and deposits found in India.
- CLO4** Identify various industrial and ore minerals with the help of their physical properties.

Module I (15 hours)

Goldsmith geochemical Classification

Tenor, Prospects, Resource and Reserves of ore minerals

Classification of Ore Deposits:

Modified Lindgren's Scheme; Bateman Scheme; Based on Tectonic Setting

Processes Forming Mineral Deposits

Requirements for ore deposit formation

Syngenetic and Epigenetic deposits

Magmatic Ore Forming Processes

Orthomagmatic ore formation (Bushveld; Sudbury)

Ore deposits at Mid-Ocean Ridges (Black and White Smokers) and in ophiolites (podiform chromites)

Ore formation related to alkaline magmatic rocks, carbonatites and kimberlites

Ore deposits in pegmatites

Module II (15 hours)

Magmatic-Hydrothermal Ore Forming Systems

Hydrothermal ore formation (Source of Hydrothermal Solutions; Textures and Structures; Host rock alteration)

Volcanogenic ore deposits (VMS; Terrestrial epithermal gold, silver and base metal)

Porphyry copper (Mo-Au-Sn-W) deposits

Hydrothermal-metasomatic ore deposits

Skarn, Greisen

Supergene Ore Formation Systems

Residual (eluvial) ore deposits

Supergene enrichment by descending (vadose) solutions

Sedimentary Ore Formation Systems

Black shales in metallogenesis (European Copper Shale)

Autochthonous iron and manganese Deposits

Sediment-hosted & submarine-exhalative (sedex) base metal deposits

Mississippi Valley type (MVT) Lead-Zinc deposits

Placer deposits

Metamorphic Ore Forming System

Orogenic Cu-Zn-Au deposits

Ore Deposits in Space and time

Metallogenic Epochs

Plate Tectonic Setting of Ore Deposits

Module III

(15 hours)

Indian occurrences of

Metallic Deposits:

Iron

Manganese

Chromium

Copper-Lead-Zinc

Gold

Non metallic Deposits:

Diamond, Baryte, Bauxite,

Nuclear Minerals

Industrial Minerals (Refractory, Abrasives, Cement, Fertilizer, Electrical and Electronics).

Practical: 1 credit

(30 hours)

- Descriptive evaluation of ore and industrial minerals in hand sample
- Introduction to reflected light microscopy of ore minerals (demonstration)
- Site visits to local mineralized geology

List of books recommended for reference

For Ore Forming Process: (E-books Available of All)

1. Pohl, L.W., 2011. Economic Geology – Principles and Practice. Wiley-Blackwell
2. Robb, L., 2005. Introduction to Ore-Forming Processes. Blackwell Publishing
3. Evans, A.M., 1993. Ore Geology and Industrial Minerals – An Introduction (3rd Ed.) Blackwell Publishing
4. Edwards, R. & Atkinson, K., 1986. Ore Deposit Geology and its influence on Mineral Exploration. Chapman and Hall Ltd.
5. Hutchison, C., Economic Deposits and their Tectonic Setting.

For Ore Deposits in Indian Context:

1. Prasad, U., 2014. Economic Geology: Economic Mineral Deposits (2nd Ed.), CBS Publishers, New Delhi
2. Srivastav, J.P., 2012. Introduction to Ore Microscopy. Prentice Hall India Learning Private Limited
3. Tiwari, A.K., 2010. Ore Geology, Economic Minerals and Mineral Economics. Atlantic
4. Gokhale, G.V.G.K., 1983. Ore Deposits of India. CBS Publishers, New Delhi

Mandatory Reading

Principle reference books used for course preparation will be Economic Geology by Walter Pohl and Economic Geology by Umeshwar Prasad.

Course Title : GEOTECTONICS

Course Code : UG-GEL-205

Credits : 4 (45 contact hours theory + 30 hours practical)

Marks : 100

Course Objectives

Ever since the creation of the earth, there have been marked changes in the distribution of land and sea. The dynamics of these changes are stupendous. The subject of Geotectonics aims at understanding the mechanism of such changes and explaining the structure of the earth and the processes responsible for the movement and redistribution of continents and seas.

Course Learning Outcomes

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

CLO1 Gain an insight into the earth's interior and generation of its magnetic field.

CLO2 Understand the theory of Continental Drift along with supporting evidences.

CLO3 Explain orogenesis and its relation with plate tectonics.

CLO4 Identify and plot various tectonic features on the earth's surface and apply the concept of plate tectonics to gain insight into earthquakes and hotspots.

Module I

(15 hours)

Interior of the earth:

Clues from the study of earthquake and density;

The earth's layers; the crust-continental crust and oceanic crust;

Crust-mantle boundary

Structure of the mantle

Low Velocity Zone (LVZ)

Core-mantle boundary; P wave shadow zone,

Nature of the core; S wave shadow zone.

Earth's Magnetic field:

Origin and nature

Dynamo hypothesis and Herndon's Georeactor Theory.

