

M.Sc., BRANCH - GEOLOGY
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF EXAMINATIONS 2012-2013 ONWARDS

Semester-I

Code	Theory & Practical			
		L	P	C
GEOC 101	Geomorphology & Structural Geology	4	0	3
GEOC 102	Advanced crystallography, Mineralogy and Mineral optics	4	0	4
GEOC 103	Indian Stratigraphy and Marine Geology	4	0	3
ENGE 116	Soft Skill (English)	3	0	4
GEOP 104	Practical – I Structural geology, Crystallography and field visits reports.	0	14	4
	Total	15	14	18

Geological Mapping training - Two week's duration

Semester- II

Code	Theory & Practical			
		L	P	C
GEOC 201	Geophysical Exploration	4	0	4
GEOC 202	Photo Geology, Remote sensing & GIS Modeling	4	0	4
GEOC 203	Hydrogeology and Engineering Geology	4	0	4
GEOP 204	Practical – II Mineralogy, Mineral optics , Geological Mapping camp report	0	8	4
GEOP 205	Practical – III Photogeology-Remote sensing, Digital image processing and GIS	0	8	4
GEOP 206	Practical – IV Geophysics, Hydrogeology and Engineering Geology & Surveying	0	6	3
Option-1	Optional – I Geostatistics	3	0	4
	Total	15	22	27

Industrial/ institutional training -Three week's duration during Annual holidays

Semester- III

Code	Theory & Practical			
		L	P	C
GEOC 301	Economic Geology and Mining Geology	4	0	4
GEOC 302	Geological and Geochemical Exploration	4	0	4
GEOC 303	Advanced Igneous and Metamorphic Petrology	4	0	4
GEOC 304	Applied Sedimentology and Micropaleontology	4	0	4
GEOP 305	Practical – V- Economic Geology and Geochemical exploration, Micropaleontology, Industrial/ Institutional Training report	0	11	2
Option-2	Optional – II Basic Chemistry	3	0	4
	Total	19	11	22

Short Field visits to nearby geological interested places during week end & holidays

Semester-IV

Code	Theory & Practical			
		L	P	C
GEOC 401	Coal and Petroleum Geology	4	0	4
GEOC 402	Isotope geology & Instrumentation Techniques in Geoscience.	4	0	4
GEOC 403	Atmospheric Sciences and Meteorology	4	0	4
GEOP 404	Practical-VI. Igneous, Metamorphic Petrology & Sedimentology		8	4
GEOP 406	Dissertation and Viva-Voce		4	1
GEOO 415	Optional – III Environmental Geology and Disaster Management	3	0	2
Optional-4	Optional – IV English for competency examinations	3	0	4
	Total	18	12	23

L= Lecture: P = Practical C = Credit – (Core = 72 + Soft skill = 4 + optional = 14)

Total Papers : 25 Total Marks: 2500: Total credits : 18 + 27 + 22 + 23 = 90

End semester Theory: 25 (IA) + 75 (E) = 100

Internal Test (2) = 15; Assignment =5; Seminars = 5; **Total = 25**

Practical: 40(IA) + 60 (E) = 100

Practical: I & III,IV Test (1) = 30: Record = 10; **Total = 40**

Practical II, & V, Report= 15: Test (1) = 15 Record = 10 **Total=40**

Dissertation report-60 and Viva Voce-40

IA = Internal Assessment, E = End Semester written Examination,

GEOC101GEOMORPHOLOGY AND STRUCTURAL GEOLOGY

UNIT – I PRINCIPLES AND PROCESS OF GEOMORPHOLOGY

Basic principles and Concept of Geomorphology, erosion cycles. Historical and process Geomorphology. Processes – weathering, pedogenesis, mass movement, erosion, transportation and deposition, Influence of climate on processes. Geomorphic processes and landforms – fluvial, glacial, eolian, coastal and karst. Earth's gravity and magnetic fields and its thermal structure: Concept of Geoid and, spheroid; Isostasy. Theories of palaeomagnetism. Ice ages and their periodicity.

UNIT – II INDIAN GEOMORPHOLOGY AND APPLICATIONS OF GEOMORPHOLOGY

Indian plate tectonics: configuration of Indian plate, mobile belts in peninsular India. Evolution of Himalaya and Himalayan tectonics. Applications of geomorphology in mineral prospecting, civil engineering, hydrology, structure, lithology and environmental studies. Geomorphology of India.

Unit – III: STRUCTURAL PROPERTIES OF ROCKS:

Mechanical properties of rocks-deformation - three stages - elastic, plastic and rupture. Theory of stress and strain. Behaviour of minerals and rocks under stress. Mohr circle. Various states of stress and their representation by Mohr circles.

Unit – IV: FEATURES OF ROCKS:Geometry and analyses of brittle-ductile and ductile shear zones. Sheath folds. Geometry and mechanics of development of folds, boudins, foliations and lineations. Interference patterns of superposed fold. Geometry and mechanics of Fault; Fault-related folding. Gravity induced structures. Recognition of fold and fault in the field, determination of top and bottom of beds, introduction to map reading

Unit – V: STRUCTURAL ANALYSIS:

Structural analysis: Principles and elements of structural analysis of simple and complex structures – Microscopic to macroscopic scale. Petrofabric analysis: Field technique-laboratory technique and interpretation. Stereographic projection – equal area projection and structural analysis. Tectonites, their classification and geological significance.

BOOKS FOR STUDY

01. Billings, M.P, (1974), Structural Geology, Prentice Hall of India.
02. Davies, F. (1999). Dynamic Earth, Cambridge University Press.
03. Dayal, P. (1990). A Text Book of Geomorphology, Shukla Book Depot, Patna.
04. Duff.P.Mcl.D. (1992), Holmes, Principles of Physical Geology, Edited by 4th Ed. Chapman and Hall, London.
05. Fairbridge, R.W. (1968), Encyclopedia of Geomorphology, Reinhold Book Corporation.
06. Hobbs, Means and William, (1976), an outline of Structural Geology, Wiley International Edition.

07. Jeanm Goguel, (1962). Tectonites, W.H. Freeman & Co.,
08. King, L.C. (1967), Morphology of the Earth, 2nd Ed. Oliver & Boyd, London.
09. Leopold, L.S. et.al. (1964), Fluvial processes in Geomorphology, Eurasia Publishing House, New Delhi.
10. Park, R.C. Blackies, (1988). Geological Structures and moving plates, Chapman and Hall, New York.
11. Phillips Edward, F.C. (1994). The use of Stereographic projection in Structural Geology, Arnold Publishers.
12. Ramsay, J.G., Huber, M.I., (1987), Vol.2, The Techniques of modern Structural Geology, Folds and Fractures.
13. Robert R. Compton, (1962), John Wiley & Sons, Manual of field geology, INC, Newyork, London.
14. Sharma, H.S. (1990), Indian Geomorphology, concept Publ. Co., New Delhi.
15. Thornbury, W.S. (1969), Principles of Geomorphology, Wiley Eastern, New Delhi.
16. Windley. B.F., John Wiley & sons, (1978). The Evolving continents, Allen Cox, 1973. Plate Tectonics, Freeman and company.

GEOC 102 ADVANCED CRYSTALLOGRAPHY, MINERALOGY & MINERAL OPTICS

OBJECTIVE: Concepts in Mineralogy and Crystallography. Chemical and mathematical elements involved in the formation of natural inorganic materials. Study of physical, chemical and optical properties of minerals.

UNIT-I: CRYSTAL SYMMETRIES AND NOTATIONS:

Crystalline and amorphous states of matter, symmetry elements, translation, rotation, reflection, inversion, screw and glide-point groups. Crystal classes-Derivation of 32 crystal classes based on Schoenflies notation, Hermann Mauguin system. Bravais lattices and their derivation. An outline on space groups.

UNIT-II: X-RAY DIFFRACTION METHODS & APPLICATIONS:

X-ray diffraction method: basic principle, powder method: Bragg's law and its application. Calculation of cell dimensions. Method of identification of minerals from X-ray diffractogram. Crystal Projections: Spherical, Stereographic and Gnomonic-Zones. Zone symbols and Weiss Zone law equation, Law of anharmonic ratio-Napier's rule-Equations to Normal-Calculation of interfacial angles, axial ratios, Miller indices.

UNIT-III: OPTICAL & CHEMICAL MINERALOGY:

Optical classification of minerals: Optical properties: Refractive indices, Pleochroism, Birefringence. Optic sign, Uniaxial and biaxial interference figures. Optic axes, Optic axial angle measurements-Optic orientation-Optical anomalies. Atomic structure, Chemical bonds. Structural classification of silicate minerals. Transformation of minerals – polymorphism, polytypism, and polysomatism. Solid solution and exsolution. Isomorphism, Atomic substitution, Pseudo-morphism-Flourescence in minerals. Metamict state. Bonding of common oxides, sulphides and silicate minerals.

UNIT-IV: SILICATE STRUCTURES AND STUDY OF IMPORTANT SILICATE GROUP OF MINERALS:

Brief account of silicate structure and distinguishing features and geochemical significances of the following group of minerals. Framework silicates: Feldspar, Feldspathoid, Zeolite and Scapolite. Chain silicates: Pyroxene and Amphibole. Sheet silicates: Mica, Chlorite and clay minerals.

UNIT-V: SILICATE AND NON SILICATE MINERALOGY:

Description of chemical, optical and physical properties, distinguishing features, paragenesis of the following important group of minerals: Ortho and ring silicates: Olivine, Garnet, Alumino silicates and Epidote. Study of following individual minerals: Zircon, Staurolite, Beryl, Cordierite and Tourmaline. Non-silicate- Spinel group, Carbonates and Phosphates.

