

ANNAMALAI UNIVERSITY

MASTER OF SCIENCE

M.Sc. GEOLOGY

DEGREE COURSE

UNDER CBCS

(With effect from 2021-2022)

The Course of Study and the Scheme of Examination

Sl. No.	Study Components		Ins. hrs./ week	Credit	Title of the Paper	Maximum Marks		
	Course Title					CIA	Uni. Exam	Total Marks
SEMESTER I								
1.	Core-Theory	Paper-1	5	4	Applied Geomorphology	25	75	100
2.	Core-Theory	Paper-2	5	4	Structural Geology and Geotectonics	25	75	100
3.	Core-Theory	Paper-3	5	4	Mineralogy	25	75	100
4.	Core-Theory	Paper-4	5	4	Palaeontology	25	75	100
	Core-Practical	Paper1-	4	-	Practical –I Structural Geology, Mineralogy and Palaeontology	-	-	-
Internal Elective for same major students (Choose any one)								
5.	Core Elective	Paper-1	3	3	A. OreGeology B. FuelGeology C. MarineGeology	25	75	100
External Elective for other major students (Inter/multidisciplinary papers)								
6.	Open Elective	Paper-1	3	3	A. Meteorology and ClimateChange B. Geohazards C. Water ResourcesManagement	25	75	100
			30	22		150	450	600
SEMESTER II								
7.	Core-Theory	Paper-5	4	4	Igneous and Metamorphic Petrology	25	75	100
8.	Core-Theory	Paper-6	4	4	Sedimentology	25	75	100
9.	Core-Theory	Paper-7	4	4	Stratigraphic Principles and IndianStratigraphy	25	75	100
10.	Core-Theory	Paper-8	4	4	Exploration Geology	25	75	100
11.	Core-Practical	Paper-1	-	3	Practical –I Structural Geology,Mineralogy and Palaeontology	25	75	100
12.	Core-Practical	Paper-2	4	3	Petrology and Sedimentology	25	75	100

Internal Elective for same major students (Choose any one)								
13.	Core Elective	Paper-2	4	3	A. Palaeobotany B. Sequence Stratigraphy C. Petroleum Exploration	25	75	100
External Elective for other major students (Inter/multidisciplinary papers)								
14.	Open Elective	Paper-2	4	3	A. Earth System Science B. Gemology C. Soil Geology	25	75	100
15.	*Field Study		-	2	Geological Mapping/ Field Training	100	-	100
16.	Compulsory Paper		2	2	Human Rights	25	75	100
			30	32		325	675	1000
SEMESTER III						<i>CIA</i>	<i>Uni. Exam</i>	<i>Total Marks</i>
17.	Core-Theory	Paper-9	4	3	Remote Sensing and Digital Image Processing	25	75	100
18.	Core-Theory	Paper-10	5	3	Economic Geology	25	75	100
19.	Core-Theory	Paper-11	5	3	Hydrogeology	25	75	100
	Core-Practical	Paper-3	5	-	Economic Geology and Mining Geology	-	-	-
	Core-Practical	Paper-4	5	-	Hydrogeology, Remote Sensing and GIS	-	-	-
Internal Elective for same major students (Choose any one)								
20.	Core Elective	Paper-3	3	3	A. Field Geology B. Analytical Techniques and Instrumentation C. Micropaleontology	25	75	100
External Elective for other major students (Inter/multi-disciplinary papers)								
21.	Open Elective	Paper-3	3	3	A. Rainwater Harvesting and Artificial Groundwater Recharge B. Environmental Geology C. Water Quality Analysis	25	75	100
22.	**MOOC Courses		-	-	Massive Open Online Courses (MOOC)	-	-	100
			30	15		125	375	600
SEMESTER IV						<i>CIA</i>	<i>Uni. Exam</i>	<i>Total Marks</i>
23.	Core-Theory	Paper-12	5	4	Geographic Information System (GIS) and Applications	25	75	100
24.	Core-Theory	Project	11	5	Project with viva voce Examination-Compulsory	100 (75Project+25 Viva)		100
25.	Core-Practical	Paper-3	4	3	Economic Geology and Mining Geology	25	75	100
26.	Core-Practical	Paper-4	4	3	Hydrogeology, Remote Sensing and GIS	25	75	100
Internal Elective for same major students (Choose any one)								
27.	Core Elective	Paper-4	3	3	A. Industrial Minerals and Mineral Economics B. Mining and Engineering Geology C. Applied Geology and	25	75	100

Geostatistics									
External Elective for other major students (Inter/multi-disciplinary papers)									
28.	Open Elective	Paper -4	3	3	A. Geoheritage, Geoparks and Geotourism B. Introduction to Geospatial Technology C. Disaster Management	25	75	100	
			30	21		150	450	600	
			120	90				2800	

*** Field Study**

There will be field study which is compulsory in the first semester of all PG courses with 2 credits. This field study should be related to the subject concerned with social impact. Field and Topic should be registered by the students in the first semester of their study along with the name of a mentor before the end of the month of August. The report with problem identification and proposed solution should be written in not less than 25 pages in a standard format and it should be submitted at the end of second semester. The period for undergoing the field study is 30 hours beyond the instructional hours of the respective programme. Students shall consult their mentors within campus and experts outside the campus for selecting the field and topic of the field study. The following members may be nominated for confirming the topic and evaluating the field study report.

- i) Head of the respective department
- ii) Mentor
- iii) One faculty from other department

****MOOC Courses**

Inclusion of the Massive Open Online Courses (MOOCs) with zero credit available on SWAYAM, NPTEL and other such portals approved by the University Authorities.

ANNAMALAI UNIVERSITY

MASTER OF SCIENCE

M.Sc. GEOLOGY

SYLLABUS

UNDER CBCS

(With effect from 2021-2022)

APPLIED GEOMORPHOLOGY

Unit I

Definition of Geomorphology. Evolution of geomorphic concepts. Principles/laws of geomorphology. Endogenic and exogenic driving forces. Resisting forces. Dynamic equilibrium of driving and resisting forces and Threshold. Modern concepts, quantitative geomorphology, process geomorphology.

Unit II

Role of tectonics, climate, slope, lithology, vegetation, land cover/land use and human in landscape evolution. Spatio-temporal scale of geomorphic processes. Mineral stability series. Physical, chemical and biological weathering. Soil profiles, Types of soils. Erosional and Depositional landforms. Agents of geomorphic processes – Volcanism, Gravity, glaciers, wind, rivers, tides, waves, currents.

Unit III

Classification of mountains, Types of volcanoes. Volcanic landforms. Isostasy, Tectonic landforms, Gravity landforms. Climate zones of the World. Genesis, distribution and types of glaciers. Landforms in glaciated regions. Aeolian process as a geomorphic agent. Aeolian landforms. Characteristics of dry and wet deserts.

Unit IV

Overland and subsurface flow. Fluvial process. Types of drainage pattern. Fluvial landforms. Types of Deltas. Classification of coast lines, Depositional and erosional coast lines. Coastal and marine landforms.

Unit V

Geomorphic sub-divisions of Indian sub-continent – Himalayan landscape, Indo-Gangetic plains, Deccan Plateau, Coastal low lands. Application of Geomorphology in groundwater exploration, environmental and natural resource management. Geomorphic mapping methods and tools.

Text / Reference Books

1. Bloom.A.L. (1992), Surface of the Earth, Prentice Hall India, New Delhi
2. Gass, I.G., Smith, P.S & Wilson, R.C.L., 2ndEdt., (1972), Understanding the Earth, The English Language Books Society, London
3. Holmes.A, (1972), Principles of Physical Geology The English Language Book

Society and Nelson

4. Jacob,J, Russel, R.D & Wilson, J.T, (1959), Physics and Geology, McGraw – Hill, New York.
5. Leopold,L.S, Wolman, K & Miller, J.P, (1970), Fluvial processes in Geomorphology, Eurasia Publishing House Pvt Ltd., New Delhi.
6. Richard Huggett (2007) Fundamentals of Geomorphology. II Edition.
7. Robert, S.A. and Suzanne, P.A.,(2010) Geomorphology – The mechanics and chemistry of landscapes. Cambridge University Press.
8. Routledge N. Y. Ritter,D.F., Kochel, R.C.,Miller, J.R.,(2002) Process Geomorphology, Waveland press,.
9. Sagan, C. (1973). , Planetary Engineering on Mars, Icarus, 20, 513.
10. Sharma.H.S. (1990) Indian Geomorphology. Concept Pub. Co., New Delhi.
11. Thornbury, W.D., (2004) Principles of Geomorphology. II edition. Wiley Eastern Ltd. New Delhi.
12. Wyllie., P.J, (1971), Dynamic Earth, John Wiley & sons, New York.

PAPER 2

STRUCTURAL GEOLOGY AND GEOTECTONIC

Unit I

Deformation, Stress and Strain

Deformation: Definition - Components of deformation. Strain: Homogeneous and heterogeneous deformation - One-dimensional strain, Strain in two dimensions, Three-dimensional strain - The strain ellipsoid. Uniaxial strain (compaction) - Pure shear and coaxial deformations - Simple shear - Progressive deformation and flow parameters - Steady-state deformation - Incremental deformation - Strain compatibility and boundary conditions. Stress: Definitions, magnitudes and units - Stress on a surface - Stress at a point - Stress components - The stress tensor (matrix) Deviatoric stress and mean stress Mohr circle and diagram. Rheology: Rheology and continuum mechanics - Idealized conditions - Elastic materials - Plasticity and flow: permanent deformation - The role of temperature, water, etc. Definition of plastic, ductile and brittle deformation.

Unit II

Brittle Deformation

Fracture : Brittle deformation mechanisms - Types of fractures - Failure and fracture criteria - Fracture termination and interaction - Fluid pressure, effective stress and poroelasticity. Joints: Definition and characteristics - Kinematics and stress -How, why and where joints form - Joint distributions - Growth and morphology of joints - Joints, permeability and fluid flow.

Faults: Fault anatomy – Types of Faults – Recognition of Faults – Fault Geometry – Characteristics of Normal Faults – Shape and Displacement of Normal Faults – Kinematic Models of Normal Fault, Thrust or reverse faults, and strike-slip faults - Contractual faults - Thrust faults - Ramps, thrusts and folds - Extensional regimes: Extensional faults Fault systems Low-angle faults and core complexes - Ramp-flat-ramp geometries - Rifting Half-grabens and accommodation Strike-slip, transpression and transtension: Strike-slip faults - Transfer faults -Transcurrent faults - Development and anatomy of strike-slip faults – Transpression and transtension.

Unit III

Ductile Deformation

Folds and folding: Geometric parts of Folds – Kinematic of Flexural folding, Passive shear folding, Homogeneous flattening, Folding of multilayer - Formation of Kink and Chevron folds-Superposed folding. Folding: mechanisms and processes - Fold interference patterns and refolded folds - Fold in shear zones - Folding at shallow crustal

depths.

Foliation and cleavage: Basic concepts - Types of foliation: Slaty cleavage or schistosity - Fracture cleavage- Crenulations cleavage – Shear cleavage – Bedding cleavage – Axial plane cleavage. Cleavage development- Cleavage, folds and strain.

Lamination: Types of Lamination: Intersection Lamination – Crenulation Lamination – Mineral Lamination – Stretched – pebble Lamination – Rodding Lamination – Mullion Lamination – Boundinage – Pencil Structures. Lineations related to plastic deformation Lineations in the brittle regime Lineations and kinematics.

Unit IV

Boudinage, Shear zones, and salt tectonics

Boudinage: Boudinage and pinch-and-swell structures - Geometry, viscosity and strain - Asymmetric boudinage and rotation - Foliation boudinage - Boudinage and the strain ellipse.

Shear zones and mylonites: Definition: shear zone - The ideal plastic shear zone Adding pure shear to a simple shear zone Non-plane strain shear zones Mylonites and kinematic indicators.

Salt tectonics Salt tectonics and halokinesis Salt properties and rheology Salt diapirism, salt geometry and the flow of salt Rising diapirs: processes Salt diapirism in the extensional regime Diapirism in the contractional regime Diapirism in strike-slip settings Salt collapse by karstification Salt décollements.

Unit V

Geotectonics

Plate tectonics: Concept of plate and plate movements, nature of convergent, divergent and conservative plate margins. Plate tectonics in relation to igneous, sedimentary and metamorphic processes and mineralization. Triple junctions, aulocogens, plume theory, island arcs. Nature and origin of earth's magnetic field. Evolution of Himalaya and Himalayan tectonics.

Text / Reference Books

1. Badgley.P.C. (1965), Structural and Tectonic Principles, Harper International, New York.
2. Belousov,V.V.(1968).Structural Geology, Mir Publishers.
3. Billing, M.P.(1972).Structural Geology, Prentice-Hall.
4. Chiplonkar C.W. & Power K.B., (1988), Geological Maps, DastaneRamchandra& Co., Pune.
5. Condie, K.C.,(1976).Plate tectonics and Crustal evolution.
6. Davis,G.H., 1984.Structural Geology of Rocks and Regions. John Wiley & Sons.

7. De Sitter. L.U. (1956), Structural Geology, McGraw Hill, New York.
8. Haakon Fossen, 2010. Structural Geology, Cambridge University Press.
9. Hill. E.S. (1972), Elements of Structural Geology, John Wiley, New York
10. Hobbs, B.E., Means, W.D. and Williams, P.F. John Wiley, (1976) An outline of structural geology,
11. Paor, D. (1996). Structural Geology and Personal Computer, Pergamon,
12. Park, R.G., (1983). Foundations of Structural Geology, Blackie and Sons Ltd.
13. Ragan, D M John Wiley, (1985) Structural geology - An Introduction to Geometrical Techniques,
14. Ramsay.J.G&Huber.M.I, (1983), The Techniques of Modern Structural Geology: Vol I – Strain Analysis.
15. Ramsay.J.G&Huber.M.I, (1987), The Techniques of Modern Structural Geology: Vol II – Folds & Fractures
16. Rowland, S.M. and Duebendorfer, E.M. (1994).Structural Analysis and Synthesis, Pergamon,
17. Twiss, Robert J. and Moores, Eldridge M., (2007). Structural geology, W.H.Freeman and Company, New York., p.742
18. Uemura, T., and Mizutani, S., (1979). Geological Structures, Ed.Volume.John Wiley & Sons.
19. Windley, B.F.,(1976).The Evolving Continents. Jhon Wiley and, New York.

