

Name of the Department : **Department of Studies in Earth Science**

Program: **M.Sc., Earth Science and Resource Management,**  
Code: **ESARM**

Semester: **Odd Semester (I & III)**

I Semester	Code	Course	Hard Core/ Soft Core	LTP	Credit Value	Remarks
		Physical Geology & Geotectonics	Hard Core	301	4	
		Mineral kingdom	Hard Core	202	4	
		Geology & Stratigraphy of India	Hard Core	310	4	
		Nano Geoscience	Soft Core	200	2	
		Marine Geoscience	Soft Core	200	2	
		Geostatistics	Soft Core	201	3	
		Environmental Geology	Soft Core	201	3	
		Gemmology	Soft Core	200	2	
		Stratigraphy, Paleontology & Economic Geology – MK1	Soft Core	200	2	
III Semester	Code	Course	Hard Core/ Soft Core	LTP	Credit Value	Remarks
		Mineral Resources	Hard Core	301	4	
		Vertebrate & Invertebrate Palaeontology	Hard Core	211	4	
		Sedimentology & Geomorphology	Hard Core	211	4	
		Mineral Economics	Soft Core	200	2	
		Analytical Techniques in Geology	Soft Core	110	2	
		Materials Science & Nanotechnology	Soft Core	200	2	
		Precambrian Geology & Crustal Evolution	Soft Core	200	2	
		Experimental Mineralogy & Petrology	Soft Core	200	2	

Semester: **EVEN SEMESTER (II & IV)**

II Semester	Code	Course	Hard Core/ Soft Core	LTP	Credit Value	Remarks
		Geo informatics	Hard Core	202	4	
		Groundwater Geology	Hard Core	211	4	
		Geochemical Thermodynamics	Hard Core	301	4	
		Minor Project (FW & Technical Report)	Hard Core	004	4	
		Mining methods and Mineral Processing	Soft Core	200	2	
		Surveying	Soft Core	101	2	
		Micropaleontology and palynology	Soft Core	200	2	
		Engineering Geology	Soft Core	200	2	
		Mineralogy, Petrology, Structural Geology & Geodynamics-MK2	Soft Core	200	2	
IV Semester	Code	Course	Hard Core/ Soft Core	LTP	Credit Value	Remarks
		Rock Kingdom	Hard Core	301	4	
		Geological Prospection and Exploration	Hard Core	301	4	
		Major Project ( Dissertation)	Hard Core	006	6	
		Climatology	Soft Core	110	2	
		Sequence Stratigraphy & Petroleum Geology	Soft Core	200	2	
		Coal and Nuclear energy resources	Soft Core	200	2	
		Water shed Management	Soft Core	200	2	
		Crystal Growth	Soft Core	110	2	

**OPEN ELECTIVE**

**Offered by Department of Earth Science**

Semester	Code	Course	LTP	Credit Value	Remarks
ODD		Nanotechnology	400	4	
EVEN		Basics of Earth Science	400	4	
	80390	Minerals and rocks	400	4	

M.Sc., DEGREE COURSE IN EARTH SCIENCE AND RESOURCE MANAGEMENT  
(Two year – Four Semester Scheme)  
SYLLABUS  
(With New Regulations - CBCCEPS)

ODD SEMESTER

SEMESTER – 1

**HARD CORE**

**PHYSICAL GEOLOGY & GEOTECTONICS [LTP / Credits = 301/4]**

**Lecture 1:** PHYSICAL GEOLOGY -Introduction to geology and branches of geology. Geological Time Scale. Origin of the Earth . Age of the earth. Interior of the Earth.. Principles of Isostasy.

**Lecture 2:** GEOTECTONICS - Rock deformation: Earth forces, Static and dynamic conditions, Mechanical characters of the rock. Kinds of Rock deformation: Mechanics of rock deformation. Relationship between Stress and Strain in rock compressive strength, tensile strength, Shear strength in rock;, Mechanics of Plastic deformation, Stress and strain ellipsoids.

**Lecture:3** Folds and Foldings, Fault and Faulting, Unconformities, Plutons, Joints, Cleavage and Schistosity Lineation and Foliation, Mylonites and Pseudotachyllites. Concepts of plate tectonics – convergent and divergent plate margins, sea floor spreading and geosynclines.

**Practical:** Construction of geological cross section., Structure contour maps, Tracing of outcrops, Interpretation of underground structure from borehole data, Solution to fault problems, Use of stereographic projection in structural calculation, Construction of rose diagram for structural data.

**Reference:**

1. Billings, M.P.(1978) Structural geology – Prentice – Hall of India Private Ltd. New Delhi.
2. Suppe,J. (1985) – Principles of structural geology – Prentice – Hall.
3. Price,N.J. and Cosgrove, J.W. (1990) Analysis of Geological structure. Camb. Univ. Press.
4. Hobbs, B.E. Means D and Millions, P.F. (1976) an outline of structural geology. Wiley
5. Ramsay, J.G. (1967) – Folding and fracturing of rocks. Mc.Graw Hills New York.
6. Badgley P.C. – Structural Geology for the exploration geologist.
7. Whitten, T – Structural Geology.
8. Ramsay, J.G. Structural Analysis of Metamorphic Tectonites.
9. Thornbury, W.D – Principles of Geomorphology
10. Dayal. P – A Text book of Geomorphology

**MINERAL KINGDOM [LTP / Credits = 202/4]**

**Lecture:1 Crystallography:** Form theory of Crystals, Symmetry Operations, Derivation of 32 point groups. Hermann Maguin and Schoenflies notations, Brevais space lattice, Miller Indices, Zone and Zone Laws, Projections, Atomic and ionic radii, Bond length and measurements of Radius, Radius ratio and co-ordination polyhedra, Cordination Number, Pauling’s Rules, Spheres in Closest packing, Packing Index. Voids in closest packing, Classification & Co-ordination of voids, Chemical & Physical Variation in Crystals, Derivative Structures. Crystal Defects / Crystal Imperfections, Structural defects.

**Lecture:2 Mineralogy:** Structure, Chemistry, Paragenesis, Optical and physical properties of Olivine, Garnet, Kyanite, Silliminite, Andalusite, Epidote, Pyroxene, Amphibole, Mica, Feldspar and Silica and non-silicate group of Minerals.

**Practical:1 Crystallography:** Determination of Grades of symmetry in Crystals and their projections. Determination of Axial Ratios and angle between the faces by using Stereo net. Napier’s Rule.

**Practical:2 Mineralogy:** Megascopic identification of minerals, Determination of Birefringence of Minerals using Berek's compensator. Determination of mineral formula based on mineral analysis. Interpretation and Identification of minerals by Powder XRD patterns.

**Reference:**

1. An Introduction to crystallography - F.C.Phillips.
2. Elementary Crystallography - Buerger
3. Solids - Azaraoff.
4. Elements of X-ray Crystallography - Azaraoff.
5. Elements of Optical Mineralogy part I and II - Winchell
6. Optical Mineralogy - P.R.J. Naidu.
7. Fundamentals of Crystal chemistry – T.R.N.Kutty and J.A.K.Tareen(Orient Longman)
8. A Basic Course in Crystallography- J.A.K.Tareen and T.R.N.Kutty

**GEOLOGY AND STRATIGRAPHY OF INDIA [LTP / CREDITS = 310/4]**

**Lecture 1 Precambrian Era** – Introduction, Physical features, Physiographic features and Tectonic features of India. Brief studies on – *Dharwar Craton, Baster Craton, Singhbhum Craton, Bundelkhand Craton and Aravalli Craton*. A brief account on – *Eastern Ghats Mobile Belt, Pandyan Mobile Belt and Satpura Mobile Belt*. Precambrian of Himalaya. Proterozoic Sedimentary Basins - *Bijawar and Sonari, Gwalior, Abujhmar, Papaghni sub-basin, Vindhyan, Chhattisgarh, Khariar, Ampani, Indravati, Sabri, Pranhita-Godavari, Cuddapah, Kaladgi and Bhima*.

**Lecture 2 Paleozoic Era:** Introduction, Tethyan Basin, Paleozoic Life, Trace fossils and Stromatolites. Precambrian/Cambrian boundary, pC/C boundary in Himalayan basins. *Cambrian* – Jammu and Kashmir, Himachal Pradesh, Tal Basins and Uttaranchal. *Ordovician and Silurian* - Jammu and Kashmir, Himachal Pradesh and Uttaranchal. *Devonian* - Jammu and Kashmir, Himachal Pradesh and Uttaranchal. *Carboniferous* - Jammu and Kashmir, Eastern Karakoram, Himachal Pradesh and Uttaranchal. *Permian* - Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Bhutan Arunachal Pradesh and Peninsular India-Cauvery Basin. *Gondwana Supergroup* – Introduction, Characteristics, Stratigraphy and Structure, Classification and Age, Life in Gondwana, Coastal Gondwana Basins, Gondwana in Extra-Peninsular India, Environmental of deposition and Economic Significance.

