

DEPARTMENT OF EARTH SCIENCES
PONDICHERRY UNIVERSITY, PONDICHERRY

Course structure of M. Sc. Applied Geology

| Semester | Hard-core Courses | | | Soft-core Courses | | |
|---------------------------------|-------------------|--------------------------------------|---------|-------------------|--|---------|
| | Course # | Name of the Course | Credits | Course # | Name of the Course | Credits |
| I | EASC 411 | Advanced Mineralogy | 4 | EASC 415 | Basic Geochemistry | 3 |
| | EASC 412 | Structural Geology | 3 | EASC 416 | Numerical Methods & Computer Programming | 3 |
| | EASC 413 | Applied Paleontology | 3 | EASC 417 | Computer Applications in Earth Sciences | 3 |
| | EASC 414 | Advanced Geology Lab I | 4 | | | |
| II | EASC 421 | Igneous & Metamorphic Petrology | 4 | EASC 427 | Isotope Geology | 3 |
| | EASC 422 | Stratigraphy | 2 | EASC 428 | Global Tectonics | 2 |
| | EASC 423 | Geomorphology | 2 | | | |
| | EASC 424 | Introduction to Remote sensing & GIS | 3 | | | |
| | EASC 425 | Advanced Geology Lab II | 4 | | | |
| | EASC 426 | Advanced Field Training I | 3 | | | |
| III | EASC 511 | Geology of Mineral Deposits | 4 | EASC 516 | Marine Geology & Oceanography | 2 |
| | EASC 512 | Sedimentology | 2 | EASC 517 | Quaternary Geology | 2 |
| | EASC 513 | Geohydrology | 2 | EASC 518 | Coal & Petroleum Geology | 2 |
| | EASC 514 | Solid Earth Geophysics | 2 | EASC 519 | Mineral Economics | 2 |
| | EASC 515 | Advanced Geology Lab III | 3 | EASC 520 | Professional Training | 3 |
| IV | EASC 521 | Geoexploration | 4 | EASC 527 | Environmental Geology | 2 |
| | EASC 522 | Engineering Geology | 2 | EASC 528 | Mining Geology | 2 |
| | EASC 523 | Project | 4 | EASC 529 | Well Logging | 2 |
| | EASC 525 | Advanced Geology Lab IV | 2 | EASC 530 | Advanced Remote Sensing & GIS | 3 |
| | EASC 526 | Advanced Field Training II | 3 | | | |
| Total Credits to be accumulated | | | 60 | Minimum Credits | | 12 |

Note: Minimum of 72 credits need to be earned for completion of the M. Sc. Course.

EASC-411 ADVANCED MINERALOGY

Crystallography: Basic laws. Derivation and determination of point groups. Crystal forms. Space lattice and unit cell. Concept of space group. Introductory X-ray crystallography. X-ray diffractometer. Bragg equation and reflection indices. Calculation of cell dimensions.

Mineral Optics: Behaviour of light in isotropic, uniaxial and biaxial crystals. Interference figures. Universal stage.

Crystal Chemistry: Types of bonding in minerals. Chemical composition and unit cell content. Isomorphism. Solid solution and polymorphism. Chemical classification of minerals.

Rock and Ore forming minerals: Structure, P-T stabilities, paragenesis and mode of alteration of silicates, oxides, carbonates, phosphates, sulphates and halides.

Text Books

Deer, W.A., Howie, R.A. & Zussman, J. 1962. Rock forming minerals. Vol. 1 to 5. Longmans, London.

Blackburn, W.H. & Dennen, W.H. 1988. Principles of mineralogy. WCM Publishers, Iowa.

Kerr, P.F. 1959. Optical mineralogy. 3rd edition. McGraw Hill, New York.

Winchell, A.N. & Winchell, H. 1951. Elements of optical mineralogy. Part II. 4th edition. Wiley, New York.

EASC-412 STRUCTURAL GEOLOGY

Stress and Strain: Mechanical properties of rocks. Concept of stress and strain. Two dimensional stress and strain analyses. Mohr's circle. Types of strain ellipsoids and their geological significance. Strain analysis of naturally deformed rocks.

Folds

Geometry and classification of folds. Mechanics and dynamics of folding. Evidence of buckling. Superposed folding and interference pattern. Distribution of strains in folds.

Faults and Shear zones

Classification of faults. Features associated with normal faults, strike-slip faults, overthrusts and nappes. Causes and dynamics of faulting. Strain significance of faults. Recognition criteria of faulting. Classification and geometry of different types of shear zones. Strain variation in shear zones. Shear sense indicators.

Joints

Joints and veins. Classification of joints. Joint related structures. Analysis of joints and their tectonic significance.

Unconformity

Types of unconformity, their recognition criteria. Importance of unconformity in tectono-stratigraphic correlation.

Foliations and Lineations

Morphology and types of foliations and lineations. Mesoscopic and microscopic characters of cleavages. Strain significance of cleavages. Mechanisms of cleavage development. Significance of linear structures. Geometry and development of boudinage structures. Tectonites.

Structural analysis: Principles and elements of structural analysis. Geometrical analysis of simple and complex structures on mesoscopic to macroscopic scale.

Text Books:

1. Ramsay, J.G. & Huber, M.I. 1983. The Techniques of modern structural geology. V.1. Strain Analysis.
2. Ramsay, J.G. & Huber, M.I. 1987. The Techniques of modern structural geology. V.2. Folds and Fractures.
3. Park, R.G. Foundations of structural geology.
4. Turner, F.J. & Weiss, L.E. 1963. Structural analysis of metamorphic tectonites.
5. Price, N.J. & Cosgrove, J.W. 1990. Analysis of Geological structures. Cambridge University Press.
6. Davis, G.H. 1984. Structural Geology of Rocks and Regions.
7. Ghosh, S.K. 1993. Structural Geology: Fundamentals and modern developments.
8. Suppe, J. 1985 Principles of structural geology. Printice-Hall.

EASC-413 APPLIED PALEONTOLOGY

Definition and Scope.

Fossils and their preservation. Principles of taxonomic classification and nomenclature. Organic evolution and fossil record. Principles of paleoecology, biostratigraphy and paleogeography.

