

## Postgraduate Syllabus of Geology

The M. Sc. Examination will consist of four semesters, consisting of four theory papers in each semester I & III; however there will be five theory papers including one elective paper in semester II; four theory papers including one elective paper & one Dissertation in Semester IV. Each theory paper will be of three hours duration. The core papers are of 100 marks (75 external + 25 internal) and other papers are of 75 marks (55 external + 20 internal). There will be two practical examinations (Practical A and B) in semester I, III & IV, each of four hours duration and of 100 marks (70 for written examination + 30 for internal assessment). The evaluation of Dissertation would be done by external examiner. The semester II will have three practical examination out of which Practical A and practical B are of four hours duration and of 100 marks (70 for written examination + 30 for internal assessment) and practical C would be of four hours duration with 50 marks (35 for written examination + 15 for internal assessment). In semester II & IV students will have to opt one paper as elective paper from given options.

Internal assessment will be made on the basis of assignments, presentation, seminar, and test and class room attendance. There will be two field excursions (Mapping and Exploration) each in semester I & III for 50 marks each and of three weeks duration. It is essential to pass separately in theory papers, practical, dissertation, field work and seminar. The modified curriculum will be applicable from the academic session 2014-15.

### **SEMESTER: I**

<b>Paper Code</b>	<b>Paper Title</b>	<b>Max mark</b>
4611	Igneous Petrology	75
4612	Metamorphic Petrology	75
4613	Sedimentology	75
4614	Structural Geology	75
4615	Internal Assessment Theory (4611+ 4612 + 4613+ 4614)	100
4616	Practical – A (4611+ 4612)	100
4617	Practical – B (4613+ 4614)	100
4618	Field Work (Mapping)	50
<b>Total marks : Theory 400 + Practical 200 + Field work 50 = 650</b>		

## SEMESTER – I

### Igneous Petrology

#### Theory

**Unit-I:** Magma generation in the mantle, their nature and evolution; Magmatic processes: Partial melting, fractional crystallization, assimilation, liquid immiscibility.

**Unit-II:** Study of phase equilibria in binary (Diopside-Anorthite, Forsterite- Silica, Leucite-Silica, Albite-Anorthite, Orthoclase-Anorthite) and ternary silicate systems (Orthoclase-Albite-Silica, Diopside-Albite-Anorthite, Diopside-Forsterite-Silica, Fayalite-Leucite-Silica) in the light of modern experimental works.

**Unit-III:** Petrography and interpretation of igneous textures in terms of rate of nucleation and crystal growth; IUGS classification schemes of igneous rocks: Ultramafic, mafic and felsic igneous rocks; total-alkali-silica (TAS) classification of volcanic igneous rocks.

**Unit-IV:** Petrogenesis and tectonic setting of major igneous rock types and suites: Ultramafic rocks-komatiite, lamprophyres, kimberlite; Ophiolites, flood basalt, anorthosite, Tonalite-Trondhjemite-Granodiorite (TTG), granitoids, alkaline rocks and carbonatites with special reference to Indian examples.

#### Books Recommended

- Phillpotts, A.R. (1994) Principles of Igneous and Metamorphic Petrology, Prentice Hall of India.
- Best, M. G. (2003) Igneous and Metamorphic Petrology, 2nd Edn., Blackwell.
- Bose, M. K. (1997) Igneous Petrology, World Press, Kolkata.
- Cox, K. G., Bell, J. D. and Pankhurst, R. J. (1979) The Interpretation of Igneous Rocks, Unwin Hyman.
- McBirney, A. R. (1993) Igneous petrology. Jones & Bartlet Publication.
- LeMaitre R. W. (2002) Igneous Rocks: A Classification and Glossary of Terms, Cambridge University Press.
- Wilson, M. (1993) Igneous Petrogenesis, Chapman and Hall, London.
- Kumar, S, and Singh, R. N. (2014) Modelling of Magmatic and Allied Processes. Springer, Switzerland.

### Metamorphic Petrology

#### Theory

**Unit-I:** Mineralogical Phase rule of open and closed systems; Types of metamorphism; Texture of regional & contact metamorphic rocks, deformation and metamorphism; Nature and types of metamorphic reactions; Concept and classification of metamorphic facies; Facies series; Graphical representation of minerals in ACF, AKF, AFM and A'F'M' diagrams; Time relation between phases of deformation and metamorphic crystallization.

**Unit-II:** Description of each facies of low pressure, medium to high pressure and very high pressure with special reference to characteristic minerals, subdivisions into zones/sub facies, mineral assemblages, metamorphic reactions and pressure-temperature conditions of metamorphism. Introduction to Ultra-high temperature and Ultra-high pressure metamorphism. Metamorphism of shale, mafic and calcareous rocks.

**Unit-III:** Isograds and Reaction Isograds; Schreinemakers rule and construction of Petrogenetic grids; Metamorphic differentiation; Anatexis and origin of migmatites; Paired metamorphic belts.

**Unit-IV:** Gibb's free energy; Entropy; Enthalpy; Clausius-Clapeyron equation; Geothermobarometry; Pressure-Temperature-Time (P-T-t) paths.

### **Books Recommended**

- Turner, F.J. (1980) Metamorphic Petrology, McGraw Hill, New York.
- Yardley, B.W.D. (1989) An introduction to Metamorphic Petrology, Longman Scientific and Technical, New York.
- Philpotts, A.R. (1994) Principles of Igneous and Metamorphic Petrology, Prentice Hall.
- Kretz, R. (1994) Metamorphic Crystallization, John Wiley.
- Bucher, K. and Frey, M. (2002) Petrogenesis of Metamorphic Rocks (7th Rev. Ed.), Springer-Verlag.
- Powell, R. (1978) Equilibrium thermodynamics in Petrology: An Introduction, Harper and Row Publ., London.
- Wood, B.J. and Fraser, D.G. (1976) Elementary Thermodynamics for Geologists, Oxford University Press,
- Spry, A. (1976) Metamorphic Textures, Pergamon Press.
- Winter, J.D. (2001) An introduction to Igneous and Metamorphic Petrology, Prentice Hall.

## **Sedimentology**

### **Theory**

**Unit- I:** Texture – Shape, size, fabric and surface texture, Methods of textural analysis, textural parameters and their significance.

**Unit- II:** Fluid flow mechanics and formation of sedimentary bed forms. Concept of facies and implication of facies in environmental interpretation and basin analysis.