BOOKS FOR STUDY:

01. Azaroff, L.V. & W.H.Berger, (1959). The powder method, Mc Graw Hill Book Co., American mineralogist special volumes on Mineralogy.
02. Babu, S.K. and D.K.Sinha, (1987), Practical Manual of Crystal Optics, CBS Publishers & Distributors.
03. Berger, W.H. (1956). Elements of Crystallography, John Wiley and sons.
04. Berry Mason, L.G. (1961). Mineralogy, John Wiley & Sons
05. Dana, E.S. (1935). A Text Book of Mineralogy, John Wiley & Sons
06. Deer, W.A, Howie, R.A and Zussman, J, Longmans, (1966), An Introduction to Rock Forming minerals,
07. Deer, W.A., Howie, R.A., Zussman, J., (1962), Longmans,. Rock forming minerals (Vols1-5).
08. Ernest, E. Walhstrom, (1960). Optical Crystallography, John Wiley & Sons
09. Kerr, B. F. (1959), Optical Mineralogy, 5th Ed. Mc Graw Hill, New York, Evans, 1966. An introduction to Crystal chemistry, R.C., Cambridge University Press,
10. Mitra, S. (1986) Fundamentals of Optical, Spectroscopic and X-ray Mineralogy, S.R.Technico Book House, Ashok Raj Path, Patna.
11. Ralph, B.Grim, (1953), Clay mineralogy, Mc Graw Hill Book Co.,

GEOC 103 INDIAN STRATIGRAPHY AND MARINE GEOLOGY

UNIT-I: PRINCIPLES OF STRATIGRAPHY AND PRECAMBRIAN OF INDIA

Principles of stratigraphy, Geological time-scale. Nomenclature and the modern stratigraphic code. Lithostratigraphic, chronostratigraphic and biostratigraphic subdivisions. Concept of sequence stratigraphy. Methods of stratigraphic correlation including Shaw's Graphic correlation. Stratigraphic correlation of fossiliferous and unfossiliferous strata. Dharwar-Stratigraphy and their economic importance-Cuddapah Basin structure and tectonics, Stratigraphy and economic importance; Vindhyan system, its fossils, age and economic importance.

UNIT-II: PALEOZOIC & MESOZOIC ROCKS OF INDIA

Cambrian to carboniferous system, their distributions, geological succession and fossils. Age discussion of the saline series-Gondwana group-classification, geological succession, distribution, correlation, structure, sedimentation, fossils, palaeogeography and economic importance. Triassic and Jurassic system of extra peninsular region and Kutch, their stratigraphy, classification and faunal characteristics. Cretaceous system, Trichinopoly and Pondicherry, its stratigraphy, distribution and faunal characteristics, Palaeogeography of Cretaceous Period.

UNIT-III: CENOZOIC, QUATERNARY GEOLOGY & IGNEOUS PROVINCES OF INDIA

Deccan traps and their distribution, structural features-inter-trappean and infra-trappean beds, Lameta beds, age and economic importance. Tertiary group; Cretaceous-Tertiary transition in India. Siwaliks - their distribution, constitution, sedimentation, climate, fossil assemblages and correlation. Quaternary geology; Pleistocene-Holocene system-division and distribution-Glacial and interglacial periods - igneous epochs in India.

UNIT-IV: MARINE ENVIRONMENT AND PROCESS

Origin of ocean water- Physical and chemical properties of sea water- Morphology of oceans: Continental margins, continental shelf, Continental slope, rise, submarine canyon, ocean floor, Abyssal hills, sea mounts and trenches. Ocean circulation: Causes and characters, surface currents, deep water circulation. Ocean waves and tides. Shore and Shoreline processes - sediment types, character, movement and distribution. Satellite applications in marine process. Sea level processes and Sea level changes. Sea Surface temperature.

UNIT-V: MARINE ENVIRONMENT & PRODUCTS:

Deep sea sediments and classification. Life in the ocean; major environmental domains, modes of marine life. Marine resources: heavy minerals, petroleum hydrocarbons, gas hydrates, Mn-nodules, Phosphorite, L.St. Evaporites (Salt and gypsum). Marine pollution, Coastal zone management and conservation. Thermohaline circulation and oceanic conveyor belt. Formation of Bottom waters; major water masses of the world's oceans. Oceanic sediments: Factors controlling the deposition and distribution of oceanic sediments; geochronology of oceanic sediments, diagenetic changes in oxic and anoxic environments. Tectonic evolution of the ocean basins, Marine mineral resources in Indian continent, evolution of east and west coast of India.

BOOKS FOR STUDY:

01. Arkall, W.S. (1956), Jurassic Geology of the World, Oliver and Boyd Ltd., Edinburg.
02. Bowen, D.C. (1978), Quaternary Geology, Pergamon press.
03. Detrich, G. (1963), General Oceanography, Interscience, London.
04. Gignox, M.(1960), Stratigraphic Geology, Paris.
05. Grabau, A.W., (1957), Principles of Stratigraphy, John Wiley and Sons, Newyork.
06. James, (1982), Deltas, Process of deposition and models for exploration, M.Colman,2nd Ed. International Human Resources Development Corporation, Boston.
07. Krishnan, M.S. (1982), Geology of India and Burma, 6th Edition, CBS Publishers and distributors.
08. Palivaal, B.S. (1998), The Indian Precambrian, Scientific Publishers, Jodhpur.
09. Ravindra Kumar, (1985), Fundamentals of Historical Geology and Stratigraphy of India, Wiley Eastern Ltd, New Delhi.
10. Read, H.H, and Watson, (1972), Earth's History,1, 2, Vols.,London
11. Wadia, D.Tata (1975), Geology of India, McGraw Hill Pub. Co., 4th Ed.
12. Weller, J.M. (1960), Stratigraphic principles and practice, Harper & Bros, Publishers, New York.
13. Keith Stowe, (1979), Ocean science, John Wiley and Sons, Newyork.
14. Kennett, J.P. (1982), Marine Geology, Prentice Hall, Inc. New Jersey.
15. King, (1967), An Introduction to oceanography, Mc Graw Hill Book Co., New York.
19. Kuenen, Ph.H. (1950), John. John Wiley & Sons, Marine Geology.
20. Shepard, F.P. (1960), Submarine Geology, John Hopkins press.

GEOC 201GEOPHYSICAL EXPLORATION

OBJECTIVE: To know and understand the Physical properties of the Earth and its application to the exploration of Mineral resources.

UNIT I Field Theory:

Introduction of field theory, Gauss's law, Maxwell's equation, Laplace and Poisson's equations and its applications; Electric field in material space, electromagnetic theory and displacement currents; Electrostatic boundary value problems; Magnetostatic field; Magnetic forces, materials and devices; wave propagation and wave guides; power law and Helmholtz's theorem; Green's theorem, Stokes's theorem, Gauss's theorem, Isomorphism extension theorem, Luroth's theorem, Primitive element theorem, Wedderburn's little theorem, Simpson's rule, bisection methods, Numerical solution and partial differential equations, Gauss's quadrature formula.

UNIT –II. Gravity, Magnetic fields and Methods

Normal gravity field; Clairaut's theorem; Shape of the earth; Deflection of the vertical, Geoid, Geophysical properties of rocks. Principles of major methods, their applications and limitations.

Geomagnetic field, Secular and transient variations and their concepts. Palaeomagnetism concepts. Gravity and Magnetic methods: Fundamental principles, types of gravimeter, and field procedures. Corrections and reduction of anomalies; ambiguity; interpretation of anomalies of simple geometric bodies, single pole, sphere, horizontal cylinder, sheet, dyke and fault. Correlation and interpretation of data. Application of gravity and magnetic methods in mineral exploration

UNIT- III. Electrical and Electromagnetic Methods:

Electrical methods: Principles of self potential method, Resistivity method, Electrical Resistivity Tomography (ERT). Electrical profiling and sounding, typical sounding curves, Induced polarization methods. Electromagnetic field techniques; transient electromagnetic methods; magneto-telluric method; geomagnetic depth sounding.

UNIT- IV. Seismology and Seismic Methods:

Elements of earthquake seismology; seismic sources, faulting source, double couple hypothesis, elastodynamics, Haskell's function, focal mechanism and fault plane solutions; seismic gaps; Generalized Snell's Law; Ray theory; reflection, refraction, diffraction; Seismic methods : Principles of reflection and refraction methods, seismic energy sources; detectors; recording and telemetry devices; Field procedures, and weathering corrections; Interpretation of a refraction seismic data by graphical and analytical techniques; seismic reflection data processing, velocity analysis, F-K filtering, stacking and application in petroleum exploration

UNIT- V. Well logging

Well logging principles and concepts. Open hole, cased hole and production logging; Electrical logs; lateral, latero, induction, S.P; porosity logs; sonic, density, neutron; natural gamma;; logging while drilling.

BOOKS FOR STUDY:

1. Mathew N.O, Sadiku, 2007.Elements of Electromagnetics,, Fourth edition, Oxford University Press.
2. B.D. Gupta, 2001. Mathematical physics., Sangam Books Limited.
3. S.S. Sastry, 2005.Introductory Methods of Numerical Analysis, , PHI Learning Pvt Ltd. Delhi.