PAPER -3

MINERALOGY

Unit I

Crystallography: Atomic structure of crystal, space lattice and unit cell. Bonding in minerals. Nature of crystal. Symmetry elements. System of crystallization. Weiss and Millerian system of crystal notation. Interfacial angle. Twin crystals and Irregularities of crystals.

Unit II

X- rays study of crystal: Application of X- rays in the study of crystal structures. Classification and structure of silicates. Classification and structure of clay minerals. Mineral identification by X- rays and Differential Thermal Analysis (DTA).

Unit III

Mineral optics: Nature of light, polarized light. Double refraction. Snell's law. Parts and function of petrological microscope. Optical properties of minerals, uniaxial and biaxial minerals. Relative relief (RI) of minerals by Becke-line test. Extension angle and its types.

Unit IV

Crystal chemistry: Crystalline and amorphous, Isomorphism, Polymorphism and Pseudomorphism. Physical properties of minerals. Chemical classification of minerals. Precious and semiprecious minerals. Chemical identification of industrial and ore minerals.

Unit V

Rock and ore forming minerals: Physical, chemical, optical properties and mode of occurrence of olivine group, pyroxene group, amphibole group, feldspar group, mica group, quartz group and spinel group. *Paragenesis and mode of alteration:* Silicates, oxides, carbonates, sulphates and halides.

Text / Reference Books

1. Andrew Puttins.,(1992),Introduction to mineral sciences, Cambridge University Press.,
2. Battey,M.H.,(1972),Mineralogy for students,
3. Berry Mason, (2004), Mineralogy, CBS Publishers, New Delhi.
4. Brian Mason, (1966), Principles of Geochemistry, Wiley & Sons, New York.
5. De Jong,W.F.,(1955), General crystallography,Freeman.
6. Deer, W., Howie, R.A. & Zussman, J., (1996), The Rock forming minerals. Longman.
7. Hans-Rudolt Wenk and Andrei Bulakh.,(2004), Minerals – Their constitution and origin.Cambridge University Press.
8. Hurlbut.C.C, (1961), Dana's Manual of Mineralogy, New York
9. Hutchison, C.S., (1974), laboratory handbook of Petrographic Techniques. John

- Wiley.
10. Joseph .V.Smith., (1982), Geometrical and structural crystallography. John Wiley& sons.
 11. Keith Frye.,(1974), Modern Mineralogy.Prentice-Hall.Inc New Jersey.
Klein, C and Hurlbut, Jr., C.S. (1993), Manual of Mineralogy. John Wiley.
 12. Kerr.P.F. (1959), Optical Mineralogy, McGraw Hill, Tokyo.
 13. Martin.J.Burger.,(1970), Contemporary Cyrstallography.McGraw-Hill book company.
 14. Oliver and Boyd. Dana,E.S.(1962),Text book of Mineralogy Revised by Ford,W.E.Wiley.
 15. Phillips, Wm, R. & Griffen, D.T., (1986), Optical Mineralogy, CBS edition.
 16. Phillips,F.C.,(1963),Introduction to crystallography,Thomas Nelson.
 17. Phillips,W.J.&N.,(1980), An introduction to mineralogy for geologist. John Wiley& sons.
 18. Putnis Andrew., (1992), Introduction to Mineral Science, Cambridge University Press.

PAPER - 4

PALAEONTOLOGY

Unit I

Principles

Definition of palaeontology. Theories on the origin and evolutionary history of Life. Fossilization process and the nature of fossil record. Definitions for Species, index fossil, cosmopolitan species, fossil assemblage, fossil diversity, phylogeny. Types of biozones. Geological timescale. Morphological classification and Nomenclature. Cladistics. Species evolution, proliferation and extinction through time.

Unit II

Invertebrate Paleontology I

Morphology, taxonomy, age, distribution and ecological niches of Anthozoa, Trilobita, Graptoloidea, Porifera, Bryozoa.

Unit III

Invertebrate Paleontology II

Morphology, taxonomy, age, distribution and ecological niches of Brachiopoda, Bivalvia, Gastropoda, Cephalopoda, and Echinoidea.

Unit IV

Vertebrate Paleontology

Evolutionary history of Reptilian, Avian, Piscean, and Amphibian fauna. Evolution of mammals. Evolution of horse, elephant and human. Functional morphology.

Unit V

Paleontological applications

Introduction to palynology, micropaleontology, ichnology, Taphonomy and basin analysis. Applications of palaeontology in palaeoclimatic and palaeoenvironmental studies, age fixation and stratigraphic correlation, hydrocarbon exploration.

Text / Reference Books

1. Arnold.R (1947), An Introduction to Palaeobotany, McGraw Hill, New York
2. Arumugam (1989), Organic evolution, Sara Publication, Kanyakumari
3. Benton, M.J. and Harper, D.A.T., (2009) Introduction to Paleobiology and the fossil record. Wiley-Blackwell. London.
4. Clarkson E.N.K. (1986). Invertebrate paleontology and evolution. George Allen & Unwin.
5. Colbert, E. (1955), The Evolution of Vertebrates, John Wiley, New York.
6. Jain, P.C & Anantharaman, M.S (1996), Palaeontology, Evolution and Animal Distribution, Vishal Publications
7. Moore R.C., Lalicker & Fisher (1952). Invertebrate fossil. McGraw Hill Book Co., San Francisco.
8. Murray, J.W., (1985) Atlas of invertebrate macrofossils. Longman. London.

9. Nield, E.W. and Tucker, V.C.T., (1985) Palaeontology: An introduction. Pergamon Press Ltd., Oxford.
10. Raup D.M. & Stanley (1985). Principles of paleontology. CBS Publ. & Distributors, New Delhi.
11. Romer, A.S (1959), The Vertebrate Story, University of Chicago Press 4thEdt. Chicago
12. Sherock, R.R & Twenohofel, W.H (1953), Principles of Invertebrate Palaeontology, New York
13. Swinnerton, H.H (1961), Outlines of Palaeontology, Edward Arnold Publ. Ltd., London.

Core Practical - paper 1
STRUCTURAL GEOLOGY, MINERALOGY AND PALAEOONTOLOGY

Structural Geology

1. Preparation and interpretation of geological maps and sections.
2. Structural problems concerning economic mineral deposits.
3. Plotting and interpretation of petrofabric data and resultant diagrams.

Mineralogy

4. Study of symmetry and forms in the crystal models.
5. X-rays and X-ray refraction, Powder method, Determination of unit cell parameters.
6. Crystal projections –Stereographic projection, Spherical Projection and Gnomonic projection.
4. Study of common rock forming minerals under petrological microscope.
5. Colour enhancement and gem testing.
6. Determination of relative relief (RI) of minerals by Becke-line test.
7. Determination of sign of elongation of minerals.
8. Determination of pleochroic scheme of minerals.
9. Determination of optic sign of uniaxial and biaxial minerals.
10. Determination of extension angle and its types.
11. Identification of rock forming minerals in hand specimens.
12. Mineralogical calculations.
13. Chemical examination of Industrial and ore minerals.

Palaeontology

Morphological descriptions, systematics and illustrations of representative fossils belonging to Trilobita, Gastropoda, Bivalvia, Cephalopoda, Brachiopoda, and Echinodermata.

Interpretation of palaeoclimate and palaeoenvironment based on fossil data.

Biostratigraphic zonal assignment.

Identification of source, reservoir and seal facies with fossil data.

Text / Reference Books

1. Murray, J.W. (1985), Atlas of Invertebrate Macrofossils, Longman.
2. Woods, H. (1966), Invertebrate Palaeontology, International Book Bureau,

**CORE ELECTIVE
PAPER-1
(to choose 1 out of 3)**

A. ORE GEOLOGY

Unit I

Concept of ore bearing fluids, their origin and migration; Wall rock alteration; Structural, physicochemical and stratigraphic controls of ore localization; Ore deposits in relation to plate tectonics; Organic matters in ores and their significance; Fluid inclusions in ore - principles, assumptions, limitations and applications.

Unit II

Mineralogy, classification and genesis of ore deposits associated with orthomagmatic res of ultramafic-mafic rocks; Ores of felsic-silicic igneous rocks; Ores of sedimentary affiliation - biochemical, chemical and clastic sedimentation, placers and residual concentration deposits; Ores of metamorphic affiliations.

Unit III

Study of ore minerals related to the following metals with special reference to their ineralogy, genesis, specification (if any), uses and distribution in India: Fe, Mn, Cr, Cu, Pb, Zn. Al, Mg, Sn, and W.

Unit IV

Introduction to ore microscopy, techniques, methods, textures and microstructures of res, interpretation of ore texture and optical properties of common sulphide, oxide ore minerals; Industrial application of ore microscopy.

Unit V

Megascopic study of Indian metallic ores and industrial minerals in hand specimens; Study of ore structures in hand specimens; Study of optical properties and identification of important ore minerals under ore-microscope; Preparation of maps showing distribution of metallic and industrial minerals in India and also classical world mineral deposits.

Text / Reference Books

1. Branes, H.L. (1979): Geochemistry of Hydrothermal Ore Deposits, John Willey.
2. Cuilbert, J.M. and Park, Jr. C.F.(1986): The Geology of Ore Deposits, Freidman.
3. Evans, A.M. (1993): Ore Geology and Industrial Minerals, Blackwell.
4. James R. Craig and David J.Vaughan (1994): Ore Microscopy and Petrography.
5. Klemm, D.D. and Schnieder, H.J. (1977): Time and Strata Bound Ore Deposits, Springer-Verlag.
6. Mookherjee, A. (2000): Ore Genesis-A Holistic Approach, Allied Publisher.
7. Ramdhor, P. (1969): The Ore Minerals and their Intergowths, Pergamon Press.
8. Stanton, R.L. (1972): Ore Petrology, McGraw Hill.
9. Wolf, K.H. (1976-1981): Hand Book of Stratabound and Stratiform Ore Deposits, Elsevier Publ.

B. FUEL GEOLOGY

Unit I

Coal Geology

Coal Petrology: Origin of Coal; Classification and optical properties of macerals and microlithotypes. Techniques and methods of coal microscopy. Application of coal petrology. Classification of coal in terms of Rank, Grade and Type. Indian classification for coking and non-coking coals. International classifications (I.S.O. and Alpern's classification).

Unit II

Coal as a source rock in petroleum generation. Coal exploration and estimation of coal reserves. Indian coal reserves and production of coal in India. Coalbed methane – a new energy resource. Elementary idea about generation of methane in coal beds, coal as a reservoir and coal bed methane exploration.

Unit III

Petroleum Geology

Petroleum – its composition and Properties; Origin (formation of Source rock Kerogen, organic maturation and thermal cracking of kerogen) and migration of petroleum. Reservoir rocks-porosity and permeability. Reservoir traps – structural, stratigraphic and combination traps. Oil field fluids – water, oil and gas.

Unit IV

Methods of prospecting for oil and gas (geological modeling); Elementary knowledge of drilling and logging procedures - Oil shale - An outline of oil belts of the world. Onshore and offshore petroliferous basins of India. Oil policy of India. Gas Hydrates: Exposure to gas hydrates and future prospective.

Unit V

Atomic Energy

Concept of atomic energy. Radioactive minerals. Mode of occurrence and association of atomic minerals in nature. Methods of exploration for atomic minerals. Productive geological horizons of atomic minerals in India, Geothermal energy: Principles of utilization of Earth's heat. Types of geothermal source-Applications, exploration, distribution of geothermal energy. Geothermal sources in India.-Future scenario.

Text / Reference Books

1. Chandra, D., Singh, R.M. Singh, M.P., (2000): Textbook of Coal (Indian context). Tara Book Agency, Varanasi.
2. Singh, M.P. (Ed.) (1998): Coal and organic Petrology. Hindustan Publishing Corporation, New Delhi.

3. Scott, A.C., (1987): Coal and Coal-bearing strata: Recent Advances. The geological Society of London, Publication no. 32, Blackwell scientific Publications.
4. Stach, E., Mackowsky, M-Th., Taylor, G.H., Chandra, D., Teichmuller, M. and Teichmuller R., (1982): Stach Textbook of Coal petrology. GebruderBorntraeger, Stuttgart.
5. Holson, G.D. and Tiratso, E.N., (1985): Introduction to Petroleum Geology. Gulf Publishing, Houston, Texas.
6. Tissot, B.P. and Welte, D.H., (1984): Petroleum Formation and Occurrence, Springer – Verlag.
7. North, F.K., (1985): Petroleum Geology. Allen Unwin.
8. Selley, R.C., (1998): Elements of Petroleum Geology. Academic Press.
9. Durrance, E.M. (1986): Radioactivity in Geology-principles and application. Ellis Hoorwool.
10. Dahlkamp, F.J., (1993): Uranium Ore Deposits. Springer Verlag.
11. VBoyle, R.W., (1982): Geochemical prospecting for Thorium and Uranium deposits, Elsevier

C. MARINE GEOLOGY

Unit I Introduction

History of Marine Geology ,Waves, tides, currents, turbidity currents, long shore currents, rip currents, circulation, Wave Action: wave reflection, refraction and diffraction – Seiche and tsunamis – Coastal Zone Morphology (Estuaries, deltas, bays, raised beaches, features of wave erosion and deposition, tombolos, mud banks) – Deep sea Morphology (Continental shelf, Continental slope, abyssal plains, sea mounts, guyots, fracture pattern.

Unit II

Marine Processes and Geomorphic features

Littoral processes - Evolution of headlands and bays - Beaches - Raised and sunken features – Evolution and classification of sea coasts and shore lines. Terrestrial-lacustrine-shallow marine-deep sea - siliciclastic versus carbonate sedimentation - deep ocean silica burps - shelf-to-basin transport phenomena turbidites and gravity flows – Submarine groundwater discharge.

Unit III Seafloor Tectonics

Causes of marine regression and transgression – Description of important regressions and transgressions in the geological past – Eustasy –Origin and distribution of ocean basins – Palaeoceanography- Ocean floor tectonics: Characteristics of Oceanic Plate – Geologic processes along Oceanic Plate boundaries – Seafloor Spreading – Evidence - lithospheric plates –divergent plate boundaries – Trenches as convergent plate boundaries – Subduction zones – Transform fault boundaries

Unit IV Marine Sediments and Marine Geochemistry

Marine sedimentation – Sources, types and distribution of marine sediments – Transport of sea bottom sediment - Rate of deposition – Mineral resources. Marine phosphorite, glauconites, barium sulphate concretions, Polymetallic nodules – Gas hydrates - Beach placers. Terrigenous, Biogenic and Chemical Types – Placer Deposits. Distribution of temperature, salinity and density.

