Choice Based Credit System (CBCS)

UNIVERSITY OF DELHI

FACULTY OF SCIENCE

UNDERGRADUATE PROGRAMME
(Courses effective from Academic Year 2015-16)

SYLLABUS OF COURSES TO BE OFFERED
Core Courses, Elective Courses & Ability Enhancement Courses

Disclaimer: The CBCS syllabus is uploaded as given by the Faculty concerned to the Academic Council. The same has been approved as it is by the Academic Council on 13.7.2015 and Executive Council on 14.7.2015. Any query may kindly be addressed to the concerned Faculty.

Undergraduate Programme Secretariat

Preamble

The University Grants Commission (UGC) has initiated several measures to bring equity, efficiency and excellence in the Higher Education System of country. The important measures taken to enhance academic standards and quality in higher education include innovation and improvements in curriculum, teaching-learning process, examination and evaluation systems, besides governance and other matters.

The UGC has formulated various regulations and guidelines from time to time to improve the higher education system and maintain minimum standards and quality across the Higher Educational Institutions (HEIs) in India. The academic reforms recommended by the UGC in the recent past have led to overall improvement in the higher education system. However, due to lot of diversity in the system of higher education, there are multiple approaches followed by universities towards examination, evaluation and grading system. While the HEIs must have the flexibility and freedom in designing the examination and evaluation methods that best fits the curriculum, syllabi and teaching–learning methods, there is a need to devise a sensible system for awarding the grades based on the performance of students. Presently the performance of the students is reported using the conventional system of marks secured in the examinations or grades or both. The conversion from marks to letter grades and the letter grades used vary widely across the HEIs in the country. This creates difficulty for the academia and the employers to understand and infer the performance of the students graduating from different universities and colleges based on grades.

The grading system is considered to be better than the conventional marks system and hence it has been followed in the top institutions in India and abroad. So it is desirable to introduce uniform grading system. This will facilitate student mobility across institutions within and across countries and also enable potential employers to assess the performance of students. To bring in the desired uniformity, in grading system and method for computing the cumulative grade point average (CGPA) based on the performance of students in the examinations, the UGC has formulated these guidelines.

CHOICE BASED CREDIT SYSTEM (CBCS):

The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill based courses. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Therefore, it is necessary to introduce uniform grading system in the entire higher education in India. This will benefit the students to move across institutions within India to begin with and across countries. The uniform grading system will also enable potential employers in assessing the performance of the candidates. In order to bring uniformity in evaluation system and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations, the UGC has formulated the guidelines to be followed.

Outline of Choice Based Credit System:

1. **Core Course:** A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.
2. **Elective Course:** Generally a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill is called an Elective Course.
   - **2.1 Discipline Specific Elective (DSE) Course**: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).
   - **2.2 Dissertation/Project**: An elective course designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member is called dissertation/project.
   - **2.3 Generic Elective (GE) Course**: An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.
     P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/subject and vice versa and such electives may also be referred to as Generic Elective.
3. **Ability Enhancement Courses (AEC)/Competency Improvement Courses/Skill Development Courses/Foundation Course:** The Ability Enhancement (AE) Courses may be of two kinds: AE Compulsory Course (AECC) and AE Elective Course (AEEC). "AECC" courses are the courses based upon the content that leads to Knowledge enhancement. They ((i) Environmental Science, (ii) English/MIL Communication) are mandatory for all disciplines. AEEC courses are value-based and/or skill-based and are aimed at providing hands-on-training, competencies, skills, etc.
   - **3.1** AE Compulsory Course (AECC): Environmental Science, English Communication/MIL Communication.
   - **3.2** AE Elective Course (AEEC): These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based instruction.

Project work/Dissertation is considered as a special course involving application of knowledge in solving / analyzing /exploring a real life situation / difficult problem. A Project/Dissertation work would be of 6 credits. A Project/Dissertation work may be given in lieu of a discipline specific elective paper.

Details of courses under B.A (Honors), B.Com (Honors) & B.Sc. (Honors)

Course	*Credits	
	Theory+ Practical	Theory + Tutorial
I. Core Course		
(14 Papers)	14X4= 56	14X5=70
Core Course Practical / Tutorial*		
(14 Papers)	14X2=28	14X1=14
II. Elective Course		
(8 Papers)		
A.1. Discipline Specific Elective	4X4=16	4X5=20
(4 Papers)		
A.2. Discipline Specific Elective		
Practical/ Tutorial*	4 X 2=8	4X1=4
(4 Papers)		
B.1. Generic Elective/		
Interdisciplinary	4X4=16	4X5=20
(4 Papers)		
B.2. Generic Elective		
Practical/ Tutorial*	4 X 2=8	4X1=4
(4 Papers)		

- **Optional Dissertation or project work in place of one Discipline Specific** E**lective paper (6 credits) in 6th Semester**

III. Ability Enhancement Courses		
1. **Ability Enhancement Compulsory**		
(2 Papers of 2 credit each)	2 X 2=4	2 X 2=4
Environmental Science		
English/MIL Communication		
2. **Ability Enhancement Elective** (Skill Based)		
(Minimum 2)	2 X 2=4	2 X 2=4
(2 Papers of 2 credit each)		
Total credit	**140**	**140**

Institute should evolve a system/policy about ECA/ General Interest/Hobby/Sports/NCC/NSS/related courses on its own.

*** wherever there is a practical there will be no tutorial and vice-versa**

SEMESTER	COURSE OPTED	COURSE NAME	CREDIT
I	Ability Enhancement: compulsory course - I	Communicative English	2
	Core Course - I	Earth System Science	4
	Core Course – I (Practical)		2
	Core Course - II	Mineral Science	4
	Core Course – II (Practical)		2
	Generic Elective – I	GE - I	4
	Generic Elective - I (Practical)	GE - I	2
		Total Credit	**20**
SEMESTER	**COURSE OPTED**	**COURSE NAME**	**CREDIT**
II	Ability Enhancement: compulsory course - II	Environmental Science	2
	Core Course – III	Elements of Geochemistry	4
	Core Course – III (Practical)		2
	Core Course - IV	Structural Geology	4
	Core Course – IV (Practical)		2
	Skill enhancement course - I	Field Work - I	2
	Generic Elective - II	GE – II	4
		Total Credit	**20**

SEMESTER	COURSE OPTED	COURSE NAME	CREDIT
III	Core Course – V	Igneous Petrology	4
	Core Course – V (Practical)		2
	Core Course - VI	Sedimentary Petrology	4
	Core Course – VI (Practical)		2
	Core Course – VII	Paleontology	4
	Core Course – VII (Practical)		2
	Generic Elective - III		4
	Generic Elective - III (Practical)		2
		Total Credit	**24**
SEMESTER	**COURSE OPTED**	**COURSE NAME**	**CREDIT**
IV	Core Course – VIII	Metamorphic Petrology	4
	Core Course – VIII (Practical)		2
	Core Course – IX	Stratigraphic Principles and Indian Stratigraphy	4
	Core Course IX Practical		2
	Core Course – X	Hydrogeology	4
	Core Course – X (Practical)		2
	Skill Enhancement Course - II	Field Work - II	2
	Generic Elective - IV	GE - 4	4
	Generic Elective - IV (Practical)		2
		Total Credit	**26**

SEMESTER	COURSE OPTED	COURSE NAME	CREDIT
V	Core Course – XI	Economic Geology	4
	Core Course – XI (Practical)		2
	Core Course – XII	Geomorphology	4
	Core Course – XII (Practical)		2
	Discipline Specific Elective - I	DCE - I	4
	Discipline Specific Elective - I (Practical)		2
	Discipline Specific Elective - II	DCE - II	4
	Discipline Specific Elective - II (Practical)		2
		Total Credit	**24**
SEMESTER	**COURSE OPTED**	**COURSE NAME**	**CREDIT**
VI	Core Course – XIII	Engineering Geology	4
	Core Course – XIII (Practical)		2
	Core Course – XIV	Remote Sensing & GIS	4
	Core Course – XIV (Practical)		2
	Discipline Specific Elective - III	DSE - III	4
	Discipline Specific Elective (Practical - III)		2
	Discipline Specific Elective - IV	DSE - IV	4
	Discipline Specific Elective (Practical - IV)		2
	Skill Enhancement Course - III	SEC – III (Field Work)	2
		Total Credit	**26**
Grand Total of Credits in Six Semesters			**140**

CORE COURSE: GEOLOGY

Paper -I

EARTH SYSTEM SCIENCE

(CREDITS: THEORY-4, PRACTICALS-2)

THEORY

LECTURES:

Unit 1: Earth as a planet

Holistic understanding of dynamic planet 'Earth' through Astronomy, Geology, Meteorology and Oceanography.

