Syllabus of M.Sc. (Geology) Semester System - 2004-05

Candidates who have passed the three year B.Sc. (Hons.) examination of the Banaras Hindu University or any other equivalent examination of other universities with Geology as one of the major subjects will be considered eligible for admission to the Four Semester M.Sc. Course in Geology.

The M.Sc. course in Geology shall be imparted to the students for two academic sessions consisting of four semesters as given below. Candidates will be examined and evaluated on grade basis at the end of each semester in the different courses of theory and practical as per the credits given against each course. The M.Sc. Geology will consist of (a) Core Courses, (b) Major Elective Courses and (c) Minor Elective Courses.

(a) The Core courses will be compulsory for all the students admitted to M.Sc. Geology. There will be twelve core courses covering major branches of Geology and two sessions of two to three weeks of Geological Field training and Viva-voce examination in the field. The attendance in the Geological Field Training will be compulsory for all the students. The field training and Viva-Voce examination will be conducted by at least two internal examiners (faculty members) during first and third semesters. For the Geological Field Training 4 credits (70 marks) shall be assigned to evaluation of the report while 1.5 credits (30 marks) shall be assigned to Viva-voce examination in the field. The semester breaks can also be utilized for the geological field training. After the field training, the students will be required to submit a detailed field report to the concerned teacher for evaluation.

(b) The Major Elective Courses shall be partly replaced by Project Oriented Dissertation in a specialized field of Geology. The area of Dissertation shall be assigned to the students at the end of Ist Semester based on the merit of the students and expertise available in the Department. The Project Oriented Dissertation must be submitted by the end of fourth Semester with a seminar presentation before the faculty members and the board of examiners for the purpose of evaluation. During the course of completion of the Dissertation work the students will be required to complete various assignments given to them by their respective supervisors for the purpose of their evaluation. The Dissertation shall be of 16.5 credits out of which 12 credits (150 marks) will be evaluated by the Board of Examiners through a presentation and Viva-Voce examination while 4.5 credits (50 marks) will be evaluated by the respective supervisor.

(c) The students shall select the Major and Minor Elective Courses after the end of 2nd Semester and 3rd Semester. The students may select any number of major and minor elective courses, which should fulfill the minimum requirement of credits for each semester, but the total number of credits should not be less than 22 and more than 28.

The details of courses, semester-wise schedule and credits for each course are given below:

M.Sc. Geology Syllabus, Semester System 2004-05

SEMESTER –I

COURSE NO.	CORE COURSES	Credit for theory	Credit for Practical
GLMC 101	Structural Geology	2.5	1
GLMC 102	Mineralogy and Crystallography	2.5	1
GLMC 103	Igneous Petrology	2.5	1
GLMC 104	Sedimentology	2.5	1
GLMC 105	Metamorphic Petrology and Thermodynamics	2.5	1
GLMC 106	Geological Field Training	4+1.5	
Total Number of Credits for Semester I =23 (12.5 Theory +5 Practical + 5.5 Field Training)			

SEMESTER -II

COURSE NO.	CORE COURSES	Credit for theory	Credit for Practical
GLMC 201	Geomorphology and Geotectonics	2.5	1
GLMC 202	Geochemistry	2.5	1
GLMC 203	General and Invertebrate Palaeontology	2.5	1
GLMC 204	Micropaleontology and Oceanography	2.5	1
GLMC 205	Stratigraphy	3.5	1
GLMC 206	Ore Geology	2.5	1
Total Number of Credits for Semester II = 22 (16 Theory + 6 Practical)			

SEMESTER -III

COURSE NO.	CORE COURSES	Credit for theory	Credit for Practical
GLMC 301	Fuel Geology	2.5	1
GLMC 302	Geological Field Training	4+1.5	
COURSE NO.	MAJOR ELECTIVE COURSES	Credit for theory	Credit for Practical
GLMMA 303	Hydrogeology	2.5	1
GLMMA 304	Environmental Geology and Natural Hazards	2.5	1
GLMMA 305	Remote Sensing and GIS in Geology	2.5	1
GLMMA 306	Engineering Geology and Surveying	2.5	1
COURSE NO.	MINOR ELECTIVE COURSES	Credit for theory	Credit for Practical
GLMMI 307	Mineral Exploration and Mineral Economics	2	1
GLMMI 308	Gemology	2	1
GLMMI 309	Palaeobotany	2	1
Total Number of Credits for Semester III = 22.5 (12 Theory + 5 Practical +5.5 Field Training)			

SEMESTER - IV

COURSE NO.	MINOR ELECTIVE COURSES	Credit for theory	Credit for Practical
GLMMI 401	Elements of Mining and Ore Dressing	2	1
GLMMI 402	Soil Geology	2	1
GLMMI 403	Petroleum Exploration	2	1
GLMMI 404	Vertebrate Palaeontology	2	1
COURSE NO.	MAJOR ELECTIVE COURSES		
GLMMA 405	Project Oriented Dissertation	12+4.5	
Total Number of Credits for Semester IV = 22.5 (4 Theory + 2 Practical + 16.5 Dissertation)			

Minimum Number of Credits for Core Courses = 54

Minimum Number of Credits for Major Elective Course = 27

Minimum Number of Credits for Minor Elective Course = 09

SEMESTER I

Course No. GLMC-101: Structural Geology

Theory

Mechanical principles, properties of rocks and their controlling factors. Theory of rock failure. Concept of stress and strain; Two-dimensional strain and stress analyses; Types of strain ellipses and ellipsoids their properties and geological significance. Methods of strain measurements in naturally deformed rocks.

Mechanics of folding and buckling. Fold development and distribution of strains in folds.

Brittle and ductile shear zones, Geometry and products of shear zones, Mylonites and Cataclasites; Causes and dynamics of faulting: Strike-slip Faults, Normal Faults, Thrust Faults; Thin-skinned deformation; Decollement.

Planar and linear fabrics in deformed rocks, their origin and significance.

Basic idea about petrofabrics and use of Universal stage.

Stereographic and equal area projections for representing different types of fabrics, π and β diagrams. Geometrical analysis of simple and complex structures on macroscopic scale.

Basic idea on the structure and tectonics of Himalaya.

Practicals

Preparation and interpretation of Geological maps and sections.

Structural problems based on orthographic and stereographic projections, concerning economic deposit.

Recording and plotting of the field data

Study of the hand specimen of deformed structures

Strain estimation from the data already collected from the field.

Study of dip-isogons from the fold profiles.

Books Recommended

Ramsay, J.G. (1967): Folding and fracturing of rocks. McGraw Hill.

Turner, F.J. and Weiss, L.E. (1963): Structural analysis of Metamorphic Tectonites. McGraw Hill.

Hobbs, B.E., Means, W.D. and Williams, P.F. (1976): An outline of Structural Geology. John Wiley and Sons. New York.

Ghosh, S.K. (1993): Structural Geology: Fundamental and Modern Developments. Pergamon Press.

Ramsay, J.G. and Huber, M.I.(1983): Techniques of Modern Structural Geology. Vol. I. Strain Analysis. Academic Press.

Ramsay, J.G. and Huber, M.I. (1987): Techniques of Modern Structural Geology. Vol. II. Folds and Fractures. Academic Press.

Course No. GLMC-102: Mineralogy & Crystallography

Theory

Mineralogy

Structure and classification of silicates.

A detailed study of the important silicates (listed below) with reference to general and structural formulae, classification, atomic structure, polymorphs/structural states, chemistry including substitution of elements/solid solution and experimental work on pressure-temperature stability of the minerals, modes of occurrence and alterations.

