Three/Four Year Degree Course

(With Multiple Entry / Exit Option)

Based on NEP-2020 (w.e.f. 2024-2025)

Geology

ସମ୍ବଲପୁର ବିଶ୍ୱବିଦ୍ୟାଳୟ
Sambalpur University
Accredited With Grade-A by NAAC (Third Cycle)

Odisha State Higher Education Council, Bhubaneswar

Government of Odisha

CONTENTS

PROGRAMME OUTCOMES (POs)

PO No	POs for B.Sc, Programmes
PO1	Critical Thinking: Students will have the capability to apply analytic thought to a body of knowledge; analyze and evaluate evidence, arguments, claims and beliefs on the basis of empirical evidence; identify relevant assumptions or implications; formulate coherent arguments; critically evaluate practices, policies and theories by Following scientific approach to knowledge development.

PO2	Effective Communication: Students will acquire the ability to express thoughts and ideas effectively in writing and orally in English and regional language and make meaningful interpretation by people, ideas, books, media and technology.
PO3	Social Interaction: Elicit views of others, mediated disagreements and help to reach conclusions in group settings.
PO4	Effective Citizenship: Demonstrate empathetic social concern and equity centered national development, and the ability to act with an informed awareness of issues and participate in civic life through volunteering.
PO5	Values and Ethics: Recognize different value systems including own, understand the moral dimensions of different decisions, and accept responsibility for them.
PO6	Environment and Sustainability: Understand the issues of environmental contexts and sustainable development.
PO7	Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes

PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO No	**PSOs for B.Sc. Programme in Geology**

PSO1	A fundamental / systematic or coherent understanding of the academic field of Geology, its different learning areas and applications in basic Geology like Mineralogy, Petrology, Stratigraphic, Paleontology, Economicgeology, Hydrogeology, etc. and its linkages with related interdisciplinary areas/subjects like Geography, Environmental sciences, Physics, Chemistry, Mathematics, Life sciences, Atmospheric sciences, Remote Sensing, Computer science, Information Technology.
PSO2	Procedural knowledge that create different types of professionals related to the disciplinary/subject area of Geology, including professionals engaged in research and development, teaching and government/public service.
PSO3	Skills in areas related to one's specialization area within the disciplinary/subject area of Geology and current and emerging developments in the field of Geosciences.
PSO4	Demonstrate the ability to use skills in Geology and its related areas of technology or formulating and tackling geosciences-related problems and identifying and applying appropriate geological principles and methodologies to solve a wide range of problems associated with geosciences.
PSO5	Plan and execute Geology-related experiments or investigations, analyze and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and purpose- written packages, and report accurately the findings of the experiment/investigations while relating the conclusions/findings to relevant theories in Geology.
PSO6	Problem-solving skills that are required to solve different types of geosciences related problems with well-defined solutions and tackle open-ended problems that belong to the disciplinary area boundaries; Investigative skills, including skills of independent investigation of geosciences related issues and problems.
PSO7	Communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise manner to different groups/audiences of technical or popular nature.
PSO8	Analytical skills involving paying attention to detail and ability to construct logical arguments using correct technical language related to Geology and ability to translate them with popular language when needed.
PSO9	Demonstrate professional behavior such as Being objective, unbiased and truthful in all aspectsofworkandavoidingunethical,irrationalbehaviorsuchasfabricating,falsifyingor misrepresenting data or committing plagiarism. Theability to identify the potential ethical issues in work-related situations. Appreciation of intellectual property, environmental and sustainability issues and promoting safe learning and working environment.

STRUCTURE AND REGULATION

Title and Commencement

The NEP 2020 framework facilitates a restructured degree programme with multiple entry and exit option for single major, double major and with or without major option. It promotes multi/Interdisciplinary choices subjects and disciplines. It inspires to meet the 21st century requirements of quality of Higher Education and needs of India to be a developed country. Its objective is to build well rounded creative individuals and citizens. This is meant for 3/4 years Undergraduate Degree Programmes covering all disciplines of the State Public Universities, coming under the Higher Education Department, Government of Odisha. It aims to coverage multiple disciplines such as Science, Arts, Humanities and Business Studies etc.

Academic Year

Two consecutive (one odd+ subsequent even one) semesters constitute one academic year.

Choice Based Credit System (CBCS)

The CBCS allows students to choose courses from a range of options and earn credits for the courses they complete. It is designed to provide flexibility and enable students to pursue their interests and strengths.

The students select courses from the prescribed courses i.e., Core, Multidisciplinary, Ability Enhancement Course (AEC), Skill Enhancement Course (SEC), Value Added Course (VAC), Summer Internship and Research Project/ Dissertation etc.

- **Course** refers to 'paper', which is component of a programme.
- **Core** is the subject of main focus. A core can be a Major Core(**Core-I**) or a Minor Core (**Core-II** or **Core III**)
- **Major or Honours** will be awarded provided the students acquire 92 credits from a single subject under Core-I in the 4yr.Program.
- **Credit** is a unit by which the course work is measured. One credit is equivalent to one hour of lecture/tutorial or two hours of practical work/field work per week in a semester. One Credit will be generally equivalent to 15 hours of instructions in a whole semester

Duration &Types of Courses

Candidate has to complete the Three /Four years course within **Seven Years** from the date of admission. Under no circumstances, the candidate will be allowed to appear the back log examination beyond the specific period. A candidate admitted in the academic year 2024-25 has to complete the programme by 2030-31 (On multiple exit and entry option under four/three-year programme, the candidate has to enter him self/her self latest by 2029-30 or 2030-31 with completion of either two year or one year respectively).

Each semester shall comprise of 15weeks of academic activities with a minimum of 90working days. The undergraduate programmes shall extend over four academic years (Eight Semesters) with multiple entry and exit options.

The students can exit a course as follows:

i. Certificate Course-One academic year i.e. First & Second Semesters and a summer/ Vocational Course and Community Work (Table1) ii. Diploma Course-Two academic years i.e. First, Second, Third & Fourth Semesters and a Summer/Vocational Course and Community Work (Table 2) iii. Three Year Degree Course with Single Major (Table3) iv. Three Year Degree Course with Double Major (Table4)

v. Three Year Degree Course with Three Cores as Minor stream (Table5) vi. Four Year Honours without Research with Major (Table6) vii. Four Year Honours with Research (Table7)

Table1: Structure for Certificate Course (1year)

Sem	Core-I	Core-II	Core-III	MD	AEC	SEC	VAC	CES/ FW/I	Total
I	2x4=8 Core-I Core-II	1x4=4 Core-I		1x3=3	1x4=4 **Odia**		1x3=3 **ESDM**		22
II	2x4=8 Core-III Core-IV		1x4=4 Core-I	1x3=3	1x4=4 **English**	1x3=3			22
Total Credit	**16**	**4**	**4**	**6**	**8**	**3**	**3**		**44**
Vocational Course of 4credits for certificate course(Total 48 credits)									

NB:Core-I. II & III are Major and Minor Subjects, MD (Multidisciplinary), AEC (Ability enhancement Courses), SEC (Skill Enhancement Courses), VAC (Value Added Courses), CES (Community Engagement and Services), FW (Field Work), I (Internship) Table2:Structure for Diploma Course (2years)

Sem	Core-I	Core-II	Core-III	MD	AEC	SEC	VAC	CES/ FW/I	Total
I	2x4=8 Core-I Core-II	1x4=4 Core-I		1x3=3	1x4=4 **Odia**		1x3=3 **ESDM**		22
II	2x4=8 Core-III Core-IV		1x4=4 Core-I	1x3=3	1x3=3 **English**	1x3=3			22
III	3x4=12 Core-V Core-VI Core-VII	1x4=4 Core-V		1x3=3			1x3=3		22
IV	3x4= 12 Core-VIII Core-IX Core-X		1x4=4 Core-V					1x4=4	20
Total Credit	**40**	**8**	**8**	**9**	**8**	**3**	**6**	**4**	**86**
Vocational Course of 4credits for Diploma/ Certificate Course (total 90)									

Table3:Three-year Degree with Single Major and Two Minors:

Sem	Core-I	Core-II	Core-III	MD	AEC	SEC	VAC	CES/FW/I	Total
I	2x4=8 Core-I Core-II	1x4= Core-I		1x3=3	1x4=4 **Odia**		1x3=3 **ESDM**		22
II	2x4=8 Core-I II Core-IV		1x4= Core-I	1x3=3	1x4=4 **English**	1x3=3			22
III	3x4=12 Core-V Core-VI Core-VII	1x4= Core-V		1x3=3			1x3=3		22
IV	3x4=12 Core-VIII Core-IX Core-X		1x4= Core-V					1x4=4	20
V	3x4=12 Core-X Core-XII Core-XIII	1x4=4 Core-VI				1x3=3	1x3=3		22
VI	2x4=8 Core-XIV Core-XV		1x4=4 Core-VI			1x3=3	1x3=3		18
Total Credit	**60**	**12**	**12**	**9**	**8**	**9**	**12**	**4**	**126**

In case a student opts for NCC and clears 'C' certificate additional 16 Credit shall be awarded and total credit shall be 126+16 = 142 Credit

Table4:Three-years Degree with Double Majors

Sem	Core-I	Core-II		MD	AEC	SEC	VAC	CES/FW/I	Total
I	2x4=8 Core-I Core-II	1x4=4 Core-I		1x3=3	1x4=4 **Odia**		1x3=3 **ESDM**		22
II	2x4=8 Core-I II Core-IV			1x3=3	1x4=4 **English**	1x3=3			22
III	3x4=12 Core-V Core-VI Core-VII	1x4=4 Core-V		1x3=3			1x3=3		22
IV	3x4=12 Core-VIII Core-IX Core-X							1x4=4	20
V	3x4=12 Core-XI Core-XII Core-XIII	1x4=4 Core-VI				1x3=3	1x3=3		22
VI	2x4=8 Core-XIV Core-XV					1x3=3	1x3=3 PM		18
Total Credit	**60**	**48**		**9**	**8**	**9**	**12**	**4**	**150**

Table5: Three-years Degree with Three Cores without Major

Sem	Core-I	Core-II	Core-III	MD	AEC	SEC	VAC	CES/FW/I	Total
I	1x4=4 Core-I	1x4=4 Core-I	1x4=4 Core-I	1x3=3	1x4=4 **Odia**		1x3=3 **ESDM**		22
II	1x4=4 Core-II	1x4=4 Core-II	1x4=4 Core-II	1x3=3	1x4=4 **English**	1x3=3			22
III	1x4=4 Core-V	1x4=4 Core-V	1x4=4 Core-V	1x3=3			1x3=3		22
IV	2x4=8 Core-VI Core-X	2x4=8 Core-VI Core-X	2x4=8 Core-VI Core-X					1x4=4	20
V	1x4=4 Core-XII	1x4=4 Core-XII	1x4=4 Core-XII			1x3=3	1x3=3		22
VI	1x4=4 Core-XIV	1x4=4 Core-XIV	1x4=4 Core-XIV			1x3=3	1x3=3		18
TOTAL	**28**	**28**	**28**	**9**	**8**	**9**	**12**	**4**	**126**

Table6: Four-years Honours without Research

Sem	Core-I	Core-II	Core-II	MD	AEC	SEC	VAC	CES/FW/I	Total
I	2x4=8 Core-I Core-II	1x4=4 Core-I		1x3=3	1x4=4 **Odia**		1x3=3 **ESDM**		22
II	2x4=8 Core-I II Core-IV		1x4=4 Core-I	1x3=3	1x4=4 **English**	1x3=3			22
III	3x4=12 Core-V Core-VI Core-VII	1x4=4 Core-V		1x3=3			1x3=3		22
IV	3x4=12 Core-VIII Core-IX Core-X		1x4=4 Core-V					1x4=4	20
V	3x4=12 Core-X Core-XII Core-XIII	1x4=4 Core-VI				1x3=3	1x3=3		22
VI	2x4=8 Core-XIV Core-XV		1x4=4 Core-VI			1x3=3	1x3=3		18
VII	4x4=16 Core-XVI Core-XVII Core-XVIII Core-XIX	1x4=4 Core-XIV							
VIII	4x4=16 Core-XX Core-XXI Core-XXII Core-XXIII		1x4=4 Core-XIV						
Total Credit	92	**16**	**16**	**9**	**8**	**9**	**12**	**4**	**166**

