

NAGALAND UNIVERSITY

CURRICULUM AND CREDIT FRAMEWORK FOR UNDERGRADUATE PROGRAMMES

**Four Years (Eight Semesters)
Under-Graduate Programme under
Choice Based Credit System - 2023**

CORE COURSES IN GEOLOGY

**Approved by 36th Academic Council
(on 17th May, 2023)**

Major Courses (Core Papers):

Paper Code	Course Code	Title of the Paper	Total Credit
FIRST SEMESTER			
C-1	GEOL-101	Earth System Science (3 Credits)	4
	GEOL-102	Practical on Earth System Science (1 Credit)	
C-2	GEOL-103	Structural Geology (3 Credits)	4
	GEOL-104	Practical on Structural Geology (1 Credit)	
SECOND SEMESTER			
C-3	GEOL-201	Elements of Geochemistry (3 Credits)	4
	GEOL-202	Practical on Elements of Geochemistry (1 Credits)	
C-4	GEOL-203	Mineral Science (3 Credits)	4
	GEOL-204	Practical on Mineral Science (1 Credit)	
THIRD SEMESTER			
C-5	GEOL-301	Igneous Petrology (3 Credits)	4
	GEOL-302	Practical on Igneous Petrology (1 Credit)	
C-6	GEOL-303	Metamorphic Petrology (3 Credit)	4
	GEOL-304	Practical on Metamorphic Petrology (1 Credit)	
FOURTH SEMESTER			
C-7	GEOL-401	Sedimentary Petrology (3 Credit)	
	GEOL-402	Practical on Sedimentary Petrology (1 Credit)	
C-8	GEOL-403	Palaeontology (3 Credits)	4
	GEOL-404	Practical on Palaeontology (1 Credit)	
FIFTH SEMESTER			
C-9	GEOL-501	Geomorphology (3 Credits)	4
	GEOL-502	Practical on Geomorphology (1 Credit)	
C-10	GEOL-503	Economic Geology (3 Credits)	4
	GEOL-504	Practical on Economic Geology (1 Credit)	

C-11	GEOL-505 GEOL-506	Stratigraphic Principles and Indian Stratigraphy (3 Credits) Practical on Stratigraphic Principles and Indian Stratigraphy (1 Credit)	4
SIXTH SEMESTER			
C-12	GEOL-601 GEOL-602	Engineering and Exploration Geology (3 Credits) Practical on Engineering and Exploration Geology (1 Credit)	4
C-13	GEOL-603 GEOL-604	Remote Sensing and GIS (3 Credits) Practical on Remote Sensing and GIS (1 Credit)	4
C-14	GEOL -605 GEOL-606	Hydrogeology (3 Credits) Practical on Hydrogeology (1 Credit)	4
C-15	GEOL -607	Geological Field Work	4
SEVENTH SEMESTER			
C-16	GEOL-701 GEOL-702	Geology of Nagaland (3 Credits) Practical on Geology of Nagaland (1 Credit)	4
C-17	GEOL-703 GEOL-704	Environmental Geology (3 Credits) Practical on Environmental Geology (1 Credit)	4
C-18	GEOL-705 GEOL-706	Fuel Geology (3 Credits) Practical on Fuel Geology (1 Credit)	4
C-19	GEOL- 707	Research Methodology (Common Course for all Under-Graduate Departments)	4
EIGHTH SEMESTER			
C-20	GEOL-801	Will be proposed later	4
C-21	GEOL-802	Research Project	12
Honours students not undertaking Research Project will undertake 3 theory courses for 12 Credits in lieu of the Research Project/Dissertation.			

Course Code: GEOL -101

Course Name: Earth System Sciences

Credit: 03

Unit 1: Introduction to various branches of Geology. General characteristics and origin of the Universe. The terrestrial and jovian planets. Earth in the solar system - origin, size, shape, mass, density, rotational and revolution parameters and its age. Formation of core, mantle, crust, hydrosphere, atmosphere and biosphere. Convection in Earth's core and production of its magnetic field.

Unit 2: Concept of plate tectonics, sea-floor spreading and continental drift. Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, transform faults and island arcs. Origin of oceans, continents, mountains and rift valleys. Earthquake and earthquake belts, Volcanoes-types, products and their distribution.

Unit 3: Oceanic current system and effect of Coriolis force, Concepts of eustasy, Land-air-sea interaction. Wave erosion and beach processes. Atmospheric circulation, weather and climatic changes. Earth's heat budget. Soils- processes of formation, soil profile and soil types.

Unit 4: Nature of stratigraphic records. Standard stratigraphic time scale and introduction to the concept of time in geological studies. Introduction to geochronological methods and their application in geological studies. History of development in the concepts of uniformitarianism, catastrophism and neptunism. Laws of superposition and faunal succession. Introduction to geomorphology of Indian subcontinent.

Unit 5: Distribution of elements in solar system and in Earth. Chemical differentiation and composition of the Earth. General concepts about geochemical cycles and mass balance. Geochemical behaviour of major elements. Mass conservation of elements and isotopic fractionation.

Course Code: GEOL -102

Course Name: Practical on Earth System Sciences

Credit: 1

Study of major geomorphic features and their relationships with outcrops through physiographic models. Study of soil profile of any specific area. Study of distribution of major lithostratigraphic units on the map of India. Study of major ocean currents of the world. Study of seismic profile of a specific area and its interpretation

Suggested readings:

- Duff, P. M. D., & Duff, D. (Eds.). (1993). Holmes' principles of physical geology. Taylor & Francis.
- Emiliani, C. (1992). Planet earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press.
- Gross, M. G. (1977). Oceanography: A view of the earth.