**Lecture 3: Mesozoic Era** – Introduction, Life of Mesozoic Era, *Triassic* - Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Sikkim, Rajasthan and Kutch. Permo-Triassic Boundary. *Jurassic* – Kutch, Rajasthan, Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Jharkhand and Bhutan. *Cretaceous* – Gujarat, Rajasthan, Jammu and Kashmir, Himachal Pradesh, Uttaranchal, East Coast, Trichinopoly, Narmada Basin, Lameta Formation, Jharkhand, Assam/Meghalaya, Andaman and Nicobar Islands. Cretaceous/Tertiary Boundary. *Deccan Volcanic Province* – Introduction, Regional Stratigraphy, Subprovinces, Volcano-Plutonic Complexes, Petrology and Petrogenesis, Inter-Trappean beds, Distribution and its age.

**Cenozoic Era** – Introduction, Distribution, Climate, Correlation, Fauna and Flora, Classification and Stratigraphy. *Paleogene* – Introduction, Fauna and Flora, Stratigraphy and Distribution. *Neogene* – Introduction, Fauna and Flora, Stratigraphy and Distribution. *Quaternary* – Introduction, Distribution, Quaternary climatic changes, Quaternary Sea level changes. Siwalik – Stratigraphy and Sedimentation, Distribution and Fauna of Siwalik. Geology of Offshore Basins. Morphology and Evaluation.

**Tutorial** – Assignments/Seminars/Test/Discussion.

**References:**

1. Geology of India Vol.1 & 2. M.Ramakrishnan and R Vaidyanathan
2. Geology of India – Wadia, D.N., Mc Millan and Co.
3. Geology of India and Burma – Krishnan M.S. Higginbotham, Madras.
4. A hand book of the Geology of the Mysore State – B. Rama Rao, Bangalore press.
5. Precambrian Stratigraphy and Geochronology of the Peninsular India – Sarkar, S.N. Dhanbad Publishers.
6. Review papers on the Stratigraphy of India –Rec.Geol.Surv.India Vol.101, Part 2.1972Cretaceous Tertiary formations –Geol.Soc. India, seminar Vol. 1958.
7. Paleozoic of Himalayas. HPC publ.
8. Reconnaissance Rb-Sr dating of the Precambrian of Southern Peninsular India-Crawford, A.R., J.G.S.I 1972. 117-126.

## **SOFT CORE**

### **NANOGEOSCIENCE [LTP / Credits = 200/2]**

**Lecture:1** Introduction to Nanoscience and Nanogeoscience. History of nanogeoscience. Nanominerals – definition, size, shape, mineral structure, properties, origin and occurrences. Commonly occurring nanominerals and nanocrystals. Differences in properties between bulk minerals and nanominerals. Nanomaterials world. Nanogeochemistry – introduction and its significance in the origin and distribution of various rocks and minerals.

**Lecture:2** Basic experimental methods of synthesis of some selected nanominerals. Applications of nanominerals in nanotechnology. Nanofossils – definition and occurrence. Significance of nanofossils in geoscience. Nanostructures and their occurrence in rocks and fossils. Significance of nanostructures in geosciences as indicators of geoenvironment, genesis of rocks and minerals, origin and evolution of life. Instruments used in the observation of nanominerals, nanofossils and nanostructures.

#### **Reference:**

### **MARINE GEOSCIENCE [LTP / Credits = 200/2]**

**Lecture:1** Introduction. Morphology and physiographic features of the ocean floor. Classification of sub marine topography. Physico-chemical characteristic of sea water - distribution of temperature, salinity and density of sea water. Waves, Tides, Currents and their significance.

**Lecture:2** Ocean deposits- source, nature and distribution of marine sediments. Marine resources- type of marine resources and their distribution and utilization, fresh water resources, marine mineral resources, marine energy resources and marine food resources, manganese nodules, methods of its exploitation.

#### **Reference:**

1. Maohotra, A K, Ocean Science and Technology
2. Tchernia, P, Descriptive regional oceanography
3. K. Siddhartha, Oceanography- A brief Introduction
4. William A Anikouchine and Richard W Stenberg, The world Ocean- An Introduction to oceanography
5. Cuchlaine A M King, Oceanography for Geographers
6. H V. Thurman, Introduction to oceanography
7. William A Anikouchine and Richard W Stenberg, The world Ocean- An Introduction to oceanography
8. Cuchlaine A M King, Oceanography for Geographers
9. H V. Thurman, Introduction to oceanography

### **GEOSTATISTICS AND COMPUTER APPLICATIONS [LTP / Credits = 201/3]**

**Lecture:1** Measures of central tendency – Averages; Measures of dispersion; and skewness and kurtosis of the given geological parameters. Frequency distribution, Measurement of central tendency using frequency table. Correlation and regression analysis.

**Lecture:2** Probability, Testing of Hypothesis – t-test, F – test, and Chi square test with examples from geological populations and discussing their significance. Calculation of statistical problems, mineral formula using Microsoft excel program, Generation of graphs – line graph Histogram, Pie graph, and Trilinear plots.

**Practical:1** Solving problems using Geological data, on Measures of central tendency, Frequency Distribution, Correlation and Regression and Testing of Hypothesis. Calculation of statistical problems, mineral formula using Microsoft excel program, Generation of graphs – line graph Histogram, Pie graph, and Trilinear plots.

**Reference:**

1. Statistics for Geoscientists - D.Marsal/D.F. Merriam
2. Microcomputer Applications in Geology - J.T.Hanley & D.F. Merriam.
3. An Introduction to Applied Geostatistics - E.H.Isaaks and R.M. Srivastava
4. Concepts in Geostatistics - R.B.Mc Cammon
5. Statistics and Data Analysis in Geology - Davis.

**ENVIRONMENTAL GEOLOGY [LTP / CREDITS = 210/3]**

**Lecture:1** Introduction to, Environmental education and management. Earth's environment segments-lithosphere, hydrosphere, atmosphere and biosphere. Concept of ecosystem. Energy circulation in atmosphere and other spheres. Interaction of atmosphere, hydrosphere, biosphere and their mutual relationship with lithosphere. Records of palaeo – temperature. Global warming caused due to fossil fuels; volcanic eruptions and deforestation. Humans as center of biosphere, change in human-environment relationship. Impact of major human activities on the environment, Environment impact assessment. Environment degradation. Contamination of surface water and groundwater due to industrialization, urbanization and agriculture. Water logging – problems due to construction of canals, reservoirs and dams. Soil profiles and soil quality degradation due to irrigation, use of fertilizers and pesticides. Impact of overexploitation of earth's natural resources on environment: Mineral resources and Energy resources.

**Lecture:2** Environmental pollution; causes, effects and control of soil, water, air and noise pollution. Mining and the environment marine pollution. Wastes and sources and types. Waste disposal and management methods (domestic, municipal, agricultural, industrial, biomedical, nuclear waste, etc.). Important environmental legislation. Environmental protection. Sewage treatment methods. Disaster management-droughts, landslides, floods, cyclones and earthquakes.

**Tutorial:** Assignments/Seminar/Test/Discussion

**REFERENCES**

- Valdiya. K.S, 2001: Environmental Geology-Indian context. Tata Mc Graw Hill.  
Keller. E.A, 2004: Environmental Geology. Bell and Howell USA.  
Bryant.E., 1999: Natural Hazards. Cambridge University Press.  
Subramaniam. V. 2001: Textbook in Environmental Science. Narosa International.  
Bell. F.G. 2003: Geological Hazards. Routeledge, London.12  
Smith. K. 2002: Environmental Hazards. Routeledge, London.  
Carla, 2006: Environmental Geology. Prentice Hall  
Valdia, K.S, 2004: Geology, Environment and Society. McGraw Hil

**GEMMOLOGY [LTP / CREDITS = 200/2]**

**Lecture 1:** Introduction to Gemology, classification of gemstones, detailed study of different physical characters and Optical properties of minerals with special reference of to gem minerals. Physico-optical effects in gem stones. Colour and cause of colour in gems.

**Lecture 2:** Cutting and polishing of gemstones. A detailed study of important precious and semi-precious gem minerals- their characters and occurrences- world occurrences in general and Indian occurrences in particular. Precious Varieties:1. Diamond, 2. Ruby, 3. Sapphire, 4. Topaz, 5. Emerald ii) Semi-Precious varieties: Garnets, Quartz ,Lapislazuli, Turquoise and Organic gems.

**Reference**

1. Gems and Gem industry in India-GSI Memoir 45- R.V Karanth.
2. Gem and Gem Minerals – EH Kvens and CB Slawsan
3. Encyclopedia of Minerals and Gem stones - Edited by Michael O' Don Oghal.
4. Precious stones - by Max-Bauer Vol. I and II. Publisher Dover publications Ink. New york.
5. Rutley's Elements of Mineralogy- by H.H. Read, CBS publication
6. Dana's Manual of Mineralogy
7. GEMS by R.Webster - Batter work and co. ltd., London

8. Gemstones - Herbert Smith - Published by Methuen co. Ltd., London
9. Introduction to Rock forming minerals-Deer, Howie and Zussman.
10. Physical Geology-P.K.Mukherjee
11. Geology of India-R.Vaidyanathan and M.Ramakrishnan
12. Geology of Karantaka-B.P.Radhakrishna
13. Mineral Resources of Karnataka-B.P Radhakrishna

**MINERALOGY, PETROLOGY, STRUCTURAL GEOLOGY AND GEODYNAMICS.**  
**MK -1[LTP / CREDITS = 200/2]**

**Lecture:1** Definition and Branches of Mineralogy. Physical and Chemical Properties of Minerals, Chemical properties of Minerals bonding, Classification of minerals,. Petrological microscope, Optical properties of minerals. **PETROLOGY-** Introduction to Classification, Igneous, Sedimentary and Metamorphic rocks. Forms of Igneous rocks Structures and Textures, Sedimentary rocks, Sedimentation, Classification and Structures of Sedimentary Rocks. Metamorphic rocks, Definition and Agents of Metamorphism, Kinds of Metamorphism, Structures / textures of Metamorphic Rocks

**Lecture:2** **STRUCTURAL GEOLOGY** and **GEODYNAMICS**-Introduction and importance of structural Geology. Primary and Secondary Structures. Introduction and Scope of geodynamics, Geological Agents- epigene and Hypogene agents. Age of the Earth, Volcanoes, and Earth Quakes, .