Table7:Four-yearHonourswithResearch

Sem	Core-I	Core-II	Core-II	MD	AEC	SEC	VAC	CES/FW/I	Total
I	2x4=8 Core-I Core-II	1x4=4 Core-I		1x3=3	1x4=4 **Odia**		1x3=3 **ESDM**		22
II	2x4=8 Core-I II Core-IV		1x4=4 Core-I	1x3=3	1x4=4 **English**	1x3=3			22
III	3x4=12 Core-V Core-VI Core-VII	1x4=4 Core-V		1x3=3			1x3=3		22
IV	3x4=12 Core-VIII Core-IX Core-X		1x4=4 Core-V					1x4=4	20
V	3x4=12 Core-X Core-XII Core-XIII	1x4=4 Core-VI				1x3=3	1x3=3		22
VI	2x4=8 Core-XIV Core-XV		1x4=4 Core-VI			1x3=3	1x3=3		18
VII	4x4=16 Core-XVI Core-XVII Core-XVIII Core-XIX (Any3)	1x4=4 Core-XIV							
VIII	Core-XX Core-XXI Core-XXII Core-XXIII (Any2)		1x4=4 Core-XIV					1x12 **Research**	
Total Credit	**80**	**16**	**16**	**9**	**8**	**9**	**12**	**16**	**166**

Assessment:

A. Distribution of Marks in Semester End and Continuous Evaluation:

Course Type	Maximum Marks	Term end Theory	Term End Practical	Continuous Evaluation	Mid Sem Theory	Mid Sem Practical
Without Practical	100	60	NIL	20	20	NIL
With Practical	100	50	20	10	10	10

B. Distribution of Sessional Marks:

Course Type	Maximum Marks	Mid Semester	Attendance	Surprise Test/Quiz	Assignment /Presentation
Without Practical	40	20 (Theory)	5 (>95%) 4(85%-94%) 3(75%-84%)	10	5
With Practical	30	20(Theory +Practical)		5	Nil

C. Examination Question Pattern of Term End Examination:

Part	Question Pattern	With Practical	Without Practical
Part-1 Objective	MCQ or Answer in one word/sentence	1 x10= 10	1 x10= 10
Part-2Very Short Type	Answer in max50 words (All compulsory)	2 x9 =18	2 x9 =18
Part-3Short Type	Answer in250 words (answer 8 out of 10)	5 x8 =40	5 x8 =40
Part-4 Long Type	Answer in 800 words (answer 4 out of 5)	8 x4 =32	8 x4 =32
	Total	100	100
Practical Paper (20 Marks)		One Major Experiment- 10 marks Record–5marks Viva-5 marks	

CORE COURSES (4Credit Hours)

1. Core Courses (*4 Credits each*) Core-I-Geology(Major/ Hons.) Core-II-Geology(Minor/ Pass) Core-III-Geology(Minor/ Pass)

SLNO	COURSE CODE	COURSENAME
1	Core-I	GENERAL GEOLOGY
2	Core- II	HISTORICAL GEOLOGY
3	Core- III	CRYSTALLOGRAPHY
4	Core- IV	MINERALOGY AND MINERALOPTICS
5	Core - V	GEOCHEMISTRY AND ELEMENTARY PETROLOGY
6	Core - VI	ELEMENTARY ECONOMIC GEOLOGY
7	Core - VII	PALEONTOLOGY
8	Core - VIII	STRATIGRAPHY
9	Core - IX	IGNEOUSPETROLOGY
10	Core - X	SEDIMENTARYPETROLOGY
11	Core - XI	METAMORPHICPETROLOGY
12	Core -XII	REMOTESENSING AND GIS
13	Core - XIII	STRUCTURAL GEOLOGY AND TECTONICS
14	Core- XIV	ENGINEERING GEOLOGY AND ROCK MECHANICS
15	Core -XV	HYDROGEOLOGY
16	Core - XVI	EXPLORATION AND MINING GEOLOGY
17	Core - XVII	ECONOMI CMINERALS OF INDIA
18	Core - XIII	LABORATORY INSTRUMENTATION AND ANALYSIS
19	Core - XIX	GEOLOGY AND MINERAL RESOURCES OF ODISHA
20	Core- XX	FUEL GEOLOGY
21	Core- XXI	ENVIRONMENTAL GEOLOGY
22	Core- XII	ORE MICROSCOPY
23	Core-XXIII	INTRODUCTION TO GEOSTATISTICS

SEMESTER-I

Core I - General Geology

(ORIGIN OF EARTH, IT'S EVOLUTION AND LANDFORMS)

Course Objectives:

- To introduce fundamental aspects of Earth and Planetary system and Geological time-scale
  To introduce the Internal Structure and processes of Earth.
- To associate with the naturally occurring landforms with erosive and depositional action of the rivers, wind, glaciers and oceans.

Learning Outcomes:

- Understand the scientific theories and evidence supporting the origin of the Earth and the Solar system
- Analyze the processes involved in the early evolution of the Earth including differentiation, accretion, and the formation of the Earth's internal structure and processes.
- Understand the internal structure and processes within the earth which impacts surface processes like volcanism and earthquakes.
- Evaluate the surface processes and agents like water, wind, glacier and oceans in shaping the various landforms.

Unit-I: **Earth as a planet**

Geology - its perspective, scope and subdivisions; Solar System and its planets. The terrestrial and Jovian planets. Origin of Earth in the solar system. About Earth (size, shape, mass, density, rotational and revolution parameters). Radioactivity and age of the earth.

Unit-II: Internal structure of the Earth

Seismology and internal structure of the earth, Formation of core, mantle, crust, Convection in Earth's core and its magnetic field. Volcanoes: Types, products and distribution. Earthquakes - intensity, causes and distribution.

Unit-III: **Denudation and Geological Action of water**

Weathering and Erosion, Mass wasting; Geological works of river. Types of drainage pattern. Geological action of underground water.

Unit-IV: Geological action of Wind, Glaciers & Ocean

Geological action of glacier, wind and ocean and landforms produced by them. Wave erosion and beach processes.

Suggested Practical:

- Topographic Maps and Interpretation**.**
- Contour Patterns and Drawing of Profiles Volcanoes and their

Occurrences Earthquakes and Seismic Zones. **Text Book:**

✓ *Steven Earle(2015)Physical Geology (available online at https://opentextbc.ca/geology/)*

✓ *G.B. Mohapatra (2018)Text book of Physical Geology, CBS Publishers*

Core- II -Historical Geology

(DYNAMIC EARTH, IT'S ROCK AND FOSSIL RECORDS)

Course Objectives:

- To introduce crustal processes which shape the Earth's surface
- To explain the theory of plate tectonics and its evidences To provide the basis of Geologic timescale
- To introduce fossils and its use to establish evolution of life through hgeological time.

Learning Outcome:

- Analyze land forms and the causative crustal processes
- Understand the role of plate tectonics in shaping Earth's surface and its various land forms
- Appreciate the evolution of life through geological time through stratigraphy and its correlation Explain evolution of vertebrate and origin from fossil records

Unit-I:Crustal Processes & Landforms

Diastrophism–Epeirogeny and orogeny, Isostasy–concept and theories; Geosynclines, Origin of oceans, continents, mountains and rift valleys.

Unit-II: PlateTectonics

Plate tectonics–concept and types of plate margins, Continental drift–evidences and causes; Sea-floor spreading;, Mid-oceanic ridge, trenches, transform faults; Island arc.

Unit-III: Geological Time Scale and Rock records

Geological Time Scale, Principles of Stratigraphy, Stratigraphic units; Stratigraphic correlation and Indian equivalences, Geomorphic and tectonic divisions of India.

Unit-IV: Fossils and Evolution of Life on Earth

Fossils, types and fossilization, Geological significance of fossils. Origin of life and evolution – ancient and modern concepts, evidences, theories and types, Types of fossil specimens.

Suggested Practical:

- Identification of Land forms from Tectonic Maps ○ Ring o f Fire
  - ○ Different types of plate boundaries ○ Triple junctions
- Identification of Vertebrate Fossils
- Identification of Invertebrate fossils
- Identification of Plant fossils **Text Book:**
  - ✓ *Wicander,Monroe (2012)Historical Geology, Cenage Learning*. **SuggestedReadings:**
- Shah, S.K.(2018),Historical Geology of India, Scientific Publishers.
- Poort & Carlson (2005) Historical Geology: Interpretations and Applications, Pearson Prentice Hall

Semester II

Core III-Crystallography

Course Objectives

- To explain the principles of crystallography and crystal systems.
- To introduce crystallographic calculation using Miller's indices, Lattice parameters and crystallographic axes
- To provide a methodical approach to identification and classification of mineral crystals based on their crystallographic properties.

Learning Outcomes

- Understand the principles of crystallography and crystal systems.
- Explain the fundamental concepts of crystallography, including crystal lattice, unit cell, symmetry elements, and crystal systems.
- Identify and classify crystals based on their crystal systems and symmetry properties. Interpretcrystallographicdata,includingcrystalsymmetryandcrystallographicdirections Analyze crystal structure and properties of minerals.

Unit-I:Elements of crystallography and isometric system

Crystalline and non-crystalline substances, Crystals - definition, characteristics, intercepts, parameters, indices and forms (Open and closed, General and Special). Symmetry elements and classification of crystals in to six systems. Hermann-Mauguin symbol; Holohedrism, hemihedrism, hemi-morphism and enantiomorphism. Twinning, zone and zonal laws.

Unit-II: Normal classes-A

Study of axial relationship, symmetry elements and forms present in normal classes of isometric, tetragonal, hexagonal and Trigonal system.

Unit-III: Normal classes-B

Study of axial relationship, symmetry elements and forms present in normal classes of orthorhombic, monoclinic and triclinic system.

Unit-IV: Lower crystal classes

Study of axial relationship, symmetry elements and forms present in lower classes of isometric system. Projection of crystals, Bravais lattice.

Practical:

- Identification of symmetry elements from crystallographic models
- Stereographic projection of crystals belonging to isometric and tetragonal normal class

Text Book:

- ✓ Crystallography by JD Dana.

Suggested Books:

- ✓ Practicalapproachtocrystallographyandmineralogy,R.N.Hota(2011),CBSPub.&Dist., New Delhi
- ✓ Flint, F.(1964):Essentials of Crystallography, Peace Pub., Russia.
- ✓ Babu, S.K.(1987): Practical Manual of Crystal Optics, CBS Pub.& Dist.
- ✓ Ford W.E.,(2006) Dana's Text Book of Mineralogy CBS Pub.& Dist. New Delhi

Core IV-Mineralogy and Mineral Optics

Course Objective:

- To introduce Minerals and their properties
- To provide the basis of mineral classification
- To provide an understanding of an optical microscope and how to observe optical properties of minerals in thin sections

Learning Outcome:

- Identify and classify minerals in hand specimens
- Observe optical properties and identify minerals under the microscope
- Describe the macro and microscopic properties of minerals and mineral groups

Unit–I:Elements of mineralogy

Chemical bonding and compound formation, Definition and classification of minerals. Physical properties of minerals, Silicate structure and its classification. Isomorphism, polymorphism and pseudo-morphism.

Unit-II: Silicate groups

Study of atomic structure, chemistry, physical, optical properties and uses of minerals of Olivine, Pyroxene, Amphibole, Garnet, Feldspar, Feldspathoids, silica and Mica groups.

Unit-III: Principles of mineral optics

Nature of light rays and their propagation, internal reflection, double refraction, interference and polarization. Nicol Prism and polaroids. Petrological microscope - parts and their functions. Preparation of thin section of minerals and rocks.

Unit-IV: Optical properties

Behaviour of light in thin section and production of interference colours. Order of interference colour, twinkling, Optic axis, Uniaxial and biaxial minerals. Isotropism and anisotropism, Extinction and extinction angle. Pleochroism, pleochroic scheme, Birefringence; Outline of study of optical characters of minerals in thin sections.

Practical:

- Megascopic identification of Minerals
- Microscopic identification of Minerals;
- Measurement of extinction angle; sign of elongation and order of interference color.

Text Book:

- ✓ *Dexter Perkins(2002)Mineralogy ,Prentice-Hall of India, New Delhi.*

Suggested Readings:

- ✓ *Klein,C.,Dutrow,B.,Dwight,J.&Klein.(2007).ManualofMineralScience(afterJamesD. Dana). J. Wiley &Sons.*
- ✓ *Kerr, P.F.(1959).Optical Mineralogy. McGraw-Hill.*
- ✓ *Verma, P.K.(2010).Optical Mineralogy (Four Colour).AneBooksPvt.Ltd.*
- ✓ *Deer, W.A., Howie, R.A., & Zussman, J.(1992).An introduction to the rock-forming minerals(Vol. 696). London: Longman.*
- ✓ *Hota, R. N. (2017) Practical approach to crystallography and mineralogy, CBS Publishers and Distributors, New Delhi.*

Semester III

Core V - Geochemistry and Elementary Petrology

Course Objectives:

- To introduce the chemical characteristics and cosmic abundance of elements
- To explain the geochemistry of water and sediments
- To classify and name of the rocks based on their mineral composition and properties
- To explain the petrographic characteristics and petrographic features, such as mineral assemblages, textures, and structures, exhibited by rocks.