Unit V Applied Marine Geology

Trenches and Submarine Canyons – Bengal Fan). Biogenic structures: Reefs of corals and algae Mid-ocean ridges, and the structure of the oceanic crust - Coastal processes and the structure of continental margins.Coastal zone regulation in India – India as Pioneer Investor in Seabed mining. Seafloor geologic process – Volcanism and seismicity.

Text / Reference Books

1. King, C.A.M., (1975). Introduction to marine Geology and Geomorphology. Edward Arnold, London.

2. Radhakrishnan, V., (1996). General Geology V.V.P. Publishers, Tuticorin.
3. Seabold, E. and Berger, W.H. , (1982). The Sea Floor, Springer Verlag. Kuenen, Ph.H., 1950. Marine Geology. John Wiley and Sons.
4. Shepard, F.P., (1978). Geological Oceanography, Heinmann, London.
5. Shepard, F.P., (1973). Submarine Geology,
6. Harper and Row. Kurekian, K.K., 1990. Ocean, Prentice Hall.
7. Svedrup, J.F., (1969). The Ocean, A Scientific American book, W.H. Freeman and company, San Francisco.
8. Kennett, J.P. (1982). Marine Geology. Prentice Hall. New Jersey.
9. Weisberg, C.P. (1979). Oceanography. McGraw Hill. New York.

**OPEN ELECTIVE
PAPER-1
(to choose 1 out of 3)**

A. METEOROLOGY AND CLIMATE CHANGE

Unit I

Meteorology and radiation

Meteorology: introduction, definition, scales in meteorology, branches and applications. Earth Radiation balance: Sun's Energy output, Incoming radiation, Energy spectra of sun and earth, Insulation, Insulation over the globe, insulation losses in atmosphere, long wave radiation, Global radiation balance, Solar energy.

Unit II

Atmosphere, temperature and precipitation

Atmosphere: Composition and structure of atmosphere, Layered structure of atmosphere. Temperature: Introduction, factors influences air temperature, Surface temperature, air temperature, daily cycle of temperature, annual cycle of temperature, urban heat island. Precipitation: Precipitation processes, orographic precipitation, convection precipitation, frontal type of precipitation.

Unit III

El Nino and weather forecasting

El Nino: Introduction, upwelling. El Nino La Nino events and consequences: unusual weather and rainfall, sea surface temperatures, atmospheric consequences, economic consequence. Detection and prediction of El Nino. Weather forecasting: Persistence, trends, climatology, analog and numerical weather prediction methods. Forecasting surface features: Anti cyclone, cyclone, cold front and warm fronts. Forecasting precipitation: effect of frontal lifting, effect of moisture, rain and snow.

Unit IV

Climate change

Introduction, definition. Classification of climate; Koppen's, Bergeron, Thornthwaite's and Strahler classification. Climate change, Palaeoclimatology, Climatic changes through geological time, Geological records of climate, Assessing climate change, Human intervention on climate change. Green house effect, green house gases, Climatic change and global warming, Kyoto protocol.

Unit V

Causes and impact of climate change

Causes of climate change: Astronomical theories, Plate Tectonism, Ocean circulation pattern, Changes in compositions of atmosphere, Changes in solar radiation. Impact of climate change: Rising of CO₂, impact on atmospheric circulation & weather pattern, biosphere, hydrosphere, sea level changes, Adaptation provinces.

Text / Reference Books

1. Alan .H. Strahler and Arthur N.Strahlur 1992.Modern Physical Geography Fourth Editions John Wiley & Sons.In.p638.,

2. Alan Strahler and Arthur Strahler (2002). Physical Geography, 2nd edition John Wiley & Sons Inc.P748.
3. Byers(2005), Meteorology, The Encyclopedia Britannica 15th Ed.
4. Dorothy J.Meeritts and Andrew De (1997)Wet & Kirsten Menking, Environmental Geology – W.H.Freeman and Company, New York ,,
5. Horace General, (1994)Meteorology New York Mc Graw Hill.
6. John.M. Das (1995)The Monsoons, National Book house Trust, New Delhi (Third Edition).,
7. Rev.Fr.S.Ignacimuthu (2010) Environmental Studies, MJP Publishers,
8. Travis Hudson (2012) Living with Earth- An Introduction to Environmental Geology, PHI Learning Private Ltd,

B. GEOHAZARDS

Unit I

Natural Hazard – definition -Earth's processes: catastrophic geological hazards: study of floods, tsunamis, Landslides, Earthquakes, Volcanism and avalanches – with a view to assess the magnitude of the problem, prediction and perception of the hazards. Laws and regulations towards hazard management.

Unit II

Earthquakes-Definition –focus -epicenter-seismic waves-intensity and magnitude-Richter scales – Tsunami -Seismograph- seismogram-seismicity in Indian region - Seismic gaps - mitigation measures and management. Preparation of seismic hazard map.-Seismic Gap.

Unit III

Volcanoes-Definition-structure - types –Global distribution - mitigation measures and management.Avalanche – Definition – types – mitigation.Flood- Definition - causes - vulnerable zones in India-Mitigation measures and management.Coastal erosion – its causes-mitigation measures and management.

Unit IV

Landslides- types -slow flowage, rapid flowage, sliding and subsidence – causes and mechanism - Vulnerable zones in India - mitigation measures and management. Deforestation and land degradation-Cyclone- Definition -causes - vulnerable zones in India-mitigation measures and management.

Unit V

Mass movement – factor influencing slope stability – types of mass movement – hazards of mass movement – strategies for their reduction and the role of geology. Soil erosion – Soil formation – soil classification – factor influencing soil erosion – hazards of soil erosion – Drought – types, mitigation measures.

Text / Reference Books

1. Geology, environment, Society K.S.Valdiya (2004) Universities Press (India) Private Limited, Hyderabad,India
2. Coping with natural hazards: Indian context K.S.Valdiya (2004) Orient Longman Private Limited, Hyderabad,India.
3. Engineering and general geology Parbin Singh (2003) S.K.Kataria and sons Delhi India
4. Genaral Geology V.Radhakrishnan (1996) V.V.P.Publishers, Tuticorin,India.
5. Lundgren (1986). Environment Geology, Rentice Hall Publishers, New Jersey.
- 6.

C. WATER RESOURCES MANAGEMENT

Unit I

Introduction: Definition, concepts of watershed, major objectives of watershed management, effects of watershed on community, ecosystem, Monitoring and evaluation of watershed.

Unit II

Principles of watershed management: Delineating the watershed. natural processes at work in watershed, common elements of watershed management, multidisciplinary approach in watershed management, participatory resources mapping and appraisal, benefits of watershed approach.

Unit III

Degradation agents in watershed: Flood, drought, fire, wind storms, erosion and deposition. Climate change. Glacial movement, Tectonic activity. Volcanic eruption. Human-induced changes. Impact of the degradation of watersheds in hydrology.

Unit IV

Engineering measures for soil conservation: Rainfall parameters. Types of soil erosion. contour bunding, Surplusing structures contour and straggled trenching, gully control structures, graded bunding, bench terracing, land leveling and grading.

Unit V

Water Conservation and Harvesting: Water conservation methods for crop land, Treatment of catchments. *Rainwater harvesting structures:* Check dam, farm pond, percolation tank, basin, ditch and furrow, channel, flooding, irrigation, subsurface dyke, nalla bund and pit methods. Conjunctive use of surface and groundwater.

Text / Reference Books

1. Rajora,R.,(1998), Integrated Watershed Management, Rewat Publications, New Delhi.
2. Tideman.E.M., (1996), Watershed Management: Guideline for Indian Conditions, Omega Scientific Publishers,372p.
3. Lal.S., (2004), Watershed, Development, Management and Technology, Mangal Deep Publications,358p.
4. Paranjape,S.et.al.,(1998), Watershed Based Development: A Source Book, Bharat Gyan Vigyan Samathi, New Delhi.
5. Suresh,R.,(2002), Soil and Water Conservation Engineering, Standard Publishers and Distributers, Delhi.
6. Kakade,B.K.,(2002), Soil and Water Conservation Structures in Watershed Development Programmes ,BAIF Development Research Foundation, Pune.

SEMESTER II

PAPER-5

IGNEOUS AND METAMORPHIC PETROLOGY

Unit – I

Energy and the Mantle heat engine: Forms of energy - Flow and Transformation of Energy- Heat Flow in the Earth (Pressure and Temperature variations with depth) – Mantle melting and magma generation – Volatile fluids in melts – Nature of volatiles – solubility of volatiles in silicate melts – Exsolution of volatiles from a melt. Chemical dynamics of melts and crystals Textures: Primary textures (Rates of Nucleation, growth, and diffusion – Nucleation at Preferred sites – compositional zoning – crystallization sequence – differential movement of crystals and melt- cumulative textures- volcanic textures crystal /melt interactions) – Secondary textures – exsolution – secondary reactions and replacements- deformation.

Unit – II

Magma Diversity: Partial melting- Magmatic differentiation - Fractional crystallization, Volatile transport, Liquid immiscibility, Magma mixing and Assimilation. Basics of thermodynamics and Phase diagrams: Gibbs free energy – the Gibbs free energy for a phase – Gibbs free energy for reaction - Phase equilibrium and the Phase rule - One component system (SiO₂)- Two (binary) component system – Binary systems with complete solid solution (Plagioclase system, Ab-An) – Binary Eutectic System (Diopside – Anorthite) – Binary Peritectic systems.

Unit – III

Classification and Nomenclature of igneous rocks: The IUGS classification – calculations and plotting – Phaneritic rocks – Aphanitic rocks – Pyroclastic rocks. Magmatic Petrotectonic Associations: Oceanic spreading ridges and related basaltic rocks – Mantle plumes and oceanic island volcanic rocks – Plume heads and basalt flood plateau lavas – Arc magmatism – Oceanic island arcs – Continental margin magmatic arcs. Paragenesis: Ophiolite – Characteristics – origin and emplacement – Anorogenic A –type felsic rocks – characteristics – Petrogenesis – Granitoid rocks – Continental rift associations bimodal and alkaline rocks – Alkaline orphans (mostly in stable cratons) - Lamprophyres.

Unit – IV

Concept of Metamorphism: The limits of metamorphism – Metamorphic agents and changes – Temperature, Pressure, Deviatoric stress, and Metamorphic fluids. Types of metamorphism: Contact Metamorphism: Pyrometamorphism – Regional metamorphism: Orogenic Metamorphism – Burial Metamorphism – Ocean Floor Metamorphism – Hydrothermal Metamorphism – Fault-zone Metamorphism - Metamorphic structures and textures – The processes of deformation, recovery, and recrystallisation- Textures of contact metamorphism – High-Strain metamorphic textures – Regional orogenic metamorphic textures –Gneissose structure and layers – Deformation versus metamorphic mineral growth – Analysis of polydeformed and polymetamorphised rocks – Replacement textures and reaction rims. Classification of

metamorphic rocks: Foliated and lineated rocks – Non-foliated and non-lineated rocks-
Specific metamorphic types – High-strain rocks.

Unit – V

Stable Mineral Assemblages in Metamorphic rocks: Equilibrium Mineral Assemblages –
The Phase rule in Metamorphic systems – Chemographic diagrams: The ACF diagram –
The AKF diagram – Projecting in chemographic diagrams. Metamorphic facies and
facies series – Metamorphism of mafic rocks – Metamorphic fluids, Mass transport and
Metasomatism - Anatexis and migmatites - Geothermobarometry.

Text / Reference Books

1. Alexander R. McBirney, 2ndEdti., (1993), Igneous Petrology, CBS Publishers and Distributors, New Delhi.
2. Asworth, J.R. (Ed) (1985), Migmatites. Blackie.
3. Baskar Rao, B. (1986), Metamorphic Petrology. Oxford & IBH.
4. Best, M.G. (2002), Igneous and Metamorphic Petrology, 2nd edition, Blackwell Publishers.
5. Bose, M.K. (1997), Igneous Petrology, The World Press Pvt Ltd., Calcutta.
6. Bowen N.L. (1995), The evolution of Igneous Rocks – Princeton University Press, Carmichael, I.S.E.
7. Carmichael, I.S.E., Turner, F.J. and Verhoogen, J. (1974), Igneous Petrology McGraw – Hill, New York.
8. Chatterjee, S.C. (1974), Petrography of the Igneous and Metamorphic rocks of India Macmillan.
9. Cox, K.G., Bell, J.D. and Pankhurst, R.J. (1979), Interpretation of igneous rocks. George Allen Unwin
10. Ernst, W.G. (1976), Petrologic Phase Equilibria, W.H. Freeman & Co, USA.
11. Freeman W.H. (1982), Petrography, An introduction to the study of rocks in thin sections - Howell, William and Turner.
12. Hall, A. (1987), Igneous Petrology. Longman Scientific & Technical.
13. Harker A. (1909), Natural History of Igneous rocks – Mc.Millan.
14. Hyndman, D.W. (1985), Petrology of igneous and metamorphic rocks. McGraw Hill.
15. Loren A. Raymond, WCB Publ. (1995), Petrology, The Study of Igneous, Sedimentary and Metamorphic Rocks.
16. Mason R. (1984), Petrology of Metamorphic Rocks, CBS Publishers & Distributors, New Delhi
17. Mason, R. (1984), Petrology of metamorphic rocks. CBS Publishers and Distributors.
18. McBirney, A.R. (1993), Igneous Petrology. CBS Publishers and Distributors. pp.508.
19. Miyashiro, A. (1973), Metamorphism and Metamorphic belts, John Wiley and

Sons, New York

20. Nockolds, S.R., Knox O.B., Chinner, G.A (1979), Petrology for Students, Cambridge University Press.
21. Philpotts A. R.(1990), Principles of Igneous and Metamorphic Petrology, Prentice Hall.
22. Robin Gill. (2010), Igneous Rocks and Processes: A Practical Guide Wiley-Blackwell Publ.,
23. Spray, A.H.(1969), Metamorphic textures. Pergamon Press.
24. Turner, F.J. & Verhoogen, J.(1974), Igneous Petrology. McGraw Hill. pp.694
25. Turner, F.J.(1980), Metamorphic Petrology. McGraw Hill.
26. William, H, Turner, F.J, & Gilbert, C.M, (1954), Petrography, San Francisco
27. Winkler, H.G.E.(1979), Petrogenesis of metamorphic rocks. Springer Verlag.
28. Winter, John D., (2012) Principles of Igneous and Metamorphic Petrology, Pearson Education Inc., Publishing as Pearson Prentice Hall, New Jersey, U.S.A. pp.702.

