Three/Four Yr. Degree Course
(Single Major & Double Minor with Research)
based on NEP-2020
GEOLOGY

(Effective from Session 2026-27)
(Batch: 2026-2029)

SAMBALPUR UNIVERSITY
JYOTI-VIHAR, BURLA, SAMBALPUR, ODISHA-768019

The model curriculum and credit frame work for under graduate programmes as multiple entry and exit option with research and without research of National Education Policy-2020.

I. ***Certificate Course:*** *One Academic Year (Frist & Second Semester and Summer Vocational Course and Community Work)* ***44 Credits***
II. ***Diploma Course:*** *Two Academic year (Frist, Second, Third & Fourth Semester and Summer Vocational Course and Community Work)* ***86 Credits***
III. ***3yr. Degree Course:*** *Three Academic Year (Frist, Second, Third, Fourth, Fifth & Sixth Semester and Community Work)* ***126 Credits***
IV. ***4yr. Degree Course (Honours):*** *Four Academic Year (Frist, Second, Third, Fourth, Fifth, Sixth, Seven & Eight Semester and Community Work)* ***166 Credits***
V. ***4yr. Degree Course (Honours with Research):*** *Four Academic Year (Frist, Second, Third, Fourth, Fifth, Sixth, Seven & Eight Semester and Community Work)* ***166 Credits***

Type of Course:

I. ***Major (Core-I):*** *is the subject of main focus and the degree will be awarded in that discipline.*

II. ***Minor Stream (Core-II):*** *helps a student to gain a brooder understanding knowledge beyond the major discipline. A student may gather 28 credits from a single subject*

III. ***Multidisciplinary U.G. Progrmme (09 Credits):*** *Three introductory-level Multidisciplinary Course baskets are offered for students to choose any one from each semester outside of the subject/discipline/faculty: A group of related subject i.e., faculty (Arts/Commerce/Science). The student can opt three different subject/course for each semester examination.*

IV. ***Ability Enhancement Course (AEC 08 Credits):*** *Student are required to achieve competency in a Modern Indian Language (MIL)and in the English language with special emphasis on language and communication skills (not literally skill). Literature and Linguistic courses shall be offered in major core and minor stream. In lieu of Odia, a student may opt for only Sanskrit, Hindi or Urdu.*

V. ***Skill Enhancement Course (SEC 09 Credits):*** *A student has to opt the Skill Enhancement courses from the basket as per the subject available in the institution. The students can opt for any one course for each semester examination and these courses are aimed at imparting practical skills, hands-on training, soft skills, etc., to enhance the employability of students.*

VI. ***Value Added Course (VAC 12 Credits):*** *The VAC course basket are prearranged for the students to choose for each semester's examination.*

VII. ***Summer Internship/Apprenticeship/Summer Project (04 Credits with 120 Hours):*** *Community Engagement and Services/ Field work/ Internship programme is mandatory for all students of 4th Semester undergraduate Programmes of NEP-2020 carrying 4 credits which shall be completed in 120h (Students admitted in the session 2024-25 onwards) under affiliated colleges of Sambalpur University.*

A. *Internship:* *A course requiring students to participate in a professional activity or work experience or cooperative education activity with an entity external to the education institution, normally under the supervision of an expert of the given external entity. A key aspect of the internship is induction into actual work situations.*

• Internships may be undertaken anywhere in India, subject to institutional approval and compliance with credit requirements.

• Internships involve working with local industry, government or private organizations, business organizations, artists, crafts persons, NGOS, Private Sector organizations, Government / Public Sector institutions, Industries, MSMEs (Online or Offline) and similar entities to provide opportunities for students to actively engage in on-site experiential learning.

*• **Online / Digital Internship Opportunities:** Internship may also be undertaken in online or hybrid mode through recognized Government of India platforms, subject to institutional approval and fulfilment of credit requirements.*

• Students may undertake internships or field work through their own arrangement, subject to prior approval of the concerned HEI.