## SEMESTER III

### MINERAL RESOURCES [ LTP / CREDITS = 301/4]

**Lecture 1: Ore Geology- I:** Ore – bearing fluids: magma, hydrothermal fluids, meteoric waters, seawaters, connate waters, metamorphic fluids. Depositional textures: exsolution, replacement, colloidal – colloform and open-space filling textures. Wall rock alteration: reaction between wall rocks and fluids, alteration assemblages and types of alteration. Paragenesis and zoning in mineral deposits. Classification of ore deposits. Deposits related to ultramafic-mafic rocks (layered intrusions, anorthosites, kimberlites, carbonates, komatiites). Deposits related to intermediate to felsic rocks (Iron deposits, porphyry Mo, pegmatites, granitic Tin and U, skarn deposits with typical examples).

**Lecture 2: Ore Geology- II:** Deposits related to weathering – Nickel laterite deposits, Deposits related to clastic sedimentation: placer deposits – Witwatersrand gold and U deposits. Chemical sedimentation: phosphate deposits, evaporates, manganese nodules, Ore deposits related to subaerial (Epithermal gold – Au) and submarine volcanism (Kuroko Cu–Zn, Japan, BIFs). Ore deposits related to metamorphism, metallogenic provinces, Epochs and plate Tectonic – classification of ore deposits.

**Lecture 3: Ore Geology- III:** Metallic deposits of India: Iron, Manganese, Copper, Chromium, Gold, Lead, Zinc and Bauxite deposits, Non-metallic deposits (Industrial minerals) – Minerals used as fertilizers, refractories, abrasives, pigments, ceramic and glass-making materials.

**Practical:** Megascopic identification of ore minerals based on physical properties: oxides and hydroxides, carbonates, sulfides, silicates and other ore minerals group.

Ore microscopy: Identification of ore minerals based on optical properties: colour, reflectance, bireflectance, reflection pleochroism, isotropism, anisotropism: internal reflections, textures, mode of occurrence: chromite, ilmenite, Ti-magnetite, hematite, pyrite, sphalerite, galena, chalcocopyrite, covellite, Bornite, pyrrotite, Arsenopyrite, Pyrolusite.

#### Reference:

1. The geology of ore deposits - John M. Guilbert and Charles F. Park, Jr. W.H. Freeman and Co., New York. 1986.
2. Interpretation of ore textures - Bastin, E.S.
3. Economic Mineral deposits by Jenson and Bateman, A.M.
4. Ore microscopy - Cameron, E.N.
5. Textures of the ore minerals - Edwards, A.B.
6. Ore deposits - Park, Jr. C.F.
7. Geology of Mineral deposits - Smirnov, U.J.
8. The ore minerals and their intergrowths - Ramhor, Dr. Paul.
9. Ore Petrology - Stanton, R.L.
10. India's mineral resources – Sinha and Krishnaswamy, S.
11. Metallic and Industrial minerals - Lamey Carl, A.
12. Introduction to India's economic minerals - Sharma, N.L. & Ram . K.S.
13. A treatise on industrial minerals of India-Sinha, R.L.
14. Mineral deposits of India, Mukerjee 1999: Allied publications.

### VERTEBRATE & INVERTEBRATE PALAEOONTOLOGY [ LTP / CREDITS = 211/4]

**Lecture:1** Origin and Evolution of Life; Introduction to Microfossils; Classification and Applications of Microfossils; Separation of various Microfossils: Morphology, stratigraphic significance and applications of - Foraminifera, Ostracoda, Palynofossils, Acritarchs, Bryozoa, Chitinozoa, Conodont, Scleritons, Diatom, Radiolarians, Dinoflagellates, and Nanoplanktons. Application of microfossils in fossil fuel exploration, paleoclimate interpretation and maturation of sediments, Oxygen and Carbon Isotope studies on Fossils.

**Lecture:2** PLANT, INVERTEBRATE AND VERTEBRATE FOSSILS-*Palaeobotany* - Plants through geological age – Precambrian Algae and Stromatolites; Paleozoic, Mesozoic and Cenozoic plants – Bryophytes, Pteridophytes, Gymnosperms and Angiosperms their stratigraphic significance. *Invertebrates* – Classification, morphology, evolutionary trends, paleoecology and stratigraphic distribution of the following groups – Brachiopods, Pelecypods, Cephalopods, Trilobites and



Graptolites. *Vertebrates*- Evolution and geological significance of the following -Fish, Amphibians Reptiles, and Man.

**Tutorial:1** Assignments/Seminar/Test/Discussion

**Practical:1** Identification, Diagnosis and Geological distribution of the following Groups: Invertebrate – Brachiopods – 5 genera, Cephalopoda: 5 genera, Pelecypoda: 5 Genera, Trilobita: 5 genera, Graptozoa: 2 genera, Plant fossils: 6 genera, Microfossils- Foraminifera: 8 genera, Ostracoda: 3 genera, Palynofossils: 6 genera. Problems on biostratigraphy, Palaeo-ecology and Interpretation of Seismic Profiles.

**References:**

1. Clarkson, E.N.K., 1998, *Invertebrate Palaeontology and Evolution*, IV edition, publ., Blackwell
2. Stearn, C.W. & Carroll R.L. 1989, *Paleontology-the Record of Life*, Publ. John Wiley.
3. Smith, A.B, 1994, *Systematics And The Fossils Record-Documenting Evolutionary Patterns.*, publ, Blackwell
4. Prothero. D.R., 1998, *Bringing Fossils to Life- An Introduction to Palaeobiology.*, publ., Mc Graw Hill
5. D.J.Jones, 1956. *Microfossils*
6. F.T.Banner and A.R.Lord., *Aspects of Micropaleontology*
7. M.P.Glaessner, *Principles of Micropalaeontology*
8. M.D.Brasier, 1955, *Microfossils*, Publ.George allan and Wiley & Sons
9. Romer.A, *Vertebrate Palaeontology*
10. Colbert, *Introduction to Vertebrate Palaeontology*
11. Sukla., A.C & Misra S.P, 1975, *Study of Palaeobotany* Vikar Publ.House
12. Sripad.N.Agashe, *Palaeobotany*
13. Maohotra,A K, Ocean Science and Technology
14. Tchernia,P, Descriptive regional oceanography
15. K.Siddhartha, Oceanography- A brief Introduction
16. Willam A Anikouchine and Richard W Stenberg, The world Ocean- An Introduction to oceanography
17. Cuchlaine A M King, Oceanography for Geographers
18. H V.Thurman, Introduction to oceanography

**SEDIMENTALOGY & GEOMORPHOLOGY [ LTP / CREDITS = 211/4]**

**Lecture:1** Aims and Scope of Sedimentology, Development growth and Prospects of Sedimentology in India, Sedimentary facies and environment. Detailed petrographic parameter of Gravels and Conglomerates, Sands and Sandstones, Shales, and Argillite, Limestone and Dolomite, Evaporites, Provenance studies, Heavy mineral studies, Grain size parameter Modes and Mechanism controls of sedimentation, Stock's law, Sedimentary structures, Tectonics and sedimentation, Cyclic sediments purpose and scope of basin analysis

**Lecture 2:** Introduction and classification of Relief orders of earth . Principles of Geomorphology. Classification of Geomorphic processes. Land forms develop due the interaction of geomorphic agents- fluvial, aeolian, karst, glacial and coastal cycle.

**Tutorial:** Assignments/Seminar/Test/Discussion

**Practical:1** Identification of Sedimentary rocks in hand specimens and thin sections. Identification of structures in Sedimentary rocks.

**Reference:**

1. Sedimentary petrology – Pettijohn.
2. Petrography – An introduction to the study of rocks in thin sections – H Kowell,,Williams and Turner.
3. Manual of sedimentary petrology – Krumbein and Pettijohn.
4. Principles of sedimentation – Twenhofel.

5. Sequence in layered rocks – Shrock, R.R
6. Procedures in sedimentary petrology – R.E. Carvar
7. Origin of sedimentary rocks – Blatt, Middleton and Hurray.
8. Microscope sedimentary petrology – A.V. Carrozi.
9. Sand and Sand Stones – Pettijohn, Potter and Siever.
10. Petrology of sedimentary rocks – R.L.Folk.
11. Hand book of subsurface geology – C.A.Moore
12. Marine Geology and Oceanography of the Arctic seas – Yvonne Herman.
13. Thornbury, W.D – Principles of Geomorphology
14. Dayal. P – A Text book of Geomorphology

## **SOFT CORE**

### **MINERAL ECONOMICS [LTP / CREDITS = 200/2]**

**Lecture 1:** Introduction and concepts of mineral economics. Peculiarities in mineral deposits. Concepts in mineral exploration and mineral resource estimation. Classification of Indian mineral resources. Role of mineral industry in national economy. Strategic, critical and essential minerals. India's status in mineral production. Changing patterns of mineral consumption.