Introduction to various branches of Earth Sciences.

General characteristics and origin of the Universe, Solar System and its planets. The terrestrial and jovian planets.

Meteorites and Asteroids

Earth in the solar system - origin, size, shape, mass, density, rotational and revolution parameters and its age.

Unit 2: Earth's magnetic field

Earth's magnetic field

Formation of core, mantle, crust, hydrosphere, atmosphere and biosphere

Convection in Earth's core and production of its magnetic field

Mechanical layering of the Earth.

Unit 3: Plate Tectonics

Concept of plate tectonics, sea-floor spreading and continental drift

Geodynamic elements of Earth- Mid Oceanic Ridges, trenches, transform faults and island arcs

Origin of oceans, continents, mountains and rift valleys

Earthquake and earthquake belts

Volcanoes- types, products and their distribution.

Unit 4: Hydrosphere and Atmosphere

Oceanic current system and effect of Coriolis force

Concepts of eustasy

Land-air-sea interaction

Wave erosion and beach processes

Atmospheric circulation

Weather and climatic changes

Earth's heat budget.

Unit 5: Soil

Soils- processes of formation, soil profile and soil types.

Unit 6: Understanding the past from stratigraphic records

Nature of stratigraphic records

Standard stratigraphic time scale and introduction to the concept of time in geological studies

Introduction to geochronological methods and their application in geological studies

History of development in concepts of uniformitarianism, catastrophism and neptunism

Laws of superposition and faunal succession

Introduction to geology and geomorphology of Indian subcontinent.

Unit 7: Cosmic abundance of elements
Distribution of elements in solar system and in Earth
Chemical differentiation and composition of the Earth
General concepts about geochemical cycles and mass balance
Properties of elements
Geochemical behavior of major elements
Mass conservation of elements and isotopic fractionation.

PRACTICALS:

Study of major geomorphic features and their relationships with outcrops through physiographic models.
Detailed study of topographic sheets and preparation of physiographic description of an area
Study of soil profile of any specific area
Study of distribution of major lithostratigraphic units on the map of India
Study of distribution of major dams on map of India and their impact on river systems
Study of major ocean currents of the World
Study of seismic profile of a specific area and its interpretation

SUGGESTED READINGS:

1. Duff, P. M. D., & Duff, D. (Eds.). (1993). *Holmes' principles of physical geology*. Taylor & Francis.
2. Emiliani, C. (1992). *Planet earth: cosmology, geology, and the evolution of life and environment*. Cambridge University Press.
3. Gross, M. G. (1977). Oceanography: A view of the earth.

CORE COURSE: GEOLOGY

Paper -II

MINERAL SCIENCE

(CREDITS: THEORY-4, PRACTICALS-2)

THEORY

LECTURES:

Unit 1: Crystallography
Elementary ideas about crystal morphology in relation to internal structures
Crystal parameters and indices
Crystal symmetry and classification of crystals into six systems and 32 point groups

Unit 2: Crystal symmetry and projections
Elements of crystal chemistry and aspects of crystal structures
Stereographic projections of symmetry elements and forms

Unit 3: Rock forming minerals
Minerals - definition and classification, physical and chemical properties
Composition of common rock-forming minerals
Silicate and non-silicate structures; CCP and HCP structures

Unit 4: Properties of light and optical microscopy
Nature of light and principles of optical mineralogy
Introduction to the petrological microscope and identification of common rock-forming minerals

PRACTICALS:

Observation and documentation on symmetry of crystals
Study of physical properties of minerals in hand specimen
Silicates: Olivine, Garnet, Andalusite, SilIimanite, Kyanite, Staurolite, Beryl, Tourmaline, Augite, Actinolite, Tremolite, Hornblende, Serpentine, Talc, Muscovite, Biotite, Phlogopite, Quartz, Orthoclase, Plagioclase, Microcline, Nepheline, Sodalite, Zeolite
Quartz varieties: Chert, Flint, Chalcedony, Agate, Jasper, Amethyst, Rose quartz, Smoky quartz, Rock crystal.
Native Metals/non-metals, Sulfides, Oxides- Copper, Sulfur, Graphite, Pyrite, Corundum, Magnetite
Hydroxides, Halides, Carbonates, Sulfates, Phosphates: Psilomelane, Fluorite, Calcite, Malachite, Gypsum, Apatite.
Study of some key silicate minerals under optical microscope and their characteristic properties

SUGGESTED READINGS:

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.

CORE COURSE: GEOLOGY

Paper -III

ELEMENTS OF GEOCHEMISTRY
(CREDITS: THEORY-4, PRACTICALS-2)
THEORY
LECTURES:

Unit 1: Concepts of geochemistry
Introduction to properties of elements: The periodic table
Chemical bonding, states of matter and atomic environment of elements
Geochemical classification of elements

Unit 2: Layered structure of Earth and geochemistry
Composition of different Earth reservoirs and the nuclides and radioactivity
Conservation of mass, isotopic and elemental fractionation
Concept of radiogenic isotopes in geochronology and isotopic tracers

Unit 3: Element transport
Advection and diffusion
Chromatography
Aqueous geochemistry- basic concepts and speciation in solutions, Eh, pH relations
Elements of marine chemistry
Mineral reactions- diagenesis and hydrothermal reactions.

Unit 4: Geochemistry of solid Earth
The solid Earth – geochemical variability of magma and its products.
The Earth in the solar system, the formation of solar system
Composition of the bulk silicate Earth
Meteorites

Unit 5: Geochemical behavior of selected elements like Si, Al, K, Na etc.

PRACTICALS:
Types of geochemical data analysis and interpretation; of common geochemical plots.
Geochemical analysis of geological materials.
Geochemical variation diagrams and its interpretations.

SUGGESTED READINGS:

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

CORE COURSE: GEOLOGY

Paper -IV

STRUCTURAL GEOLOGY

(CREDITS: THEORY-4, PRACTICALS-2)

THEORY

LECTURES:

Unit 1: Structure and Topography
Effects of topography on structural features, Topographic and structural maps; Importance representative factors of the map

Unit 2: Stress and strain in rocks
Concept of rock deformation: Stress and Strain in rocks, Strain ellipses of different types and their geological significance.
Planar and linear structures; Concept of dip and strike; Outcrop patterns of different structures.

Unit 3: Folds
Fold morphology; Geometric and genetic classification of folds; Introduction to the mechanics of folding: Buckling, Bending, Flexural slip and flow folding

Unit 4: 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

Unit 5: Fractures and faults
Geometric and genetic classification of fractures and faults
Effects of faulting on the outcrops
Geologic/geomorphic criteria for recognition of faults and fault plane solutions

PRACTICALS:
Basic idea of topographic contours, Topographic sheets of various scales.
Introduction to Geological maps: Lithological and Structural maps
Structural contouring and 3-point problems of dip and strike
Drawing profile sections and interpretation of geological maps of different complexities Exercises of stereographic projections of mesoscopic structural data (planar, linear, folded etc.)