Invertebrate paleontology : an overview. Morphology, classification, evolutionary trend, composition and structure of shells of selected groups of organisms - Porifera, Bryozoa, Mollusca, Brachiopoda. Geological history, geographical distribution and description of more important genera of Trilobita, Echinoides, Coelenterata and Graptoloidea.

Micropaleontology : Sampling methods and sample processing techniques. Types of microfossils. Calcareous Microfossils - Foraminifera - major morphologic groups; Benthic Foraminifera; depth biotopes, value in paleobathymetric determination. Larger foraminifera - their utility in Indian stratigraphy. Planktonic foraminifera and calcareous nannofossils. Ostracoda - outline morphology, paleoecology & geological history. Brief knowledge about pteropods, calpionellids and calcareous algae.

Siliceous Microfossils : Radiolaria-outline morphology, classification. Brief knowledge of marine diatoms and silicoflagellates.

Phosphatic Microfossils : Conodont - outline morphology, paleoecology and geologic significance.

Organic Walled Microfossils : Brief account of dinoflagellates and acritarchs.

Palynology : General morphology of spores and pollen, their geological significance.

Applications : Micropaleontology in petroleum exploration. Environmental significance of microfossils - correlation of paleofacies, and paleobathymetry estimation of paleotemperature. The role of micropaleontology in marine geology and oceanography.

Vertebrate paleontology : Succession of vertebrate life through geologic time. Broad classification and study of some characteristic Indian vertebrate genera. Indian pre-Tertiary vertebrate - their distribution and paleogeographic implication; extinction of dinosaurs. Indian Tertiary vertebrate - Siwalik mammals; phylogeny - Equidae & Proboscidae. Indian fossil Hominoides and modern theories regarding human evolution.

Paleobotany : Application of palynology - morphology of spores and pollens. Elementary idea about dinoflagellates, nanoplankton, calcareous algae & stromatolites. Morphology and taxonomy of selected megaplant fossils of Gondwana Super Group; elementary idea about Tertiary flora.

Text Books:

1. B.U. Hag and A. Boersma (1978). Introduction to marine micropaleontology. Elsevier, Netherlands, 376p.
2. J.P. Kennet & M.S. Srinivasan (1983). Neogene-Planktonic Foraminifera. Hutchison Ross Publ. Co., U.S.A., 263p.
3. M.D. Brasier (1980). Microfossils. George Allen & Unwin, London, 193p.
4. G. Bignot (1985). Elements of Micropaleontology. Graham & Trotman, London, 212p.
5. E.N.K. Clarkson (1986). Invertebrate paleontology and evolution. George Allen & Unwin.
6. R.C. Moore, Lalicker & Fisher (1952). Invertebrate fossil. McGraw Hill Book Co., San Francisco.
7. D.M. Raup & Stanley (1985). Principles of paleontology. CBS Publ. & Distributors, New Delhi.
8. C.A. Arnold (1947). An Introduction to paleontology. McGraw Hill Book Co., San Francisco.

Hard Core course

4 credits

EASC-414 ADVANCED GEOLOGY LAB – I

Part 1: Mineralogy (1 credit)

Identification of minerals in hand specimen. Study of optical properties of minerals in transmitted light and their identification in thin section. Identification of minerals from X-ray diffractogram. Indexing and calculation of cell parameters of minerals in isometric, tetragonal and orthorhombic systems. Calculation of chemical formula of minerals from analytical data.

Part 2: Structural Geology (2 credits)

Interpretation of geological maps and drawing sections. Fold analysis by dip isogon method. Strain analysis from deformed objects. Structural problems concerning mineral deposits. Elementary structural analysis by stereographic methods.

Part 3: Paleontology (1 credit)

Techniques of separation of microfossils. Study of important benthic and planktonic foraminifera useful in bottom and surface water oceanography. Study of larger foraminifera important to the Indian stratigraphy.

Soft Core Course

3 Credits

EASC-415 BASIC GEOCHEMISTRY

Origin of chemical elements, abundance of elements in cosmos, solar system and earth. Distribution of elements in core, mantle, crust, hydrosphere and atmosphere.

Nuclides and atoms. Electronic configuration of atoms, arrangement of atoms in periodic table, electronegativity, ionization potential, chemical bonding.

Crystal Structure and classification of silicate structures, controls on crystal growth and transformations. Thermodynamics and thermodynamic control on distribution of chemical species (between co-existing phases). Thermodynamics of mixing and solutions. Kinetics and metastability.

Geochemistry of igneous and metamorphic processes. Distribution coefficients and determination of Pressure and Temperature conditions. Trace element geochemistry.

Geochemistry of weathering, transportation and deposition. Study of Eh-pH diagram.

Radioactivity. Decay of radioactive atoms and growth of radiogenic atoms. Application of radioactivity in geochronology and in understanding geological processes.

Application of Geochemistry in mineral exploration and in solving environmental problems.

Text Books

1. B. Mason : Principles of Geochemistry
2. K.B. Krauskopf : Introduction to Geochemistry
3. P. Henderson : Inorganic Geochemistry
4. H. Jaffe : Introduction to Crystal Chemistry

EASC-417 COMPUTER APPLICATIONS IN EARTH SCIENCES

Introduction to computers: PC configuration, CPU, I/O, memory, networking and peripheral devices. Operating system, BIOS, drivers and application software.

DOS platform: Boot sequence, system files, internal and external commands, file structure and commands. Brief exposure to DOS programs and utilities for geoscience applications.

Windows platform: Sharing of memory, time, program and data, features of graphical user interface, configuring desktop environment, installing and running applications. Working with spread sheet, presentation graphics, database and imaging software for geoscience applications. Image formats and compression techniques. Data compression and anti-virus programs. Network environment, LAN and internet protocols, internet resources in geosciences. Brief exposure to HTML and web publishing.

Linux platform: Common Linux features, file structure and commands, security features. Working with Red Hat Linux, text mode and desk top environments, installing and running geoscience applications.

Text Books:

Crumlish (2000) The internet. 2nd Edition. BPB Publishers, New Delhi.

David Nash (2001) Linux in easy steps. IDG Books, New Delhi.

Nathan Wallace (2000) Windows 2000 in easy steps. IDG Books, New Delhi.