**Lecture 2:** National Mineral Policy. Mineral Concession Rules. Mineral legislation in India. Mineral production, processing, coproducts and byproducts. Mineral inventory. Consumption and substitution of minerals. Demand Analysis and market survey. Mineral conservation and environment. Mineral information system. Marine mineral resources and Law of Sea.

#### **Reference:**

1. Mineral Economics by Truscot, John Wiley and Sons, Inc, 1987.
1. An introduction to mineral Economics – K.K.Chatterjee. publisher : - Wiley Eastern. 1993.
2. Mineral Economics : - R.K. Ssinha and N.L.Sharma. Oxford and IBH publication

### **ANALYTICAL TECHNIQUES IN GEOLOGY [LTP / CREDITS = 110/2]**

**Lecture:1** Introduction to instrumental methods of chemical analysis, Spectroscopy photometry and spectrophotometer, Infrared spectroscopy – FTIR. Atomic Absorption spectroscopy (AAS), and Inductively coupled Plasma (ICP-MS) analysis technique, Thermal analysis techniques – DTA, TGA, DSC etc., Electron Microscopy – SEM, TEM, AFM; X-Ray powder diffraction techniques (XRD), X-ray Fluorescence (XRF) technique, Electro probe micro analysis technique, (EDAX, WDS). Neutron Activation Analysis (NAA)

**Tutorial:** Assignments/Seminar/Test/Discussion

#### **Reference:**

1. Silicate analysis by Potts
2. Petrographic techniques by Hutchinson

### **MATERIAL SCIENCE AND NANOTECHNOLOGY [LTP / Credits = 200/2]**

**Lecture:1** Introduction to Materials Science – Natural materials and synthetic materials. Introduction to nanotechnology – basics, definition. History of nanotechnology. Importance of Materials and Nanomaterials in modern technology and their relation to other branches of science. Types of materials based on composition, size, properties and applications. Inorganic, organic, biologic and composites. Bulk, small, fine, ultrafine, nanomaterials. Electronic, semiconductors, superconductors, superionic conductors, magnetic, optic, opto-electronic, spintronics, lasers, photonic, ceramic, bioceramics, biomedical, biosensors, bioimagers, photocatalysts, quantum dots, polymers, alloys, composites, etc.

**Lecture:2** Study of properties of materials – bulk to nanosize materials. Size effect of materials on properties. Quantization effect on the properties of materials with examples. Various techniques employed in materials synthesis and fabrication depending upon the size and applications. Concept of the quality of materials and the suitability of the processing method. Processing of Important materials

for modern technology and including nanotechnology. Characterization techniques in materials science and nanotechnology.

**Reference:**

1. Springer Handbook of Nanotechnology - Bharat Bhusan
2. Chemistry of nanomaterials : Synthesis, properties and applications by CNR Rao et.al.
3. Encyclopedia of Nanotechnology- Hari Singh Nalwa
4. Introduction to Nanotechnology - Charles P. Poole Jr. and Franks. J. Qwens
5. Handbook of Hydrothermal Technology - K. Byrappa and M. Yoshimura (2001)
6. Advanced Drug Delivery Reviews - K. Byrappa, N. Ohara and T. Adschiri, (2007)
7. Hydrothermal Technology for Nanotechnology, Progress in Crystal Growth and Characterization of Materials (2007).K. Byrappa and T. Adschiri,
8. Special Edition of Journal of Materials Science volume 41, No. 6 (2006).K. Byrappa and M. Yoshimura (Guest Editors).
9. Special Edition of Journal of Materials Science, Volume 43, No.7 (2008).K. Byrappa and T. Adschiri (Guest Editors):
10. Handbook of Crystal Growth Technology – K. Byrappa and T. Ohachi (2003)  
Publishers: William Andrew, USA and Springer, Germany.
11. Crystal Growth of Technologically Important Electronic Materials – K. Byrappa,
12. T. Ohachi, H. Klapper and R. Fornari (2003). Publishers: Allied Publishers, Delhi.

**PRECAMBRIAN GEOLOGY AND CRUSTAL EVOLUTION [LTP / CREDITS = 200/2]**

**Lecture:1** Evolution of lithosphere, hydrosphere, atmosphere, biosphere, and cryosphere; lithological, geochemical and Geochronological characteristics of granite – greenstone and granulite belts.

**Lecture:2** Cratonic nuclei and mobile belts. Evolution of Proterozoic sedimentary basins of India. Plate tectonics during Precambrian

**Reference:**

1. Archaean Geology- C.S. Pichamuthu
2. Early Precambrian supracrustal of southern Karantaka-Memoir 112. Geol.Surv. Ind
3. Geology of Karantaka- B.P Radhakrishna
4. Geology of India (Volume 1 and 2)- R.Vaidyanathan and M. Ramakrishnan
5. Geology of India and Burma- M.S Krishnan
6. Geology of India- M. Wadia

**EXPERIMENTAL MINERALOGY AND PETROLOGY [LTP / CREDITS = 200/2]**

**Lecture:1** History and Scope of experimental Mineralogy, Experimental Philosophy, Conditions, starting materials and measurements. Instrumentation for Open system, closed system - near surface, moderate to high pressure systems.

**Lecture:2** Experiments for measurement of viscosity, construction of phase diagram/ stability field diagram, retrieve thermodynamic parameters from constructed phase diagram. Experiments on solid – solid reactions, solid – fluid reactions. Experiments involving fluids only – PVT, Solubility studies.

**Reference:**

1. Analytical Petrography – Ragland
2. Kinetics and Mineral Equilibrium in mineral reaction – Advances in Physical Geochemistry III, Springer Verlag, New York,
3. Igneous Petrology – Carmichael A N., Turner and Verhoogen
4. Reviews in Mineralogy – Mineralogical society of America
5. Chemical Thermodynamics for Earth Scientists by Philip Fletcher

## EVEN SEMESTER

### Semester II

#### HARD CORE

#### GEO INFORMATICS [LTP/ Credits =202/4]

**Lecture:1 Remote Sensing:** Introduction, Sensors- Capabilities, active and passive sensors, thermal sensors, atmospheric sensors, Different Indian satellites-Cartosat, Oceansat, Edusat, Air borne radars, ASTER, Modis, LISS3, PAN, Land Sat MSS, TM, SPOT, ICOS and Quick Bird, Vidicon camera, line scanning system, push broom system, radar interferometry, Ground based sensors and scanners.

**Lecture:2 GIS:** Components of GIS, GIS tasks, Data stores, Data index, Data model – Vector & Raster model, TIN model, Database concepts- DBMS architecture & models, Object relational and oriented DBMS, Analytical capabilities of GIS, Architecture of Intelligent GIS, Geographic co-ordinate system, map projections and parameters, Map concepts.

**Practical:1 Remote Sensing:** Visual interpretation of topo maps, satellite imageries to create layers (lithology, drainage pattern, lineaments, structures, water bodies, land use/land cover, vegetation, and mining and mineralised zones)

**Practical:2 GIS:** Map registration, digitisation, thematic layer preparation using GIS softwares. ERDAS – Image processing, Geo-referencing, Image rectification, Mosaic. Subsetting, supervised and unsupervised classification.

#### Reference:

1. Text book of Remote sensing and geographical Information system, 1<sup>st</sup> & 2<sup>nd</sup> Ed. By M. Anjireddy, BS Publications, Hyderabad
2. SIRO-DBMS: A database tool kit for Geographical system – Abel, D.J. 1989
3. Remote sensing principles and Interpretations, 3<sup>rd</sup> edition, Floyd. F. Sabins
4. Applications of Remote sensing and GIS by H T Basavarajappa, Et. Al
5. Concepts and techniques of GIS by Albert K W Yeung, PH series in Geographic information science, New Delhi – 2005
6. An Introduction to Geographical System – Ian Heywood, Sarah Cornelius, Steve Carver
7. Cartography: Visualization of Geospatial data – Menno-Jan Kraak and Ferjan Ormeling
8. Principles and application of Photogeology – Shiv N Pandey
9. Aerial photographic interpretation, Principles and applications - D.R.Leuder.
10. Photogeology - Miller, J.C.
11. Manual of colour aerial photography -Ed. Smith, J.T.Jr.
12. Manual of photogrammetry - Ed: Morrie M.Thompson.
13. Manual of Remote sensing - Ed: Robert G Reeves.
14. Theory of pattern recognition and modern forecasting - V.Karpin and Wright Pattern.
15. Remote sensing in Geology - Parry S. Siegal & Alan. R.Gillespie
16. Manual of photographic interpretation - Ed: Colwell, R.N.
17. Principles of Remote Sensing – Patel Singh; SP publication
18. Digital Remote Sensing – Pritivish Nag M Kudrat ; Concept publication
19. Principles of GIS for land and resources assessment, Burrough, P.A., 1986, Oxford.
20. Introductory cartography, Campbell, 1984, Prentice Hall
21. Map data processing, Freeman and Pieroni, 1980, Academic Press.
22. An introduction to Geographical information systems: Ian Heywood et. al.
23. Geographical information systems Vol 1 & 2. Edited by: Paul A.Longley, Michael F.Goodchild, David J. Maguire & David W.Rhind.
24. Geographical information systems and digital image processing – Muralikrishna 1999. Allied Publication
25. Fundamentals of remote sensing and Geoinformatics , by Anjireddy, Hyderabad ed. 1 and 2.
26. Advanced GIS in Websites. And Internet.
27. Applications of GIS Vol.1 and 2

## **GROUNDWATER GEOLOGY [LTP / CREDITS = 211/4]**

**Lecture:1** Physical Hydrogeology: Definition, scope, distribution, global water budget, India's water budget, Hydrological cycle, origin of groundwater, Groundwater occurrences in igneous and metamorphic rocks, vertical distribution of groundwater, groundwater movement, classification and types of aquifers, porosity, permeability, specific yield, specific retention, storage, transmissibility.