(a) Nesosilicates/Orthosilicates: Olivine Group, Humite Group. Garnet Group, Aluminosilicate Group (Kyanite, Andalusite, Sillimanite).

(b) Sorosilicates: Melilite Group

(c) Cyclosilicates: Beryl

(d) Inosilicates: Pyroxene Group, Amphibole Group.

(e) Phyllosilicates: Kaolinite Group, Serpentine Group, Pyrophyllite, Talc, Mica Group, Chlorite.

(f) Tectosilicates: Feldspar Group, Cordierite.

Optical Mineralogy

Optical crystallography of uniaxial and biaxial crystals, Indicatrix, pleochroism, Interference figures, crystal orientation, 2V and 2E.

Crystallography

Derivation of 32 classes of symmetry.

International system of crystallographic notation and study of Stereograms.

Different types of crystal projections – spherical and stereographic and their uses.

Twinning and Twin Laws: common types of twins and their examples in minerals.

Liquid Crystals.

Space Lattice and Symmetry of internal structures – 14 Bravais Lattice. Introduction to space group.

Historical development of X-ray Crystallography, and Bragg's Equation.

Powder method in X-ray crystallography.

Practicals

Mineralogy

Identification of rock-forming minerals in hand specimens. Atomic structure models.

Optical Mineralogy

Determination of length fast and length-slow characters of minerals.

Determination of order of interference colours.

Scheme of pleochroism and absorption of a given mineral in thin section.

Determination of extinction angle and composition of plagioclase.

Study of interference figures of uniaxial and biaxial crystals, determination of optic signs.

Crystallography

Goniometer and its use in measuring interfacial angle of crystals and calculation of axial ratio.

Representation of symmetry elements of crystals belonging to 32 classes of symmetry and study of their stereograms.

Books Recommended

Dana, E.S. and Ford, W.E.: A textbook of Mineralogy. Wiley Eastern Limited.

Deer, W.A., Howie, R.A. & Zussman, J. : An Introduction to the rock forming minerals, ELBS and Longman

Berry, L.G., Mason, B. and Dietrich, R.V.: Mineralogy, CBS Publishers

Phillips, F.C. Introduction to Crystallography.

Kerr, P.F.: Optical Mineralogy. McGraw Hill Book Company.

Moorhouse, W.W.: Optical Mineralogy.

Winchell, E.N. : Elements of Optical Mineralogy.

Nesse, D.W.: Optical Mineralogy, McGraw Hill.

Course No. GLMC-103: Igneous Petrology

Theory

Magma: Its physics, nature, factors affecting magma and evolution. Petrology and melting of mantle. Generation of magmas in different tectonic environments.

The Phase equilibrium of binary (Ab-An, Ab-Or, Di-An, Fo-Si) and ternary (Di-Ab-An, Di-Fo-Si, Di-Fo-An, Ne-Ks-Si, Fo-An-Si) systems and its relation to magma genesis and crystallization in the light of modern experimental works.

Interpretation of igneous textures in terms of rate of nucleation and crystal growth.

IUGS classification of the Igneous rocks. CIPW Norm.

Petrology and petrogenesis of major igneous rock types giving Indian examples of Ultramafic, Basaltic, Granitic, Alkaline, Ophiolite, Carbonatite, Nephelinite-Ijolilte, Lammproits, and Layered igneous rocks.

Plume magmatism and hot spots. Mantle metasomatism. Mantle heterogeneities.

Partial melting (batch and fractional melting), crystal fractionation [equilibrium and fractional (Rayleigh) crystallization], contamination (AFC process) and dynamic melting.

Practicals

Megascopic and microscopic study of different igneous rocks.

Calculation of CIPW Norms.

Books recommended

Bose, M.K., 1997. Igneous Petrology, World Press, Kolkata.

Best, Myron G., 2002. Igneous and Metamorphic Petrology, Blackwell Science.

Cox, K.G., Bell, J.D. and Pankhurst, R.J.,1993: The Interpretation of Igneous Rocks. Champman & Hall, London.

Faure, G. : Origin of Igneous Rocks, Springer.

Hall,A., 1997 : Igneous Petrology, Longman.

LeMaitre, R.W., 2002. Igneous Rocks: A Classification and Glossary of Terms, Cambridge University Press.

McBirney, 1994. Igneous Petrology, CBS Publishers, Delhi.

Phillpotts, A.R., 1994. Principles of Igneous and Metamorphic Petrology, Prentice Hall of India.

Sood, M.K., 1982: Modern Igneous Petrology. Wiley-Interscience Publ., New York.

Srivastava, Rajesh K. and Chandra, R., 1995: Magmatism in Relation to Diverse Tectonic Settings.

A.A. Balkema, Rotterdam.

Wilson, M., 1993: Igneous Petrogenesis. Chapman & Hall, London.

Winter, J.D., 2001: An Introduction to Igneous and Metamorphic Petrology. Prentice Hall, New Jersey.

Course No. GLMC-104: Sedimentology

Theory

Origin of Terrigenous Clastic and Non-clastic Grains; Weathering and its Products; Chemical Weathering of Granite and Basalt, Submarine Weathering.

Major Carbonate Minerals; Carbonate Grains of Biological origin.

Simple Fluid Flow Concepts and Sediment Transport; Sediment Gravity Flows and their Deposits.

Important Bed Forms and Sedimentary Structures – their Genesis and Stratigraphic Significance. Palaeocurrent Analysis; Classification of sedimentary basins.

Grain size, Textural Parameters and their Significance. Textural and compositional maturity. Petrography and origin of Sandstones, Limestones and Mudrocks.

Sedimentary facies, methods of their analysis and interpretation of Depositional Environments. Processes and Characteristics of Eolian, Fluvial, Barrier-beach, Tidal-flats and Deep Sea Environments.

Diagenesis of Clastic and Non-Clastic rocks, Stages and Processes of Diagenesis, Compaction and Cementation by Silica, Carbonate and Iron-Oxide, Dolomitization.

Heavy Minerals and their Importance in Determination of Provenance.

Practicals

Microscopic Examination of Important Rock-types.

Heavy Mineral Separation; their Microscopic Characters, Graphic Representation and Interpretation.

Grain-size Analysis by sieving Method: Plotting of size-distribution data as Frequency and Cumulative. Curves; Computation of Statistical Parameters and Interpretation.

Study of Clastic and Non-clastic Rocks in Hand Specimens.

Assemblages of Sedimentary Structures and their Palaeoenvironmental significance. Palaeocurrent Analysis.

Study of Vertical Profile Sections of some Selected Sedimentary Environment.

Books Recommended

Blatt, H., Middleton, G.V. and Murray, R.C. (1980): Origin of Sedimentary Rocks, Prentice-Hall Inc.

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

Lindholm, R.C. (1987) A Practical Approach to Sedimentology. Allen & Unwin, London.

Pettijohn, F.J. (1975): Sedimentary Rocks. 3rd Edn. Harper and Row Publ., New Delhi.

Reineck, H.E. and Singh, I.B. (1973): Depositional Sedimentary Environments. Springer-Verlag.

Selley, R. C. (2000) Applied Sedimentology, Academic Press.

Tucker, M.E. (1981): Sedimentary Petrology: An Introduction, Wiley & Sons, New York.

Course No. GLMC-105: Metamorphic Petrology and Thermodynamics

Theory

Mineralogical Phase Rule for Closed and Open Systems. Nature of Metamorphic Reactions, Concept and Classification of Metamorphic Facies and Facies Series, Introduction to Ultrahigh Temperature and Ultrahigh Pressure Metamorphism, Description of each Facies of Low – Pressure, Medium to High – Pressure and very High Pressure with special reference to characteristic Minerals, subdivision into Zones/Subfacies, Mineral Assemblages, Metamorphic Reactions and Pressure – Temperature Conditions of Metamorphism.