B. *Community Engagement and Services/ Field work:* *Community Engagement activities shall be conducted through NSS. Students not enrolled under NSS may undertake community engagement projects / field work for 120h duration under the supervision of faculty members.*

- *After completion of Internship students will collect an internship completion certificate from the organization /competent authority.*
- ***Submission of Report and Evaluation:*** *Students opted for Internship/ Community engagement projects/ Field work are required to submit a report to the Institution for evaluation. Supporting documents like feedback from the host Organisation, geotagged photos and other relevant documents should be submitted with the report.*

Table-I: Course Table Structure for Certificate Course: Exit after first Academic Year

One Academic Year: (1st & 2nd Semester and a Summer Vocational Course and Community Work)

Semester	Core-I	Core-II	Core-III	Multidisciplinary	AEC	SEC	VAC	Community Engagement & Field Work	Credit
I	2x4=8	1x4=4		1x3=3	1x4=4		1x3=3		22
II	2x4=8		1x4=4	1x3=3	1x4=4	1x3=3			22
Total	**4x8=16**	**1x4=4**	**1x4=4**	**2x3=6**	**2x4=8**	**1x3=3**	**1x3=3**		**44**

Table-II: Course Table Structure for Diploma Certificate Course: Exit after Second Academic Year

Two Academic Year: (1st, 2nd, 3rd & 4th Semester and a Summer Vocational Course and Community Work)

Semester	Core-I	Core-II	Core-III	Multidisciplinary	AEC	SEC	VAC	Community Engagement & Field Work	Credit
I	2x4=8	1x4=4		1x3=3	1x4=4		1x3=3		22
II	2x4=8		1x4=4	1x3=3	1x4=4	1x3=3			22
									44
III	3x4=12	1x4=4		1x3=3			1x3=3		22
IV	3x4=12		1x4=4						20
									42
Total	**10x4=40**	**2x4=8**	**2x4=8**	**3x3=9**	**2x4=8**	**1x3=3**	**2x3=6**		**86**

Table-III: Course Table Structure for Three Years Degree Course with Single Major and Two Minor

Semester	Core-I	Core-II	Core-III	Multidisciplinary	AEC	SEC	VAC	Community Engagement & Field Work	Credit
I	2x4=8	1x4=4		1x3=3	1x4=4		1x3=3		22
II	2x4=8		1x4=4	1x3=3	1x4=4	1x3=3			22
									44
III	3x4=12	1x4=4		1x3=3			1x3=3		22
IV	3x4=12		1x4=4					1x4=4	20
									42
V	3x3=12	1x4=4				1x3=3	1x3=3		22
VI	2x4=8		1x4=4			1x3=3	1x3=3		18
									40
Total	**15x4=60**	**3x4=12**	**3x4=12**	**3x3=9**	**2x4=8**	**3x3=9**	**4x3=12**	**1x4=4**	**126**

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

Table-IV: Course Table Structure for Three Years Degree Course with Double Major

Semester	*Core-I*	*Core-II*	*Multidisciplinary*	*AEC*	*SEC*	*VAC*	*Community Engagement & Field Work*	*Credit*
I	*2x4=8*	*2x4=8*	*1x3=3*	*1x4=4*		*1x3=3*		*26*
II	*2x4=8*	*2x4=8*	*1x3=3*	*1x4=4*	*1x3=3*			*26*
								52
III	*3x4=12*	*2x4=8*	*1x3=3*			*1x3=3*		*26*
IV	*3x4=12*	*2x4=8*					*1x4=4*	*24*
								50
V	*3x3=12*	*2x4=8*			*1x3=3*	*1x3=3*		*26*
VI	*2x4=8*	*2x4=8*			*1x3=3*	*1x3=3*		*22*
								48
Total	***15x4=60***	***12x4=48***	***3x3=9***	***2x4=8***	***3x3=9***	***4x3=12***	***1x4=4***	***150***

Table-V: Course Table Structure for Fourth Year Honours without Research

Semester	*Core-I*	*Core-II*	*Core-III*	*Multidisciplinary*	*AEC*	*SEC*	*VAC*	*Community Engagement & Field Work*	*Credit*
I	*2x4=8*	*1x4=4*		*1x3=3*	*1x4=4*		*1x3=3*		*22*
II	*2x4=8*		*1x4=4*	*1x3=3*	*1x4=4*	*1x3=3*			*22*
									44
III	*3x4=12*	*1x4=4*		*1x3=3*			*1x3=3*		*22*
IV	*3x4=12*		*1x4=4*					*1x4=4*	*20*
									42
V	*3x3=12*	*1x4=4*				*1x3=3*	*1x3=3*		*22*
VI	*2x4=8*		*1x4=4*			*1x3=3*	*1x3=3*		*18*
									40
VII	*4x4=16*	*1x4=4*							*20*
VIII	*4x4=16*	*1x4=4*							*20*
Total	***23x4=92***	***5x4=20***	***3x4=12***	***3x3=9***	***2x4=8***	***3x3=9***	***4x3=12***	***1x4=4***	***166***