PC complete. 2nd Edition. BPB Publishers, New Delhi. (2000)

Peter Ingram (2000) Networking in easy steps. Dreamtech Press, New Delhi.

Stultz (1996) Illustrated MS-DOS 6.22. BPB Publishers, New Delhi.

EASC-421 IGNEOUS AND METAMORPHIC PETROLOGY

Magmas: their nature, cooling behaviour and properties. Solubility of CO₂ and H₂O in silicate melts. Generation of magma.

Classification of igneous rocks. Definition, geochemistry, phase equilibria studies and paragenesis of basaltic rocks, lamprophyres, rocks of nephelinite-carbonatite association, peridotites, kimberlites, ophiolites, granites and rhyolites, gabbro and anorthosite.

Laws of thermodynamics. Gibbs free energy. Concept of activity, fugacity, ideal and non-ideal solutions. Geothermobarometry.

Mineralogical phase rule of close and open system. Concept and classification of metamorphic facies; description of each facies of low pressures, medium to high pressures and very high pressures. Mineral assemblages, metamorphic reactions and P-T conditions of metamorphism. P-T time path.

Metamorphic differentiation. Anatexis and origin of migmatites. Regional metamorphism and paired metamorphic belts. Petrogenesis of Charnockites.

Text Books

- Hyndman, D.W. 1985. Petrology of igneous and metamorphic rocks. McGraw Hill.
- Carmichel, I.S.E., Turner, F.J. & Verhoogen, J. 1974. Igneous Petrology. McGraw Hill.
- Cox, K.G. Bell, J.D. and Pankhurst, R.J. 1979. Interpretation of igneous rocks. George Allen Unwin.
- Turner, F.J. 1980. Metamorphic Petrology. McGraw Hill.
- Winkler, H.G.E. 1979 Petrogenesis of metamorphic rocks. Springer Verlag.
- Bhaskar Rao, B. 1986. Metamorphic Petrology. Oxford & IBH.
- Wood, B.J. and Fraser, D.G. 1976. Elements of thermodynamics for Geologists. Oxford University Press.
- Best, M.G. 1986. Igneous and Metamorphic Petrology. CBS publisher.
- Spray, A.H. 1969. Metamorphic textures. Pergamon Press.
- Philpotts, A.R. 1990. Principles of Igneous and Metamorphic Petrology. Printice Hall.
- Mason, R. 1984. Petrology of Metamorphic Rocks. CBS Publishers and Distributors.
- Yardley, B.W.D. 1989. An introduction of Metamorphic Petrology. Longman.
- McBirney, A.R. (1993) Igneous Petrology, CBS Publishers and Distributors.
- Hall, A. (1987) Igneous Petrology. Longan Scientific & Technical.
- Ashworth, J.R. (Ed) (1985) Migmatites. Blackie.

EASC-422 STRATIGRAPHY

Stratigraphic principles and practices. Classification and code of stratigraphic nomenclatures. Stratification and stratigraphic column.

Lateral variation and facies. Graphic representation of stratigraphic data.

World stratigraphy: Brief description of the principal, stratigraphic units of the world in type areas. Paleogeographic reconstruction.

Indian stratigraphy: Physiographic subdivisions, structures and tectonic history of the Indian subcontinent. Study of the various geological formations of Precambrian, Paleozoic, Mesozoic, Tertiary and Quaternary Eras: distribution, geological succession, classification, correlation, paleogeography and life of each period.

Gondwana Super Group - Distribution, succession, classification, flora and fauna, lower and upper age limit, structure of Gondwana basin, climate and paleogeography. Deccan Traps and associated sedimentary formations. Age of Deccan traps. Himalayan orogeny. Glacial and interglacial deposits.

Boundary problem of Precambrian - Cambrian; Permo-Triassic; Mesozoic - Tertiary.

Text Books

M.S. Krishnan 1982. Geology of India and Burma. CBS Publ. & Distributors, New Delhi.

C.O. Dunbar & J. Rodgers 1957 Principles of stratigraphy. John Wiley and Sons, New York.

Ravindra Kumar 1978. Historical Geology and Stratigraphy of India.

Hard Core Course

2 Credits

EASC-423 GEOMORPHOLOGY

Introduction: geomorphic principles and processes. Theory of uniformitarianism. Control of geomorphological features by geological structures, lithology, diastrophism, climate and time. Geomorphological cycles.

Rock weathering and soils: physical and chemical weathering. Karst topography, soil profile, classification of soils.

Streams: hydrological cycle, transport of sediments, distribution of suspended sediments and different modes of sediment transportation, regime concept, erosional features. The concept of grade, equilibrium and cycle of erosion. Channel pattern. Flood plain, terraces and alluvial cones. Morphometric studies.

Hillslopes: forms relation to lithology and structural weakness in rock, environmental; control and mass movement, modification by overland flow of hillslopes.

Desert: erosion, transportation and deposition by wind.

Oceans: waves, tides and currents, coastal erosion and submergence.

Glaciers: types of glaciers and movement. Crevasses, erosional features. Glacial and fluvoglacial deposits.

Lakes: Classification and mode of formation.

Geomorphic features of India: Extra-Peninsular region, Indo-Gangetic plain and Peninsula - their geomorphic evolution.

Environmental geomorphology: elementary concept.

Text Books

W.D. Thornbury (1969) Principles of Geomorphology. Wiley Eastern Ltd. New Delhi.

H.S. Sharma (1990) Indian Geomorphology. Concept Pub. Co., New Delhi.

L.B. Leopold (1976) Fluvial processes in geomorphology. E.P.H. Publishing House, New Delhi.

Duff, P. Mc L. D. (Ed) (1992) Holmes principles of physical geology. 4th edition, Chapman & Hall, London.

EASC-424 INTRODUCTION TO REMOTE SENSING & GIS

Electromagnetic radiations. Development in aerial photography. Geometry and types of aerial photographs. Scale of photographs. Types of aerial cameras, films, and filters. Panchromatic, colour and infra-red films. Multiband photography. Tilt and height displacement. Vertical exaggeration. Stereoscopy. Construction and use of photogrammetric instruments. Mosaic.