SUGGESTED READINGS:

1. Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley
2. Billings, M. P. (1987) Structural Geology, 4th edition, Prentice-Hall.
3. Park, R. G. (2004) Foundations of Structural Geology.Chapman & Hall.
4. Pollard, D. D. (2005) Fundamental of Structural Geology. Cambridge University Press.
5. Ragan, D. M. (2009) Structural Geology: an introduction to geometrical techniques (4th Ed). Cambridge University Press (For Practical)
6. Lahee F. H. (1962) Field Geology. McGraw Hill

CORE COURSE: GEOLOGY

Paper -V

IGNEOUS PETROLOGY

(CREDITS: THEORY-4, PRACTICALS-2)

THEORY

LECTURES:

Unit 1: Concepts of Igneous petrology
Introduction to petrology: Heat flow, geothermal gradients through time, origin and nature of magma

Unit 2: Forms
Classification of igneous rocks
Textures and structures of igneous rocks
Mode of occurrence of Igneous rocks

Unit 3: Phase diagrams and petrogenesis
Binary and Ternary Phase diagrams in understanding crystal-melt equilibrium in basaltic and granitic magmas
Magma generation in crust and mantle, their emplacement and evolution

Unit 4: Magmatism in different tectonic settings
Magmatism in the oceanic domains (MORB, OIB)
Magmatism along the plate margins (Island arcs/continental arcs)

Unit 5: Petrogenesis of Igneous rocks
Petrogenesis of Felsic and Mafic igneous rocks
Komatiites, Granitoides, Basalt, Gabbros
Alkaline rocks, kimberlites and lamproites.

PRACTICALS:

Study of important igneous rocks in hand specimens and thin sections- granite, granodiorite, diorite, gabbro, anorthosites, ultramafic rocks, basalts, andesites, trachyte, rhyolite, dacite,

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. McBirney, A. R. (1984). Igneous Petrology. San Francisco (Freeman, Cooper & Company) and Oxford (Oxford Univ. Press),
6. Myron G. Best (2001). Igneous and Metamorphic Petrology,
7. K. G. Cox, J. D. Bell. (1979). The Interpretation of Igneous Rocks. Springer/Chapman & Hall.
8. Bose M.K. (1997). Igneous Petrology.
9. G W Tyrrell. (1926). Principles of Petrology. Springer

CORE COURSE: GEOLOGY

Paper -VI

SEDIMENTARY PETROLOGY

(CREDITS: THEORY-4, PRACTICALS-2)

THEORY

LECTURES:

Unit 1: Origin of sediments
Weathering and sedimentary flux: Physical and chemical weathering, soils and paleosols.

Unit 2: Sediment granulometry
Grain size scale, particle size distribution, Environmental connotation; particle shape and fabric

Unit 3: Sedimentary textures, structures and environment
Fluid flow, sediment transport and sedimentary structures: Types of fluids, Laminar vs. turbulent flow, Particle entrainment, transport and deposition.
Paleocurrent analysis- Paleocurrents for different sedimentary environments
Sedimentary structure- Primary and syn-sedimentary structures

Unit 4: Varieties of sedimentary rocks
Siliciclastic rocks: Conglomerates, sandstones, mudrocks.
Carbonate rocks, controls of carbonate deposition, components and classification of limestone, dolomite and dolomitisation

Unit 5: Diagenesis
Concepts of diagenesis
Stages of diagenesis
Compaction and cementation.

PRACTICALS:
Exercises on sedimentary structures
Particle size distribution and statistical treatment
Paleocurrent analysis
Petrography of clastic and non-clastic rocks through hand specimens and thin sections

SUGGESTED READINGS:

1. Prothero, D. R., & Schwab, F. (2004). Sedimentary geology. Macmillan.
2. Tucker, M. E. (2006) Sedimenary 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

CORE COURSE: GEOLOGY

Paper -VII

PALEONTOLOGY

(CREDITS: THEORY-4, PRACTICALS-2)

THEORY

LECTURES:

Unit 1: Fossilization and fossil record
Nature and importance of fossil record; Fossilization processes and modes of preservation

Unit 2: Taxonomy and Species concept
Species concept with special reference to paleontology, Taxonomic hierarchy Theory of organic evolution interpreted from fossil record

Unit 3: Invertebrates
Brief introduction to important invertebrate groups (Bivalvia, Gastropoda, Brachiopoda) and their biostratigraphic significance
Significance of ammonites in Mesozoic biostratigraphy and their paleobiogeographic implications
Functional adaptation in trilobites and ammonoids.

Unit 4: Vertebrates
Origin of vertebrates and major steps in vertebrate evolution.
Mesozoic reptiles with special reference to origin diversity and extinction of dinosaurs
Evolution of horse and intercontinental migrations.
Human evolution.

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

Unit 6: Application of fossils in Stratigraphy
Biozones, index fossils, correlation
Role of fossils in sequence stratigraphy
Fossils and paleoenvironmental analysis
Fossils and paleobiogeography, biogeographic provinces, dispersals and barriers
Paleoecology – fossils as a window to the evolution of ecosystems

PRACTICALS:
Study of fossils showing various modes of preservation
Study of diagnostic morphological characters, systematic position, stratigraphic position and age of various invertebrate, vertebrate and plant fossils

SUGGESTED READINGS

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. Shukla, A. C., & Misra, S. P. (1975). Essentials of paleobotany. Vikas Publisher
5. Armstrong, H. A., & Brasier, M.D. (2005) Microfossils. Blackwell Publishing.

CORE COURSE: GEOLOGY

Paper -VIII

METAMORPHIC PETROLOGY

(CREDITS: THEORY-4, PRACTICALS-2)

THEORY

LECTURES:

Unit 1: Metamorphism: controls and types.
Definition of metamorphism. Factors controlling metamorphism Types of metamorphism - contact, regional, fault zone metamorphism, impact metamorphism.

Unit 2: Metamorphic facies and grades
Index minerals, Chemographic projections
Metamorphic zones and isograde s.
Concept of metamorphic facies and grade
Mineralogical phase rule of closed and open system
Structure and textures of metamorphic rocks

Unit 3: Metamorphism and Tectonism
Relationship between metamorphism and deformation
Metamorphic mineral reactions (prograde and retrograde)

Unit 4: Migmatites and their origin
Metasomatism and role of fluids in metamorphism

Unit 5: Metamorphic rock associations- schists, gneisses, khondalites, charnockites, blue schists and eclogites

PRACTICALS:
Megascopic and microscopic study (textural and mineralogical) of the following metamorphic rocks:
Low grade metamorphic rocks: serpentinites, albite-epidote-chloritequartz schist, slate, ta1c-tremolite-ca1cite-quartz schist.
Medium to high grade metamorphic rocks: Gneisses, amphibolite, hornfels, garnetiferous schists, sillimanite-kyanite-bearing rocks, Granulites, eclogite, diopside-forsterite marble.
Laboratory exercises in graphic plots for petrochemistry and interpretation of assemblages.

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

CORE COURSE: GEOLOGY

Paper -IX

STRATIGRAPHIC PRINCIPLES AND INDIAN STRATIGRAPHY

(CREDITS: THEORY-4, PRACTICALS-2)

THEORY

LECTURES:

Unit 1: Principles of stratigraphy
Fundamentals of litho-, bio- and chrono-stratigraphy
Introduction to concepts of dynamic stratigraphy (chemostratigraphy, seismic stratigraphy, sequence stratigraphy)

Unit 2: Code of stratigraphic nomenclature
International Stratigraphic Code – development of a standardized stratigraphic nomenclature.
Concepts of Stratotypes. Global Stratotype Section and Point (GSSP).
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
Walther's Law of Facies.
Concept of paleogeographic reconstruction

Unit 4: Physiographic and tectonic subdivisions of India
Brief introduction to the physiographic and tectonic subdivisions of India.
Introduction to Indian Shield
Introduction to Proterozoic basins of India.
Geology of Vindhyan and Cudappah basins of India

Unit 5: Phanerozoic Stratigraphy of India
Paleozoic Succession of Kashmir and its correlatives from Spiti and Zanskar Stratigraphy
Structure and hydrocarbon potential of Gondwana basins.
Mesozoic stratigraphy of India:
a. Triassic successions of Spiti,
b. Jurassic of Kutch,
c. Cretaceous, successions of Cauvery basins
Cenozoic stratigraphy of India:
a. Kutch basin,
b. Siwalik successions,
c. Assam, Andaman and Arakan basins.
Stratigraphy and structure of Krishna-Godavari basin, Cauvery basin, Bombay offshore basin, Kutch and Saurashtra basins and their potential for hydrocarbon exploration

Unit 6: Volcanic provinces of India
a. Deccan,
b. Rajmahal,
c. Sylhet Trap

Unit 7: Stratigraphic boundaries
Important Stratigraphic boundaries in India - a. Precambrian-Cambrian boundary, b. Permian-Triassic boundary, and c. Cretaceous-Tertiary boundary

PRACTICALS: -

1. Study of geological map of India and identification of major stratigraphic units.
2. Study of rocks in hand specimens from known Indian stratigraphic horizons
3. Drawing various paleogeographic maps of Precambrian time
4. Study of different Proterozoic supercontinent reconstructions.