Table-VI: Course Table Structure for Fourth Year Honours with Research

Semester	*Core-I*	*Core-II*	*Core-III*	*Multidisciplinary*	*AEC*	*SEC*	*VAC*	*Community Engagement & Field Work*	*Credit*
I	*2x4=8*	*1x4=4*		*1x3=3*	*1x4=4*		*1x3=3*		*22*
II	*2x4=8*		*1x4=4*	*1x3=3*	*1x4=4*	*1x3=3*			*22*
									44
III	*3x4=12*	*1x4=4*		*1x3=3*			*1x3=3*		*22*
IV	*3x4=12*		*1x4=4*					*1x4=4*	*20*
									42
V	*3x3=12*	*1x4=4*				*1x3=3*	*1x3=3*		*22*
VI	*2x4=8*		*1x4=4*			*1x3=3*	*1x3=3*		*18*
									40
VII	*3x3=12*	*2x4=8*							*20*
VIII	*2x4=8*							***Research 12***	*20*
Total	***20x4=80***	***5x4=20***	***3x4=12***	***3x3=9***	***2x4=8***	***3x3=9***	***4x3=12***	***16***	***166***

COURSE AT A GLANCE (NEP-UG)

SUBJECT - GEOLOGY **ACADEMIC SESSION: 2026-29**

CORE-I COURSE

Course Number	Semester	Course Title	Type of Paper P-Practical NP-Non-practical	Credit Hour	Maximum Weightage of Marks
Paper-I	I	GENERAL GEOLOGY	P	4	100
Paper-II		HISTORICAL GEOLOGY	P	4	100
Paper-III	II	CRYSTALLOGRAPHY	P	4	100
Paper-IV		MINERALOGY AND MINERALOPTICS	P	4	100

Paper-V	III	GEOCHEMISTRY AND ELEMENTRY PETROLOGY	P	4	100
Paper-VI		ELEMENTRY ECONOMIC GEOLOGY	P	4	100
Paper-VII		PALENTOLOGY	P	4	100
Paper-VIII	IV	STRATIGRAPHY	P	4	100
Paper-IX		IGNEOUSSPETROLOGY	P	4	100
Paper-X		SEDIMENTRYPETROLOGY	P	4	100
Paper-XI	V	METAMORPHICPETROLOGY	P	4	100
Paper-XII		REMOTESENSING AND GIS	P	4	100
Paper-XIII		STRUCTURAL GEOLOGY AND TECTONICS	P	4	100
Paper-XIV	VI	ENGINNERING GEOLOGY AND ROCK MECHANICS	P	4	100
Paper-XV		HYDROGEOLOGY	P	4	100
Paper-XVI	VII	EXPLORATION AND MINING GEOLOGY	P	4	100
Paper-XVII		ECONOMIC MINERALS OF INDIA	P	4	100
Paper-XVIII		LABORATARY INSTRUMENTATION AND ANALYSIS	P	4	100
Paper-XIX		GEOLOGY AND MINERALS RESOURCES OF ODISHA	P	4	100
Paper-XX	VIII	FUEL GEOLOGY	P	4	100
Paper-XXI		ENVIRONMENTAL GEOLOGY	P	4	100
Paper-XXII		ORE MICROSCOPY	P	4	100
Paper-XXIII		INTRODUCTION TO GEOSTATISTICS	P	4	100

CORE-II/CORE-III COURSE

Course Number	Semester Core-II/ Core-III	Course Title	Type of Paper P-Practical NP-Non-practical	Credit Hour	Maximum Weightage of Marks
Paper-I	I/II	GENERAL GEOLOGY	P	4	100
Paper-II	III/IV	GEOCHEMISTRY AND ELEMENTRY PETEROLOGY	P	4	100
Paper-III	V/VI	ELEMENTARY ECONOMIC GEOLOGY	P	4	100
Paper-IV	VII	ENGINNERING GEOLOGY AND ROCK MECHANICS	P	4	100
Paper-V	VIII		P	4	100

ABILITY ENHANCEMENT COURSE (AEC) UNDER NEP-2020

Sl. No.	Semester	Course	Credit hour (CH)	Full Mark
Paper-I	I	Odia/Hindi/Sanskrit/Urdu	4	100
Paper-II	II	English	4	100

MULTIDISCIPLINARY COURSE:

NOTE: THIS IS APPLICABLE FOR STUDENT ADMISSION FOR THE 2026-27 BATCH.