Learning Outcomes

- Explain the geochemistry of water and sediments
- Classify elements based on their geochemistry and mode of affinity.
- Elaborate on the cosmic abundance of elements
- Explain the petrographic characteristics and petrographic features of rocks.

Unit-I: Elements of Geochemistry

Chemical bonding, states of matter and atomic environment of elements. Cosmic abundance of elements; composition of planets and meteorites. Structure and composition of earth. Conservation of mass, isotopic and elemental fractionation. Concept of radiogenic isotopes in geochronology and isotopic tracers.

Unit-II: Geochemical Classification of Elements

Geochemical classification of elements, Primary geochemical differentiation; Atomic substitution. Advection and diffusion; Solid solution, Chromatography; Elements of marine chemistry; Mineral reactions- diagenesis and hydrothermal reactions.

Unit-III: Cosmic Abundance of Elements

Distribution of elements in solar system; Chemical differentiation and composition of the Earth; General concepts about geochemical cycles and mass balance; Geo-chemical behavior of major elements.

Unit–IV: Elements of Petrology

Types of rocks, Physical properties, genesis, evolution and types of magma. Processes of formation of sedimentary rocks; origin of metamorphic rocks.

Practical:

- Geochemical data analysis and interpretation of common geochemical plots.
- Geochemical phase variation diagrams and its interpretations.
- Rock classification and Megascopic identification of rocks **Text book:**

- ✓ *Principles of Geochemistry, Brian Mason*
- ✓ *Principles of Petrology: An Introduction to the Science of Rocks,Tyrrell,G.W.* **Suggested Readings**:
- ✓ *Essentials of geochemistry, John V Walther*
- ✓ *Petrology of Igneous, Sedimentary and Metamorphic Rocks, Sachin Changotra*
- ✓ *Petrography, An Introduction to the Study of Rocks.Williams,H.,F.J.Turner,andC.M. Gilbert.*

15 Core VI- Elementary Economic Geology

Course Objective

- To explain the process of formation of ore deposits.
- To discourse on Indian distribution of metallic and non-metallic ore minerals
- To provide an understanding of the various economic minerals found in India.

Learning Outcomes:

- Understand the primary and secondary processes of ore formation
- Apply principles of ore-genesis and geo-thermometry
- Appreciate the distribution of various metallic and non-metallic ores in India.

Unit-I: Ore Minerals & Primary Processes

Process of formation of ore bodies: Magmatic concentration, Hydrothermal processes, Wall rock alteration and Paragenesis, Zoning.

Unit-II: Secondary Processes

Residual and mechanical concentration, Oxidation and Supergene enrichment, Sedimentation, Evaporation & Metamorphism.

Unit-III: Ore-Genesis

Ore genesis, Syngenetic & Epigenetic Ores, Formation of Magmatic, Hydrothermal, Metamorphic Fluids and their concentration. Geo-thermometry, definition, classification, methods for preparation of geological thermometry.

Unit-IV: Economic Minerals of India

Metallic and Non-metallic ores of India: Metallic ores, Non-metallic and industrial rocks and minerals, atomic minerals, Gem & Gemstones.

Practical:

 Distribution of Economic Minerals by type in India and the world
Problems in geo-thermometry.

Textbooks:

- ✓ *Tiwari, S.K.(2010)Ore Geology, Economic Minerals and Mineral Economics, Atlantic Publishers & Distributors (P) Limited*
- ✓ *Laurence Robb.(2005)Introduction to ore forming processes. Wiley.*

Suggested Reading:

- ✓ *Guilbert, John M. and Charles Frederick Park (2007) The Geology of Ore Deposits, Waveland Press 4.*
- ✓ *Arogyaswamy R.N.P. (2017) Courses in mining geology, Oxford and IBH publishers*
- ✓ *Evans, A.M.(1993) Ore Geology and Industrial minerals. Wiley*
- ✓ *Ridley,J.(2013):Ore Deposit Geology. Cambridge University Press,UK.P398.*
- ✓ *Guilbert, J.M. and Park Jr.,C.F.(1986) The Geology of Ore deposits. Freeman & Co.*

16 Core VII-Paleontology

Course Objectives

- To introduce the principle sand methods of paleontology

- To expose students to fossils, their modes of formation ,classification and application in paleontological dating.
- To use fossil records for reconstruction of the evolutionary history of organisms.
- To discourse on ancient environments and climate change from fossil evidences including mass extinctions. **Learning Outcomes:**
- Understand the principles of paleontology which include fossil identification, excavation techniques, and paleontological dating.
- Apply these techniques to analyze and interpret fossil records.
- Analyze and interpret the fossil record to reconstruct the evolutionary history of organisms and understand past ecosystems.
- Infer about ancient environments, climate change, and mass extinctions from fossil records.

Unit-I:Introductionto Paleontology

Fossilization – conditions, processes (Taphonomy) and modes. Taxonomic hierarchy and Nomenclature. Concept of bio-stratigraphy, Geological Time Scale and organic evolution.

Unit-II: Invertebrate Fossils

Introduction to important invertebrate groups (e.g. Trilobita, Mollusca) and their biostratigraphy significance. Morphology and evolution of Brachiopods, Pelecypods, Cephalopods & Gastropods, Trilobites, Echinoids, Corals and Graptolites

Unit-III: Vertebrate Paleontology

Origin and division of vertebrates and major stages of evolution. Reptiles and mammals and their evolution from fossil records. Siwalik fauna, Evolution of horse, elephant and homo sapiens.

Unit-IV: Paleo-botany & Palynology

Gondwana flora and their significance. Separation of spores and pollens. Utility of palynological studies in different fields.

Practical:

- Identification of important invertebrate and plant fossils;
- Drawing and labeling of fossils;
- Arrangement of fossils in geo-chronological order; **Textbook:**

✓ *Foote,M.and Miller,I.A.(2007)Principles of Paleontology.W.H.Freeman and company* ✓ *Clarkson,E.N.K.(2012)Invertebrate paleontology and evolution,4thEdition, Blackwell Publishing.*

Suggested readings:

- ✓ *Raup, D.M., Stanley, S.M. Freeman ,W.H.(1971) Principles of Paleontology* ✓ *Benton, M.(2009).Vertebrate paleontology. John Wiley & Sons.*
- ✓ *Shukla,A.C.&Misra,S.P.(1975).Essentials of paleobotany.Vikas Publisher*
- ✓ *Armstrong,H.A.,&Brasier,M.D.(2005) Microfossils. Blackwell Publishing.*
- ✓ *Benton,M.J.and Harper,D.A.T.(2009) Introduction to Paleobiology and the Fossil Record. Wiley-Blackwell*

Semester IV

Core VIII - Stratigraphy

Course Objectives

- Introduce the principles of stratigraphy and geological timescale

- Exposure on Stratigraphic Nomenclature and Indian stratigraphic systems and their significance
- Describe the use of fossils for paleo-ecology, paleo-biogeography, paleo-climate and paleo-environmental study **Learning Outcome:**
- Explain the principles of advanced stratigraphy and details of geological time scale
- Assess Indian stratigraphic systems and their significance
- Discuss on the use of fossils for paleoecology, paleobiogeography, paleoclimate and paleo-environmental study

Unit -I: Introduction

Definition and scope of Stratigraphy, Principles of Stratigraphy, Geological Time Scale. Stratigraphic Contacts and types (conformable contacts, unconformities)., Stratigraphic correlation and types, Classification and nomenclature of units, Indian code of Stratigraphic Nomenclature, Elements of Paleo-geography

Unit-II: Precambrian Stratigraphy of India

Precambrian stratigraphy of Karnataka, Odisha, Jharkhand, Rajasthan, Madhya Pradesh and Maharashtra. Stratigraphy of Cuddapah and Vindhyan basins, Delhi Super-group

Unit–III: Paleozoic and Mesozoic Stratigraphy of India

Gondwana rocks with special emphasis on fossils, climate and economic importance. Triassic of Spiti, Jurassic of Kutch and Cretaceous of Trichinopoly.

Unit-IV: Cenozoic Stratigraphy of India

Deccan Traps, Tertiary of Assam, Siwalik (with special reference to mammal fossils).

Practical:

- Drawing of stratigraphic units in outline map of India and Odisha;
- Identification and interpretation of stratigraphic assemblages;
- Drawing of pale-ogeographic maps as mentioned in theory **Textbook:**

✓ *Ramakrishnan &Vaidyanadhan (2008) Geology of India, Volumes1& 2, Geological society of India, Bangalore.*

✓ *Boggs,S.,1995.PrinciplesofSedimentologyandStratigraphy,PrenticeHall,NewJersey.*

Suggested readings:

✓ *Krishnan,M.S.(1982) Geology of India and Burma, CBS Publishers, Delhi ✓ Doyle,P.& Bennett,M.R.(1996)Unlocking the Stratigraphic Record .John Wiley ✓ Valdiya,K.S.(2010)The making of India, Mac millan India Pvt.Ltd.*

18 Core IX Igneous Petrology

Course Objectives

- To introduce Igneous processes and products
- To classify the various igneous rocks based on their genesis ,mineral composition and texture To analyze the petrographic characteristics and processes of formation of igneous rocks:
- To interpret rock characteristics to deduce the magmatic processes, including magma differentiation, fractional crystallization, assimilation, and magma mixing.

Learning Outcomes:

- Understand the basis for classification and nomenclature of igneous rocks:
- Identify igneous rocks based on their mineral composition, texture and mode of occurrence.
- Evaluate the petrographic characteristics and interpret the igneous processes involved.
- Deduce the magmatic processes, including magma differentiation, fractional crystallization, assimilation, and magma mixing

Unit-I: Introductory Concepts

Magma generation in the crust and upper mantle. Physical properties of magma -temperature, viscosity, density and volatile content. Modes of emplacement of igneous rocks: volcanic, hypabyssal, plutonic

Unit-II: Forms,Texture and Micro-structure

Mode of occurrence of igneous rocks. Forms of igneous rocks. Crystallinity, granularity, shapes and mutual relations of grains; nucleation and growth of minerals in magma; Different textures and microstructures and their occurrence (e.g. panidiomorphic, hypidiomorphic, allotriomorphic, porphyritic, vitrophyric, poikilitic, ophitic, sub-ophitic, intergranular, intersertal, pilotaxitic, trachytic, graphic, granophyric, rapakivi, orbicular, corona, perthitic, myrmekitic, variolitic, speherulitic and spinifex.) Bowen's reaction series, differentiation and assimilation of magma and diversity of igneous rocks.

Unit-III: Classification and Petrographic Analysis

Bases of classification of igneous rocks: mineralogical, textural, chemical, chemicomineralogical and associational. Norm and mode. Standard classification schemes – Niggli, Hatch and Wells and IUGS. TAS diagram for volcanic rocks; Petrography of important igneous rocks (felsic, mafic, ultramafic and Alkaline)

Unit-IV: Phase Diagrams

Phase rule and its application to eutectic, peritectic and solid solution system. Phase equilibria in the following binary and ternary systems under high dry and wet pressure with respect to their nature under low pressure, and their petrogenetic significance: diopside – anorthite, forsterite – silica, albite – anorthite, albite – orthoclase, diopside – albite – anorthite, forsterite – diopside – silica and nepheline - kalsilite – silica.

Practical:

- Megascopic identification of important igneous rocks.
- Microscopic identification of important igneous rocks **Textbook:**
  - ✓ *Winter,J.D.(2014).Principles of igneous and metamorphic petrology. Pearson.*
  - ✓ *Hota,R.N.(2017)Practical approach to petrology,CBS PublishersandDistributors,NewDelhi*

Suggested readings:

- ✓ *Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Rout ledge.*
- ✓ *Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.* ✓ *Myron G.Best(2001).Igneou sand Metamorphic Petrology* ✓ *Bose M.K.(1997).Igneous Petrology.*
- ✓ *GW Tyrrell.(1926).Principles of Petrology. Springer*

Core X - Sedimentary Petrology

Course Objectives:

- To introduce the concepts and principles of sedimentary processes and products
- To observe sedimentary rocks and their properties in hand specimen and under the petrographic microscope
- To introduce the different sedimentary environments, facies and their association
- To provide an overview of the different mechanisms of basin formation and provenance analysis

Learning Outcomes:

- Evaluate and identify various sedimentary rocks
- Analyze the sedimentary textures and deduce the depositional environment
- Determine the direction of younging in a succession by observing sedimentary structures.