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.

CORE COURSE: GEOLOGY

Paper -X

HYDROGEOLOGY

(CREDITS: THEORY-4, PRACTICALS-2)

THEORY

LECTURES:

Unit 1: Introduction and basic concepts
Scope of hydrogeology and its societal relevance
Hydrologic cycle: precipitation, evapo-transpiration, run-off, infiltration and subsurface movement of water.
Rock properties affecting groundwater, Vertical distribution of subsurface water
Types of aquifer, aquifer parameters, anisotropy and heterogeneity of aquifers

Unit 2: Groundwater flow
Darcy's law and its validity
Intrinsic permeability and hydraulic conductivity
Groundwater flow rates and flow direction
Laminar and turbulent groundwater flow

Unit 3: Well hydraulics and Groundwater exploration
Basic Concepts (drawdown; specific capacity etc)
Elementary concepts related to equilibrium and non-equilibrium conditions for water flow to a well in confined and unconfined aquifers.
Surface-based groundwater exploration methods
Introduction to subsurface borehole logging methods

Unit 4: Groundwater chemistry
Physical and chemical properties of water and water quality
Introduction to methods of interpreting groundwater quality data using standard graphical plots
Sea water intrusion in coastal aquifers

Unit 5: Groundwater management
Surface and subsurface water interaction
Groundwater level fluctuations
Basic concepts of water balance studies, issues related to groundwater resources development and management
Rainwater harvesting and artificial recharge of groundwater

PRACTICALS:
Preparation and interpretation of water level contour maps and depth to water level maps
Study, preparation and analysis of hydrographs for differing groundwater conditions
Water potential zones of India (map study).
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, Groundwater flow, Well hydraulics etc.

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.

CORE COURSE: GEOLOGY
Paper -XI
ECONOMIC GEOLOGY
(CREDITS: THEORY-4, PRACTICALS-2)
THEORY
LECTURES:

Unit 1 Ores and gangues

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

Unit 2: Mineral deposits and Classical concepts of Ore formation
Mineral occurrence, Mineral deposit and Ore deposit
Historical concepts of ore genesis: Man's earliest vocation- Mining
Plutonist and Neptunist concepts of ore genesis

Unit 3: Mineral exploration
Exploration and exploitation techniques
Remote Sensing, Geophysical and Geochemical Explorations
Geological mapping at different scales, drilling, borehole logs and transverse sections

Unit 4: Structure and texture of ore deposits
Concordant and discordant ore bodies
Endogenous processes: Magmatic concentration, skarns, greisens, and hydrothermal deposits Exogenous processes: weathering products and residual deposits, oxidation and supergene enrichment, placer deposits,

Unit 5: Ore grade and Reserve, assessment of grade, reserve estimation

Unit 6: Metallic and Nonmetallic ores
Metallogenic provinces and epochs
Important deposits of India including atomic minerals
Non-metallic and industrial rocks and minerals, in India.
Introduction to gemstones.

PRACTICALS:
Megascopic identification
Study of microscopic properties of ore forming minerals (Oxides and sulphides).
Preparation of maps: Distribution of important ores and other economic minerals in India.

SUGGESTED READINGS:

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

CORE COURSE: GEOLOGY

Paper -XII

GEOMORPHOLOGY

(CREDITS: THEORY-4, PRACTICALS-2)

THEORY

LECTURES:

Unit 1: Introduction to Geomorphology,
Endogenic and Exogenic processes

Unit 2: Geoid, Topography, Hypsometry, Global Hypsometry, Major Morphological features Large Scale Topography - Ocean basins, 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: Endogenic- Exogenic interactions, Rates of uplift and denudation, Tectonics and drainage development, Sea-level change, Long-term landscape development

Unit 5: Overview of Indian Geomorphology, Extraterrestrial landforms

PRACTICALS:

Reading topographic maps ,Concept of scale Preparation of a topographic profile , Preparation of longitudinal profile of a river; Preparing Hack Profile; Calculating Stream length gradient index, Morphometry of a drainage basin,Calculating different morphometric parameters , Preparation of geomorphic map , Interpretation of geomorphic processes from the geomorphology of the area

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.

CORE COURSE: GEOLOGY

Paper -XIII

ENGINEERING GEOLOGY

(CREDITS: THEORY-4, PRACTICALS-2)

THEORY

LECTURES:

Unit 1: Geology vs. Engineering, 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: Intact Rock and Rock Mass properties
Rock aggregates; Significance as Construction Material

Unit 5: Concept, Mechanism and Significance of Rock Quality Designation (RQD)
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

Unit 9: Case histories related to Indian Civil Engineering Projects

PRACTICALS:

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. 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.
3. Goodman, R.E., 1993. Engineering Geology: Rock in Engineering constructions. John Wiley & Sons, N.Y.
4. Waltham, T., 2009. Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.
5. Bell: F.G-, 2006. Basic Environmental and Engineering Geology Whittles Publishing.
6. Bell, .F.G, 2007. *Engineering Geology*, Butterworth-Heineman

CORE COURSE: GEOLOGY

Paper -XIV

REMOTE SENSING AND GIS

(CREDITS: THEORY-4, PRACTICALS-2)

THEORY

LECTURES:

Unit 1: Photogeology

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

Elements of air photo interpretation

Identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms

Unit 2: Remote Sensing, Concepts in Remote Sensing

Sensors and scanners

Satellites and their characteristics

Data formats- Raster and Vector

Unit 3: Digital Image Processing, Image Errors, Rectification and Restoration, FCC, Image Enhancement, Filtering, Image Rationing, Image classification and accuracy assessment.

GIS integration and Case studies-Indian Examples

Unit 4: GIS, Datum, Coordinate systems and Projection systems

Spatial data models and data editing

Introduction to DEM analysis

Unit 5: GPS, Concepts of GPS

Integrating GPS data with GIS

Applications in earth system sciences

PRACTICALS:

Aerial Photo interpretation, identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms

Introduction to DIP and GIS softwares. Digital Image Processing exercises including analysis of satellite data in different bands and interpretation of various objects on the basis of their spectral signaturesCreating a FCC from raw data,Registration of satellite data with a toposheet of the area Enhancing the satellite images; Generating NDVI images and other image ratio and its interpretation Classification of images.DEM analysis: generating slope map, aspect map and drainage network map and its applications

SUGGESTED READINGS:

1. Demers, M.N., 1997. *Fundamentals of Geographic Information System*, John Wiley & sons. Inc.
2. Hoffmann-Wellenhof, B., Lichtenegger, H. and Collins, J., 2001. *GPS: Theory & Practice*, Springer Wien New York.
3. Jensen, J.R., 1996. *Introductory Digital Image Processing: A Remote Sensing Perspective*, Springer- Verlag.
4. Lillesand, T. M. & Kiefer, R.W., 2007. *Remote Sensing and Image Interpretation*, Wiley.
5. Richards, J.A. and Jia, X., 1999. *Remote Sensing Digital Image Analysis*, Springer-Verlag.

DISCIPLINE SPECIFIC ELECTIVE

Paper - I

EXPLORATION GEOLOGY

(CREDITS: THEORY-4, PRACTICALS-2)

THEORY

LECTURES:

Unit 1: Mineral Resources

Resource reserve definitions, Mineral resources in industries – historical perspective and present, A brief overview of classification of mineral deposits with respect to processes of formation in relation to exploration strategies.

Unit 2: Prospecting and Exploration,

Principles of mineral exploration, Prospecting and exploration- conceptualization, methodology and stages, Sampling, subsurface sampling including pitting, trenching and drilling, Geochemical exploration.

Unit 3: Evaluation of data

Evaluation of sampling data

Mean, mode, median, standard deviation and variance

Unit 4: Drilling and Logging

Core and non-core drilling

Planning of bore holes and location of boreholes on ground

Core-logging

Unit 5: Reserve estimations and Errors

Principles of reserve estimation, density and bulk density

Factors affecting reliability of reserve estimation

Reserve estimation based on geometrical models (square, rectangular, triangular and polygon blocks)

Regular and irregular grid patterns, statistics and error estimation

PRACTICALS:

1. Identification of anomaly
2. Concept of weighted average in anomaly detection
3. Geological cross-section
4. Models of reserve 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.

