NAGALAND UNIVERSITY
DEPARTMENT OF GEOLOGY
KOHIMA CAMPUS, MERIEMA

M.Sc. Geology Syllabus (2017)

The Post-Graduate program in Geology leading to M.Sc. degree of the University will be of two years duration covered in four semesters. This comprises nineteen compulsory courses including one choice-based dissertation through lectures, tutorials and supervision. All courses are compulsory, each comprising one theory paper of 4 credits (80 marks). Two theory papers are combined to one practical paper each of 4 credits (80 marks). Students are to undertake one project work (dissertation) for 5 credits (100 marks). There shall be two compulsory geological fieldwork/training programs of up to 3 weeks duration each, during the 1st and 3rd semester. Results of those students who do not attend geological fieldwork/training will remain withheld. The course will culminate with all students facing a Grand Viva.

The project work will be allotted during the 1st semester. A dissertation based on the project work should be submitted at the end of the 4th semester. Students are to clear all courses for award of M.Sc. degree in Geology.

Students will be evaluated by continuous assessment, i.e., sessional work (internal assessment tests) comprising 25 percent of credit value. For the purpose three tests per paper (theory and practical) for each course will be conducted. A student must appear and qualify all tests and attend at least 75% classes in individual papers, failing which he/she will not be eligible to be admitted to the Semester End Examinations.

Admission to the course and performance in sessional work and semester examinations will be governed by the Rules and Regulations of the Ordinances of the Nagaland University, in force from time to time.

M.Sc. Geology Syllabus, 2017

Semester-wise Course Distribution

Semester	Course No.	Course Title	Max. Marks	Credit
I	GL-101	Geomorphology and Remote Sensing	80	4
	GL-102	Structural Geology and Geodynamics	80	4
	GL-103	Palaeontology	80	4
	GL-104	Mineralogy	80	4
	GL-105	Practical on GL-101 and GL-102	80	4
	GL-106	Practical on GL-103 and GL-104	80	4
	GL-107	Geological Fieldwork/Training of 3 Weeks	60	3
	Total		**540**	**27**
II	GL-201	Igneous Petrology	80	4
	GL-202	Metamorphic Petrology	80	4
	GL-203	Sedimentology	80	4
	GL-204	Ore Geology	80	4
	GL-205	Practical on GL-201 and GL-202	80	4
	GL-206	Practical on GL-203 and GL-204	80	4
	Total		**480**	**24**
III	GL-301	Hydrogeology	80	4
	GL-302	Geochemistry	80	4
	GL-303	Fuel Geology	80	4
	GL-304	Stratigraphy	80	4
	GL-305	Practical on GL-301 and GL-302	80	4
	GL-306	Practical on GL-303 and GL-304	80	4
	GL-307	Geological Fieldwork/Training of 3 Weeks	60	3
	Total		**540**	**27**
IV	GL-401	Environmental and Engineering Geology	80	4
	GL-402	Mineral Exploration and Mining Geology	80	4
	GL-403	Marine and Quaternary Geology	80	4
	GL-404	Practical on GL-401 and GL-402	60	3
	GL-405	Dissertation (Elective) i) Structural Geology & Geodynamics ii) Igneous Petrology iii) Sedimentology iv) Economic Geology v) Engineering Geology vi) Hydrogeology vii) Environmental Geology	100	5
	GL-406	Grand Viva	40	2
	Total		**440**	**22**
	GRAND TOTAL		**2000**	**100**

- All Courses are Compulsory

Course No. : GL-101
Course Title : Geomorphology and Remote Sensing
Credit : 4 (Contact Hours - 48)

UNIT - I

Concepts and perception of geomorphology. Landscape development: Davisian model, its merits and demerits; Penck's and King's models. Denudational processes: weathering, erosion and transportation. Weathering products and soils: profiles, types and duricrusts; Geomorphological mapping based on genesis of landforms. Geomorphic indicators of neotectonic movements: stream channel morphology changes, drainage modifications, fault reactivation, uplift-subsidence patterns in coastal areas. Geomorphology of India: features and zones.

UNIT - II

Geomorphic processes and landforms: fluvial, glacial, eolian and karst. River and drainage basin: drainage pattern, morphometric analysis, Geomorphology of shorelines and ocean floors. Hill slopes: their characteristics and development. Applied geomorphology: mineral prospecting, hydrogeology, civil engineering and environmental studies.

UNIT - III

Principles of remote sensing: energy sources and radiation, atmospheric absorption, interaction of energy with earth's surface. Electromagnetic spectrum: characteristics, optical region, infra-red, thermal infra-red and microwave regions and spectral bands. Spectra of common natural objects: soil, rock, water and vegetation. General orbital and sensor characteristics of remote sensing satellites. Space research in India: Bhaskara and IRS systems and their applications. Landsat, Seasat, Modis Terra and other important foreign satellite systems. Introduction to Lidar and Radar remote sensing.

UNIT - IV

Principles and applications of photogrammetry. Elements of photo and image interpretation. Digital image processing: characteristics of remote sensing data, pre-processing, enhancements and classification. Remote sensing applications in interpreting structure and tectonics, lithological mapping, mineral resources, natural hazards and groundwater potential. Principles and components of Geographic Information System. Global positioning systems.

Books Recommended

- Agarwal, C.S. and Garg, P.K. 2000: Text book on Remote Sensing in Natural Resources Monitoring and Management. Wheeler Publishing.
- Bloom, A.L. 2003: Geomorphology - A Systematic Analysis of Late Cenozoic Landforms. Pearson Education, New Delhi.
- Chorley, R.J., Schumm, S.A. and Sugden, D.E. (Eds) 1985: Geomorphology. Methuen.
- Drury, S.A. 1987: Image Interpretation in Geology. Allen & Unwin.
- Duda, R.O. and. Hart. P.E. 1973: Pattern Classification and Scene Analysis. Wiley & Sons.
- Gupta, R.P. 1990: Remote Sensing Geology. Springer Verlag.
- Heywood, I., Cornelius, S. and Carver, S. 1998: An Introduction to GIS. Longman.

- Jensen, J.R. 1986: Introductory Digital Image Processing - A Remote Sensing Perspective. Prentice Hall.
- Joseph, G. 2011: Fundamentals of Remote Sensing. Cambridge University Press.
- Kale, V.S. and Gupta, A. 2001: Introduction to Geomorphology. Orient Longman.
- Lillesand, T.M. 2000: Remote Sensing and Image Interpretation. John Wiley.
- Lillesand, T.M. and Kiefer, R.W. 1987: Remote Sensing and Image Interpretation. John Wiley.
- Miller, V.C. and Miller, C.F. 1961: Photogeology. McGraw Hill.
- Moffitt, F.H. and Mikhail, E.M. 1980: Photogrammetry. Harper & Row.
- Naqi, M., 2005: Encyclopaedia of Geomorphology (vol. 1). Anmol Publications, New Delhi.
- Paine, D.P. 1981: Aerial Photography and Image Interpretation for Resource Management. John Wiley.
- Pandey, S.N. 1987: Principles and Applications of Photogeology. Wiley Eastern.
- Rampal, K.K. 1999: Handbook of Aerial Photography and Interpretation. Concept Publishing Co., New Delhi.
- Ray, R.G. 1969: Aerial Photographs in Geologic Interpretations. USGS Prof. Paper.
- Rees, W.G. 1990: Physical Principles of Remote Sensing. Cambridge University Press.
- Richards, J.A. and Xiuping, J. 1998: Remote Sensing Digital Image Analysis: An Introduction. Springer Verlag.
- Sabbins, F.F. 1985: Remote Sensing - Principles and Applications. Freeman.
- Schowengerdt, R.A. 1983: Techniques for Image Processing and Classification in Remote Sensing. Academic Press.
- Siegal, B.S. and Gillespie, A.R. 1980: Remote Sensing in Geology. John Wiley.
- Summerfield, M.A. (Ed) 1999: Geomorphology and Global Tectonics. John Wiley.
- Thorn, C.E. 1998: Introduction to Theoretical Geomorphology. Unwin Hyman.
- Thornbury, W.D. 1996: Principles of Geomorphology. John Wiley.