**Lecture:2** Groundwater Exploration: Surface methods, geological, geomorphological, Structural and biological, geophysical methods. Role of remote sensing in groundwater targeting. **Groundwater management and recharge:** Groundwater recharge, Artificial recharge Water harvesting, watershed-wasteland management, structures, contour, bunds, contour barriers (Vegetative and stones), contour trenching, check dams, percolation pond, irrigation tank. Groundwater runoff, **Water Quality:** Physical, chemical and biological properties of water, **Groundwater pollution: Surface water pollution** by disposal of wastes, dumps, sewages, septic tanks, land fills, **Subsurface pollution:** Water table pollution, pollution by fertilizers and pesticides, Impact of ground water pollution by mining activities.

**Tutorials:1** Assignments/Seminar/Test/Discussion

**Practical:1** Problems pertaining to rainfall measurements, rainfall estimation, Selection and sites for rain gauge stations Arithmetic, Theissen polygon methods, water balance studies, Grid-deviation water table studies, Water table fluctuations, water budget, Determination of groundwater quality studies.

### **Reference:**

1. Groundwater-C.F.Tolman
2. Groundwater Hydrology-D.K.Todd
3. Hydrology-S.N.Davis and R.J.M Dewiest
4. Groundwater studies-R.H.Brown and others
5. Groundwater Hydrology-Herman Bouver
6. Hydrology-C.W.Fetter
7. Hand book of Applied hydrology-Van te Chew
8. Groundwater and wells-Hohnson Publications
9. Applied Hydrology-Chow M.Mays.Mac.Graw Hill Publication
10. Hydrology and wetland conservation-Gulam
11. Groundwater survey and investigation-Guatham Mahajan
12. Hydrology-Raghunath
13. Hydrogeology-Karant
14. Ecology, Environment and Pollution – A Balasubramanian

## **GEOCHEMICAL THERMODYNAMICS [LTP / CREDITS = 301/4]**

**Lecture:1** Thermodynamics: Basic concepts and conventions, System and surrounding, classification and state of the systems, State functions, Time dependent and time independent processes, Thermodynamic Equilibrium and equilibrium constant, First law of thermodynamics – expressions for Internal energy, heat, work, Enthalpy, Hess's Law of heat of summation, Heat capacity, heats of formations and heats of reactions, Kirchoff's equation.. Reversibility and Irreversibility, concept of Entropy, types of disorders Second law of thermodynamics and derivation of expressions of entropy. Gibbs free energy, Clapeyron equation, Third law of thermodynamics. Partial molar quantities, chemical potential, fugacity and activity, Application of thermodynamics for phase equilibrium studies

**Lecture:2** Phase equilibrium studies: Basic concepts, phase and component, Degrees of freedom, Phase rule. Unary system with examples of P-T diagrams of water, silica,  $Al_2SiO_5$ , Carbon and other systems and application of phase rule and application of Clapeyron equation. Critical point and supercritical fluids. Binary systems with examples of two dimensional sections like – Diop- Anor system, Nepheline-silica, forsterite-silica and others. discussion on congruent and incongruent melting, eutectic crystallization, Partial melting, Equilibrium and fractional crystallization, Miscibility and immiscibility in solids and liquids, thermal divide and thermal valley, Peritectic point, Binary systems with solid solutions with examples of Fo-Fa, Ab-An etc., complete and partial solid solution, sub solidus

reactions, perthites and antiperthites, Ternary systems with examples on immiscible solids and solid solutions.

**Lecture:3** Geochemistry: Basic concepts and Scope of Geochemistry. Geochemical classification of elements, Age, origin and composition of the universe with special reference to solar system. Meteorites - Classification composition and their origin. Differentiation of the Earth. Biochemical classification of element and geochemical cycles. Geochronology -Radio activity decay schemes, Radiometric dating. Radiogenic Isotopes: strontium isotopes and neodymium. isotopes, Application of radiogenic isotopes : U-Pb, Rb-Sr and Sm-Nd isotope systematics and stable isotopes.

**Practical:** P-T calculations and construction of P-T diagrams. Petrochemical Calculations- Niggli Verte and Niggli Bases, CIPW Norm calculations. Modal analyses plots. Construction of variation and discriminate diagrams using major, trace and REE geochemistry data and interpretation. Calculation of half life isotopes

**References:**

1. Rare earth element Geochemistry by Henderson
2. Geochemistry by Rankama and Sahama
3. Petrologic Phase equilibria – W.G.Ernst
4. The Interpretation of Geological Phase diagrams - Ernest G Ehlers
5. Petrogenesis – Wilson
6. Solutions, Minerals and Equilibria – Garrels and Christ, 1966
7. Simulating the Earth- J.R. Holloway and B.J. Wood, 1988
8. Basic analytical Petrography – Ragland, 1989
9. Principles of Igneous and Metamorphic Petrology by Antony R Philpotts, 1979.1.
10. Geochemical Thermodynamics by Darrell Kirk Nordstrom and James L. Munoz
11. Chemical Thermodynamics for earth scientists by Philip Fletcher, 1993
12. Chemical Fundamentals of Geology by Robin Gill.
13. Elementary Thermodynamics by B.J. Wood and D.G. Fraser, 1976
14. Equilibrium Thermodynamics by Roger Powell
15. Principles of Geochemistry – Brian Mason
16. Geochemistry by Anderson
17. Chemical Thermodynamics by Bruce H Mahan

**MINOR PROJECT (FIELD WORK AND TECHNICAL REPORT) [LTP / Credits = 004/4]**

Field area selection, collection of literature, planning for field work, Reading toposheet, Reconnaissance survey, Observation of the exposures, recording and taking measurements of exposures in the field, collection of representative samples. Detailed mapping and preparation of field map. Report writing and submission prior to the commencement of main examination.

Evaluation pattern:

1. The Field work and technical report will be evaluated as follows:
  - a. Main examination - evaluated for 70 marks: 50 marks for hard copy of the field report submitted, which will be evaluated by both Internal and external examiners, and 20 marks for viva voce.
  - b. Internal Assessment - evaluated for 30 marks:
    - i. C1 - 15 marks evaluated through test
    - ii. C2 – 15 marks evaluated for the draft copy of the field report.
2. If any of the internal examiners is absent on the day of examination the chairperson will be the internal examiner.

**Reference:**

1. Field Geology by Lahee
2. Field geology by Compton

## SOFT CORE:

### MINING METHODS AND MINERAL PROCESSING [LTP / Credits = 200/2]

**Lecture 1: MINING METHODS:** Mining terminology, methods of mining, open cast, underground and alluvial mining. Mining of metalliferous ore deposits. Factors affecting mine layout development, surface mining, Mining Machinery, Basic operations of Large open-pit mine. Methods of stopping, shaft sinking. Mine support and ventilation. Blasting and explosives. Coal mining methods..

**Lecture 2: MINERAL DRESSING:** Definition and Scope of Mineral dressing, Physical and Chemical Properties of minerals made use of in Mineral dressing. Comminution : Principles, theories of Comminution, ore grindability. Crushers : Primary and Secondary Crushers. Grinding Mills (Tumbling Mills):- types of Mills : Rod, Ball and Autogenous mills. Industrial Screening : Screens and their types. Classification : Types of classifiers. Gravity concentration : principles. Types of Gravity separators ; Heavy Medium Separation - Separating Vessels. Magnetic Separation : Types of Magnetic Separators. Froth Flotation technique of Separation of Complex Sulfide over : Reagents : Collectors, Frothers and Regulators - Activators & Depressants.

#### Reference:

1. Elements of Mining Geology - Young
2. Elements of Mining - Lewis
3. Mining of mineral deposits - Shevyekov
4. Introduction of mining - stoces
5. Principles of Mining Geology, Arogyaswamy..
6. Principles of mineral dressing -0 Gaudin-Tata Mc. Graw Hill Publishing co.,
7. Text books of ore dressing - Richards and Looke Mc.Graw Hill Pub.Co. Inc.
8. Elements of ore dressing - Roberts.
9. Mineral processing - Pryor
10. Handbook of Mineral dressing - Taggart
11. Elements of dressing - Taggarat.