**Unit-III:** Diagenesis -Physical and chemical processes. Evidences of diagenesis in sandstones, mud rocks and carbonate rocks. Evaporites, siliceous, phosphatic and ferruginous rocks.

**Unit- IV:** Conglomerates, Petrogenesis of sandstone, problem of greywacke, plate tectonics and sandstone composition, Argillaceous rocks-composition and classification. Dolomites, limestones - their petrographic characteristic and classification.

### **Suggested Readings:**

1. Blatt, H., Middleton, G.V. and Murray, R.C. (1980): Origin of Sedimentary Rocks, Prentice-Hall Inc.
2. Collins, J.D., and Thompson, D.B. (1982): Sedimentary Structures, George Allen and Unwin, London.
3. Lindholm, R.C. (1987) A Practical Approach to Sedimentology, Allen and Unwin, London.
4. Miall, A.D. (2000): Principles of Basin Analysis, Springer-Verlag.
5. Pettijohn, F.J. (1975): Sedimentary Rocks (3rd Ed.), Harper and Row Publ., New Delhi.
6. Reading, H.G. (1997): Sedimentary Environments and facies, Blackwell Scientific Publication.
7. Reineck, H.E. and Singh, I.B. (1973): Depositional Sedimentary Environments, Springer-Verlag.
8. Selley, R. C. (2000) Applied Sedimentology, Academic Press.
9. Tucker, M.E. (1981): Sedimentary Petrology: An Introduction, Wiley and Sons, New York.
10. Tucker, M.E. (1990): Carbonate Sedimentology, Blackwell Scientific Publicatio

## **Structural Geology**

### **Theory**

**Unit-1:** Concept of stress and strain. Stress-strain relationships of elastic, plastic and viscous materials. Two dimensional strain and stress analyses. Types of strain ellipses and ellipsoids; their properties and significance. Mechanical principles and properties of rocks and their controlling factors. Theory of rock failure; brittle and ductile deformation.

**Unit-II:** Mechanics of folding and buckling. Folds geometry and classification. Superimposed folds and their interference patterns. Analytical methods of determining fold style. Causes and dynamics of faulting. Normal faults and strike – slip faults. Overthrust and nappe with implications to thrust tectonics. Thin skinned deformation and decollement. Salt domes and diapers. Concept of balanced cross sections.

**Unit-III:** Joints, rock cleavage and foliations; their origin, domain character, relationship with major structures and geological significance. Transposed foliations. Linear structures and boudinage; their origin, relationship with major structures and significance. Deformation of linear structures.

**Unit-IV:** Brittle and ductile shear zones; their geometry, strain pattern, kinematics and significance. Rotation of structural elements. Concept of petrofabric analysis. Use of stereographic and equal area projections for representing different types of fabric.

### **Suggested Readings:**

1. Ramsay J. G, 1967. Folding and Fracturing of Rocks. McGraw Hill.
2. Turner F.J. and Weiss, L.E., 1963. Structural Analysis of Metamorphic Tectonites. McGraw Hill.
3. Davis G. R., 1984. Structural Geology of Rocks and Region. John Wiley.
4. Ramsay J.G. and Huber, M.I., 1987. Modern Structural Geology, Vol. I & II. Academic Press.
5. Price N. J. and Cosgrove, J. W., 1990. Analysis of Geological Structures. Cambridge Univ. Press.
6. Bayle B., 1992. Mechanics in Structural Geology. Springer Verlag.
7. Ghosh, S. K., 1995. Structural Geology: Fundamentals of Modern Development. Pergamon.
8. Robert D. Hatcher, 1994. Structural Geology: Principles Concepts and Problems (2nd Edition)

9. Moores E. and Twiss R.J., 1995. Tectonics. Freeman.
10. Valdiya K.S., 1998. Dynamic Himalaya. University Press.
11. Passchier C. w. and Treuw R. a. J., 2005: Microtectonics, Springer.
12. Richard H. Groshong (Jul 24, 2008). 3-D Structural Geology: A Practical Guide to Quantitative Surface and Subsurface Map Interpretation. Springer
13. Donal M. Rangan, 2009. Structural Geology: An introduction to Geometrical Techniques. Cambridge, University Press.

## **Practical**

### **PRACTICAL-A:**

#### **Practical: Igneous petrology**

Megascopic and microscopic studies of major igneous rock types: CIPW norm calculation: Introduction to software: Newpet, Sinclass, GCD kit.

#### **Practical: Metamorphic Petrology**

Study of metamorphic rocks of different metamorphic facies in hand specimens. Calculation of ACF, AKF, AFM and A'F'M values from the given chemical data/structural formula of minerals and their graphical representation.

Study of metamorphic rocks in thin sections with reference to texture/structure, time relation between phases of deformation and metamorphic crystallization, mineral association, parent rock, metamorphic facies/sub-facies/zones to which rock can be assigned and representation of assemblage in ACF, AKF, AFM and A'F'M' diagrams.

Estimation of pressure and temperature from important models of Geothermobarometry.

## **Practical**

### **PRACTICAL-B:**

#### **Practical : Sedimentology**

Detailed study of clastic and non clastic rocks in hand specimen. Study of assemblages of sedimentary structures in context to their palaeo-environment significance. Microscopic examination of important rock types. Heavy mineral separation, their petrographic characters, graphical representation and representation and interpretation. Grain size analysis by sieving method, plotting of size distribution data as frequency and cumulative curves. Computation of statistical parameters and interpretation.

#### **Practical : Structural Geology**

1. Study of naturally deformed rocks in hand specimens.
2. Geometrical analysis of folds and faults.
3. Preparation and interpretation of geological maps.
4. Applications of stereographic and equal area projections.
5. Strain analysis using software and manually.

## **Field Training**

## SEMESTER – II

Paper Code	Paper Title	Max mark
4621	Mineralogy and Geochemistry	75
4622	Economic Geology	55
4623	Stratigraphy	55
4624	Palaeontology	55
4625	Sequence Stratigraphy and Basin Analysis (Elective paper)	55
4626	Advance techniques in Structural Geology (Elective paper)	55
	Internal Assessment Theory ( 4621+ 4622+ 4623+ 4624+ 4625/4626)	105
4627	Practical - A-Mineralogy and Geochemistry & Economic Geology	100
4628	Practical – B- Stratigraphy & Palaeontology	100
4629	Practical-C- Elective Paper (Sequence Stratigraphy and Basin Analysis)	50
4630	Practical-C- Elective Paper (Advance techniques in Structural Geology)	50
<b>Total marks : Theory 400 + Practical 250 = 650</b>		

## SEMESTER – II

### Mineralogy and Geochemistry

#### Theory

**Unit-I:** Structural classification of silicates; Study of following group of minerals with reference to chemical and structural formula, classification, atomic structure, chemistry, physical and optical properties, occurrences: Olivine, Garnet, Pyroxene, Amphibole, Mica, Feldspars, Feldspathoids, Silica and Al silicates.