Course No. : GL-102
Course Title : Structural Geology and Geodynamics
Credit : 4 (Contact Hours - 48)

UNIT - I

Concept of stress and strain; behaviour of rocks under stress. Mohr's stress circle: various states of stress and their representation by Mohr circles. Types of strain ellipses and ellipsoids, their properties and geological significance. Measurement of strain in naturally deformed rocks. Mechanical principles and properties of rocks and their controlling factors. Theory of rock failure.

UNIT - II

Fold and folding: concept and geometric classification. Mechanics of folding. Fractures and joints: their nomenclature, age relationship, origin and significance. Causes and dynamics of faulting. Concept of petrofabrics: planar and linear fabrics in deformed rocks, their origin and significance. Significance and limitations of π and β diagrams. Shear zones: brittle and ductile shear zones, geometry and products of shear zones. Mylonites and cataclasites: their origin and significance.

UNIT - III

Physico-chemical and seismic properties of the Earth's interior. Continental drift: geological and geophysical evidences and objections. Plate tectonics and important associated geological features: oceanic trenches, volcanic arcs, accretionary wedges, mid-ocean ridge topography, magnetic anomaly stripes and transform faults. Mechanism of plate tectonics. Concept of super continents, their assembly and breakup.

UNIT - IV

Gravity anomalies at mid-ocean ridges, deep sea trenches, continental shield areas and mountain chains. Palaeomagnetism and its application for determining palaeoposition of continents. Isostasy, orogeny and epeirogeny. Seismicity at plate boundaries. Origin of Himalayas. Tectonic model of Indo-Myanmar ophiolite belt.

Books Recommended

- Badgley, P.C. 1965: Structure and Tectonics. Harper & Row.
- Bailey, B. 1992: Mechanics in Structural Geology. Springer Verlag.
- Condie, K.C. 1982: Plate Tectonics and Crustal Evolution (2nd ed). Pergammon Press.
- Davis, G.H. 1984: Structural Geology of Rocks and Regions. John Wiley.
- Fossen, H. 2010: Structural Geology. Cambridge University Press.
- Ghosh, S.K. 1995: Structural Geology - Fundamentals of Modern Developments. Pergammon Press.
- Hobbs, B.E., Means, W.D. and Williams, P.F. 1976: An Outline of Structural Geology. John Wiley.
- Keary, P., Klepeis, K.A and Vine, F.J. 2009: Global Tectonics (3rd ed). Blackwell.
- Keary, P. and Vine, F.J. 1990: Global Tectonics. Blackwell.
- Moores, E. and Twiss, R.J. 1995: Tectonics. Freeman.
- Passchier, C.W. and Trouw, R.A.J. 2005: Microtectonics (2nd ed). Springer Verlag.
- Pluijm, B.A. van der and Marshak, S. 1997: Earth Structure: An Introduction to Structural Geology and Tectonics. McGraw Hill.
- Price, N.J. and Cosgrove, J.W. 1990: Analysis of Geological Structures. Cambridge University Press.

- Ramsay, J.G. 1967: Folding and Fracturing of Rocks. McGraw Hill.
- Ramsay, J.G. and Huber, M.I. 1987: Modern Structural Geology (vol. 1 & 2). Academic Press.
- Storetvedt, K.N. 1997: Our Evolving Planet: Earth's History in New Perspective. Bergen (Norway), Alma Mater Fortag.
- Summerfields, M.A. 2000: Geomorphology and Global Tectonics. Springer Verlag.
- Suppe, J. 1985: Principles of Structural Geology. Prentice Hall.
- Twiss, R.J and Moores, E.M. 2007: Structural Geology (2^{nd} ed). Freeman.
- Valdiya, K.S. 1998: Dynamic Himalaya. University Press, Hyderabad.

Course No. : GL-103
Course Title : Palaeontology
Credit : 4 (Contact Hours - 48)

UNIT - I

Modern taxonomy: species concept, biometrics and phylogenetic analysis. Mechanisms of evolution; micro-evolution, trans-specific evolution, radiation and speciation. Migration and dispersal. Origin of life; limiting environmental factors. Major events in the history of Precambrian and Phanerozoic life. Mass extinction events.

UNIT - II

Morphology, classification and distribution of gastropods, echinoderms, bryozoa and cnidarian (corals). Evolutionary trends of ammonoids and trilobites. Functional morphology of bivalves and brachiopods. Introduction to ichnofossils.

UNIT - III

Palaeontological perspective: basic idea about statistical application in palaeontology. Use of palaeontological data in stratigraphy, palaeoecology, taphonomy and evolution. Palaeo-biogeographic provinces. Stable isotopes and palaeoclimates. Plant fossils: Gondwana flora and their significance.

UNIT - IV

Vertebrate palaeontology: classification and significance of vertebrate fossils. Brief study of vertebrate life through ages. Evolution of reptiles and mammals. Siwalik vertebrate fauna. Micropalaeontology: classification and significance of microfossils. Applications of palynology.

Books Recommended

- Clarkson, E.N.K. 1998: Invertebrate Palaeontology and Evolution. Blackwell.
- Prothero, D.R. 1998: Bringing Fossils to Life - An Introduction to Palaeobiology. McGraw Hill.
- Smith, A.B. 1994: Systematics and the Fossil Record - Documenting Evolutionary Patterns. Blackwell.
- Stearn, C.W. and Carroll, R.L. 1989: Palaeontology - The Record of Life. John Wiley.

Course No. : GL-104
Course Title : Mineralogy
Credit : 4 (Contact Hours - 48)

UNIT - I

Chemical bonding in minerals, ionic radius ratio and coordination number. Solid solution and exsolution. Polymorphism, polytypism, isomorphism and pseudomorphism. Defects in minerals. Structural classification of silicates. Chemical composition, crystal structure, mineral chemistry and paragenesis of olivine group, garnet group, aluminosilicate (Al_2SiO_5) group, epidote group, beryl and pyroxene group.

UNIT - II

Chemical composition, crystal structure, mineral chemistry and paragenesis of amphibole group, mica group, feldspar group, cordierite, quartz and diamond. Chemical composition and paragenesis of accessory minerals: apatite, tourmaline, calcite, dolomite, corundum, scapolite, sphene and zircon. Average mineralogical composition of the crust and mantle; mineral transformations in the mantle with depth. Gems and semi-precious minerals.