Geocentric axial dipole,

Paleomagnetism,

Marine magnetic anomalies,

Magnetic reversals and magnetic stripes

Module II

(15 hours)

Continental drift:

Wegener's hypothesis.

- Evidences: Continental fit; similarity of rock sequences and mountain ranges; glacial evidence, fossil evidence;

Paleomagnetism and Polar wandering.

Plate tectonics:

Plate margins, plate boundaries and associated activities,

Triple junctions;

Divergent, Oceanic Ridges, Sea floor spreading, transform faults; hotspots.

Convergent: oceanic–oceanic, oceanic-continental, continental-continental; oceanic trenches, subduction zones

Transform boundaries;

Wilson Cycle (Rift valleys, the Red sea and the Gulf of Aden)

Geometrical aspects and mechanism of plate motion.

Module III

(15 hours)

Mountain building: Orogenesis

Plate boundaries and orogenesis: Orogenesis at oceanic-oceanic plate boundaries, oceanic-continental plate boundaries and continental-continental plate boundaries.

Case study: Tracking the rise of Himalayas.

Case study: Frequency of Earthquakes in North India and AlpineMediterranean belt

Case Study: Occurrence of Tsunami in SE Asia

Case study: Occurrence of volcanic activity along Pacific Ocean Basin

Ophiolite- Origins and Importance

Mélanges

Flysch and Molasse

Practical: 1 credit

(30 hours)

1. Plotting of oceanic ridges, trenches, subduction zones, sea mounts, plate boundaries, plate spreading rates, old and young fold mountain.
2. Distribution of earthquakes, volcanoes, hotspots & hotspot related volcanic islands
3. Distribution of age of Atlantic Ocean floor
4. Exercises in plate tectonics and location of epicenter of earthquake

List of books recommended for reference

Mandatory reading

- Monroe, S. J and R. Wicander., 2014. The Changing Earth: Exploring Geology and Evolution, Brooks Cole Publishers.
- Marshak, S., 2011. Earth: Portrait of a Planet, W. W. Norton & Company.
- Prasad, C. V. R. K., 2005. Elementary Exercises in Geology, Universities Press.
- Skinner, J. B and S, C. Porter., 2003. The Dynamic Earth: An Introduction to Physical Geology, John Wiley and Sons.
- Condie, K. C., 1997. Plate Tectonics and Crustal Evolution, Butterworth-Heinemann.
- Duff, D and Holmes, A., 1993, *Holmes Principles of Physical Geology*, Springer.

Course Title : SEDIMENTARY PETROLOGY

Course Code : UG-GEL-206

Credits : 4 (45 contact hours theory + 30 hours practical)

Marks : 100

Course Objectives

To provide an understanding of the origin of sedimentary rocks, the relationship of sedimentary processes to plate tectonics, and the use of sedimentary rocks in the study of the geological past.

Course Learning Outcomes

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

CLO1 Explain the origin of sedimentary rocks and relate it to the associated textures and environments of deposition.

CLO2 Gain insight into the process of formation of sedimentary rocks by studying the various sedimentary structures.

CLO3 Explain the various classes of sedimentary rocks.

CLO4 To identify, describe and classify rocks using hand specimens and rock thin sections and to calculate various textural parameters of sedimentary rocks.

Module I

(15 hours)

The Origin of Sedimentary Rocks:

Erosion, transportation and deposition of sediments.

Hjulstrom's diagram

Provenance

Components of clastic sediments: Heavy, Clay, Quartz, Feldspars, other minerals

Maturity: Textural, Mineralogical and Chemical Index of Alteration (CIA) and Chemical Index of Weathering (CIW) with respect to source rock.

Sedimentary Textures

Grain Size, Udden-Wentworth Size Scale modified after McPherson (1999), Phi Scale, Roundness and Sphericity.

Classification of Sedimentary rocks (Pettijohn's, Folk's and Dunham's, Embry & Klovan)

Module II

(15 hours)

Primary sedimentary structures

Depositional, Erosional

Secondary sedimentary structures

Chemical, biogenic

Soft sediment deformations

Environment of deposition and sedimentary facies

Basins - Plate tectonics and sedimentation

Turbidites

Module III

(15 hours)

Clastic Sedimentary Rocks

Sandstones, Breccias and Conglomerates:

Textures, Structures, Mineral composition, Textural maturity,

Mudrocks:

Structures, Colour, Mineral composition; Oil shales

Non-clastic Sedimentary Rocks

Limestones and Dolomites:

Textures; Mineralogy; Structures; Diagenesis, Reefs and Palaeoclimate; Dolomites: Dolomitization.

Residual: (Laterite and Bauxite); Origin and Climate.

Carbonaceous sediments: Nature and form of organic residues; The Coal series

Miscellaneous sedimentary rocks- Phosphate deposits and Evaporites, Siliceous rocks.

Practical: 1credit

(30 hours)

1. Study and identification of sedimentary rocks w.r.t textures, structures, their classification.
2. Study of sedimentary rocks in thin sections
3. Exercises in grain size and shape analysis.