DISCIPLINE SPECIFIC ELECTIVE

Paper -II

EARTH AND CLIMATE

(CREDITS: THEORY-4, PRACTICALS-2)

THEORY

LECTURES:

Unit 1: Climate system: Forcing and Responses
Components of the climate system
Climate forcing, Climate controlling factors
Climate system response, response rates and interactions within the climate system
Feedbacks in climate system

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

Unit 3: Atmosphere - Hydrosphere
Layering of atmosphere and atmospheric Circulation
Atmosphere and ocean interaction and its effect on climate
Heat transfer in ocean
Global oceanic conveyor belt and its control on earth's climate
Surface and deep circulation
Sea ice and glacial ice

Unit 4: Response of biosphere to Earth's climate
Climate Change: natural vs. anthropogenic effects
Humans and climate change
Future perspectives
Brief introduction to archives of climate change
Archive based climate change data from the Indian continent

Unit 5: Orbital cyclicity and climate
Milankovitch cycles and variability in the climate
Glacial-interglacial stages

The Last Glacial maximum (LGM)
Pleistocene Glacial-Interglacial cycles
Younger Dryas
Marine isotope stages

Unit 6: Monsoon
Mechanism of monsoon
Monsoonal variation through time
Factors associated with monsoonal intensity
Effects of monsoon

PRACTICALS:

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

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 Barlatt
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

DISCIPLINE SPECIFIC ELECTIVE

Paper -III

FUEL GEOLOGY

(CREDITS: THEORY-4, PRACTICALS-2)

THEORY

LECTURES:

Unit 1: Coal
Definition and origin of Coal
Basic classification of coal
Fundamentals of Coal Petrology - Introduction to lithotypes, microlithotypes and macerals in coal
Proximate and Ultimate analysis

Unit 2: Coal as a fuel
Coal Bed Methane (CBM): global and Indian scenario
Underground coal gasification
Coal liquefaction

Unit 3: Petroleum
Chemical composition and physical properties of crudes in nature
Origin of petroleum
Maturation of kerogen; Biogenic and Thermal effect

Unit 4: Petroleum Reservoirs and Traps
Reservoir rocks: general attributes and petrophysical properties.
Classification of reservoir rocks - clastic and chemical.
Hydrocarbon traps: definition, anticlinal theory and trap theory
Classification of hydrocarbon traps - structural, stratigraphic and combination
Time of trap formation and time of hydrocarbon accumulation.
Cap rocks - definition and general properties.
Plate tectonics and global distribution of hydrocarbon reserves

Unit 5: Other fuels
Gas Hydrate
Nuclear Fuel

PRACTICALS:
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

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.
4. Bastia, R., & Radhakrishna, M. (2012). Basin evolution and petroleum prospectivity of the continental margins of India (Vol. 59). Newnes.

DISCIPLINE SPECIFIC ELECTIVE
Paper -IV
RIVER SCIENCE
(CREDITS: THEORY-4, PRACTICALS-2)
THEORY
LECTURES:

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

Unit 2: River basin
Sediment source and catchment erosion processes
Sediment load and sediment yield
Sediment transport processes in rivers
Erosion and sedimentation processes in channel.

Unit 3: Drainage
Drainage network
Quantitative analysis of network organization - morphometry
Random Topology (RT) model and fractal analysis
Role of drainage network in flux transfer
Evolution of drainage network in geological time scale.

Unit 4: Rivers in time and space
River diversity in space, Patterns of alluvial rivers - braided, meandering and anabranching channels,
Dynamics of alluvial rivers
Channel patterns in stratigraphic sequences
Different classification approaches in fluvial geomorphology and its applications.

Unit 5: Channels and Landscapes
Bedrock channels, Bedrock incision process
River response to climate, tectonics and human disturbance
Bedrock channel processes and evolution of fluvial landscapes.

Unit 6: Fluvial hazards
Integrated approach to stream management
Introduction to river ecology.

PRACTICALS:

Stream power calculation
Longitudinal profile analysis
Hydrograph analysis and other related problems

SUGGESTED READINGS:

1. Davies, T. (2008) Fundamentals of hydrology. Routledge Publications.
2. Knighton, D. (1998) Fluvial forms and processes: A new perspective. Amold 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 y American Society of Civil Engineering,
8. Tinkler, K.J., Wohl, E.E. (eds.) 1998. Rivers over rock. American Geophyscial UnionMonogrpah, Washington, DC.

DISCIPLINE SPECIFIC ELECTIVE

Paper -V

EVOLUTION OF LIFE THROUGH TIME

(CREDITS: THEORY-4, PRACTICALS-2)

THEORY

LECTURES:

Unit 1: Life through ages
Fossils and chemical remains of ancient life.
Geological Time Scale with emphasis on major bio-events.
Fossilization processes and modes of fossil preservation.
Exceptional preservation sites- age and fauna

Unit 2: Geobiology
Biosphere as a system, processes and products
Biogeochemical cycles
Abundance and diversity of microbes, extremophiles
Microbes-mineral interactions, microbial mats

Unit 3: Origin of life,
Possible life sustaining sites in the solar system, life sustaining elements and isotope records
Archean life: Earth's oldest life, Transition from Archean to Proterozoic, the oxygen revolution and radiation of life
Precambrian macrofossils – The garden of Ediacara
The Snow Ball Earth Hypothesis

Unit 4: Paleozoic Life
The Cambrian Explosion.
Biomineralization and skeletalization
Origin of vertebrates and radiation of fishes
Origin of tetrapods - Life out of water
Early land plants and impact of land vegetation

Unit 5: Mesozoic Life
Life after the largest (P/T) mass extinction, life in the Jurassic seas
Origin of mammals
Rise and fall of dinosaurs
Origin of birds; and spread of flowering plants

Unit 6: Cenozoic Life
Aftermath of end Cretaceous mass extinction – radiation of placental mammals
Evolution of modern grasslands and co-evolution of hoofed grazers
Rise of modern plants and vegetation
Back to water – Evolution of Whales

Unit 7: The age of humans
Hominid dispersals and climate setting
Climate Change during the Phanerozoic - continental break-ups and collisions

Plate tectonics and its effects on climate and life
Effects of life on climate and geology

PRACTICALS:
1. Study of modes of fossil preservation
2. Study of fossils from different stratigraphic levels
3.Exercises related to major evolutionary trends in important groups of animals and plants

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
4. Cowen, R., 2000 History of Life, Blackwell

DISCIPLINE SPECIFIC ELECTIVE

Paper -VI

URBAN GEOLOGY

(CREDITS: THEORY-4, PRACTICALS-2)

THEORY

LECTURES:

Unit 1: Geology and Society
Necessity of Geology in Urban life.
Geology in Urban Constructions
Geotechnical feature and mapping for subsurface in Metropolitan areas
Building materials, Excavation and cutting in urban areas.

Unit 2: Geology and Urban Agriculture
Soil studies, Chemistry and geochemistry of soil in relation to ground water and fertilizer
Effect of pollutants on vegetable contamination

Unit 3: Urban land use
Geotechnical site characterization, Geotechnical and land use mapping, Decision making in urban landuse, Geological problems in construction of underground structures in urban areas
Urban Tunneling: Tunneling for road and rail in urban areas, Method, Equipments, Importance of Geology

Unit 4: Urban water
Water lagging in built-up areas, Source of water, Standards for various uses of water
Sources of contamination
Waste waters: Sources and its disinfection and treatment, Ground water surveys and resource development.

Unit 5: Urban wastes and Treatment, Geotechnical characterization for waste sites, Domestic waste, Industrial waste, Mine drainage, Power production waste, Radioactive waste, Need for special purpose mapping for selection of waste disposal sites.

Unit 6: GIS in Urban Geology

GIS-An introduction, Application in Urban development, Application in landuse, Application in GW Exploration.

Unit 7: Precaution from seismic hazard in Urban planning
Seismic Hazards: Micro-zonations of hazard based on engineering geological features, Urban-subservice network.