UNIT - III

Concept of symmetry. Space lattice and internal symmetry of crystals: 14 Bravais lattices, point group and space groups. Twinning and twin laws - common types of twins and their examples in minerals. Optical crystallography of uniaxial and biaxial minerals: birefringence, indicatrix, pleochroic scheme, interference figures, 2V and 2E and dispersion in minerals.

UNIT - IV

Determination of optic sign. Accessory plates and sign of elongation: length fast and length slow vibrations. Basic principles and geological applications of X-ray diffractometry, thermoluminescence, atomic absorption spectrophotometry, inductively coupled plasma - atomic emission spectrometry, X-ray fluorescence spectrometry, scanning and transmission electron microscopy and electron-probe microanalysis.

Books Recommended

- Deer, W.A., Howie, R.A. and Zussman, J. 1996: The Rock Forming Minerals. Longman.
- Hutchinson, C.S. 1974: Laboratory Handbook of Petrographic Techniques. John Wiley.
- Klein, C. and Hurlbut, C.S. (Jr) 1993: Manual of Mineralogy. John Wiley.
- Phillips, W.R. and Griffin, D.T. 1986: Optical Mineralogy. CBS Publishers.
- Putnis, A. 1992: Introduction to Mineral Sciences. Cambridge University Press.
- Spear, F.S. 1993: Mineralogical Phase Equilibria and Pressure-Temperature-Time Paths. Mineralogical Society of America Publications.

Course No. : GL-105
Course Title : Practical on GL-101 and GL-102
Credit : 4 (Contact Hours - 48)

Drainage patterns and analysis. Study of nature of aerial photographs: resolution, mosaic and image parallax. Determination of scale, height, dip, slope, vertical exaggeration and image distortion. Identification of features on single vertical aerial photographs and satellite imagery. Interpretation of cultural details and preparation of land use map using satellite imagery. Exercises on MSS, TM, FCC, IR, Thermal IR, Radar and SPOT images for geological and geomorphological mapping and vegetation, water and mineral resource evaluation. Preparation of false color composites and study of multi-spectral scans and spectral patterns. Image rectification and registration. Exercises on digital image processing. GPS demonstration in the field.

Preparation and interpretation of geological maps and sections. Study of map projections. Structural problems concerning economic mineral deposits. Recording and plotting of field data. Plotting and interpretation of petrofabric data and resultant diagrams. Study of large scale tectonic features of the earth.

Course No. : GL-106
Course Title : Practical on GL-103 and GL-104
Credit : 4 (Contact Hours - 48)

Study of the morphological characters of some important invertebrate fossils belonging to Brachiopoda, Bivalvia, Gastropoda, Ammonoidea, Trilobita, Echinoidea and corals. 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. Measurements of dimensional parameters and preparation of elementary bivariate growth curves and scatter plots. Study of important fossils from Indian stratigraphic horizons.

Study of important rock forming minerals in hand specimen and atomic structure models. Determination of extinction angle and composition of plagioclase. Microscopic study of common rock-forming minerals. Calculation of mineral formulae. Stereographic projection of crystals. Sample preparation for powder diffraction by XRD and interpretation of X-ray diffractograms of common minerals and components of bulk rocks.

Course No. : GL-201
Course Title : Igneous Petrology
Credit : 4 (Contact Hours - 48)

UNIT - I

Origin and characteristics of magma; partial melting, magma generation and diversification. Factors controlling the ascent of magmas. Phase equilibrium in igneous systems: binary (Ab-An, Di-An and Fo-SiO_2) and ternary systems (Di-Ab-An, Di-Fo-SiO_2, Ne-Ks-SiO_2); their relation to magma genesis. Bowen's reaction principle: reaction series and its application to petrogenesis. Magmatic evolution and differentiation.

UNIT - II

Structures and textures: definition and description, rock examples and genetic implications of common structures and textures of igneous rocks. Classification of igneous rocks: textural, mineralogical, chemical (CIPW) and IUGS. Rock suite, petrographic provinces and associations. Magmatism and tectonics: inter-relationship between tectonic settings and igneous rock suites.

UNIT - III

Form, structure, texture, mineral constituents, petrogenesis and distribution of ultramafic rocks (dunite-peridotite-pyroxenite suite, kimberlites and komatiites), basic rocks (gabbro-gabbroic rocks, anorthosites, dolerites and basalts), intermediate rocks (diorite-syenite suite and andesites), acidic rocks (granite - granitoids and rhyolites), alkaline rocks (nepheline syenite and carbonatites) and ophiolite suites.

UNIT - IV

Petrogenetic provinces: flood basalts (Deccan Trap) and Rajmahal basalt, layered gabbroic intrusions (Bushveld Complex, Skaergaard Intrusion and Stillwater Complex), carbonatites and alkaline rock complexes of India. Oceanic rift valleys, MORB, tholeiites and ophiolites.

Books Recommended

- Best, M.G. 1986: Igneous Petrology. CBS Publishers.
- Bose, M.K. 1997: Igneous Petrology. World Press.
- Hatch, F.H., Wells, A.K. and Wells, M.K. 1984: Petrology of Igneous Rocks. CBS Publishers.
- McBirney, A.R. 1993: Igneous Petrology. Jones & Bartlett.
- Nockolds, S.R., Knox, R.W.O.B. and Chinner, G.A. 1979: Petrology for Students. Cambridge University Press.
- Perchuk, L.L. and Kushiro, I. (Eds) 1991: Physical Chemistry of Magmas. Springer Verlag.
- Philpotts, A. 1992: Igneous and Metamorphic Petrology. Prentice Hall.

Course No. : GL-202
Course Title : Metamorphic Petrology
Credit : 4 (Contact Hours - 48)

UNIT - I

Concepts and theory: types of metamorphism and their controlling factors. Textures, structures and petrographic classification of common metamorphic rocks. Chemographic diagram and representation of mineral assemblages. Metamorphic facies: description of facies of low pressure (albite-epidote-hornfels, pyroxene-hornfels), medium to high pressure (greenschist, amphibolite and granulite) and very high pressure (eclogite) with reference to characteristic minerals and P-T conditions. Schrienemakers rule and petrogenetic grid.

UNIT - II

Prograde and retrograde metamorphism. Metasomatism: deformation textures and textures related to recrystallization. Metamorphic reactions, elemental exchange and Pressure-Temperature conditions of isograds. Mineral assemblage equilibrium/reaction textures and geo-thermo barometry. Role of fluids in metamorphic reactions.

UNIT - III

Regional and thermal metamorphism of pelitic rocks, basic and ultrabasic rocks and impure, silicious carbonate rocks. Metamorphism of granitoids, charnockites and migmatites. Metamorphic differentiation.

UNIT - IV

Metamorphism in space and time: anatexis and origin of migmatites. Regional metamorphism and paired metamorphic belts with reference to plate tectonics. Archaean and Proterozoic terrains. Extraterrestrial metamorphism (Impact and Shock metamorphism). Polymetamorphism. Pressure-Temperature-time paths.