4. Brooks, A.R. (1972), Geobotany and Biogeochemistry in mineral exploration, Harper and Row.
5. Dobrin, M.B. (1960), Introduction to Geophysical prospecting, , Mc Graw Hill Book Co., New Delhi.
6. D.A. Cox, (1995), The elements of Earth , Oxford University Press, New York
7. Govett, G.J.S. (Ed) (1983). Handbook of Exploration Geochemistry, Elsevier.
8. Hawkes, H.E. and Webb, (1965), Geochemistry in Mineral Exploration, Harper and Row Publishers.
9. Mason and Moore, (1985), Principles of Geochemistry, Wiley Eastern Ltd. New Delhi.
10. Mc Kinstry, H.E. (1960). Mining Geology, Asia publishing house, Course in Mining Geology.
11. Parasnis, D.S. (1975). Principles of Applied Geophysics, Chapman and Hall. Pacal, 2nd Ed. 1977,
12. Ramachandran Rao, M.B. (1975), Outlines of Geophysical prospecting (A Manual for Geologists) Prasa Ranga, University of Mysore,
13. Rose, A.W.Hawks, H.E. and Webb, J.A. (1979), Geochemistry in Mineral Exploration, Academic press.
14. Sharma, P.V. (1986), Geophysical methods in Geology, Elsevier.
15. Stanislane, M. (1984), Introduction to Applied Geophysics, Reidel Publishers.
16. Telford.W.M, Sheriff, R.E., Gelot, L.P, (2001), Applied Geophysics (Second Edition) Cambridge University press.London.

GEOC 202 PHOTO GEOLOGY, REMOTE SENSING&GIS AND MODELLING

OBJECTIVE: To understand the concepts, interpretation techniques, applications of aerial photo and satellite remote sensing images.

UNIT–I: Aerial Photography

Introduction of aerial photography: Scale of photographs, displacement and distortions significance. Stereoscope, viewing and stereoscopic parallax. Photo mosaics, aerial triangulation, orthophotographs. Fundamentals of photogrammetry, tone, texture. Fundamentals of digital photogrammetry. Concepts of map projection. Applications of aerial photo in geomorphology, geology(drainage pattern, structure, soils & vegetation) and geotechnical.

UNIT – II: principles of remote sensing and thermal remote sensing

Remote sensing concept, definition and types, an overview of Indian space mission. Electromagnetic spectrum, energy sources and radiation principles. Energy interaction in the atmosphere, energy interactions with earth's surface, Atmospheric windows, Types of sensors and platforms. Resolution and scanning mechanism. Basic principles of Thermal Remote Sensing. Black body radiation, thermal inertia.

UNIT – III Microwave and Image Processing

Passive microwave Remote Sensing: Basics: Physics of Radar waves, Spectral Characteristics. Active microwave Remote sensing: SLR spectroscopy and RADAR geometry. SAR interferometry principles.

Image processing: Digital data-concepts of image processing. Image rectification and restoration. Geometric correction, Radiometric correction. Image enhancement and filtering. Image, Classification. Hyperspectral imaging: Concepts and techniques.

UNIT – IV: Introduction to GIS and Data Sources

Global Positioning Systems: Definition and basic concepts. Data types and models. Spatial/Geometrical data-Raster data, Vector data, Attribute data, spaghetti and topology model. Advantages and disadvantages of raster and vector data formats. Data sources: map scanning and digitizing, topology building, editing, cleaning, linking of spatial and non-spatial data. Data processing: Updating, correction and map projection. Advanced data models. Grid model, TIN model, Network model and combination of models.

UNIT-V Spatial Analysis and Application

Logic, general arithmetic, statistical and geometric operations. Query and report generation from attribute data. Overlay, buffer zones, raster and vector overlay methods. Spatial interpolation. Web GIS: overview advantages and limitations.

Application of Remote Sensing and GIS: in landform and land use mapping, structural mapping, hydrogeological studies, Natural hazard management. and mineral exploration. GIS modelling.

BOOKS FOR STUDY:

01. Curran, P, (1985), Principles of Remote sensing, Longman, London.
02. Drury, S.A, (1987), Image interpretation in Geology, Allen and Unwin. Drury, S.A. 1990, A guide to Remote Sensing, Oxford Science Publication.
03. Gupta, R.P, (1991), Remote sensing geology, Springer - Verlag, Heidelberg.
04. Lillesand, T.M and Keifer, R.W, (1987), Remote sensing & Image interpretation, 3rd Ed., John Wiley and sons.
05. Miller, F.H. and Kikhal, E.M. (1980), Photogrammetry, Harper and Row publishers, New York.
06. Miller, V.C. (1961), Photogeology, Mc Graw Hill, New York.
07. Pandey, S.N. (1987), Principles of applications of photogeology, Wiley Eastern Ltd., New Delhi.
08. Paul R.Wolf and Bon A. Dewitt, (1974), Elements of Photogrammetry, Mc Graw Hill, New York, Tokyo.
09. Ray.R.G, (1969), Aerial photographs in geological interpretation, USGS proc., Pap.373. Rampal; Handbook of aerial photography and image interpretation for resource management, John Wiley & sons, New York.
10. Sabbins, F.F, (1985), Remote sensing principles and application, Freeman, Sanfrancisco.
11. Schanda, E, (1976), Remote sensing for Environmental sciences, Springer-Verlag.
12. Verstappan, T.H, (1977), Remote sensing in Geomorphology, Elsevier scientific publishing co., Amsterdam.

GEOC 203: HYDROGEOLOGY AND ENGINEERING GEOLOGY

OBJECTIVE: To know and understand about the distribution and abundance and threat to water resources. techniques to find ground water resource.

To know about the engineering properties and rocks and geological features.

UNIT -I: Origin, Occurrence and Distribution of Water

Origin of water: meteoric, juvenile, magmatic and sea waters, Hydrologic cycle - precipitation, runoff, infiltration and evapotranspiration, Hydrographs. Subsurface movement and vertical distribution of groundwater, Springs, Classification of aquifers, Concepts of drainage basin and groundwater basin. Hydrological properties of rocks - specific yield, specific retention, porosity, hydraulic conductivity, transmissibility, storage coefficient, water table fluctuations -causative factors, water table contour maps, Water bearing characteristics of different geological formations, Hydro-stratigraphic units, Groundwater provinces of India.

UNIT -II: Well hydraulics and Well design

Theory of groundwater flow, Darcy's law and its applications, methods of determination of permeability in laboratory and in field. Types of wells, drilling methods, construction, design, development and maintenance of wells. Specific capacity and its determination. Unconfined, confined, steady, unsteady and radial flow conditions, Pumps tests - methods, data analysis and interpretation for hydrogeologic boundaries, Evaluation of aquifer parameters using Thiem, Theis, Jacob and Walton methods

UNIT -III: Groundwater Chemistry and Management

Groundwater quality - Physical and chemical properties of water, Quality criteria for different uses, Graphical representation of water quality data, Groundwater quality in different provinces of India - Problems of arsenic and fluoride, Saline water intrusion in coastal and other aquifers and its prevention. Groundwater development in urban areas and rain water harvesting, Artificial recharge methods, Groundwater problems in arid regions and remediation. Groundwater balance and methods of estimation. Groundwater legislation. Sustainability criteria and managing renewable and non-renewable groundwater resources.

UNIT -IV: Major Isotopes in Groundwater

Stable isotopes in water cycle: Relation between $^{18}\text{O}/^{16}\text{O}$ and $^2\text{H}/^1\text{H}$ in natural waters, Evaporation, Clouds and Precipitation, marine and continental atmosphere. Isotope effects in precipitation: The latitude / annual temperature effect, Seasonal effect, Oceanic and continental precipitation. Altitude effect, Amount effect. Inter-annual variations, Small-scale variations, Palaeoclimate reconstruction. Tritium in the atmosphere, Characteristics of tritium, Geophysical aspects, Hydrological aspects. Atmospheric CO_2 , Atmospheric CO_2 concentrations, Stable carbon isotopes in atmospheric CO_2 , Stable oxygen isotopes in atmospheric CO_2 . Radiocarbon in atmospheric CO_2 . Water Sampling and Treatment, Water sampling and storage. Laboratory

treatment of water samples : $^{18}\text{O}/^{16}\text{O}$ analysis , $^2\text{H}/^1\text{H}$ analysis, ^3H analysis of water , ^{14}C analysis of dissolved inorganic carbon , $^{13}\text{C}/^{12}\text{C}$ analysis of dissolved inorganic carbon.

UNIT- V: Concepts in Engineering geology:-

Role of geology in Engineering projects: Engineering properties of rocks. Choice of rocks as constructional, road metals and their distribution in India, Nature and properties of building stones. Seismic zones and designing structures. Soil mechanics. Stability of slopes. Geological considerations in the construction of tunnels, dams, bridges roads and reservoirs. Dams classification and parts of dams. Systematic dam site investigation. Geological, geomorphologic and geophysical investigations for foundation studies. Water fitness of reservoirs and, failure of dams. Important river valley projects of India. Tunnels: types, systematic investigations of sites and problems in the construction of tunnels.