PAPER-6

SEDIMENTOLOGY

Unit I Principles

Definition and principles of Sedimentology. Development of Sedimentology as an interdisciplinary subject of geoscience. Time and space in Sedimentology. Completeness of sedimentary record. Primary and indirect modes of data acquisition in Sedimentology.

Unit II

Rock cycle. Processes of sediment genesis, transport and deposition. Physical, chemical and biological sedimentary structures. Sediment texture – classification of unconsolidated sediments, siliciclastics, carbonates, evaporates, volcanoclastics, and miscellaneous types.

Unit III

Controlling factors of sedimentation – Tectonics, eustatic cycles, climate and sediment influx. Facies concepts. Facies association, facies succession, depositional models. Facies successions formed under gravity, glacial, lacustrine, aeolian, fluvial, coastal and deep sea environments.

Unit IV

Classification of sedimentary basins. Diagenesis of sediments – Stages, zones and environments of diagenesis. Compaction, Porosity types and evolution, cementation, neomorphism, dissolution-recrystallization, dolomitization, and silicification. Palaeocurrent, heavy mineral and clay mineral analyses for provenance and basin analysis.

Unit V

An overview on Sedimentary basins of India. Applications of Sedimentology for palaeoclimatic and palaeoenvironmental interpretation. Study of sedimentary geochemistry for understanding depositional and diagenetic processes.

Text / Reference Books

1. Collins J.D. and D.B. Thompson (1982) Sedimentary Structures. George Allen & Unwin, London.
2. Flugel, E.V., (2002) Microfacies analysis of limestones. Elsevier.
3. Leeder, M., 1999. Sedimentology and Sedimentary Basins. From Turbulence to Tectonics. Blackwell, Oxford, 592 pp
4. Lindholm, R., (1988) A practical approach to Sedimentology. Blackwell publication.
5. Nicholls, G. (1999) Sedimentology and Stratigraphy. Wiley-Blackwell,.

6. Pettijohn F.J. (1975) Sedimentary rocks. Harper and Row Publ., New Delhi.
7. Selley, R.C., (2000) Applied sedimentology, 2nd Edn., Academic Press,.
8. Sengupta.S.M, (2007), Introduction to Sedimentology, CBS Publishers & Distributors, New Delhi.
9. Tucker M.E. and V.P.Wright (1990) Carbonate Sedimentology. Blackwell publication.

PAPER-7

STRATIGRAPHIC PRINCIPLES AND INDIAN STRATIGRAPHY

Unit I

Principles of Stratigraphy: Stratigraphic Principles and approaches to measurement of geological time. Recent developments in stratigraphic classification and Geological Time Scale. International Stratigraphic Code- development of a standardized stratigraphic nomenclature. Concepts of Stratotypes, Global Stratotype Section and Point (GSSP). Principles of Stratigraphic Classification, Categories of Stratigraphic Classification and concept of Litho, Bio and Chrono Stratigraphy. Brief idea about sequence, magneto- seismic- chemo- and event, cyclo- Stratigraphy. Stratigraphic correlations. Approaches to paleogeography.

Unit II

Precambrian stratigraphy: Precambrian stratigraphic succession of and economic importance of Dharwar Supergroup, Eastern Ghats and Southern Granulite belt, Singhbhum-Chhotanagpur-Orissa belt with special reference to Sausar, Sakoli and Iron Ore Groups, Dongargarh and Aravalli Supergroups. Proterozoic stratigraphy of Cuddapah, Vindhyan, Delhi Supergroups and their equivalents. Precambrian-Cambrian boundary.

Unit III

Paleozoic stratigraphy: History, tectonics, life and paleogeography during the Paleozoic Era. Stratigraphic frame work and fossil contents of the Paleozoic rocks of India with special reference to Kashmir and Spiti. Permian-Triassic boundary.

Gondwana stratigraphy: Concept, classification, sedimentation and paleoclimates, fauna, flora, age and economic potential of Gondwana Supergroup.

Unit IV

Mesozoic stratigraphy: Classification, geographic distribution, lithologic characteristics, fauna and flora economic potential of Triassic, Jurassic and Cretaceous systems in principal basins of India with special reference to Triassic of Spiti, Jurassic of Kutch and Cretaceous of Tiruchirappalli (formerly Trichinopoly). Deccan traps. Cretaceous-Tertiary boundary.

Unit V

Cenozoic stratigraphy: Classification, depositional characteristics, fauna and flora and economic potential of the Palaeogene, Neogene and Quaternary Systems with special reference to Siwalik Group, Assam-Arakan region, Andaman-Nicobar Islands and its equivalents. Himalayan orogeny. Quaternary deposits and their significance. Paleogene-Neogene and Neogene-Quaternary boundary.

Text / Reference Books

1. Danbar, C.O. and Rodgers, J. (1957) Principles of Stratigraphy. John Wiley & Sons.

2. Doyle, P. & Bennett. M.R. (1996) *Unlocking the Stratigraphic Record* (John Willey).
3. GSI Misc. Publ. No. 30. (2006) *Geology and Mineral Resources of the States of India*
4. Krishnan, M.S. (1982) *Geology of India and Burma*. CBS Publishers, Delhi
Naqvi, S.M. and Rogers, J.J.W. (1987) *Precambrian Geology of India*. Oxford University Press.
5. Pascoe, E.H.(1968) *A Manual of the Geology of India & Burma (Vols.I-IV)* Govt. of India Press, Delhi
6. Ramkrishnan, M. and Vaidhyanadhan, R. (2008) *Geology of India, Volume I and II*, Geological Society of India, Bangalore
7. Ravindra kumar. (1985) *Fundamentals of Historical Geology and Stratigraphy of India*. Wiley Eastern Ltd., New Delhi.
8. Robert, M. S. (1989) *Stratigraphy: Principles and Methods*, Van Nostrand Reinhold, New York. ,
9. Wadia, D.N. (1998) *Geology of India*. Tata McGraw Hill, India.

PAPER - 8

EXPLORATION GEOLOGY

UNIT I

Geological Exploration

Introduction: Ore genesis in relation to minerals exploration. Regional local parameters for exploration. *Exploration:* Geological techniques and procedures of exploration. Regional (concept-based) exploration-different stages, planning and operations. Resources and reserves-Classification of resources and reserves. Documentation of exploration data.

UNIT II

Geological Mapping & Exploration Techniques

Geological mapping: reconnaissance and detailed mapping-Selection of sites for geological prospecting. Different stages of exploration: objectives and tasks involved; preliminary studies and reconnaissance surveys. *Geologic aspects of drilling-*Types of drills- drill bits, core / sludge recovery, core logging; Drilling methods, planning, selection of sites, angle and direction of bore-holes. *Methods of sampling:* Weighting of samples and calculation of average grades-mathematical and statistical methods.

UNIT III

Geophysical Exploration: I

Gravity method: Nature of gravity and its variation. Accuracy and precision of measurements. Gravimeters. Field procedures. Corrections. Free-air & Bouger anomalies. Interpretation of anomalies. Explorations for minerals. *Magnetic method:* Geomagnetic field and its variations. Magnetometers. Field procedures for land and airborne surveys. Exploration for minerals and oil and engineering sites.

UNIT IV

Geophysical Exploration: II

Seismic method: Seismic waves and their speeds in rocks. Snell's law. Critical refraction. Instruments and field procedures for seismic refraction method. Corrections, Interpretation of data. Seismic reflection methods for oil exploration. Equipment for seismic reflection. Time and depth sections. *Electrical methods:* Introduction to S.P method and its use. Resistivity, true and apparent D.C. resistivity, true and apparent D.C. resistivity equipment, electrode arrangement, field procedure, and use for mineral exploration and at engineering sites.

UNIT V

Geochemical Exploration

Mobility: Geochemical cycle. Mobility and association of elements. Geochemical tracers-elements and isotopes. *Dispersion:* Primary and secondary geochemical dispersion patterns. Geochemical and metallogenic provinces. *Methods of geochemical exploration:* Lithochemical methods-Pedochemical methods-Atmochemical geobotanical and biogeochemical methods. Geochemical sampling techniques-statistical analysis and interpretation of geochemical prospecting data.

Text / Reference Book

1. F.J. Pettijohn (1975) Sedimentary rocks. Harper and Row Publ., New Delhi.
2. Flugel, E.V., (2002) Microfacies analysis of limestones. Elsevier.
3. J.D. Collins and D.B. Thompson (1982) Sedimentary Structures. George Allen & Unwin, London.
4. Lindholm, R., (1988) A practical approach to Sedimentology. Blackwell publication.
5. M.E. Tucker and V.P.Wright (1990) Carbonate Sedimentology. Blackwell publication. Nicholls, G. Sedimentology and Stratigraphy.
6. Wiley-Blackwell, (1999) Selley, R.C., Applied sedimentology, 2nd Edn., Academic Press, 2000. Leeder, M., (1999) Sedimentology and Sedimentary Basins. From Turbulence to Tectonics. Blackwell, Oxford, 592 pp.

Core- Practical - Paper-2

PETROLOGY AND SEDIMENTOLOGY

Igneous Petrology

1. Megascopy of ultramafic, basic, intermediate and acidic igneous rocks.
2. Microscopy of ultramafic, basic, intermediate and acidic igneous rocks.
3. Modal classification of ultramafic, and basic igneous rocks following the IUGS nomenclature.
4. Modal classification of intermediate and acidic igneous rocks following the IUGS nomenclature.
5. Chemical classification of igneous rocks in the $(\text{Na}_2\text{O}+\text{K}_2\text{O})$ vs SiO_2 diagram.
6. Calculation of the CIPW norm of gabbro
7. Calculation of the CIPW norm of diorite.
8. Calculation of the CIPW norm of granite
9. Calculation of the CIPW norm of syenite
10. Calculation of the CIPW norm nepheline syenite.

Metamorphic Petrology

1. Megascopy of metamorphic rocks: slates, phyllites, schists and gneisses.
2. Megascopy of metamorphic rocks: amphibolites, charnockites, khondalites, eclogites.
3. Megascopy of metamorphic rocks: marbles and quartzites.
4. Microscopy of metamorphic rocks: slates, phyllites, schists and gneisses.
5. Microscopy of metamorphic rocks: amphibolites, charnockites, khondalites and eclogites.
6. Microscopy of metamorphic rocks: marbles and quartzites.
7. Construction and interpretation of ACF diagrams.
8. Construction and interpretation of AFM diagrams.

Sedimentology

1. Megascopic study of sedimentary rocks and their identification through characteristic features.
2. Granulometric analysis of unconsolidated sediments and interpreting their modes of transport, and environments of deposition.
3. Petrographic study of clastic and non-clastic rocks and interpreting textural properties, depositional environments and diagenesis.
4. Separation and analysis of heavy minerals from unconsolidated sediments and understanding provenance.
5. Construction of facies succession and depositional models with facies characteristics

**Core Elective
Papers-2
(to choose 1 out of 3)**

A. PALAEOBOTANY

Unit-I

Introduction and approach to palaeobotany, occurrence of plant fossils, their collection and preparation techniques.

Unit-II

principles of nomenclature (concept of genera and form genera), Classification of fossil plants and broad characters of major plant groups. Nature of palaeobotanical record.

Unit-III

Application of palaeobotany in assessing palaeoclimate and palaeoenvironment. Dendrochronology and its application.

Unit-IV

Palynology and its applications, Distribution of pre-Gondwana, Gondwana.

Unit-V

Inter-trappean and Tertiary Floras of India and its relationship with other contemporaneous fossil floras of the world.

Text / Reference Book

1. Arnold, C.A. (1947) An introduction to Palaeobotany, McGraw Hill
2. Andrews Jr., H.N. Studies in Palaeobotany. Viley, New Yorks.
3. Chester, R.A. (1987). An introduction to Palaeobotony, Tata McGraw Hill.
4. Alfred Traverse (1988): Paleopalynology, Unwin Hyman, USA.
5. Bergland, B.E. (1986): Handbook of Holocene paleoecology and paleohydrology, John Wiley, New York.
6. Jones, T.P. and Rowe, T.P. (1999): Fossil Plants and Spores Modern Techniques, Geological Soc.of London.
7. Pipero, Dologes, R. (1988): Phytolith analysis: an Archaeobiological and Geological perspective, Academic Press.
8. Prothero, D.R. (2004): Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.), McGraw Hill.
9. Seaward, A.C. (1991): Plant fossils, Today's and Tomorrow, New Delhi.
10. Shipad N. Agashe (1995): Paleobotany, Oxford and IBH Publ., New Delhi.
11. Stewart, Wilson N. and Rothwell Gar W. (1993): Paleobotany and the Evolution of Plants, Cambridge Univ. Press

B. SEQUENCE STRATIGRAPHY

Unit-I

Approaches to measurement of geological time; Concept of sequence stratigraphy; brief ideas of magnetoseismic-chemo- and event stratigraphy and stratigraphic correlation

Unit-II

Precambrian geochronology; Precambrian chronostratigraphy of Rajasthan, Dharwar craton, Eastern Ghat belt, Southern Granulite belt and Singhbhum-Chotanagpur-Orissa belt; Proterozoic stratigraphy of Son valley, Cuddapah and Kurnool basins; Precambrian/Cambrian boundary.

Unit-III

Stratigraphy of the marine Palaeozoic rock formations of India, Permian/Triassic boundary, Classification, depositional characteristics, fauna and flora of Triassic, Jurassic and Cretaceous systems in principal basins of India.

Unit-IV

Cretaceous/Tertiary boundary, Classification, depositional characteristics, fauna and flora of the Palaeogene and Neogene systems in their type localities and their equivalents in India; Epoch boundaries of the Cenozoic in India.

Unit-V

Study of rocks in hand specimens from known Indian stratigraphic horizons and type localities; Exercises on stratigraphic classification and correlation, sequence, and magneto stratigraphic interpretations.