Books Recommended

- Best, M.G. 2003: Igneous and Metamorphic Petrology. Blackwell.
- Bucher, K. and Frey, M. 1994: Petrogenesis of Metamorphic Rocks. Springer Verlag.
- Frost, B.R. and Frost, C.D. 2014: Essentials of Igneous and Metamorphic Petrology. Cambridge University Press.
- Kornprobst, J. 2003: Metamorphic Rocks and Their Geodynamic Significance. Kluwer Academic.
- Kretz, R. 1994: Metamorphic Crystallization. John Wiley.
- Philipotts, A. 1992: Igneous and Metamorphic Petrology. Prentice Hall.
- Spry, A. 1976: Metamorphic Textures. Pergammon Press.
- Turner, F.J. 1980: Metamorphic Petrology. McGraw Hill.
- Williams, H., Turner, F.J. and Gilbert, C.M. 1985: Petrography - An Introduction to the Study of Rocks in Thin Section. (2^{nd} ed). CBS Publishers.
- Winkler, H.G.F. 1979: Petrogenesis of Metamorphic Rocks (5^{th} ed). Springer Verlag.
- Winter, J.D. 2001: An Introduction to Igneous and Metamorphic Petrology. Prentice Hall.
- Yardley, B.W. 1989: An Introduction of Metamorphic Petrology. Longman.

Course No. : GL-203
Course Title : Sedimentology
Credit : 4 (Contact Hours - 48)

UNIT - I

Sedimentology: definition and scope. Earth surface processes: generation of sediment flux, processes of transport and sedimentation and generation of primary and chemogenic sedimentary structures. Classification of sedimentary structures. Allogenic and autogenic controls on sedimentation and role of tectonics and climate in sedimentation.

UNIT - II

Sedimentary facies and depositional environments: continental alluvial-fluvial, lacustrine, desert-aeolian, glacial, deltaic, shallow marine, coastal clastic and deep sea sedimentary systems. Shallow water carbonate systems. Continental and marine evaporites.

UNIT - III

Evolution and classification of sedimentary basins: tectonics and sedimentation. Clastic petrofacies, classification of sandstones, volcaniclastics. Application of geochemistry to sedimentological problems. Sedimentation patterns and depositional environments of major undeformed and deformed sedimentary basins of India (Vindhyan, Gondwana, Siwalik, Assam-Arakan and Bengal basins).

UNIT - IV

Field and laboratory techniques in sedimentology: cathodo-luminescence petrography and scanning electron microscopy. Recording of sedimentary structures and preparation of lithologs. Methods of palaeocurrent determination and basin analysis. Significance of ichnofossils in depositional environments. Diagenesis and fluid flow mechanics. Diagenesis of mudstones, sandstones and carbonate rocks. Origin of various types of cements.

Books Recommended

- Allen, J.R.L. 1985: Principles of Physical Sedimentation. Allen & Unwin.
- Allen, P. 1997: Earth Surface Processes. Blackwell.
- Bhattacharya, A. and Chakraborti, C. 2000: Analyses of Sedimentary Successions. Oxford-IBH.
- Blatt, H., Murray, G.V., and Middleton, R.C. 1980: Origin of Sedimentary Rocks. Prentice Hall.
- Boggs, S. (Jr) 1995: Principles of Sedimentology and Stratigraphy. Prentice Hall.
- Carver, R.E. 1971: Procedures of Sedimentary Petrology. John Wiley.
- Davis, R.A. (Jr) 1992: Depositional Systems. Prentice Hall.
- Einsele, G. 1992: Sedimentary Basins. Springer Verlag.
- Friedman, G.M. and Sanders, J.E. 1978: Principles of Sedimentology. John Wiley.
- Guy Plint, A. 1995: Sedimentary Facies Analysis. Spl. Publ., IAS No. 22. Blackwell.
- Miall, A.D. 1996: The Geology of Fluvial Deposits. Springer Verlag.
- Miall, A.D. 1997: The Geology of Stratigraphic Sequences. Springer Verlag.
- Miall, A.D. 2000: Principles of Sedimentary Basin Analysis. Springer Verlag.
- Nichols, G. 1999: Sedimentology and Stratigraphy. Blackwell.
- Pettijohn, F.J., Potter, P.E. and Siever, R. 1990: Sand and Sandstone. Springer Verlag.
- Prothero, D.R. and Schwab, F. 1996: Sedimentary Geology. Freeman.
- Reading, H.G. 1996: Sedimentary Environments. Blackwell.

- Reineck, H.E. and Singh, I.B. 1980: Depositional Sedimentary Environments. Springer Verlag.
- Sengupta, S. 1997: Introduction to Sedimentology. Oxford-IBH.
- Tucker, M. 1988: Techniques in Sedimentology. Blackwell.

Course No. : GL-204
Course Title : Ore Geology
Credit : 4 (Contact Hours - 48)

UNIT - I

Modern concept of ore genesis. Spatial and temporal distribution of ore deposits - a global perspective. Ore deposits in relation to plate tectonics. Mode of occurrence and morphology of ore bodies and their relationship with host rocks. Ore mineral textures, paragenesis and metal zoning of ores and their significance. Concept of ore bearing fluids, their origin and migration; wall rock alteration. Structural, physico-chemical and stratigraphic controls of ore localization.

UNIT - II

Chemical composition of ores and their applications - bulk chemistry, trace elements, REE and stable isotopes. Modern analogue of the ore-forming systems: black smokers and Mn-nodules. Mineralogy, genesis, use and Indian distribution of ore minerals related to Fe, Mn, Cr, Cu, Pb, Zn, Al, Mg, Au, Sn, W and U. Metallogenic provinces and mineral belts of India.

UNIT - III

Fluid inclusion in ores: principles, assumption, limitations and applications. Petrological ore associations with Indian examples wherever feasible: orthomagmatic ores of mafic-ultramafic associations (diamond in kimberlite, REE in carbonatites, Ti-V ores, chromite and PGE, Ni ores and Cyprus type Cu-Zn). Ores of silicic igneous rocks and associated hydrothermal fluids (Kiruna type Fe-P, pegmatites, greisens, skarns, porphyry associations and Kuroko-type Zn-Pb-Cu).

UNIT - IV

Ores of sedimentary affiliation: chemical and clastic sedimentation, stratiform and stratabound ore deposits (Mn, Fe and non-ferrous ores), placers and palaeoplacers. Beach placer deposits of India. Ores of metamorphic affiliation: metamorphosed ores versus metamorphogenic ores. Ores related to weathering and weathered surfaces: laterite, bauxite and Ni/Au laterite. Supergene enrichment and related ore deposits.

Books Recommended

- Barnes, H.L. 1979: Geochemistry of Hydrothermal Ore Deposits. John Wiley.
- Craig, J.M. and Vaughan, D.J. 1981: Ore Petrography and Mineralogy. John Wiley.
- Evans, A.M. 1993: Ore Geology and Industrial Minerals. Blackwell.
- Guilbert, J.M. and Park, C.F. (Jr) 1986: The Geology of Ore Deposits. Freeman.
- Klemm, D.D. and Schneider, H.J. 1977: Time and Stratabound Ore Deposits. Springer Verlag.
- Mookherjee, A. 2000: Ore Genesis - A Holistic Approach. Allied Publishers.
- Ramdohr, P. 1969: The Ore Minerals and Their Intergrowths. Pergammon Press.
- Sawkins, F.J. 1984: Metal Deposits in Relation to Plate Tectonics. Springer Verlag.
- Stanton, R.L. 1972: Ore Petrology. McGraw Hill.
- Torling, D.H. 1981: Economic Geology and Geotectonics. Blackwell.
- Wolf, K.H. 1991: Handbook of Stratabound and Stratiform Ore Deposits. Elsevier.

