

Vidyasagar University

Curriculum for B.Sc. Honours in Geology [Choice Based Credit System]

Semester-I

Sl.No.	Name of the Subject	Nature	Code	Teaching Scheme in hour per week			Credit	Marks
				L	T	P		
C1	C1T: Earth System Science	Core Course-1		4	0	0	6	75
	C1P: Earth System Science Lab (Practical)	Core Course1 [Practical]		0	0	4		
C2	C2T: Mineral Science	Core Course-2		4	0	0	6	75
	C2P: Mineral Science Lab (Practical)	Core Course-2 [Practical]		0	0	4		
GE-1	GE-1	GE					4/5	75
	GE-1	GE					2/1	
AECC	English	AECC					2	50
Total Credits =20								

L=Lecture, T=Tutorial, P=Practical

AECC- Ability Enhancement Compulsory Course: English /Modern Indian Language

Interdisciplinary/Generic Elective (GE) from other Department

[Four papers are to be taken and each paper will be of 6 credits]:

**[Papers are to be taken from any of the following discipline (GE-1 Mathematics)]:
Physics/Chemistry/Mathematics/Geography /Computer Sc/Botany/Zoology**

Semester-1
Core Courses

Core-1

CC-1: EARTH SYSTEM SCIENCE

Credits 06

C1T: EARTH SYSTEM SCIENCE (Theory)

Credits 04

THEORY

Unit 1: Earth System Science

1. Definition and scope; General characteristics and origin of the Universe, Solar System and its planets; the Terrestrial and Jovian planets.
2. Meteorites and Asteroids
3. Earth in the solar system - origin, size, shape, mass, density, rotational and revolution parameters and its age.

Unit 2: Solid Earth, Hydrosphere, Atmosphere and Biosphere

1. Internal constitution - its recognition vis-à-vis solid earth geophysics: crust, mantle, core, evidence from seismic waves
2. Earthquake and earthquake belts: Seismic waves and internal constitution of the Earth
3. Volcanoes and volcanism, distribution of volcanoes
4. Concept of isostasy
5. Hydrosphere, atmosphere and biosphere: Elementary idea
6. Nature of Earth's magnetic field and geothermal gradient.
7. Fossil, Evolution and Charles Darwin

Unit 3: Plate Tectonics

1. Historical development of the concept of continental drift and plate tectonics
2. Plates and Plate boundaries
3. Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, transform faults and island arcs
4. Plate tectonics: mountain belts and rift valleys

Unit 4: Hydrosphere and Atmosphere

Oceanic current system and effect of Coriolis force
Concepts of eustasy
Land-sea interaction along coast
Weather and climatic changes

Unit 5: Earth surface processes

Weathering; erosion; mass wasting; Geological work of wind, river and glacier
Formation of soil, soil profile and soil types

Unit 6: Cosmic abundance of elements

Distribution of elements in solar system and in Earth

Introduction to chemical differentiation and composition of the Earth
General concepts about geochemical cycles

Unit 7: Understanding the past from stratigraphic records

1. Nature of stratigraphic records
2. Fundamental laws of stratigraphy: Laws of superposition and faunal succession, Concepts of neptunism, plutonism, uniformitarianism.
3. Concept of time and geological time scale. Absolute and relative time in Geology.
4. Concept of radiometric dating. Radiometric dating of rocks and minerals: U-Pb, Pb-Pb, K Ar, Rb-Sr, Sm-Nd method. Dating igneous and sedimentary rocks.

C1P: EARTH SYSTEM SCIENCE(Practical)

Credits 02

1. Study of major geomorphic features and their relationships with outcrops through physiographic models and maps
2. Detailed study of topographic sheets and preparation of physiographic description of an area
3. Study of distribution of cratons, mobile belts and major sedimentary basins on the map of India.
4. Identification, state of preservation of fossils

Reference books:

Duff, P. M. D., & Duff, D. (Eds.). (1993). Holmes' principles of physical geology. Taylor & Francis.

- ▶ Emiliani, C. (1992). Planet earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press.
 - ▶ Gross, M. G. (1977). Oceanography: A view of the earth.
 - ▶ Tarback, E. J. and Lutgens, F.K. (2006). Earth Science. Pearson Prentice Hall. New Jersey
 - ▶ Grotzinger, J., Jordan, T.H., Press, F and Siever, R. (2007) Understanding Earth (Fifth Edition). W. H. Freeman and company. New York.
 - ▶ Environmental Science – Earth as a Living Planet. By – Daniel B. Botkin & Edward A. Keller, John Wiley & Sons.
- Principles of Paleontology , Raupund Stanley, Foot and Miller.

CORE - 2

CC-2T: MINERAL SCIENCE

Credits 06

C2T2: MINERAL SCIENCE (Theory)

Credits 04

Unit 1: Crystallography

1. Elementary ideas about crystal morphology in relation to internal structures
2. Crystal parameters and Miller indices
3. Crystal symmetry and classification of crystals into point groups, space groups and crystal systems
4. Stereographic projections of symmetry elements and forms, Herman Mauguin notation

Unit 2: Rock forming minerals

1. Minerals - definition and classification, physical and chemical properties
2. Chemical classification of minerals
3. Composition of common oxides, carbonated, sulphides and sulphates and phosphates
4. Composition of common rock-forming minerals

Unit 3: Atomic arrangements and Mineralogical structure

1. Crystal structure and its controls: bonding and coordination principles, atomic arrangement: unit cell, CCP and HCP structures.
2. Brief idea about Pauling's rules, Solid solution, Pseudomorphism and Polymorphism: elementary concept on principle types – common polymorphic forms of C, SiO₂ and Al₂SiO₅
3. Classification of silicate groups based on structure and derivation of structural formulae based on composition.

Unit 4: Optical mineralogy

1. Optical behaviour of crystals – Isotropic and anisotropic minerals; Nicol prism and its principle;
2. Refractive index of minerals; Uniaxial & Biaxial minerals; Optical indicatrix of uniaxial and biaxial minerals; Birefringence, Interference colour and use of interference colour chart; Relation between crystallographic and optical axes of crystals
3. Pleochroism and pleochroic scheme; Extinction; Study of interference figures; Optic sign of uniaxial and biaxial minerals

C2P: MINERAL SCIENCE (Practical)

Credits 02

1. Study of the symmetry of crystals
2. Study of physical properties of minerals in hand specimen: Olivine, Garnet, Silimanite, Kyanite, Staurolite, Beryl, Tourmaline, Pyroxene, Actinolite, Tremolite, Hornblende, Serpentine, Talc, Muscovite, Biotite, Quartz, Alkali feldspar, Plagioclase, Nepheline, Sodalite, Zeolite, Pyrite, Chalcopyrite, Galena, Sphalerite, Graphite, Magnetite, Haematite, Fluorite, Calcite, Dolomite, Gypsum, Asbestos, Ilmenite, Chromite, Pyrolusite, Psilomelane, Bauxite
3. Study of optical properties of common rock-forming minerals: quartz, orthoclase, microcline, plagioclase, perthite, nepheline, olivine, orthopyroxene, clinopyroxene, hornblende, staurolite, garnet, muscovite, biotite, calcite

References:

1. Klein, C., Dutrow, B., Dwight, J., & Klein, C. (2007). The 23rd Edition of the Manual of Mineral Science (after James D. Dana). J. Wiley & Sons.
2. Kerr, P. F. (1959). Optical Mineralogy. McGraw-Hill.
3. Verma, P. K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt Ltd.
4. Deer, W. A., Howie, R. A., & Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman.

Generic Elective Syllabus

GE-1 [Interdisciplinary for other department]

GE-1: Essentials of Geology

Credits 06

GE1T: Essentials of Geology

Credits 04

Essentials of Geology
Unit 1
Introduction to geology: scope, sub-disciplines and relationship with other branches of sciences.
Unit 2
Earth in the solar system, origin Earth's size, shape, mass, density, rotational and evolutionary parameters Solar System- Introduction to Various planets - Terrestrial Planets Solar System- Introduction to Various planets - Jovian Planets
Unit 3: Solid Earth, Hydrosphere, Atmosphere and Biosphere
Mechanical layering of the Earth: lithosphere, asthenosphere, mantle and core. Earthquake and earthquake belts: seismic waves and internal constitution of the Earth. Volcanoes and volcanism, distribution of volcanoes. Concept of isostasy. Formation of core, mantle, crust, atmosphere, hydrosphere and biosphere. Convection in Earth's core and production of its magnetic field. Geothermal gradient and internal heat of the Earth.
Unit: 4. Rocks, Mineral and fossils
Definition. General character. Usefulness.
Unit5: Plate Tectonics
Fundamental Earth process: Plate tectonics. Plates and plate boundaries. Origin of oceans, continents, mountains and rift valleys
Unit6: Earth's Surface Processes
Weathering and Erosion. Landforms in deserts, glaciated region and river valleys.
Unit 7:
Age of the earth; radioactivity and its application in determining the age of the Earth.
Reference Books
▶ Holmes' Principles of Physical Geology. (1992). Chapman & Hall.
▶ Emiliani, C, (1992). Planet Earth, Cosmology, Geology and the Evolution of Life and Environment. Cambridge University Press.
▶ Gross, M.G. (1977). Oceanography: A view of the Earth. Prentice Hall.