Text / Reference Book

1. Boggs, S. (2001): Principles of Sedimentology and Stratigraphy, Prentice Hall.
2. Danbar, C.O. and Rodgers, J. (1957): Principles of Stratigraphy, John Wiley and Sons.
3. Doyle, P. and Bennett. M.R. (1996): Unlocking the Stratigraphic Record, John Wiley and Sons.
4. Krishnan, M.S. (1982): Geology of India and Burma, C.B.S. Publ. and Distributors, Delhi.
5. Naqvi, S.M. and Rogers, J.J.W. (1987): Precambrian Geology of India, Oxford University Press.
6. Pascoe, E.H. (1968): A Manual of the Geology of India and Burma (Vols.I-IV), Govt. of India Press, Delhi.
7. Pomeroy, C. (1982): The Cenozoic Era? Tertiary and Quaternary, Ellis Harwood Ltd., Halsted Press.
8. Schoch, Robert, M. (1989): Stratigraphy: Principles and Methods, Van Nostrand Reinhold, New York.

C. PETROLEUM EXPLORATION

Unit-I

Identification and characterization (Petrographic and geochemical) of petroleum source rocks. Amount, type and maturation of organic matter. Oil and source rock correlation. Locating petroleum prospects based on principles of petroleum generation and migration (geological modeling).

Unit-II

Quantitative evaluation of oil and gas prospects through geochemical modeling. reconstruction of paleogeothermal gradient. Migration modeling. Inputs for the assessment of accumulation of petroleum.

Unit-III

Elementary knowledge of geophysical methods of exploration: Magnetic, Gravity and Seismic methods. Elementary knowledge of well drilling: cable-tool drilling, rotary drilling and various types of drilling units.

Unit-IV

Borehole model, Elementary knowledge of Wireline logs: Resistivity, SP, Gamma, Density, Sonic and Neutronlogs. Application of logs in petrophysical analysis and facies analysis.

Unit-V

Megascopic and microscopic study of cores. Preparation of geological maps and sections, and derivation of geological history in relation to petroleum prospects. Calculation of oil reserves. Exercise on maturation studies. Petrographic characterization of petroleum source rocks. Interpretation of electric and porosity logs.

Text / Reference Book

1. Holson, G.D. and Tiratso, E.N. (1985) Introduction of Petroleum Geology. Gulf Publishing, Houston, Texas
2. Tissot, B.P. and Welte, D.H. (1984) Petroleum Formation and Occurrence. Springer –Verlag
3. North, F.K. (1985) Petroleum Geology. Allen Unwin.
4. Selley, R.C. (1998) Elements of Petroleum Geology. Academic Press.
5. Hunt, J.M. (1996) Petroleum Geochemistry and Geology, 2nd Edition Freeman, San Francisco.
6. Jahn, F., Cook, M. and Graham, M. (1998) Hydrocarbon exploration and production. Elsevier
7. Barker, C. (1996) Thermal Modeling of Petroleum Generation, Elsevier.
8. Darling, Toby (2005) Well Logging and Formation Evaluation (Gulf Drilling Guides) 2005, Second ed. edition Gulf Professional Publishing.
9. Schlumberger Log Interpretation Principles/Application, Schlumberger Wireline & testing 225
10. Schlumberger Drive sugar land, Texas 774778.

**OPEN ELCTIVE
PAPERS-2
(to choose 1 out of 3)**

A. EARTH SYSTEM SCIENCE

Unit I

Space Science

Introduction to various branches of Earth Sciences. Solar System, Age of the Earth, Origin of Solar system. Meteors and Meteorites. Earth Dynamics : Interior of the Earth, Composition of the Earth, Seismic waves, Seismograph, Plate Tectonics, Basics of Earthquake Engineering, Landslides, Volcanoes.

Unit II

Geological Oceanography:

Sea waves, Tides, Ocean currents, Geological work of seas and oceans, Tsunami and its causes, Warning system and mitigation.

Unit III

Hydrogeology

Hydrogeology: Water table- Aquifer- Groundwater fluctuations and groundwater composition, Hydrological cycle. Glaciology: Glacier types, Different type of glaciers, Landforms formed by glacier. Petrology - Geological bodies and their structures: Rock, mineral, batholiths, dyke, sill, fold fault, joint, unconformity.

Unit IV

Earth's Atmosphere :

Structure and composition of atmosphere, Atmospheric circulation, Geological work of wind, Greenhouse effect and global warming, Carbon dioxide sequestration. Steps to maintain clean and pollution free atmosphere with governing laws, precautionary measures against disasters.

Unit V

Biosphere:

Origin of life, Evolution of life through ages, Geological time scale, biodiversity and its conservation. Natural Resources: Renewable and non-renewable resources, Mineral and fossil fuel resources and their geological setting, mining of minerals and conservation, effect of mining on surface environment

Text / Reference Books

1. Holme's 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

B. GEMMOLOY

Unit I

Introduction to Gems - Basic properties of gems. Formation of gem stones. Nature of gem material: quality necessary in gems-beauty, rarity, durability. Distinction between crystalline, amorphous and metamict materials. Crystal form and habit. Classification of gem stones. Observations with hand lens (10x)-importance and uses. Units of measurement: metric scale, carat, pearl and grain.

Unit II

Nature of crystals: distinction between crystalline and amorphous material, crystal symmetry, Twinning, parallel growth, crystal form, crystal habit, seven crystal system. Identification of rough stones.

Unit III

Physical properties: hardness its applications in gemmology and limitations. Cleavage, Fracture, parting, and their importance in gemology and lapidary work. Specific gravity-utility and determination by hydrostatic weighing, heavy liquids, floatation and pycnometer. Inclusions and other features of gemstones.

Unit IV

Optical properties: The electromagnetic spectrum, reflection and its importance in gemology-lustre, aventurescence, sheen, chatoyancy, asterism, luminescence, play of colours, labradorescence, inclusions etc.. Laws of refraction, refractive index (R.I), total reflection- in design of refractometer. Construction and use of refractometer. Polariscopes-construction and use in gemmology. Dichroscope-construction, use of Chelsea colour filter, Infra-red ultraviolet and x-rays in gem identification.

Unit V

Enhancement and treatments- enhancement methods - coloured and colourless impregnation, dyeing, bleaching and its identification. Methods of treatment – laser drilling, irradiation, heat treatment, surface modifications, diffusion treatment and its identification. Composites - types, classification and identification.

Text / Reference Books

1. Karan R.V.(2000),Gem and gemindustry in India,Memoir 45,Geological Society of India,Bangalore.,
2. Anderson,B.W(1990).Gem testing (10th edition),Butterworth Scientific,London.,
3. Babu,T.M.(1998) Dimands in India.Geological society of India, Bangalore.,
4. Hall,C.(1994).Gemstone,Dorling Kindesley,London.

5. Deer, W.A., Howie, R.A. and Zussman, S. (1992). An introduction to rock forming minerals, ELBS, London.
6. Kerr, P.F. (1997). Optical mineralogy, 4th Ed. McGraw Hill Book & Co New York., Gemmology 2nd Ed. - Peter Read (1991) Butterworth-Heinemann Ltd. London., Gems 5th Ed. Peter Read. Butterworth, London
7. Richard Laddicoat (1987), Hand book of gem identification- G.I.A.
8. Santa Monica., Edward Gubelin (1986) Photo Atlas of Inclusions in Gem Stones- ABC Edition Zurich., Gem Testing 10th Ed.
9. B.W. Anderson (1990) Butterworth Scientific London., Gemstone Enhancement 2nd Edition,
10. Nassan K. (1994) Butterworths London., Gems 5th Ed. Webster Butterworths London., Hall, C. Gemstones. ISBN 1564584992.
11. Dorling Kindersley, (1994)., Read, P. Gemmology. ISBN 0750644117.
12. Butterworth Heinemann, (1999)., O' Donoghue, M. Identification of Gemstones. ISBN 0750655127.

C. SOIL GEOLOGY

Unit-I

Concept of soil, components of soil, soil profile; Process of soil formation, pedogenic processes; Classification of soil, mineral and chemical composition of soils, mineral stability during weathering; Soil organic matter form and function; A brief introduction to methods of soil conservation.

Unit-II

Fabric analysis - size and shape, concepts of size and shape, grade scale, methods of analysis, presentation of data, analysis and field grading; Concepts of structure fabric: Soil fabric, soil structure, soil texture and field grading units;

Unit-III

Peds and pedality, size and shape of peds, pedality, primary, secondary and tertiary structures and their interpretation; Voids - concepts, size, shape, arrangement and morphological classification.

Unit-IV

Paleosols - Field recognition, description, origin and causes; Paleosol in stratigraphic records; Significance of paleosol study; Paleosols and human evolution.

Unit-V

Calcrete - definition, classification, calcrete formation, pedogenic calcrete soil profile, macro features in calcretes, micromorphology (petrography), calcretes from Quaternary and ancient sedimentary sequences; significance of calcretes; Laterite - characteristics, genesis, Indian occurrences.

Text / Reference Books

1. Brady, N.C.:/: Nature and properties of soils.
2. Gerrard, A.J.J. : Soil and Land forms
3. Govinda Rajan, S.V. & Gopala Rao, K.H.G.: Studies of Soils of India.
4. Gurrison, S. (1989): The Chemistry of Soils, Oxford University Press.
5. Hunt, C.B.: Geology of Soils
6. Jeffe, J.S.: The A.B.C. of soils
7. Terzaghi, K. & Pock, R.G.: Soil Mechanics in Engineering
8. Taylor, D.W.: Fundamentals of Soil Mechanics
9. Wright, V. Paul (Editor): Paleosols: their recognition and interpretation, Blackwell Scientific Publication.
10. Wright, V. Paul and Tucker, M.E. (1991) Calcretes. Blackwell Scientific Publication.

SEMESTER III

PAPER -9

REMOTE SENSING AND DIGITAL IMAGE PROCESSING

Unit I

Passive Microwave Remote Sensing: Basic physics of RADAR waves, spectral characteristics of RADAR waves, microwave radiometers. Active Microwave Remote Sensing: RADAR- definition and development, Radar Systems – geometric characteristics, SLR stereoscopy and RADAR grammetry. SAR interferometry- principle, LIDAR Remote Sensing: Altimetric LiDAR: Physics of laser, spectral characteristics of laser, laser interaction with objects, Airborne Altimetric LiDAR principle.

Unit II

Hyper-spectral Remote Sensing: Hyper-spectral Imaging: Hyper spectral concepts, data collection systems, calibration techniques, data processing techniques; preprocessing, N-dimensional scatter-plots, Spectral mixture analysis, Spectral Matching, Mixture tuned matched filtering, Classification techniques. Hyper-spectral Remote Sensing: Developments and future missions in India.

Unit III

Digital Image Processing: Introduction- Data Formats – Band sequential and Band interleaved characteristics -Compression – Data products; Image display system – Image data encoding and decoding. Image Rectification and Restoration: Geometric correction- Skew corrections – Resampling interpolation methods – Panoramic distortion. Radiometric correction -Sun elevation - Atmospheric correction. Geometric Restoration – Striping – Random error – Earth-Sun distance correction – Atmospheric correction.

Unit IV

Image Enhancement: Contrast Manipulation – Gray-Level Thresholding–Density Slicing - Contrast Stretching – Linear & Non-linear - Convolution spatial filtering – Sobel and Laplatian, High and low pass filtering – Histogram equalization. Edge Enhancement – Band ratioing.

Unit V

Information Extraction: Principal Component Analysis- Ratio Images- Multispectral Classification – Supervised Classification- Minimum distance classifier, parallelepiped classifier, Gaussian maximum likelihood classifier -Unsupervised classification. Classification accuracy assessment. Image Analysis: Pattern recognition – Shape analysis- Textural and contextual analysis.

Reference Books:

1. Fawaz T Ulaby, Richard K Moore and Adrian K Fung, Microwave Remote Sensing active and passive, Vol. 1, 2 and 3 Addison – Wesley Publication company. 1981, 1982, and 1986.
2. Robert M Haralick and Simonnet, Image processing for remote sensing 1983.
3. Travett J W (1986). Imaging Radar for Resources surveys, Chapman and Hall, London.
4. Lillisand, T.M & R.W. Kiefer. (2008). Remote sensing and Image Interpretation, John Wiley and Sons Inc.
5. Gupta R.P (2014). Remote Sensing Geology, Springer.
6. Sabins F F (2007). Remote Sensing: Principles and Interpretation, W H Freeman And Company.
7. Curran, P.B. (1985). Principles of Remote Sensing. ELBS. London.
8. John R Jensen (2017). Introductory Digital Image Processing: A Remote Sensing Perspective, Pearson.
9. Robert A. Schowengerdt (1997). Remote sensing Models and methods for image processing, Academic Press

PAPER -10

ECONOMIC GEOLOGY

Unit I

Scope of economic geology. Mode of occurrence and morphology of ore bodies and relationship with host rocks - Structures of ore and gangue minerals. Modern concepts of ore genesis. Fluid inclusions- Wall rock alteration. Geothermometry- geobarometry.

Unit II

Paragenesis and zoning in mineral deposits- Metallogenic Epochs and Provinces. Structural, physico-chemical and stratigraphic controls of ore localization. Study of ore forming processes- Orthomagmatic processes- Sedimentary processes- Metamorphic processes- Hydrothermal processes. Ore deposits in relation to plate tectonics.

Unit III

Mineralogy, mode of occurrence, uses and distribution in India of the following metalliferous deposits – Iron, Manganese, Aluminium, Copper, Gold, lead, Zinc, Chromium, Molybdenum, Rare Earth Group of metals.

Unit IV

The study of non-metallic mineral deposits with reference to geology, mode of occurrence, origin, uses and distribution in India of Mica, Asbestos, Barytes, Gypsum, Limestone, Garnet, Corundum, Calcite, Quartz, Feldspar, Clays, Kyanite, Sillimanite, Graphite, Talc, Fluorite, Beryl and Gem minerals.

Unit V

Introduction to ore microscopy, techniques, methods, textures and microstructures of ores, interpretation of ore texture and optical properties of common sulphide, oxide ore minerals; Industrial application of ore microscopy.