**Unit-II:** Formation of Uniaxial and Bi-axial interference figures, Interference colors, Pleochroism and determination of pleochroic scheme, Interference figures and determination of optic sign; Extinction; Uniaxial and Biaxial indicatrix and dispersion in minerals. Petrographical microscope; Mica, Gypsum and Quartz plates; Universal stage and their uses in the determination of optical properties of minerals.

**Unit-III:** Composition of Earth and its constituents (Crust, mantle and core); Ionic and co-ordination number; Rules of ionic substitution, coupled substitution; Distribution coefficient: Capture admission and camouflage, Geochemical classification of elements; Behaviour of major and trace including rare earth elements during magmatic crystallization.

**Unit-IV:** Near-surface geochemical environment: Eh-pH diagram; Principle of chemical mass balance and rock- cycle; Chemical weathering of minerals and rocks. Radiogenic isotopes in geochronology and petrogenesis: Rb-Sr, Sm-Nd, U-Pb isotopic system.

#### Books Recommended

- Battey, M.H. (1981) Mineralogy for students 2nd Edn. Longmans. Berry, L.G. and Mason, B. and
- Deer, W.A., Howie, R.A., and Zussman, J. (1992) An Introduction to the rock forming minerals, Longman.
- Sharma, R. S. and Sharma, A. (2014) Crystallography and mineralogy. Graduate Text Book Series, Geological Society of India, Bangalore.
- Klein, C. and Hurlbut, Jr., C.S. (1993) Manual of Mineralogy, John Wiley.
- Kerr, P.F. (1977) Optical Mineralogy 4th Edn., McGraw-Hill
- Putnis, Andrew (1992) Introduction to Mineral Sciences, Cambridge University Press.
- Winchell, A.N. (1962) Elements of Optical Mineralogy, John Wiley.
- Allegre, C.J. and Michard, G. (1974) Introduction to Geochemistry, Reidel, Holland.
- Evans, R.C. (1964) Introduction to Crystal Chemistry, Cambridge Univ. Press.
- Faure, G. (1998) Principles and applications of geochemistry, 2nd Edn., Prentice Hall, New Jersey, 593p.
- Faure, G. (1986) Principles of Isotope Geology, 2nd Edn., John Wiley.
- Krauskopf, K.B. (1967) Introduction to Geochemistry, McGraw Hill.
- Mason, B. and Moore, C.B. (1991) Introduction to Geochemistry, Wiley Eastern.
- Rollinson, H.R. (1993) Using geochemical data: Evaluation, Presentation, Interpretation, Longman, U.K.

## **Economic Geology**

### **Theory**

**Unit-I:** Geological setting, characteristics and genesis of ferrous, base and noble metals.

**Unit-II:** Methods of mineral deposit studies including ore microscopy, fluid inclusions and isotopic systematic.

**Unit-III:** Origin, migration and entrapment of petroleum. Properties of source and reservoir rocks. Structural, stratigraphic and combination traps. Petroliferous basins of India.

**Unit-IV:** Origin of coal deposits. Classification, rank and grading of coal. Coal resources of India. Gas hydrates, coal bed methane and nuclear resources. Occurrence of mineral resources in the Himalaya.

### **Suggested Readings:**

1. Craig, J.M. & Vaughan, D.J., 1981: Ore Petrography and Mineralogy-John Wiley
2. Evans, A.M., 1993: Ore Geology and Industrial Minerals-Blackwell
3. Sawkins, F.J., 1984: Metal deposits in relation to plate tectonics-Springer Verlag
4. Stanton, R.L., 1972: Ore Petrography-McGraw Hill
5. Torling, D.H., 1981: Economic Geology and Geotectonics-blackwell Sci publ.
6. Barnes, H.L., 1979: Geochemistry of Hydrothermal Ore Deposits-John Wiley
7. Klemm, D.D. and Schneider, H.J., 1977: Time and Strata Bound Ore Deposits-

Springer Verlag  
8. Guibert, J.M. and Park, Jr. C.F., 1986: The Geology of Ore Deposits-Freeman  
9. Mookherjee, A., 2000: Ore genesis-a Holistic Approach-Allied Publisher

## **Stratigraphy**

### **Theory**

#### **Unit I**

Recent development in stratigraphic classification, Code of stratigraphic nomenclature. Concept of sequence stratigraphy. Modern methods of stratigraphic correlation. Steps in stratigraphic studies. Approaches of paleogeography. Earth's climatic history.

#### **Unit II**

Brief ideas of quantitative, magneto, seismic, chemo and event stratigraphy. Evolution and biostratigraphy – controlling factor, zonation, time significance, quantitative stratigraphy, cyclostratigraphy, pedostratigraphy.

#### **Unit III**

Evolution of the early crust, lithological, geochemical and stratigraphic characteristics of granite-greenstone and granulite belts of India and global correlation. Proterozoic formations of Peninsular – Extrapeninsular India.

#### **Unit IV**

Precambrian life, stratigraphic records India. Boundary problems: Archaen-Proterozoic, Precambrian-Cambrian, Permo-Triassic, Cretaceous – Tertiary, Neogene-Quaternary. In Brief: Paleozoic-Mesozoic and Cenozoic stratigraphy, fossils, Paleogeography, Paleoclimate, Tectonism and economic deposits. Concept status scheme of classification.

#### **Suggested Books**

1. Stratigraphic Principles & Practice, J. Marvin Weller
2. Principles of stratigraphy V-2, Amadeus W. Grabau
3. Principles of Stratigraphy, Carl O. Dunbar and John Rodgers
4. Stratigraphy, D.N. Wadia
5. Geology of India & Burma, M.S. Krishnan
6. Fundamentals of historical geology and stratigraphy of India, Ravindra Kumar
7. A Guide to Stratigraphic Classification, Terminology and Procedure, Hollis Hedberg, John Wiley and Sons

# Palaeontology

## Theory

**Unit 1:** Theories of origin of life. Organic evolution-Punctuated equilibrium and phyletic gradualism models. Mass extinctions and their causes. Ichnology, classification and use.