Elements of photo interpretation: tone, texture, pattern, drainage and lineaments. Spectral signatures. Land forms. Structural and lithological interpretation. Aerial photographs in field mapping.

Application of mineral and groundwater exploration, engineering geology.

Aerial Remote Sensing Laboratory Exercises: Study of stereoscopic view and elements of photo recognition. Identification of drainage pattern, landforms, rock types and structures.

Text Books

Avery, T.U. and Berlin, G.L. 1992 Fundamentals of remote sensing and air photo interpretation. McMillion Publishing Co., New York.

Campbell, J. B. (1996) Introduction to Remote Sensing. 622pp.

Drury, S.A. 1987. Image interpretation in Geology. Chapman and Hall.

Gupta, R.P. (1991) Remote Sensing Geology. Springer-Verlag. 356pp.

Miller, V.C. & Miller, C.F. 1961. Photogeology. McGraw Hill, New York.

Pandey, S.N. 1987. Principles and applications of photogeology. Wiley Eastern, New Delhi.

Ray, R.G. 1969 Aerial photographs in geologic interpretation. USGS Professional Paper 373.

Hard Core course

4 credits

EASC-425 ADVANCED GEOLOGY LAB II

Part 1: Igneous & Metamorphic Petrology (2 credits)

Study of igneous rocks and metamorphic rocks of different facies mineral assemblage, texture and structure) in hand specimen and in thin sections. Calculations of CIPW norms of igneous rocks. Plotting chemical data in various diagrams and trace element modeling to infer petrogenetic conditions. Graphic representation of metamorphic mineral assemblage in ACF and AFM diagrams.

Part 2: Geochemistry (2 credits)

Introduction to methods of sampling in field, and sample preparation. Lab protocols and safety. Understanding of basic principles of geochemical methods for the analysis of rocks, soils, and aqueous fluids. Hands on training of solution preparation for analysis. Introduction to key aspects of data presentation, analysis and interpretation. Principles and hands-on application of the major analytical tools necessary to characterize the geochemistry of natural systems including: Spectrophotometer, Flame photometer, AAS and ICP-AES.

Hard Core Course

3 credits

EASC-426 ADVANCED FIELD TRAINING – I

Geological field training on lithological and structural mapping in sedimentary, igneous and metamorphic terrains. Study of igneous, metamorphic and sedimentary rocks and fossil occurrences in the field. Total duration of the training will be about three weeks in the field.

EASC-427 ISOTOPE GEOLOGY

Discovery of radioactivity, stable and radiogenic isotopes. Literature on isotope geology.

Nuclear structure, atomic weights, nuclear stability and abundance.

Theory and mechanism of decay, particles emitted, positron, negatron and alpha decay, effect of mineral/crystal structures, growth and retention of daughter isotopes in earth systems.

Abundances of unstable nuclides in earth, core, mantle, crust, oceans and different rock types; their decay schemes, radioactive elements as major elements, minor elements and trace elements and their geochemical behaviour.

Mass spectrometer: Instrumentation, chemical separation, isotope dilution and ratio analysis.

Methods of dating: Isochron method, model/mineral ages, Fission track, ^{40}Ar - ^{39}Ar , U and Th disequilibrium, concordia method, ^{14}C , Be and Al. Interpretation and geological significance of ages.

Isotope systematics of K-Ar, Rb-Sr, Sm-Nd, U-Th-Pb in igneous, metamorphic and sedimentary rocks and in evolution of ocean, crust and mantle.

Stable isotopes of oxygen and hydrogen, carbon, nitrogen and sulphur. Fractionation of stable isotopes in lithosphere, hydrosphere and atmosphere. Stable isotope geothermometry and geobarometry.

Isotopes in mineral exploration, petroleum exploration, paleo-climate evaluation, health and environmental aspects.

Text Books

Faure, G. (1986). Principles of Isotope Geology. John Wiley, 589p.

Doe, B.R. (1970) Lead isotopes. Springer Verlag, 137p.

Faure, G. and Powell, J.L. (1972) Strontium Isotope Geology. Springer Verlag, 188p.

EASC-428 GLOBAL TECTONICS

Introduction

Earth and its shape. Internal structure of the Earth. Physiographic features and crustal types. Seismic, density, thermal and chemical characters of crust, mantle and core.

Plate Tectonics

Concept of plate tectonics. Types of plate boundaries. Characteristic features of accretionary, conservative and destructive boundaries.

Accretionary Plate Boundary

Physiography, structure, distribution, magmatism and metamorphism along Mid-oceanic ridges. Sea-floor spreading. Continental rifting.

Conservative Plate Boundaries

Physiography, structure and types of transform faults. Their relation to slipping rates.

Consuming Plate Boundaries

Geometry of Benioff zones. Sedimentation, magmatism and metamorphism in subduction zones. development of Island arcs.

Global tectonics and Mountain Building

Origin and composition of Archaean crusts. Proterozoic orogenic belts. Geosynclines and mountain building activity. Pacific and Andean-type margins. Collision tectonics. Obduction and ophiolite emplacement.

Tectonic Activity within Indian plate

Configuration of Indian plate. Mobile belts in Peninsular India. Aravalli and Godavari rift zones. Ninety Degree east ridge. Evolution of the Himalaya and Himalayan tectonics.

Text Books

Le Pichon, and J.Francheteau. Plate tectonics.

Windley, B.F. (1995) The evolving continents. John Wiley & Sons, 526 pp.

Rogers, J.J.W. A history of the Earth. Cambridge University Press.

Fowler, C.M.R. (1990) The solid Earth: an introduction to Global Geophysics. Cambridge University Press.

Brown, G.C. and Mussett, A.E. The Inaccessible Earth: an integrated view of its structure and composition. Chapman and Hall.

Brown, G., Hawkesworth, C. and Wilson, C. (1992) Understanding the earth. Cambridge University Press.

Condie, K.C. (1976) Plate Tectonics and Continental Evolution. Pergamon Press Inc.

Kearey, P. and Vine, F.J. (1996) Global Tectonics. Blackwell Science.

Soft Core Course

3 Credits

EASC-429 COMPUTER APPLICATIONS IN GEOSCIENCES

Introduction to computers:

Hardware components: CPU, I/O devices, information storage, storage media. Software components: computer programs; stored program concept; operating system; use of DOS and WINDOWS.