Isograds and Reaction Isograds, Schrienemakers Rule and Construction of Petrogenetic Grids, Metamorphic Differentiation, Anatexis and Origin of Migmatites in the light of experimental studies,

Regional Metamorphism and Paired Metamorphic Belts with reference to the theory of Plate Tectonics, Pressure – temperature – time paths.

Laws of Thermodynamics, Gibb's Free – Energy, Entropy, Δ G of Metamorphic Reactions (Solid-Solid and Dehydration Reactions). Clausius – Clapeyron Equation, Geothermobarometry.

Practicals

A detailed study of textures in Rock Sections with reference to time relations between the phases of deformation and recrystalization of minerals, Calculation of ACF, AKF and AFM values from chemical and structural formulation of minerals and their graphical representation. Study of Metamorphic Rocks in thin sections belonging to different facies with emphasis on texture/structure, mineral composition, parent rock, metamorphic facies/subfacies/zone to which the rock can be assigned and graphical representation of the assemblage in ACF, AKF and AFM diagrams. Study of metamorphic rocks of different metamorphic facies in Hand Specimens. Estimation of Pressure and Temperature from important models of Geothermobarometry.

Books Recommended

Winter, J.D. 2001 : An introduction to Igneous and Metamorphic Petrology, Prentice Hall.

Philpotts, A.R. 1994 : Principles of Igneous and Metamorphic Petrology, Prentice Hall.

Bucher, K. and Martin, F. 2002 : Petrogenesis of Metamorphic Rocks, Springer – Verlag, 7th Revised Edition.

Yardley, B.W.D. 1989 : An introduction to Metamorphic Petrology, Longman Scientific & Technical, New York.

Spear, F. S. 1993 : Mineralogical Phase Equilibria and pressure – temperature – time Paths, Mineralogical Society of America.

Powell, R. 1978 : Equilibrium thermodynamics in Petrology: An Introduction, Harper & Row Publishers, London.

Wood, B.J. and Fraser, D.G. 1976: Elementary Thermodynamics for Geologists, Oxford University Press, London.

Rastogi, R.P. and Mishra, R.R. 1993: An Introduction to Chemical Thermodynamics, Vikash Publishing House.

Yardley, B.W.D., Mackenzie, W.S. and Guilford, C. 1995 : Atlas of Metamorphic Rocks and their textures, Longman Scientific & Technical, England.

Spry, A. 1976 : Metamorphic Textures, Pergamon Press.

Blatt, H. and Tracy, R.J. 1996 : Petrology (Igneous, Sedimentary, Metamorphic), W.H. Freeman & Co., New York.

Kerr, P.F. 1959 : Optical Mineralogy, McGraw Hill Book Company Inc., New York.

Course No. GLMC 106: Geological Field Training

Students will be required to carry out fieldwork for 2-3 weeks in suitable geological areas to study various aspects of field geology and submit a report thereon.

SEMESTER II

Course No. GLMC-201: Geomorphology & Geotectonics

Theory

Geomorphology

Basic concepts and significance of Geomorphology;

Typical landforms and their evolution;

An elementary idea about morphogenesis and morphography; Morphometric analysis; Morphochronology, Geomagnetism,

Brief study of Terrain Evaluation for strategic purposes.

Geomorphology of India – Peninsular, extra-peninsular and Indo-Gangetic Plains.

Application of Geomorphology in Mineral Prospecting, Civil Engineering, Hydrogeology and Environmental studies.

Geotectonics

Fundamental concept of geotectonics, its practical and theoretical importance.

Organic and Epeirogenic Phases; Concept and theories of Isostasy;

Origin and significance of Mid-Oceanic Ridges and Trenches;

Island arcs and mountain chains, their global distribution and evolution.

Concept of Sea floor spreading;

Evidence of continental drift, Concept of Plate Tectonics, Nature and types of Plate Margins, Geometry and Mechanism of Plate Motion. Tectonic and Economic significance of Plate Tectonics.

Palaeomagnetism, Polar Wandering and reversal of earth's magnetic field. Geomagnetic time scale.

Tectonics of Pre-cambrian Organic Belts of India.

Practicals

Drainage and Slope Morphometry, Hypsometry,

Geomorphology through topo-sheets, Geomorphology through aerial photos and satellite Imagery, Terrain aspect mapping.

Books recommended

Geomorphology

Thornbury, W.D. 1980: Principles of Geomorphology. Wiley Eastern Ltd., New York.

Holmes, A. 1992: Holmes Principles of Physical Geology Edited by P. McL. D. Duff. Chapman and Hall, London.

Halis, J.R. 1983: Applied Geomorphology

Sharma, H.S. 1990: Indian Geomorphology. Concept Publishing Co. New Delhi.

Geotectonics

Gass I.G. et al 1982: Understanding the Earth. Artemis Press (Pvt.) Ltd. U.K.

Windley B. 1973: The Evolving continents. John Wiley & Sons, New York.

Condie, Kent. C. 1982. Plate Tectonics and Crystal Evolution Pergamon Press Inc.

Course No. GLMC-202: Geochemistry

Theory

Section A – Geochemistry

Introduction of Geochemistry and Cosmochemistry. Chemical composition and properties of Earth's layers. Atmosphere: its layers, chemical composition and evolution of Atmosphere.

Meteorites, classification, mineralogy, origin, significance and phenomena of fall.

Stable isotope geochemistry of Carbon and Oxygen and its application in Geology.

Radiogenic isotopes. Decay scheme of K-Ar, U-Pb and Rb-Sr.

Geochemistry of Uranium and Lithium.

Geochemical cycle; Minor cycle and Major cycle.

Geochemical classification of elements. Periodic table with special reference to rare earth elements and transition elements.

Section B – Crystal Chemistry

Structure and types of atoms. Types of chemical bonding. Ionic radii. Coordination number. Lattice energy. Ionization potential. Electronegativity. Pauling's rule. Isomorphism and polymorphism. Crystal structure of elements and simple compounds with reference to Non-silicate minerals – (i) Natural elements: closed packed structures, structures of AS, Sb, Bi, Diamond and graphite, (ii) Structure of some simple compounds – AX structure (NaCl, CaCl, ZnS, NiAs), AX2 structure (Fluorite, Rutile, etc.) A brief idea about some other compounds such as A_2X_3 (Corundum), ABX_3 (Calcite, Ilmenite), and AB_2X_4(Spinel).

Principles of ionic substitution in minerals.

Practicals

Rock analyses (Rapid method of silicate analysis) and FeO determination by titration method. Determination of Loss on Ignition (LOI) of rock samples.

Preparation of classificatory and variation diagrams and their interpretation.

Study of crystal models of non-silicate minerals and elements.

Books Recommended

Rankama, K. and Sahama, Th. G. (1950) Geochemistry. Univ. Chicago Press.

Mason, B. and Moore, C.B. (1991) Introduction to Geochemistry, Wiley Eastern.

Krauskopf, K.B. (1967): Introduction to Geochemistry. McGraw Hill.

Fife, W.S. (1964) : Geochemistry of Solids. McGraw Hill.

Evans, R.C. (1964): Introduction to Crystal Chemistry. Cambridge Univ. Press

Bloss, F.D. (1971): Crystallography and Crystal Chemistry. Holt, Rinehart, and Winston, New York.

Klein, C. and Hurlbut, C.S. (1993): Manual of Mineralogy. John Wiley & Sons, New York.