Essentials of Geology

PRACTICALS

1. **Study of topographic sheets and description of physiographic features of an area.**
2. **Study of geological maps with simple outcrop patterns.**
3. **Study of distribution of major lithostratigraphic units on the map of India.**
4. **Study of important rocks, minerals and fossils (the items may be fixed by the department concern).**

Vidyasagar University
Curriculum for B.Sc. Honours in Geology [Choice Based Credit System]

Semester-II

Sl.No.	Name of the Subject	Nature	Code	Teaching Scheme in hour per week			Credit	Marks
				L	T	P		
C3	C3T: Elements of Geochemistry	Core Course-3		4	0	0	6	75
	C3P: Elements of Geochemistry (Lab)	Core Course-3 [Practical]		0	0	4		
C4	C4T: Structural Geology	Core Course-4		4	0	0	6	75
	C4P: Structural Geology(Lab)	Core Course-4 [Practical]		0	0	4		
GE-2	GE-2	GE					4/5	75
	GE-2	GE					2/1	
AECC-2	Environmental Studies	AECC					4	100
Total Credits =22								

L=Lecture, T=Tutorial, P=Practical

AECC- Ability Enhancement Compulsory Course: Environmental Studies.

Interdisciplinary/Generic Elective (GE) from other Department

[Four papers are to be taken and each paper will be of 6 credits]:

[Papers are to be taken from any of the following discipline (GE-2 from Mathematics)]:

Physics/Chemistry/Mathematics/Geography /Computer Sc/Botany/Zoology

Semester-II

Core Courses

Core-3

CC-3 : Elements of Geochemistry

Credits 06

C3 T : Elements of Geochemistry

Credits 04

Unit 1: Basic Concepts

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

Unit 2: Layered structure of Earth and geochemistry

1. Composition of the bulk silicate Earth
2. Composition of core
3. Composition of mantle: depleted mantle and enriched mantle
4. Composition of crust: Continental and Oceanic
5. Isotope geology: Isotopic and elemental fractionation
6. Radiogenic and stable isotopes in Earth materials

Unit 3: Element transport

1. Advection and diffusion Chromatography
2. Aqueous geochemistry- basic concepts and speciation in solutions, Eh, pH relations
3. Elements of marine chemistry
4. Mineral reactions- diagenesis and hydrothermal reactions.

Unit 4: Geochemistry of solid Earth

Geochemical variability of magma and its products. Melting processes.

Unit 5: Geochemical behavior of selected elements

Si, Al, K, Na, Ca, Fe, Mg, Ti.

Reference Books

- Mason, B. (1986) Principles of Geochemistry. 3rd Edition, Wiley New York.
- Rollinson, H. (2007) Using geochemical data – evaluation, presentation and interpretation. 2nd Edition. Publisher Longman Scientific & Technical.
- Walther, J. V. (2009). Essentials of geochemistry. Jones & Bartlett Publishers.
- Albarède, F. (2003). Geochemistry: an introduction. Cambridge University Press.
- Faure, Gunter and Teresa M. Mensing (2004). Isotopes Principles and Applications, Wiley India Pvt. Ltd

List of Practical

1. Geochemical variation diagrams and its interpretations:
 - a. Bivariate and trivariate plots to delineate the control of different compositional variables:
 - i. Harker variation diagram
 - ii. AFM diagram
 - iii. MgO diagram
 - b. Chemical variation diagrams based on major elements:
 - i. Alkali-lime index
 - ii. Iron enrichment index
 - iii. Aluminium saturation index
 - iv. Alkalinity index diagrams

Core-4

CC-4: Structural Geology

Credits 06

C4T: Structural Geology

Credits 04

Unit 1: Basic structural elements

1. Diastrophic and non- diastrophic structures
2. Structural elements: planar and linear structures, concept of strike and dip, trend and plunge, rake/pitch
3. Application of primary sedimentary and igneous structure in structural geology. Unconformity and its types; recognition of Unconformity
4. Concept of scale of observation of structures
5. Topographic maps. Outcrop patterns of different structures

Unit 2: Stress and strain in rocks

1. Concept of rock deformation: Concept of Stress. Basic idea of Shear zone
2. Concept of Strain: Homogeneous and inhomogeneous strain, Rotational and irrotational strain in rocks,
3. Strain ellipsoids of different types and their geological significance.
4. Flinn and Ramsay's diagram
5. Concept of Rock deformation: Brittle and ductile deformation.

Unit 3: Folds

1. Fold morphology
2. Geometric and genetic classification of folds
3. Introduction to the mechanics of folding: Buckling, Bending, Flexural slip and flow folding

Foliation and lineation

Description and origin of foliations: axial plane cleavage and its tectonic significance
Description and origin of lineation and relationship with the major structures

Fractures and faults

1. Geometric and genetic classification of fractures and faults Effects of faulting on the outcrops
2. Geologic/geomorphic criteria for recognition of faults and fault plane solutions

Reference Books

- Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley Billings, M. P. (1987) Structural Geology, 4th edition, 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 (4th Ed). Cambridge University Press (For Practical) Lahee F. H. (1962) Field Geology. McGraw Hill

C4 P: Structural Geology (Lab)

Credits 02

List of Practical

1. Basic idea of topographic maps, Topographic sheets of various scales
2. Interpretation of topographic maps
3. Interpretation of Geological maps with unconformity, fault, fold and igneous bodies
Construction of structural cross section
4. Stereographic projections of planes and lines
5. True dip and apparent dip problems, 3-point problems, fold problems, fault problems and their solutions through stereographic projection methods

Generic Elective Syllabus

GE-2 [Interdisciplinary for other department]

GE2: Physics and Chemistry of Earth

Credits 06

GE2 T - Physics and Chemistry of Earth

Credits 04

Unit 1

1. Continents, continental margins, oceans

Unit 2

1. Earth's interior - variation of physical quantities and seismic wave velocity inside the earth, major sub divisions and discontinuities.
2. Concepts of Isostasy; Airy and Pratt Model
3. Constitutions of Core and mantle: Seismological and other geophysical constraints
4. Convection in the mantle

Unit 3

1. Earth's magnetic field: Character and genesis.
2. Secular variation and westward drift
3. Solar activity and magnetic disturbance

Unit 4

1. Origin of elements/nucleosynthesis. Abundance of the elements in the solar system / planet earth geochemical classification of elements.
2. Earth accretion and early differentiation
3. Isotopes and their applications in understanding Earth processes. Stable isotopes: Stable isotope fractionation. Oxygen isotopes

Unit 5

1. Basic concept of environmental geochemistry
2. Geological disposal of nuclear waste
3. Lead and other heavy metals in environment and their effect on human health

Reference Books

- Holmes, A., Principles of Physical Geology, 1992, Chapman and Hall
- Condie, K.C. Plate Tectonics and Crustal Evolution, Pergamon Press, 1989.
- Krauskopf, K. B., & Dennis, K. Bird, 1995, Introduction to Geochemistry. McGraw-Hill
- Faure, G. Principles and Applications of Geochemistry, 2/e (1998), Prentice Hall, 600 pp.
- Anderson, G. M. (1996). Thermodynamics of natural systems. John Wiley & Sons Inc.
- Steiner, E. (2008). The chemistry maths book. Oxford University Press.
- Yates, P. (2007) Chemical calculations. 2nd Ed. CRC Press.
- Turcotte, D. and Schubert, G. Geodynamic. Second Edition. Cambridge

List of Practical

1. Method of plotting in triangular diagrams
2. Projection of major element data on Harker's diagram to characterize magmatic differentiation
3. Study of trace elements through
 - a) Projection of chondrite/primitive normalized trace elements to characterize sources
 - b) Projection of trace elements on tectonic discrimination diagrams
4. Problems on isostasy

Vidyasagar University

Curriculum for B.Sc (Honours) in Geology [Choice Based Credit System]

Semester-III

Course	Course Code	Name of the Subjects	Course Type/ Nature	Teaching Scheme in hour per week			Credit	Marks
				L	T	P		
CC-5		C5T: Igneous Petrology	Core Course - 5	4	0	0	6	75
		C5P: Igneous Petrology– II Lab		0	0	4		
CC-6		C6T: Sedimentary Petrology	Core Course - 6	4	0	0	6	75
		C6P: Sedimentary Petrology Lab		0	0	4		
CC-7		C7T: Paleontology	Core Course - 7	4	0	0	6	75
		C7P: Paleontology Lab		0	0	4		
GE-3		TBD	Generic Elective -3				6	75
SEC-1		SEC-1: Field Geology I- Basic Field Training Or SEC-1: Field Geology II-Geological Mapping and Structural Geology Field	Skill Enhancement Course-1	1	1	0	2	50
Semester Total							26	350

L=Lecture, T= Tutorial, P=Practical, CC = Core Course, GE= Generic Elective, SEC = Skill Enhancement Course, TBD = to be decided

Generic Elective (GE) (Interdisciplinary) from other Department [Four papers are to be taken and each paper will be of 6 credits]: Papers are to be taken from any of the following discipline: **Physics/Chemistry/Mathematics/Geography /Computer Sc/Botany/Zoology**