UnitI: Sedimentary Processes

Weathering & Erosion. Fluid flow and Sediment transport. Deposition and lithification. Diagenesis and its type. Depositional Environments (Continental, Transitional and Marine).

UnitII: Texture, Fabric and Structures

Texture (grain size and shape) and its significance. Grain fabric and its interpretation, Sedimentary structures and determination of paleo-current and direction of younging.

UnitIII: Classification & Petrography

Clastic and Carbonate classification. Petrographic notes on sandstones, conglomerate, shale, limestone and breccia and their occurrences in India. Dolomite and dolomitisation.

UnitIV: Sedimentary Basins & Provenance Analysis

Sedimentary Basins and types, Sedimentary Provenance and provenance Analysis, Heavy minerals and their significance, Sedimentary Basins of India.

Practical:

- Megascopic and Microscopic identification of sedimentary rocks.
- Grain size Analysis, Paleo-current Analysis **Textbooks:**

- ✓ *Nichols,G.(2009)SedimentologyandStratigraphySecondEdition.WileyBlackwell*
- ✓ *Boggs,S.,1995.PrinciplesofSedimentologyandStratigraphy,PrenticeHall,NewJersey*.

Suggested readings:

- ✓ *Prothero, D.R.,& Schwab, F.(2004).Sedimentary geology. Macmillan.*
- ✓ *Tucker,M.E.(2006)Sedimentary Petrology, Blackwell Publishing.*
- ✓ *Hota,R.N.(2017)Practical approach to petrology,CBSPublishersandDistributors,NewDelhi*

Semester V

Core XI- Metamorphic Petrology

Course Objectives

- To introduce the origin of metamorphic rocks in different geological environments.
- To discourse on the different physical and chemical processes affecting metamorphic rocks of various types.
- To describe the effect of tectonics on metamorphism.

LearningOutcome:

- Identify metamorphic rocks by evaluating their properties Evaluate the stages of metamorphism from phase diagrams Analyze the effect of tectonics on metamorphism.

Unit-I: Metamorphism: Factors and Types

Introduction and definition of metamorphism. Factors controlling metamorphism: Agents and types of metamorphism, ACF and AKF diagrams.

Unit-II: Metamorphic facies and Grades

Index minerals, Metamorphic zones and grades. Concept of metamorphic facies; Mineralogical phase rule of closed and open systems; Structure and textures of metamorphic rocks.

Unit-III: Metamorphism and Tectonism

Relationship between metamorphism and deformation; Metamorphic mineral reactions (prograde and retrograde); Migmatites and their origin; Metasomatism and role of fluids in metamorphism. Classification of metamorphic rocks; Metamorphic differentiation.

Unit-IV: Metamorphic Petrography

Petrographic notes on important rock types like schists, gneisses, granulite, marble, quartzite, slate, phyllites, khondalite, charnockite and eclogites and their Indian occurrences.

Practical:

- Megascopic identification of metamorphic rocks.
- Microscopic examination of metamorphic rocks.
- Metamorphic equations and phase diagrams **Text Book:**

- ✓ *Yardley,B.W.,&Yardley,B.W.D.(1989).An introduction to metamorphic petrology. Longman Earth Science Series.*

Suggested Readings:

- ✓ *Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.*
- ✓ *Winter,J.D.(2014).Principles of igneous and metamorphic petrology. Pearson.*
- ✓ *Rollinson,H.R.(2014).Using geochemical data: evaluation, presentation, interpretation. Routledge.*
- ✓ *Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.*
- ✓ *Hota, R.N.(2017)Practical approach to petrology,CBSPublishersandDistributors,New Delhi.*

Core XII - Remote Sensing and GIS

Course Objective:

- To introduce the basic concepts of remote sensing.
- To discourse of satellite sensors, platforms and their products
- To utilize remote sensing images to interpret features and classify land cover
- To introduce the concept of modeling spatial objects in GIS

Learning Outcome:

- Identify the properties in a remote sensing imagery
- Process a digital image to enhance and derive indices Use GIS to model real world objects Perform basic overlay analysis using GIS.

Unit-I: Energy Sources and Interactions

Energy sources and principles of radiation, Energy radiation, reflection, scattering and absorption, Black body radiation, Energy interaction in the atmosphere and with earth surface features, spectral reflectance curves

Unit-II: Satellites and Platforms

Types of platforms and sensors; resolution of sensors- spatial, spectral, radiometric and temporal. Satellites: Types and orbits. Earth Observation Satellites: LANDSAT, ASTER, SPOT, IRS, their sensor characteristics and application. Microwave and Hyper-spectral remote sensing.

Unit-III: Image Corrections, Visualisation and Interpretation

Geometric corrections, ground control points and co-registration, atmospheric corrections, concepts of colour, contrast stretching, filtering and edge enhancement, density slicing and thres holding. Image Interpretation

Unit-IV: Geographic Information Systems (GIS)

GIS Fundamentals, Geographic Coordinate Systems and Map Projections. Conceptual models of spatial information- raster and vector data models, advantages and disadvantages of raster and vector data models, non-spatial information and concept of database, GIS applications across disciplines.

Practical:

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  Interpretation of various aeolian ,glacial, fluvial and marine land forms from Satellite Imagery.
- Visualization of False Colour Composites(FCC)
- GIS Layers and Spatial Interpolation **Textbooks:**
- *Reddy, A.(2014).Text book of. Remote Sensing and Geographical Information Systems. Fourth Edition. B S Publications*

Suggested Readings:

- ✓ *Gupta R.P. Remote Sensing Geology, Springer*
- ✓ *Demers,M.N.(2012).Fundamentals of GIS,4thEdition,WileyBlackwell* ✓ *Burrough ,P.A.(2016).Principles of GIS.3rdEdition,OUP*

Core XIII-Structural Geology& Tectonics

Course Objectives

- To introduce structural geology and its relation to tectonics
- To explain the various deformations observed in rocks under different stress conditions
- To discourse on the mechanism of various geological structures like folds, faults &s hear zones.
- To describe the tectonic evolution of continents and oceans, evolution of the Himalayas **Learning Outcomes:**
- Identify and describe the stress conditions from observing the deformations Evaluate geological structures like folds, faults, shear zones etc.
- Analyze the conditions leading to the tectonic evolution of continents and oceans, evolution of the Himalayas.

Unit-I:Rock Deformation

Introduction, Attitude of beds; V's rule; Deformation, concept of stress and strain; Strain ellipses of different types and their geological significances. Effects of topography on structural features, Topographic and structural maps; Outlier, Inlier, Nappe, Klippe and Fenster.

Unit-II: Folds

Fold morphology; Geometric and genetic classification of folds; Introduction to the mechanics of folding: Buckling, Bending, Flexural slip and flow folding; Recognition of folds in field and map, causes of folding, Top and bottom criteria of deformed strata.

Unit-III: Faults and Joints

Fault- classification, mechanism, significance, recognition in the field and map, general effects of faulting on outcrops. Joints - geometry, classification and significance.

Unit-IV: Unconformities, Foliation and Lineation

Unconformity - types, significance, recognition in the field and map, difference between fault and unconformity. Foliation - types and relation with major structures, Lineation - types and relation with major structures; Salt domes and diapirs.

Practical:

-

Interpretation of structure, stratigraphy and geologic history from maps;

- Completion of outcrops and drawing of sections;
- Three-point problems;
- Thickness and depth problems;

Text Book:

- ✓ *Davis,G.R.(1984)Structural Geology of Rocks and Region.JohnWiley* **Suggested Readings:**
- ✓ *Billings, M.P.(1987)Structural Geology,4thedition,Prentice-Hall.*
- ✓ *Park,R.G.(2004)Foundations of Structural Geology. Chapman &Hall.*
- ✓ *Pollard,D.D.(2005)Fundamental of Structural Geology. Cambridge University Press.*
- ✓ *Ragan,D.M.(2009)Structural Geology: an introduction to geometrical techniques (4thEd). Cambridge University Press (For Practical)*
- ✓ *Lahee ,F.H.(1962) Field Geology. McGrawHill*

Semester VI

Core XIV- Engineering Geology & Rock Mechanics

Course Objectives

- To introduce the mechanical properties of rocks
- To expose students to the geological problems related to foundation, dam, tunnel, roads and bridges.
- To evaluate rock mass and building materials and stability of slopes.

LearningOutcome:

- Define the mechanical properties of rocks
- Solve the geological problems related to foundation, dam, tunnel, roads and bridge. Characterize rock mass and building materials Address issues related to stability of slopes.

Unit-I: Engineering Properties and Classification

Engineering properties of Rock and Soil. Rock strength and failure, Mohr circle. Building materials. Rock mass classification – Rock Quality Designation(RQD).

Unit-II: Slopes and Slope Stability

Soil-classification, erosion and conservation. Slopes and Slope failure, Geological factors, Slope history and examples of Slope failure. Landslides and its type.

Unit-III: Geology of Tunnels and Bridges

Tunnels and its types, Bridges and its types, Geological considerations of tunnel alignment and bridge site selection. Earthquake resistant structures.

Unit-IV Reservoirs & Dams

Practical:

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Types of dams; Geological considerations of Dam site and reservoir site selection. Case studies of Dams (e.g. Hirakud dam, Rengali dam).

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Engineering properties of rocks.

- Structural maps and tunnel Alignment
- Topographic maps and bridge site selection **Textbooks**:
  - ✓ *N Chena Kesavulu ,Engineering geology*
  - ✓ *SPGarg, Physical and Engineering Geology* **Suggested Readings**:
  - ✓ *Blyth & Frieta s(1984)A Geology for Engineers.7thEdition, Elsevier*
  - ✓ *Verma,B.P.(2017).Engineering Geology and Rock mechanics.4thEdition.Khanna Publishers.*

Core XV- Hydrogeology

Course Objectives

- To introduce the properties of rocks which make them an aquifer
- To introduce the principles and processes of groundwater flow including Darcy's law, hydraulic conductivity, and aquifer properties.
- To elaborate on groundwater flow patterns, groundwater recharge and discharge mechanisms, and the factors influencing groundwater movement and contamination.

Learning Outcomes:

- Explain the principles and processes of ground water flow including Darcy's law, hydraulic conductivity, and aquifer properties.
- Analyze and interpret groundwater flow patterns, groundwater recharge and discharge mechanisms, and the factors influencing groundwater movement and contamination.
- Apply hydrogeological techniques for groundwater assessment and management.
- Design and implement groundwater monitoring programs, evaluate aquifer properties, analyze groundwater quality, and propose appropriate strategies for sustainable groundwater use and protection.

Unit-I: Hydrological Properties of Rocks

Hydrological cycle, vertical zonation of ground water, Properties of water bearing formations -porosity, permeability, specific yield, specific retention, storativity. Aquifer types-Confined and unconfined aquifers, aquitard, aquiclude, aquifuse. Darcy’s law.

Unit-II: Ground Water Quality and Pollution

Physical and chemical Quality of ground water and its use in domestic, agriculture and industries. Groundwater pollution and its mitigation. Arsenic and Fluoride contamination in ground water.

Unit-III: Groundwater Management

Practical:

-

Groundwater basin, Water table fluctuation, Artificial recharge of groundwater, Rainwater Harvesting. Cone of depression. Sea-water intrusion.

Unit-IV: Ground Water Distribution and Exploration

Ground water provinces of India and Odisha. Ground Water exploration methods (Geological and Geophysical).

Practical:

- Solving numerical problems(as per theory) Groundwater prospect Mapping
- Laboratory records and viva voce.

Textbooks:

- ✓ *Groundwater Hydrology (3rd edition) (2005) by David Keith Todd and Larry W. Mays. JohnWiley & Sons, Inc.*

Suggested Readings:

- ✓ C.W.Fetter(2014)Applied Hydrogeology, Pearson: New International Edition.
- ✓ B.B.S.Singhal and R.P.Gupta(2010)Applied Hydrogeology of Fractured Rocks(2nd edition), Springer
- ✓ Hydrogeology –Principles and Practice (2ndedition) (2014) by Kevin M.Hiscock and Victor F. Bense. Wiley Blackwell.
- ✓ Groundwater Scienc e(2ndedition) (2013) by Charles Fitts. Academic Press.
- ✓ Applied Hydrology (International Edition) (1988) byVenTe Chow,David R Maidment and Larry W Mays. McGraw-Hill Book Company.
- ✓ Ground Water(3rdedition)(2007)byH.M.Raghunath. New Age International Publishers.