### SURVEYING [LTP / CREDITS = 101/2]

**Lecture:**1 Introduction to surveying . Chain survey, Compass survey, Plane table survey, Dumpy level survey, Theodolite survey, Total station and GPS survey.

**Practical:**1 Chain survey, Compass survey, Plane table survey, Dumpy level survey, GPS survey. All these data collected by various surveys and interpretation.

#### Reference:

1. Surveying and Levelling – Late T.P. Kanetkar and S.V. Kulkarni.
2. Surveying – Punmia.

### MICRO PALEONTOLOGY AND PALYNOLOGY [LTP / Credits = 200/2]

**Lecture:**1 A brief introduction to applications of microfossils in Stratigraphy, Biostratigraphy Bio Zonation, Paleoecology, Paleoenvironmental depositional studies. Applications of Microfossil in maturation of sediments and methods of interpretation. Microfossil colours as an Index in identification of sediments of organic content. Palynology Introduction to Palynology and its application. Spores and pollens and distribution pattern in Geological records.

**Lecture 2:** Study of morphological features in Paleocological interpretations. A detail morphology of Nanofossils and its application in Nonogeoscience. Problems on Biostratigraphical and paleoecological studies using microfossils – case studies. Statistical micropaleontology and its application. Role of microfossils in fossil fuel explorations.

#### Reference:

1. Clarkson, E.N.K., 1998, *Invertebrate Palaeontology and Evolution*, IV edition, publ., Blackwell
2. Stearn, C.W. & Carroll R.L. 1989, *Paleontology-the Record of Life* , Publ. John Wiley.
3. Smith, A.B, 1994, *Systematics And The Fossils Record-Documenting Evolutionary Patterns.*, publ, Blackwell
4. Prothero. D.R., 1998, *Bringing Fossils to Life- An Introduction to Palaeobiology.*, publ., Mc Graw Hill

5. D.J.Jones, 1956. *Microfossils*
6. F.T.Banner and A.R.Lord., *Aspects of Micropaleontology*
7. M.P.Glaessner, *Principles of Micropalaeontology*
8. M.D.Brasier, 1955, *Microfossils*, Publ.George allan and Wiley & Sons
9. Romer.A, *Vertebrate Palaeontology*
10. Colbert, *Introduction to Vertebrate Palaeontology*
11. Sukla., A.C & Misra S.P, 1975, *Study of Palaeobotany* Vikar Publ.House
12. Sripad.N.Agashe, *Palaeobotany*
13. Aspects of Palynology by Tshaetae.

### **ENGINEERING GEOLOGY [LTP / Credits = 200/2]**

**Lecture:1** Engineering properties of rocks. Rocks as construction material, Geological considerations in selecting sites for tunnels, bridges, Dams and reservoirs, highways, Reservoir sedimentation: Causes – effects- basin, channel and geological factors, climatic influence, monitoring- desilting methods.

**Lecture:2** Geological investigation of landslides – hazards – hazards zonation mapping – stability analysis mitigation measures. Coastal Erosion: Near shore dynamics, erosion mechanisms- longshore drift, Effects of coastal erosion – Controlling methods – barriers groins, sea walls, Jetties and stone revetments. Geology of soils and elements of soil and soil mechanics.

#### **Reference:**

1. Plate tectonics and crustal evolution – Condie,K.C.
2. Manual of Field geology – Compton.
3. Soil their Orgin, constitution and classification – Robinson G.W
4. Soils – Tambane and others
5. Nature and Properties of Soil- Harry O Buckmen Nylc C. Brady
6. Fundamentals of Soil Science – Miling, Truck and Forth. H.D( 1984) John willey
7. Introduction to Physical Geology – Strahler, A.N – 1965 – Willey
8. Climatology – Stringer (1982) Surjeet Publication Soil Atlas of Karnataka, NBSSLUP Publication.

### **STRATIGRAPHY, PALAEOONTOLOGY AND ECONOMIC GEOLOGY: MK2 [LTP / CREDITS = 200/2]**

**Lecture:1** Stratigraphy and Paleontology- Introduction and relationship with other branches of Geology. Stratigraphic principles. Nature of Geological Record. Branches of Stratigraphy, Correlation – Physical and Biological Criteria. Standard Stratigraphic scale. Introduction to Palaeontology - Classification of life. Fossils: Definition , fossilization, types of fossils, Casts and Molds. Tracks and Trails. Uses of fossils. Morphology and Geological distribution of - Foraminifera, Brachiopods, Mollusca- Lamellibranchs, Gastropods, Cephalopods, Echinoids & Trilobites. Plant fossils - Morphology and distribution of Lepidodendron, Siggillaria, Calamites, Glossopteris, Ptillophyllum.

**Lecture:2. ECONOMIC GEOLOGY-** Introduction - Definition and importance of Economic Geology. Ore minerals, Gangue minerals, Tenor and Grade of Ore. Ore Genesis - Principles and Ore formation Processes: Magmatic concentration, contact metasomatism, hydrothermal processes: cavity filling and replacement, weathering: Residual and Mechanic concentrations, sedimentation: Oxidation and supergene enrichment and metamorphism. Examples of metallic and non metallic deposits.

1. Introduction to Palaeontology by Woods
2. Introduction to Palaeontology by Jain and Anatha ram
3. The geology of ore deposits - John M. Guilbert and charles. F.Park, Jr.W.H.Freeman and Co., New York. 1986.
4. General Geology by PK Mukerjee.
5. Interpretation of ore textures - Bastin, E.S.
6. Economic Mineral deposits by Jenson and Bateman, A.M. Introduction to India's economic minerals - Sharma, N.L. & Ram . K.S.
7. A treatise on industrial minerals of India-Sinha, R.L.
8. Mineral deposits of India, Mukerjee 1999: Allied publications.



## SEMESTER – IV

### HARD CORE

#### ROCK KINGDOM [LTP / CREDITS = 301/4]

**Lecture:1 *Igneous Rocks*:** Classification of Igneous rocks based on geological occurrence, mineralogy and chemical composition. Forms of Igneous rocks. Classification, mineralogy, origin of Granite, Gabbro, Kimberlite, Anorthosite, Carbonatite rocks.

**Lecture:2** Mineralogy, classification and origin Pegmatites Dolerite, Basalt, Rhyolite, Trachyte, Andesite rocks. Origin and evolution of Deccan Basalts.

**Lecture:3 *Petrogenesis*:** Steady-state geotherms. Genesis, properties, emplacement, crystallization and differentiation of magmas. Role of volatiles in magma evolution (effect of volatiles on melt equilibria). Magma-mixing, mingling and immiscibility, Gravitational, Filter - Pressing, gas-streaming and fractional crystallisation. Assimilation Processes and mechanism. Magmatic differentiation of rare earth and trace elements as monitors of magma evolutionary processes; mantle melting models and derivation of primary magmas.

**Practical:1 *Mega & Microscopic studies of Igneous Rocks*** – Identification of minerals in hand specimen based on physical properties. Identification of microstructures and textures of igneous rocks.

#### Reference:

1. Petrology - V. Hyndman Ed. II
2. The evolution of igneous rocks - Bowen, N.L. Princeton Uni. Press
3. Natural History of igneous rocks - Herker, A. Mc. Millan.
4. Petrography, An introduction to the study of rocks in thin sections - Howell, William and Turner, W.H. Freeman.
5. Igneous Petrology - Carmichael, Turner and Verrhoogen Mc. Graw Hill.
6. Migmatites and origin of the granitic rocks - Mehnert, K.R. Elsevier Publication.
7. Granite Petrology and granite problem - Marino V. Elsevier.
8. Basalt, Vols. I & II - Poldervaart and Hess, H.H.
9. Ultramafic rocks - Wyllie, P.J. Heffer.
10. Introduction to Petrology - Bailey B. Prentice Hall.
11. Igneous Petrology - Middlemost.

#### GEOLOGICAL PROSPECTION AND EXPLORATION [LTP / CREDITS = 301/4]

**Lecture:1 *Geological Exploration***- Mode of occurrence of commercial-grade deposits of Fe, Mn, Ag-(W), Cu, Pb-Zn, Ti, Ni, Mo, Sn, Al, Pt - group. U-Th. Geological criteria for mineral prospecting. Indications of ore. Geological prospecting methods. Small and large scale geological mapping. Methods of geological exploration - exploratory grids, location and documentation of exploratory workings (pits, trenches underground workings), drilling, core logging. Sampling techniques and evaluation of grade.

**Lecture:2 *Geochemical Exploration*:** Geochemical cycle, mobility of elements and geochemical anomaly. Mode of occurrence of trace elements. Primary dispersion patterns of deep seated origin, syngenetic and epigenetic. Geochemical rock surveys. Weathering and its products. Mobility of elements in the surficial environment and surficial dispersion patterns and forms. Anomalies in residual and transported overburden. Anomalies in waters and drainage sediments. Uptake of mineral matter by plants. Biogeochemical anomalies and survey techniques. Vapour geochemistry.