Modalities of selection of Generic Electives (GE): A student shall have to choose **04** Generic Elective (GE1 to GE4) strictly from **02** subjects / disciplines of choice taking exactly **02** courses from each subjects of disciplines. Such a student shall have to study the curriculum of Generic Elective (GE) of a subject or discipline specified for the relevant semester

Semester-III

Core Course (CC)

CC-5: Igneous Petrology

Credits 06

C5T: Igneous Petrology

Credits 04

Unit 1: Introduction to Igneous petrology

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

Unit 2: Forms of Igneous rock bodies

1. Mode of occurrence of Igneous rocks
2. Forms of igneous rocks

Unit 3: Texture and microstructure of Igneous rocks

1. Crystallinity, granularity, shapes and mutual relations of grains; nucleation and growth of igneous minerals
2. Description of the following textures and microstructures with their occurrence in different rocks - panidiomorphic, hypidiomorphic, allotriomorphic, porphyritic, vitrophyric, poikilitic, ophitic, sub-ophitic, intergranular, intersertal, pilotaxitic, trachytic, graphic, granophyric, rapakivi, orbicular, corona, perthitic, myrmekitic, variolitic, speherulitic & spinifex
3. Binary and Ternary Phase diagrams in understanding crystal-melt equilibrium in basaltic and granitic magmas
4. Magma generation in crust and mantle, their emplacement and evolution

Unit 4: Classification of igneous rocks

1. Bases of classification of igneous rocks: mineralogical, textural, chemical, chemico-mineralogical and associational; Norm and mode; Standard classification schemes – Niggli, Wells & Wells and IUGS. TAS diagram for volcanic rocks
2. Composition and texture of important igneous rocks: Granitoids, Pegmatite, Syenite, Monzonite, Diorite, Norite, Gabbro, Anthrothosite, Dolerite, Pyroxenites, Peridotite, Lamprophyres, Carbonatite, Rhyolite, Andesite, Dacite, Basalt, Komatiite

Unit 5: Phase Diagrams

Phase Rule and its application to eutectic, peritectic and solid solution system: Phase equilibria in the following binary and ternary systems, and their petrogenetic significance: diopside – anorthite, forsterite – silica, albite – anorthite, albite – orthoclase, diopside – albite – anorthite, forsterite – diopside – silica and nepheline - kalsilite – silica.

Unit 6: Petrogenesis of Igneous rocks

1. Magma generation in crust and mantle, their emplacement and evolution
2. Petrogenesis of Felsic and Mafic igneous rocks: Granitoids, Basalt, Gabbros, Anorthosite, Komatiites, Alkaline rocks, Kimberlites

Unit 7: Magmatism in different tectonic settings

1. Magmatism in the oceanic domains (MORB, OIB)
2. Magmatism along the subduction zones: Island arcs and continental arcs
3. Magmatism along continental rifts

Reference Books:

1. Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
2. Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
3. Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.
4. Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
5. Myron G. Best (2001). Igneous and Metamorphic Petrology,
6. K. G. Cox, J. D. Bell. (1979). The Interpretation of Igneous Rocks. Springer/Chapman & Hall.
7. Bose M.K. (1997). Igneous Petrology.
8. Frost B. R. and Frost C. D (2014). Essentials of Igneous and Metamorphic Petrology. Cambridge University Press.

C5P: Igneous Petrology– II Lab

Credits 02

List of Practical

1. Study of important igneous rocks in hand specimens and thin sections: granite, granodiorite, diorite, syenite, nepheline syenite, gabbro, anorthosites, ultramafic rocks, basalts, andesites, trachyte, rhyolite, dacite
2. Norm calculation. Visual estimation of modes from thin sections
3. Plotting of mode in IUGS classification of plutonic rocks (Streckeisen diagram)

CC-6: Sedimentary Petrology

Credits 06

C6T: Sedimentary Petrology

Credits 04

Unit 1: Introduction to Sedimentology

Outline of sedimentation process: Definition of sediment; origin of sediments: mechanical and chemical sediments; source rock or provenance

Unit 2: Granulometry

Grain size: concept and size scale, particle size distribution, environmental connotation; particle shape and fabric; Sedimentary textures

Unit 3: Basic hydraulics and Sedimentary structures

1. Fluid flow: Types of fluids, Laminar and turbulent flow, subcritical, critical and supercritical flows; concept of mean flow velocity, unit discharge and bed shear stress; flow profile and flow separation; particle entrainment, transport and deposition
2. Mass flow: types, mechanisms and controlling factors, process-product relationship

3. Penecontemporaneous deformation: mechanisms and controlling factors
4. Sedimentary structure: Primary and penecontemporaneous deformation structures
5. Bedform stability diagram
6. Paleocurrent analysis: Data acquisition, methodology, different palaeocurrent patterns

Unit 4: Sedimentary rocks

1. Siliciclastic rocks: Components and classification(s) of conglomerates and sandstones
2. Tectonic control on sandstone composition
3. General introduction to Mudrocks, Carbonate rocks; controlling factors of carbonate deposition; components and classifications of limestone; dolomite and dolomitisation

Unit 5: Diagenesis

1. Concepts of diagenesis
2. Stages of diagenesis: diagenetic changes in sand and carbonate deposits, lithification

Reference Books:

1. Prothero, D. R., & Schwab, F. (2004). Sedimentary geology. Macmillan.
2. Tucker, M. E. (2006) Sedimentary Petrology, Blackwell Publishing.
3. Collinson, J. D. & Thompson, D. B. (1988) Sedimentary structures, Unwin-Hyman, London.
4. Nichols, G. (2009) Sedimentology and Stratigraphy Second Edition. Wiley Blackwell

C6P: Sedimentary Petrology Lab

Credits 02

List of Practical

1. Identification of sedimentary structures
2. Particle size distribution and statistical analysis
3. Paleocurrent analysis
4. Petrographic study of clastic and non-clastic rocks through hand specimens and thin sections

CC-7: Paleontology

Credits 06

C7T: Paleontology

Credits 04

Unit 1: Fossilization and fossil record

1. Fossilization: definition of fossil, fossilization processes and modes of preservation, exceptional preservation
2. Taphonomy: definition, different types of taphonomic filters

Unit 2: Taxonomy and Systematics

1. Taxonomy: concept of taxonomy and taxonomic hierarchy
2. Biological and morphological species concept

Unit 3: Evolution and History of Life

1. Theory of organic Evolution: theory, concept of adaptation and variation, Natural Selection. Precambrian – doubtful organic traces of life during the Precambrian, Ediacaran fauna
2. Paleozoic – Cambrian Explosion of life. Episodes of mass extinction
3. Plants: Appearance of angiosperma and gymnosperma
4. Appearance of fish, amphibia, reptiles, birds, mammals and humans
5. Mass extinction: five major extinction episodes and their causes; effect of extinction

Unit 4: Invertebrates and Vertebrates

1. Brief introduction to important invertebrate groups (Bivalvia, Gastropoda, Brachiopoda) and their biostratigraphic significance
2. Significance of ammonites in Mesozoic biostratigraphy and their paleobiogeographic implications. Functional adaptation in trilobites and ammonoids
3. Origin of vertebrates and major steps in vertebrate evolution
4. Mesozoic reptiles with special reference to origin, diversity and extinction of dinosaurs
5. Evolution of horse and intercontinental migrations
6. Human evolution

Unit 5: Introduction to Paleobotany, Gondwana Flora Introduction to Ichnology.

1. Introduction to Paleobotany, Gondwana Flora, Plants as indicator of past climate
2. Ichnology and its application in paleoecology

Unit 6: Application of fossils in Stratigraphy

1. Definitions: Biozones, index fossils, stratigraphic correlation, examples - significance of ammonites in Mesozoic paleobiostratigraphy
2. Application of fossils in Paleoenvironmental analysis
3. Fossils and paleobiogeography, biogeographic provinces, dispersals and barriers. Paleoenvironmental analysis

Reference Books:

1. Raup, D. M., Stanley, S. M., Freeman, W. H. (1971) Principles of Paleontology
2. Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution 4th Edition by Blackwell Publishing.
3. Benton, M. (2009). Vertebrate paleontology. John Wiley & Sons.
4. Benton, M. J., Harper, D. A. T. (2010). Introduction to Paleobiology and the Fossil Record , Wiley-Blackwell.
5. Shukla, A. C., & Misra, S. P. (1975). Essentials of paleobotany. Vikas Publisher

C7P: Paleontology Lab

Credits 02

List of Practical

1. Study of fossils with various modes of preservation
2. Study of systematic position, stratigraphic position and age of various invertebrate, vertebrate and plant fossils
3. Study of functional morphological characters of different groups (Bivalvia, Gastropods, Brachiopoda, Echinodermata, Ammonoidea, Gondwana flora, vertebrates)
4. Identification of feeding habits from vertebrate (horse, elephants, Sus) teeth
5. Hard part morphology and identification of common Brachiopoda, Anthozoa, Trilobita, Echinoidea, Gastropoda. Identification of Gondwana flora

Skill Enhancement Course (SEC)

SEC-1: Field Geology I- Basic Field Training

Credits 02

Unit 1

Topographic sheet: Methods of naming. Features scale. Map reading.