Course No. : GL-205
Course Title : Practical on GL-201 and GL-202
Credit : 4 (Contact Hours - 48)

Megascopic study of major igneous rocks in hand specimens. Microscopic study (texture and mineral constituents) of important igneous rocks. Modal analysis and Niggli value calculations for important igneous rocks.

Megascopic and microscopic studies of metamorphic rocks of different metamorphic facies with emphasis on their textures/structures, mineral composition and parent rocks. Calculation of ACF, AKF and AFM values from chemical and structural formulation of minerals and their graphical representation. Estimation of pressure and temperature from important models of geothermobarometry. Interpretation of reactions textures.

Course No. : GL-206
Course Title : Practical on GL-203 and GL-204
Credit : 4 (Contact Hours - 48)

Detailed study of clastic and non-clastic rocks in hand specimens. Study of primary, secondary and biogenic sedimentary structures in hand specimens, photographic atlases, field photographs and at outcrops, where possible. Microscopic examination of important rock types. Exercises related to palaeocurrent data from different environments. Tilt corrections of palaeocurrent data. Exercises related to analysis and interpretation of depositional sedimentary environments using actual case histories from the Indian stratigraphic record. Determination of porosity in clastic and chemical sedimentary rocks. Detailed study of diagenetic features in thin sections. Separation and study of heavy minerals. Exercises on mineralogical and geochemical data plots for environmental interpretations.

Megascopic study of metallic ores in hand specimen. Megascopic study of structures and fabric of different ores and their associations. Mineralogical and textural studies of common ore minerals under ore-microscope and petrological study of industrial and non-metallic minerals. Determination of reflectivity and micro-hardness of common ore minerals. Preparation of maps showing distribution of important metallic and industrial minerals in India and the world.

Course No. : GL-301
Course Title : Hydrogeology
Credit : 4 (Contact Hours - 48)

UNIT I

Distribution of water in the earth's crust. Water balance. Subsurface occurrence of groundwater. Concept of drainage and groundwater basins. Hydrological properties of rocks: porosity, permeability, specific yield and specific retention. Aquifer parameters: hydraulic conductivity, transmissivity and storage coefficient. Types of aquifers; water table and piezometric surfaces. Springs. Barometric and tidal efficiencies. Hydrographs. Geological formations favoring groundwater occurrence. Geologic and geomorphic controls on groundwater.

UNIT II

Groundwater movement: Darcy's law and its applications. Determination of hydraulic conductivity in the laboratory and field. Well hydraulics: steady, unsteady and radial flow through aquifers. Hydrostratigraphic units. Pumping tests: methods, data analysis and interpretation. Groundwater table contour maps; fluctuations of water table and piezometric surface.

UNIT III

Over exploitation of groundwater and groundwater mining. Groundwater problems in urban areas. Groundwater management in arid and semi-arid areas. Hydrogeology of arid zones and wetlands of India. Climate change impact on groundwater resources. Concept of sustainable development of groundwater resources. Rainwater harvesting and aquifer recharge. Conjunctive uses of surface and groundwater. Sea water intrusion. Groundwater legislation.

UNIT IV

Physical and chemical properties of water; quality criteria for different uses. Groundwater pollution: natural and anthropogenic contaminants. Water quality in the various groundwater provinces of India. Radioisotopes in hydrogeological studies. Geologic and hydrogeologic methods of exploration; hydrogeomorphic and lineament mapping. Surface geophysical methods: seismic, gravity and geo-electrical. Subsurface geophysical methods; types of water wells and methods of construction. Design, development, maintenance and revitalization of wells.

Books Recommended

- Alley, W.M. 1993: Regional Groundwater Quality. VNR, New York.
- Davies, S.N. and Dewiest, R.J.M. 1966: Hydrogeology. John Wiley.
- Fetter, C.W. 1990: Applied Hydrogeology. Merrill Publishing.
- Freeze, R.A. and Cherry, J.A. 1979: Groundwater. Prentice Hall.
- Garg, S.P. 1982: Groundwater and Tube Wells. Oxford-IBH.
- Hudak, P.F. 2000: Principles of Hydrogeology. Lewis Publishers.
- Karanth, K.R. 1987: Groundwater Assessment - Development and Management. Tata-McGraw Hill.
- Mahajan, G. 1990: Evaluation and Development of Ground Water. DK Publishers.

- Mahajan, G. 1995: Ground Water. DK Publishers.
- Pitchaiah, P.S. (Ed) 1995: Ground Water. Ashish Publishing House, New Delhi.
- Raghunath, N.M. 1982: Ground Water. Wiley Eastern.
- Singhal, B.B.S. 1986: Engineering Geosciences. Savita Prakashan.
- Subramaniam, V. 2000: Water. Kingston Publications.
- Todd, D.K. 1980: Groundwater Hydrology. John Wiley.
- USDI, 1993: Groundwater Manual. Scientific Publishers, Jodhpur.
- Viessman, W., Knapp, J.W., Lewis, G.L. and Harbaugh, T.E. 1977: Introduction to Hydrology. Harper & Row.
- Walton, W.C. 1988: Groundwater Resource Evaluation. McGraw Hill.

Course No. : GL-302
Course Title : Geochemistry
Credit : 4 (Contact Hours - 48)

UNIT - I

Origin of the solar system. Earth in relation to the solar system. Cosmic abundance of elements. Composition of meteorites and the earth. Periodic table and special properties of transition and rare earth elements. Goldschmidt's geochemical classification of elements. Trace elements and REE; their importance in fractional crystallization during magmatic/ partial melting.

UNIT - II

Introduction to isotope geochemistry. Geochronology and age of the Earth. Stable isotopes and their applications. Law of radioactivity and principles of isotopic dating. Radioactive decay schemes of U-Th-Pb, Rb/Sr and Sm-Nd for dating of rocks. Geochemistry and evolution of the hydrosphere, biosphere and atmosphere.

UNIT - III

Elementary crystal chemistry and thermodynamics: concept of free energy, activity, fugacity and equilibrium constant. Thermodynamics of ideal and non-ideal solutions. Principles of ionic substitution in minerals. Concept of simple distribution coefficient; element partitioning in mineral assemblages and its use in P-T estimation. Nucleation and diffusion process in igneous, sedimentary and metamorphic environments.

UNIT - IV

Chemistry of natural waters. Redox reactions and Eh-pH diagrams and their applications. Minerals / mineral assemblages as sensors of ambient environments. Geochemical cycle. Principles of geochemical prospecting. Geochemical studies of aerosols and surface, marine and ground water. Rock weathering and soil formation.