Basic:

Computer algorithms and flow charts for problem solving. Variables, arithmetic statements and built-in functions. Logical statements, comparisons and string functions. User defined functions. Control statements (GOTO, IF THEN, IF THENELSE, FOR NEXT, GOSUB, RETURN). Input/Output statements.

Numerical Analysis:

Programming examples to handle following methods of numerical analysis in geosciences: matrix inversion, eigen values and eigen vectors; analysis of variance; linear/polynomial regression; trend surface analysis; elements of multivariate analysis; factor analysis, discriminant function analysis.

Use of Software Packages in Geosciences:

Data-base and spread-sheet applications in geosciences. Graphical representation of data.

Illustrative Project:

Independent exercise on computer application in any aspect of geosciences. Suggested topics include: calculation of structural formula of minerals from chemical composition; calculation of unit cell parameters from XRD chart; CIPW norm calculation and projection of rock composition in petrological diagrams; trace element modelling of partial melting, fractional crystallisation and assimilation processes; inversion of rare earth element abundance data; fitting of isochrons and age determination using isotope data; modelling isotope evolution of Sr, Nd and Pb in mantle; analysis of recurrence of geological events; correlation of bore hole data and modelling of sub-surface geological characteristics; spatial distribution of data and recognition of anomalies; ore reserve calculation; modeling contaminant migration in groundwater.

Text Books

Davis, J.C. (1984) Statistics and data analysis in geology. John Wiley, New York.

Rajaraman, V. (1984) Computer oriented numerical methods. Prentice Hall, New Delhi.

Hard Core Course

4 Credits

EASC-511 GEOLOGY OF MINERAL DEPOSITS

Mineral deposits, morphology of ore bodies, structure and texture of ores, ore paragenesis. Source of ore forming material. Physico-chemical environment of ore formation; mineralogical, trace element and stable isotope geothermometers; fluid inclusion studies. Genetic classification of mineral deposits. Metallogenetic epochs and provinces; mineralisation at plate boundaries.

Nature and origin of mineral deposits associated with different rocks and their Indian examples: magmatic deposits in ultramafic, mafic and felsic association; post-magmatic deposits; sedimentary deposits; syn-sedimentary deposits; deposits formed in near surface environment by residual concentration, infiltration and supergene enrichment; metamorphic and metamorphosed deposits.

Text Books

- Barnes, H.L. (Ed.). 1997. *Geochemistry of hydrothermal ore deposits*. John Wiley & Sons.
- Craig, J.R. & Vaughan, 1994. *Ore microscopy and ore petrography*. John Wiley & Sons.
- Evans, A.M. 1992. *Ore geology and industrial minerals*. Blackwell Science.
- Jensen, M.L. & Bateman, A.M. 1981. *Economic mineral deposits*. John Wiley & Sons.
- Misra, K.C. 1999. *Understanding mineral deposits*. Kluwer Academic Publishers.
- Mookherjee, A. 1998. *Ore genesis – a holistic approach*. Allied Publishers.
- Stanton, R.L. 1981. *Ore Petrology*. McGraw Hill.

EASC-512 SEDIMENTOLOGY

Sedimentary processes: weathering, sediment transport by fluids. Simple fluid flow concept.

Textures of clastic and non-clastic rocks. Sedimentary structures: classification, genesis and significance. Use of structures and textures in basin studies.

Sedimentary environment: physical and chemical properties of depositional environment and its classification. Lithologies, structures and vertical sequences formed in fluvial, deltaic, coastal, deep sea, glacial, aeolian and carbonate depositional environments.

Provincance: light minerals, heavy minerals and insoluble residue in provincance studies and correlation of sedimentary rocks.

Diagenesis: compaction, cementation, chemical alteration and recrystallisation. Sedimentation and Tectonics: tectonic control of sedimentation. Geosynclines and their lithological associations. Plate tectonics in relation to type and evolution of basins.

Clay Minerals: classification, techniques of identification, diagenesis and use in environmental interpretation.

Text Books

F.J. Pettijohn (1975) Sedimentary rocks. Harper and Row Publ., New Delhi.

Blatt, Middleton & Murray (1980) Origin of sedimentary rocks. Printice Hall Inc.

J.D. Collins and D.B. Thompson (1982) Sedimentary Structures. George Allen & Unwin, London.

M.E. Tucker (1981) Sedimentary Petrology: an introduction. John Willey & Sons, New York.

Hard Core Course

2 credits

EASC-513 GEOHYDROLOGY

Hydrological cycle. Surface and sub-surface distribution of water, aquifers, aquicludes, aquitard, aquifuge. Physical properties of reservoir rocks. Darcy's law and its range validity. Groundwater flow under steady and unsteady conditions. Occurrence of groundwater in different rock types. Ground water provinces of India.

Fresh and salt water relationship in coastal areas. Ghyzen-Herzberg principle. Prevention and control of sea water intrusion.

Quality and geochemistry of groundwater. Groundwater exploration and management. Natural and artificial recharge of groundwater. Modeling of aquifer systems.

Text Books

Todd, D.K. 1988. Groundwater Hydrology. John Willey and Sons.

Davis, S.N. & De Wiest, R.J.N. 1966. Hydrogeology. John Wiley & Sons, New York.

Raghunath, H.M. 1983. Groundwater. Willey Eastern, Calcutta.

EASC-514 SOLID EARTH GEOPHYSICS

Introduction

The earth and the solar system Important physical parameters and properties of the planet earth: gravitational, electrical, magnetic, thermal and chemical.

Seismology

Earthquakes. Observational seismology, magnitude and intensity scales. Seismic waves. Seismological instruments and observatories. Travel time curves. Crust, mantle and Core. Phase transition inside the Earth. Internal distribution of density and other physical parameters. Magnitude and energy of earthquakes. World-wide distribution of earthquakes. Sources of strain energy. Earthquake prediction.

Geodesy and Isostasy

Shape of the earth. Gravitational potential and acceleration. Gravity anomalies. Modern survey methods. Isostasy. Calculation of isostatic correction. Significance of isostatic anomalies. Major geoid and gravity anomalies of the Earth.