Text/Reference Books:

1. Anthony Evans, (1993) Ore Geology and Industrial Mineral, John Wiley & sons, USA,
2. Bateman Allan .M. (1962) Economic Mineral Deposits, Asian Publishing House, 2nd Edition.
3. Coggin, B. and Dey, A.K. (1955) India's Mineral Wealth, oup.
4. Craig, J.M. & Vaughan, D.J., (1981): ore Petrography and Mineralogy. John Wiley
5. Cuilbert, J.M. and Park,Jr. C.F.(1986): The Geology of Ore Deposits, Freidman.
6. Debb.S. (1980) Industrial Minerals and Rocks of India, Allied,Publishers.
7. Edwards, R. and Atkinson, K. (1986) Ore deposit geology, Ist Edition, Chapman and Hall. New Delhi,.
8. Evans, A.M. (1993): Ore Geology and Industrial Minerals, Blackwell.
9. Gokhale, K.V.G.K. and Rao , T.C (1978)- Ore deposits of India, their distribution and processing, Thompson press,.
10. James R. Craig and David J.Vaughan (1994): Ore Microscopy and Petrography.
11. Jansen M.L. & Bateman A.M.: (1981), Economic Mineral Deposits, John Wiley & Sons, Singapore.
12. Klemm, D.D. and Schnieder, H.J. (1977): Time and Strata Bound Ore Deposits, Springer-Verlag.
13. Krishnaswamy ,S. - India's Mineral Resources, oxford and IBH.
14. Lindgren W. (1933)Mineral Deposits, McGraw Hill,.
15. Mookherjee, A. (2000): Ore Genesis-A Holistic Approach, Allied Publisher.
16. Park, C.F. and Macdiarmid, R.A (1970) Ore deposits, Freeman,
17. R.M. Umathay, (2006)Mineral Deposits of India, Dattsons, New Delhi, India,
18. Ramdhor, P. (1969): The Ore Minerals and their Intergrowths, Pergamon Press.
19. Robb, L. (2005)Introduction to ore-forming processes, Blackwell publishing, U.K.,.
20. Stanton, R.L. (1972): Ore Petrology, McGraw Hill.
21. Wolf, K.H. (1976-1981): Hand Book of Stratabound and Stratiform Ore Deposits, Elsevier Publications.
22. Meher,D.N. Wadia, (1994), Mineral of India, National Book Trust, New Delhi.
23. Sinha.R.K and Sharma.N.L.(1970), Mineral Economics, Oxford IBH Publishing Co., New Delhi.

PAPER -11

HYDROGEOLOGY

Unit I

Hydrogeology: Hydrologic cycle and its components, Origin and age of groundwater, Occurrence of groundwater, Global distribution of fresh water. Vertical distribution of groundwater. Aquifers: Types of aquifers. Springs: Types of springs. Hydrologic properties of rocks: Porosity, Permeability, Specific yield, Specific retention, Hydraulic conductivity, Transmissivity and Storage coefficient.

Unit II

Groundwater movements: Sub surface movement, Base flow, Effluent flow and influent flow. Darcy's law, Reynold's number, Laminar flow and turbulence flow. Water level fluctuation: Water table and Piezometric surface and its fluctuations. Pumping test: objective, layout of the test and its measurement.

Unit III

Water well technology: Well types, drilling methods, construction of well, design of well, development and maintenance of wells. Artificial recharge of groundwater: Concept and methods. Saline water intrusion in aquifers: Saline water intrusion, Ghyben–Herzberg's relationship between fresh and saline water, Prevention and control of salt water intrusion in the coastal aquifers.

Unit IV

Groundwater quality: Chemical composition of groundwater, major cations and anions, trace elements and their sources. Water quality measurements: physical, chemical and biological parameters. Graphical representation of hydrochemical data: Piper's facies analysis. Groundwater contaminations and Pollutions: Problems related to arsenic and fluoride contamination, radio isotopes in hydrogeological studies. Trace element and health hazards, Impact of urbanization. Hydrogeochemical provinces of India.

Unit V

Groundwater exploration techniques: Surface investigation of groundwater-Geologic method, electrical resistivity method, seismic method, gravity and magnetic method. Subsurface investigation of groundwater: test drilling, water level measurements. Application of Geophysical logging in Groundwater exploration. Groundwater provinces of India.

Text / Reference Books:

1. Alley, W.M., (1993), Regional Groundwater Quality-VNR, New York
2. Davies, S.N. and De Wiest, D.R., (1966), Hydrogeology-John Wiley & sons, Inc, New York, 463p.
3. Fetter, C.W., (1990), Applied Hydrogeology-McGraw Hill, Publisher, New Delhi.
4. Freeze, R.A. and John, A., (1979), Groundwater, Cherry, Prentice Hall, Inc, 604p.
5. Handa, O.P (1984), Groundwater Drilling, Oxford & I.B.H. Publishing Co.
6. Hem J.D., (1970), Study and interpretation of the chemical characteristics of
7. Hiscock, K., (2005), Hydrogeology, Principles and Practice, Blackwell Publishing, 389p.
8. Karanth, K.R., (1987), Groundwater Assessment, Development and Management-Tata McGraw Hill New Delhi 720p.
9. Kazmann, (1973), Modern Hydrology, Harper and sons Publishers, New Delhi.
10. Manning, J.C., (2007), Applied Principles of Hydrology, CBS Publishers and Distributors, New Delhi.
11. Raghunath, H.M., (2007), Groundwater 3rd edition, New Age International Publishers, 520p.
12. Reddy and Rami, J.P., (2008), A Textbook of Hydrology, University Science Press, Bangalore.
13. Schwartz, F.W and Zhang, H., (2003), Fundamentals of groundwater, John Wiley & sons, Inc, New York, 583p.
14. Shaw, E.M., (1994), Hydrology in Practice, 3rd edition, Chapman and Hall, London, 569p.
15. Subramaniam, V., (2000), Water-Kingston Publ. London.
16. Todd, D.K., (1980), Groundwater Hydrology-John Wiley & sons publishers, New York, 535p.
17. Tolman, C. (1972), Groundwater, McGraw Hill Book Company.
18. Walton, W.C. (1970). Groundwater Resource Evaluation, McGraw Hill Book Company.

PRACTICAL-III

ECONOMIC GEOLOGY AND MINING GEOLOGY

Economic Geology

Study of Industrial and ore minerals with special emphasis on physical, chemical characteristics, mode of occurrences and uses.

Mining Geology

Problems relating to evaluation of Ore reserves.

PRACTICAL – IV

HYDROGEOLOGY, REMOTE SENSING AND GIS

Hydrogeology

Estimation of chemical dissolved constituents: major, minor and traces ingroundwater using standard laboratory techniques.

Diagrammatic representation of hydrochemical data: bar, circular radial, multivariate schoeller diagram, four coordinated diagrams, stiffs diagram, horizontal and vertical scale diagram. Plotting on maps-Piper, U.S. Salinity Laboratory diagram, Wilcox's, Doneen's, Gibb's and Durov's plots.

Groundwater exploration techniques: geophysical and geological methods of ground water exploration.

Pumping test: time draw down and time recovery tests and evaluation of aquifer parameters.

Remote sensing and GIS

Aerial Photography: Stereovision Test, Pocket & Mirror Steoscope-3D Observation, Identification photo/image Recognition elements. Interpretation of drainage pattern, landforms, rock types and structures.

Satellite remotesensing: Demarcation of marginal information, Interpretation of satellite data for geomorphology, structure, lithology and land use land cover. Exposure to Digital Image Processing techniques, spectral plot for different features.

GIS: Geo-Referencing, Digitization, Preparation of Vector and Raster Image, Buffer analysis and Overlay analysis.

CORE ELECTIVE

PAPER - 3

(to choose one out of 3)

A. FIELD GEOLOGY

UNIT I

Definition and scope of Field Geology – Prior planning – Basic equipment required for field work – Types of field investigations. Field work objectives and types of data collected. Introduction to topographic maps: parts, symbols, and other information. Basic concepts: relief, contours, slope, gradients, profiles and sections. Interpretation of topographic maps. Base map preparation and map scale.

UNIT II

Rock outcrops and their surficial expressions. Basic concepts: strike, dip, apparent dip and rock trends. Introduction to the outcrop features used in mapping: foliations, lineations, bedding, and lithological contacts. Geological mapping: Techniques of mapping: Traverse methods: Compass and Contact traverse, Exposure mapping, Variable lithology mapping, Line maps. Preparation of field note based data sheet.

UNIT III

Field Equipments: Clinometer compass: different parts and their functions. Measuring attitude of linear structures – determination of bearings – advantages and limitations. Brunton Compass: different parts and their functions - measuring attitude and trends – determination of bearings – adjustments – magnetic declination in topographic sheets - advantages and limitations. Brief account on the utility of Prismatic Compass and Plane Table in mapping open cast mines and quarries.

UNIT IV

Brief account of the following: Use of Aerial Photographs in geological mapping, Structural mapping, Stratigraphic mapping methods. Outline of mapping methodology for – igneous terrain, sedimentary terrain and metamorphic terrain. Methods of mapping in areas with

sparse outcrops. Outcrop structural features common to all rock types. Outline of use and applications of GPS in field geology. Sample location techniques in digital base maps.

UNIT V

Field geological report: Parts and preparation. Geological and topographic map symbols. Brief introduction of field indicators used in geological mapping: geomorphological, weathering, mineral composition and petrography. Geological materials: types of samples – mineral, ore, fossil, rock. Methods of sampling - care and packing of samples in the field. Outline of preparation of thin sections of geological samples.

Reference Books:

1. Compton, R.R. (1985). *Geology in the Field*, John Wiley & Sons Inc., New Delhi.
2. McClay, K.R. (2003) *The Mapping of Geological Structures*, 2nd ed., John Wiley & Sons Ltd, New Delhi.
3. Compton, R.R. (1966). *Manual of Field Geology*. 2nd ed., New York, Wiley.
4. Lahee, F (1987). *Field Geology*, CBS Publishers, New Delhi.
5. Mathur, S.M. (2001). *Guide to Field Geology*. Prentice Hall India. New Delhi.
6. Gokhale, N.W. (2001). *A Guide to Field Geology*. CBS Publishers, New Delhi.
7. Coe, A.L. (ed). (2010). *Geological Field Techniques*. Open University Press, Milton Keynes, UK.
8. Barnes, J.W. (2004). *Basic Geological Mapping*. John Wiley & Sons Inc., New Delhi.
9. Freeman, T. (1999). *Procedures in Field Geology*. John Wiley & Sons Inc., New Delhi.

CORE ELECTIVE

PAPER - 3

B. ANALYTICAL TECHNIQUES AND INSTRUMENTATION

Unit I

Introduction to analytical chemistry: Qualitative and quantitative analysis. Classification of methods. Types of instrumental analysis, various instrumental techniques and laboratory safety.

Unit II

Laboratory techniques: Laboratory operation and practices. Units of measurements. Laboratory notes. Errors and evaluation. Determination of accuracy. Statistical evaluation of data.

Unit III

Petrological microscope: Principles, parts, operation and application of Petrological microscope, Ore microscope and Scanning electron microscope. Preparation of thin section. Preparation of rock powder for chemical analysis. Rock digestion through acid treatment, Rock digestion through fusion with alkali salts.

Unit IV

Geochemical sampling techniques: Sampling methods and principles, Types of sampling, sampling interval. Heavy mineral separation methods. Flame photometer and UV spectrometer: Basic principles, parts, operation and mechanism.

Unit V

Instruments used for geochemical analysis: Basic concept and techniques of Atomic Absorption Spectrometer (AAS), Inductively Coupled Plasma - Atomic Emission

Spectrometer (ICP-AES), X-Ray Diffraction (XRD), X-Ray Fluorescence (XRF) and Differential Thermal Analysis (DTA).

Text / Reference Books:

1. Dana, E.S., (1955), Text book of Mineralogy, John Wiley., Deer,
2. W.A., Howie, R.A. and Zussman, J., (1996), The Rock forming Minerals-Longman.,
3. Flint, Y., (1970), Basic crystallography, Mid Publishers.,
4. Francis Rouessac and Annick Rouessac., (2007), Chemical Analysis (Modern Instrumentation Methods and Techniques) John Wiley & sons, 574p.,
5. Hutchinson, C.S., (1974), Laboratory Handbook of Petrographic Techniques-John Wiley.,
6. Kerr, P.F., (1959), Optical Mineralogy, McGraw Hill.,
7. Klein, C. and Hurlbut, Jr. C.S., (1993), Manual of Mineralogy-John Wiley.,
8. Madhu Arora., (2008), Analytical chemistry-Himalaya Publishing House, Mumbai., Phillips,
9. Wm, R. and Griffen, D.T., (1996), Optical Mineralogy-CBS Edition.,
10. Putnis, Andrew, (1992), Introduction to Mineral Sciences-Cambridge University Press.,
11. Spear, F.S. (1993), Mineralogical Phase Equilibria and Pressure-Temperature-Time paths-Mineralogical Society of America Publ.

CORE ELECTIVE

PAPER - 3

C. MICROPALAEONTOLOGY

Unit I

Principles of Micropaleontology: Microfossils - definition, types of microfossils, uses of microfossils in various fields of Geological Sciences and Industry. Definition, scope and relationship of micropaleontology with ocean sciences. Historical developments and recent trends in micropaleontological studies including deep sea drilling (JOIDES, DSDP, ODP, IODP, JGOFS). Modern field and laboratory techniques in the study of microfossils: surface and sub-surface sampling methods, processing and separation of microfossils, preparation of faunal slides and thin sections. Field and Laboratory equipment's used for micropaleontological studies.

Unit II

Calcareous Microfossils I: Dimorphism, test morphology, wall structure, chamber shape and arrangements, aperture openings and ornamentation of foraminifera. Classification and evolution of foraminifera. Ecology, paleoecology and geological distribution of foraminifera. Application of foraminifera in stratigraphy with special reference to Jurassic, Cretaceous and Tertiary periods in India.

Unit III

Calcareous Microfossils II: Morphology, hinge types, ornamentation, sculpture, orientation of carapace, classification and geological distribution of Ostracoda. Significance of ostracodes in ecology and paleo-ecological studies. Sample preparation techniques, morphology, ecology, application and geological distribution of calcareous nannofossils. Brief study of pteropods, calpionellids, calcareous algae and bryozoa.

Unit IV

Phosphatic, Siliceous and Organic-Walled Microfossils: Extraction methods, outline of morphology, composition and stratigraphic significance of conodonts. Preparation

techniques, major morphological groups and application of radiolarians. Sample collection, preparation techniques, morphology and application of diatoms. Maceration techniques, outline of morphology and application of fossil spores and pollen.

Unit V

Application of Microfossils: Application of microfossils in biostratigraphy - First Appearance Datum (FAD) and Last Appearance Datum (LAD), units of biostratigraphy and biostratigraphic correlation. Application of Microfossils in understanding patterns causes and types of global events. Micropaleontology in hydrocarbon exploration – sequence stratigraphy, subsidence analysis, thermal history and biosteering. Application of microfossils in interpretation of paleoenvironment and paleoclimate – paleobathymetry, back-tracking technique, paleo-temperature estimation and sea-level change, ocean eutrophication, acidification, environmental monitoring, paleoclimate and paleomonsoon. Application of micropaleontology in oceanography, paleogeography and engineering geology.