1. *A basket of semester wise MDC Courses (**Table-I**) have been approved by Sambalpur University, which will be applicable to all the U.G. programme in the affiliated colleges under Sambalpur University.*
2. *Students have to opt for one subject in each semester from the semester- wise subject list provided in the basket.*
3. *During the counselling, students are to be encouraged to opt for courses outside their discipline/faculty. (A Group of related subjects, i.e., Faculty: Science/Arts/Commerce).*
4. *The students are expected to choose MDC from the subjects other than their major subjects. For example, a Home Science student cannot be allowed to opt MDC from Home Science and have to choose from any other Department.*

NOTE: ***The student cannot opt for a course already chosen in earlier semester. Ex: The subject chosen by a student in the 1st Semester cannot be chosen in 2nd Semester and the subject chosen in 1st & 2nd semester cannot be chosen in 3rd semester.***

Table -1: List of MDC Course at UG level

SEMESTER-I

MULTIDISCIPLINARY COURSE (MDC) *UNDER NEP-2020*					
Sl. No.	*Department to teach*	*Semester* *Course*	*Type of Paper P- Practical NP-Non-practical*	*Credit hour (CH)*	*Full Mark*
1.	*Chemistry*	*Environmental Chemistry*	*NP*	*3*	*100*
2.	*Botany*	*Gardening and Vermicomposting*	*NP*	*3*	*100*
3.	*Economics*	*Economics in Everyday Life*	*NP*	*3*	*100*
4.	*History*	*History of Education in Modern India*	*NP*	*3*	*100*
5.	*Odia*	Tulanatmaka Sahitya	*NP*	*3*	*100*
6.	*Political Science*	*Political Process in India*	*NP*	*3*	*100*
7.	*English*	*Ethical Literature*	*NP*	*3*	*100*
8.	*Commerce*	*Financial literacy*	*NP*	*3*	*100*
9.	*Education*	*Educational Psychology*	*NP*	*3*	*100*
10.	*Mathematics*	*Discrete Mathematics*	*NP*	*3*	*100*
11.	*Sociology*	*Sociology for Social Workers*	*NP*	*3*	*100*
12.	*Physics*	*Biophysics*	*NP*	*3*	*100*

SEMESTER-II

MULTIDISCIPLINARY COURSE (MDC) UNDER NEP-2020					
Sl. No.	*Department to teach*	*Semester* *Course*	*Type of Paper P- Practical NP-Non-practical*	*Credit hour (CH)*	*Full Mark*
1.	*Statistics*	*Survival Analysis and Biostatistics*	*NP*	*3*	*100*
2.	*Zoology*	*Apiculture*	*NP*	*3*	*100*
3.	*Education*	*Gender and Education*	*NP*	*3*	*100*
4.	*Geography/Geology*	*Climatology*	*NP*	*3*	*100*
5.	*Philosophy*	*Vedic Culture*	*NP*	*3*	*100*
6.	*Hindi*	*विज्ञापन अवधारणा और प्रयोजनमूलक अध्यन*	*NP*	*3*	*100*
7.	*Home Science*	*Food Science and Nutrition*	*NP*	*3*	*100*
8.	*Commerce*	*Fundamentals of Entrepreneurship and E-Commerce*	*NP*	*3*	*100*
9.	*Economics*	*Demography*	*NP*	*3*	*100*
10.	*Mathematics*	*Introduction to Programming with MATLAB*	*NP*	*3*	*100*
11.	*Political Science*	*Indian Administration*	*NP*	*3*	*100*
12.	*History/Geography*	*Sustainable Tourism*	*NP*	*3*	*100*

SEMESTER-III

MULTIDISCIPLINARY COURSE (MDC) UNDER NEP-2020					
Sl. No.	*Department to teach*	*Semester* *Course*	*Type of Paper P- Practical NP-Non-practical*	*Credit hour (CH)*	*Full Mark*
1.	*Mathematics/Computer Science*	*Programming C++*	*NP*	*3*	*100*
2.	*Physics*	*Introduction to Spectroscopy*	*NP*	*3*	*100*
3.	*History/ Sanskrit*	*Indian Knowledge System*	*NP*	*3*	*100*
4.	*Political Science*	*Human Rights*	*NP*	*3*	*100*
5.	*Botany/Zoology*	*Environmental issues and Challenges*	*NP*	*3*	*100*
6.	*Commerce*	*Entrepreneurship Development and*	*NP*	*3*	*100*

		start up			
7.	*Psychology*	*Health Psychology*	*NP*	*3*	*100*
8.	*Philosophy*	*Philosophy of Bhagavad Gita*	*NP*	*3*	*100*
9.	*Botany*	*Herbarium Preparations*	*NP*	*3*	*100*
10.	*Education*	*Educations Thinkers of Modern India*	*NP*	*3*	*100*
11.	*Sociology*	*Public Policy*	*NP*	*3*	*100*
12.	*Library & Information Science*	*Management of Libraries*	*NP*	*3*	*100*

SKILL ENHANCEDMENT COURSE:

NOTE: THIS IS APPLICABLE FOR STUDENT ADMISSION FOR THE 2026-27 BATCH.