PRACTICALS:

1. Map Reading
2. Ground water flow direction estimation
3. Case studies of Urban flood; Flood hydrographs
4. Case studies of urban planning

SUGGESTED READINGS:

1. Huggenberger, P. and Eptin, J. 2011 Urban Geology: Process-Oriented Concepts for Adaptive and Integrated Resource Management. Springer
2. Lollino, G. et al. (Ed.), Engineering Geology for Society and Territory. Springer

DISCIPLINE SPECIFIC ELECTIVE

Paper -VII

INTRODUCTION TO GEOPHYSICS
(CREDITS: THEORY-4, PRACTICALS-2)
THEORY
LECTURES:

Unit 1: Geology and Geophysics
Interrelationship between geology and geophysics, Role of geological and geophysical data in explaining geodynamical features of the earth.

Unit 2: General and Exploration geophysics
Different types of geophysical methods - gravity, magnetic, electrical and seismic; their principles and applications
Concepts and Usage of corrections in geophysical data

Unit 3: Geophysical field operations
Different types of surveys, grid and route surveys, profiling and sounding techniques
Scales of survey, Presentation of geophysical data

Unit 4: Application of Geophysical methods
Regional geophysics, oil and gas geophysics, ore geophysics, groundwater geophysics, engineering geophysics

Unit 5: Geophysical anomalies
Correction to measured quantities, geophysical, anomaly, regional and residual (local) anomalies, factors controlling anomaly, and depth of exploration

Unit 6: Integrated geophysical methods
Ambiguities in geophysical interpretation, planning and execution of geophysical surveys

PRACTICALS:

Anomaly and background- Graphical method
Study and interpretation of seismic reflector geometry
Problems on gravity anomaly

SUGGESTED READINGS:

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, New Delhi.
4. Telford, W. M., Geldart, L. P., & Sheriff, R. E. (1990). *Applied geophysics* (Vol. 1). Cambridge university press.
5. Lowrie, W. (2007). Fundamentals of geophysics. Cambridge University Press.

SKILL ENHANCEMENT COURSE
FIELD GEOLOGY -I
(Basic field training)
(CREDITS: 2)

Unit 1: Orientation of Topographic sheet in field, marking location in toposheet, Bearing (Front and back). Concepts of map reading, Distance, height and pace approximation

Unit 2: Identification of rock types in field; structures and texture of rocks, Use of hand lense

Unit 3: Basic field measurement techniques: Bedding dip and strike, Litholog measurement

Unit 4: Reading contours and topography

SKILL ENHANCEMENT COURSE
FIELD GEOLOGY -II
(Geological Mapping)
(CREDITS: 2)

Unit 1: Geological mapping, stratigraphic correlation

Unit 2: Primary (scalars and vectors) and secondary structures (linear and planar)

Unit 3: Trend, plunge, Rake/Pitch

Unit 4: Stereoplots of linear and planar structures, Orientation analyses

SKILL ENHANCEMENT COURSE

FIELD GEOLOGY -III

(Economic Geology field)

(CREDITS: 2)

Module I

Unit 1: Visit to any mineral deposit

Unit 2: Mode occurrence of ore, Ore mineralogy

Unit 3: Ore-Host rock interrelation

Unit 4: Ore formation process

Unit 5: Basic techniques of surveying, concept of outcrop mapping

Module 2

Unit 1: Visit to underground or open cast mine

Unit 2: Practical experience of mining methods

Unit 3: Underground mapping/ Bench mapping

Unit 4: Isopach and Isochore maps

SKILL ENHANCEMENT COURSE

FIELD GEOLOGY -IV

(Himalayan Geology field)

(CREDITS: 2)

Identification and characterization of major structural boundaries in Himalaya viz. MBT, MFT etc.
or
Field along any suitable transect of Himalayan foreland
or
Field transect in Siwalik
or
Identification of Himalayan and pre-Himalayan elements

SKILL ENHANCEMENT COURSE
FIELD GEOLOGY -V

(Precambrian Geology field)

(CREDITS: 2)

Field transect in any Precambrian terrain

Study of craton ensemble including basic intrusive suites

Precambrian sedimentary basin

Basement-Cover relation in: a. fold belts, b. sedimentary successions

SKILL ENHANCEMENT COURSE
FIELD GEOLOGY - VI

(Visit to Engineering Project sites)

(CREDITS: 2)

Unit 1: Geological mapping of a project site (Dam sites, Tunnel alignments etc)

Unit 2: On site visit & to study various geotechnical aspects related to the project site.

Unit 3: Identification of geotechnical problems of a project site and remedial measures to be taken.

Unit 4: Identification of environmental problems of a project site and remedial measures to be taken.

Unit 5: Computation of rock mass Properties (RQD, RSR, RMR & Q) in the field.

Unit 6: Identification of potential suspected/probable sites of Natural Disaster and suggestions about corrective/preventive measures.

SKILL ENHANCEMENT COURSE
FIELD GEOLOGY -VII

(Stratigraphy and paleontology-related field)

(CREDITS: 2)

Field training along Phanerozoic basin of India

Documentation of stratigraphic details in the field

Collection of sedimentological, stratigraphic and paleontological details and their representation

Facies concept and its spatio-temporal relation (Walther's Law) and concept of facies distribution at basinal-scale

Fossils sampling techniques and their descriptions

SKILL ENHANCEMENT COURSE

PROJECT WORK -VIII

(CREDITS: 2)

GENERIC ELECTIVE -I

ESSENTIALS OF GEOLOGY

(CREDITS: THEORY-4, PRACTICAL-2)

THEORY

LECTURES:

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 evolutional parameters

Solar System- Introduction to Various planets - Terrestrial Planets
Solar System- Introduction to Various planets - Jovian Planets
Internal constitution of the earth - core, mantle and crust

Unit 3: Convections in the earth's core and production of magnetic field
Composition of earth in comparison to other bodies in the solar system

Unit 4: Origin and composition of hydrosphere and atmosphere
Origin of biosphere
Origin of oceans, continents and mountains

Unit 5: Age of the earth; Radioactivity and its application in determining the age of the Earth, rocks, minerals and fossils

PRACTICALS:

1. Study of major geomorphic features and their relationships with outcrops through physiographic models.
2. Detailed study of topographic sheets and preparation of physiographic description of an area
3. Study of soil profile of any specific area
4. Study of distribution of major lithostratigraphic units on the map of India
5. Study of distribution of major dams on map of India and their impact on river systems
6. Study of major ocean currents of the World
7. Study of seismic profile of a specific area and its interpretation

SUGGESTED READINGS:

1. Holmes' Principles of Physical Geology. 1992. Chapman & Hall.
2. Emiliani, C, 1992. Planet Earth, Cosmology, Geology and the Evolution of Life and Environment. Cambridge University Press.
3. Gross,M.G., 1977. *Oceanography: A view of the Earth*, Prentice Hall.

GENERIC ELECTIVE -II

ROCKS AND MINERALS

(CREDITS: THEORY-4, PRACTICAL-2)

THEORY

LECTURES:

Unit 1: Minerals-Definitions, Physical properties of minerals
Mineralogical structure of earth, planetary minerals and native elements

Unit 2: Mineral structures
Mineralogy of the Earth's crust, mantle and core

Unit 3: Nature of light and principles of optical mineralogy
Optical classification of minerals.
An overview of environmental and radiation mineralogy, biomineralisation and gemology.

Unit 4: Rocks- Definitions and types, Basics of rock formation.
Igneous rock- magma generation and differentiation
Sedimentary rocks- surface processes and sedimentary environments
Metamorphic rocks- chemical system and types of metamorphism
Rock cycle-interactions between plate tectonics and climate systems

PRACTICALS:

1. Study of physical properties of minerals
2. Introduction to optical microscopy
3. Study of optical properties of minerals
4. Study of physical properties of rocks
5. Study of optical properties of rock under thin sections
6. Understanding crystal symmetry via wodden models
7. Stereographic projection of mineral faces
8. Mineral formula calculation
9. Crystal chemical calculation
10. Introduction to analytical techniques for rock and mineral study.