**Unit-2:** Palaeobiology (palaeoecology, communities, modern environments, functional morphology and taphonomy).

**Unit 3:** Brief morphology, evolution and classification of Brachiopoda, Mollusca (Cephalopoda, Gastropoda, Bivalvia), Trilobita.

**Unit 4:** Evolution of vertebrates, dinosaurs and its extinction.

### Selected Readings:

1. Raup and Stanley, Principles of Palaeontology,
2. Bilal U. Haq and A. Boersome , Introduction to Marine Micropalaeontology,
3. G.Bignot , Elements of Micropalaeontology,
4. Clarkson, E.N.K. (1986). Invertebrate Palaeontology and Evolution. ELBS, London.
5. Cushman, J.A. (1940). The Foraminifera, their classification and use. Harvard Univ. Press.
6. Moore, R.C. Lalliker, C.G. and Fischer, A.G. (1952). Text book of Invertebrate Palaeontology.
7. David Raup and Stanley (1985). Principles of Palaeontology., CBS Pub., Delhi
8. Glaessner, M.F. (1945). Principles of Micropaleontology. Melbourne Univ. Press.
9. Schrock, Twenhofel and Williams (1953). Principles of Invertebrate Palaeontology. CBS, Delhi

## Sequence Stratigraphy and Basin Analysis (Elective paper)

### Theory

**Unit- 1 :** Concept of sequence Stratigraphy. Evolution, order and duration of sequences. Applications and significance of sequence Stratigraphy

**Unit-2 :** Concept of facies and basin analysis. Walthers law and sedimentary environments. Sedimentary cycles, rhythms and cyclothems. Modern and ancient sedimentary environments. Continental clastic depositional sedimentary models-alluvial, fluvial, lacustrine, aeolian and glacial deposits.

**Unit-3:** Transitional and marine sedimentary facies models – deltaic, tidal flats, barrier islands , terrigenous shelves and shallow seas. Carbonate platforms and reefs and sabakhas, Continental rise and ocean basins

**Unit-4:** Sedimentation pattern and depositional environments of selected undeformed sedimentary basins of India. Himalayan sedimentary basins, Tectonic classification of sedimentary basins.

### **Books Recommended**

- (1) Reading H. G. 1996 : Sedimentary Environments and Facies, Balckwell
- (2) Reading H.E. and Singh , I.B. 1980 : Depositional Sedimentary Environments, Springer Verlag
- (3) Boggs Sam Jr, 1995 . Principles of Sedimentary and Stratigraphy , Prentice Hall
- (4) Selley R.C.,1998. Applied Sedimentology, Academic Press
- (5) Miall, A.D. 2000 : Principles of Sedimentary Basin Analysis, Springer Verlag
- (6) Eirsele , G . 1992 : Sedimentary Basins , Springers Verlag .
- (7) Bhattacharya A and Chakraborti , C .2000 . Analysis of Sedimentary Successions, Oxford and IBH .

### **Practical-**

Preparation of lithologs , Interpretation and reading depositional environments from the given idealized lithologs and data, Heavy mineral identification and provenance interpretation . Petrography of selected sedimentary rock types. Staining and Mineral identification in Carbonate rocks.

## **Advance techniques in Structural Geology (Elective paper)**

### **Theory**

**Unit-1:** Principles of geological mapping and map reading, projection diagrams. Strain markers in naturally deformed rocks and graphical representation of strain. Strain pattern and folding. Measurement of strain in deformed rocks.

**Unit-2:** Structural analysis of folds, cleavages, lineations, joints and faults. Tectonites and their type. Concept of petrofabric and symmetry- field and laboratory techniques and graphical solutions.

**Unit-3:** Types of fabric, fabric elements and interpretation on macroscopic to microscopic scale. Use of Crystallographic Preferred Orientation (CPO) and Anisotropy of Magnetic Susceptibility (AMS) in petrofabric.

**Unit-4:** Time-relationship between crystallization and deformation. Unconformities and basement-cover relations. structural behaviour of igneous rocks, diapirs and salt domes.

### **Suggested Readings:**

1. Turner F.J. and Weiss, L.E., 1963. Structural Analysis of Metamorphic Tectonites. McGraw Hill.
2. Davis G. R., 1984. Structural Geology of Rocks and Region. John Wiley.
3. Ramsay J.G. and Huber, M.I., 1987. Modern Structural Geology, Vol. I & II. Academic Press.
4. Stephen Marshak and Gautum Mitra. 1988. Basic Methods of Structural Geology.
5. Price N. J. and Cosgrove, J. W., 1990. Analysis of Geological Structures. Cambridge Univ. Press.
6. Bayle B., 1992. Mechanics in Structural Geology. Springer Verlag.
7. Tarling D. H. and Hrouda F, 1993: The Magnetic Anisotropy of Rocks. Chapman and Hall, London.
8. Valdiya K.S., 1998. Dynamic Himalaya. University Press.
9. Passchier C. w. and Treuw R. a. J., 2005: Microtectonics, Springr.

10. Richard H. Groshong (Jul 24, 2008). 3-D Structural Geology: A Practical Guide to Quantitative Surface and Subsurface Map Interpretation. Springer
11. Donal M. Rangan, 2009. Structural Geology: An introduction to Geometrical Techniques. Cambridge, University Press.
12. Davis G. R., Stephen J. Reynolds and Charles F. Kluth. 2011. Structural Geology of Rocks and Region. Amazon Press

## **Marine Geology (Elective paper)**

### **Theory**

**Unit-1:** Definition and Scope of the subject. History of development of Oceanography, Ocean Drilling Programme (ODP), and its major accomplishments.

**Unit-2:** Ocean Circulation, Surface Circulation, Concept of mixed layers, Thermocline and pycnocline, Concept of upwelling, El Nino, Deep ocean circulation, Formations of Bottom waters, Water masses of the world oceans and sea sediments (oozes etc.).

**Unit-3:** Paleoceanography: Approaches to palaeoceanographic reconstructions. Reconstruction of monsoon variability by using marine proxy records. Eustatic Changes.

**Unit-4:** Global climate pattern and energy budget, Climate controlling factors. Plate tectonics and climate change Milankovitch cycles, Atmosphere and Ocean interaction and its effect on climate. An overview of Paleoclimatic reconstruction; Pleistocene Glacial-Interglacial cycles; Future climate: Anthropogenic activity and its effect on Global climate.

### **Practical- 205 (c )**

Study of modern surface water mass assemblages of various microfossils from different oceans. Depth biotopes and estimation of paleodepth of the ocean using microfossils group. Thermocline and deep surface waters of the modern oceans.