Semester VII

Core XVI - Exploration and Mining Geology

Course Objectives:

- To introduce metallic and non-metallic ore minerals and their occurrence and distribution To elaborate on the various mineral exploration and extraction techniques
- To discourse on the methods of reserve estimation, mining and ore processing.

Learning Outcome:

- Explain the fundamental terminology like ore, tenor, gangue and grade
- Appreciate the Indian distribution of metallic and non-metallic ore minerals
- Analyze the various mineral exploration and extraction techniques and their suitability to a deposit
- Able to calculate reserve estimation

Unit-I: Mineral Exploration

Mineral deposits and Host rocks, Mineral prospecting methods – Geological (including remote sensing methods), Geochemical, Geophysical, Drilling (& Coring) methods.

Unit-II: Resource and Reserve Estimation

Concept and definitions of Resources and Reserves, Sampling and assaying, Deterministic and probabilistic methods of reserve estimation.

Unit-III: Mining

Elements of mining, its methods (alluvial mining, opencast mining and underground mining) for metallic and non-metallic ores. Shafting, ventilations, drainage and pumping. Mine safety and environment.

Unit-IV: Mineral Beneficiation

Elements of Mineral processing. Sizing (Crushing & grinding), Concentration (Gravity, magnetic and Froth Flotation) and separation methods

Practical:

- Sampling and Geochemical assaying
- Calculation of reserves– deterministic Calculation of reserves -probabilistic. **Text Book:**

✓ *Swapan Kumar Haldar: Mineral Exploration Principles and Applications, Elsevier*
Suggested Readings:

✓ *RogerMajoribanks,(2010) Geological methods in Mineral Exploration and Mining,Springer*

✓ *Subba Rao,Mineral beneficiation, CRC Press*

Core XVII - Economic Minerals of India

Course Objectives

- To discourse on Metallic and non-metallic minerals and their Indian distribution To study on the mineralogy, occurrence and usage of Industrial minerals
- To explain & describe the different methods of mineral beneficiation techniques

Learning Outcome:

- Learn about Metallic Minerals and their distribution in India
- Understand the mineralogy, occurrence and usage of Industrial minerals
- Describe the different methods of mineral beneficiation techniques

Unit -I: Introduction

Classification of Economic Minerals, Critical Minerals of India. Mineral provinces and state-wise reserves of major economic minerals of India.

Unit-II: Metallic Minerals-I

Indian distribution, mode of occurrence, properties, uses and reserves of ores of Iron, Aluminum, Chromium, Copper, Gold, lead and Zinc

Unit-III: Metallic Minerals-II

Indian distribution, mode of occurrence, properties, uses and reserves of Iron, Manganese, Titanium, Tin, Uranium, Lithium and Thorium.

Unit–IV: Non-metallic Minerals of India

Indian distribution, mode of occurrence, properties, uses and reserves of Asbestos, Barites, Beryl, Corundum, Diamond, Dolomite, Fireclay, Graphite, Fluorite, Gypsum, Kyanite, Graphite, Mica Talc and Mineral fertilisers.

Practical:

- Megascopic identification of Ore minerals Map study of Metallogenic provinces of India Ore microscope and optical properties. **Practical:**
- Gokhale,K.V.G.K.andRao,T.C.(1978)Ore deposits of India, their distribution and processing, Tata-McGraw Hill, New Delhi.
- Umathay,R.M.(2006) ,Mineral Deposits of India

Textbooks:

- ✓ *Guilbert,J.M.andParkJr.,C.F.(1986)The Geology of Oredeposits.Freeman&Co.* ✓ *Evans,A.M.(1993)Ore Geology and Industrial minerals. Wiley*
- ✓ *Deb,S.(1980)Industrial minerals and rocks of India. AlliedPublishers.*

Core XVIII – Laboratory Instrumentation & Analysis

Course Objectives

- To introduce laboratory based analytical instruments and their operation
- To explore how these instruments are used and what data sets are generated
- To introduce analysis and interpretation of lab generated data

Learning Outcomes:

- Explain the principles behind various analytical instruments
- Operate analytical instruments and produce data from samples
- Analyze and interpret data for various applications

Unit-I: Liquid Chromatography

Various sample preparation techniques, isolation of compounds from mixtures. The identification of

Compounds using various detectors, limitations and advantages of the technique

Unit-II: Gas Chromatography

Sample injection methods, Correlation of Theory and Practice through Van Deemter Plots, Important experimental variables, Quantitative separations of mixtures, limitation and advantages of the technique.

Unit-III: Mass Spectrometry

Various sample preparation techniques, acquisition of data, isolation of compounds from mixtures, identification of compounds from fragmentation patterns, limitation and advantages of the technique.

Unit-IV: X-Ray Diffraction and Atomic Absorption

Metal Analysis methods, detection limits, surface vs. Bulk Analysis, Destructive vs Nondestructive Analysis, Calculation of concentrations.

Practical/Tutorial:

- Mass spectroscopy Instruments
- XRD and its operation **28**
- Gas Chromatography instruments
- Liquid Chromatography instruments **Textbooks:**

- ✓ *Mark F Vitha, Chromatography: Principles and Instrumentation, Wiley*
- ✓ *Kaimin Shih(eds) X-Ray Diffraction, Nova*
- ✓ *Welzand Sperling,(1999)Atomic Absorption Spectroscopy, Wiley*

Core XIX - Geology and Mineral Resources of Odisha

Course Objectives

- To be excluded for students studying for the 4-year honors with research
- To introduce the physiography and stratigraphy of India
- To explore the mineral provinces and mineral resources of Odisha **Learning Outcomes:**
- Identify the major geomorphic provinces of Odisha
- Describe the stratigraphy of Odisha
- Elaborate on the metallic and non-metallic mineral potential of Odisha
- Identify the mineral-based industries of Odisha

Unit-I: Geomorphology of Odisha

Physiographic divisions of Odisha, Location, forest, rivers & waterfalls, Lakes of Odisha. Drainage system of Mahanadi river. Coastal Land forms of Odisha. Major mountains of Odisha. Climate of Odisha.

Unit-II: Stratigraphy of Odisha

Major lithotypes, Major stratigraphic divisions of Odisha, Iron-ore supergroup, Gangpur supergroup. Easternghat supergroup, Gondwana supergroup of Odisha, Quaternary deposits of Odisha.

Unit- III: Mineral Resources of Odisha

Metallic and non-metallic mineral resources of Odisha, Origin, mode of occurrence, mineralogy, Odishan distribution and uses of ores of Iron & Manganese, Bauxite, Limestone& Dolomite,Fireclay, Laterite and Magnesite. Heavy mineral deposits along coast of Odisha.

Unit-IV: Mineral-based Industries of Odisha.

Classification of industries, Large and medium scale industries of Odisha, Sukinda chromite, East-coast bauxite and Sargipalli Pb-Zn deposits, Talcher & Ib-valley coal deposits, Biramitrapur limestone deposit.

Practical:

- Megascopic identification and uses of important metallic and non-metallic minerals of Odisha;
- Distribution of important ores and other economic minerals of Odisha. Mapping mineral industries to mineral source.

Textbooks:

- ✓ *SGAT (2020)Geology and Mineral Resources of Odisha,4thEdition.*
- ✓ *Nanda, Mohanty and Mohapatra,(2022)Geology of Odisha, Geological Society of India.*

Semester VIII

Core XX - Fuel Geology

Course Objectives:

- To introduce the geology of fuel minerals like Coal & Petroleum
- To understand their occurrence, quality parameters and methods of extraction and usage To learn about alternative energy resources. **Learning Outcome:**
- Explain the origin and properties of coal
- Aware of the coal gasification and coal liquefaction methodologies
- Explain the origin, occurrence and properties of petroleum
- Illustrate the various elements of a petroleum System
- Evaluate the applicability of various methods of petroleum exploration
- Explore alternative energy sources and transitions to renewable energy.

Unit-I: Coal

Definition and origin of coal; Classification of coal. Fundamentals of Coal Petrology. Introduction to llithotypes. Proximate and ultimate analysis.

Unit-II: Coal to Petroleum

Coal Bed Methane (CBM): global and Indian scenario; Under ground coal gasification; Coal liquefaction. Kerogen and its type.

Unit-III: Petroleum Geology

Physical and Chemical Properties of Crude Petroleum. Origin of petroleum. Maturation of Kerogen: Biogenic and Thermal effect. Concept of Petroleum System.

Unit-IV: Petroleum Exploration & Distribution

Reservoir rocks: General attributes, petro-physical properties and types. Hydrocarbon traps: definition, types and classification. Seal rocks - definition and general properties.
Global distribution of Petroleum reserves and resources.

Practical:

- Study of hand specimens of coal
- Reserve estimation of coal
- Petroleum Prospect Mapping using Section Maps Well Correlation and Fence diagrams.

30 Textbooks:

✓ *Chandra,D.(2007).Chandra'sTex tbook on Applied Coal Petrology. Jijnasa Publishing* ✓ *Shelly,R.C.(2014).Elements of Petroleum geology: Third Edition, Academic Press* **Suggested Readings:**

✓ *Bjorlykke, K.(1989). Sedimentology and petroleum geology. Springer-Verlag.*

Core XXI - Environmental Geology

Course Objectives

- To be excluded for the 4years' honours with research program
- To introduce the role of geology to the environment
- To discourse about the various environmental disasters
- To expose students to disaster management and the application of Remote Sensing and GIS in the discipline.

Learning Outcome:

- Describe natural hazards and environmental disaster and their drivers.
- Illustrate application of remote sensing and GIS in disaster management.
- Interpret climate change and ensuing geomorphic responses.
- Describe natural hazards and broadly applied aspects of geomorphology

Unit-I: Natural Disasters and Disaster Management

Drought, Flood, Cyclone, Tornado, Thunderstorm; Earthquake , Landslide, Tsunami, Inundation of Coastlines

Unit-II: Elements of Climatology

Thermal Structure & Composition of Atmosphere; Elements of Climate and weather. Basis of classification; Koppen's classification; Thornthwaite's classification; Brief idea on Types of Climate Found in India.

Unit-III: World Weather Circulation

Jet stream and its influence on world weather; Air Mass, their classification and influence on world weather; Fronts (Front classification). Mechanism of monsoon; Factors associated with Monsoonal intensity; Effects of monsoon.

Unit-IV:Climate Change

Milankovitch cycles and variability in the climate; Glacial-interglacial stages; The Last Glacial maximum (LGM).Glacial periods, sea-level rise, effects of sea level rise, Rise of carbon dioxide in the atmosphere, green-house gases, green-house effect and global warming, Desertification.

Practical:

Tutorials and Seminars **Text**

Book:

- ✓ *Bell,F.G.,1999.Geological Hazards, Routledge, London.*

Suggested Readings:

- ✓ *Bryant,E.,1985.Natural Hazards, Cambridge University Press.*
- ✓ *Smith,K.,1992.Environmental Hazards. Routledge, London*

Core XXII - Ore Microscopy

Course Objective

- To introduce students to optical examination of adsorbing(ore)minerals
- To educate students on the interaction of polarized light reflected from crystalline polished surface of ore minerals

Learning Outcome:

- Acquire the capability of basic determination of Ore minerals in reflected light
- Illustrate the capability to identify ore minerals and their stage of alteration
- Interpret mineral paragenesis from polished sections

Unit-I: Introduction to Ore Microscopy

Ore Microscope and its parts and components. Polarization for reflected light, Sample preparation for ore microscopy

Unit-II: Optical Properties for Ore Mineral Identification

Qualitative methods for identification of Ore Minerals, Qualitative optical properties of ore minerals, Qualitative testing of hardness of ore minerals.

Unit-III: Morphological and Structural Properties

Morphological properties of ore minerals. Structural properties of Ore mineral aggregates and mineral aggregates.

Unit-IV: Mineral Paragenesis

Basic classification, Systematic qualitative optical study of ore minerals, Native elements, sulphides, sulfo-salts, oxides, hydroxides and gangue minerals.

Practical:

- Ore Microscope
- Identification of Sulfides and Sulfo-salts
- Identification of Oxides and Hydroxides
- Gangue Mineral identification **Text Book:**
  - ✓ *Craig, J.R., Vaughan, D.J.: 1981. Ore Microscopy and Ore Petrography, John Wiley and sonsInc. New York.*

Suggested Readings:

- ✓ *Castroviejo,R.(2023)A Practical Guide to Ore Microscopy– Volume1,Springer*

32 Core XXIII – Introduction to Geo-Statistics

Course Objective

- To introduce students to geo-statistics and its applications
- To demonstrate geo-statistical procedures for solving geological problems
- To provide a mathematical basis for estimation and prediction **Learning Outcome**:
  - Understand the basic concepts in geo-statistics
  - Apply probability theory to perform univariate and multivariate analysis
  - Model spatial data using variograms and perform interpolations

Unit-I: Theory of Regionalized Variables

Introduction, Role and Scope of geo-statistics, Geo-statistics versus simple interpolation & its limitations Univariate, bivariate and multivariate analysis, Gaussian distribution and central limit theorem

Unit-II: Variograms and Anisotropies

Scatter plots and Variograms, Variogram Models and Semi-variogram Irregular data and Anisotropy.