Chain survey –types –accessories –cross staff –optical square-base, tie, check line setting –ranging line–offset distance. Compass surveying–description–bearings–local attraction–errors and its correction. Levelling–dumpy level–temporary adjustment–levelling staff–recording reducing level by both methods. Theodolite–use–measurement of horizontal angles – repetition and reiteration methods –vertical angles

BOOKS FOR STUDY:

01. Davie and De Weist, (1965), Hydrology, John Wiley and Sons.
02. Gautam Mahajan, (1995), Groundwater Surveys and Investigations, Ashes Publishing House, New Delhi.
03. Geohydrology, Rogar, J.M.Deweist, (1965), John Wiley and sons.
04. Howrman Bower, (1965), Ground water Hydrology, Mc Graw Hill Book Co.
05. Karanth, K.R. (1986), Hydrology, S.R.Technico Book house, Ashok Raj path, patna-6.
06. Karanth, K.R. (1998), Groundwater Management, S.R.Technico Book house, Ashok Raj path, patna-6.
07. Krynine, D.P. and Judd, W.R. (1957), Principles of Engineering and Geotechniques, Mc Graw Hill Book co.
08. Legget, H.F. (1962). Geology and Engineering, Mc Graw Hill Book co.
09. Ragunath, H.M. (1983). Ground water, John wiley & sons,
- 10.** Rogar, J.M. Deweist, (1965), Geohydrology John wiley and sons,
11. Subramanya, K. (1994). Engineering Hydrology, Tata Mc Graw Hill.
12. Todd, D.K. (1980).Groundwater Hydrology, John Wiley and Sons, 2nd Ed.
13. Tolman, C.P. (1998), Ground water, Mc Graw Hill Book Co.
14. Zaruba, Q. and Menci, V. (1976). Engineering Geology, Elsevier Scientific Publishing Co.,

GEOC 301 ECONOMIC GEOLOGY AND MINING GEOLOGY

OBJECTIVES: To know about the economic mineral processes and the distribution of metallic and non-metallic minerals deposits in India. Ores and their genesis. Emphasizing to understand the various techniques in mining, mine environment and mineral economics.

UNIT-I: PROCESS OF MINERAL DEPOSITS

Classification of mineral deposits. Process of formation of mineral deposits - Magmatic concentration, sublimation, contact metasomatism, hydrothermal process, sedimentation, evaporation, residual and mechanical concentration, oxidation and supergene enrichment and metamorphism. Controls and localization of mineral deposits. Metallogenic epochs and provinces. Geological thermometry.

UNIT-II: METALLIC AND NON METALLIC MINERALS

Study of following metallic mineral deposits, their origin, occurrence & distribution in India and uses: Gold, Silver, Platinum, Aluminium, Iron, Manganese, Chromium, Vanadium, Molybdenum, Tungsten, Nickel, Cobalt and Titanium, Copper, Lead, Zinc, Magnesium and atomic minerals. Study of important non-metallic industrial minerals including origin, occurrence, distribution in India and uses - asbestos, mica, baryte, talc, ceramic minerals, building stones, cement raw materials, mineral pigments. Refractory materials, abrasive minerals, fertilizer minerals, and gemstones.

Unit-III: ORE PETROLOGY & MINERAL ECONOMICS

Principles of Ore microscopy and Ore microscope. Polishing and mounting of ores. Physical and optical properties of ore minerals. Ore textures and paragenesis. Micro chemical techniques and application of ore microscopy. Mineral economics and its concept. Peculiarities inherent in mineral industry. Strategic, critical and essential minerals. Tenor, grade, cut-off grades and specification of minerals with relevant to domestic examples. National mineral policy 2008 – India's mineral production, export & import and price of major minerals in India and mineral taxation.

UNIT –IV: EXPLORATION AND SURFACE MINING

Methods of investigation of ore bodies: rock sampling techniques. Ore reserve estimation. Introduction to mining. Classification of mining methods. Cycles of mining operation. Surface mining, drilling methods and types of drills. Mine explosives and bench parameters, mine haulage.

UNIT –V: SUB SURFACE MINING AND MINE ENVIRONMENT:

Subsurface mining methods. Basic concepts. Shaft, adit, winze, raise, stope, mine support and ventilation. Outline of underground coal mining methods. Mine machineries, organization and structure of a mine. Role of geologist in mining industry. Mining legislations. Preparation of mine plan, mining scheme. Environmental impact assessment and management plans, mine accidents, miner's diseases.

BOOKS FOR STUDY:

01. Aiyengar, N.K.N. (1964), Minerals of Madras, Dept. of Industries and Commerce, Madras.
02. Alan M. Bateman, (1961), Economic mineral deposits, Asia Publishing House.
03. Arogyaswami, R.N.P. (1970). Course in Mining Geology, Oxford and IBH Publishing house,
04. Deb, S. (1980), Industrial minerals and Rocks of India, Allied Publishers Pvt. Ltd.

05. Gokhale, K.V.G. K. and T.G. Rao, (1972), Ore deposits of India, Thompson press Ltd., Delhi – 6, India.
06. Krishnaswamy, S. (1972). India's mineral Resources, Oxford & IBH Publishing Co.,
07. Lindgren, W. (1933), Mineral deposits, Mc Graw Hill Book Co.
08. Mc Kinstry, H.E. (1960). Mining Geology, Asia publishing house,
09. Sinha, R.K. and Sharma, B.N.L (1973). Mineral Economics, Oxford and IBH Publishing Co.,
10. William, C.Peters, (1989) Exploration and Mining Geology, John Wiley and sons, Second Ed.
11. Young, C.J. (1940). Elements of Mining, Mc Graw Hill Book co.,

GEOC 302 GEOLOGICAL AND GEOCHEMICAL EXPLORATIONS

OBJECTIVE: To develop skill in the exploration of Earth resources using geological, and geochemical tools. To know the different sampling methods and sample preparation for exploration of mineral resources.

UNIT –I: GEOLOGICAL MAPPING:

Reconnaissance Vs detailed mapping, surface mapping. Degree of precision, choice of scales, isolation of outcrops. Sampling, general principles. Methods of sampling: channel, chip, grab, pitting, trenching, digging. Sampling errors and precautions. Topographic expression of ore bodies: Physiographic relations of placer deposits, guides to channels, location of pay streaks. Physiography in relation to oxidation and enrichment. Residual ores, supergene sulphide zones; mineralogical guides. Rock alteration: nature of alteration, target rings of mineral distribution.

UNIT –II: GUIDES FOR EXPLORATION:

Physiographic guides, Stratigraphic and lithological guides, supergene deposits, reasons for favorability, competent Vs incompetent formations. Examples of favorable formations-applications. Fracture pattern as guides: (Structural guides): Mechanical principle of fracturing, vein patterns. Contacts and folds as guides: Contacts, folds, folds younger than the ore; folds older than ore; dislocated ore bodies. Persistence of ore in depth: probable position and shape at deeper levels pitch and changes in shape.

UNIT –III: INTRODUCTION TO GEOCHEMISTRY OF EARTH AND GEOCHEMICAL PROCESSES IN THE ENVIRONMENT:

Geochemistry, Introduction, definition, aim and scope. Origin and abundance of elements. Distribution of elements in lithosphere. Geochemical cycle- Geochemical classification of elements. Geochemical differentiation of elements in exogenic and endogenic cycle. Redox reactions and Eh-pH diagrams and their applications.

UNIT-IV: CONCEPTS IN GEOCHEMICAL EXPLORATION TECHNIQUES-I:

Geochemical Exploration: Geochemistry in Mineral Exploration: Introduction, Principles of geochemical exploration, geochemical environment. Study of geochemical dispersion, mobility, geochemical association. Methods of surveying and sampling: Anomalies, background value, threshold value, path finder elements.

UNIT-V: CONCEPTS IN GEOCHEMICAL EXPLORATION TECHNIQUES-II:

Methods of geochemical exploration: (a) Litho-geochemical prospecting (b) Hydrogeochemical prospecting (c) Biogeochemical prospecting (d) Geobotanical prospecting. Anomalies in Residual overburden. Leached ore outcrops, Gossans and Residual soils transported overburden. Geochemical

anomalies map and interpretation of data. Geochemical trace element indicators and their significance. Problems in geological interpretation of geochemical data.

BOOKS FOR STUDY:

01. Jenners, 1987. Geochemical exploration, Universal Books Distributors Co.,
02. Rankama and Sahama, (1950), Geochemistry, University of Chicago Press,
03. Arthur Brownlow 1982, Geochemistry, Prentice Hall,
04. Fyfe, W.S. 1964, Geochemistry of solids. Mc Graw Hill Book Co.,
05. Goldschmidt, V.M. 1954, Geochemistry, Oxford University press.
06. Henderson, P. Inorganic geochemistry.
07. Kovalevskii, A.L. 1979, Biogeochemical exploration for mineral deposits, Oxonian press.
08. Krauskopf, K.B., 1986, Introduction to geochemistry, , Mc Graw Hill.
09. Mason, B. 1971, Principles of Geochemistry, John Wiley & Sons.
10. Mason, B. and Moore, C.B. 1991, Introduction to Geochemistry, Wiley Eastern
11. H.E. Hawkes, J.S. Webb. 1979. Geochemistry in Mineral Exploration, : Academic Press, London

GEOC 303 ADVANCED IGNEOUS & METAMORPHIC PETROLOGY

Objective: Understanding the origin and nature of igneous and metamorphic rocks

UNIT-I: PROPERTIES AND CLASSIFICATION OF IGNEOUS ROCKS

Forms, textures and structures of igneous rocks and their petro-genetic significance. Classification of igneous rocks: mineralogical, chemical, C.I.P.W. Niggli and Streikeissen-UGS-Classification. Phase-equilibrium studies of binary and ternary silicate system: Albite-Anorthite system, Albite - Anorthite - Diopside system, Anorthite-Forsterite-Silica system, Diopside-foresterite-Silica system with reference to petro-genesis of igneous rocks. Crystallization of basaltic magma in relation to the tectonic setting.

UNIT-II: PETROGRAPHY OF IGNEOUS ROCKS

Petrography of igneous rocks- -Petrography and petrogenesis of Granites, Pegmatites, Alkaline rocks, Mono-mineralic rocks. Anorthosites and Dunites, Lamprophyres, Carbonatites, Charnockites and Ultra-mafics.