Geomagnetism and Paleomagnetism

Magnetic potential of the earth. Paleomagnetism. Reversals of the geomagnetic field. Polar wandering and Continental drift. Paleomagnetism of Indian Peninsula and the Himalaya.

Heat Flow

Thermal history of the earth. Temperature inside the earth. Thermal structures of the continental and oceanic lithosphere. Radioactive heat sources. Heat flow measurements. Regions of anomalous heat flow. Hot spots. Relationship of heat flow to radioactivity of the Earth.

Plate Tectonics

The concept of plate tectonics. Plate boundaries. Present-day plate motions. Reconstruction of past plate motions.

Text Books

Fowler, C.M.R. (1990) The solid earth: An introduction to Global Geophysics. Cambridge University Press.

Bullen and Bolt. Introduction to the theory of Seismology.

Bath, M. Introduction to Seismology.

McElhiry. Paleomagnetism and Plate Tectonics.

Le Pichan. Plate tectonics.

Verma, R.K. Gravity field, Siesmicity and Tectonics of Indian Peninsula and the Himalayas.

Bolt, B.A. (1993) Earthqakes. W.H. Freeman & Co.

Hard Core course

3 credits

EASC-515 ADVANCED GEOLOGY LAB III

Part 1: Ore Mineralogy (2 credits)

Identification of economic minerals in hand specimen. Study of optical properties of opaque minerals in reflected light and their identification in polished block/thin section. Study of ore textures and interpretation of paragenesis.

Part 2: Sedimentology (1 credit)

Study of clastic and non-clastic rocks in hand specimen. Microscopic examination of important rock types. Separation of heavy minerals and study of their microscopic characteristics. Grain size analysis by sieving, plotting of size distribution data. Determination of roundness and sphericity of grains.

Soft Core Course

2 Credits

EASC-516 MARINE GEOLOGY AND OCEANOGRAPHY

Origin of seas and oceans. Ocean morphology, oceanic crust and ocean margin; sea bottom topography - continental margin, shelf, slope, submarine canyon; ocean basin floor; abyssal hills, plains and gaps; mid-oceanic rise; mid-oceanic ridges- origin, crust and flank province.

Ocean circulation: turbidity current, submarine and sedimentation processes. Oceanic sediments and microfossils. marine stratigraphy, correlation and chronology. Tectonic history of oceans. Mineral resources of the oceans.

Historical development of oceanography. Methods of measuring the properties of sea. Deep sea record. Sea level processes and sea level changes. Major oceanographic events in the Cenozoic.

Text Books

J.P.Kennet (1982) Marine geology. Printice Hall Inc., New Jersey, 813p.

E. Seibold & W.H.Berger (1982) The sea floor. Springer-Verlag, Berlin.

J.Weisberg & H. Parish (1974). Introductory Oceanography. McGraw Hill.

B.W.Pipkin, D.S.Gorslin, R.E.Casey & D.E. Hammord (1972). Laboratory exercises in oceanography. W.H.Freeman & Co., San Francisco, 255p.

Soft core course

2 credits

EASC-517 QUATERNARY GEOLOGY

Quaternary Geology - an overview. Quaternary environments. Quaternary stratigraphy, lithology, genesis of quaternary deposits, fauna and flora, paleogeography and economic importance of Quaternary resources.

Major climatic changes during Quaternary period - Ice age, Pleis-tocene climate. Quaternary sea level changes and coastal geo-morphology. Atmospheric composition, ocean circulation and biological processes during Quaternary.

Quaternary fluvial, eolian and glacial systems. Paleoenvironments of Quaternary period in India. Evolution of Quaternary land forms in India. Study of lake deposits and laterites of India.

Text Books:

Holmes, A. : Principles of Physical Geology, ELBS, U.K.

Bird, E.C.F: Coastline changes. John Wiley & Sons, New York.

Stowe, K. : Exploring Ocean Science: John Wiley, New York.

Bloom, A.L.: Geomorphology - A Systematic Analysis of Late Cenozoic Landforms. Prentice-Hall, New Delhi.

Wadia et al : Quaternary environments and geoarchaeology of India. Geol. Soc. India, Bangalore.

Thornbury, W.D. :Principles of Geomorphology, Wiley Eastern, New Delhi.

Vaidyanathan, R. (ed) : Quaternary Deltas of India: Geol. Soc. India, Bangalore.

Davis R.A. (ed) Coastal sedimentary environments. Springer Verlag, New York.

Ahmad, E. : Coastal Geomorphology of India. Orient Longman, New Delhi.

Leeder, M.R. : Sedimentary process and product: George Allen & Unwin, London.

EASC-518 COAL AND PETROLEUM GEOLOGY

Coal: Origin of Coal, sedimentology of coal bearing strata, mode of occurrence of structures associated with coal seams, classification of coal, chemical analysis of coal.

Coal petrology: Study of Macroscopic and Microscopic constituents of coals. Elementary knowledge about the application of reflectance and fluorescence study of coal Basic idea about the coal preparation, carbonization, coal forming epochs in the geological past. Coal deposits of India and depositional environment of some important coal fields of India. Methods of Coal prospecting and estimation of its reserves. Coal Industry in India.

Petroleum: Historical development of petroleum geology. Physical and chemical properties of petroleum and related substances. Surface and subsurface geographic and stratigraphic occurrence of petroleum.

Origin of petroleum: inorganic and organic theories of source of petroleum. Environments and processes of transformation of source material to petroleum hydrocarbons. Migration of petroleum hydrocarbons: primary and secondary migration. Factors causing migration of petroleum Reservoir rocks: characteristics of reservoir rocks and their types. Principles of determination of porosity and permeability. Traps: characteristics and classification. Structural, stratigraphic, combination and fluid barrier traps. Accumulation of fluid petroleum Exploration: a review of prospecting methods as applied to the exploration of petroleum accumulations Estimation of petroleum reserves: brief outline of methods of estimation of petroleum reserves Petroleum prospects: Important oil & gas fields and petroleum prospects of India.

Text Books:

Stutzar, O and NOC, A.C.: Geology of Coal. University of Chicago Press, Chicago.