Unit-III: Linear Geo-statistics and Kriging

Regionalised Variables and Spatial Correlation, Non-stationary variables and variance, Co-variance and Kriging and Interpolation and correlation

Unit-IV: Estimation of in-situ reserves

Problem of Estimation, Deterministic estimation, Estimation criteria, Probabilistic estimation using Kriging

Practical:

- Univariate and Bivariate analysis
- Kriging based interpolation
- Variograms and Semi-variograms
- Ore reserve estimation **Text Book:**

✓ *Mehrotra, Anul Kumar(2020) Geo-statistics for Beginners, Zorba Books*

Suggestedreadings:

✓ *Kitanidis, P.K.(1997)Introduction to Geo-statistics:Cambridge University Press* ✓ *Stein,M.L.(1999) Interpolation of Spatial Data: Some Theory for Kriging. Springer.* ✓ *Wackernagel, Hans(1998) Multivariate Geostatistics (2nded.)Springer.*

2. Multidisciplinary Courses

*(3 courses to be chosen from **basket of Multidisciplinary Courses** for Semester-I/II/III* with 3 credits each)

03 Selected Subjects from the Multi-Disciplinary Courses:

1.	**Oceanography**
2.	**Climatology**
3.	**Waste Management**

Oceanography

Course Objective:

- To introduce the oceans, its bathymetric divisions and features.
- To learn about waves and currents
- To learn about the properties of seawater
- To learn about ocean current and its impact on environment

Learning Outcome:

- Describe the ocean floor topographic features.
- Understand the origin of waves, tides and current.
- Describe the properties of seawater and their interaction with energy.
- Understand the various ocean currents and water mass circulation and their drivers.

Unit - I: Introduction to Oceanography

Ocean Floor Topography – Continental Shelf, Continental Slope, Continental Margin, Continental Rise, Submarine Canyons, Mid Oceanic Ridges, Trenches, Abyssal Plains. Wave theories, Tides-type of tides, tidal currents, rip currents.

Unit - II: Properties of Seawater

Salinity and chlorinity; temperature; thermal properties of sea water; density and stability, conductivity, viscosity, heat budget, colligative and other properties of sea water.

Unit - III: Ocean Currents and Circulation

Definition, direct and indirect forces acting on sea water, surface currents, Coriolis effect, geostrophic currents, upwelling, sinking, circulation, El-Nino, La-Nina, significance of major ocean currents of the world, measurement of currents. Thermo-haline circulation.

Suggested practical:

Observed the oceanographic divisions using Google Earth.
Creating bathymetric profiles
GEBCO Undersea features and landforms,
Major currents and Ocean circulation patterns of world oceans.

Textbook:

Trujilo, A. and Thurman, H. (2012) Essentials of Oceanography, 12th Edition, Pearson **Suggested Readings:**

Gross, M. G. (1977). Oceanography: A view of the earth.
Invitation to Oceanography (2009) Paul R. Pinet Jones & Barlett Learning

Climatology

Course Objective:

- To introduce Climate, climate change and its implications.
- To explain climate system and heat budget of earth
- To introduce the mechanism and effects of Monsoon
- To provide an understanding of Atmosphere and Hydrosphere and their circulation patterns

Learning Outcome:
- Describe a systematic observation on Climate and implications of climate change.
- Explain the significance of climate and climate change
- Elaborate the heat budget and the mechanism of monsoon
- Evaluate the various circulation patterns of Atmosphere and Hydrosphere and its impact on climate

Unit - I: Climate system and classification and Climate change

Components of the climate system, Climate controlling factors, Climate system response, response rates and interactions within the climate system. Basis of classification; Koppen's classification; Thornthwaite's classification; Brief idea on Types of Climate found in India. Climate forcing and feedbacks,.

Unit - II: Heat budget of Earth and Interactions Incoming solar radiation, receipt and storage of heat; Heat transformation; Earth's heat budget. Interactions amongst various sources of earth's heat; Monsoon, its mechanism and its intensity influencing factors; Effects of monsoon.

Unit - III: Atmosphere & Hydrosphere

Stratification of atmosphere and atmospheric circulation; Atmosphere-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.

Practical

1. Study of distribution of major climatic regimes of India on map.
2. Distribution of major wind patterns on World map. 3. Ocean currents and heat circulation

Text Book:

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

Suggested Readings:

Rohli, R.V. and Vega, A.J., 2007.Climatology. Jones and Barlatt. Lutgens, F., Tarbuck, E., and Tasa, D., 2009. The Atmosphere: An Introduction to Meteorology. Pearson Publisher. Aguado, E., and Burt, J., 2009. Understanding weather.

Waste Management

Course Objectives:

- To provide students with a fundamental understanding of waste generation, management practices, and their environmental impacts.

- To equip students with skills in handling, reducing, and managing waste effectively using sustainable practices.
- To make students aware of global and national waste management policies.
- To explore modern technological solutions and innovative approaches for waste reduction and resource recovery.

Learning Outcomes:

- Understand the Classification and Sources of Waste:
- Apply Waste Management Techniques:
- Evaluate Solid and Hazardous Waste Management Systems:
- Develop Sustainable Waste Management Plans:
- Utilize Technological Solutions for Waste Management:
- Address Emerging Challenges in Waste Management:
- Engage in Practical Waste Management Initiatives:

Unit -1: Fundamentals of Waste Management

Types and Sources of Waste : Definition of waste and classification: municipal solid waste, hazardous waste, biomedical waste, e-waste, and agricultural waste. Sources of waste: residential, industrial, commercial, and agricultural. Waste Characteristics: Physical, chemical, and biological properties of various waste types. Waste Management Hierarchy: Concepts of waste prevention, minimization, reuse, recycling, recovery, and disposal. Global and National Waste Management Policies: Overview of global waste management practices (e.g., circular economy, zero waste strategies), Indian Waste Management Rules: Solid Waste Management Rules, E-Waste Management Rules, and Hazardous Waste Management Rules.

Unit- 2: Solid Waste and Hazardous Waste Management

Solid Waste Management**:** Waste collection, transportation, and segregation methods. Processing of waste: composting, vermin-composting, incineration, pyrolysis, and gasification, Role of landfills and landfill management techniques. Recycling and Resource Recovery: Techniques for recycling materials: paper, plastics, metals, and glass,Benefits and challenges of material recovery and resource recovery facilities.Hazardous and Biomedical Waste Management: Definition, sources, and classification of hazardous waste. Safe handling, transportation, and disposal of hazardous and biomedical waste. Regulatory framework for hazardous waste management, including the Biomedical Waste Management Rules in India.

Unit 3: Sustainable Waste Management Practices

Waste-to-Energy Technologies: Overview of waste-to-energy conversion methods: biogas generation, refuse-derived fuel (RDF), and incineration for power. Pros and cons of waste-to-energy plants. E-Waste Management: Definition, sources, and components of e-waste. E-waste recycling, recovery of valuable materials, and environmental concerns. E-Waste Management Rules, 2016 (India). Zero Waste Concept and Community-Based Waste Management: Principles of zero waste

and its application in urban waste management. Role of local communities, NGOs, and startups in waste reduction. Case studies of zero-waste initiatives. Role of Technology in Waste Management: Use of smart technologies, IoT, and data analytics in optimizing waste collection and segregation. Digital tools for waste tracking and monitoring.

Practical:

- **Practical 1:** Conduct a waste audit of an institution, assessing waste generation, segregation, and disposal practices.
- **Practical 2:** Develop a waste management plan for a local community or campus.
- **Practical 3:** Visit a recycling facility, landfill, or waste-to-energy plant and prepare a report on its operation.
- **Practical 4:** Design and execute a waste minimization awareness campaign.
- **Practical 5:** Simulation of recycling processes and composting techniques in the lab.

Textbooks:

Debra R. Reinhart, Timothy G. Townsend (2017) *Waste Management: Concepts and Applications;* Waveland Press

M. Dutta (2018) *Solid and Hazardous Waste Management: Science and Engineering;* New Age International Publishers

Suggested Readings:

George Tchobanoglous, Frank Kreith (2002) *Handbook of Solid Waste Management;* McGraw-Hill Education

Bruce E. Rittmann, Perry L. McCarty (2012) *Environmental Biotechnology: Principles and Applications;* McGraw-Hill Education

Rakesh Johri *(2008) E-Waste: Implications, Regulations, and Management in India and Current Global Best Practices;*The Energy and Resources Institute (TERI)

Michael D. La Grega, Phillip L. Buckingham (2001) *Hazardous Waste Management;* McGraw-Hill Education

Marc J. Rogoff (2011) *Waste-to-Energy: Technologies and Project Implementation*

3. Ability Enhancement Courses

(Odia and English are the compulsory courses under Semester-I/II respectively with 4 Credits each)

4. Skill Enhancement Courses (SEC)

*(3 courses to be chosen from **baskets of SEC** for Semester-I/II/III respectively with3 credits each)*

03 Selected Subjects from the Skill Enhancement Courses:

1.	**Monitoring Soil Quality**
2.	**Monitoring Water Quality**
3.	**Carbon footprint and water Footprint**

Monitoring Soil Quality

Course Objectives:

This course aims to provide undergraduate students with an understanding of soil quality monitoring techniques, soil health assessment, and the role of soil in the environment. Students will learn to analyze soil properties, evaluate soil quality, and understand the impact of land use and management practices on soil health.

Learning Outcomes:

Upon completion of this course, students will be able to:

- Understand the importance of soil quality and its impact on the environment.
- Identify and measure key soil properties related to soil health.
- Apply various soil monitoring techniques in practical settings.
- Interpret soil quality data for sustainable land management practices.

Unit 1: Introduction to Soil Quality

- **Concept of Soil Quality:**
  - Definition and importance of soil quality in agriculture and the environment.
  - Relationship between soil quality, soil health, and ecosystem services.
- **Soil Functions:**
  - Roles of soil in plant growth, water filtration, nutrient cycling, and carbon storage.
  - Impact of soil quality on food security and environmental sustainability.
- **Indicators of Soil Quality:**
  - Physical, chemical, and biological indicators of soil quality. ○ Soil texture, structure, moisture, pH, organic matter, nutrient levels, and microbial activity.
- **Soil Health Assessment:**
  - Methods for assessing soil health. ○ Understanding the Soil Health Card and its significance.

Unit 2: Soil Monitoring Techniques

- **Soil Sampling Methods:**
  - Types of soil sampling: random, systematic, and targeted sampling.
  - Guidelines for soil sampling (depth, timing, and frequency).
- **Laboratory Techniques for Soil Analysis:**
  - Procedures for analyzing soil physical properties (texture, structure, porosity).
  - Chemical analysis: pH, electrical conductivity, nutrient content (N, P, K).
  - Biological analysis: microbial biomass, enzyme activity, and soil respiration.
- **In-situ Soil Monitoring:**
  - Use of portable devices for real-time soil monitoring.
  - Techniques for assessing soil moisture and temperature.
- **Data Interpretation:**
  - Understanding soil test results and their implications for land management. ○ Threshold values for soil quality indicators.

Unit 3: Soil Quality Management and Sustainable Practices

- **Land Use and Soil Quality:**
  - Impact of different land uses (agriculture, forestry, urbanization) on soil quality.
  - Soil degradation and its causes (erosion, compaction, salinization).
- **Soil Conservation Practices:**
  - Techniques for improving soil quality (crop rotation, cover cropping, conservation tillage). ○ Role of organic amendments (compost, green manure) in enhancing soil health.
- **Monitoring Soil Quality Over Time:**
  - Importance of long-term soil quality monitoring for sustainable land use.
  - Case studies of successful soil quality management programs.
- **Policy and Legislation:**
  - Overview of policies related to soil conservation and quality monitoring in India.
  - Role of government and NGOs in promoting sustainable soil management practices.