Course No.GLMC-203: General and Invertebrate Palaeontology

Theory

Modern Taxonomy, Identification of fossils, Describing a fossil specimen, Ontogenic variation.

Micro-evolution, Trans-specific evolution, Radiation, Speciation, Elements and types of heterochrony, Migration and dispersal.

Precambrian Life. Palaeoecology: Concepts and approaches. Taphonomy: Definition, processes and applications. Trace fossils: Kinds and classification; their significance in palaeoenvironmental reconstruction.

Classification of Brachiopoda, Bivalvia, Ammonoidea and Cnidaria (corals)

Evolutionary trends and Geological history of Brachiopoda, Bivalvia, Gastropoda, Ammonoidea, Trilobita, Echinoidea and Cnidaria (corals).

Palaeoecology/Functional Morphology of Bivalves and Brachiopods.

Practicals

Study of the morphological characters of some important Invertebrate Fossils belonging to Brachiopoda, Bivalvia, Gastropoda, Ammonoidea, Trilobita, Echinoidea and Corals. Determination of valves and dental formula of Heterodont Bivalves. Shell petrography of Bivalves and Brachiopods.

Study of an assorted group of trace fossils.

Study of ammonoid suture pattern, coiling, whorl section and ontogenic variation; exercises in ammonoid heterochrony.

Measurements of dimensional parameters and preparation of elementary bivariate growth curves and scatter plots.

Books Recommended

Raup, D.M. and Stanley, S.M. (1985) Principles of Palaeontology (CBS Publications)

Clarksons, E.N.K. (1998) Invertebrate Palaeontology and Evolution

Boardman, R.S. Cheetham, A.M. & Rowell, A.J. (1988) Fossil Invertebrates (Blackwell)

Stearn, C.W. and Carroll, R.L. (1989) Palaeontology – the record of life (John Wiley)

Smith, A.B.(1994) Systematics & Fossil Record – Documenting Evolutionary Patterns (Blackwell)

Prothero, D.R. (1998) Bringing Fossil to Life – An Introduction to Palaeontology (McGraw Hill)

Horowitz, A.S. & Potter, E.D. (1971) – Introductory Petrography of Fossils (Springer Verlag)

Mayr, E. (1971) – Population, Species and Evolution (Harvard)

Dobzhansky, Ayala, Stebbins & Valentine (1977) – Evolution (Freeman)

Course No. GLMC–204: Micropaleontology and Oceanography

Theory

Section – A: Micropaleontology and its Application in studying modern and ancient environments.

Introduction: Definition and scope of the Subject. Relationship of Micropaleontology with Ocean Science. Surface and Subsurface sampling methods including deep sea drilling. Introduction to important Deep Sea Drilling Vessels like Sagar Kanya, GLOMAR Challenger, JOIDES Resolution and Chikyu. Sampling Modern Ocean Biogenic Flux including Sediment Trap sampling. Sample processing techniques. Equipments for micropaleontological studies.

Brief Study of the following Types of Microfossils and their application in Oceanography

1. Calcareous Microfossils

(a) Foraminifera: Planktic Foraminifera, their modern biogeography, coiling, surface ultrastructure, outline of morphology. Benthic foraminifera, their brief morphology. Larger Foraminifera and their outline of morphology.

Application in Oceanography: Significance of planktic foraminifera in Cenozoic oceanic biostratigraphy and application in paleoceanographic and paleoclimatic interpretation. Importance of Planktic foraminifera in determining timing of closing and opening of Ocean Gateways during Cenozoic. Application of benthic foraminifera in Paleobathymetric reconstructions and bottom water paleoceanography. Benthic foraminifera as indicators of environmental change. Application of larger foraminifera in paleoclimatology and Indian stratigraphy.

(b) Calcareous nannofossils: Outline of morphology, modern biogeography,

Application in Oceanography: Application of Calcareous nannofossils in surface water paleoceanographic reconstructions. Calcareous nannofossils and Paleoclimate. Significance of Calcareous nannofossils in Oceanic biostratigraphy.

(c) Ostracoda : Outline of morphology and wall structure.

Application in Oceanography: Significance of Ostracoda in Quaternary paleoceanographic and paleoclimatic studies. Environmental applications of Ostracoda including ancient and modern continental environments. Geochemistry of the Ostracod shell and Holocene climatic variability. Applications in Oceanic biostratigraphy.

Pteropods, Calpionellids and Calcareous Algae: Brief Introduction of each group.

Application in Oceanography: Pteropods as indicators of past oceanic water masses and bathometers. Stratigraphic significance of Calpionellids and Calcareous Algae.

(2) Siliceous Microfossils

(a) **Radiolaria:** Outline of morphology. Modern biogeography.

(b) **Diatoms and silicoflagellates** : Brief knowledge of each group. (No morphological details).

Application in Oceanography and environmental studies : Use of Radiolaria in determining past sea surface temperatures. Application of Diatoms in interpreting ancient and modern lacustrine environment like lake Eutrophication, lake acidification. Diatoms and sea level changes. Diatoms and Sea ice cover during Quaternary. Diatoms and paleoceanography of Equatorial upwelling systems during Quaternary. Application of silicoflagellates in paleoclimatic interpretation. Importance of Siliceous microfossils in marine Geology and oceanography.

(3) Phosphatic Microfossils

Conodonts. Outline of morphology, paleoecology, zoological affinities.

Application in Oceanography: Environmental significance of Conodonts. Conodont colour alteration index and its use. Stratigraphic significance of Conodonts with special reference to India.

(4) Organic Walled Microfossils

Brief knowledge of **Acritarchs** and **Dianoflagellates**.

Application in environmental studies. Ecological response of dinocysts. Surface water temperatures from Dinocysts. Dinoflagellates in identifying ancient coast lines. Paleosalilnity and nutrients level from Dinocysts. Acritarchs in Indian Stratigraphy.

Palynology: Outline of morphology of Pollens and Spores. Pollens and Spores in marine realm. Environmental application of Pollen and Spores.

(5) Application of Micropaleontology in Petroleum Exploration

Section B: Oceanography

Historical perspective: History of development of Marine Geology and oceanography.

Physical Oceanography: Methods of measuring properties of sea water. Molecular structure of water. Temperature and salinity distribution in surface of the ocean. Salt composition and residence time. Dissolved gases in seawater. Carbon dioxide and carbonate cycle.

Ocean circulation: The Ocean Conveyor belt and its role in controlling world's climate. Surface circulation; concept of mixed layer, thermocline and pycnocline, Coriolis Force and Ekman Spiral, Upwelling, El nino. Processes affecting biological productivity of ocean margin waters. Deep Ocean Circulation, concept of thermohaline circulation, formation of bottom waters; water masses of the world oceans. Oxygen minimum layer in the ocean. Major currents of the world's ocean.

Deep-Sea Sediments and Processes: Deep-sea sediments and their relation to oceanic processes such as solution, productivity, and dilution. Sediment distributions in time and space as related to tectonic models. Deep Sea hiatuses and their causes. Calcite and Aragonite Compensation depth and significance.

Ocean Resources: Mineral resources of the ocean including polymetalic nodules. Marine Gas Hydrates and their economic potential.

Marine Pollution : Marine Pollution emphasizing geochemical aspects of the sources, transport, and fate of pollutants in the coastal marine environment. Interpreting marine pollution with the help of microfossils during Quaternary.