Moor, E.S.(ed): Coal, its properties, analysis, classification, geology, extraction, uses and distribution. John Wiley & Sons.

Stach et.al.: Text book of Coal Petrology. Gebruder Borntraegu, Stuttgart.

Scott, A.C.: Coal and Coal-bearing Strata: Recent Advances. Geol. Soc. Publ. No.32, Blackwell.

Levorson, A.I. Geology of Petroleum.

Lanes, K.K. Petroleum Geology.

Russel, W.L. Principles of Petroleum Geology

Pirson, S.J. Oil Reservoir Engineering.

Lalicker, C.G. Principles of Petroleum Geology.

Soft Core Course

2 Credits

EASC-519 MINERAL ECONOMICS

Concept of mineral economics and its importance in national development. International mineral trade; peculiarities inherent in mineral industry. Mineral supply as a stock: assessment of world mineral supplies, reserves and resources, technology and price.

Mineral legislation; national mineral policy; mineral taxation, preservation of environment, mineral conservation. The mines and minerals (regulation and development) act. Structure and organization of mineral industry; valuation of mineral property.

Future mineral consumption and world economy; energy demand and supply in future; marine mineral resources; developments in mineral exploration and exploitation.

Text Books

Sinha, R.K. & Sharma, N.L. Mineral economics. Oxford & IBH.

Govett, G.J.S. & Govett, M.H. 1976. World mineral supplies. Elsevier, Amsterdam.

Soft Core course

3 credits

EASC-520 PROFESSIONAL TRAINING

Intensive field and/or laboratory training on any applied aspect of geology including exploration and mining practices, petroleum well logging and related well site operations, geotechnical and geo-environmental investigations etc. Training will be conducted through professional organisations engaged in above activities. Total duration of the training will be about three weeks in the field.

EASC-521 GEOEXPLORATION**Part 1: Geological & Geochemical Exploration**

Introduction to past and present exploration practices. Prospecting criteria of various mineral deposits. Ore guides, regional and local parameters for exploration. Different stages and practices of geological prospecting, regional and detailed exploration. Methods of sampling: rock, soil, stream sediment, vegetation and vapour samples. Drilling methods: selection of sites, angle and direction of bore holes, logging, borehole deviation. Mobility of elements and geochemical cycle. Primary and secondary geochemical dispersion patterns. Background, threshold and anomalies. Methods and Practices of geochemical exploration. Evaluation of exploration data. Ore reserve estimation. Application of geostatistics.

Part 2: Geophysical Exploration

Basic philosophy of the methods of geophysical prospecting. Role of geophysics in oil, mineral and groundwater exploration. Natural and artificial fields. Geophysical methods, measurements and anomalies. Gravity method: density and rock types, correlation to gravity data, regional and local anomalies, target mass estimation, sample interpretation. Magnetic method: induced and remnant magnetisation, magnetic minerals, variation in magnetic susceptibility with rock types, qualitative interpretation of magnetic anomalies. Electrical method: electrical conduction in earth materials, resistivity method, resistance, resistivity and conductivity, electrode arrays, sounding and profiling, sample interpretation of two or three layer cases. Seismic method: elastic properties of materials, seismic waves and velocities, seismic rays refraction and reflection, Snell's law, critical refraction, seismic refraction method, travel time plots and simple interpretation of two, three and dipping layers. Seismic reflection method-principle and simple interpretation.

Text Books

- Indian Bureau of Mines, 1979. Mineral exploration. IBM, Nagpur.
Peters, W.C. 1978. Exploration and mining geology. John Wiley & Sons, New York.
Rose, A.W., Hawkes, H.E. & Webb, J.S. 1979. Geochemistry in mineral exploration. Academic Press, London.
Levinson, A.A. 1974. Introduction to exploration geochemistry. Applied Publication Co., Calgary.
Dorbin, M.B. Introduction to geophysical prospecting.
Parasnis, D.S. Principles of applied geophysics.
Ramachandra Rao. Geophysical prospecting for geologists.

Hard Core Course

2 Credits

EASC-522 ENGINEERING GEOLOGY

Introduction: role of geology in planning, designing and construction of engineering structures. Mechanical properties of rocks, stresses in rocks, modulus of elasticity, deformation. Poisson's ratio, and their measurement.

Design of engineering structures: dams, tunnels, bridges, highways; influence of geological factors on these. Geological investigations for selection of sites for engineering structures, with Indian case histories.

Landslides: classification, analysis of slope stability, monitoring slope movements, hazard zonation mapping.

Text Books

Krynine, D.P. & Judd, W.R. 1957. Principles of engineering geology and geotechnics. McGraw Hill, New York.

Bell, F.G. 1983. Fundamentals of engineering geology.

Beavis, F.C. 1985. Engineering geology.

Goodman, R.E. 1980. Introduction to rock mechanics.

Schuster, R.L. & Krizek, R.J. 1978. Landslide analysis and control. National Academy of Science, Washington DC.

Hard Core course

4 credits

EASC-523 PROJECT

Individual project work on applied aspects of current interest in geosciences. One faculty member of the Department will be assigned as the Supervisor. In case of inter-disciplinary project, one more faculty member from related discipline can be co-opted as the second Supervisor.

Hard Core Course

2 Credits

EASC-525 ADVANCED GEOLOGY LAB IV

Part 1: Geological & Geochemical Exploration (1 credit)

Map exercises on use of geological and geochemical prospecting criteria. Selection of suitable sampling method. Recognition of anomalies. Preparation of level plans and sections. Various methods of reserve estimation.

Part 2: Geophysical Exploration (1 credit)

Detection of buried graphite sheet using SP method. Electrical profiling and sounding. Gravity measurement at few selected points, study of the drift of gravimeter. Measurement of horizontal and vertical components of the earth's magnetic field. Measurement of total magnetic field using Fluxgate Magnetometer. Simple exercises on seismic exploration.

Hard Core Course

3 Credits

EASC-526 ADVANCED FIELD TRAINING II

Study of various geological features of mineral deposits in working mines. Methods of mining. Underground mine mapping, quality control operations. Geological operations at exploration sites. Field work related to petroleum exploration, engineering and environmental geological studies. Total duration of the training will be about three weeks in the field.