Unit 2

1. Use of topographic sheets in field. Marking location in topographic sheet using physical features and bearing.
2. Use of GPS in field.
3. Distance, height and pace approximation in field.

Unit 3

1. Identification of rock types.
2. Identification of sedimentary and tectonic structures in field.

Unit 4

1. Clinometer and Brunton compass: Use of the instruments in measuring geological data in field. Techniques of measurement of orientation data in field.
2. Litholog measurement

Unit 5

1. Recording field data in maps and notebooks.
2. Report writing.

OR

SEC-1: Field Geology II-Geological Mapping and Structural Geology Field

Credits 02

Unit 1

Preparation of a geological map of a small area with homoclinal or gently folded beds.

Unit 2

Stereographic plots of orientation data and their interpretation.

Generic Elective Syllabus
GE-3 [Interdisciplinary for other department]

GE-3 - Fossils and Their Applications **Credits 06**

GE3T - Fossils and Their Applications **Credits 04**

Unit 1: Introduction to Fossils

Definition of fossil, fossilization processes (taphonomy), taphonomic attributes and its implications, modes of fossil preservation, role of fossils in development of geological time scale and fossils sampling techniques.

Unit 2: Species concept

Definition of species, species problem in paleontology, speciation, methods of description and naming of fossils, code of systematic nomenclature

Unit 3: Introduction to various fossils groups

Brief introduction of important fossils groups: invertebrate, vertebrate, microfossils, spore, pollens and plant fossils. Important age-diagnostic Fossiliferous horizons of India

Unit 4: Application of fossils

Principles and methods of paleoecology, application of fossils in the study of paleoecology, paleobiogeography and paleoclimate

Unit 5: Economic importance of fossils

Implication of larger benthic and micropaleontology in hydrocarbon exploration: identification of reservoirs and their correlation. Application of spore and pollens in correlation of coal seams, spore and pollens as indicator of thermal maturity of hydrocarbons reservoirs, fossils associated with mineral deposits, fossils as an indicator of pollution.

Reference Books

1. Schoch, R.M. 1989. Stratigraphy, Principles and Methods. VanNostrand Reinhold.
2. Clarkson, E.N.K. 1998. Invertebrate Paleontology and Evolution George Allen & Unwin Prothero, D.R. 1998. Bringing fossils to life - An introduction to Paleobiology, McGraw Hill.
3. Benton, M.J. 2005. Vertebrate paleontology (3rd edition). Blackwell Scientific, Oxford.
4. Colbert's Evolution of the Vertebrates: A History of the Backboned Animals Through Time, Edwin H. Colbert, Michael Morales, Eli C. Minkoff, John Wiley & Sons, 1991.

GE3P: Fossils and their Applications Lab **Credits 02**

List of Practical

1. Study of fossils showing various modes of fossilization
2. Study of important fossils from India (list may be prepared by the department concern)

Vidyasagar University

Curriculum for B.Sc (Honours) in Geology [Choice Based Credit System]

Semester-IV

Course	Course Code	Name of the Subjects	Course Type/ Nature	Teaching Scheme in hour per week			Credit	Marks
				L	T	P		
CC-8		C8T: Metamorphic Petrology	Core Course - 8	4	0	0	6	75
		C8P: Metamorphic Paleontology Lab		0	0	4		
CC-9		C9T: Principles of Stratigraphy and Precambrian Stratigraphy of India	Core Course - 9	4	0	0	6	75
		C9P: Stratigraphic Principles and Indian Stratigraphy Lab		0	0	4		
CC-10		C10T: Phanerozoic Stratigraphy of India	Core Course - 10	4	0	0	6	75
		C10P: Phanerozoic Stratigraphy of India Lab		0	0	4		
GE-4		TBD	Generic Elective-4				6	75
SEC-2			Skill Enhancement Course-2	0	0	4	2	50
Semester Total							26	350

L=Lecture, T= Tutorial, P=Practical, CC = Core Course, GE= Generic Elective, SEC = Skill Enhancement Course, TBD = to be decided

Generic Elective (GE) (Interdisciplinary) from other Department [Each paper will be of 6 credits]
Papers are to be taken from any of the following discipline: **Physics/Chemistry/Mathematics/Geography /Computer Sc/Botany/Zoology**

Modalities of selection of Generic Electives (GE): A student shall have to choose **04** Generic Elective (GE1 to GE4) strictly from **02** subjects / disciplines of choice taking exactly **02** courses from each subjects of disciplines. Such a student shall have to study the curriculum of Generic Elective (GE) of a subject or discipline specified for the relevant semester

Semester-IV
Core Course (CC)

CC-8: Metamorphic Petrology

Credits 06

C8T: Metamorphic Petrology

Credits 04

Course Contents:

Unit I: Metamorphism: controls and types.

1. Definition of metamorphism. Factors controlling metamorphism, Types of metamorphism—contact, regional, fault zone metamorphism, impact metamorphism
2. Causes of metamorphism and concept of metamorphic P-T-t paths

Unit 2: Metamorphic Facies and Grades. Metamorphic Structures and Textures

1. Index minerals, metamorphic zones and isograds. Structure and textures of metamorphic rocks
2. Concept of metamorphic facies and grade
3. Mineralogical phase rule of closed and open system
4. Composition-paragenesis diagrams. ACF, AKF and AFM diagrams
5. Metamorphic products of pelitic, carbonate and mafic igneous rocks

Unit 3: Metamorphic reactions. Metamorphism and deformation.

1. Progressive and retrogressive metamorphism
2. Prograde and retrograde metamorphic minerals reactions.
3. Relationship between metamorphism and deformation.

Unit 4: Migmatites and their origin

1. Metasomatism and role of fluids in metamorphism.
2. Brief idea of crustal anatexis. Migmatites and its origin.

Unit 5: Metamorphic rock associations and plate tectonic settings

Regional occurrence and tectonic significance of metamorphic rocks: Metamorphism along convergent plate margins, in continent-continent collisions, in rifting terrains and sea floor metamorphism.

Suggested Readings:

1. Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press
2. Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
3. Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.
4. Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
5. Yardley, B. W. D. (1989). An introduction to metamorphic petrology. Longman Scientific and Technical, London.
6. Spear F. S. 1993. Metamorphic phase equilibria and Pressure-Temperature-Time paths.
7. Mineralogical Society of America. Monograph. 799 p.

C8P: Metamorphic Paleontology Lab

Credits 02

List of Practical

1. Hand specimen study of following metamorphic rocks: Slate, Phyllite, Schist, Gneiss, Amphibolite, Charnockite, Khondalite, Mafic granulite, Marble
2. Textural and mineralogical study of following metamorphic rocks in thin sections: slate, varieties of schists, gneiss, amphibolite, charnockite, khondalite, mafic granulite, eclogite, marble, high Mg-Al granulites
3. Graphical plots of metamorphic mineral assemblages using chemographic diagrams

CC-9: Principles of Stratigraphy and Precambrian Stratigraphy of India

Credits 06

C9T: Principles of Stratigraphy and Precambrian Stratigraphy of India

Credits 04

Course Contents:

Unit 1: Principles of stratigraphy

1. Fundamentals of lithostratigraphy, biostratigraphy and chronostratigraphy.
2. Introduction to concepts of dynamic stratigraphy (chemostratigraphy, seismic stratigraphy, sequence stratigraphy).
3. Relevance of Type section.
4. Principles of stratigraphic correlation.

Unit 2: Code of stratigraphic nomenclature

1. International Stratigraphic Code – development of a standardized stratigraphic nomenclature
2. Concepts of Stratotypes. Global Stratotype Section and Point (GSSP)
3. Brief introduction to the concepts of lithostratigraphy, biostratigraphy, chronostratigraphy, seismic stratigraphy, chemostratigraphy, magnetostratigraphy, sequence stratigraphy and their subdivisions with Indian examples

Unit 3: Principles of stratigraphic analysis Facies concept in stratigraphy

1. Walther's Law of Facies.
2. Concept of paleogeographic reconstruction

Unit 4: Stratigraphic boundaries in India

1. Archaean-Proterozoic boundary.
2. Precambrian-Cambrian boundary and their status in global perspective.

Unit 5: Physiographic and tectonic subdivisions of India

1. Brief introduction to the physiographic and tectonic subdivisions of India
2. Introduction to Indian Shield, Craton
3. Introduction to Indian Precambrian belts.
4. Introduction to Proterozoic basins of India

Unit 6: Geologic evolution Important Precambrian terrains

1. Geologic evolution with emphasis on sedimentation, lithology, magmatism, structure, metamorphism and geochronology of: Singhbhum, Dharwar, Rajasthan, Central India and Eastern Ghats.
2. Vindhyan and Cudappah basins of India.

Suggested Readings:

1. Krishnan, M. S. (1982) Geology of India and Burma, CBS Publishers, Delhi
2. Doyle, P. & Bennett, M. R. (1996) Unlocking the Stratigraphic Record. John Wiley
3. Ramakrishnan, M. & Vaidyanadhan, R. (2008) Geology of India Volumes 1 & 2, Geological society of India, Bangalore.
4. Valdiya, K. S. (2010). The making of India, Macmillan India Pvt. Ltd.