Books Recommended

- Faure, G. 1986: Principles of Isotope Geology. John Wiley.
- Gill, R. 1997: Chemical Fundamentals of Geology. Chapman & Hall.
- Govett, G.J.S. (Ed) 1983: Handbook of Exploration Geochemistry. Elsevier.
- Henderson, P. 1987: Inorganic Geochemistry. Pergammon Press.
- Hoefs, J.M. 1980: Stable Isotope Geology. John Wiley.
- Krauskopf, K.B. 1967: Introduction to Geochemistry. McGraw Hill.
- Marshal, C.P. and Fairbridge, R.W. 1999: Encyclopaedia of Geochemistry. Kluwer Academic.
- Mason, B. and Moore, C.B. 1991: Introduction to Geochemistry. Wiley Eastern.
- Nordstrorm, D.K. and Munoz, J.L. 1986: Geochemical Thermodynamics. Blackwell.
- Rastogi, R.P. and Mishra, R.R. 1993: An Introduction to Chemical Thermodynamics. Vikas Publishing House.
- Spear, F.S. 1993: Mineralogical Phase Equilibria and P-T-T Paths. Mineralogical Society of America.

Course No. : GL-303
Course Title : Fuel Geology (Coal, Petroleum and Atomic Minerals)
Credit : 4 (Contact Hours - 48)

UNIT - I

Coal: definition and origin of kerogen and coal. Sedimentology of coal bearing strata. Rank, grade and type of coal. Indian and international classifications. Chemical characterization: proximate and ultimate analysis. Macroscopic ingredients and microscopic constituents. Concept of maceral and microlithotypes: their physical, chemical and optical properties. Maceral analysis of coal: minerals and organic matter in coal. Coal petrology and its applications in solving industrial and geological problems.

UNIT - II

Coal-bed methane: a new energy resource. Maturation of coal and generation of methane in coal beds; coal as reservoir. Fundamentals of coal-bed methane exploration and production. Coal forming epochs. Geological and geographical distribution of coal deposits in India. Detailed geology of Jharia coalfield. Methods of coal prospecting and estimation of coal reserves. Coal production and problems of coal industry in India. Uses of coal for various industries (carbonization, liquefaction, power generation and gasification).

UNIT - III

Petroleum: composition and different fractions. Origin, nature and migration (primary and secondary) of oil and gas. Transformation of organic matter into kerogen; organic maturation and thermal cracking of kerogen. Characteristics of reservoir rocks and traps (structural and/or stratigraphic). Oilfield fluids: water, oil and gas occurrences. Drilling and geological logging procedures. Major oil-bearing basins of India. Geology of the Bombay High and Digboi oilfields. Position of oil and natural gas in India: present status and future prospects.

UNIT - IV

Mineralogy and geochemistry of radioactive minerals. Atomic fuels: mode of occurrence and association of atomic minerals in nature. Atomic minerals as source of energy. Productive geological horizons of India, i.e., Jaduguda, Cuddapah and Domiasat uranium deposits. Beach placers and thorium deposits of India. Position of atomic minerals in India and their future prospects.

Books Recommended

- Boyle, R.W. 1982: Geochemical Prospecting for Thorium and Uranium Deposits. Elsevier.
- Chandra, D., Singh, R.M. and Singh, M.P. 2000: Textbook of Coal (Indian Context). Tara Book Agency, Varanasi.
- Dahlkamp, F.J. 1993: Uranium Ore Deposits. Springer Verlag.
- Durrance, E.M. 1986: Radioactivity in Geology - Principles and Application. Ellis Harwood.
- Holson, G.D. and Tiratsoo, E.N. 1982: Introduction to Petroleum Geology. Gulf Publishers.
- North, F.K. 1985: Petroleum Geology. Allen & Unwin.
- Selley, R.C. 1998: Elements of Petroleum Geology. Academic Press.

- Singh, M.P. (Ed) 1998: Coal and Organic Petrology. Hindustan Publishing Co., New Delhi.
- Stach, E., Mackowsky, M.T.H., Taylor, G.H., Chandra, D. and Teichmuller, M.R. 1982: Statch's Text Book of Coal Petrology. Gebruder Borntraeger.
- Taylor, G.H., Teichmuller, M., Davis, A., Diessel, C.F.K., Littke, R. and Robert, P. 1998: Organic Petrology. Gebruder Borntraeger.
- Tissot, B.P. and Welte, D.H. 1984: Petroleum Formation and Occurrence. Springer Verlag.

Course No. : GL-304
Course Title : Stratigraphy
Credit : 4 (Contact Hours - 48)

UNIT - I

History and development of stratigraphy and stratigraphic procedures (surface and sub-surface). Concept of litho-facies, bio-facies and chronostratigraphy. Concept of magnetostratigraphy and chemostratigraphy. Litho-, bio- and chrono-stratigraphic correlation. Stratigraphic procedures of correlation of un-fossiliferous rocks.

UNIT - II

Event stratigraphy and sequence stratigraphy. Nomenclature and the modern stratigraphic code. Radioisotopes; measuring geological time. Rock record, palaeoclimate and palaeogeography. Rise of the Himalayas and evolution of the Siwalik basin. Stratigraphic boundaries and stratigraphic boundary problems in India.

UNIT - III

Precambrian stratigraphy of India: tectonic framework, geological history and evolution of Dharwar, Cuddapah and Vindhyan supergroups. Palaeozoic formations of India with special reference to type localities, history of sedimentation and fossil contents. Mesozoic formations of India with special reference to type localities, history of sedimentation and fossil contents.

UNIT - IV

Cenozoic formations of India with special reference to type localities, history of sedimentation and fossil contents. Gondwana Supergroup and Gondwanaland. Deccan volcanic. Ophiolites and Tertiary formations of North East India with special reference to type localities, history of sedimentation and fossil contents.

Books Recommended

- Ager, D.V. 1980: Introduction to Palaeoecology. McGraw Hill.
- Bayer, U. and Seilacher, A. 1985: Sedimentary and Evolutionary Cycles. Springer Verlag.
- Boggs, S. (Jr) 1995: Principles of Sedimentology and Stratigraphy. Prentice Hall.
- Brenner, R.L. and McHargue, T.R. 1988: Integrative Stratigraphy: Concept and Applications. Prentice Hall.
- Dasgupta, A.B. and Biswas, A.K. 2000: Geology of Assam. Geological Society of India.
- Dodd, J.R. and Stanton, R.J. 1983: Palaeoecology: Concepts and Application. John Wiley.
- Doyle, P. and Bennet, M.R. 1996: Unlocking the Stratigraphic Record. John Wiley.
- Goodwin, A.M. 1991: Precambrian Geology: The Dynamic Evolution of Continental Crust. Academic Press.
- Karunakaran, C. 1972: Geology and Mineral Resources of the States of India. Misc. Publ., GSI, vol. 30.
- Kennett, P. and Ross, C.A. 1983: Palaeoecology. Longman.
- Krishnan, M.S. 1982: Geology of India and Burma (6^{th} ed). CBS Publishers.
- Kumar. G. 1997: Geology of Arunachal Pradesh. Geological Society of India.
- Kumar, R. 1985: Fundamental of Historical Geology and Stratigraphy of India (3^{rd} ed). Wiley Eastern.
- Ladd, H.S. 1957: Treatise on Marine Ecology and Palaeoecology (vol. 2). Palaeoecology Memoirs of the Geological Society of America.
- McKerrow, W.S. 1984: The Ecology of Fossils. Duckworth.