Paleoceanography: Ocean Floor Morphology, Oceanic Crust and Ocean Margins. Approaches to Paleoceanographic reconstructions. Paleoceanographic changes in relation to earth system history including impact of the oceans on climate change. Deep Sea Drilling Project (DSDP); Ocean Drilling Program (ODP) and Joint Global Ocean Flux Studies (JGOFS) and their major accomplishments. Integrated Ocean Drilling Program (IODP) and its aims and objectives. Evolution of Oceans in the Cenozoic. Ocean Gateways of the Cenozoic and their role in controlling global climates. Sea level changes during Quaternary with special reference to India.

Application of stable isotopes (Oxygen and Carbon) in Paleoceanography and Paleoclimatology. Paleoclimatic reconstructions from ice cores.

Marine Stratigraphy, correlation and chronology.

Practicals

Micropaleontology

Techniques of separation of Microfossils from matrix

Types of microfossils: Calcareous, Siliceous, Phosphatic and organic walled microfossils. SEM applications in Micropaleontology. Study of surface ultrastructures of foraminifera.

Study of important planktic foraminifera useful in surface water paleoceanography and oceanic biostratigraphy.

Study of larger benthic foraminifera useful in Indian Stratigraphy with special reference to Cenozoic petroliferous basins of India.

Oceanography

Depth biotopes and estimation of paleodepth of the ocean using benthic foraminiferal assemplages.

Identification of modern and ancient surface water mass with the help of planktic foraminiferal assemblages.

Identification of benthic foraminifera characteristic of low oxygen environment

Identification of Planktic foraminifera characteristic of Warm Mixed Layer, Thermocline and deep surface water of the Modern Oceans.

Study of Modern Surface water mass assemblages of planktic foraminifera from Indian Ocean, Atlantic Ocean and Pacific Ocean.

Books Recommended

Quaternary Environmental Micropalaeontology (Ed. Simon K. Hasllett) Arnold; Oxford University Press, New York Year. 2002.

Elements of Micropaleontology by G. Bignot; Grahm and Trottman, London. Year 1985.

Microfossils by M.D. Braiser; Geogrge Allen and Unwin, Year 1980.

Micropaleontology in Petroleum exploration by R.W. Jones. Clarendon Press Oxford, 1996.

Elements of Dynamic Oceanography by David Tolmazin. Allen and Unwin Year 1985.

Oceanography; A view of the Earth by M. Grant Gross. Prentice Hall, Year 1977.

Global Warming by John Houghton, Cambridge Univ. Press. Year 1997.

Introduction to Marine Micropaleontology, by Haq and Boersma, Elsevier Year 1978.

Neogene Planktonic Foraminifera: A phylogenetic Atlas, by Kennett and Srinivasan, Hutchinson Ross, USA, 1983.

Course No. GLMC-205: Stratigraphy

Theory

General

Approaches to measurements of Geological time. Concepts of Sequence stratigraphy; brief ideas of quantitative-, magneto-, seismic-, chemo- and event stratigraphy. Approaches to palaogeography. Stratigraphic correlations.

Precambrian stratigraphy

Precambrian geochronology. Chronostratigraphy of the Precambrian of Dharwar Craton, Eastern Ghats Belt, Southern Granulite Belt and Singhbhum-Chhotanagpur-Orissa Belt. Proterozoic stratigraphy of Son Valley, Cuddapah-Kurnool and Chatisgarh basins.

Precambrian-Cambrian boundary.

Marine Palaeozoic stratigraphy

Igneous activities and palaeogeography during the Palaeozoic Era.

Stratigraphy, facies, and fossil contents of the Palaeozoic rock formations of India. Permian-Triassic boundary.

Gondawana stratigraphy

Concepts, classification, fauna, flora and age limits of Gondwana Supergroup and related palaeogeography, palaeoclimate, depositional characteristics and igneous activity.

Mesozoic stratigraphy

Classification, depositional characteristics, fauna and flora of Triassic, Jurassic and Cretaceous systems in principal basins of India.

Cretaceous-Tertiary boundary.

Cenozoic stratigraphy

Classification, depositional characteristics, fauna and flora of the Palaeogene and Neogene systems in their type localities and their equivalents in India.

Epoch boundaries of the Cenozoic in India.

Practicals

Study of rocks in hand specimens from known Indian stratigraphic horizons and type localities.

Exercises on stratigraphic correlation and classification.

Exercises on Seismic and magneto-stratigraphic interpretations.

Study and understanding of plate-movements through important periods during Phanerozoic Eon.

Evolution of ocean systems during Phanerozoic.

Books Recommended

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

Naqvi, S.M. and Rogers, J.J.W. (1987) : Precambrian Geology of India. Oxford University Press.

Krishnan, M.S. (1982) : Geology of India and Burma. C.B.S. Publishers & Distributors, Delhi

Pascoe, E.H. (1968): A Manual of the Geology of India & Burma (Vols.I-IV) Govt. of India Press, Delhi

Pomerol, C. (1982) : The Cenozoic Era? Tertiary and Quaternary. Ellis Harwood Ltd., Halsted Press.

Schoch, Robert, M. (1989) : Stratigraphy: Principles and Methods, Van Nostrand Reinhold, New York.

Doyle, P. & Bennett. M.R. (1996) : Unlocking the Stratigraphic Record (John Willey).

Course No. GLMC-206: Ore Geology

Theory

Concept of ore bearing fluids, their origin and migration. Wall-rock alteration. Structural, physicochemical and stratigraphic controls of ore localization. Paragenesis, paragenetic sequence and zoning in metallic ore deposits. Ore deposits in relation to plate tectonics. Fluid inclusions in ore: principles, assumptions, limitations and applications. Geothermometry, geobarometry and isotope studies in ore geology.

Mineralogy, classification and genesis of petrological ore associations: Orthomagmatic ores of ultramafic-mafic association, ores of felsic-silicic igneous rocks: ores related to submarine volcanism, biochemical, chemical and clastic sedimentation; placers and residual concentration deposits. Ores of metamorphic affiliations.

A detailed study of ore minerals related to the following metals with special reference to their mineralogy, genesis, specification if any, uses and distribution in India: Fe, Mn, Cr, Cu, Pb, Zn, Al, Mg, Au, Sn and W.

Study of important industrial minerals of India with particular reference to the following: Iron and Steel industry, refractory industry, fertilizer industry, cement industry, chemical industry and abrasives.

Practicals

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

Books Recommended

Evans, A.M. (1993) Ore Geology and Industrial Minerals, Blackwell.

Stanton, R.L. (1972) Ore Petrology, McGraw Hill.

Barnes, H.L.(1979) Geochemistry of Hydrothermal Ore Deposits, John Wiley.

Klemm, D.D. and Schneider, H.J. (1977) Time and Strata Bound Ore Deposits. Springer Verlag.

Guilbert, J.M. and Park, Jr. C.F. (1986) The Geology of Ore Deposits. Freeman.

Mookherjee, A. (2000) Ore Genesis – A Holistic Approach. Allied Publisher.

Wolf, K.H. (1976-1981) Hand Book of Stratabouond and Stratiform Ore Deposits. Elsevier.

Ramdohr, P. (1969) The Ore Minerals and their Intergrowths. Pergamon Press.

SEMESTER III

Course No. GLMC-301: Fuel Geology

Theory

Coal Geology

Definition and origin of coal. Sedimentology of coal bearing strata, types of seam discontinuities and structures associated with coal seams. Chemical analysis of coal (proximate and ultimate analysis).