C9P: Stratigraphic Principles and Indian Stratigraphy Lab

Credits 02

List of Practical

1. Study of geological map of India and identification of major stratigraphic units
2. Major features of paleogeographic maps – Precambrian

CC-10: Phanerozoic Stratigraphy of India

Credits 06

C10T: Phanerozoic Stratigraphy of India

Credits 04

Course Contents:

Unit 1: Introduction

1. Definition.
2. Important Stratigraphic boundaries during Phanerozoic time in India - a. Precambrian-Cambrian boundary, b. Permian-Triassic boundary, and c. Cretaceous-Tertiary boundary.

Unit 2: Important Palaeozoic successions in India

Important Palaeozoic successions in India with emphasis on succession, lithology, flora and fauna, correlation and palaeoenvironment of the following:

1. Paleozoic Succession of Kashmir
2. Stratigraphy Structure of Gondwana basins.
3. Mesozoic stratigraphy of India:
 - a. Triassic successions of Spiti,
 - b. Jurassic of Kutch,
 - c. Triassic and Jurassic non marine successions of peninsular India (Upper Gondwana formations, relevant Formations of Rajasthan basin)
 - d. Cretaceous, successions of Cauvery basins
 - e. Lameta and Jabalpur Formations
4. Cenozoic stratigraphy of India:
 - a. Kutch basin,
 - b. Siwalik successions,
 - c. Assam, Andaman and Arakan basins.
5. Stratigraphy and structure of Krishna-Godavari basin, Cauvery basin, Bombay offshore basin, Kutch and Saurashtra basins and their potential for hydrocarbon exploration

Unit 3: Stratigraphy of the intertrappeans

1. Deccan,
2. Rajmahal,
3. Sylhet Trap

Unit 4: Quaternary Geology

1. Definition
2. Principles of subdivision of Quaternary succession in India.

C10P: Phanerozoic Stratigraphy of India Lab

Credits 02

List of Practical

1. Study of geological map of India and identification of major Phanerozoic stratigraphic units.
2. Stratigraphic correlation of Phanerozoic stratigraphic units in geological map of India
3. Proterozoic supercontinent reconstructions

Skill Enhancement Course (SEC)

SEC-2: Field Geology

Credits 02

SEC2P: Field Geology

Course Contents:

A. Field Geology : Stratigraphy and structure related field

1. Preparation of a Geological map of a small area with folded/faulted beds.
2. Interrelation between different structural elements and their interpretations

Or

B. Field Geology : Stratigraphy Sedimentology - related field

List of Trainings to be covered

1. Field training in a sedimentary basin. Documentation of stratigraphic details in the field.
2. Collection of sedimentological, and stratigraphical and paleontological details and their representation.

Or

C. Field Geology : Himalayan Geology Field

1. Preparation of a geological transect map in the Himalayas

Or

D. Field Geology : Economic Geology Field

1. Visit to an underground or open cast mine.
2. Underground mapping/Bench mapping Study

Or

E. Field Geology :Visit to Engineering / Exploration Geology Project Sites

1. Geological mapping of a project site (Dam sites, tunnel, etc).
2. Identification of environmental problems of a project site and remedial measures to be taken.

Generic Elective (GE)
[Interdisciplinary for other department]

GE-4: Earth Resources

Credits 06

GE-4T Earth Resources

Credits 04

Course Contents:

Unit 1

1. Resource reserve definitions; mineral, energy and water resources
2. A brief overview of classification of mineral deposits with respect to processes of formation

Unit 2

1. Difference between Energy, Power and Electricity
2. Renewable and Non- Renewable Sources of Energy
3. The concept and significance of Renewability: Social, Economic, Political and Environmental Dimension of Energy

Unit 3

1. Resources of Natural Oil and Gas
2. Coal and Nuclear Minerals
3. Potential of Hydroelectric Power, Solar Energy, Wind, Wave and Biomass Based power and Energy

Unit 4

1. Ground water resources in India and its role in economic development of the country
2. Current Scenario and Future Prospects of Solar Power, Hydrogen Power and Fuel Cells.

Suggested Readings:

1. Energy and the Environment by Fowler, J.M 1984. McGraw-Hill

2. Global Energy Perspectives by Nebojsa Nakicenovic 1998, Cambridge University Press.
3. Energy Resources and Systems: Fundamentals and Non-Renewable Resources by Tushar K. Ghosh and M. A. Prelas. 2009, Springer
4. Introduction to Wind Energy Systems: Hermann-Josef Wagner and Jyotirmay Mathur. 2009, Springer.
5. Renewable Energy Conversion, Transmission and Storage. Bent Sorensen, 2007

GE4P: Earth Resources Lab

Credits 02

List of Practical:

1. Study of coal and Hand specimen
2. Plotting of major Indian oil fields on map of India
3. Problems related to assessment of possible oil exploration site from geological maps and sections.
4. Construction of cross section of mineral deposits from maps and drill hole data.
5. Estimation of reserves.
6. Preparation and interpretation of depth to water level maps and water level contour maps

OR

GE-4: Nuclear Waste Management

Credits 06

GE4T: Nuclear Waste Management

Credits 04

Course Contents:

Nuclear Waste Management

Theory and Concepts

Nuclear reactors and generation of nuclear waste, nuclear fuel cycle, basic concepts about nuclear waste management. Classification, composition and types of nuclear waste, their sources and characteristics. Introduction to immobilization and vitrification processes. Nuclear waste forms and containments. Immobilization of nuclear waste in synthetic (AVS, BBS, SON 68 and R7T7) glasses and natural glass/rocks (acidic: obsidian, rhyolite and basic: nephilinite and basaltic). Glass/rock characterization and its long-term performance assessment. Geochemistry of glass/rock-water interaction- solution and neo formed mineral chemistry.

Glass/rock alteration studies by mathematical modeling using EQ3/6 and GWB. Nuclear waste confinement and safe disposal in deep geological repository. Application of clays as natural barrier.

Suggested Readings:

1. Saling, J. (2001). Radioactive waste management. CRC Press.
2. Ojovan, M. I., & Lee, W. E. (2013). An introduction to nuclear waste immobilisation. Newnes.
3. T.G. Wolery: reaction path modeling of aqueous geochemical systems.
4. Bethke, C. M. (2007). Geochemical and biogeochemical reaction modeling. Cambridge University Press.

GE4P: Nuclear Waste Management Lab

Credits 02

List of Practical

1. Determination of physical properties such as hardness, durability, melting and pouring temperatures
2. Chemical characterization of synthetic and natural glass
3. Mathematical modeling and extrapolation of synthetic glass alterations
4. Mathematical modelling and extrapolation of natural acidic (obsidian, rhyolite) and basic (nephilinite and basaltic) glasses
5. Determination of rate of alteration and recognition of neo-formed minerals
6. Calculation of retention coefficient for glass residue

Vidyasagar University

Curriculum for B.Sc. (Honours) in Geology [Choice Based Credit System]

Semester-V

Course	Course Code	Name of the Subjects	Course Type/ Nature	Teaching Scheme in hour per week			Credit	Marks
				L	T	P		
CC- 11		C11T: Hydrogeology	Core Course-11	4	0	0	6	75
		- Lab		0	0	4		
CC- 12		C12T: Economic Geology	Core Course-12	4	0	0	6	75
		- Lab		0	0	4		
DSE-1			Discipline Specific Electives -1	4	0	4	6	75
DSE-2			Discipline Specific Electives -2	4/5	0/1	4/0	6	75
Semester Total							24	300

L= Lecture, T= Tutorial, P = Practical, CC - Core Course, TBD - To be decided, DSE: Discipline Specific Elective.

Semester-V

List of Core Course (CC)

CC-11: Hydrogeology

CC-12: Economic Geology

Discipline Specific Electives (DSE)

DSE-1: Earth & Climate

Or

DSE-1: Introduction to Geophysics

DSE-2: Fuel Geology

Or

DSE-2: Evolution of life through time

SEMESTER –V
Core Courses (CC)

CC-11: Hydrogeology

Credits 06

C11T: Hydrogeology

Credits 04

Course Contents:

Unit 1: Introduction and basic concepts

1. Scope of hydrogeology and its societal relevance. Global and Indian distribution of water resource.
2. Hydrologic cycle: precipitation, evapo-transpiration, run-off, infiltration and groundwater flow. Basic concept of hydrographs Origin of groundwater, Vertical distribution of subsurface water, Genetic classification of groundwater.
3. Classification of rocks with respect to water bearing characteristics, geomorphic and geologic controls of groundwater, Types of aquifer– unconfined, confined and semi-confined. Water table and piezometric surface. Groundwater provinces in India and West Bengal.
4. Rock properties affecting groundwater: Porosity, void ratio, specific retention and Storage coefficient - specific yield, specific storage and storativity, Anisotropy and heterogeneity of aquifers.