- Moullade, M. and Nairn, A.E.M. 1983: Palaeozoic, Mesozoic and Cenozoic (vol. 1-3). Elsevier.
- Nandy, D.R. 2001: Geodynamics of Northeastern India and the Adjoining Region. ACB Publications.
- Naqvi, S.M. 2005: Geology and Evolution of the Indian Plate (4 Ga to 4 Ka). Capital Publishing Co.
- Naqvi, S.M. and Rogers, J.J.W. 1987: Precambrian Geology of India. Oxford University Press.
- Pascoe, E.H. 1968. A Manual of Geology of India and Burma (vol. 1-4). GoI Press.
- Payton, C.E. 1977: Seismic Stratigraphy - Applications to Hydrocarbon Exploration. AAPG Publications.
- Pomerol, C. 1982: The Cenozoic Era: Tertiary and Quaternary. Ellis Harwood.
- Sheriff, R.E. 1980: Seismic Stratigraphy. International Human Resources Dev. Corp., Boston.
- Tarling, D.H. 1983: Palaeomagnetism - Principles and Applications in Geology, Geophysics and Archaeology. Chapman & Hall.
- Wadia, D.N. 1957: Geology of India (3rd ed). Macmillan.

Course No. : GL-305
Course Title : Practical on GL-301 and GL-302
Credit : 4 (Contact Hours - 48)

Delineation of hydrological boundaries and water table contour maps. Chemical analysis of water and graphical representation. Preparation of hydrogeomorphic maps using toposheets, aerial photos and satellite imagery. Determination of porosity, hydraulic conductivity, etc. from mechanical analysis data of aquifer material. Evaluation of aquifer parameters from pumping tests. Analysis and interpretation of geophysical well logs. Estimation of TDS using resistivity and SP logs.

Calculation of structural formulae of important mineral groups such as pyroxene, amphibole, olivine and garnet. Preparation of solutions A and B of rock samples for chemical analysis. Use of flame photometer, colorimeter and spectrophotometer. Calculation of normative minerals from rock compositions using CIPW norms. Presentation of analytical data and plotting of variations in binary and triangular diagrams and their interpretation.

Course No. : GL-306
Course Title : Practical on GL-303 and GL-304
Credit : 4 (Contact Hours - 48)

Megascopic characterization of banded coals. Proximate analysis of coal. Completion of outcrops in maps. Calculation of coal reserves. Preparation of polished mounts of coal. Microscopic examination of polished coal pellets. Identification of macerals in coal. Megascopic 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 geological sections of U-Th bearing rocks of India. Megascopic study of some uranium and thorium bearing minerals and rocks.

Study of important rocks from Indian stratigraphic horizons. Exercises on stratigraphic classification and correlation. Exercises on sequence stratigraphy. Exercises on stratigraphic interpretation of seismic records and other geophysical records. Study of palaeogeographic maps of various geologic periods.

Course No. : GL-401
Course Title : Environmental and Engineering Geology
Credit : 4 (Contact Hours - 48)

UNIT - I

Environmental Geology: fundamental concepts, scope and objectives. Geological record of climate change; causes and impact of climate change. El Niño and La Niña. Global warming, green house effect and ozone depletion. Carbon sequestration. Air and noise pollution: environmental problems; National standards. Deforestation and land degradation. Geological aspects of environmental health.

UNIT - II

Alternative energy resources and their management. Elements of Environmental Impact Assessment. Waste management: solid, liquid and radioactive. River and coastal erosion. Cyclones and storms. Applications of GIS in Environmental Management. Environmental Legislations in India.

UNIT - III

Geological studies and evaluation in planning, design and construction of major civil structures. Elementary concepts of rock and soil mechanics. Site investigation, characterization and problems related to civil engineering projects. Problems of groundwater in engineering projects. Coastal geotechniques. Environmental considerations related to civil engineering projects. Resource evaluation of construction materials. Landslides and earthquakes: their significance, causes, preparedness and mitigation. Recent trends in geotechnical engineering. Geotechnical case studies of major projects in India.

UNIT - IV

Geological and geotechnical investigations for dams, reservoirs and spillways, tunnels, underground caverns, bridges, highways and shorelines. Influence of geological conditions on foundation and design of buildings. Aseismic designs of buildings.

Books Recommended

- Alley, W.M. 1993: Regional Groundwater Quality. VNR, New York.
- Bell, F.G. 1999: Geological Hazards. Routledge.
- Bryant, E. 1985: Natural Hazards. Cambridge University Press.
- Fetter, C.W. 1990: Applied Hydrogeology. Merrill Publishing.
- Karanth, K.R. 1987: Groundwater Assessment - Development and Management. Tata-McGraw Hill.
- Keller, E.A. 1978: Environmental Geology. Bell & Howell.
- Krynine, D.H. and Judd, W.R. 1998: Principles of Engineering Geology. CBS Publishers.
- Murthy, V.N.S. 2001: Principles of Soil Mechanics and Foundation Engineering (5^{th} ed). CBS Publishers.
- Patwardhan, A.M. 1999: The Dynamic Earth System. Prentice Hall.
- Punmia, B.C. 2000: Soil Mechanics and Foundations 13^{th} ed). Laxmi Publications.
- Sharma, P.V. 1997: Environmental and Engineering Geophysics. Cambridge University Press.
- Smith, K. 1992: Environmental Hazards. Routledge.
- Subramaniam, V. 2001: Textbook of Environmental Science. Narosa International.
- Terzaghi, K. 1943: Theoretical Soil Mechanics. Wiley & Sons.

- Todd, D.K. 1980: Groundwater Hydrology. John Wiley.
- Valdiya, K.S. 1987: Environmental Geology - Indian Context. Tata-McGraw Hill.
- Venkatramaiah, C. 1995: Geotechnical Engineering (2nd ed). New Age International.

Course No. : GL-402
Course Title : Mineral Exploration and Mining Geology
Credit : 4 (Contact Hours - 48)

UNIT - I

Definition of reserves and resources; mineral resources in industries. Principles of mineral prospecting and exploration - conceptualisation, methodology and stages. Geological criteria and guides for prospecting of mineral deposits. Factors controlling ore localization. Surface and sub-surface sampling including pitting, trenching and drilling (core and non-core drilling). Geomorphological and remote sensing techniques in mineral exploration.

UNIT - II

Basic principles of exploration geochemistry: geochemical environment, geochemical dispersion, association of elements, geochemical distribution patterns and principles of interpretation. Geochemical anomalies: epigenetic anomalies, formation of diffusion aureoles, leakage anomalies and coefficient of aqueous migration. Pedogeochemical, lithogeochemical, biogeochemical and geobotanical surveys in mineral exploration. Principles of reserve estimation, density and bulk density and factors affecting reliability of reserve estimation.

UNIT - III

Interrelationship between geology and geophysics. Geophysical prospecting methods: gravity, magnetic, electrical and seismic; their principles and applications. Geophysical field operations: grid and route surveys, profiling and sounding techniques, scales of survey and presentation of geophysical data.