UNIT-III: MAGMATIC PROCESS

Diversity of igneous rocks. Reaction principle, magmatic crystallization, differentiation, assimilation. Petrographic province and variation diagrams. Plate tectonics and magmatic evolution. Trace elements in igneous rocks and their significance. Fluid inclusion studies of igneous rocks. Plate tectonics in relation to magma.

UNIT-IV: METAMORPHIC ROCKS AND PROPERTIES

Metamorphic textures, structures and their significance. Grades, zones and facies of metamorphism. A critical review of facies concept, graphical representation of facies: A.C.F. and A.K.F. diagrams. Goldschmidt's mineralogical phase rule and its application - stress and anti-stress minerals. Geothermometry and Geobarometry, Fluid inclusion studies in metamorphic rocks.

UNIT-V: TYPES OF METAMORPHISM, AGE AND ITS RELATION TO TECTONICS

Retrograde metamorphism, metamorphic differentiation, metasomatism, granitisation and migmatites. Metamorphism in relation to magma and orogeny. Application of geochronological methods-Sm/Nd, U/Pb method. Determination of age of metamorphic rocks. Plate tectonics in relation to metamorphism. Regional and contact metamorphism of pelitic and impure calcareous rocks. Paired metamorphic belts. Petrogenetic aspects of important rock suites of India, such as the Deccan Traps, layered intrusive complexes, anorthosites, carbonatites, charnockites, khondalites and granitoids.

BOOKS FOR STUDY:

01. Anthony Hall, (1987), Igneous petrology, ELBS publishers.
 02. Barkar, S. (1983), Igneous rocks, Daniel, Prentice Hall, Englewood Cliffs, New Jersey
 03. Barker, A.J.Chapman and Hill, (1989). Introduction to metamorphic textures and microstructures,
 04. Barth, T.F.W. 1962. Theoretical petrology, John & Wiley and sons.
 05. Bose, M.K. (1997), Igneous petrology, World Press.
 06. Edwin Roedder, (1986), Fluid inclusions Publisher Mineralogical Society of America, Printed by Book Crafters, Inc. Chelsea, Michigan.
 07. Hess, H.H. and Poldervaart, A. (1967), Basalts, Vols, I and II, Ed., Interscience pub.
 08. Moorhouse, W.W. (1969), The study of rocks in thin sections, Harper and sons.
 09. Myron G.Best, (1982), Igneous and Metamorphic petrology, W.H.Freeman and Co., New York.
 10. Nockolds, S.R, Knox, R.W.O.B, Chinner, G.A. (1979), petrology for students, Cambridge University Press.
 11. Paul, C.Hess, (1989), Origin of Igneous rocks, Harvard University press, Cambridge, London, England.
 12. Phillipotts, A. (1992) Igneous and Metamorphic petrology, Prentice Hall.
 13. Roger Mason, (1984), Petrology of the metamorphic rocks, CBS Pub. & Distributors.
 14. Turner, F.J. & Verhoogen, J. (1960). Igneous and Metamorphic petrology, Mc Graw Hill Book Co.,
 15. Turner, F.J. and Gilbert, C.M. (1954). Petrography H.Williams, W.H.Freeman and Co.,
 16. Tyrell, G.W. (1989), Principles of petrology, Methuren and Co., (Students ed.)
 17. Wahlstrom, E.E. (1961). Theoretical Igneous petrology, John Wiley & Sons,
- Winkler, H.G.S. (1979). Petrogenesis of Metamorphic rocks, Springer Verlag Vth Ed

GEOC 304 APPLIED SEDIMENTOLOGY AND MICROPALAEONTOLOGY

OBJECTIVE: Aims to study about sediments, sedimentation processes at various environments along with associated life there on.

UNIT-I: ORIGIN AND CLASSIFICATION OF SEDIMENTS:

Origin of sediments. lithification and diagenesis. Classification and composition of sedimentary rocks. Textures and structures of sedimentary rocks. Definition, measurement, and interpretation of grain size. - Folk and Dunhalm classification of carbonate rocks. Physical properties of particles, porosity and permeability. Geochemical classification of sediments: resistates, hydrozates, oxidates, redusates, precipitates, evaporates. Metamorphism as a geochemical phenomenon.

UNIT-II: TRANSPORTATION AND SEDIMENTATION:

Introduction, Aqueous , Eolian ,Glacial, Gravitational processes. Heavy mineral zones and their provenance. Paleocurrents and paleogeography and their significance. Biogenic and chemical sedimentary structures. Petrography and mineralogy of clastic and non clastic rocks. . Tectonics and sedimentation.

Unit-III: Depositional Environments:

Environmental analysis: Sedimentary environment and facies concept, parameters and classification of environments. Facies model and environmental reconstruction - Alluvial Environments, Shore environment and cyclic sequences. Concept of sedimentary model- Walther's law. Sedimentary basins: Concept and classification: crustal sag, Arc-related and divergent plate boundary basins-basin evolution.

UNIT-IV: MICROPALAEONTOLOGY:

Introduction, Micropaleontological classification, sampling methods and sample processing techniques. Bathymetric distribution of microfossils. Morphological characters and palaeoecology of Foraminifera, Radiolarians, Diatoms and flagellates.

UNIT-V: PALYNOFOSSILS AND SIGNIFICANCE

Palynofossils: Separation techniques, General morphology. Spores and pollens and their geological significance. Application of Micropaleontology in geological and petroleum exploration. significance of microfossils in determination of age and correlation of palaeoclimate, palaeofacies and tectonism from microfaunal evidence.

BOOK FOR STUDY:

01. Alex S.D. Maltman, (1994). The geological deformation of sediments, Chapman Hall,
02. Folk, R.L. (1961). Petrology of Sedimentary rocks, Hemphills,
03. Galloway. W.C. and D.K.Hobdew, (1996). Terrigenous clastic sedimentary systems, Springer, Verlag, New York.
04. Gary Nichols, (1999). Sedimentology and Stratigraphy, Blackwell Science Ltd., London,
05. Kennet, J.P and Srinivasan; M.S, (1951). Foraminifera, W.H.Freeman & Co.,
06. Pettijohn, F.J, (1975). Sedimentary rocks, Harper & Bros. 3rd Ed.
07. Reineck, H.E., and Singh.J.P. (1980). Depositional sedimentary environments, Springer Verlag, New York.
08. Roy Lindholm, (1989), A Practical Approach to Sedimentology, Allen and Unwin, USA.

09. Sanders, G.M, (1978). Principles of Sedimentology, Friedman, E.J. John Wiley and sons, New York,
10. Twenhofel, W.H. (1950). Principles of sedimentation, Mc Graw Hill Book Co.,
11. Wilson, J.L, (1975). Carbonate facies in geological history, Springer Verlag, New York,
12. Bigot, G, (1985), Elements of micropaleontology, Graham & Trotman, London.
13. Kennet, J.P and Srinivasan; M.S, (1951). Foraminifera, W.H. Freeman & Co.,
Microfossils, M.D., Brasier, (1980), George Allen & Unwin, London.

GEOC 401: COAL AND PETROLEUM GEOLOGY

OBJECTIVE: To gain knowledge about the hydrocarbons, their formation, varieties and distribution. To understand the different sedimentary basins of India and methods of exploration of petroleum.

UNIT –I: Coal Formation, Varieties and Distribution

Geological basis of coal formation. Physical and chemical properties of coal. Varieties and ranks of coal. Development of coal facies. Types of deposition and diagenesis of coal. Coalification and bituminization. Coal bed methane and gas hydrates.

UNIT–II: Coal processes and coal Petrography

Prospecting and valuation of coal lands, Sampling of coal, Carbonization and gasification of coal, Coal petrography. Lignite deposits in India. Production of coal: export and import, conservation of coal. Distribution of Gondwana and Tertiary coal fields in India.

UNIT–III: Geology of Petroleum and Petroliferous Basins of India

Physical and Chemical properties of Petroleum. Origin, of petroleum and natural gas, source rocks, reservoir rocks and traps. Migration and accumulation of oil and gas. Porosity and permeability of reservoir rock. Types of petroliferous basins, relations between basin type and hydrocarbon richness. Classification of petroliferous basins of India, Detailed study of stratigraphy, structure and petroleum geology of Assam shelf, Cambay, Bombay, Krishna-Godavari and Cauvery Basins.

Unit–IV: Oil well Drilling Technology

Introduction to drilling methods: types of drilling operations, designing of oil well. Down hole equipment: drilling rigs, its components and functions. Drilling fluids, well-heads, casing and cementing operations. Principles of kick control, fishing jobs. Drilling methods and equipment for directional, horizontal and multilateral wells. Types of offshore drilling rigs.

UNIT–V: Well-site Geology, Formation Evaluation

Duties of a well-site geologist. Geotechnical order. Mud logging. Fundamentals of Petrophysics. Archie's Formula- porosity, permeability, Preparation of composite logs. Principles of formation testing. Well completion, Enhanced oil recovery techniques. Gas hydrates and coal bed methane.