### **Suggested Reading:**

1. Paleoclimatology by J.J. Bhatt
2. Oceanography by Savander Singh
3. Paleoclimatology: climate through ages by C.E. Brooks
4. Climate Change in Pre history by W.J. Burrough
5. Introduction to Physical Oceanography by R.h. Stewart
6. Gross, M.G, 1977. *Oceanography: A view of the Earth*, Prentice Hall.
7. Haq and Boersma, 1978. *Introduction to Marine Micropaleontology*, Elsevier.
8. Haslett, S.K., 2002. *Quaternary Environmental Micropaleontology*, Oxford University Press, New York.
9. Tolmazin, D\_1985. *Elements of Dynamic Oceanography*, Allen and Unwin.
10. Bigg, G., 1999 Ocean and Climate. Springer- Verlag
11. Bradley, F., 2000. Paleoclimatology: Reconstructing Climates of the Quaternary. Springer-Verlag
12. Maher and Thompson, 2000. Quaternary Climates, Environments and Magnetism. Cambridge University Press.
13. Williams, Durnkerley, Decker, Kershaw and Chhappell, 1998. Quaternary Environments. Wiley and Sons.

# Advanced Mineralogy and Thermodynamics (Elective paper)

## Theory

**Unit-1:** Fundamental concepts: Equilibrium, disequilibrium, steady state; exact/inexact Differentials; first and second laws of thermodynamics; combined first and second laws; enthalpy; free energy functions; criteria for spontaneity and equilibrium; the third law of thermodynamics and finite entropies.

**Unit-II:** Phase equilibria in simple systems: Derivation of Gibbs phase rule; chemography; free energy surfaces; Clapeyron equation; Morey-Schreinemakers rules; calculation of univariant lines in simple systems

**Unit-III:** Thermodynamics of solutions: Partial molal properties, chemical potential; Gibbs-Duhem equation and phase rule; ideal solutions; non-ideal solutions, fugacity, activity, standard states, activity coefficients, and excess functions; solution modeling and equation of state; calculation of activities in gas mixtures, ideal and non-ideal crystalline solutions; electrolyte theory.

**Unit-IV:** Phase equilibria: The equilibrium constant; temperature, pressure and compositional dependence of equilibrium constant; chemical potential diagrams; oxidation-reduction diagrams; calculation of one-, two- and three-component phase diagrams. Thermodynamic data: Measurements and estimations; sources of data; computerized Phase diagram. constructions; TWQ and THERMOCALC software.

## Suggested Readings

1. Chemical Thermodynamics: Basic Theory and Methods. By I. M. Klotz and R. M. Rosenberg. The Benjamin/Cummings Publishing Company.
2. Thermodynamics of Solids. By R. A. Swalin. John Willey & Sons.
3. Geochemical Thermodynamics. By D. K. Nordstrom and J. A. Munoz. The Benjamin/Cummings Publishing Company.
4. Short Course on Application of Thermodynamics to Petrology and ore Deposits. By H. J. Greenwood (Editor). Mineralogical Association of Canada.
5. Elementary Thermodynamics for Geologists. By B. J. Wood and D. G. Fraser. Oxford University Press.
6. Anderson, G.M. Thermodynamics of Natural Systems, Cambridge University Press, 2005.
7. Winter, J. D. Introduction to Igneous and Metamorphic Petrology. Prentice-Hall, 2001.
8. Drever, J.I. The Geochemistry of Natural Waters, 3rd Edn., Prentice Hall, 1997.
9. Faure, G. Principles of Isotope Geology, 2nd Edn., John Wiley, 1986.
10. Mason, B. and Moore, C. B. Principles of Geochemistry, 4th Edn., John Wiley, 1982.

## **Practical- A**

### **Practical : Mineralogy and Geochemistry**

Study of physical and optical properties of important rock forming minerals; Determination of An content of plagioclase feldspars; Determination of elongation and optic sign of minerals; Determination of Pleochroism and absorption schemes.

Construction of geochemical variation diagrams (Spidergrams; Harker's variation diagrams; addition-substraction diagrams); Calculation of stoichiometric formula from chemical analysis of minerals.

### **Practical : Economic Geology**

Study of ores in hand specimen. Geographical distribution of classic ore deposits of India and world. Study of metallic minerals under the reflecting microscope.

## **Practical- B**

### **Practical: Stratigraphy**

Study of characteristics stratigraphic rocks of India and their distribution. Chronostratigraphic/Lithostratigraphic placement of important stratigraphic rocks of India.

### **Practical: Palaeontology**

Systematic description of Brachiopoda, Bivalvia, Cephalopoda and Gastropoda; vertebrates

## **Practical-C- ( Elective Paper)**

### **Practical:- Sequence Stratigraphy and Basin Analysis**

Preparation of lithologs , Interpretation and reading depositional environments from the given idealized lithologs and data, Heavy mineral identification and provenance interpretation . Petrography of selected sedimentary rock types. Staining and Mineral identification in Carbonate rocks.

**Or**

### **Practical:- Advanced Techniques in Structural Geology**

Preparation and interpretation of balanced cross sections. Uses of stereographic techniques in solving structural problems. Plotting and interpretation of petrofabric data and diagrams. Measurement of strain in naturally deformed rocks.

### SEMESTER – III

<b>Paper code</b>	<b>Paper Title</b>	<b>Max mark</b>
4631	Geodynamics	75
4632	Remote Sensing and GIS	75
4633	Ground Water Hydrology	55
4634	Micropaleontology and Oceanography	55
	Internal Assessment Theory ( 4631+ 4632 + 4633+ 4634)	90
4635	Presentation: Dissertation-I (Problem and Method)	25
4636	Practical – A ( 302 + 303)	100
4637	Practical – B ( 304)	50
4638	Field Training	50
<b>Total marks: Theory 350 + Practical 150 + Dissertation 25 + Field work 50 = 575</b>		

## Geodynamics

### Theory

**Unit-I:** Planetary evolution of the earth and its internal structure. Heterogeneity of the earth crust. Major tectonic features of the Oceanic and Continental crust. Isostasy and epeirogeny.

**Unit-II:** Gravity and magnetic anomalies and heat flow patterns at Mid-ocean ridges, deep sea trenches, continental shield areas and mountain chains. Continental drift-geological and geophysical evidence, mechanics, objections, present status. Nature of plate margins.