Coal Petrology – concept of 'Lithotype', 'Maceral' and 'Microlithotype'. Classification and optical properties of macerals and microlithotypes. Techniques and methods of coal microscopy. Elementary knowledge of the application of reflectance and fluorescence microscopy. Application of coal petrology. Classification of coal in terms of Rank, Grade and Type. Indian classification for coking and non-coking coals. International classifications (I.S.O. and Alpern's classification). Elementary Idea about coal preparation, coal carbonization, coal gasification, coal hydrogenation, coal combustion and fertilizer form coal. Coal as a source rock in petroleum generation.

Coalbed methane – a new energy resource. Elementary idea about generation of methane in coal beds, coal as a reservoir and coalbed methane exploration.

Geological and geographical distribution of coal and lignite deposits in India. Coal exploration and estimation of coal reserves. Indian coal reserves and production of coal in India.

Petroleum Geology

Petroleum – its composition. Origin (Formation of source rocks-kerogen, organic maturation and thermal cracking of kerogen) and migration of petroleum. Reservoir rocks-porosity and permeability. Reservoir traps – structural, stratigraphic and combination traps. Oilfield fluids – water, oil and gas. Methods of prospecting for oil and gas (geological modeling). Elementary knowledge of drilling and logging procedures. Oil shale. An outline of oil belts of the world. Onshore and offshore petroliferous basins of India. Geology of productive oilfields of India.

Atomic Fuel

Concept of atomic energy. Mode of occurrence and association of atomic minerals in nature. Methods of exploration for atomic minerals. Productive geological horizons of atomic minerals in India.

Practicals

Macroscopic characterization of banded coals. Completion of outcrop in the given maps and calculation of coal reserve. Preparation of polished particulate mounts of coal. Microscopic examination of polished particulate mounts (identification of macerals). Proximate analysis of coal.

Macroscopic and microscopic study of cores and well cuttings. Study of geological maps and sections of important oilfields of India. Calculation of oil reserves.

Study of uranium and thorium bearing geological sections of the country. Macroscopic examination of some uranium and thorium bearing minerals and rocks.

Books Recommended

Taylor,G.H., Teichmuller, M., Davis, A., Diesel, C.F.K., Little, R. and Robert P., 1998: Organic Petrology, Gebruder Borntraeger, Stuttgart.

Chandra, D., Singh, R.M. Singh, M.P., 2000: Textbook of Coal (Indian context). Tara Book Agency, Varanasi.

Singh, M.P. (Ed.) 1998: Coal and organic Petrology. Hindustan Publishing Corporation, New Delhi.

Scott, A.C., 1987: Coal and Coal-bearing strata: Recent Advances. The geological Society of London, Publication no. 32, Blackwell scientific Publications.

Stach, E., Mackowsky, M-Th., Taylor, G.H., Chandra, D., Teichumullelr, M. and Teichmuller R., 1982: Stach Textbook of Coal petrology. Gebruder Borntraeger, Stuttgart.

Holson, G.D. and Tiratso, E.N., 1985: Introduction to Petroleum Geology. Gulf Publishing, Houston, Texas.

Tissot, B.P. and Welte, D.H., 1984: Petroleum Formation and Occurrence, Springer – Veralg.

North, F.K., 1985: Petroleum Geology. Allen Unwin.

Selley, R.C., 1998: Elements of Petroleum Geology. Academic Press.

Durrance, E.M. 1986: Radioactivity in Geology-principles and application. Ellis Hoorwool.

Dahlkamp, F.J., 1993: Uranium Ore Deposits. Springer Verlag.

Boyle, R.W., 1982: Geochemical prospecting for Thorium and Uranium deposits, Elsevier.

Course No. GLMC – 302: GEOLOGICAL FIELD TRAINING

2-3 weeks of geological field work in some appropriate areas of economic mineral deposits and visit to various laboratories of repute. Submission of report thereon.

Course No. GLMMA-303: Hydrogeology

Theory

Estimation and methods of water treatment for various uses; Problem of Arsenic and fluoride and remedial measures for their treatment. Quality Problems in India.

Water level fluctuations: Causative factors and their measurements. Artificial recharge of water: Recharging by surface water and rain water harvesting. Consumptive and conjunctive use of surface and ground water, problem of overexploitation, ground water legislation.

Water Well Technology: Well types, drilling methods, construction design, development and maintenance of wells. Water management in rural and urban areas.

Coastal water and its management. Arid zone Ground water, Ground water in hard rocks and non-indurated sediments – their management. Ground water exploration.

Practicals

Delineations of hydrological boundaries on water table contour maps and estimation of aquifer properties as hydraulic conductivity. Storage coefficient and Transmissivity. Analysis of hydrographs for various components. Chemical and Physical analysis of water and presentation of data for uses in Irrigation. Drinking and Industry. Evaluation of Pumping Tests data for Aquifer parameters. Interpretation of Geophysical data for fresh and Saline Ground water.

Books Recommended

Todd, D.K. (1988): Ground Water Hydrology, John Wiley & Sons, New York.

Davies, S.N. and Dc-West, R.J.N. (1966): Hydrogeology, John Willey & Sons, New York.

Ground Water and Wells (1977): UOP, Johnson, Div. St. Paul. Min. USA

Raghunath, H.M. (1983): Ground Water, Wiley Eastern Ltd., Calcutta

Driscoll, F.G.(1988): Ground Water and Wells, UOP, Johnson Div. St. Paul. Min. USA

Course No. GLMMA-304: Environmental Geology and Natural Hazards

Theory

Time scales of global changes in the ecosystems and climate. Impact of circulations in atmosphere and oceans on climate, rainfall and agriculture.

Carbon di-oxide in atmosphere, limestone deposits in the geological sequences, records of palaeotemperatures in ice cores of glaciers. Global warming caused by CO_2 increase in present atmosphere due to indiscrete exploitation of fossil fuels, volcanic eruptions and deforestation.

Cenozoic climate extremes, evolution of life, especially the impact on human evolution.

Impact assessment of degradation and contamination of surface water and ground water quality due to industrialization and urbanization. Water logging problems due to the indiscrete construction of canals, reservoirs and dams. Soil profiles and soil quality degradation due to irrigation, use of fertilizers and pesticides.

Influence of neotectonics in seismic hazard assessment. Preparation of seismic hazards maps. Distribution, magnitude and intensity of earthquakes. Landslide hazards: causes and investigations; floods, their causes and control.

Practicals

Study of seismic and flood-prone areas in India. Analyses for alkalinity, acidity, pH and conductivity (electrical) in water samples. Classification of ground water for use in drinking, irrigation and industrial purposes. Presentation of chemical analyses data and plotting chemical classification diagram. Evaluation of environmental impact of air pollution groundwater, landslides, deforestation, cultivation and building construction in specified areas.

Books Recommended

Valdiya, K.S. (1987) Environmental Geology – Indian Context. Tata McGraw Hill.

Keller, E.A. (1978) Environmental Geology, Bell and Howell, USA.

Bryant, E. (1985) Natural Hazards, Cambridge University Press.

Patwardhan, A.M. (1999) The Dynamic Earth System. Prentice Hall.

Subramaniam, V. (2001) Textbook in Environmental Science, Narosa International.

Bell, F.G. (1999) Geological Hazards, Routledge, London.

Smith, K. (1992) Environmental Hazards. Routledge, London.

Course No. GLMMA-305: Remote Sensing and GIS in Geology

Theory

Fundamental Principles

Electromagnetic Radiation – Characteristics and Remote Sensing Regions and bands; Aerial photos – types, scale, resolution; properties of aerial photos, stereoscopic parallax, Relief displacement; General Orbital characteristics of remote sensing satellites; General sensor characteristics of remote sensing satellites; Spectra of common natural objects – soil, rock, water and vegetation.