Text / Reference Books:

1. Armstrong, H. and Brasier, M.D., (2005). Microfossils. Blackwell Publishing.
2. Bignot, G., (1985). Elements of Micropaleontology. Graham and Trotman.
3. Brasier, M.D., (1980). Principles of Microfossils. George Allen & Unwin.
4. Burger, H.R. (1992)- Exploration Geophysics of the Shallow Subsurface: Prentice Hall.,
5. Parasnis D.S. (1975). Principles of Applied Geophysics, Chapman and Hall.
6. Dobrin M.B. (1981) Introduction to Geophysical prospecting. McGraw Hill International Book Company.
7. Dobrin, M.B. (1976) :-Introduction to Geophysical Prospecting Brooks,
8. Glaessner, M.F., (1945). Principles of Micropaleontology.
9. Gunter Faure. (1998) – Principles and applications of Geochemistry–Pearson
10. Haq B.U. & Boersma A (1998). Introduction to Marine Micropaleontology, Elsevier.
11. Jones, D.J. (1969). Introduction to Microfossils. Hafner Publishing Co., New York.
12. Jones, R.W., (1996). Micropaleontology in Petroleum Exploration. Oxford.
13. Kathal, P.K., (1997). Microfossils and their applications. CBS Publishers.
14. Kearey, P and Brooks, M (1984) An Introduction to Geophysical Exploration-ELBS.,

15. Lowire. W. (1997) - Fundamentals of Geophysics. Cambridge Low price Editions.,
16. Martin, R.E. (2000). Environmental Micropaleontology. Springer.
17. Mason.B (1966); Principles of Geochemistry – Willey Toppan.
18. Mathur S.M. (2001) – Guide to Field Geology: Prentice Hall of India
19. McKinstry H.E. (1960) - Mining Geology: Asia Publishing House
20. RamachandraRao M.B.(1975) – Outlines of Geophysical Prospecting – A manual for Geologist: University of Mysore.
21. Robinson. E.S. and Coruh.C. (2002)- Basic Exploration Geophysics– John Wiley.,
22. Sharma,P.V. (1986), Geophysical methods in Geology, Elsevier
23. Stanislane, M. (1984), Introduction to Applied Geophysics, Reidel Publishers

OPEN ELECTIVE

PAPER - 3

(to choose one out of 3)

A. RAINWATER HARVESTING AND ARTIFICIAL GROUNDWATER RECHARGE

Unit I

Hydrological cycle and its components. Surface water and groundwater. Vertical distribution of groundwater. Over-exploitation of groundwater - Need for artificial recharge and rainwater harvesting - types of wells - drilling technology - design, construction and development of water wells: dug, bore and tube wells.

Unit II

Types of pumps - various artificial recharge structures: recharge ponds - recharge pits - percolation ponds - basin spreading - surface and subsurface dykes - recharge wells - recharge bore wells. Rainwater harvesting in urban areas: RWH structures - design - construction.

Unit III

Estimation of probable runoff from an area including from rooftops - maintenance and monitoring of RWH structures. Study of benefits - effects on local groundwater environments - remedial measures. Recycling of domestic water - sources of water to recharge in urban areas. Aquifer and its types.

Unit IV

Water table and its fluctuations. Water quality parameters. BIS and WHO standards. Watershed management strategy. Salt water intrusion and remedial measures. Interlinking of rivers in India. Indian monsoon pattern. Role of meteorological department.

Unit V

Groundwater management strategy, recycling of effluent water, sources of water contamination and remedial measures. Impact of urbanization on water resources. Definition for river basin, sub basin, watershed and micro watershed. Role of public in watershed management practices at village level.

Text / Reference Books:

1. Rajora, R., (1998), Integrated Watershed Management, Rewat Publications, New Delhi. Tideman, E. M.,
2. Lal, S., (2004), Watershed, Development, Management and Technology, Mangal Deep Publications, 358p.
3. Paranjape, S. et al., (1998), Watershed Based Development: A Source Book, Bharat Gyan Vigyan Samathi, New Delhi.
4. Suresh, R., (2002), Soil and Water Conservation Engineering, Standard Publishers and Distributors, Delhi.
5. Kakade, B. K., (2002), Soil and Water Conservation Structures in Watershed Development Programmes, BAIF Development Research Foundation, Pune.

OPEN ELECTIVE

PAPER - 3

B. ENVIRONMENTAL GEOLOGY

Unit I

Environmental Geology

Earth's place in space. Fundamentals concepts of Environmental Geology: Human Population Growth - Sustainability - Earth as a System - Hazardous Earth Processes - Scientific Knowledge and Values. Internal Structure of the Earth and Plate Tectonics - Plate Tectonics & Environmental Geology. Minerals and Rocks. Ecology and Geology.

Unit II

Natural Hazards

Hazards, Disasters, and Nature Processes - Evaluating Hazards: History, Linkages, Disaster Prediction, and Risk Assessment - Fundamentals principles concerning Nature Hazards - Human response to Hazards - Global Climate and Hazards - Population Increase, Land - use Change and Nature Hazards.

Unit III

Volcanoes and Earthquakes

Earthquakes: Magnitude and intensity. Plate boundary related Earthquakes - Earthquake processes (Faulting, Tectonic group). Earthquake shaking (seismic waves, seismograph) - Earthquake cycle - Earthquake caused by Human Activity - Effects of Earthquakes - Tsunami - Earthquake risk and Earthquake prediction - Earthquake warning system. Volcanic activity - Volcanic Hazards, Forecasting volcanic activity. Landslides: Human use Landslide - Minimizing the Landslide Hazards - Perception of Landslides.

Unit IV

River, Flooding, and Coastal Hazards

Rivers and Flooding: Sediments in River - River velocity, Discharge, Erosion, and Sediments deposition - Effects of Land - use Change - Channel Pattern & Floodplain Formation - River Flooding - Urbanization & Flooding - The Nature and Extent of Flood Hazards - Adjustments to Flood Hazards - Perception of Flooding. Coastal processes: Erosion - Coastal Hazards & Engineering structure - Human activity and Coastal erosion - Perception of and Adjustment to Coastal Hazards.

Unit V

Resources and Pollution

Water Resources: A brief global prospective surface water - Groundwater - Interactions between surface water and Ground water - Desalination - Water Managements - Water and Ecosystem. Water Pollution: Selected Water Pollutions - Oxygen - Demanding Waste - Pathogenic Organisms - Nutrients - Toxic Substances - Synthetic Organic Chemicals - Heavy Metals - Surface Water Pollution and Treatment - Point Source and Non-point Source - Ground water Pollution and Treatment. Mineral resources: Mineral of Human use - Geology of Mineral Resources - Environmental Impact of Mineral Development - Recycling Mineral Resource Energy. Geothermal Energy.

Text / Reference Books:

1. Bennett, M. R. B., Doyle, P. (1997) Environmental Geology By. John Wiley & Sons, New York. Rekha Ghosh and D. S. Chatterjee. Environmental Geology – Geoecosystems Protection in Mining Areas. Capital Publ. Co., New Delhi.
2. Carla W. Montgomery WCH Wm.C (1989). Environmental Geology, Brown Publishers Dubuque, Iowa
3. Chiras, D.D, (1989) Environmental Science – A framework for decision making, Addison – Wesley Publishing Company. New York.,
4. Davis, N. et. Al., (1976) Environmental Geosciences, John Wiley and Sons, New York.,
5. Detwiler, T.R, (1971) Man's Impact on Environment, McGraw Hill
6. Keith, L. H. (1996) Principles of Environmental Sampling. ACS Professional Reference book, Amer. Chem. Soc., Washington DC.
7. Khoshoo, T. L. (1988) Environmental Concerns and Strategies. Ashish Publ. New Delhi.
8. Montgomery, C.W., (1989) Environmental Geology, Brown publications.,
9. Ray, P. K. and Prasad, A. K. (1995) Pollution and Health. Wiley Eastern Publ., New Delhi.,
10. Strahler, A.N., (1973) Environmental Geology, John Wiley and sons, New York.,
11. Subramanian, V. (2002), A Text book in Environmental Science, Narosa Publishing House, New Delhi
12. Valdiya, K. S. (1987) Environmental Geology - Indian Context. McGraw Hill Publ.,

OPEN ELECTIVE

PAPER - 3

C. WATER QUALITY ANALYSIS

Unit I

Physical properties of water: Colour, odour, taste, temperature, turbidity and viscosity. Methods of analysis of physical properties. World Health Organization (WHO) and Bureau of Indian Standards (BSI).

Unit II

Chemical properties of water: pH-alkalinity, acidity and their measurements, ionization potential, gas solubility, precipitation and dissolution of ions, equivalent weight and its measurements, colloids and coagulation, insoluble components and their measurements.

Unit III

Laboratory methods of Analysis: standard solutions-determination of Ph-Hardness Dissolved oxygen-BOD-COD, TDS-TSS. Determination of F, Cl, N, P, K, Na, Ca, Mg, Fe, CaCO₃, HCO₃ & Trace Metals.

Unit IV

Utility of standards required for potable, Agricultural and Industrial purposes. Tools used for assessing the quality of water.

UNIT V

Water pollution: Urban, Industrial pollution and remedial measures. Arsenic and Fluoride content in water. Recycling of water, water borne diseases, Reverse Osmosis (RO) system and Desalination of water. (Content – 3 Hrs. Assessment – 2 Hrs.) (5 Hrs.)

Reference Books:

1. Davis, N.S., DeWeist, R.J.M. (1996) Hydrogeology, John Wiley, New York.
2. Todd, D.K., (2002) Ground Water 3rd edition, John Wiley, Singapore.
3. Freeze, R.A., Cherry, J.A. (1979) Ground water, Prentice Hall, New Jersey.
4. Sawyer, C.N., McCarty, P.L., (1978) Chemistry for Sanitary Engineers, 3rd edition, McGraw Hill, New York.
5. APHA (1980) Standard Methods for the Examination of Water and Waste Water, 15th edition, American Water Association and Pollution Control Federation, New York.

SEMESTER IV

PAPER - 12

GEOGRAPHIC INFORMATION SYSTEM (GIS) AND APPLICATIONS

Unit 1

Introduction to GIS: Definition, Basic Concepts, history and evolution, Components, applications areas, and overview of GIS. Data structure: Spatial and Non-spatial. Data formats – Advantages and disadvantages of raster and vector data. Polygon structures – Arc Node structures. Digitization: Manual and Automatic.

Unit II

Spatial data: introduction, maps and their influence on the character of spatial data.

Thematic characteristics. Other sources of spatial data. Map Projection and its types. Attribute data management, introduction, database, creating a data base, GIS data base applications. Spatial -Raster -Vector - data base development, data input and editing.

Unit III

Spatial data models - Spaghetti model, Topology model, Grid model, Digital Terrain models, and TIN model. Attributedatamanagement-introduction -datamodels-creatingadatabase- GISdatabaseapplications.

Unit IV

Spatial Analysis: Logic, general arithmetic, statistical, geometric operations. Query and report generation from attribute data, geometric data search and retrieval, classification reclassification, integrated geometry and attributes, overlay, buffer zones, raster data overlay, integrated data analysis. Spatial interpolation techniques. Exposure to GIS software's. Definition and concept of Web GIS - advantages and limitations of Web GIS.

Unit V

GIS Applications in Natural Resource management, Mineral resources exploration, Geology, Ground water potential zone, locating sites suitable for ground water recharging, groundwater contamination. Mapping and monitoring of forest cover, land use land cover mapping. Coastal Zone Management.

Reference Books:

1. Concepts and Techniques of Geographic Information Systems CP Lo Albert K W Yeung, 2005 Prentice Hall of India.
2. Principles of GIS for Land Resources Assessment by P.A. Burrough, Oxford : Science publications, 1986.
3. Geographic Information Systems – An introduction by Tor Bernhardsen, John Wiley and Sons, Inc, New York, 2002.
4. GIS – A computing Perspective by Micheal F. Worboys, Taylor & Francis, 1995.
5. Geographical Information Systems – Principles and Applications, Volume I edited by David J. Maguire, Michael F Goodchild and David W Rhind, John Wiley Sons. Inc., New York 1991.
6. Geographical Information Systems – Principles and Applications, Volume II edited by David J. Maguire, Michael F Goodchild and David W Rhind, John Wiley Sons. Inc., New York 1991.
7. Amdahl G (2002) Disaster Response: GIS for Public Safety, Published by ESRI, Redlands California.

PRACTICAL-III

ECONOMIC GEOLOGY AND MINING GEOLOGY

Economic Geology

Study of, Industrial and ore minerals with special emphasis on physical, chemical characteristic mode of occurrences and uses

Mining Geology

Problems relating to evaluation of Ore reserves.

PRACTICAL – IV

HYDROGEOLOGY, REMOTE SENSING AND GIS

Hydrogeology

Estimation of chemical dissolved constituents: major, minor and traces ingroundwater using standard laboratory techniques.

Diagrammatic representation of hydrochemical data: bar, circular radial, multivariate schoeller diagram, fourcoordinatediagram, stiffs diagram, horizontal and vertical scale diagram. Plotting on maps-Piper, U.S. Salinity Laboratory diagram, Wilcox, Doneen, Gibbs and Durov plots.

Groundwater exploration techniques: geophysical and geological methods of ground water exploration.

Pumping test: time draw down and time recovery tests and evaluation of aquifer parameters.

Remote sensing and GIS

Aerial Photography: Stereovision Test, Pocket & Mirror Steoscope-3D Observation, Demarcation of marginal informations, Interpretation of drainage pattern, landforms, rock types and structures.

Satellite remotesensing: Identification photo Recognition elements. Interpretation of satellite data for geomorphology, structure and lithology. Exposure to Digital Image Processing techniques, spectral plot for different features.

GIS: Geo-Referencing. Digitization, Preparation of Vector and Raster Image, Buffer analysis, and Overlay analysis.

CORE ELECTIVE

PAPER - 4

(to choose one out of 3)

A. INDUSTRIAL MINERALS AND MINERAL ECONOMICS

Unit I

Introduction: Industrial minerals and rocks. Identification of minerals: Physical properties of minerals. Mineral wealth of Tamil Nadu. Mineral based Industries in India. Geology, Mode of occurrence and origin of the raw materials of the following Industries: Refractory and abrasives.