Practical: Soil Quality Monitoring Techniques

- **Field Sampling:**
  - Practical exercises in soil sampling techniques (site selection, depth determination).
  - Collection and labeling of soil samples for laboratory analysis.
- **Laboratory Analysis:**
  - Hands-on experience in analyzing soil properties (texture, pH, nutrient content).
  - Conducting microbial analysis and measuring enzyme activities.
- **In-situ Monitoring:**
  - Using portable soil sensors for moisture and temperature measurement.
  - Recording and interpreting data from field instruments.
- **Project Work:** ○ Field-based project where students monitor and assess soil quality in a local area. ○ Preparation of a report detailing findings, data analysis, and recommendations for soil management.

Textbooks:

1. *Soil Quality: Agricultural and Environmental Perspectives* by A. B. Doran and M. R. Zeiss.
2. *Soil Ecology and Management* by E. K. Paul.
3. *Principles and Practice of Soil Science: The Soil as a Natural Resource* by P. A. Murphy.

Suggested Readings:

1. *Soil Health Assessment: A Guide for Farmers and Extension Agents* by J. L. Havlin et al.
2. *The Nature and Properties of Soils* by N. C. Brady and R. R. Weil.
3. *Soil and Environmental Quality* by R. E. Smith.
4. *Soil Fertility and Fertilizers: An Introduction to Nutrient Management* by J. L. Havlin, *et al.*
5.

Monitoring Water Quality

Course Objectives:

This course aims to provide undergraduate students with an understanding of water quality monitoring techniques, the importance of clean water, and the impact of human activities on water resources. Students will learn to assess water quality parameters, utilize monitoring tools, and analyze data to make informed decisions for sustainable water management.

Learning Outcomes:

- Understand the significance of water quality monitoring for health and environmental sustainability.
- Identify and measure key water quality parameters.
- Use various tools and techniques for water quality assessment.
- Interpret water quality data and propose management strategies for water resources.

Unit 1: Introduction to Water Quality

- **Concept of Water Quality:**
  - Definition of water quality and its importance in environmental and public health.
  - Overview of water quality standards and guidelines (WHO, ISI).
- **Key Water Quality Parameters:** ○ Physical parameters: temperature, turbidity, color, taste, and odor. ○ Chemical parameters: pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nutrients (nitrogen, phosphorus).
  - Biological parameters: coliform bacteria, pathogens, and algal blooms.
- **Sources of Water Pollution:**
  - Point and non-point sources of pollution. ○ Impact of urbanization, industrialization, and agricultural practices on water quality. ○ Role of land use in water quality degradation.

Unit 2: Water Quality Monitoring Techniques

- **Water Sampling Techniques:**
  - Types of water sampling: grab sampling, composite sampling, and in-situ sampling.
  - Guidelines for sampling freshwater, marine, and groundwater sources.
- **Laboratory Analysis Methods:**
  - Procedures for analyzing physical parameters (temperature, turbidity). ○ Chemical analysis: methods for determining pH, DO, BOD, COD, and nutrient levels.
  - Microbiological analysis: techniques for detecting coliforms and pathogens.
- **Field Monitoring Techniques:**
  - Use of portable water quality testing kits and sensors for real-time monitoring. ○ Understanding and using data loggers for continuous monitoring of water quality parameters.
- **Data Interpretation:**
  - How to read and interpret laboratory and field data. ○ Understanding the significance of various water quality indicators.

Unit 3: Water Quality Management and Policy

Water Quality Assessment:

- Techniques for assessing the overall quality of water bodies (rivers, lakes, groundwater).
- Risk assessment related to water quality and public health implications.
- **Water Quality Management Practices:**
  - Strategies for maintaining and improving water quality. ○ Role of wetlands, riparian buffers, and sustainable land management in water quality protection.
- **Regulatory Framework:**
  - Overview of policies and regulations governing water quality in India (Water Act, NGT guidelines). ○ Role of governmental and non-governmental organizations in water quality monitoring and management.
- **Case Studies:**
  - Examination of successful water quality management initiatives and policies in India and globally. ○ Analysis of challenges and solutions in water quality management.

Practical:

- **Field Sampling:**
  - Hands-on experience in water sampling techniques (site selection, collection methods).
  - Recording environmental conditions during sampling.
- **Laboratory Analysis:**
  - Practical exercises in analyzing physical and chemical water quality parameters (pH, DO, BOD).
  - Microbiological testing for coliform bacteria and pathogens.

- **In-situ Monitoring:**
    - Use of portable water quality sensors and kits for real-time analysis.
    - Data collection and interpretation of results from field instruments.
- **Project Work:** ○ Field-based project where students assess the water quality of a local water body.
    - Preparation of a report detailing findings, data analysis, and recommendations for water quality improvement.

Textbooks:

1. Sawyer, C. N., McCarty, P. L., & Parkin, G. F. (2003). *Chemistry for Environmental Engineering and Science.* McGraw-Hill.
2. Peavy, H. S., Rowe, D. R., & Tchobanoglous, G. (1985). *Environmental Engineering.* McGraw-Hill.
3. APHA (2017). *Standard Methods for the Examination of Water and Wastewater.* American Public Health Association.

Suggested Readings:

1. Nathanson, J. A., & Schneider, H. J. (2007). *Basic Environmental Technology: Water Supply, Waste Management and Pollution Control.* Pearson.
2. Metcalf & Eddy. (2003). *Wastewater Engineering: Treatment and Reuse.* McGraw-Hill.
3. Chapman, D. (1996). *Water Quality Assessments: A Guide to Use of Biota, Sediments, and Water in Environmental Monitoring.* UNESCO.
4. Fatta-Kassinos, D., Dionysiou, D. D., & Kummerer, K. (2016). *Advanced Treatment Technologies for Urban Wastewater Reuse.* Springer.
5. WHO (2006). *Guidelines for Drinking-Water Quality.* World Health Organization.

Carbon Footprint and Water Footprint

Course Objectives:

The course aims to provide students with a comprehensive understanding of the concepts of carbon and water footprints, their significance in environmental sustainability, and practical strategies for minimizing them. This course will enhance students' skills in assessing, managing, and reducing environmental impacts, aligning with the NEP 2020 emphasis on skill-based learning.

Learning Outcomes:

Upon completion of this course, students will:

- Understand the concepts of carbon and water footprints.
- Be able to calculate personal, organizational, and product-based carbon and water footprints.
- Gain knowledge about the environmental, social, and economic impacts of high carbon and water footprints.
- Learn about sustainable practices to reduce footprints in various sectors.
- Develop skills to apply sustainable strategies in daily life and future workplaces.

Unit 1: Introduction to Carbon Footprint

- **1.1 Definition and Importance** ○ Understanding the concept of carbon footprint.
  - Importance of carbon footprint in climate change and sustainability.
- **1.2 Sources of Carbon Emissions** ○ Natural and anthropogenic sources of carbon emissions.
  - Role of energy consumption, transportation, and industry in carbon footprints.
- **1.3 Calculation of Carbon Footprint** ○ Overview of methods for calculating carbon footprints. ○ Use of tools and calculators for estimating individual and organizational footprints.

Unit 2: Introduction to Water Footprint

- **2.1 Definition and Importance** ○ Understanding the concept of water footprint.
  - Importance of water footprint in water resource management and sustainability.
- **2.2 Components of Water Footprint** ○ Direct and indirect water footprints.
  - Blue, green, and grey water footprints.
- **2.3 Calculation of Water Footprint** ○ Overview of methods for calculating water footprints. ○ Use of tools and calculators for estimating individual and organizational water footprints.

Unit 3: Strategies for Reducing Footprints

- **3.1 Reducing Carbon Footprint** ○ Energy efficiency, renewable energy sources, and sustainable transportation.
  - Role of lifestyle changes and corporate social responsibility.
- **3.2 Reducing Water Footprint** ○ Water conservation techniques and sustainable water management practices.
  - Role of individuals, industries, and governments in reducing water footprints.
- **3.3 Case Studies and Best Practices** ○ Analysis of successful initiatives aimed at reducing carbon and water footprints.
  - Review of policies and programs in India addressing carbon and water footprints.

Practical :

1. **Practical 1:** Carbon Footprint Calculation ○ Use online tools to calculate personal or household carbon footprint.
   - Analyze results and identify areas for improvement.
2. **Practical 2:** Water Footprint Calculation ○ Use online tools to calculate personal or household water footprint.
   - Analyze results and identify strategies for reduction.
3. **Practical 3:** Case Study Analysis ○ Conduct a case study on a company or community that successfully reduced its carbon or water footprint.
   - Present findings to the class.

4. **Practical 4:** Developing a Footprint Reduction Plan ○ Create a personalized plan to reduce carbon and water footprints based on practical calculations. ○ Set measurable goals and identify resources for implementation.

Textbooks:

1. Wiedmann, T., & Minx, J. (2008). *A Definition of Carbon Footprint.* Routledge.
2. Hoekstra, A. Y. (2011). *The Water Footprint of Modern Consumer Society.* Routledge.
3. Whitmarsh, L., O'Neill, S., & Lorenzoni, I. (2012). *Engaging the Public with Climate Change: Behaviour Change and Communication.* Earthscan.

Suggested Readings:

1. *Carbon Footprint Analysis* by Mathews, H. S., Hendrickson, C. T., & Weber, C. L. (2008). Springer.
2. Chapagain, A. K., & Hoekstra, A. Y. (2008). *The Global Component of Freshwater Demand and Supply: An Assessment of Virtual Water Flows Between Nations as a Result of Trade in Agricultural and Industrial Products.* Water International.
3. Gleick, P. H. (2014). *The World's Water: The Biennial Report on Freshwater Resources.* Island Press.
4. *Sustainability: A Systems Approach* by Meadows, D. H., & Randers, J. (2012). Earthscan.
5. *Energy and Carbon Emissions Management* by R. F. Lockwood (2016). CRC Press.

5. Value Added Courses

a. Environmental Studies and Disaster management compulsory under Semester-I with3 Credits

b. *3 courses to be chosen from* ***baskets of VAC*** *for Semester-III/V/VI with 3 credits each*

03 Selected Subjects from the Value Aided Courses:

1.	**Geological Mapping and Cartography**
2.	**Exportation Geochemistry**
3.	**Climate Change and Disaster Risk Reduction**

ENVIRONMENTAL STUDIES
&
DISASTER MANAGEMENT(ESDM)

(AECC I)
SEMESTER-1
FOR UNDER GRADUATE COURSES ARTS, SCIENCE AND COMMERCE
FULL MARK-100(Credit-4)

Unit 1: Multidisciplinary nature of environmental studies (12 Periods)
Definition, scope and importance
Need for public awareness

Environmental Pollution
Definition
• Cause, effects and control measures of:-

a) Air pollution
b) Water pollution
c) Soil pollution
d) Marine pollution
e) Noise pollution
f) Radiation pollution

Unit 2: Natural Resources: (12 Periods)
Renewable and non-renewable resources:
Natural resources and associated problems.

a) Forest resources: Use and over-exploitation, deforestation, case studies.
Timber extraction, mining, dams and their effects on forest and tribal people.
b) Water resources : Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.
c) Mineral resources : Use and exploitation, environmental effects of extracting and using mineral resources, case studies.
d) Food resources : World food problems, changes caused by agriculture and
Overgrazing, effects of modern agriculture, fertilizer-pesticide problems, waterlogging, salinity, case studies.
e) Energy resources : Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. Case studies.

Biodiversity:-
Introduction-Definition;Biogeographically classification of India
India as a mega diversity nation. Hot sports of biodiversity, Threats to biodiversity. Endangered and endemic species of India. Conservation of biodiversity. In Situ and Ex-so conservation of biodiversity

Unit-3: Disaster Management (12 Periods)

1. **Disaster Management:** Types of disasters (natural and Man-made) and their causes and effect)

2. **Vulnerability Assessment and Risk analysis:** Vulnerability to various disasters(Flood, Cyclone, Earthquake, Heat waves, Desertification and Lighting)

3. **Institutional Framework:** Institutional arrangements for disaster management (National Disaster Management Authority (NDMA), State Disaster Management Authority (SDMA), Disaster Management Act, 2005,District Disaster Management Authority(DDMA),National Disaster Response Force(NDRF) and Odisha Disaster Rapid Action Force(ODRAF)
4. **Preparedness measures:** Disaster Management cycle, Early Warning System, Pre-Disaster and Post-Disaster Preparedness, strengthening of SDMA and DDMA, Community Preparedness for flood cyclone, heat waves, fire safety, lightening and snake biting. Stakeholders participation, Corporate Social Responsibility (CSR)
5. **Survival Skills:** Survival skills adopted during and after disaster (Flood, Fire, Earthquake, Cyclone and Lightening), Disaster Management Act-2005, Compensation and Insurance

Unit 4: Social Issues and the Environment (9 Periods) A.

a) Environmental Ethics: Issues and possible solutions.
b) Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case studies
c) Environment Protection Act
d) Air(Preservation Control of Pollution) Act
e) Water(Preservation Control of Pollution) Act
f) Wildlife Protection Act
g) Forest Conservation Act
h) Solid waste management Cause, effect and Control Measure of Urban and Industrial waste (Role of each individual in conservation of Natural resources and prevention of pollution)

B. Human Population and the Environment

Population Ecology: Individuals, species, population, community
Human population growth, population control method
Urbanisation and its effect on society

Unit 5: Field work (15 Periods of 30 hrs)

Visit to an area to document environmental assets: river/forest/flora/fauna, etc.