**Lecture:3 *Geophysical Exploration***- Geophysical anomalies, Electrical prospecting: Resistivity method, important electrode arrangements, instruments, application of electrical methods in ground

water investigation. Magnetic prospecting: Magnetic properties of rocks and minerals, Earth's magnetic field, instrument and measurements, interpretation of magnetic anomalies. Gravity prospecting: Earth's gravity field, regional and local gravity anomalies, instruments, interpretation of gravity anomalies. Seismic prospecting: Elastic properties of different rocks and minerals, refraction and reflection technique time-distance relation for horizontal interfaces, seismic instruments and records. Radio metric methods: Radioactivity of rocks and minerals, instruments and measurements of radiation, Well logging: Different techniques of logging.

**Practical:1** Delineation of ore deposit based on exploration data. Classification of ore reserves. Economic evaluation of ore deposit. Preparation of technical report. Geochemical methods in mineral exploration and choice of materials and methods. Interpretation of Geochemical maps for locating ore mineralization. Preparation of geochemical anomaly maps. Resistivity methods: Curve matching techniques and s-line method.

**Reference:**

1. Geochemistry in mineral exploration Rose, A.W Hawkes. H.E & Webb J.S. 1979.
2. Principles of geochemical prospecting. Ginzburg. I.I. Petgamon Press, N.Y. London.
3. Biochemical methods of Prospecting - Malyuga, D.P.
4. Principles of Mining Geology, Arokiaswamy.
5. Geological prospecting and exploration – Kreiter, V.M.
6. Rock geochemistry in Mineral Exploration. G.J.S.Govett. Elsevier Publication. 1983.
7. Introduction to geophysical prospecting - Milton B Dobrin
8. Geophysical prospecting for oil – Nettleton L L
9. Exploration geophysics – Jakaosku J J
10. Outlines of geophysical prospecting - A manual for geologists – M B Ramachandra Rao
11. Geophysical Methods in Geology – P V Sharama
12. Applied Geophysics in search for minerals – Eve A S Keys
13. Geophysical Exploration – Heilava C H
14. Exploration Geophysics for geologist and Engineers – Bhimasanakaran and Gaur
15. Mining Geophysics – D S Paransis
16. Principles of Applied Geophysics – D S Paransis
17. Introduction to Geophysics – C H Howel

**MAJOR PROJECT (DISSERTATION) [LTP / CREDITS = 006/6]**

Preparation of dissertation on the topic assigned. This include literature collection, identification of objectives, methodology, description of the analytical instruments used, data collected and its interpretation, results and discussion followed by conclusions.

The dissertation so prepared has to be submitted in the bound form two copies ONE month before the commencement of the practical examination. A certificate duly signed by the candidate and the guide has to be enclosed, stating that the material collected and presented in the Dissertation has NOT been submitted for the award of any Degree/Diploma in this university or in any other university.

Dissertation evaluation pattern:

3. The dissertation will be evaluated as follows:
  - a. Main examination - evaluated for 70 marks: 50 marks for hard copy of the dissertation submitted, which will be evaluated by both Internal and external examiners, and 20 marks for viva voce.
  - b. Internal Assessment - evaluated for 30 marks:
    - i. C1 - 15 marks evaluated through test
    - ii. C2 – 15 marks evaluated for the draft copy of the dissertation.
4. If any of the internal examiners is absent on the day of examination the chairperson will be the internal examiner.

## **SOFT CORE**

### **CLIMATOLOGY [LTP / CREDITS = 200/2]**

**Lecture 1:** Earth's Domains- Brief introduction on Lithosphere, Atmosphere, Biosphere and Atmosphere. Elements of Atmosphere and its measurements with instruments. Structure of Atmosphere and its characters. Circulation of Winds- Planetary and local winds. Basics of Weather and Climate. Global Temperature and Pressure belts. Heat Budget of the Earth. Atmospheric circulation: Atmospheric stability and instability. Air masses and types.

**Lecture 2:** Tropical and Temperate Cyclones and its distribution. Basis of Climatic classification. Monsoons and Jet Stream. Koppen's and Thornthwaite's scheme of climatic Classifications. Classification of world climate and zones. Green house effect, Global warming causes and its effects. Ozone depletion and its effects. Role of Anthropogenic activities in climatic changes with case studies.

#### **References:**

1. Collings.V.K (1987) Weather, radar and Flood forecasting, John Wiley and sons.
2. Crithfield.H.J (1996) General Climatology, Prentice Hall, New Jersey.
3. Menon P.A (1989) Our weather, National Book Trust, New Delhi.
4. Smith.K. (1975), Principles of Applied Climatology, McGraw Hill book Co., London
5. Climatology by Miller, Austin A Publication: London Methuen and company 1961 . xii, 320p.
6. General climatology by Flohn, H [ed.] Publication: Amsterdam Elsevier Publishing company 1969 . xi, 266p.Date:1969
7. Climatology and the world's climates by Rumney, George RPublication: London The Macmillan Company 1968 . x, 656p.Date:1968
8. Climatology by Miller, A.AustinPublication: London Methuen And Co 1938 . x, 304pp
9. Climatology by Haurwitz, BernhardPublication: New York Mc Graw-Hill 1944 . xi, 409p.
10. Methods in climatology by Conrad, VictorPublication: Cambridge Harvard University Press 1946 . xx, 228p.Date:1946
11. Climatology by Kendrew, W GPublication: Oxford The Clarendon Press 1957 . xv, 400p.
12. Climatology by Blair, Thomas APublication: New York Prentice-Hall 1942 . xvi, 484p.
13. Introduction to climatology for the topics by Ayoade, J OPublication: Chichester John Wiley and Sons 1983 . xv, 258p.Date:1983

### **SEQUENCE STRATIGRAPHY AND PETROLEUM GEOLOGY [LTP / CREDITS = 200/2]**

**Lecture:1** Introduction to Sequence Stratigraphy and its significance. Terms and concepts of Sequence Stratigraphy and its relationship with other branches of Stratigraphy. Sedimentary basin analysis through sequence Stratigraphy. Out crop and subsurface procedures. Global sea level changes/ eustatic sea level changes. Applications of sequence stratigraphy in petroleum exploration with case studies

**LECTURE 2:PETROLEUM GEOLOGY:** Origin, migration and entrapment of natural hydrocarbons. Types of petroleum traps. Geographical and geological distributions of onshore and offshore petroliferous basins of India.

#### **Reference:**

1. Sequence stratigraphy- BHP petroleum (America) Inc – Michael Yeaman, Lavy Holcomb, Gill Tailor 1990
2. Sequence stratigraphy – BP Exporation. Stockley Park UK Bridge London, Publ. Blackwell science
3. Sea Level Changes- An Integrated Approach Spl. Pbln.42, Barbara H.Lidz, Editor of Spl. Publ. Oklahoma USA 1998
4. Sequence in Layered Rocks- Blatt Middleton & Humay
5. Sedimentary Petrology- Pettijhon

6. India's mineral resources by Sinha and Krishnaswamy .
7. Petroleum Geology by Levorsen. A.I
8. ONGC-Reports
9. Memoirs and Journals of Geological Society of India.
10. Coal deposits J.H. Tatch-1980
11. Petroleum formation and occurrence- B.P Tissot and D.H Welte
12. Petroleum Geology by K.K Llandes.

### **COAL & NUCLEAR ENERGY RESOURCES [LTP / CREDITS = 200/2]**

**Lecture 1:** Definition, origin of coal. Stratigraphy of coal measures. Fundamentals of coal petrology, peat, lignite, bituminous and anthracite coal. Constituents of coal. Industrial application of coal. Indian coal deposits-Geological setting, origin, mode of occurrence and distribution of Gondwana and Tertiary coalfields.

**Lecture 2:** Introduction to Nuclear energy and nuclear minerals. Classification, occurrence, distribution and genesis of nuclear mineral deposits of India. Future prospects of Nuclear energy in India. Nuclear waste disposal.

#### **Reference:**

1. Nuclear geology and Atomic mineral Resources – S.N. Virnave. Published by Bharati Bhawan 1995.
2. Mineral Resources of India – D.K. Benerjee. Published by the world press.
3. Radioactive minerals – R. Dhanaraju –2005 published by Geological Society of India.

### **WATER SHED MANAGEMENT [LTP / CREDITS = 200/2]**

**Lecture:1.Watershed:** History, definition and concept, principles and objectives of watershed management, integrated watershed management, delineation of watershed. Assessment, conservation,development and utilization of natural resources, land capability,classification,soil and water conservation in arable and non-arable lands.

**Lecture: 2.**Soil and water conservation in watershed: Introduction, importance, structures, contour bunds, contour barriers (vegetative and stones) contour trench, check dams, percolation pond, irrigation tank, watershed identification, resource mapping, development and impact assessment,socio-economic development in watersheds. Project preparation and impact assessment of watershed projects-case studies on watershed management in India.

#### **Reference:**

1. Dhruva Narayanan V.V.Sastry,G.,and Patanaik,U.S.,1990,Watershed management by ICAR,New Delhi.
2. Gurumel sing,venkataraman,C.Sastry,G., Joshi,1980,Manual of soil and water conservation practices,Published by Oxford IBH
3. Gopal Iyer K and Upendranath Raop 2005-Watershed management ans sustainable Kanishka publications,distributors,New Delhi-110002
4. Panda S C,Principles and practices of water management,Agrobios.
5. Shashidhar, K.C., 2004, Watershed management Published By Kannada sahithya parishath, Bangalore.
6. Suresh lal 2004, watershed development management and technology,Mangaldeep punlications,Jaipur,India.