BOOKS FOR STUDY:

1. Asquith, G. and Gibson, C (1982), Basic Well Log, Analysis for Geologists, Academic Press, London.
2. Baker, R. A. (2001), Primer of Oil well Drilling: A Basic Text of Oil and Gas Drilling, Petroleum Extension Service, University of Texas at Austin.
3. Biswas, S.K., Dave, A., Garg, P., Pandey, J., Maithani, A. and Thomas, N.J. (Eds.). (1993) Proceedings of 2nd Seminar on Petroliferous Basins of India, Dehra Dun, Dec.18-20, 1991, Vol. 1, 2 & 3 Indian Petroleum Publishers, Dehradun.
4. Bjorkee, K.o., (1989). Sedimentology and Petroleum Geology, Springer Books (India),
5. Chilinger, G.V. and Vorabutr, P. (1981), Drilling and Drilling Fluids. Elsevier Science, Amsterdam.
6. Darling, T. (2005), Well Logging and Formation Evaluation, Elsevier Science, Amsterdam.
7. Ganju, P.N. (1955), Memoirs of the GSI Petrology of Indian coals, Vol.83.
8. Gupta, P.K. and Nandi, P.K. (1995), Wellsite Geological Techniques and Formation Evaluation: A User's Manual, Vol. I, Oil and Natural Gas Corporation, Dehra Dun.
9. Hunt J.M. (1996), Petroleum Geochemistry and Geology, 2nd Edition, W.H. Freeman, San Fransisco.
10. Hyne, N.J. (2001), Nontechnical Guide to Petroleum Geology, Exploration, Drilling and Production, 2nd edition, Pennwell Corporation, Tulsa, Oklahoma.
11. Levorson, A.L. Vakils, (1972), Geology of Petroleum, Peter and Simon Limited, Bombay,
12. Moore, E.S. (1980). Coal, John Wiley & Sons,
13. North, F.K. (1985), Petroleum Geology, Allen & Unwin, London.
14. Ross C.A, (1984), Geology of Coal, Narosa book distributors.
15. Selley, R.C. (1997), Elements of Petroleum Geology, 2nd Edition, Academic Press, London.
16. Serra, O. (1984), Fundamentals of Well Log Interpretation, Vol.1 and 2. Elsevier, Amsterdam.

GEOC 402 ISOTOPE GEOLOGY AND INSTRUMENTATION TECHNIQUES IN GEOSCIENCE

Objective: To know the basic principles of Isotopes, Types of isotopes and their applications in the mineral exploration techniques and instrumentation to identify the isotopes and radionuclides. To become familiar about Exploration of Isotopes. To gain knowledge in the isotope Analytical Instruments used in Atomic Mineral Exploration. .

Unit - I INTRODUCTION

Basic principles of Isotope Geology: Mechanism of Radioactive decay and Decay series, Stable and Radioactive Isotopes. Stable isotopes, Isotope ratios and Concentrations, Isotope fractionation, Relation between atomic and Molecular isotope ratios. Radionuclide and Nuclear instability, Nuclear structure, Atomic weights, Nuclear decay and Radiation.

Unit - II RADIOACTIVE ISOTOPES

Isochron method, Model/Mineral ages, Fission track, ^{40}Ar - ^{39}Ar , U-Th disequilibrium, concordia method, ^{14}C , Be and Al. Interpretation and geological significance of ages. Radiometric dating methods – Lead method, Rb-Sr, K-Ar, C^{14} methods, Fission track dating. Scintillation counters, Nuclear Fission and Fusion techniques. Nuclear reactions, Natural production - Anthropogenic releases of radionuclides. Distribution of Radioactive elements in Igneous, Sedimentary and Metamorphic rocks, Sediment and Waters.

Unit - III STABLE ISOTOPES

Fractionation of stable isotopes in Lithosphere, Hydrosphere and Atmosphere and their applied aspect. Isotopes in Mineral exploration, Petroleum exploration, Palaeoclimate evaluation. Principles affecting stable isotope composition, continental effect, amount effect, altitude effect. Seasonal variation of isotopic composition in rain water. Nuclear power projects and power stations in India

INSTRUMENTATION TECHNIQUES I

Separation of minerals-Magnetic separation-Dielectric separation of mineral particles. Electrostatic separation-Separation; panning- rolling, sieving and hand picking.. Principles of geological application of cathode luminiscence, Flame photometer, Spectrophotometer, atomic absorption spectrophotometry, inductively coupled plasma-atomic emission spectrometry.

Unit - 5 INSTRUMENTATION TECHNIQUES II

Principles of Chromatography. X-ray fluorescence spectrometry, Scanning and Transmission electron microscopy, Micro probe analysis. Thermal ionization and gas source mass spectrometry. Isotope Ratio Mass spectrometer, Analytical methods Carbon, Nitrogen, Sulphur, Strontium.

BOOKS FOR STUDY:

01. Aswathnarayana, U. (1985), Principles of Nuclear Geology, Oxonian Press (P) Ltd., New Delhi.
02. Cox, D.A. (1995). The elements of Earth, Oxford University Press, New York.
03. Doe, B.R. (1970) Lead Isotopes, Springer Verlag.
04. Faure, G. and Powell, J.L. (1972) Strontium Isotopes Geology, Springer Verlag.
05. Faure, G. (1986), Principles of Isotope Geology, John Wiley & Sons, New York, 2nd ed.
06. Henry Faul, (1954). Nuclear Geology, John Wiley & Sons, New York,
07. Kalavaro Rankama, (1963). Progress in Isotope Geology, John Wiley and Sons, New York,
08. Kalvero Rankama, (1954), Progress in Isotope Geology, Pergamon press, London.

09. Rankama and Sahama, (1950), Geochemistry, University of Chicago Press,
10. Robert D. Ninger, D. (1955). Minerals of Atomic energy, Van Nostrand Co.,
11. Virnave, S.N. (1999). Nuclear Geology and Atomic Mineral Resources, Bharati Bhawan Publishers & Distributors,
12. B.K.Sharma, 1998, Instrumental methods of chemical analysis, GOEL, Publishing House, Meerus.
13. Galen.W.Ewing, 1975, Instrumental Techniques of chemical analysis, , 4th Ed. International student Ed. Mc Graw Hill, Book Co.,

GEOC 403 ATMOSPHERIC SCIENCES AND METEOROLOGY

Objective: To know and understand the atmospheric process and fundamentals and concepts of Meteorology.

Unit - 1 Fundamentals of Metrology

Principles of Meteorology, Thermal Structure of the Atmosphere and its Composition. Radiation: Basic Laws - Rayleigh and Mie scattering, Multiple scattering, Radiation from the Sun, Solar Constant, Effect of Clouds, Surface and Planetary Albedo. Emission and Absorption of Terrestrial Radiation, Radiation windows, Radiative Transfer, Greenhouse effect, Net radiation budget; Thermodynamics of dry and moist air: Specific gas constant, Adiabatic and Isoentropic processes, entropy and enthalpy, Moisture variables, Virtual temperature; Vertical stability of the atmosphere: Dry and moist air parcel and slice methods. Tropical convection.

UNIT II Cloud Physics and Dynamic Meteorology:

Cloud classification, Condensation Nuclei, Growth of Cloud drops and ice-crystals, Precipitation Mechanisms: Recipitation of warm and mixed clouds, Artificial precipitation, Hail suppression, Fog and Cloud – Dissipation, Radar observation of Clouds and Precipitation, Radar echoes of hail storm and Tornadoes, Radar observation of Hurricanes. Basic equations and fundamental forces: Pressure, Gravity, Centripetal and Coriolis forces, Continuity equation in Cartesian and Isobaric coordinates. Divergence and Vertical motion Rossby, Richardson, Reynolds and Froude numbers. Circulation, Vorticity and Divergence; Atmospheric Turbulence: Atmospheric Energetics:

UNIT III General Circulation and Climate Modelling:

Observed zonally symmetric Circulations, Meridional circulation models, Mean Meridional and Eddy transport of momentum and Energy, Angular momentum and Energy budgets; Zonally asymmetric features of general circulation; Standing eddies; East-West circulations in Tropics: Climate variability and Forcings; Feedback processes, Low frequency variability, MJO (Madden-Julian oscillation), ENSO, QBO (quasi-biennial oscillation) and Sunspot cycles. Basic principles of general circulation modelling; Grid-point and Spectral GCMs; Role of the ocean in climate Modeling; Internal variability of ocean fields (SST, winds, circulation, etc.) and its Relationship with Monsoon, Concepts of Ocean – Atmosphere coupled Models.

UNIT IV Synoptic Meteorology:

Tropical Meteorology: Trade wind inversion, ITCZ; Monsoon trough tropical cyclones, Their structure and Development theory; Monsoon depressions;; Western disturbances; SW and NE monsoons; Synoptic features associated with onset, Withdrawal, Break active and Weak monsoons and their prediction. Air masses and fronts: Sources, Origin and Classification of Air masses; and Fronts, Frontogenesis and Frontolysis; Structure of Cold and Warm fronts; Weather systems associated with fronts. Extra-Tropical synoptic scale features: Extratropical Cyclones and Anticyclones.

UNIT V Satellite Meteorology

Meteorological Satellites – Polar orbiting and Geostationary Satellites, Visible and Infrared radiometers, Multiscanner radiometers; Identification of Synoptic systems, Fog and Sandstorms, Detection of Cyclones, Estimation of SST, Cloud top Temperatures, Winds and Rainfall: Temperature and Humidity soundings.

BOOKS FOR STUDY:

[Donald Ahrens](#), C. (2008) Meteorology Today.

[Frederick K. Lutgens](#), Edward J. Tarbuck, Dennis Tasa , (2009) The Atmosphere: An Introduction to Meteorology (11th Edition).

[Steven A. Ackerman](#), Meteorology, John A. Knox, (2011) Third Edition.

[Frederick K. Lutgens](#), Edward J. Tarbuck, [Dennis Tasa](#), (2006) The Atmosphere: An Introduction to Meteorology (10th Edition) .