- Visit to a local polluted site- Urban/Rural/Industrial/Agricultural
- Study of common plants, insects, birds and basic principles of identification.
- Study of simple ecosystems-pond, river, Delhi Ridge ,etc.

Geological Mapping & Cartography

Objective:

- To be taught for the 1-year certificate program
- To introduce elements of Geological Maps and its components
- To interpret landforms on geological Maps
- To explain how geological features are represented in a geological map
- To use tools for preparing geological maps

46 Learning Outcome:

- Describe the elements of a geological map
- Explain the significance of ap elements and legend items
- Filed data Collection, sampling and representation in a geological map
- Prepare a geological map
- Use a geological map for field mapping

Unit - I: Introduction

Geological Map and map components, Scale and symbology, Toposheet numbering, map reading and locating self in field,

Unit - II: Field Measurements

Geological compass and field measurements, Measuring dip and strike, Mapping and representation of lithological contacts, Concept of V-rule and its significance

Unit - III: Mapping Structures:

Folds and Faults and their mapping. Representation of different types of folds and faults. Unconformities and their representation. Techniques of litho-sections Unit - IV: GIS Cartography GIS and Maps, Projection and scale, Map elements – Layout design, north arrow, representative ratio, symbology and legend. Map printing

Text Book:

C W Hayes Handbook for Field Geologists

Maltair & Maltair, 20189, Concepts of Cartography, Remote Sensing & GIS

Suggested Readings:

Compton, R. R., 1985, Geology in the Field, Wiley, New York. Lisle,

Braham, Barnes, 2011, Basic Geological mapping

Exploration Geochemistry

Course Objective:

- To be taught for the Diploma Certificate program
- To introduce sampling techniques in practice
- To explain how field data is collected, stored and sample prepared for analysis
- To learn about geochemical assay and their tabulation
- To use basic statistical tools for QA/QC and generate plots **Learning Outcome:**
- Able to collect samples and record them
- Able to prepare samples for analysis
- Explore geochemical assay data and perform QA/QC using statistical tools
- Interpret statistical data and generate plots

Unit - I: Introduction

Qualitative vs Quantitative Geochemical analysis, Dry and wet tests, Water and Soil sample analysis, Sample preparation and digestion methods. **Unit - II: Rock (& Mineral) Analysis**

Estimation of Oxides by Gravimetry, EDTA and photometry. Wilson's Method and Volhard's method

47 Unit - III: Ore Analysis

Estimation of antimony, arsenic cobalt, chromite, manganese iron, magnesium, molybdenum and Nickel ore

Unit - IV: Assay QA/AC and Plots

Quality control of Assay data, Statistical parameters for error analysis. Using geochemical data – organizing, checking integrity, plotting. Bivariate plots, ternary plots, Elemental ratio plots

Text Book:

R N Hota, 2019 Geochemical Analysis, CBS Publications

Rollison and Pease, 1993, Using Geochemical Data, Cambridge University Press

1. Levinson, A. A. (1980). *Introduction to Exploration Geochemistry.* Applied Publishing Ltd.
2. Rose, A. W., Hawkes, H. E., & Webb, J. S. (1979). *Geochemistry in Mineral Exploration.* Academic Press.
3. Govett, G. J. S. (1983). *Handbook of Exploration Geochemistry.* Elsevier.

Suggested Readings:

1. Butt, C. R. M., & Zeegers, H. (1992). *Regolith Exploration Geochemistry in Tropical and Subtropical Terrains.* Elsevier.
2. Hale, M. (2000). *Geochemical Remote Sensing of the Subsurface.* Pergamon.
3. Marjoribanks, R. (2010). *Geological Methods in Mineral Exploration and Mining.* Springer.
4. Chork, C., & Clark, I. (1999). *Practical Geo-statistics.* Ecosse North America Llc.

Climate Change and Disaster Risk Reduction

Course Objectives:

- To understand the challenges of climate change
- To gain a comprehensive understanding of the Disaster Management Cycle.
- To get acquainted with disaster management policies and laws in India.
- To discuss community-based disaster management practices and understand disaster risk and vulnerability.

Learning Outcomes :

- Able to examine the impacts of climate change globally and particularly in Odisha, and to understand the relationship between the greenhouse effect, climate change, and various types of disasters.
- Able to demonstrate awareness of policies and Laws
- Able to analyze social dimensions of climate change and disasters

Unit I: Climate Change and Disaster:

Concept, nature, and severity of climate change. Causes of climate change. SDGs- 13: Climate Action. Impact of climate change: globally in general and Odisha in particular. Greenhouse effect, climate change and disaster. Definition, Types of disaster (natural and manmade disaster), mining disaster, tropical cyclone, flood, lightning, forest fire, earthquake, and Tsunami.

Unit II: Disaster Management Cycle:

Disaster phase, Response phase, Recovery phase, Risk reduction phase, Preparedness phase. The Process of Disaster Management: mitigation, preparedness, response, and recovery. Sendai Framework for DRR: 2015- 2030

Unit III: Disaster Management Laws, Policy, and Institution:

National Disaster Management Act (2005), National Policy on Disaster Management (2009), National Disaster Management Agency (NDMA), State Disaster management Agency (SDMA), National Disaster Response Force (NDRF), National Institute of Disaster Management (NIDM), India Disaster Resource Network (IDRN). The role of INGOs and NGOs.

Unit IV: Disaster Risk Reduction (DRR) Fundamentals

Community based disaster management practices (case studies). Understanding disaster risk and vulnerability. Disaster Warning and Evacuation: Factors influencing evacuation. Social dimensions of climate change and disasters. Gender responsive approaches in DRR.

Reading List:

- ✓ Anandha Kumar K.J and Ajinder Walia (2013) India Disaster Report, NIDM: New Delhi.
- ✓ Community Based Disaster Preparedness (2013) Course Book, Assam State Disaster Management Authority & Doctors For You
- ✓ Gupta. Anil K et, al (Ed) (2014). Training Module Mainstreaming Climate Change Adaptation and Disaster Risk Reduction into District Level Development Plans, NIDM: New Delhi.
- ✓ Gadnayak, B B and Routray, J K (2010), A path to disaster resilient communities, Lambert Publishing Academy, Germany.
- ✓ https://www.lappublishing.com/catalog/details/store/hu/book/978-3-8433-6666-3/ a path-todisaster-resilientcommunities?search=Bibhuti%20Bhusan%20Gadanayak
- ✓ National Policy on Disaster Management (2009), NDMA, Government of India, New Delhi file:///C:/Users/User/Downloads/national-dm-policy2009.pdf
- ✓ National Disaster Management Act (2005), NDMA, Government of India, New Delhi file:///C:/Users/User/Downloads/DM_act2005.pdf
- ✓ State Disaster Management Policy (2005), Government of Orissa Revenue Department, Odisha https://www.osdma.org/plan-and-policy/state-disaster-management-plan/#gsc.tab=0
- ✓ Odisha State Action Plan on Climate Change (2018-23), Forest & Environment Department Government of Odisha 3 file:///C:/Users/User/Downloads/State%20Action%20Plan%20on%20Climate%20Change%202018-23.pdf
- ✓ Building Disaster Risk Reduction in Asia: A Way Forward ADPC Looks Ahead To 2015 file:///C:/Users/User/Downloads/kobe.pdf
- ✓ Disaster Risk Reduction Information Kit for Media, Scaling-up Community-Based Disaster Risk Reduction in Lao PDR file:///C:/Users/User/Downloads/2016-pt37Na-ADPCInformation_Kit_for_Media_Lao_PDR.pdf Satendra and Kaushik. D (2013) Forest Fire Disaster Management NIDM: New Delhi.
- ✓ Disaster Risk Reduction in the United Nations (2009) Roles, mandates and areas of work of key United Nations entities, UNISDR. file:///C:/Users/User/Downloads/9866_DisasterRiskReductionintheUnitedNat.pdf ✓ Vogelbacher (2013) Flood Disaster Risk Management NIDM: New Delhi.
- ✓ Kaushik. A.D. (2012) Flood Risk Mitigation and Management: A Training of Trainers Module, NIDM: New Delhi.

- ✓ Major epidemic and pandemic diseases file:///C:/Users/User/Downloads/12-EPIDEMIC-HR.pdf
- ✓ Noncommunicable diseases & Communicable diseases https://www.who.int/ourwork/communicable-and noncommunicable-diseases-and-mental health
- ✓ Kaushik. A.D. (2012) Flood Risk Mitigation and Management: A Training of Trainers Module, NIDM: New Delhi.

6. Summer Vocational Course

(Students may opt for vocational courses after 2_{nd} Semester and 4_{th} Semester for Certificate Course or Diploma Course respectively with 4 credit each)

02 Selected Subjects from the Summer Vocational courses:

1.	**Geological Mapping and Cartography**
2.	**Exportation Geochemistry**

Geological Mapping and Cartography Course

Objective:

- To be taught for the 1-year certificate program
- To introduce elements of Geological Maps and its components
- To interpret landforms on geological Maps
- To explain how geological features are represented in a geological map
- To use tools for preparing geological maps

Learning Outcome:

- Describe the elements of a geological map
- Explain the significance of ap elements and legend items
- Filed data Collection, sampling and representation in a geological map
- Prepare a geological map
- Use a geological map for field mapping

Unit - I: Introduction:

Geological Map and map components, Scale and symbology, Toposheet numbering, map reading and locating self in field,

Unit - II: Field Measurements:

Geological compass and field measurements, Measuring dip and strike, Mapping and representation of lithological contacts, Concept of V-rule and its significance

Unit - III: Mapping of Structures:

Folds and Faults and their mapping. Representation of different types of folds and faults. Unconformities and their representation. Techniques of litho-sections Unit - IV: GIS Cartography GIS and Maps, Projection and scale, Map elements – Layout design, north arrow, representative ratio, symbology and legend. Map printing

Unit 4: Project Work and Presentation:

Conducting a mini-project on geological mapping of a selected area, Fieldwork to gather data and prepare a geological map**,** Preparing a report on the mapping project, Presenting findings to the class, including a discussion of the challenges faced and solutions implemented.

Text Book:

C W Hayes Handbook for Field Geologists

Maltair & Maltair, 20189, Concepts of Cartography, Remote Sensing & GIS

Suggested readings: Compton, R. R., 1985, Geology in the Field, Wiley, New York.

Lisle, Braham, Barnes, 2011, Basic Geological mapping

Exploration Geochemistry

Course Objective:

- To be taught for the Diploma Certificate program
- To introduce sampling techniques in practice
- To explain how field data is collected, stored and sample prepared for analysis
- To learn about geochemical assay and their tabulation
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Learning Outcome:

- Able to collect samples and record them
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Unit - I: Introduction

Qualitative vs Quantitative Geochemical analysis, Dry and wet tests, Water and Soil sample analysis, Sample preparation and digestion methods.

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Estimation of Oxides by Gravimetry, EDTA and photometry. Wilson's Method and Volhard's method

Unit - III: Ore Analysis

Estimation of antimony, arsenic cobalt, chromite, manganese iron, magnesium, molybdenum and Nickel ore

Unit - IV: Assay QA/AC and Plots

Quality control of Assay data, Statistical parameters for error analysis. Using geochemical data – organizing, checking integrity, plotting. Bivariate plots, ternary plots, Elemental ratio plots

Text Book:

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Rose, A. W., Hawkes, H. E., & Webb, J. S. (1979). *Geochemistry in Mineral Exploration.* Academic Press.

Govett, G. J. S. (1983). *Handbook of Exploration Geochemistry.* Elsevier.

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Butt, C. R. M., & Zeegers, H. (1992). *Regolith Exploration Geochemistry in Tropical and Subtropical Terrains.* Elsevier.

Hale, M. (2000). *Geochemical Remote Sensing of the Subsurface.* Pergamon.

Marjoribanks, R. (2010). *Geological Methods in Mineral Exploration and Mining.* Springer. Chork, C., & Clark, I. (1999). *Practical Geostatistics.* Ecosse North America Llc.