Unit II

Mode of occurrence, origin and distribution of economic minerals of India: Ceramic materials, construction materials-cement raw materials, mineral pigments, asbestos, mica and fullers earth. Mineral fertilizers: Geology, source, uses, production and distribution of potash, nitrates, phosphates, gypsum, lime, sulphur, and minor fertilizer minerals.

Unit III

Mode of occurrence, origin and distribution of industrial minerals: Industrial properties of rocks: Building stones, decorative stones: Granite Industry: Granites, black Granites (Dolerites) their mode of occurrence, origin and distribution. Cement Industry: Limestone, gypsum - Origin and distribution in Tamil Nadu. Gem Industries: Gem varieties. Clay mineralogy: Physico-chemical and structural properties of clay minerals.

Unit IV

Mineral economics and its concepts. Classification and mineral resources. Peculiarities inherent in mineral Industry. National mineral Policy and conservation of mineral resources. Mines and Mineral legislation in India, Mining laws in various lands, Law of Seabed for marine mineral resources. Mineral taxation.

Unit V

Strategic, critical and essential minerals, present and future mineral supplies of World, India's mineral production, Consumption, export and import details and their role in National economy. Tenor, grade and specification of important minerals with relevant to domestic examples.

Reference Books:

1. Aiyengar, N.K.N.1964, Minerals of Madras, Dept. of Industries and Commerce, Madras,
2. Alan M.Bateman , 1961, Economic mineral deposits, Asia Publishing House, Mining Geology, H.E. McKinstry, Asia publishing house, 1960.
3. Coggin Brown, J. &Dey, A.K.1955, India's Mineral Wealth, Oxford University Press,
4. Deb, S., 1980, Industrial minerals and Rocks of India, Allied Publishers Pvt. Ltd.
5. Evans, A.M. (1993) Ore Geology and industrial minerals, Blackwell.

6. Gkhale, K.V.G.K. and Rao, T.G.1972, Ore deposits of India, Thompson press Ltd., Delhi – 6, Indias
7. Krishnaswamy, S.1972, Mineral Resources, , Oxford and IBH Publishing Co.,
8. Lindgren, W. 1933, Mineral deposits, McGraw Hill Book Co.,
9. Minerals for Atomic Energy, Robert, D.Nininger,D.vanNostrand Co., 1955.
10. Ralph, B.Grim, 1968, Clay Mineralogy, , McGraw Hill Book, Co.,
11. Sinha, R.K and Sharma , B.N.L., 2019, Mineral Economics, Fourth edition, Oxford and IBH Publishing Co

CORE ELECTIVE

PAPER - 4

B. MINING AND ENGINEERING GEOLOGY

MINING GEOLOGY

Unit I

Mining terminology, classification, geological factors considered for the selection of mining method viz.- Alluvial/Surface mining, Quarrying, Open-cast mining, and Underground mining methods; Geological conditions for-Types of openings, their position, shape and size -adits, inclines, shafts, levels, cross-cuts, winzes and raises. Types of drilling methods. Explosive types, composition and its applications. Surface mining *machineries*.

Unit II

Alluvial mining: Types of placer mining, Panning, hydraulicking, Mechanical methods. Opencast mining Methods – bench cut, glory hole, strip mining. Factors considered for mechanization and transportation. Underground mining methods - board and pillar, room and pillar, long wall mining. Mine supports, Mine ventilation and Drainage. Mining hazards. Mines and Minerals Act.

ENGINEERING GEOLOGY

Unit III

Scope of geology in civil engineering and mining industry. Various stages of engineering geological investigations for civil engineering projects. Engineering properties of rocks, rock discontinuities, physical characters of building stones, concrete and other aggregates. Use of remote sensing in engineering geology.

Unit IV

Geological considerations for the construction of dams and reservoir sites. Types of dams, dam foundation, rock problems. Geotechnical evaluations of tunnel alignments

and transportation routes. Methods of tunneling; Classification of ground for tunneling purposes; various types of support.

Unit V

Geological considerations for the construction of roads/ highways and bridges. Mass Movements with special emphasis on landslide and causes of hill slope instability. Engineering consideration of seismicity, influence of geological condition on foundation and design of buildings, seismic resistant structure, earthquake problems in India.

Text / Reference Books:

1. Arogyaswamy, R.N.P. (1994). Course in mining Geology. Oxford IBH – New Delhi.,
2. Chandra, B. Krishna, J and Chandrasekaran, A. (1994). Elements of Earthquake Engineering. South Asian Publishers.
3. Deshmukh, R.T. (1993) High Technology in Drilling and Exploration, Oxford-IBH, New Delhi.,
4. Gupta, H.K. and Rastogi, B.K. (1976). Elements of mining Technology Dhanbad publishers. Dhanbad.
5. Indian Bureau of Mines (1979) Dams and Earthquakes. Elsevier Scientific Publishing Company.,
6. Mineral exploration. IBM, Nagpur., Krynine, D.H. & Judd, W.R. (1998) Principles of Engineering Geology, CBS Edition.,
7. Mckinstry, H.E. (1980). Mining Geology, Prentice Hall, N.Y., Parbinsingh 1991.
8. Peters, W.C. (1987) A Text Book of Engineering & General Geology. Kataria & Sons.,
9. R.W. (1997). Geological methods in Mineral Exploration and Mining, Chapman & Hall, London.
10. Schultz, J.R. & Cleaves, A.B. (1951). Geology in Engineering, John Willey & Sons.,
11. Stahler A.N. and Strahler A.M. (1973). Environmental Geoscience-John Wiley & Sons., Venkatramiah, 1989 Engineering Geology. Wiley

CORE ELECTIVE

PAPER - 4

C. APPLIED GEOLOGY AND GEOSTATISTICS

UNIT I

Mining methods—criterion for selecting mining method. Sea bed mining. Exploitation/Recovery/Mining/Extraction of petroleum. Mining legislation in India. Plans to be prepared and maintained in a mine – EMP, Mining Plan, Mine Closure Plan, Surface Plan, etc. Underground gasification of coal and lignite. Fundamentals of ore dressing - crushing, grinding, sizing, jigging, tabling, floatation. Spiraling, Magnetic and electrostatic separation. Beneficiation of ores by bio-leaching method.

UNIT II

Scales of measurement: nominal, ordinal, interval and ratio. Averages: Mean, Median, Mode, Geometric mean and Harmonic mean. Measures of dispersion: Range, Mean deviation, Variance, Standard deviation, and quartile deviation, coefficient of variation (Only the Concepts & numerical problems in the field of geology). Elements of probability: random experiments, sample space, event, disjoint events, definitions of probability, independence of events. Addition theorem, multiplication theorem, Bayes' theorem.

UNIT III

Concept of Random variables, probability distributions; standard probability distributions: Binomial, Poisson, and Normal. Importance of sampling in data collection; sampling techniques: simple random sampling, systematic sampling, stratified sampling and cluster sampling. Parameter and statistic; sampling distributions: normal, t, chi square and F.

UNIT IV

Introduction to statistical inference: Estimation, testing of hypothesis (basic principles, importance of statistical inference in decision making with suitable examples in Geology); t-test of mean, t-test for equality of means, Chi square test of

independence, analysis of variance: one-way and two-way (numerical problems); Non-parametric tests (name of the tests and their applications only).

UNIT V

Geological measurements of sequences of data: Correlation and simple linear regression (concepts, least squares method, simple problems in geology); Moving averages and Kriging, trend analysis, multiple regression, principle component analysis, discriminant analysis, cluster analysis, factor analysis.

Reference Books:

1. Davis J. C. Statistics and data analysis in Geology. Wiley.
2. Harbadigh J. M. and Merriam U. F. Computer applications in stratigraphic analysis. Wiley 1968.
3. Miller R. L. and Khan T. S. Statistical analysis in geological analysis. Wiley 1962.
4. Moroney K. J. Facts from figures. Penguin 1952.
5. Krumbein M. B. and Gray Hill H. A. Introduction to statistical methods.
6. Gaudin A. M. Principles of mineral dressing. McGraw Hill.
7. Taggart A. P. Handbook of mineral dressing. Wiley.
8. Paul P., Mishra G. C. and Panda D. K. Modern mining equipments beyond 2000AD as applicable to the limestone mining industry. National Council for Cement and Building, Materials, New Delhi.
10. Bhaskarathondaiman K. Blasting technology. India Cements, Tirunelveli.
11. Biran K. K. and Ramaswamy P. Surface miner – ecofriendly equipment for open cast mines. Mining engineers journal, V. 1(11), 2000.
12. Surana I. S. Mining without drilling and blasting Mining Engineers Journal v 2(9), 2000.

OPEN ELECTIVE

PAPER - 4

(to choose one out of 3)

A. GEOHERITAGE, GEOPARKS AND GEOTOURISM

Unit I

Introduction and importance of Geodiversity, Geoheritage, Geoconservation; Geoparks and Geotourism; History of the concept

Unit II

Geological outcrops and society; Threats to geodiversity; Conservation, protection, maintenance of geological sites and related features of National importance; Conservation of geosites as a tool to protect geoheritage.

Unit III

Potential geoparks and geosites in India; Rajasthan, Odisha, Karnataka, Andhra Pradesh, Madhya Pradesh, Telangana, Tamil Nadu, Kerala, Gujarat, Himachal Pradesh

Unit IV

UNESCO geoparks, Geopark networks across the globe; Geotourism and National geological Monuments.

Unit V

Guidelines for selection of Geosites; Geoheritage laws, Role of local, state and national governments; Current status of Geoheritage protection in the country; Global geoheritage and protection laws.

Reference Books:

1. A Monograph on National geoheritage monuments of India, Indian National Trust for Art and Cultural Heritage, Natural Heritage Division, New Delhi
2. Ranawat, P. S., George, S., 2016 Potential Geoheritage&Geotourism Sites in India International Journal of Scientific and Research Publications, Volume 9, Issue 6, June 2019
3. EzzouraErrami, Margaret Brocx (Ed.) 2009. Geoheritage, Geoparks and GeotourismConservation and Management Series Springer. P 268.

OPEN ELECTIVE

PAPER - 4

B. INTRODUCTION TO GEOSPATIAL TECHNOLOGY

Unit I

Remote Sensing: Definition, Electromagnetic spectrum – Energy sources – Electromagnetic spectrum with atmosphere and earth surface features – spectral signatures – atmospheric windows.

Unit II

Types of remote sensing based on Energy sources – active and passive, Platforms – aerial and satellite, and Sensors – optical, thermal and microwave. Satellite orbiting mechanisms, types of resolution. A short account of LANDSAT, SPOT and Indian Remote Sensing satellites. Introduction to GPS.

Unit III

Geographic Information System: Definition, components of GIS, Data structures: Spatial and Non-spatial, Advantages and Disadvantages of spatial data. Polygon structures: Arc Node structures. Digitization: Manual and Automatic. Data input and output.

Unit IV

Spatial Analysis: Logic, general, arithmetic, statistical, geometric operations. Query and report generation from attribute data, geometric data search and retrieval, classification reclassification, integrated geometry and attributes, overlay, buffer zones, raster data overlay, integrated data analysis. Spatial interpolation techniques. Exposure to GIS software's. Definition and concept of Web GIS.

Unit V

Remote Sensing and GIS Applications: Natural Resource management, Urban planning, Agriculture, Geology, Ground water potential zone, locating sites suitable for ground water recharging, groundwater contamination. Mapping and monitoring land use land cover mapping. Coastal Zone Management.

Text and Reference Books:

1. Burrough P A (1986). Principles of GIS for Land Resources Assessment, Oxford University Press.
2. ChorPang Lo and Albert K W Yeung (2016). Concepts and Techniques of Geographic Information Systems. Pearson.
3. Curran P.B. (1985). Principles of Remote Sensing. ELBS. London.
4. Gupta R.P. (2003). Remote Sensing Geology. Springer. New Delhi.
5. Lillesand T.M & R.W. Kiefer. (2000). Remote Sensing and Image Interpretation. Wiley.
6. Micheal F. Worboys (1995). GIS – A computing Perspective. Taylor & Francis.
7. Miller V.C. (1961). Photogeology. McGraw Hill. New York.
8. Reddy A. (2010). Principles of Remote Sensing and GIS. CBS. Delhi.
9. Sabins F.F. (1974). Remote Sensing Principles and Interpretation. Freeman. New York.
10. Tor Bernhardsen (2002). Geographic Information Systems – An introduction. John Wiley and Sons, Inc, New York.

OPEN ELECTIVE

PAPER - 4

C. DISASTER MANAGEMENT

Unit I

Introduction to Disaster: Definition, Nature, Importance of Hazard, Risk, Vulnerability and Disaster- Dimensions & Scope of Disaster Management - India's Key Hazards – Vulnerabilities - National disaster management framework - Disaster Management Cycle. Types of disaster: natural and manmade.

Unit II

Natural Disaster: Natural Disasters - Definition and nature, their types and effects. Floods, drought, cyclone, earthquakes, tsunami, landslides, avalanches, volcanic eruptions, Heat and cold waves, Climatic change: global warming, Sea level rise, ozone depletion.

Unit III

Man Made Disasters: Definition, Causes and Impacts: Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire, oil fire, air pollution, water pollution, deforestation and industrial waste water pollution.

Unit IV

Disaster Mitigation: Concepts – Need - Mitigation measures – Guiding principles. Types of disaster mitigation: Structural and Non-structural. Preparedness vs. Mitigation. Disaster Mitigation strategies: Government of India Initiative.

Unit V

Disaster Management: Pre- disaster stage (preparedness) - Preparing hazard zonation maps, Predictability/ forecasting & warning - Preparing disaster preparedness plan - Land use zoning - Preparedness through Information, education. Emergency Stage - Rescue training for search & operation - Immediate relief - Assessment surveys. Post Disaster stage: Rehabilitation - Social Aspect - Economic Aspect and Environmental Aspect. Indian scenario of hazard preparedness.

Text and Reference Books:

1. Sharma.S.R, "Disaster management", A P H Publishers, 2011.
2. VenuGopalRao.K, "Geoinformatics for Disaster Management", Manglam Publishers and Distributors, 2010.
3. Singh.R.B, "Natural Hazards and Disaster Management: Vulnerability and Mitigation", Rawat Publications, 2006.
4. Gupta.H.K, "Disaster Management", University Press, India, 2003.
5. Gupta.M.C, "Manuals on Natural Disaster management in India", National Centre for Disaster Management, IIPA, New Delhi, 2001.