**Unit-III:** Palaeomagnetism, magnetostratigraphy, seafloor spreading, mechanics of plate motion and Plate Tectonics. Island arcs, oceanic islands, hotspots and plume tectonics. Seismic belts of the earth vis-a-vis plate movements

**Unit-IV:** Orogeny, geodynamic evolution of Indian cratons and mobile belts. Structure and origin of the Himalaya. Metallogeny in relation to plate tectonics. Neotectonic movements-concepts and evidence.

### Suggested Readings:

1. Valdiya, K.S., Aspects of tectonics
2. Kearey P., Klepeis K.A., & Nive F.J., Global Tectonics
3. Valdiya, K.S., Making of India
4. Windley B.F., Evolving Continents
5. Willey, P.J., Plate Tectonics
6. Condie, K.C., Plate Tectonics
7. Cox, A. And Hort, R.B., Plate Tectonics
8. Moores, E. and Twiss, R.J. 1995: Tectonics-Freeman

9. Keary, P. and Vine, F.J. 1990: Global Tectonics-Balckwell
10. Storetvedt, K.N. 1997: Our Evolving Planet: Earth's History in New Perspective-Bergen (Norway), Alma Mater Fortag
11. Valdiya, K.S., 1998: Dynamic Himalaya-Universal Press, Hyderabad
12. Summerfield, M.A., 2000: Geomorphology and Global Tectonics-Springer Verlag

## **Remote Sensing And GIS**

### **Theory**

**Unit I:** Definition of remote. Remote sensing platforms: Air- and space-based.

**Unit II:** Types and characteristics of sensors. Concepts of mono-band, multispectral and hyperspectral remote sensing. Basics of optical, thermal and microwave remote sensing. Concept of LiDAR. Characteristics of IRS sensors.

**Unit III:** The structure of Digital Image. Conceptual aspects of Digital Image Processing. Basic processes of image rectification, enhancement and classification.

Definition and components of Geographic Information System (GIS). Raster and vector data formats. Basic knowledge about data acquisition, manipulation, analyses and representation in GIS.

**Unit IV:** Application of remote sensing and GIS in geomorphological investigations, tectonic investigations, lithological mapping, groundwater exploration, mineral exploration, Oil & Gas exploration and geohazard management.

### **Recommended Books**

1. Lillesand, T.M., Kiefer, R. W. and Chapman, J. (2007): Remote Sensing and Image Interpretation, 6<sup>th</sup> Edition. Wiley
2. Gupta, R. P. (2003). Remote Sensing Geology. 2<sup>nd</sup> Edition. Springer
3. Drury, S.A. (1993). Image Interpretation in Geology. 2<sup>nd</sup> Edition. Chapman & Hall
4. Jensen, J.R. (2000). Remote Sensing of the Environment, An earth Resource Perspective. Pearson Education.
5. DeMers M.N. (2008). Fundamentals of geographic Information System. 4<sup>th</sup> Edition. Wiley
6. Richards, J.A. and Jia, X. (2006). Remote Sensing Digital Image Analysis: An Introduction. 4<sup>th</sup> Edition, Springer

# **Ground Water Hydrology**

## **Theory**

**Unit-I:** Hydrological Cycle, Ground Water- origin, type and occurrence. Hydrological properties of rocks- porosity, permeability, specific yield, specific retention, hydraulic conductivity, transmissibility and storage coefficient. Subsurface movement and vertical distribution of Ground Water.

**Unit- II:** Aquifer and their types. Confined and unconfined aquifers. Darcy Law, its range and validity.

**Unit-III:** Quality of Ground water: Chemical characteristics of ground water in relation to various uses- domestic, irrigation and industrial purposes. Ground water artificial recharge- methods and factors controlling recharge.

**Unit-IV:** Geological and geophysical methods of ground water exploration.

## **Books Recommended:**

1. Todd, D.K., 1980: Groundwater Hydrology- John Wiley
2. Davis, S.N. and De Wiest, R.J.M., 1966: Hydrogeology- John Wiley
3. Freeze, R.A. and Cherry, J.A., 1979: Ground Water- Prentice Hall
4. Fetter, C.W., 1990: Applied Hydrogeology- Merrill Publishing
5. Ragunath, N.M., 1982: Ground Water- Wiley Eastern
6. Karanth, K.R., 1987: Groundwater Assessment- Development and Management- Tata McGraw Hill
7. Alley, W.M., 1993: Regional Ground Water Quality- VNR, New York
8. Subramaniam, V., 2000: Water- Kingston Publication, London.

# **Micropaleontology and Oceanography**

## **Theory**

### **Unit-I**

Definition and scope of the subject, surface and subsurface sampling methods, sample processing and techniques.

### **Unit-II**

History of development of Oceanography. Methods of measuring properties of sea water. Ocean drilling Programme (ODP) and its major accomplishments.

### **Unit-III**

Ocean circulation, surface circulation and concept of mixed layers. Thermocline and Pycnocline, concept of upwelling. El Nino and deep Ocean circulation. Formation of bottom, bottom water, water masses of the world ocean and sea sediments (oozes etc.).

### **Unit-IV**

Introduction, detailed morphology, geological distribution evolution and applications of Foraminifers, ostracoda, Calcareous Nannofossils, radiolaria, diatoms and conodonts.

### **Suggested Reading:**

1. Introduction to marine micropalaeontology, Bibal U. Haq
2. Elements of Micropalaeontology, by G. Pignot
3. Applied Geological Micropalaeontology, Pokornig Valdimir

### **Practical- A**

#### **Practical: Remote Sensing and GIS**

Determination of the scale of aerial photographs and imageries. Visual interpretation of aerial photographs and imageries for geomorphological, lithological, tectonic and mapping.

#### **Practical Ground Water Hydrology**

Hydrological properties of rock and soil characteristics- Specific gravity, degree of saturation, moisture content, void ratio, porosity and permeability. Delineation and description of hydrochemical and Ground water province of India.

### **Practical- B**

#### **Practical: Micropaleontology and Oceanography**

Techniques of separation of microfossil from the matrix, Types of microfossils, Study of representative genera of microfossils and their specification and systematic description preparation of bio-zonation charts.