SUGGESTED READINGS:

I. Earth Materials- Introduction to Mineralogy and Petrology, Cornelis Klein and Anthony Philpotts, Cambridge University Press, 2013.
2. Understanding Earth (Sixth Edition), John Grotzinger and Thomas H. Jordan, 2010, W.H. Freeman and company, New York.

GENERIC ELECTIVE -III

PHYSICS AND CHEMISTRY OF EARTH

(CREDITS: THEORY-4, PRACTICALS-2)

THEORY

LECTURES:

Unit 1: Earth: surface features
Continents, continental margins, oceans

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

Unit 3: Elements of earth's magnetism.
Secular variation and westward drift
Solar activity and magnetic disturbance

Unit 4: Elements: Origin of elements/nucleosynthesis.
Abundance of the elements in the solar system / planet earth
Geochemical classification of elements.
Earth accretion and early differentiation
Isotopes and their applications in understanding Earth processes.
Stable isotopes: Stable isotope fractionation. Oxygen isotopes
Sublithospheric Mantle (Mineralogy/phase transitions)

Unit 5: Environmental geochemistry
Geological disposal of nuclear waste
Lead in environment and effect of lead on human health

PRACTICALS:

1. Projection of major elements on binary and triangular diagrams for rock classification
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. Understanding Earth structure through behavior of seismic wave propagation
5. Problems on isostasy

SUGGESTED READINGS:

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

GENERIC ELECTIVE -IV

EARTH RESOURCES

(CREDITS: THEORY-4, PRACTICAL-2)

THEORY

LECTURES:

Unit 1: Earth Resources
Resource reserve definitions; mineral, energy and water resources in industries
Historical perspective and present
A brief overview of classification of mineral deposits with respect to processes of formation in relation to exploration strategies

Unit 2: Definition of Energy: Primary and Secondary Energy
Difference between Energy, Power and Electricity
Renewable and Non-Renewable Sources of Energy
The concept and significance of Renewability: Social, Economic, Political and Environmental Dimension of Energy

Unit 3: Major Types and Sources of Energy
Resources of Natural Oil and Gas
Coal and Nuclear Minerals
Potential of Hydroelectric Power, Solar Energy, Wind, Wave and Biomass Based power and Energy

Unit 4: Energy Sources and Power Generation: Nuclear, Hydroelectric, Solar, Wind and Wave- General Principles.
Ground water resources and its role in economic development of a country
Current Scenario and Future Prospects of Solar Power, Hydrogen Power and Fuel Cells.

PRACTICALS:
1. Plotting of major Indian oil fields on map of India
2. Problems related to hydroelectric power generation
3. Problems related to assessment of possible oil exploration site from geological maps
4. Problems related to energy demand projection of India and possible mitigation pathways
5. Problems related to biofuel

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, Springer.

GENERIC ELECTIVE -V
NATURAL HAZARDS AND DISASTER MANAGEMENT

(CREDITS: THEORY-4, TUTORIAL-1)

THEORY

LECTURES:

Unit 1: The Lithosphere and Related Hazards
Atmospheric Hazards, Hydrosphere and Related Hazards

Unit 2: Concepts of disaster
Types of disaster: natural and manmade - cyclone, flood, land slide, land subsidence, fire and earthquake, tsunami and volcanic eruption

Unit 3: Tectonics and Climate, Meteorite Impacts
Issues and concern for various causes of disasters
Disaster management, mitigation, and preparedness
Techniques of monitoring and design against the disasters
Management issues related to disaster

Unit 4: Disaster Management in India
Risk, Vulnerability and Hazard
Mitigation through capacity building
Legislative responsibilities of disaster management; disaster mapping, assessment
Pre-disaster risk & vulnerability reduction
Post disaster recovery & rehabilitation
Disaster related infrastructure development

Unit 4: Hazard Zonation Mapping
Remote-sensing and GIS applications in real time disaster monitoring
Prevention and rehabilitation

The course will also include discussions on topics determined by students in Tutorial. There would be 12 student presentations apart from the lectures. The topics would be assigned to students based on their interest.

SUGGESTED READINGS:

1. Bell, F.G., 1999. Geological Hazards, Routledge, London.
2. Bryant, E., 1985. Natural Hazards, Cambridge University Press.
3. Smith, K., 1992. Environmental Hazards. Routledge, London.
4. Subramaniam, V., 2001. Textbook in Environmental Science, Narosa International

GENERIC ELECTIVE -VI

EARTH SURFACE PROCESSES

(CREDITS: THEORY-4, PRACTICAL-2)

THEORY

LECTURES:

Unit 1: Introduction to earth surface processes
Historical development in concepts, terrestrial relief, scales in geomorphology,

Unit 2: Energy flow and relative energy of surface processes.
Weathering and formation of soils, karst and speleology, slope and catchment erosion processes, fluvial, aeolian, glacial, peri-glacial and coastal processes and resultant landforms, , Water and sediment flux in river systems, Morphometric analysis of drainage basin and geomorphology-hydrology relationship.

Unit 3: Rates and changes in surface processes
Techniques for measuring rates of processes: sediment budgeting, rock magnetism, isotope geochemical tracers, cosmogenic nuclides, OSL & C-14 dating

Unit 4: Controlling factors (tectonics, climate, sea level changes and anthropogenic) and surface processes
Climate change and geomorphic response of fluvial systems of arid and humid regions
Geomorphic response to tectonics, sea level/base level change, anthropogenic affects
Introduction to Anthropocene

Unit 5: Geomorphic concepts in cause-effect relationship
Spatial & temporal scales, geomorphic system, connectivity, buffering, magnitude-frequency concept, time lag, sensitivity, equilibrium, threshold, non-linearity & complexities
Mega geomorphology and process interrelationship

Surface processes and natural hazards; Applied aspects of geomorphology; Introduction to planetary geomorphology.

PRACTICALS:
Mapping of different landforms and interpretation of surface processes
Exercises on hill slope development, fluvial channel, sediment erosion and transport, sediment budgeting, aggradation and degradation events, drainage basin, drainage morphometry
Basic exercises on computation of rate for different surface processes

SUGGESTED READINGS:

1. Alien, P.A., 1997. *Earth Surface Processes,* Blackwell publishing.
2. Bloom, A.L., 1998. *Geomorphology: A Systematic Analysis of Late Cenozoic Landforms,* Pearson Education.
3. Bridge, J.S. and Demicco, R.V., 2008. *Earth Surface Processes, Landforms and Sediment Deposits*, Cambridge University Press.
4. Esterbrook, D.J., 1992. *Surface Processes and Landforms,* MacMillan Publ.
5. Kale, V.S. and Gupta A 2001 *1ntoduction to Geomorphology,* Orient Longman Ltd.
6. Leeder, M. and Perez-Arlucea M 2005 Physical processes in earth and environmental sciences, Blackwell' publishing.
7. Summerfield M A 1991Globle *Geomorphology* Prentice Hall.
8. Wllcock, P.R., Iverson R M (2003) Prediction in geomorphology ' AGU Publication.

GENERIC ELECTIVE -VII

INTRODUCTION TO SUSTAINABILITY

(CREDITS: THEORY-4, TUTORIAL - 1)

THEORY

LECTURES:

Unit 1: Introduction to Sustainability; basic concepts
Human Population – Past and Future trends

Unit 2: Ecosystems
Extinctions and Tragedy of Commons
Climate and Energy
Water Resources and Agriculture

Unit 3: National Resources Accounting
Environmental Economics and Policy
Measuring Sustainability
Systems interconnectivity among Primary Sustainability challenges
Sustainability Solutions: Some examples

The course will also include discussions on topics determined by students in Tutorial. There would be 12 student presentations apart from the lectures. The topics would be assigned to students based on their interest.

SUGGESTED READINGS:

1. Rogers, P.P., K. F. Jalal, and J.A. Boyd. 2007. An Introduction to Sustainable Development. Earthscan Publishers, 416 pp.
2. Brown, L. 2009. Plan B 4.0. Norton Publishers, New York. (The entire book is available in pdf format: http://www.earthpolicy.org/images/uploads/book_files/pb4book.pdf)

GENERIC ELECTIVE- VIII

FOSSILS AND THEIR APPLICATIONS

(CREDITS: THEORY-4, PRACTICALS-2)

THEORY

LECTURES:

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: Societal 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.