[C. Donald Ahrens](#), (2011) Essentials of Meteorology: An Invitation to the Atmosphere.

Donald Ahrens. C. (2008) Essentials of Meteorology.

[Sverre Pettersen](#), (2008) Introduction To Meteorology.

BarCharts, (2012). Meteorology (Quick Study: Academic).

James R. Holton, (2004). An Introduction to Dynamic Meteorology (International Geophysics).

[Storm Dunlop](#) , (2008). Guide to Weather Forecasting: All the Information You'll Need to Make Your Own Weather Forecast (Firefly Pocket series).

C. Donald Ahrens , (2008), Meteorology Today: An Introduction to Weather, Climate, and the Environment. Study Guide/Workbook .

Frank R. Spellman , (2012). The Handbook of Meteorology.

[Roland B. Stull](#), (1988). An Introduction to Boundary Layer Meteorology (Atmospheric Sciences Library).

[Storm Dunlop](#), (2003). The Weather Identification Handbook: The Ultimate Guide for Weather Watchers.

[Frederick K. Lutgens](#),, Edward J. Tarbuck, Dennis Tasa, (2012) The Atmosphere: An Introduction to Meteorology (12th Edition).

[Roland B. Stull](#), (1999). Meteorology for Scientists and Engineers.

GEOO 215 APPLIED GEOPHYSICS (Elective -I)

(For students other than Applied Geology Major)

Objective: Illustrating the new frontiers of geoscience as a tool for various exploration of mineral resources.

Unit - 1: FUNDAMENTAL PROPERTIES OF EARTH

. The earth and the solar system-important basic physical and chemical properties of the planet earth. Description and identification of important rock forming minerals-Physical & Optical. Description and identification of important rock types.

Unit - 2: CONCEPTS OF SEISMOLOGY

Seismology-Basic principles. Earthquakes - observational magnitude and intensity scales- Seismic wave-types. Seismological instruments and observations. Principle of seismic method of prospecting-seismic reflection-seismic refraction Oil resource exploration.

Unit - 3: ELECTRICAL EXPLORATION TECHNIQUES

Electrical method- Principles-Self-potential method (SP method)-Resistivity method-electromagnetic method (IP-method) instruments-interpretation of resistivity data. Exploration of Groundwater and mineral deposits.

Unit - 4: RADIOACTIVE AND GRAVITATIONAL METHODS

Gravity methods-Principles and application of gravity method. Radioactivity-Principles, applications and instruments-Exploration of radioactive minerals.

Unit -5: EARTH MAGNETIC FIELD AND EXPLORATION TECHNIQUES

Magnetic methods – Principles and applications of magnetic method. Principles of Palaeomagnetism – Geomagnetic fields.

TEXTBOOKS

Outlines of Geophysical Prospecting. A Manual for geophysics. (1987) M.B.Ramachandra Hao, Educational Pvt. Limited. Dehradun, India.

M.B.Dobrin, (1976), Introduction to Geophysical Prospecting, McGraw Hill Book Co., New York.

Rock Magnetism. (1961) Takesi Nagata, Plenum press, New- York.

REFERENCE BOOKS

Fowler, (1990). The Solid Earth: An introduction to Global Geophysics. C.M.R. Cambridge University press.

GEOO 315 APPLIED GEOCHEMISTRY (Elective II)
(For students other than Applied Geology Major)

Objective: Emphasizing the fundamental concept of earth chemistry primordial to present day condition and to have background idea about the earth nature in total.

Unit - 1: CHEMICAL ELEMENTS OF THE EARTH

Origin of chemical elements : Abundances of elements in cosmos and solar system and distribution of elements in the Earth's core, mantle, crust-hydrosphere and atmosphere.

Unit - 2: INTRODUCTION TO GEOCHEMISTRY

Geochemical cycle- geochemical signatures. Geochemical process of various rock formations. Study of Eh-pH diagrams.

Unit - 3: GEOCHEMICAL PROCESS

Geochemical classification of elements. Geochemical anomaly. Mobility, dispersion and association of elements-Analytical Geochemistry- AAS and ICP-MS.

Unit - 4: GEOCHEMISTRY OF RARE EARTH ELEMENTS

Classification and distribution of trace elements in various rock types. Geochemistry of Rare Earth Elements (REE) and their significances in Geological environments.

Unit - 5: ISOTOPE GEOCHEMISTRY

Radioactivity-Decay of radioactive atoms-Application of radioactivity in geochronology and in geological processes -Stable isotopes and its application to geology and geochemistry.

TEXTBOOKS

B.Mason, (1971) Principles of Geochemistry, John Wiley & Sons.

K.B.Krauskopf, Introduction to Geochemistry,

REFERENCE BOOKS

P. Henderson, 1982. Inorganic geochemistry,

RC. Evan, 1966. Introduction to Crystal Chemistry, Cambridge University Press,

GEOO 415.1 ENVIRONMENTAL GEOSCIENCE (Elective –III)

(For students other than Geology Major)

Objective: Aimed to make understanding the fundamental concepts on earth environment at various points of time from its origin

Unit - 1: FUNDAMENTALS OF ENVIRONMENTAL SCIENCES

Principles of environmental geology, Ecological perspective-Atmosphere, hydrosphere, asthenosphere, biosphere and lithosphere-their interaction and related problems. Man's influence on Earth's energy balance., Renewable and nonrenewable energy resources-alternative renewable sources.

Unit - 2: Natural Hazards

Natural hazards and environmental impacts-volcanoes, Earthquakes, landslides, floods, Normal and accelerated slope erosion-Problems and solution- Remedial measures. Atmospheric circulation-Clouds, Rainfall, air pollution, Ozone depletion-Global warming, Greenhouse effects, Acid rains.

Unit - 3: SOIL AND WATER POLLUTION

Water and Soil pollution-Water Quality and Health Problems -Kinds of Pollution-Industrial and Urbanisation-Pollutants types and sources. Engineering constructions like dams, highways and reservoirs-deforestation-

Unit - 4: MINERAL DEPOSITS AND MINING

Mining Metallic and nonmetallic deposits-Open cast and underground mining-overburden: gangue waste-generation, environmental impact and pollution management. Metallurgical operations-coal and fly ash, bauxite, red mud, furnace slag-waste utilization

Unit - 5: ENVIRONMENTAL LAW AND MANGEMENT.

Environmental laws related to water, air, forest conservation and othr acts. Environmental Education. Aims and Goals- Environmental ethics.. Environmental impact assessment .

TEXT BOOKS:

Strahler.A.N and Strahler, A.H. 1973. Environmental Geoscience, Wiley International Edition, Ignacimuthu.S 1998, Environmental Awareness and Protection, Phoenix Publishing House Pvt. Ltd., New Delhi

Caria W.Mantgomery, Environmental geology, W.M.Brown Publishers college, Division 2nd Ed.

REFERENCE BOOKS:

Valdiya, K.S. 1987, Environmental Geology, Indian context, Tata Mc Graw Hill.

Edward Keller, Environmental Geology, A.Charles E.Merrill Pub. Co., A. Bell & Howell Co., London, 4th Ed.

Upendra Kumar Sinha, 1986, Ganga-Pollution & Health Hazard Inter-India publication, New Delhi.Clays by W.E.Worrall

GEOO-415- ENVIRONMENTAL GEOSCIENCE AND DISASTER MANAGEMENT (Elective –IV)

Objective: Orientation towards sustainable management of natural resources and geohazards and management.

UNIT – I INTRODUCTION TO MAJOR ENVIRONMENTAL CONCEPTS AND NATURAL HAZARDS

Principles of Environmental Geology: Components of Environment, Atmosphere, hydrosphere, lithosphere, biosphere, their interactions and related problems. Renewable and non-renewable resources- types of alternative renewable energy sources- their advantages. Natural hazards – Endogenic: Tectonism, Volcanoes, Earthquakes, landslides and Exogenic: cumulative atmospheric hazards, cyclones, lightning, hailstorms, drought, cold waves, heat waves and floods. Drought and flood hazards in India.

UNIT –II ENVIRONMENTAL POLLUTION

Man's influence on earth's energy balance. Pollution-Concept and definition. concept of acid rain, greenhouse effect, Ozone depletion. Deforestation and erosion, global warming and climatic change concepts. Air pollution: Ambient air quality standard, Influence of nitrous oxide, sulphur dioxide, suspended matters on human health. Pollution-Water pollution-drinking water quality standards, Industrial discharge, municipal sewage discharge, agriculture run off. Types of pollutants: Organic, inorganic and radioactive materials-their fate in the environment. Principles of toxicity, bio concentration, bioaccumulation phenomena.

UNIT – III ENVIRONMENTAL IMPACTS DUE TO HUMAN ACTIVITY

Environmental impacts due to mining and mineral processing: Occupational hazard in opencast mines, control measures on noise and air in mines. Impact assessment of anthropogenic activities such as urbanization, river- valley projects, disposal of industrial and radioactive waste, excess withdrawal of ground water, use of fertilizers, dumping of ores, mine waste and fly-ash. Reclamation and rehabilitation of mined out areas

UNIT- IV. ENVIRONMENTAL IMPACTS ASSESSMENT TECHNIQUES

Environment legislation, International environmental agreements, Indian Environmental laws. Environmental Impact Assessment Techniques (EIA). Environmental Management Plan (EMP), concepts and components of environmental auditing. Environmental Gradients. Tolerance and Adaptation. Environmental education.