Data Processing and Interpretation (Digital Image Processing – DIP)

Characteristics of remote sensing data; preprocessing; Enhancements, Classification, Elements of photo and imagery pattern and interpretation – drainage, erosion, details, gray tones.

Application in Geology

Remote sensing applications in structure and tectonics; Systematic mapping, Mineral resources, Groundwater potentials, Environmental monitoring and mapping.

Remote Sensing and GIS

Principles and components of GIS

Remote sensing data integration with GIS; Applications of GIS in various geological aspects.

Practicals

1. Determination of scale in aerial photos.
2. Measurement of heights of objects from aerial photos
3. Study and interpretation of single and stereopair aerial photos; Preparation of interpretation keys.
4. Thematic mapping from aerial photos – structure, lithology, minerals, soils, groundwater, landforms.
5. Thematic mapping from satellite imagery/data – structure, lithology, minerals soils, groundwater, landforms.

Books Recommended

Drury, S.A. (1987) Image Interpretation in Geology. Allen and Unwin

Lillesand, T.M. and Kiefer, R.W. (1987) Remote Sensing and Image Interpretation. John Wiley.

Siegal, B.S. and Gillespie, A.R. (1980) Remote Sensing in Geology. John Wiley

Course No. GLMMA-306: Engineering Geology and Surveying

Theory

Engineering Geology

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

Geological considering for evaluation of dams and reservoir sites. Dam foundation, Rock problems, Geotechnical evaluations of tunnel alignments and transportation routes. Methods of tunneling; Classification of ground for tunneling purposes; Various types of support.

Mass Movements with special emphasis on landslide and causes of hill slope instability. Aseismic designs of buildings; influence of geological condition on foundation and design of buildings.

Surveying

Its uses and importance in geology. Common methods of surveying: Chain-Surveying; Prismatic Compass, Plane Table, Leveling and Theodolite Surveying.

Practicals

Engineering Geology

Study of properties of common rocks with reference to their utility in engineering projects. Study of maps and models of important engineering structures, dam sites and tunnels. Interpretation of geological maps for landslide problems.

Surveying

Surveying Instruments, viz. Chain, Prismatic Compass, Plane Table, Dumpy Level, Theodolite: Their uses and precautions in handling. Survey of a plot of land by means of Common Methods of Surveying.

Books Recommended

Krynine, D.H. & Judd, W.R. (1998) Principles of Engineering Geology, CBS Edition.

Schultz, J.R. & Cleaves, A.B. (1951) Geology in Engineering, John Willey & Sons, New York.

Roy Chowdhary, K.P. (1987): Surveying (Plane and Geodetic) Oxford & IBH Pub. Co., New Delhi.

Shahani, P.B.(1978): Text Book of Surveying, vol.I. Oxford & IBH Pub. Co., New Delhi.

Course No. GLMMI-307: Mineral Exploration & Mineral Economics

Theory

Mineral Exploration

Classification of mineral deposits for exploration. Host rocks of mineral deposits. Remote sensing in mineral exploration. Geological exploration: Geological criteria and guides for exploration of mineral deposits. Gossan and capping.

Geochemical exploration: mobility and geochemical associations of elements. Primary and secondary geochemical dispersion patterns. Geochemical prospecting methods. Geobotanical and Geophysical exploration methods. Use of geostatistical techniques for exploration of mineral deposits.

Samples and sampling methods. Drilling, its methods and advantages. Ore reserves, methods of ore reserves calculations

Geological modeling for mineral exploration.

Mineral Economics

Mineral economics and its concepts. Peculiarities inherent in mineral industry. Tenor, grade and specification. Strategic, critical and essential minerals. Conservation and substitution. Changing pattern of mineral requirement. National mineral policy. Indian mineral policy and legislation. Importance of minerals in national economy.

Practicals

Preparation of mineral maps of India, Graphical representation of production, export and import of important minerals. Calculation of grade and ore reserves. Interpretation of remote sensing data for mineral exploration.

Books Recommended

P.K. Banerjee and S Ghosh (1997): Elements of prospecting for non-fuel mineral deposits.

Bagchi, T.C., Sengupta, D.K., Rao, S.V.L.N. (1979): Elements of Prospecting and Exploration.

Sinha, R.K. and Sharma, N.L. (1976) Mineral Economics.

Arogyaswami, R.P.N. (1996) Courses in Mining Geology.

Course No. GLMMI-308: Gemology

Gem and Gemstones. General characteristics and chemical composition of gemstones: Physical characteristics: Form, cleavage, fracture, hardness and specific gravity; Optical characteristics: colour, luster, play of colour, refractive index, reflectivity, pleochroism, dispersion.

Application of ultraviolet rays, X-rays and Infra-red rays in gem identification.

Electrical thermal and magnetic characters of gem. Classification of gem stones.

Systematic description, genesis, mode of occurrence, distribution in India and also important world occurrences of important precious and semi-precious stones.

Synthetic gem stones: methods of synthesis, and its characteristics and identification. Gem enhancement methods and their identification: colourless/coloured impregnation, heat treatment, coating, irradiation, diffusion, treatment, etc.

Application of gemstones: (1) Technical application and (2) Application as jewels

Practicals

1. Identification of important minerals and their gem varieties in hand specimens.
2. Study of optical properties of important minerals and their gem varieties.
3. Study of faults in gemstones.
4. Identification of synthetic gemstones.

Books Recommended

Max Bauer (1968) Precious stones, Vol. I and II

Bruton Eric F.G.A. (1970) Diamonds

Orlov Yu L (1973) The Mineralogy of the Diamond

Wilson, M. (1967) Gems

Brocardo, G. (1981) Minerals and Gemstones – An identification Guide.

Course No. GLMMI-309: Palaeobotany

Theory

Introduction and approaches to Palaeobotany. Preservation and kinds of fossil plants. Occurrence of plant fossils, their collection and preparation.

Techniques of palaeobotanical studies. Difficulties of identification. Concept of genera and species, 'Form' genera. Nature of palaeobotanical record. Palynology and its applications.

Classification of fossil plants and broad characters of major plant groups.

Brief morphology of different plant parts. Taxonomy, systematic position and distribution of common representative Indian plant genera as per list given below:

Lycopodiales – *Lycopodites*; **Lepidodendrales** – *Lepidodendron, Sigillaria, Stigmaria*. **Equisetales** – *Equisetites, Phyllotheca, Schizoneura, Dicroideum*. **Calamitales** – *Calamites*, *Annularia*. **Sphenophyllales** – *Sphenophyllum*. **Filicales** – *Cladophlebis*, *Gleichenites*, *Matonidium*. **Pteridospermae** – *Glossopteris*, *Gangamopteris*, *Vertebraria*, *Taeniopteris*, *Weichselia*, *Sphenopteris*, *Neuropteris*, *Cyclopteris*, *Alethopteris*, *Pecopteris*, *Thinnfeldia*, *Rhacopteris*. **Cycadales** – *Nilssonia*, *Bucklandia*. **Bennettitales** – *Williamsonia*, *Ptilophyllum*, *Otozamites*, *Dictyozamites*, *Pterophyllum*. **Ginkgoales** – *Ginkgoites*. **Cordaitales** – *Neoggerathiopsis*, *Dadoxylon*. **Coniferales** – *Brachyphyllum*, *Pagiophyllum*, *Pdozamites*, **Elatocladus** and **Angiosperm** general Palmyxylon and Betula.

Distribution and composition of pre-Gondwana, Gondwana, Inter-trappean and Tertiary Floras of India with observations on their origin, and relationship with other contemporaneous fossil floras of the world.