### **CRYSTAL GROWTH [LTP / Credits = 110/2]**

**Lecture:1** Importance of crystal growth and their need. Classification: Solid-Solid, Liquid-Solid and Gas-Solid, Growth techniques-Conservative and Non conservative: Bridgman-Stock Berger, Czocharalski, Kyropoulos, Flux growth, Zone Melting, Verneuil,

**Lecture:2** Chemical Vapour Transport /Chemical Vapour Deposition, sintering, Sol-gel, Hydrothermal and solvothermal methods. Case studies: Synthesis of Quartz, Emerald, Diamond, Cubic zirconia, Ruby, Zeolites and opal.

#### **Reference**

## DEPARTMENT OF EARTH SCIENCE WILL OFFER THE FOLLOWING OPEN ELECTIVE

### ODD SEMESTER

#### NANOTECHNOLOGY [LTP / Credits = 400/4]

**Lecture 1:** Introduction to nanotechnology – basics, definition, History of nanotechnology, Nanotechnology in relation to other branches of science. Structure of solids – crystalline and non-crystalline. Crystal systems. Types of materials – inorganic, organic, and biological. Types of materials depending on their properties: electronic, semiconductors, superionic conductors, magnetic, optic, opto–electronic, spintronics, lasers, photonic, ceramic, bioceramics, biomedical, biosensors, bioimagers, photocatalysts, quantum dots, polymers, alloys, composites, etc.

**Lecture 2:** Size effect of materials on properties. Quantization effect on the properties of materials with examples. Nanocomposites and their applications in modern technology. Nanotubes – carbon nanotubes and other nanotubes. Nanomaterials – natural and synthetic. Nanohybrids. Nanoceramics, Nanotechnology in relation to electronic, biological, consumer and domestic applications. Applied Nanobiotechnology and Nanobiomedical Science. Nanotechnology and Food Science.

**Lecture 3:** Different methods of preparation of nanomaterials – Bottom up and Top down approaches. Different processing methods - Solid State, Solutions, Gas, Melt, etc.

**Lecture 4:** Nanomaterials Characterization – X-rays, Spectroscopic – FTIR, Laser Raman, Photoluminescence, UV-Vis spectroscopy. Electron Microscopy, Thermal Analysis, Surface characteristics, Light Scattering Techniques, Gas Adsorption, Magnetic susceptibility, Conductivity, bandgap calculations.

#### References:

1. Bharath Bhusan, Springer Handbook of Nanotechnology, 3<sup>rd</sup> edition, Springer-Verlag (2009)
2. CNR Rao and T. Cheetham, Chemistry of Nanomaterials : Synthesis, Properties and Applications, Wiley & Sons (2005)
3. Hari Singh Nalwa, Encyclopedia of Nanotechnology, American Scientific Publishers (2004)
4. K. Byrappa and M. Yoshimura, Handbook of Hydrothermal Technology, 2<sup>nd</sup> edition, Elsevier (2012)
5. K. Byrappa and T. Adschiri, Hydrothermal Technology for Nanotechnology, Progress in Crystal Growth and Characteriation of Materials, Volume 53 (2007) pp.117-166.
6. K. Byrappa and M. Yoshimura (Editors): Special Edition of Journal of Materials Science, Volume 41, No.6 (2006).
7. K. Byrappa and T. Adschiri (Editors), Special Edition of Journal of Materials Science, Volume 43, No.7 (2008).
8. Charles P. Poole Jr. and Franks J. Qwens, Introduction to Nanotechnology, Wiley & sons (2003)

### EVEN SEMESTER

#### BASICS OF EARTH SCIENCE [LTP / Credits = 400/4]

**Lecture 1:** PHYSICAL GEOLOGY -Introduction to geology. Origin of the Earth. Age of the earth. Interior of the Earth. Geological action of wind, water, glaciers, volcanoes and earthquakes. Morphology of Oceans, Principles of Isostasy and uniformitarianism.

**Lecture 2:** STRUCTURAL GEOLOGY - Rock deformation. Earth forces. Folds and Foldings, Fault and Faulting, Joints, Cleavage, Unconformities, Concepts of plate tectonics, sea floor spreading and geosynclines.

**Lecture 3: Stratigraphy-** Introduction, Definition of Stratigraphy, Branches of Stratigraphy and its relation with other branches of Geology, Principles of Stratigraphy- Law of Uniformitarianism, Law of order of superposition, Geological Time Scale. Law of Faunal Succession. Geological Record and its

nature Eon, Era, Period. Classification of Standard Stratigraphic scale. Nomenclature and units-Litho, Bio and Chrono stratigraphic units, Correlation- Lithostratigraphic and Biostratigraphic

**Lecture4: Paleontology** -Introduction, Definition of Paleontology, Classification of Plants, Invertebrate and Vertebrate fossils. Fossils-Tophonomy (Burial Law), Types of Fossilization, Mode of preservation- Mummification, Carbonization, Silification, Casts, Moulds, Tracks and Trails. Applications of Fossils. General morphological characters and Geological age of the following Invertebrate and Plant Fossils: Brachiopoda, Cephalopoda, Pelecypoda and Trilobita. Plant fossils: Glossoptris, Gangamopteris, Ptillophylum, Calamites and Lepidodendron

**References:**

1. Physical Geology by Arthur Holmes
2. Structural Geology by Billings
3. General Geology By P.K. Mukerjee
4. Physical Geology By Strahler
5. Stratigraphic Principles and Practice-Weller
6. Stratigraphy-Kumberlein and Sloss
7. Paleontology of the Invertebrates-Tasch Publ.Jhon Wiley and Sons
8. Paleontology- Henry Wood
9. Fossils Plants- Arnold
10. The Elements of Paleontology Black,R.M Pub. Cambridge university press

**MINERALS AND ROCKS [ LTP / CREDITS = 400/4]**

**Lecture - 1: CRYSTALLOGRAPHY AND CRYSTAL CHEMISTRY-** Crystal and crystal systems, Concept of Unit cell and space lattice, derivation 14 Bravais' Lattice. Schoenflies 32 crystal classes. Projections, Twinning, imperfections and defects. Spheres in closest packing: Cubic closest packing, Hexagonal closest packing, Body centered cubic packing. Packing efficiency, Voids in closest packing. coordination polyhedra and radius ratio, Pauling's rule.

**Lecture - 2: MINERALOGY –** Physical Properties and optical properties of Minerals. Chemical classification of minerals, Isomorphism, Polymorphism, Exsolution. Classification of Silicate structures, Silicates and non silicate minerals - oxides, carbonates, sulphides. Gem minerals – identification, properties and their applications.

**Lecture - 3: ROCKS:** Definition and Classification of Rocks based on Origin. Igneous rocks - Extrusive and Intrusive forms. Metamorphic rocks, types of Metamorphic rocks, Textures and Structures in Igneous and Metamorphic rocks. Sedimentary Rocks: Primary and secondary structures.

**Lecture - 4: ECONOMIC MINERAL RESOURCES -** Origin, occurrence and distribution of following mineral deposits. a) Metallic Deposits: Gold, Copper, Iron, Manganese and Aluminium. b) Non-metallic Deposits: Mica, Abrasives, Refractories and Ceramics, Fossil Fuels - Coal and Petroleum.

**Reference:**

1. An Introduction to crystallography - F.C.Phillips.
2. Elementary Crystallography - Buerger
3. Elements of X-ray Crystallography - Azaroff.
4. Text book of Mineralogy - Dana.
5. An introduction to rock forming minerals - Deer, Howie and Zussman.
6. Mineralogy - Schrock
7. Fundamentals of Crystal chemistry – T.R.N.Kutty and J.A.K.Tareen( Orient Longman)
8. A Basic Course in Crystallography- J.A.K.Tareen and T.R.N.Kutty
9. Petrology - V.Hyndman Ed. II
10. The evolution of igneous rocks - Bowen, N.L. Princeton Uni. Press
11. Natural History of igneous rocks - Herker, A.Mc. Millan.
12. Igneous Petrology - Carmichael, Turner and Verrhoogen Mc.Graw Hill.
13. Introduction to Petrology - Bailey B. Prentice Hall.
14. Igneous Petrology - Middlemost.
15. Metamorphism and Metamorphic rocks - Miyashiro, A. George, Allen and Unwin.

16. The geology of ore deposits - John M. Guilbert and Charles F. Park, Jr. W.H. Freeman and Co., New York. 1986.
17. Economic Mineral deposits Bateman, A.M.
18. Ore deposits - Park, Jr. C.F.
19. Geology of Mineral deposits - Smirnov, U.J.
20. The ore minerals and their intergrowths - Ramhor, Dr. Paul.
21. Ore Petrology - Stanton, R.L.
22. India's mineral resources - Krishnaswamy, S.
23. Metallic and Industrial minerals - Lamey Carl, A.
24. Introduction to India's economic minerals - Sharma, N.L. & Ram . K.S.
25. A treatise on industrial minerals of India-Sinha, R.L.
26. Mineral deposits of India, Mukerjee 1999: Allied publications.
27. Mineralogy by M.J. Hibbard

[Note: MK1 and MK2 soft core papers in I and II semester are compulsory soft core for those who haven't studied Geology at Undergraduate course. ]