UNIT – V DISASTER MANAGEMENT CONCEPTS

Introduction, Theoretical concepts and developments of disaster management. The role of coordination in disaster management, Different approach to disaster recovery. Planning, Prevention and preparedness. The essential strategic planning for emergency management for coastal hazards (cyclones and storms), mine hazards, dam failure, flood, landslides hazards. The role of Disaster mitigation institution- Meteorology, seismological, volcanology, hydrology, industrial safety inspectorate- institution of urban and regional planners, awareness conservation movement, education and training of disaster.

BOOKS FOR STUDY:

01. Ignacimuthu.S (1998), Environmental Awareness and Protection, Phoenix Publishing House Pvt. Ltd., New Delhi
02. Keller.E.A, (1978), Environmental Geology, A. Charles E.Merrill Pub. Co., A. Bell & Howell Co., London, 4th Ed.
03. Strahler.A.N and Strahler.A.N, A.H. (1973). Environmental Geosciences, Wiley International Edition,
04. Upendra Kumar Sinha, (1986), Ganga-Pollution & Health Hazard Inter-India publication, New Delhi.
05. Valdiya, K.S. (1987), Environmental Geology, Indian context, Tata Mc Graw Hill. Bombay.
06. Harsh .K. Gupta (2003), Disaster Management, University Press
07. Thomas D. Schneid and Larry Collins (2001), Disaster management and preparedness: Occupational safety and health guide series, CRC Press
08. R.B Singh(Ed) (2000) Disaster Management, Rawat Publication, New Delhi.

GEOG 104– PRACTICAL -I STRUCTURAL GEOLOGY CRYSTALLOGRAPHY,

OBJECTIVE: Aim to do exercises on Structural, Geology Crystallography,

STRUCTURAL GEOLOGY:

- Calculation of True dip and apparent dip.
- Determination of Throw/Heave/ Stratigraphic separation.
- Estimation of Thickness of beds,
- Elementary structural analysis with use of stereographic methods
- Interpretation of geological and contour maps.

CRYSTALLOGRAPHY,

- Identification of crystal models
- Goniometric measurement of interfacial angles.
- Stereographic projections of crystals of Isometric, Tetragonal, Hexagonal, Orthorhombic, Monoclinic and Triclinic system.
- Calculation of axial ratios, miller indices of faces application of Weiss zone law, Tangent relationships,

Napier's rule, law of anharmonic ratio and equation to normal.

GEOP 204: PRACTICAL –II. MINERALOGY AND MINERAL OPTICS

Megascopic study of important rock forming group of minerals.

Microscopic study of important rock forming group of minerals.

Calculation of molecular and structural formulae of feldspars, Pyroxenes, Amphiboles, Olivines, Garnets, Epidote.

Determination of optical properties of minerals by classical methods.

Determination of plagioclase orientation in thin section and its Anorthite content from extinction angle measurements.

Birefringence of minerals-using Berek compensator.

Pleochroic scheme,

2V by Mallards method,

Optic signs of uniaxial and biaxial minerals.

Determination of cell dimensions and identification of minerals from X-Ray diffractogram.

GEOP 205 PRACTICAL –III. PHOTOGEOLOGY, REMOTE SENSING, DIGITAL IMAGE PROCESSING AND GIS.

PHOTOGEOLOGY:

- a. Stereo test.
- b. Tracing details from stereogram and stereo pairs after basic interpretation.
- c. Determination of photo scale
- d. Identification of landforms
- e. Preparation of land use map
- f. Identification and interpretation of drainage patterns
- g. Demarcation of groundwater potential zones
- h. Identification of geological, geomorphological and structural features
- i. Preparation of geological maps

REMOTE SENSING:

- a. Study and preparation of topographic profiles from topographic maps.
- b. Interpretations of Aerial photographs-Tone, Texture
- c. Satellite imageries-visual and stereoscopic methods, Drainage Pattern
- d. Preparation and interpretation of Coastal and Fluvial landforms
- e. Preparation of Lineaments map
- f. Preparation of land use map
- g. Demarcation of Groundwater Potential zones

DIGITAL IMAGE PROCESSING

- a. Starting ERDAS imagine, and exploring the viewer interface
- b. Identifying image statistics, Histogram, contrast enhancement
- c. Band ratios, filters, georeferencing/ rectification & principal component analysis
- d. Unsupervised classification/supervised classification and mosaicing
- e. View images and Map composer

HYPER SPECTRAL

Spectral signatures of different

- a. minerals
- b. Rocks
- c. Soils
- d. vegetation

GEOGRAPHIC INFORMATION SYSTEM:

Data encoding

- a. Raster encoding
- b. Run-Length coding
- c. Quad tree coding
- d. Scanning and conversion of images

Digital Mapping

- a. Registration
- b. Digitized coverage
- c. Edited coverage
- d. Labelling and Annotation
- e. Projection and Transformation
- f. Generation of Grid map
- g. Scaling/ Area determination

GEOLOGICAL MODELLING

- a. Exercise on data input to geological modeling software,
- b. Exercise to find end product of different rock types.
- c. Model Exercise with Modflow and PHREEQC. GMS(Groundwater Modelling Systems)

GEOP 206 PRACTICAL –IV. GEOPHYSICS, HYDROGEOLOGY AND ENGINEERING GEOLOGY & SURVEYING

OBJECTIVE: Aimed to do exercises in hydrogeology and engineering geology for better understanding ground water chemistry and process. Application of geology in civil engineering project. To know the basics of engineering surveys.

GEOPHYSICS:

Interpretation of Gravity data

Interpretation of Magnetic data

Electrical resistivity field survey and data analysis,(resist software.& IP2win).

Interpretation of Seismic data

Preparation of geophysical anomaly maps

Preparation and Interpretation of Isoresistivity maps

Interpretation of Self Potential, resistivity, Gamma γ , Neutron, Sonic, Caliper, Dipmeter, and temperature logs in oil wells and water wells

HYDROGEOLOGY:

- Calculation of Rainfall by Arithmetic method.
- Determination of catchment area by Thiessen polygon method and calculation of rainfall
- Determination of catchment area by Isohyetal method and calculation of rainfall
- Determination of catchment area by Geometric method and calculation of rainfall.
- Basinwise Groundwater Budgetting.
- Calculation of Specific yield and transmissibility from the given data
- Preparation of water table contour maps from the given data
- Interpretation of well inventory data from pump test data
- Interpretation of water well logs.
- Identification of groundwater zones from resistivity data.
- Chemical analysis of major dissolved constituent of groundwater by titrimetric method
- Chemical analysis of major dissolved constituent of groundwater by spectrophotometric method
- Chemical analysis of major dissolved constituent of groundwater by flame photometric method.
- Determination and calculation of Water quality parameters pH, EC, TDS.
- Calculation of SAR, TH, NCH, TDS, EC.
- Graphical representation of chemical analysis data and identification of type of water.
- Classification of water for drinking water by using WHO standards.
- USSL Classification of water for irrigation
- Interpretation of water quality data and determination of its use.

ENGINEERING GEOLOGY:

- Engineering properties of different geological materials.
- selection of suitable places for construction of dams from the map.
- selection of suitable places for the construction of tunnels from the map.
- selection of suitable places for the construction of reservoirs from the map.
- identification of probable Flooding area from the map and suggesting remedial measures to control flood.
- Construction of retaining walls-Problems and solutions.

SURVEYING.

- Chain survey, Compass surveying, Theodolite, Demo: Theodolite and Total station.

GEOP 305 PRACTICAL –V. ECONOMIC GEOLOGY AND GEOCHEMICAL EXPLORATION, MICROPALAEONTOLOGY

ECONOMIC GEOLOGY:

- a. Megascopic identification of ores, industrial and economic minerals,
- b. Preparation of polished ore specimens
- c. Identification of ore minerals by reflected microscope
- d. Interpretation of textures and paragenesis of ore minerals
- e. Computation of ore reserves from sampling data
- f. Estimation of ore reserves by traditional methods:
 - included area method
 - extended area method
 - triangle method
 - polygonal method
 - cross section method.
- g. Calculation of in-situ and minable reserves.
- h. Estimation of oil and gas reserves by volumetric method
- i. Computation of ore reserves from maps

GEOCHEMISTRY:

- j. Sample preparation for geochemical analysis.
- k. Preparation of A solution and B for silicate analysis
- l. Preparation of rock sample for AAS
- m. Major element analysis by using spectrophotometer
- n. Na, K, analysis by using Flame spectrometer
- o. Major elemental analysis by Titrimetric methods
- p. Preparation of Geochemistry anomaly maps
- q. Determination of background, threshold values from maps and geochemical interpretations
- r. Calculation of C.I.P.W. Norm, Niggli values
- s. Variation diagrams of Harker and Niggli
- t. ACF, AKF diagrams

MICROPALAEONTOLOGY:

- u. Study of morphological characters and Identification of selected Benthic and Planktonic foraminifera for their paleo environmental significance.

GEOP 404 PRACTICAL - VI IGNEOUS, METAMORPHIC PETROLOGY & SEDIMENTOLOGY

OBJECTIVE: Aimed to do exercises in petrography, for better understanding of rocks,

PETROLOGY:

- a. Preparation of thin sections of rocks.
- b. Megascopic identification of igneous, Metamorphic rocks.
- c. Microscopic identification of important igneous, Metamorphic rocks.
- d. Interpretation of Textures and structures of some selected igneous and metamorphic rocks, Interpretation of petrogenetic significances.

SEDIMENTOLOGY:

- e. Megascopic and Microscopic study of clastic and non clastic rocks.
- f. Determination of roundness and sphericity of grains.
- g. Granulometric analysis by sieving and determination of transport and depositional condition

Separation of heavy m