Evolution of Flowering plants. Dendrochronology. Applications of Palaeobotany with particular reference to stratigraphic correlation and palaeoclimates.

Practicals

Study and identification of the important fossils plants as detailed in theory syllabus.

Books Recommended

Arnold, C.A. (1947) An introduction to Palaeobotary, McGraw Hill.

Andrews Jr., H.N. Studies in Palaeobotony. Wiley, New York.

Seaward, A.C. (1991) Plant fossils, Today's & Tomorrow, New Delhi.

Chester, R.A. (1987). An introduction to Palaeobotony, Tata McGraw Hill.

SEMESTER IV

Course No.GLMMI-401: Elements of Mining and Ore Dressing

Theory

Elements of Mining

Classification of mining methods. Mining Methods: Placer mining methods, open pit methods, Underground mining methods, Coal Mining methods and Ocean bottom mining methods; their advantages and disadvantages.

Ventilation in underground mining: Purpose, types and arrangements of ventilation in underground mining.

Mining hazards and safety measures.

Ore Dressing

Ore dressing and its importance, low grade ores and their beneficiation; Ore-microscopy and its contribution to ore-dressing techniques. Aggregate properties of minerals and rocks and their consideration in ore dressing techniques. Basic ore dressing operations viz. crushing, grinding, sizing, screening and classification. Concentration process. Magnetic and electrostatic separation, gravity concentration, Froth Floatation, Amalgamation and Agglomeration.

Dressing of Indian Metallic and non-metallic ores: Sulphide ores, non-sulphide ores, native metals, coal washing and Beneficiation of Beach Sand.

Practicals

Elements of Mining

Study of various methods of metal and local mining and their diagrammatic representation. Exercises on mine sampling and determination of tenor, cut-off grades, ore reserves, etc.

Ore Dressing

Study of flow sheets of important metallic and non-metallic ores and minerals with particular reference to Indian Ores and Minerals.

Books Recommended

Elements of Mining

McKinstry, H.E. Mining Geology, Prentice Hall, Englewood Clifts, N.J.

Clark, G.B. (1967) Elements of Mining, III ed. John Wiley.

Arogyaswami, R.P.N. (1996) Courses in Mining Geology, IV Ed. Oxford IBH.

Ore Dressing

Gaudin, A.M. Principles of Mineral Dressing. McGraw Hill Pub. Co. Ltd. Bombay.

Course No. GLMMI 402: Soil Geology

Theory

Process of Soil Formation

Concept of soil, components of soil, soil profile, pedogenic processes.

Classification of soil

Mineral stability of weathering.

Soil organic matter form and function.

Fabric Analysis

Size and shape: Concepts of size and shape, grade scale, methods of analysis, presentation of data, analysis and field grading.

Concepts of structure and fabric: Soil fabric, soil structure, soil texture and field grading units.

Peds and pedalilty: Size and shape of peds, pedality, primary, secondary and tertiary structures, interpretation.

Voids: Concepts, size, shape, arrangement and morphological classification.

Paleosols

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

Calcrete

Definition, classification, calcrete formation, pedogenic calcrete soil profile, macro features in calcretes, micromorphology (petrography), calcretes from Quaternary and ancient sedimentary sequences, significance of calcretes.

Laterite

Field and microscopic characters, genesis, Indian occurrences.

Practicals

1. Study of soils and soil profiles of various regions.
2. Grain size analysis
3. Paleosols of different stratigraphic horizons
4. Microscopic characters of calcretes and preparation of calcrete profiles (Pedogenic models)
5. Megascopic and microscopic characteristics of laterite.

Books Recommended

Govinda Rajan, S.V. & Gopala Rao, K.H.G.: Studies of Soils of India.

Terzaghi, K. & Pock, R.G.: Soil Mechanics in Engineering

Jeffe, J.S.: The A.B.C. of soils

Tayler, D.W.: Fundamentals of Soil Mechanics

Hunt,C.B.: Geology of Soils

Graddy, N.C.: Nature and properties of soils.

Gerrard, A.J.J. : Soil and Land forms

Wright;, V. Paul (Editor): Paleosols: their recognition and interpretation, Blackwell Scientific Publication.

Wright;, V. Paul and Tucker, M.E. (1991) Calcretes. Blackwell Scientific Publication.

GLMMI-403: Petroleum Exploration

Theory

Identification and characterization (Petrographic and geochemical) of petroleum source rocks. Amount, type and maturation of organic matter. Oil and source rock correlation. Locating petroleum prospects based on principles of petroleum generation and migration (geological modeling). Quantitative evaluation of oil and gas prospects through geochemical modeling. Reconstruction of paleogeothermal gradient. Migration modeling. Inputs for the assessment of accumulation of petroleum.

Elementary knowledge of geophysical methods of exploration: Magnetic, Gravity and Seismic methods. Elementary knowledge of well drilling: cable-tool drilling, rotary drilling and various types of drilling units Elementary knowledge of Logging: Electric, Radioactive and Sonic logs. Application of logs in petrophysical analysis and facies analysis.

Practicals

Megascopic and microscopic study of cores. Preparation of geological maps and sections, and derivation of geological history in relation to petroleum prospects. Calculation of oil reserves. Exercise on maturation studies. Petrographic characterization of petroleum source rocks. Preparation of SP and Resistivity logs for hydrocarbon reservoirs.

Books Recommended

Holson, G.D. and Tiratso, E.N. (1985) Introduction of Petroleum Geology. Gulf Publishing, Houston, Texas

Tissot, B.P. and Welte, D.H. (1984) Petroleum Formation and Occurrence. Springer – Verlag

North, F.K. (1985) Petroleum Geology. Allen Unwin.

Selley, R.C. (1998) Elements of Petroleum Geology. Academic Press.

Hunt, J.M. (1996) Petroleum Geochemistry and Geology, 2nd Edition Freeman, San Francisco.

John, F., Cook, M. and Graham, M.(1998) Hydrocarbon exploration and production. Elsevier

Barker, C. (1996) Thermal Modeling of Petroleum Generation, Elsevier.

Course No. GLMMI-404: Vertebrate Palaeontology

General characteristics of vertebrae. Vertebrate skeleton: Teeth and their modifications. Kinds of vertebrate fossils, nature of their record. Collection and preparation of vertebrate fossil remains.

Main classificatory characters and divisions of the vertebrates. An outline classification of Agnathans, Pisces, Amphibia, Reptilia, Aves and Mammalia.

Origin of vertebrate animals. Vertebrate life through ages, and Landmarks in Evolution.

General Account of the Gondwana Vertebrates, and Siwalik Mammals and the possible causes of their extinction. Dinosaurs and their extinction.

Evolutionary trends in Equidae, Proboscidae and Hominidae. Factors of Human Evolution: Evolution of Man, Tool culture.

Study of some important genera of Fossil vertebrate with particular reference to Indian Subcontinent.

Practicals

Study of fossil teeth and vertebrate. Study of models showing evolution of man, horse, etc. Study of skulls and limbs of some fossil genera. Study of some models of extinct vertebrate animals.

Books Recommended

Romer, A.S. (1966) Vertebrate Palaeontology (3rd Edn.) Chicago University Press

Olson, E.G. (1971) Vertebrate Palaeozoology, Wiley, New York

Benton, M.J. (1990) Vertebrate Palaeontology. Unwin Hyman, London

Swinnerton, H.H. (1950) An outline of palaeontology.

Colbert, E.H. (1984) Evolution of the Vertebrates. Willey Eastern Ltd.

Course No. GLMMA-405: Project Oriented Dissertation

It is one of the major elective courses and compulsory to each student.