Soft core course

2 credits

EASC-527 ENVIRONMENTAL GEOLOGY

INTRODUCTION: Earth, man and environment: Basic environmental problems. Geoscience factors in environmental planning. Environmental Geosciences-fundamental concepts.

THE EARTH SYSTEMS AND BIOSPHERE: Conservation of matter in various geospheres - lithosphere, hydrosphere, atmosphere and biosphere. Concepts of ecology / Ecosystems. Biogeographical zonations of earth. The earth's major ecosystems-terrestrial and aquatic.

EARTH'S PROCESSES AND GEOLOGICAL HAZARDS: Earth's processes; Concept of residence time and rates of natural cycles. Catastrophic geological hazards. Study of floods, landslides, earthquakes, volcanism and avalanche, with a view to assess the magnitude of the problem, prediction and perception of the hazards.

MINERAL RESOURCES AND ENVIRONMENT: Resource and Reserves. Environmental impact of exploitation, processing and smelting of minerals.

ENERGY RESOURCES AND ENVIRONMENT: Environmental effects associated with each types of energy resource, viz. petroleum, natural gas, hydropower, nuclear, coal, solar and wind energy.

WATER RESOURCE AND ENVIRONMENT: Global Water Balance. Ice Sheets and fluctuations of sea levels. Origin and composition of sea water. Resources of oceans. Ocean pollution by toxic wastes. Human Use of Surface and Ground Waters. Ground Water Pollution.

WASTE DISPOSAL: Solid waste disposal - geology in planning and siting of land fills. Radioactive waste management.

ENVIRONMENTAL HEALTH: Biogeochemical factors in environmental health. Human use, trace elements and health. Possible effects of imbalance of some trace elements. Diseases induced by human use of land.

ENVIRONMENTAL LAW: Environmental legislation in India.

Text Books

Keller, E.A.: Environmental Geology: CBS Publisher, New Delhi.

Valdiya, K.S. : Environmental Geology-Indian Context. Tata McGraw Hill Publ. Co., Bombay.

Coates, D.R: Geology and Society. Chapman & Hall, New York.

Bryant, E.: Natural Hazard. Camb. Univ. Press.

Soft Core course

2 credits

EASC-528 MINING GEOLOGY

Orebody reevaluation. Appraisal of exploration data for exploratory mining. Exploratory development works for mineral deposits by open-cast and underground mining methods. Mine design, metallurgical design and planning.

Environmental baseline data needed for mine planning, its acquisition and documentation during different stages of mineral exploration. Nature and extent of environmental problems due to surface and underground mining.

Mine waste management.

Role of the geologist at operative mines. Grade control in open-pit and underground operations. Blending and stock-piling of ores.

Economic appraisal of mines.

Text Books

H.E.McKinstry (1980) Mining Geology. Printice Hall, New York.

R.N.P.Arogyswamy (1994) Courses in mining geology. Oxford-IBH, New Delhi.

Indian Bureau of Mines (1979) Mineral exploration. IBM, Nagpur.

A.E. Annels (1992) Mineral deposit evaluation. Chapman and Hall, London.

R.T.Deshmukh (1993) Elements of mining technology. Dhanbad Publishers, Dhanbad.

W.C.Peters (1987) Exploration and mining geology. John Wiley & Sons, New York.

EASC-529 WELL LOGGING

Basic Concepts: Fundamentals of drilling, drilling mud, flushed zone, invaded zone and uncontaminated zone. Physical properties of reservoir rocks, porosity, formation factor, water saturation and hydrocarbon saturation.

Electrical Logging: SP log, cause of SP in bore hole, principles of measurement, factors affecting SP log and interpretation of SP log. Resistivity log, principles and interpretation of various resistivity logs and their specific uses. Induction log, theory, procedure and interpretation of shallow, medium and deep induction tools.

Radiation Logging: Nature and properties of Gamma rays. Gamma log, detection system, principle of measurement and interpretation. Gamma-Gamma log, physical principle, photo electric effect, Compton scattering and pair production, estimation of density and porosity of formations. Neutron log, Gamma-Neutron log and Neutron activation log, basic principles, the instruments and interpretation.

Temperature, Magnetic, Gravity and Sonic Logging: basic principles, logging devices and interpretation.

Applications: Various approaches for porosity estimations. Correlation of sub-surface structures and comprehensive interpretation from available logging data. Application of well logging for mineral and groundwater exploration. A few case histories.

Text Books

S.J.Pirson: Hand book of well log analysis.

E.J.Lynch: Formation evaluation. Harper & Row.

M.R.J.Wyllie: The fundamentals of well log interpretation.

Y.I.Gorbachev: Well logging. John Wiley & Sons.

Soft Core Course

3 credits

EASC-530 ADVANCED REMOTE SENSING & GIS

Mapping from ground, air and space - Principles and basic concepts of remote sensing - electromagnetic spectrum and spectral reflectance of earth's surface features - Fundamentals of image interpretation - Types of satellite imagery - Elements and techniques of visual interpretation - Principles of multi-spectral data analysis.

Principles and techniques of geological and geomorphological, hydrological and ecological mapping - Identification of tree species in forest type stratification - Identification of environmental changes and monitoring - Identification and mapping of degraded and salt affected soils - Identification of rock types and landforms for mineral/oil exploration, groundwater targeting, and drainage pattern analysis.

Need of integrated Geosphere - Biosphere - Atmosphere studies and Geographic Information Systems - Digitization of information and encoding - Vector and Raster Formats - Data compression and integration - Artificial Intelligence and Expert Systems.

Practical exercises on Study of different types of satellite data products; visual interpretation of satellite data on different scale for extraction of thematic information; digital image processing system and enhancement of data classification; exposures of PC ARC/INFO and PC-ERDAS softwares.

Text Books

- Sabin, F.F. 1987. Remote sensing: principles and interpretation. W.H. Freeman and Co.
Burrough, P.A. 1986. Principles of Geographic Information Systems for land resources assessment.
Jensen, J.R. 1986. Introductory digital image processing : a remote sensing perspective. Prentice Hall, New Jersey.
Rees, W.G. 1990. Physical principles of remote sensing.
Gupta, R.P. 1990. Remote sensing geology. Springer Verlag, Heidelberg.