1. *A basket of Skill Enhanced Course for various disciplines has been approved by the Sambalpur University and will be applicable to all undergraduate programme in the affiliated colleges under Sambalpur University.*
2. *A student may opt one SEC course form the basket during a particular semester, ensuring no repetition. Details of the SEC courses for each semester are provided in table-2.*
3. ***Artificial Intelligence has been offered as a compulsory course at 2nd semester Skill Enhancement Course.***

TABLE-2: LIST OF THE SEC COURSE AT UG LEVEL

SKILL ENHANCEDMENT COURSE (SEC) UNDER NEP-2020			
	SEMESTER-II	*Credit hour (CH)*	*Full Mark*
Paper- I	*PERSONALITY DEVELOPMENT* ***OR*** *ELECTION STUDIES AND PUBLIC OPINION* ***OR*** *QUANTITATIVE AND LOGIAL THINKING* ***OR*** *ANALYTICAL THINKING AND LOGICAL RESONING* ***OR*** *RENEWABLE ENERGY AND ENERGY HARVESTING* ***OR*** *VERMICOMPOSTING* ***OR*** *PROJECT MANAGEMENT*	*3*	*100*

SKILL ENHANCEDMENT COURSE (SEC) UNDER NEP-2020 SEMESTER-V			
Paper-II	**ARTIFICIAL INTELLIGENCE** Compulsory for all (Arts, Science & Commerce)	**Credit hour (CH)** 3	**Full Mark** 100

SKILL ENHANCEDMENT COURSE (SEC) *UNDER NEP-2020*			
	SEMESTER-VI	*Credit hour (CH)*	*Full Mark*
Paper- III	*LIFE SKILL EDUCATION* ***OR*** *QUANTITATIVE AND LOGICAL THINKING* ***OR*** *INCOME TAX E-RETURN FILING* ***OR*** *ORGANIC FARMING* ***OR*** *BIOFERTILIZERS* ***OR*** *TYPE SETTING IN LATEX* ***OR*** *FOOD FERMENTATION TECHNIQUES*	*3*	*100*

VALUE ADDED COURSES (VAC)
UNDER NEP – 2020

1. ***The student will have to study one VAC course in each semester (I, III, V, VI) irrespective of their disciplines are reflected in Table-3.***

TABLE-3: LIST OF THE VAC COURSE AT UG LEVEL

VALUE ADDED COURSES (VAC) UNDER NEP - 2020				
Paper	*Semester*	*Course title*	*Credit*	*Marks*
PAPER I	*Semester-I*	*Environmental Studies and Disaster Management*	*3*	*100*
PAPER II	*Semester-III*	*Ethics & Values*	*3*	*100*
PAPER III	*Semester-V*	*Understanding Odisha*	*3*	*100*
PAPER IV	*Semester-VI*	*Creative Writing*	*3*	*100*

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*

(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 volution 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: Plate Tectonics

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 of 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. Inter pretcrystall graphic data, including crystal symmetry and crystallographic directions 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:

- ✓ Practical approach to crystallography and mineralogy, R.N. Hota(2011),CBS Pub.& 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.*

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.*

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*

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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 paleoenvironmental 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 paleoenvironmental 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.*

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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. pan idiomorphic, hypidiomorphic, allotriomorphic, porphyritic, vitrophyric, poikilitic, ophitic, sub-ophitic, intergranular, interdental, pilotaxitic, trachytic, graphic, granophyric, rapakivi, orbicular, corona, pathetic, 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.

Learning Outcome:

- 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:

- *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

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

Practical:

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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:

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

Practical:

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.

Practical:

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.

Practical:

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

Practical:

Hill, New Delhi.

Practical:

- 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*

Practical:

Core XIX - Geology and Mineral Resources of Odisha

Practical:

- **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.

29 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

Practical:

- 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

Practical:

- 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; Underground 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.

Practical:

- 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.*

31 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

Practical:

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.

Practical:

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*

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

Regionalized Variables and Spatial Correlation, Non-stationary variables and variance, Covariance 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

- **Practical-** Oil reserve estimation

Practical:

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.*