UNIT - IV

Mining terminologies. Factors in the choice of mining methods. Surface mining: different methods of alluvial and open cast mining. Underground mining: classification of mining methods, shaft sinking, stoping, room and pillaring, long wall mining, top-slicing, sub-level caving and block caving. Ocean bottom mining. Mine hazards: mine inundation, mine fire and rock burst.

Books Recommended

- Arrogyaswami, R.N.P. 1996: Courses in Mining Geology (4th ed). Oxford IBH.
- Brooks, A.R. 1972: Geobotany and Biogeochemistry in Mineral Exploration. Harper & Row.
- Clark, G.B. 1967: Elements of Mining (3rd ed). John Wiley.
- Dobrin, M.B. 1976: Introduction to Geophysical Prospecting. McGraw Hill.
- Evans, A.M. 1995: Introduction to Mineral Exploration. Blackwell Science.
- Ginzburg. Principles of Geochemical Prospecting. Pergammon Press.
- Govett, G.J.S. 1983: Handbook of Exploration Geochemistry. Elsevier.
- Kreiter. Geological Prospecting and Exploration. Universal Press.
- Levenson, 1974: Introduction to Exploration Geochemistry. Applied Publishing Ltd.
- McKinstry, H.E. 1962: Mining Geology (2nd ed). Asia Publishing House.
- Pacal, Z. (Ed) 1977: Geochemical Prospecting Methods. Ustrendi.
- Peters, W.C. 1978: Exploration and Mining Geology. Willey & Sons.
- Rose, A.W., Hawkes, H.E. and Webb, J.A. 1979: Geochemistry in Mineral Exploration. Academic Press.

- Sharma, P.V. 1986: Geophysical Methods in Geology. Elsevier.
- Stanislave, M. 1984: Introduction to Applied Geophysics. Reidel Publications.
- Vogelsang, D. 1995: Environmental Geophysics - A Practical Guide. Springer Verlag.

Course No. : GL-403
Course Title : Marine and Quaternary Geology
Credit : 4 (Contact Hours - 48)

UNIT - I

Morphologic and tectonic domains of the ocean floor. Structure, composition and mechanism of the formation of the oceanic crust. Hydrothermal vents. Ocean margins and their significance. Ocean circulations; Coriolis effect and Ekman spiral; convergence, divergence and upwelling. Indian Ocean Dipole Thermohaline circulation and oceanic conveyor belt. Formation of bottom waters. Major water masses of the world's oceans.

UNIT - II

Oceanic sediments: factors controlling their deposition and distribution. Geochronology of oceanic sediments. Diagenetic changes in oxic and anoxic environments. Tectonic evolution of the ocean basins. Mineral resources. Approaches to palaeoceanographic reconstructions; proxy indicators for palaeoceanographic interpretation; reconstruction of monsoon variability using marine proxy records. Opening and closing of ocean gateways and their effect on circulation and climate during the Cenozoic. Sea level processes and sea level changes. Methods of quantification of palaeo-sea surface temperatures.

UNIT - III

Quaternary Geology: definition and scope. Quaternary stratigraphy: oxygen isotope stratigraphy, biostratigraphy and magnetostratigraphy. Quaternary climates: glacial-interglacial cycles, eustatic changes. Proxy indicators of palaeoenvironmental/ palaeoclimatic changes on land, ocean and cryosphere (ice core studies).

UNIT - IV

Responses of geomorphic systems to climate, sea level and tectonics on variable time scales during Quaternary. Quaternary dating methods: radiocarbon, uranium series, luminescence and amino acid. Quaternary stratigraphy of India: continental (fluvial, glacial, aeolian, palaeosols and duricrust) and marine records; continental-marine correlation of Quaternary record. Evolution of man and Stone Age cultures. Plant and animal life during Quaternary glacial and interglacial cycles. Tectonic geomorphology, neotectonics, active tectonics and their applications in natural hazard assessment.

Books Recommended

- Bradley, R.S. 2014: Paleoclimatology: Reconstructing Climates of the Quaternary (3rd ed). Springer Verlag.
- Brown, A. and Quine, T. 1999: Fluvial Processes and Environmental Change. John Wiley.
- Burbank, D.W. and Anderson, S.R. 2011: Tectonic Geomorphology (2nd ed). Wiley-Blackwell.
- Cemen, I. and Yucel Yilmaz, Y. 2017: Active Global Seismology: Neotectonics and Earthquake Potential of the Eastern Mediterranean Region. John Wiley.
- Chester, R. and Jickells, T. 2012: Marine Geochemistry (3rd ed). Wiley-Blackwell.
- Christopher, G. Kendall, St. C. and Abdulrahman, S.A. (Ed) 2011: Quaternary Carbonate and Evaporite Sedimentary Facies and their Ancient Analogues. Wiley & Sons.

- Dhital, M.R. 2015: Geology of the Nepal Himalaya: Regional Perspective of the Classic Collided Orogen. Springer Verlag.
- French, H.M. 2017: The Periglacial Environment (4th ed). John Wiley.
- Gray, M. 2013: Geodiversity: Valuing and Conserving Abiotic Nature (2nd ed). John Wiley.
- Keary, P. 2009: Global Tectonics (3rd ed). John Wiley.
- Keary, P. and Vine, F.J. 1990: Global Tectonics. Blackwell.
- Keller, E.A. and Pinter, N. 1996. Active tectonics. Prentice Hall.
- Kennett, J.P. 1982: Marine Geology. Prentice Hall.
- Mallik, T.K. 2008: Marine Geology: A Scenario Around Indian Coasts. New Academic Publishers.
- Mathur, U.B. 2005: Quaternary Geology: Indian Perspective. Geological Society of India.
- Moores, E.M. and Twiss, R.J. 1995. Tectonics. Freeman.
- Morisawa, M and Hack. T. J (Eds). 1985. Tectonic Geomorphology. Allen & Unwin.
- Narayana, A.C. 2002: Late Quaternary Geology of India and Sea Level Changes. Geological Society of India.
- O'Hara, K.D. 2014: Earth Resources and Environmental Impact. John Wiley.
- Ollier, C. 1981. Tectonics and Landform. Longman.
- Pinet, P.R. 2016: Invitation to Oceanography (7th ed). Jones & Bartlett.
- Rengers, N. 1994: Engineering Geology of Quaternary Sediments. CRC Press.
- Seibold, E. and Berger, W. 2015: The Sea Floor: An Introduction to Marine Geology (3rd ed). Springer Verlag.
- Siegert, M.J. 2000: Ice Sheets and Late Quaternary Environmental Change. John Wiley.
- Theodore, R. 2015: Oceanography. Callisto Publications.

Course No. : GL-404
Course Title : Practical on GL-401 and GL-402
Credit : 4 (Contact Hours - 48)

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

Physical characters of common rocks with reference to their utility in engineering projects. Study of maps and models of important engineering structures such as dam sites and tunnels. Interpretation of geological maps for landslide problems. Sample preparation for geotechnical tests of soils and determination of Atterberg consistency limit test, Plummet test, etc.

Study of symbols for field and mines geological mapping; exercises related to underground mining problems. Determination of tenor and cut-off grade. Exercises on reserve estimation (square, rectangular, triangular and polygon blocks).

Resistivity surveys. Exercises related to prospecting and exploration. Study of flow sheet for ore beneficiation. Exercises related to interpretation of underground mining problems.