List of books recommended for reference

- Boggs S., (2009) Petrology of Sedimentary rocks (2nd edition), Cambridge University Press.
- Blatt H; Tracy R. J and Owens B. E., (2006) Petrology- Igneous Sedimentary and Metamorphic 3rd edition W H Freeman and Company New York.
- Boggs, Jr., (2005) Principles of Sedimentology and Stratigraphy (4 edition), Prentice Hall.
- Klein, C., & Philpotts, A. R. (2013). Earth materials: Introduction to mineralogy and petrology. Cambridge University Press.
- Prothero, D. R., and Schwab, F.; (2004) Sedimentary Geology. Macmillan.
- Tucker E.M. (2001) Sedimentary Petrology (3rd Edition), Blackwell Science Ltd.
- Raymond A L (1995) Petrology-The study of Igneous Sedimentary and Metamorphic rocks. Wm. C. Brown Communications, Inc.; USA.
- Greensmith, J. (1989) Petrology of the Sedimentary rocks (7th Edition), CBS Publishers, New Delhi.
- Ehlers G.E. and Blatt H., (1987) Petrology – Igneous, Sedimentary and Metamorphic, CBS Publishers, New Delhi.
- Pettijohn F.J., (1984) Sedimentary Rocks (3rd Edition), CBS Publishers, New Delhi.
- Colinson, J D & Thompson, (1982) Sedimentary Structures, Allen & Unwin.
- Miall A. D., (1984) Principles of Sedimentary Basin Analysis (3rd update and enlarged edition), Springer.
- Antonio Azor Pérez (2011) Tectonics of Sedimentary basins: Recent Advances, edited by Busby C. J. and Ingersoll R. V., Blackwell Science.

VOCATIONAL EDUCATION AND TRAINING

Course Title : OCCUPATIONAL HEALTH AND SAFETY
Course Code : UG-GEL-VOC1
Credits : 4 (45 contact hours theory + 30 hours practical)
Marks : 100

Course Objectives

Occupational Health and Safety (OHS) awareness among students is crucial as it prepares them to become responsible and safety-conscious future workers and also equips them with essential life skills. The objective of this course is not only to provide students ability to recognize workplace hazards and understand safety protocols but also create an awareness regarding right to a safe work environment. OHS education reduces the risk of workplace accidents and contributes to healthier, more productive, and socially responsible individuals.

Course Learning Outcomes

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

- CLO1** Identify types of hazards associated with workplace.
- CLO2** Explain risks related to a workplace, risk reduction methods and significance of emergency preparedness.
- CLO3** Analyze historic incidents to understand the root cause for incidents, legal implication and management measures.
- CLO4** Design a Safe operating procedure, involving hazard identification, risk reduction and preventive measures.

Module I (15 hours)

Introduction to Occupational Health, Environmental and occupational illness.

Types of health hazards: Biological hazards, Chemical hazards, Physical hazards, Psychosocial Hazards.

Health and Safety Hazards Management in Oil and Gas Industry; Sea safety.

Hazards related to exposure to mineral dust and preventive measures: coal, silica and asbestos

Hazards related to exposure to chemicals and preventive measures

Ergonomic and Psychosocial Hazards

Measures for health protection of workers

Module II (15 hours)

Risk Determination: Probability and consequence

Risk Reduction: Hierarchy of Controls

Incidents reporting and investigation: Basic, Indirect and direct cause

Collection of Occupational Safety data: Key Performance Indicator (KPI)

Safety and emergency preparedness

Module III (15 hours)

Rights and duties: Workers' rights, Employers' responsibilities, Governments' duties.

Brief overview of OHSAS 18001(Occupational Health and Safety Assessment Series 18001)

Case Studies: Discussion on video documentaries on workplace incidents or situations.

Practical: 1 credit

(30 hours)

Maximum Marks: 25

1. Hazard Identification, classification, within the campus.
2. Risk assessment using risk matrix based on likelihood (probability) and severity (consequence)
3. Creating a Safe operating procedure
4. Safety Report analysis and discussion.
5. Visit to Institute of Petroleum Safety, Health and Environment Management, Oil and Natural Gas Corporation (IPSHEM-ONGC)

List of books recommended for reference

- Alli, B. O. (2008). Fundamental Principles of Occupational Health and Safety.
- Cheremisinoff, N. P. (2001). Practical Guide To Industrial Safety. New York: Marcel Dekker, INC.
- Hughes, P., & Ferrett, E. (2016). Introduction to Health and Safety at Work. New York: Routledge.
- International Standard ISO 45001. (2012). Geneva: iso.org.
- Park, K. (2015). Park's Textbook of Preventive and Social Medicine. Jabalpur: Bhanot.
- World Health Organization. (n.d.). Retrieved from <https://www.who.int/publications/i?healthtopics=de3038d6-fa15-4e55-af9a-614db8dcf184>