Unit 2: Groundwater flow

1. Darcy's law and its validity; Reynold's Number. Groundwater velocity.
2. Intrinsic permeability and hydraulic conductivity, Transmissivity, Measurement of hydraulic conductivity in laboratory – Constant Head Permeameter and Falling (Variable) Head Permeameter. Water Table and Piezometric surface contour maps and Groundwater flow direction, Laminar and turbulent groundwater flow

Unit 3: Well hydraulics and Groundwater exploration

1. Basic Concepts (drawdown; specific capacity etc)
2. Elementary concepts related to equilibrium and non-equilibrium (Steady and unsteady) conditions for groundwater flow to a well
3. Surface-based groundwater exploration methods Introduction to subsurface borehole logging methods

Unit 4: Groundwater chemistry

1. Physical, chemical and bacteriological properties of water and water quality
2. Introduction to methods of interpreting groundwater quality data using standard graphical plots
3. Elementary concept on Groundwater pollution: Arsenic, Fluoride and Nitrate, Sea water intrusion in coastal aquifers - Ghyben-Herzberg Relation

Unit 5: Groundwater management

1. Surface and subsurface water interaction. Recharge and discharge areas. Ground water level fluctuations. Effects of Climate Change on Ground water.
2. Basic concepts of water balance studies, issues related to groundwater resources development and management
3. Rainwater harvesting and artificial recharge of groundwater

Suggested Readings:

1. Todd, D. K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.
2. Davis, S. N. and De Weist, R.J.M. 1966. Hydrogeology, John Wiley & Sons Inc., N.Y.
3. Karanth K.R., 1987, Groundwater: Assessment, Development and management, Tata McGraw- Hill Pub. Co. Ltd.
4. Raghunath H, M. 2007, Groundwater, 3rd Ed. New Age International Publishers , New Delhi

C11P: Hydrogeology (Lab)

Credits 02

List of Practical

1. Preparation and interpretation of depth to water level maps and water level contour maps. Study, preparation and analysis of hydrographs for differing groundwater conditions
2. Water potential zones of India (map study)
3. Graphical representation of chemical quality data and water classification (C-S and Trilinear diagrams). Simple numerical problems related to: determination of permeability in field and laboratory and Groundwater flow

CC-12: Economic Geology

Credits 06

C12T: Economic Geology

Credits 04

Course Contents:

Unit 1: Ores and gangues

1. Ores, gangue minerals, tenor, grade and lodes.
2. Resources and reserves- Economic and Academic definitions

Unit 2: Mineral deposits and classical concepts of ore formation

1. Mineral occurrence, Mineral deposit and ore deposit
2. Historical concepts of ore genesis: Man's earliest vocation- Mining
3. Plutonist and Neptunist concepts of ore genesis
4. Metallogenic provinces and epochs

Unit 3: Mineral exploration

1. Exploration and exploitation techniques
2. Brief idea on: Remote Sensing, Geophysical and Geochemical Explorations
3. Geological mapping at different scales, drilling, borehole logs and transverse sections

Unit 4: Structure and texture of ore deposits

1. Concordant and discordant ore bodies
2. Endogenous processes: Magmatic concentration, skarns, greisens, and hydrothermal deposits
3. Exogenous processes: weathering products and residual deposits, oxidation and supergene enrichment, placer deposits,

Unit 5: Ore grade and Reserve

Assessment of ore grade and reserve, reserve estimation

Unit 6: Metallic and Non-metallic ores

1. Important deposits of India including atomic minerals: Study of geologic set up, mode of occurrence, mineralogy and genesis of the following ore deposits in India - Iron ore in Singhbhum and Karnataka, Manganese of Central India, Copper of Malanjkhand, lead-zinc of Zawar area, Uranium of Singh bhum.
2. Non-metallic and industrial rocks and minerals, in India.
3. Introduction to gemstones.

Suggested Readings:

1. Guilbert, J.M. and Park Jr., C.F. (1986) The Geology of Ore deposits. Freeman & Co. Bateman, A.M. and Jensen, M.L. (1990) Economic Mineral Deposits. John Wiley.
2. Evans, A.M. (1993) Ore Geology and Industrial minerals. Wiley
3. Laurence Robb. (2005) Introduction to ore forming processes. Wiley.
4. Gokhale, K.V.G.K. and Rao, T.C. (1978) Ore deposits of India their distribution and processing, Tata-McGraw Hill, New Delhi.
5. Deb, S. (1980) Industrial minerals and rocks of India. Allied Publishers.
6. Sarkar, S.C. and Gupta, A. (2014) Crustal Evolution and Metallogeny in India. Cambridge Publications.

C12P: Economic Geology (Lab)

Credits 02

List of Practical

1. Hand sample identification of important ores and non-metallic minerals
2. Study of microscopic properties of ore forming minerals (Oxides and sulphides)
3. Preparation of maps: Distribution of important ores and other economic minerals in India

Discipline Specific Electives (DSE)

DSE-1: Earth & Climate

Credits 06

DSE1T: Earth & Climate

Credits 04

Course Contents:

Unit 1: Climate system: Forcing and Responses

1. Components of the climate system.
2. Climate forcing, Climate controlling factors.
3. Climate system response, response rates and interactions within the climate system.
4. Feedbacks in climate system.

Unit 2: Heat budget of Earth

1. Incoming solar radiation, receipt and storage of heat transformation
2. Earth's heat budget. Interactions amongst various sources of earth's heat

Unit 3: Atmosphere – Hydrosphere

1. Layering of atmosphere and atmospheric Circulation
2. Atmosphere and ocean interaction and its effect on climate
3. Heat transfer in ocean
4. Global oceanic conveyor belt and its control on earth's climate
5. Surface and deep circulation
6. Sea ice and glacial ice

Unit 4: Response of biosphere to Earth's climate

1. Climate Change: natural vs. anthropogenic effects
2. Humans and climate change
3. Future perspectives
4. Brief introduction to archives of climate change
5. Brief introduction to palaeoclimate
6. Paleoclimate data from India

Unit 5: Orbital cyclicality and climate

1. Milankovitch cycles and variability in the climate
2. Glacial-interglacial stages
3. The Last Glacial maximum (LGM)
4. Pleistocene Glacial-Interglacial cycles
5. Younger Dryas
6. Isotope Palaeontology

Unit 6: Monsoon

1. Mechanism of monsoon
2. Monsoonal variation through time
3. Factors associated with monsoonal intensity
4. Effects of monsoon

Suggested Readings:

1. Rudiman, W.F., 2001. Earth's climate: past and future. Edition 2, Freeman Publisher.
2. Rohli, R.V., and Vega, A.J., 2007. Climatology. Jones and Barlett
3. Lutgens, F., Tarbuck, E., and Tasa, D., 2009. The Atmosphere: An Introduction to Meteorology. Pearson Publisher
4. Aguado, E., and Burt, J., 2009. Understanding weather Environmental Geology – an Earth System Science Approach, by – Dorothy J. Merritts, Andrew De Wet & Kristen Menking, W.H. Freeman & Company, New York.

DSE1P: Earth & Climate (Lab)

Credits 02

List of Practical

1. Study of distribution of major climatic regimes of India on map
2. Distribution of major wind patterns on World map
3. Preparation of paleogeographic maps (distribution of land and sea) of India during specific geological time intervals
4. Numerical exercises on interpretation of proxy records for paleoclimate

Or

DSE-1: Introduction to Geophysics

Credits 06

DSE1T: Introduction to Geophysics

Credits 04

Course Contents:

Unit 1: Geology and Geophysics

1. What is geophysics?
2. Interrelationship between geology and geophysics

Unit 2: General and Exploration geophysics

1. Different types of geophysical methods - gravity, magnetic, electrical and seismic; Principles of different methods. Applications of different methods. Elements of well logging.
2. Corrections in geophysical data

Unit 3: Geophysical field operations

1. Data acquisition and Processing. Data reduction. Signal and noise.
2. Different types of surveys, grid and route surveys, profiling and sounding techniques
 - a. Scales of survey
 - b. Presentation of geophysical data

Unit 4: Application of Geophysical methods

1. Regional geophysics, oil and gas geophysics, ore geophysics, groundwater geophysics, engineering geophysics
2. Geological interpretation of geophysical data

Unit 5: Geophysical anomalies

1. Correction to measured quantities, geophysical, anomaly, regional and residual (local) anomalies, factors controlling anomaly

2. Depth of exploration

Unit 6: Integrated geophysical methods

Ambiguities in geophysical interpretation, planning and execution of geophysical surveys

Suggested Reading:

1. Outlines of Geophysical Prospecting - A manual for geologists by Ramachandra Rao, M.B., Prasaranga, University of Mysore, Mysore, 1975.
2. Exploration Geophysics - An outline by Bhimasarikaram V.L.S., Association of Exploration Geophysicists, Osmania University, Hyderabad, 1990.
3. Dobrin, M.B. (1984), An introduction to Geophysical Prospecting. McGraw-Hill, NewDelhi. Telford, W. M., Geldart, L. P., & Sheriff, R. E. (1990). Applied geophysics (Vol. 1). Cambridge University Press.
4. Lowrie, W. (2007). Fundamentals of geophysics. Cambridge University Press.
5. Mussett, A. E. and Khan, M. A. (2000). Looking into the Earth. Cambridge University Press.