### **Field Training**

### **Presentation: Dissertation-I**

## SEMESTER – IV

<b>Paper Code</b>	<b>Paper Title</b>	<b>Max mark</b>
4641	Engineering Geology	55
4642	Tectonic Geomorphology	55
4643	Mineral Exploration and Mineral Economics	55
4644	Himalayan Geology (Elective paper)	55
4645	Palaeoclimatology (Elective paper)	55
	Internal Assessment Theory ( 4641+ 4642 + 4643+ 4644/4645)	80
4646	Dissertation-II Part: Thesis and Final Presentation	75
4647	Practical – A (4641 + 46422)	100
4648	Practical – B (4643)	50
<b>Total marks: Theory 300 + Practical 150 + Dissertation 75 = 525</b>		

## SEMESTER – IV

### Engineering Geology

#### Theory

##### Unit-I

Role of geology in major engineering projects. Engineering properties of rocks and soils.

##### Unit-II

Geological consideration for evaluation of Dams and reservoir sites. Reservoir induced seismicity. Dam foundation rock problems. Grouting and Rock bolting. Problem of piping in reservoir areas.

##### Unit-III

Geological evaluation of tunnel alignment. Bridges, their types and causes of their failure. Building, their types and influence of geological conditions on foundation

##### Unit-IV

Mass movement with emphasis on landslide. Causes of hill slope instability and preventive measure.

#### Book Recommended

1. Sharma P.V., Environmental and Engineering Geophysics
2. Krynine D.P. and Judd W.R., Principles of Engineering Geology and Geotechniques
3. Bell F.G., Fundamental of Engineering Geology
4. Jeger C., Rock Mechanics and Engineering
5. Valdiya K.S., Environmental Geology

6. C.C. Mathewson, Engineering Geology
7. A.C. Mc Lean and Gribble C.D., Geology for Civil Engineers
8. D.P. Coduto, Geotechnical Engineering
9. Dunn I.S., Anderson L.R. and Kiefer F.W., Fundamentals of Geotechnical Analysis

## **Tectonic Geomorphology**

### **Theory**

**Unit-I:** Definition and scope of tectonic geomorphology. Landscape evolution. Concept of Form-Process relationship in landscape evolution.

**Unit-II:** Geomorphic Markers of active tectonics: Planar and Linear. Landforms of active strike-slip faults, normal faults, reverse faults and folds. River response to active tectonics. Sudden (coseismic) versus gradual modifications in river systems. Tectonic modifications of alluvial and bedrock-channeled rivers: longitudinal profiles, river pattern, sinuosity, drainage patterns and drainage anomalies. Effects of base level.

**Unit-III:** Geomorphic Indices of active tectonics – Morphometric analysis: mountain-front sinuosity, hypsometric curve and hypsometric integral, drainage basin asymmetry, stream-length gradient index, and valley-floor width to valley height ratio.

**Unit-IV:** Fundamentals of space geodetic techniques of measuring active tectonic deformations: Global Positioning System (GPS) and Radar Interferometry.

### **Recommended Books**

1. Burbank, D.W. and Anderson, R.S. (2011). Tectonic Geomorphology 2<sup>nd</sup> Edition. Blackwell Science.
2. Burbank, D.W. and Anderson, R.S. (2001). Tectonic Geomorphology 1<sup>st</sup> Edition. Blackwell Science.
3. Keller, E.A. and Pinter, N. (1996). Active tectonics: Earthquakes, Uplift, and Landscape. Prentice Hall
4. Bull, William. (2009). Tectonically active landscapes. Wiley-Blackwell
5. Schumm, S.A, Dumont, J.F. and Holbrook, J.M. (2000). Active tectonics and alluvial rivers. Cambridge University Press.
6. Bull, W. (2007). Tectonic Geomorphology of Mountains: A new approach to palaeoseismology. Blackwell Publishing

## **Mineral Exploration and Mineral Economics**

### **Theory**

**Unit-I:** Concept of exploration. Geological, geophysical, geochemical and geobotanical criteria and methods of surface and sub-surface exploration.

**Unit-II:** Pitting, trenching, drilling and sampling methods. Methods of petroleum and ground water exploration. Estimation of grade and reserve of ores.

**Unit-III:** Principles of mineral beneficiation. Communiton classification, liberation, concentration, floatation methods, jigging, electromagnetic and magnetic separation, amalgamation, syndication.

**Unit-IV:** Strategic, critical and essential minerals. India's status in mineral production. National Mineral Policy. Substitution and conservation. Mineral concession rules. Marine mineral resources and Law of Sea.

### **Suggested Readings:**

1. Mckinstry, H.E., 1962: Mining Geology. II Ed.-Asia Publishing House
2. Clark, G.B., 1967: Elements of Mining.III Ed.-John Wiley
3. Arogyaswami, R.P.N., 1996: Courses in Mining Geology. IV Ed.-Oxford IBH
4. Mason, B.C. (1982). Principles of Geochemistry, John Wilay & Sons.
5. Jeffery, G.H, Basett, J., Mendhan, J. and Denney, R.C. (1989). Vogel's text book of quantitative Chemical analysis. 5th ed. ELBS.
6. Gill, R. (Editor), (1977). Modern analytical geochemistry. Longman , Singapore.
7. Jeffery, P.G. and Hutchison, D., (1983). Chemical methods of rock analysis. Pergamon press, Oxford, N.Y.
8. Rose, A.W., Hawkes, H.E. and Webb, J. A., (1979). Geochmeistry in Mineral Exploration. Academic Press.
9. Skoorg, D.A. et al. (2004). Fundamental of analytical chemistry. 8th ed. Thomson Books.

## **Himalayan Geology (Elective paper)**

### **Theory**

**Unit-I:** Geological terrains of Indian Subcontinent. Precambrian-Proterozoic rocks in the Himalaya, their metamorphism and igneous activities.

**Unit-II:** Himalayan province between Cambrian and Permian. Gondwana tectonics and pre-Himalayan palaeogeograpy.

**Unit-III:** Cretaceous volcanism and the Himalayan Mesozoic stratigraphy, the tectonic evolution of northern margin of the Indian plate. Collision of India with Asia and the emergence and evolution of the Himalaya, evolution of Himalayan Foreland basin.