PRACTICALS:

1. Study of fossils showing various modes of fossilization
2. Distribution of age diagnostic fossils in India
3. Biostratigraphic correlation

SUGGESTED READINGS:

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

GENERIC ELECTIVE- IX

MARTIAN GEOLOGY

(CREDITS: THEORY-4, TUTORIAL - 1)

THEORY

LECTURES:

Unit 1: MARS – OUR POTENTIAL HOME?

History of the exploration of Mars; The Journey of Mangalyaan

Evolution of Mars

Unit 2: The characteristics of Mars and its interior

The Martian atmosphere and hydrosphere.

Unit 3: Surface provinces of Mars

Surface processes on Mars and its evidences from Earth-based analogs – Impact structures, Volcanic features on Mars, Layered deposits, Eolian dunes, Debris flow, Martian outflow channels, Glacial Origin of Fretted Terrains on Mars, Mountain building

Unit 4: Geochemical analogs and Martian meteorites

Martian History Epochs of change: what went "wrong" and why?

Unit 5: Life in Mars

Is there evidence for life on Mars?
Physical and chemical conditions supportive of permanent Mars occupation; Terraforming of Mars and its challenges
New Trends for Human Missions to Mars and Human colonization of Mars
The course will also include discussions on topics determined by students in Tutorial. There would be 12 student presentations apart from the lectures. The topics would be assigned to students based on their interest.

SUGGESTED READINGS:

1. Sagan, C. (1973). Planetary Engineering on Mars, Icarus, 20, 513.
2. Fairen, A.G., Mars: Evolution, Geology and Exploration. Nova Publishers, ISBN: 978-1-62618-102-1
3. Chapman, M. (Ed.). (2007). *The geology of Mars: evidence from earth-based analogs* (Vol. 5). Cambridge University Press.
4. Ahrens, P. (2007). The Terraformation of Worlds.Nexial Quest, 22 p.
5. Gerstell, M. F.; Francisco, J. S.; Yung, Y. L.; Boxe, C.; Aaltonee, E. T. (2001). Keeping Mars warm with new super greenhouse gases. Proceedings of the National Academy of Sciences 98 (5): 2154-2157. doi:10.1073/pnas.05151159.
6. Beech, M. (2009).The Terraforming of Mars. Terraforming, 125-173.

GENERIC ELECTIVE- X

SOILS: PRESENT AND PAST

(CREDITS: THEORY-4, PRACTICALS: 2)

THEORY

LECTURES:

Unit 1: Soil forming processes: Chemical weathering, major buffer maintaining ocean/atm/biosphere O_2 and CO_2, new compounds/minerals of greater volume and lower density; Oxidation; Carbonation; Hydrolysis; Hydration; Base Exchange; Chelation; Microbial weathering

Unit 2: General soil forming regimes: Gleization; podzolization; lessivage; ferrallitizatin; calcification; salinization

Unit 3: Soil forming processes: Physical weathering, loosening and particle size reduction; pressure release; thermal expansion; growth of foreign crystal.

Unit 4: Modern soils and key pedofeatures: Soil structures; horizons; roots; Fe-Mn mottles and concretions; pedogenic carbonate

Unit 5: Introduction to paleopedology and paleosols; role of factors controlling paleosol formation- parent material, climate, vegetation, topography, time.

Units 6: Introduction to soil taxonomy and paleosol taxonomy

Unit 7: Micromorphology: Thin section analysis of paleosols

Unit 8: Geochemistry: molecular rations; chemical weathering indices

Units 9: Stable isotope geochemistry: carbon^{13} and oxygen^{18} system for vegetation, temperature, pCO_2

Unit 10: Diagenetic overprinting in fossil soils: compaction; oxidation of organic matter; cementation; illitization

Unit 11: Geological record of fossil soils- Precambrian paleosols- evolution of paleoatmospheric conditions

Unit 12: Geological record of fossil soils- Paleozoic paleosols- evolution of land animals and plants, coal, Permian-Triassic transition paleosols and extinction events

Unit 13: Geological record of fossil soils- Mesozoic-Cenozoic paleosols- fossil soils at K-T extinction event, Paleogene fossil soils at green house to ice house transition, evolution of Asian monsoon system.

Unit 14: Pleistocene-Holocene paleosols- human impact on landscape and soils, climate change, neotectonics.

Unit 15: paleosols and non-marine sequence stratigraphy based on paleopedology and sedimentology of fluvial successions.

PRACTICALS:

1- Micromorphic detailing of the paleosols- structure, horizonation, color, rhizocretions, pedogenic carbonate etc.
2- Particle size analysis and clay mineral analysis of the paleosols
3- Micromorphological analysis- thin section preparation, description, and interpretation
4- Geochemical analysis- bulk geochemistry, molecular rations and weathering indices
5- Field trip to examine modern and fossil soils- field characterization and sampling procedures

SUGGESTED READINGS:

1. Retallack, G.J. (2001) *Soils of the Past: An Introduction to Paleopedology* (2nd edition): Oxford, Blackwell Science, Ltd., 416 p.
2. Birkeland, P.W. (1999) Soil and Geomorphology. Oxford University Press (430 pp.).
3. Bullock, P., Fedoroff, N., Jongeroius, A., Stoops, G., Tursina, T. (1985) Handbook of Soil Thin Section Description. Waine Research Publication, Wolverhampton (152 pp.).
4. Sheldon, N.D., Tabor, N.J. (2009) Quantitative paleoenvironmental and paleoclimatic reconstruction using paleosols. Earth-Science Reviews 95, 1–52.
5. Stoops, G. (2003) Guidelines for analysis and distribution of soil and regolith thin sections. Soil Sci. Soc. Am., Madison, Wisconsin, 184 pp.
6. Soil Survey Staff, (2006) Key to Soil Taxonomy, 10th ed. USDA Natural Resources Conservation Service, Washington D.C.(341 pp.)
7. Bhattacharyya T., Sarkar, D., Pal, D. K. (Eds.) **Soil Survey Manual.** NBSSLUP Publication No 146.

GENERIC ELECTIVE- XI

STUDIES ON CRYOSPHERE

(CREDITS: THEORY-4, PRACTICALS: 2)

THEORY

LECTURES:

Unit 1: Introduction to Cryosphere

Cryosphere, Distribution and its components, Terrestrial and Marine cryosphere, Role of cryosphere in the climate system, Remote sensing of cryosphere and its applications.

Unit 2: Terrestrial Cryosphere

Snow formation, Snowfall and Snow cover, Metamorphism of snow, Snow and Remote sensing, Snowmelt modeling, Glacier Characteristics, Types of Glaciers, Erosional and Depositional features of Glaciers, Glacier mass balance, Surging Glaciers, Glacier hydrology, Glacier and remote sensing, Avalanches and its Characteristics, Ice caps and Ice sheets, Greenland or Antarctic Ice sheets, Sea level changes and Ice sheet, Permafrost and its features, Lake and River ice. Terrestrial Cryosphere in the present, past and future.

Unit 3: Marine Cryosphere

Ice shelves, Ice bergs, Sea ice characteristics, Ice islands, Ice streams, Mass balance of Sea ice, Ice drift and ocean circulation. Marine Cryosphere in the present, past and future

PRACTICALS:

Remote sensing

1. Linear and non-linear regression algorithms to estimate SWE (snow water equivalent) from remote sensed data (mainly microwave data)
2. Estimation of precipitation from remote sensed data

Snowmelt run-off modeling

1. Empirical (Snow cover to spring snowmelt relation)
2. One of the non-empirical model (Degree-day, modified degree-day or energy balance methods)

SUGGESTED READINGS:

1. The Global Cryosphere by Roger Berry and Thian Yew Gan
   Cambridge University Press
2. Web inputs from sites sources such as TRMM and SMMR (Scanning Multichannel Microwave Radiometer) sites

GENERIC ELECTIVE- XII

NUCLEAR WASTE MANAGEMENT
(CREDITS: THEORY-4, PRACTICALS: 2)
THEORY
LECTURES:

Nuclear Waste Management

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: nephiliniite and basaltic). Glass/rock characterization and its long-term performance assessment. Geochemistry of glass/rock-water interaction-solution and neoformed 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.

PRACTICALS:

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.

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.