DSE1P: Introduction to Geophysics (Lab)

Credits 02

List of Practical

1. Anomaly and background- Graphical method.
2. Study and interpretation of seismic reflector geometry.
3. Gravity anomaly: Problems on gravity anomaly.

DSE-2: Fuel Geology

Credits 06

DSE2T: Fuel Geology

Credits 04

Course Contents:

Unit 1: Energy Resources

Different Sources of energy: Global and Indian scenario

Unit 2: Coal

1. Definition and origin of Coal
2. Basic classification of coal.
3. Fundamentals of Coal Petrology - Introduction to lithotypes, microlithotypes and macerals in coal

4. Proximate and Ultimate
5. Major coal basins of India

Unit 3: Coal as a fuel

1. Concept of clean coal technology
2. Coal Bed Methane (CBM): global and Indian scenario
3. Underground coal gasification
4. Liquefaction of coal

Unit 4: Petroleum

1. Chemical composition and physical properties of crudes oil
2. Origin and migration of petroleum
3. Kerogen: Maturation of kerogen; Biogenic and Thermal effect

Unit 5: Petroleum Reservoirs and Traps

1. Reservoir rocks: general attributes and petrophysical properties.
2. Cap Rocks: definition and general properties
3. Hydrocarbon traps: definition, Classification of hydrocarbon traps - structural, stratigraphic and combination
 - a. Time of trap formation and time of hydrocarbon accumulation.
 - b. Plate tectonics and global distribution of hydrocarbon reserves
 - c. Petroliferous basins of India

Unit 6: Other fuels

1. Nuclear Fuel
2. Gas Hydrate

Suggested Readings:

1. Chandra D. (2007). Chandra's Textbook on applied coal petrology. Jijnasa Publishing House.
2. Shelly R. C. (2014). Elements of Petroleum geology: Third Edition, Academic Press
3. Bjorlykke, K. (1989). Sedimentology and petroleum geology. Springer-Verlag. Bastia,
4. R., & Radhakrishna, M. (2012). Basin evolution and petroleum prospectively of the continental margins of India (Vol. 59). Newness.

DSE2P: Fuel Geology (Lab)

Credits 02

List of Practical

1. Study of hand specimens of coal
2. Reserve estimation of coal
3. Section correlation and identification of hydrocarbon prospect
4. Panel and Fence diagrams

OR

DSE-2: Evolution of life through time

Credits 06

DSE2T: Evolution of life through time

Credits 06

Suggested Readings:

Unit 1: Life through ages

1. Fossils and chemical remains of ancient life.
2. Geological Time Scale with emphasis on major bio-events.
3. Biomineralization and skeletalization

Unit 2: Principles of evolution

1. Mechanism of evolution
2. Evolutionary lineages
3. Species as basic unit of lineage
4. Constraints in lineage reconstruction

Unit 3: Geobiology

1. Biosphere as a system, processes and products
2. Biogeochemical cycles
3. Abundance and diversity of microbes, extremophiles Microbes-mineral interactions, microbial mats

Unit 4: Origin of life

1. Possible life sustaining sites in the solar system, life sustaining elements and isotoperecords
2. Archean life: Earth's oldest life, Transition from Archean to Proterozoic, theoxygen revolution and radiation of life
3. Precambrian macrofossils – The garden of Ediacara The Snow Ball Earth Hypothesis

Unit 5: Paleozoic Life

1. The Cambrian Explosion.
2. Origin of vertebrates and radiation of fishes
3. Origin of tetrapods - Life out of water
4. Early land plants and impact of land vegetation

Unit 6: Mesozoic Life

1. Life after the largest (P/T) mass extinction, life in the Jurassic seas Origin of mammals
2. Rise and fall of dinosaurs
3. Origin of birds; and spread of flowering plants

Unit 7: Cenozoic Life

1. Aftermath of end Cretaceous mass extinction – radiation of placental mammals Evolution of modern grasslands and co-evolution of hoofed grazers
2. Rise of modern plants and vegetation Back to water – Evolution of Whales

Unit 8: The age of humans

1. Hominid dispersals and climate setting
2. Climate Change during the Phanerozoic - continental break-ups and collisions Plate tectonics and its effects on climate and life.
3. Effects of life on climate and geology

Unit 9: Applications of Evolution

1. Biostratigraphy and Chronostratigraphy in the context of organic evolution
2. Role of fossils in correlation
3. Basis of stage boundaries in the Phanerozoic.

Suggested Readings:

1. Stanley, S.M., (2008), Earth System History
2. Jonathan I. Lumine W. H. Freeman, Earth-Evolution of a Habitable World, Cambridge University Press.
3. Canfield, D.E. & Konhauser, K.O., (2012) Fundamentals of Geobiology, Blackwell
Cowen, R., 2000 History of Life, Blackwell.

Vidyasagar University

Curriculum for B.Sc. (Honours) in Geology [Choice Based Credit System]

Semester-VI

Course	Course Code	Name of the Subjects	Course Type/ Nature	Teaching Scheme in hour per week			Credit	Marks
				L	T	P		
CC- 13		C13T: Geomorphology, Remote Sensing and GIS	Core Course-13	4	0	0	6	75
		- Lab		0	0	4		
CC- 14		C14T: Engineering Geology	Core Course-14	4	0	0	6	75
		- Lab		0	0	4		
DSE-3		TBD	Discipline Specific Electives -3	4	0	4	6	75
DSE-4		TBD	Discipline Specific Electives -4	5	1	0	6	75
Semester Total							24	300

L= Lecture, T= Tutorial, P = Practical, CC - Core Course, TBD - To be decided, DSE: Discipline Specific Elective.

Semester-VI

List of Core Course (CC)

CC-13: Geomorphology, Remote Sensing and GIS

CC-14: Engineering Geology

Discipline Specific Electives (DSE)

DSE-3: Exploration Geology

Or

DSE-3: River Science

DSE-4: Oceanography & Marine science

Or

DSE-4: Geodynamics

SEMESTER –VI
Core Courses (CC)

CC-13: Geomorphology, Remote Sensing and GIS

Credits 06

C13T: Geomorphology, Remote Sensing and GIS

Credits 04

Course Contents:

Unit-1: Introduction to Geomorphology

1. Introduction to Geomorphology
2. Relationship between the landforms and the properties of earth material and different kind of processes
3. Endogenic and Exogenic processes

Unit-2

1. Geoid, Topography, Hypsometry, Major Morphological features of the earth surface
2. Large Scale Topography - Plate tectonics overview. Large scale mountain ranges (with emphasis on Himalaya)

Unit-3

Surficial Processes and geomorphology, Weathering and associated landforms, Hill slopes Glacial, Periglacial processes and landforms, Fluvial processes and landforms, Aeolian Processes and landforms, Coastal Processes and landforms, Landforms associated with igneous activities

Unit-4

1. Endogenic- Exogenic interactions. Rates of uplift and denudation. Tectonics and drainage development, Sea-level change, Long-term landscape development.
2. Landform dating techniques.

Unit-5: Remote Sensing, Concepts in Remote Sensing

1. Concepts in Remote Sensing.
2. Sensors and scanners.
3. Satellites and their characteristics.
4. Data formats- Raster and Vector.

Unit-6: Photogeology

1. Types and acquisition of aerial photographs; Scale and resolution; Principles of stereoscopy, relief displacement, vertical exaggeration and distortion

2. Elements of air photo interpretation
3. Identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms

Unit-7: Digital Image Processing

1. Image Errors, Rectification and Restoration, FCC, Image Enhancement, Filtering, Image Rationing.
2. Image classification and accuracy assessment.
3. GIS integration and Case studies-Indian Examples.

Unit-8: GIS and GPS

1. Datum, Coordinate systems and Projection systems.
2. Spatial data models and data editing.
3. Introduction to DEM analysis.
4. Concepts of GPS.
5. Integrating GPS data with GIS.
6. Applications in earth system sciences.

Suggested Readings:

1. Robert S. Anderson and Suzzane P. Anderson (2010): Geomorphology - The Mechanics and Chemistry of Landscapes. Cambridge University Press.
2. M.A. Summerfield (1991) Global Geomorphology. Wiley & Sons.
3. Demers, M.N., 1997. Fundamentals of Geographic Information System, John Wiley & sons. Inc.
4. Hoffmann-Wellenhof, B., Lichtenegger, H. and Collins, J., 2001. GPS: Theory & Practice, Springer Wien New York.
5. Jensen, J.R., 1996. Introductory Digital Image Processing: A Remote Sensing Perspective, Springer-Verlag.
6. Lillesand, T. M. & Kiefer, R.W., 2007. Remote Sensing and Image Interpretation, Wiley.
7. Richards, J.A. and Jia, X., 1999. Remote Sensing Digital Image Analysis, Springer Verlag.

C13P: Geomorphology, Remote Sensing and GIS Lab

Credits 02

List of Practical

1. Reading topographic maps. Preparation of a topographic profile.
2. Preparation of longitudinal profile of a river.

3. Calculating Stream length gradient index
4. Morphometry of a drainage basin.
5. Interpretation of geomorphic processes from the geomorphology of the area.
6. Aerial Photo interpretation: Identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms.
7. Introduction to DIP and GIS softwares.
8. Digital Image Processing exercises including analysis of satellite data in different bands and interpretation of various objects on the basis of their spectral signatures.
9. Registration of satellite data with a toposheet of the area.
10. DEM analysis: generating slope map, aspect map and drainage network map and its applications.
11. Use of stereoscope. Flight line determination using aerial photograph.