**Unit-IV:** Quaternary development and Holocene-recent tectonic movements and earthquakes in the Himalaya.

**Suggested Readings:**

1. Geology of the Himalayas by A. Gansser, 1964
2. Geology of Kumaun Lesser Himalaya by K.S. Valdiya., 1980
3. Dynamic Himalaya by K. S. Valdiya, 1998
4. Emergence and Evolution of Himalaya by K. S. Valdiya, 2001
5. The making of India: Geodynamic Himalaya by K. S. Valdiya, 2010
6. Geological Study of the Himalayan Mountains An Observation on the Principal Peaks of the Great Range by F. Willford, J.A. Hodgson
7. Tectonic Geology of the Himalaya by P.S. Saklani
8. Geology of the Himalayas Comprising of the Studies on Shivalik Hills, Kashmir, Kumaon, Garhwal, Nepal, Sikkim and Bhutan by Edwin T. Atkinson
9. Dimensions Of Himalayan Geology written by Dr. A.K. Biyani

**Palaeoclimatology (Elective paper)**

**Theory**

**Unit-I**

Definition of Palaeoclimatology and the Quaternary. Quaternary Stratigraphy – Oxygen Isotope stratigraphy, biostratigraphy and magnetostratigraphy. Quaternary climates – glacial-interglacial cycles,

**Unit-II**

Proxy indicators of paleoenvironmental/ paleoclimatic changes, - land, ocean and cryosphere (ice core studies). Responses of geomorphic systems to climate, sea level and tectonics on variable time scales in the Quaternary,

**Unit-III**

Quaternary dating methods, –radiocarbon, Uranium series, Luminescence, Amino-acid, relative dating methods. Quaternary stratigraphy of India– continental records (fluvial, glacial, aeolian, palaeosols and duricrust); marine records;

**Unit-IV**

Continental-marine correlation of Quaternary record. Quaternary geomorphic processes. Landscape evolution in Quaternary. Concept of tectonic geomorphology. Evolution of man and Stone Age cultures.

## **Suggested Reading:**

1. Bull, W.B., 1991. *Geomorphic Response to Climate Change*, Oxford University Press. 2:  
Bull, W.B., 2007. *Tectonic Geomorphology of Mountains*, Blackwell Publishing.
2. Burbank, W.B., and Anderson, R.S., 2001. *Tectonic Geomorphology*, Blackwell Science.
3. Keller, E.A. and Pinter N., 2001. *Active Tectonics: Earthquakes, Uplift, and Landscape*, Prentice Hall.
4. McCalpin, J., 1998. *Paleoseismology*, Academic Press.
5. Schumm, S.A. and Holbrook, 2000. *Active Tectonic and Alluvial Rivers*, Cambridge University Press!
6. Willett, S. D., 2006. *Tectonics, Climate, and Landscape Evolution*, Geological Society of America Publication.
7. Yeats R.S., Sieh. K.E. and Allen, C.R. 1997. *The geology of earthquakes*, New York. Oxford University Press.
8. Thornbury, W.D. (1969). Principles of Geomorphology. 2nd Edition. New Age International (P) Ltd.
9. Kale, V.S. and Gupta, A. (2001). Introduction to Geomorphology. Orient Longman.
10. Keller, E.A. and Pinter, N. 1996 Active Tectonics: Earthquakes, Uplifts and Landscape. Prentice Hall

## **Advanced Hydrogeology (Elective paper)**

### **Theory**

#### **Unit-I**

Hydrological cycle. Springs and their types. Origin, occurrence and movement of ground water. Ground water quality estimation and methods of treatment for various use. Ground water quality map of India.

#### **Unit-II**

Well Hydraulics: Confined, unconfined, steady, unsteady and radial flow. Water level fluctuations, their causative factors and their measurements. Methods of pumping test and analysis of test data. Evaluation of aquifer parameters.

#### **Unit-III**

Saline water intrusion on coastal aquifers, their causes and remedial measures.

#### **Unit-IV**

Surface and subsurface geological and geophysical methods of ground water exploration. Radioisotopes in hydrological studies.

### **Suggested Readings**

1. Tolman C.F., 1937 :Groundwater; Mcgraw Hill, New York and London.
2. Todd D.K., 1995: Ground water Hydrology; John Wiley and Sons

3. Driscoll F.G., 1988: Ground water and wells, UOP, Johnson Div. St. Paul. Min. USA
4. Raghunath H.M., 1990: Groundwater, Wiley Eastern Ltd.
5. Karanth K.R. 1989 : Hydrology, Tata Mc Graw Hill
6. Davis, S.N. and De Wiest, R.J.M., 1966: Hydrogeology- John Wiley
7. Freeze, R.A. and Cherry, J.A., 1979: Ground Water- Prentice Hall
8. Fetter, C.W., 1990: Applied Hydrogeology, Merrill Publishing
9. Karanth, K.R., 1987: Groundwater Assessment- Development and Management- Tata McGraw Hill
10. Alley, W.M., 1993: Regional Ground Water Quality- VNR, New York
11. Subramaniam, V., 2000: Water- Kingston Publication, London.

## **Fuel Geology (Elective paper)**

### **Theory**

**Unit-I:** Definition, origin, rank, and types of coal. Physical and petrographic characters: concept of Lithotypes, microlithotypes, and macerals. Utilization of coal. Application of coal petrology in solving geological problems and in hydrocarbon exploration.

**Unit-II:** Coal forming epochs in geological past, coal deposits of India and their distribution. Case study of some coal fields of India. Prospecting and reserves estimation, and production Coal-bed Methane: generation and exploration of coal as reservoir of methane.

**Unit-III:** Nature of petroleum: chemical composition and physical prospecting of organic matters and hydrocarbon. Origin of petroleum: organic and inorganic theories. Migration of oil and gas. Transformation of organic matter into Kerogen, organic maturation, thermal cracking of kerogen. Formation of petroleum in relation to geological processes: temperature, time, and pressure. Petroleum exploration-surface indication of oil and gas. Role of sedimentology in oil exploration, subsurface interpretation of sedimentary environments from cuttings and well log.

**Unit-IV:** Physico – chemical behavior of U and Th, classification of radioactive minerals. Mode of occurrence and association of atomic minerals in nature, atomic minerals as source of energy. Methods of prospecting and productive geological horizons of India. Origin of hydrothermal, syngenetic, pegmatitic and carbonatitic deposits of U and Th Placer deposits of Th. Nuclear power stations of the country and future prospects.

## **Practical- A**

### **Practical: Engineering Geology**

Study of engineering geological maps, preparation of cross sections and description of the terrain. Stress distribution in rocks and soils. Shear strength, angle of repose and utility of Mohr's circle, Problems related to hill slope instability and interpretation of geological maps for landslide problems

### **Practical: Tectonic Geomorphology**

Exercises on mapping of tectonic geomorphological features and computation of geomorphic indices, using map and remote sensing data.

## **Practical- B**

### **Practical: Mineral Exploration and Mineral Economics**

Ore reserve estimation and vetting of easy values. Interpretation of bore hole logs. Interpretation of seismic and resistivity data. Study of gravity data maps and their interpretation.

## **Dissertation-II Part: Thesis and final presentation**