CC-14: Engineering Geology

Credits 06

C14T: Engineering Geology

Credits 04

Course Contents:

Unit-1

Role of engineering geologists in planning, design and construction of major man-made structural features.

Unit-2

Site investigation and characterization

Unit-3

Foundation treatment; Grouting, Rock Bolting and other support mechanisms

Unit-4

Rock aggregates; Significance as Construction Material

Unit-5

Concept, Mechanism and Significance of:

a) Rock Structure Rating (RSR)

b) Rock Mass Rating (RMR)

c) Tunneling Quality Index (Q)

Geological, Geotechnical and Environmental considerations for Dams and Reservoirs

Unit-6

Tunnels and Tunneling Methods

Unit-7

Landslides: Causes, Factors and corrective/Preventive measures

Unit-8

Earthquakes: Causes, Factors and corrective/Preventive measures. Mitigating the damage caused by Earthquake

Unit-9

Case histories related to Indian Civil Engineering Projects

Suggested Readings:

1. Krynin, D.P. and Judd W.R. 1957. Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).
2. Johnson, R.B. and De Graf, J.V. 1988. Principles of Engineering Geology, John Wiley. Goodman, R.E., 1993. Engineering Geology: Rock in engineering constructions. John Wiley & Sons, N.Y.
3. Waltham, T., 2009. Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.
4. Bell: F.G., 2006. Basic Environmental and Engineering Geology Whittles Publishing.
5. Bell, .F.G, 2007. Engineering Geology, Butterworth-Heineman

C14P: Engineering Geology Lab

Credits 02

List of Practical

1. Computation of reservoir area, catchment area, reservoir capacity and reservoir life.
2. Merits, demerits & remedial measures based upon geological cross sections of project sites.
3. Computation of Index properties of rocks.
4. Computation of RQD, RSR, RMR and 'Q

Suggested Readings:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
4. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

Discipline Specific Electives (DSE)

DSE-3: Exploration Geology

Credits 06

DSE3T: Exploration Geology

Credits 04

Course Contents:

Unit-1: Mineral Resources

Resource: Definitions, Mineral resources in industries – historical perspective and present scenario, classification of mineral deposits with respect to processes of formation; exploration strategies.

Unit-2: Prospecting and Exploration

1. Principles of mineral exploration
2. Prospecting and exploration: conceptualization, methodology and stages, Sampling, subsurface sampling including pitting, trenching and drilling
3. Geochemical exploration.
4. Outline of exploration techniques for ferrous and non-ferrous metals, limestone and coal and petroleum.

Unit-3: Evaluation of data

Evaluation of sampling data - Mean, mode, median, standard deviation and variance

Unit-4: Drilling and Logging

1. Core and non-core drilling
2. Planning of bore holes and location of boreholes on ground Core-logging

Unit-5: Reserve estimations and Errors

1. Principles of reserve estimation, Factors affecting reliability of reserve estimation.
2. Reserve estimation based on geometrical models (square, rectangular, triangular and polygon blocks).
3. Regular and irregular grid patterns.
4. Statistics and error estimation.

Suggested Readings:

1. Clark, G.B. 1967. Elements of Mining. 3rd Ed. John Wiley & Sons.
2. Arogyaswami, R.P.N. 1996 Courses in Mining Geology. 4th Ed. Oxford- IBH.
3. Moon, C.J., Whateley, M.K.G., Evans, A.M., 2006, Introduction to Mineral Exploration, Blackwell Publishing.

DSE3P: Practical

Credits 02

List of Practical

1. Identification of anomaly: Gravity and Magnetic.
2. Concept of weighted average in anomaly detection.

3. Geological cross-section.
4. Models of reserve estimation.

OR

DSE-3: River Science

Credits 06

DSE3T: River Science

Credits 04

Course Contents:

Unit-1: Stream hydrology

1. Basic stream hydrology
2. Physical properties of water, sediment and channel flow
3. River discharge, River hydrographs (UH, IUH, SUH, GIUH) and its application in hydrological analysis
4. Flood frequency analysis

Unit-2: River basin

1. Sediment source and catchment erosion processes Sediment load and sediment yield
2. Sediment transport processes in rivers
3. Erosion and sedimentation processes in channel.

Unit-3: Drainage

1. Drainage network
2. Quantitative analysis of network organization – morphometry, Random Topology (RT) model and fractal analysis
3. Role of drainage network in flux transfer
4. Evolution of drainage network in geological time scale.

Unit-4: Rivers in time and space

1. River diversity in space, Patterns of alluvial rivers - braided, meandering and anabranching channels, Dynamics of alluvial rivers
2. Channel patterns in stratigraphic sequences
3. Different classification approaches in fluvial geomorphology and its applications.

Unit-5: Channels and Landscapes

1. Bedrock channels, Bedrock incision process
2. River response to climate, tectonics and human disturbance
3. Bedrock channel processes and evolution of fluvial landscapes.

Unit-6: Fluvial hazards

1. Integrated approach to stream management
2. Introduction to river ecology

Suggested Readings:

1. Davies, T. (2008): Fundamentals of hydrology. Routledge Publications.
2. Knighton, D. (1998): Fluvial forms and processes: A new perspective. Arnold Pubs.
3. Richards. K. (2004): Rivers: Forms and processes in alluvial channels. Balckburn Press.
4. Bryirely and Fryirs (2005): Geomorphology and river management. Blackwell Pub.,
5. Julien, P.Y. (2002): River Mechanics. Cambridge University Press.
6. Robert, A. (2003): River Processes: An introduction to fluvial dynamics. Arnold Publications.
7. Vanoni, V.A. (2006): Sedimentation Engineering. ASCE Manual, Published by American Society of Civil Engineering,
8. Tinkler, K.J., Wohl, E.E. (eds.) 1998: Rivers over rock. American Geophysical Union Monograph, Washington, DC.

DSE3P: Practical

Credits 02

List of Practical

1. Stream power calculation longitudinal profile analysis
2. Hydrograph analysis and other related problems

DSE-4: Oceanography & Marine science

Credits 06

DSE4T: Oceanography & Marine science

Course Contents:

Unit-1: Fundamentals of Ocean

1. Concept of land and Ocean. Land-Ocean distribution
2. Marine Provinces
3. Plate Tectonics and Sea Floor spreading

Unit-2: Chemical and Physical aspects of Ocean

1. Ocean dynamics
2. Ocean Chemistry
3. Marine Sediments

4. Sea Water: Composition, Controls on sea water composition
5. Sea-Air Interaction

Unit-3: Waves, Tides and Coasts

1. Ocean Circulation
2. Waves and Water Dynamics
3. Ocean Energy
4. The Coast: Beaches and Shoreline
5. The Coastal Ocean - Migration for Coastal Erosion

Unit-4: Life in the Ocean

1. Marine Life and the Environment
2. Biologic Productivity and in Ocean
3. Animals of the Pelagic Environment and Life
4. Animals of the Benthic environment and Life

Suggested Readings:

1. Introductory Oceanography by Harold V. Thurman, Mt. San Antonio College, Charles E. Merrill Publishing Company.
2. Oceanography for Beginners, by Pronab K. Banerjee, Allied Publishers Pvt Limited
3. Coastal Hydraulics, by A. M. Muir and C. A. Fleming 1981, The MacMillan Press Ltd, London.

OR

DSE-4: Geodynamics

Credits 06

DSE4T: Geodynamics

Course Contents:

Unit-1: Introduction

1. Definition. Continents and oceans. Continental and oceanic crust. Internal processes of earth
2. Concept of lithosphere and asthenosphere. Physical character of lithosphere and asthenosphere. Concept of plate.
3. Concept of hot spot and mantle plume. Ophiolites. Palaeomagnetism.

Unit-2: Continental Drift, Sea floor spreading and Plate tectonics

1. Wegner Continental drifts hypothesis and its evidences. Continental position in the past
2. Sea-floor spreading process and its evidences.
3. Plate tectonics model and its evidences. Distribution of plates in the Earth

Unit-3: Plate and Plate boundaries

1. Plates: Physical character of plates. Macro and micro plates.
2. Plate boundaries: types, character, Identification of boundaries. Movement of plates along boundaries. Plate velocities.
3. Volcanic arcs, island arcs, trenches, accretionary prisms, oceanic ridges, transform faults. Magmatism in oceanic ridges and in subduction zones

Unit-4:

1. Palaeomagnetism and motion of plates
2. Driving mechanisms of plates. Plate tectonics and mantle convection.
3. Supercontinents and their breakup and assembly. Wilson cycle

Suggested Readings:

1. Turcotte, D.L. and Schubert, G. Geodynamics. Second Edition. Cambridge
2. Kearey, P., Klepeis, K. A., and Vine, F. J. (2009). Global Tectonics. Third edition. Wiley Blackwell, Oxford.