Course Code: GEOL -103

Course Name: Structural Geology

Credit: 03

Unit 1: Effects of topography on structural features, topographic and structural maps, important representative factors of the map. Techniques in structural geology.

Unit 2: Concept of rock deformation: Stress and Strain in rocks and their geological significance, Planar and linear structures; dip and strike; Outcrop patterns of different structures.

Unit 3: Fold morphology; Geometric and genetic classification of folds; Introduction to the mechanics of folding: Buckling, Bending, Flexural slip and flow folding.

Unit 4: Description and origin of foliations: axial plane cleavage and its tectonic significance. Description and origin of lineation and relationship with the major structures.

Unit 5: Geometric and genetic classification of Joints and faults. Effects of faulting on the outcrops, Criteria for recognition of faults.

Course Code: GEOL-104

Course Name: Practical on Structural Geology

Credit: 01

Basic idea of topographic contours, Topographic sheets of various scales. Introduction to Geological maps: Lithological and Structural maps. Structural contouring and 3-point problems of dip and strike. Drawing profile sections and interpretation of geological maps of different complexities Exercises of stereographic projections of mesoscopic structural data (planar, linear, folded etc.).

Suggested readings:

- Billings, M. P. (1987) Structural Geology, 4th edition, Prentice-Hall.
- Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley.
- Lahee F. H. (1962) Field Geology. McGraw Hill.
- Park, R. G. (2004) Foundations of Structural Geology. Chapman & Hall.
- Pollard, D. D. (2005) Fundamental of Structural Geology. Cambridge University Press.
- Ragan, D. M. (2009) Structural Geology: an introduction to geometrical techniques (4th Ed). Cambridge University Press (for Practical).

Course code: GEOL -201

Course Name: Elements of Geochemistry

Credit: 03

Unit 1: Introduction to properties of elements: The periodic table. Chemical bonding, states of matter and concept of major, minor and trace elements. Geochemical classification of elements.

Unit 2: Composition of different Earth reservoirs and the nuclides and radioactivity. Conservation of mass, isotopic and elemental fractionation. Concept of radiogenic isotopes in geochronology and isotopic tracers.

Unit 3: Advection and diffusion. Chromatography. Aqueous geochemistry- basic concepts and speciation in solutions, Eh, pH relations. Elements of marine chemistry. Mineral reactions- diagenesis and hydrothermal reactions.

Unit 4: The solid Earth – geochemical variability of magma and its products. The Earth in the solar system. Composition of the bulk silicate Earth. Meteorites.

Unit 5: Geochemical behaviour of the following elements: Si, Al, Fe, Ca, K, Na and Mg.

Course Code: GEOL-202

Course Name: Practical on Elements of Geochemistry

Credit: 01

Types of geochemical data analysis and interpretation of common geochemical plots. Geochemical analysis of geological materials. Geochemical variation diagrams and its interpretations.

Suggested Readings:

- Albarède, F. (2003). Geochemistry: an introduction. Cambridge University Press.
- Faure, Gunter and Teresa M. Mensing (2004). Isotopes: Principles and Applications, Wiley India Pvt. Ltd.
- Mason, B. (1986) Principles of Geochemistry. 3rd Edition, Wiley New York.
- Rollinson, H. (2007) Using geochemical data – evaluation, presentation and interpretation. 2nd Edition. Publisher Longman Scientific & Technical.
- Walther, J. V. (2009). Essentials of geochemistry. Jones & Bartlett Publishers.

Course Code: GEOL-203

Course Name: Mineral Science

Credit: 03

Unit 1: Elementary ideas about crystal morphology in relation to internal structures. Crystal parameters and indices. Crystal symmetry and common crystal forms- dome, prism, pyramid and pinacoid.

Unit 2: Study of normal classes of the Isometric, Tetragonal, Hexagonal, Trigonal, Orthorhombic, Monoclinic and Triclinic systems. Classification of 32 point groups.

Unit 3: Mineral – definition, classification and physical properties. Isomorphism, polymorphism and pseudomorphism. Silicate structures. Cubic close packing and hexagonal close packing.

Unit 4: Study of common rock-forming minerals – quartz, feldspar, pyroxene, amphibole, mica, aluminosilicate, garnet and olivine groups.

Unit 5: Introduction to the petrological microscope. Nature of light: Isotropic and anisotropic substances, ordinary and polarised light, refractive index, birefringence, pleochroism, twinkling, interference colour, extinction and twinning.

Course Code: GEOL -204

Course Name: Practical on Mineral Science

Credit: 01

Observation and documentation of symmetry elements of important crystal models of cubic, tetragonal, orthorhombic, monoclinic, triclinic and hexagonal crystal systems.

Study of physical properties of minerals in hand specimens-Silicates: Olivine, Garnet, Andalusite, Sillimanite, Kyanite, Staurolite, Beryl, Tourmaline, Topaz, Augite, Tremolite, Hornblende, Serpentine, Talc, Muscovite, Biotite, Quartz, Orthoclase, Plagioclase, Microcline, Sodalite, Zeolite and Talc.

Non-silicates: Native Metals, Graphite, Gypsum, Calcite, Fluorite, Barite, Apatite, Corundum and Pyrite.

Study of some important silicate and non-silicate minerals under petrological microscope and their characteristic properties.

Suggested Readings:

- Deer, W. A., Howie, R. A. and Zussman, J. (1992). An introduction to the rock-forming minerals. London; Longman.
- Kerr, P. F. (1959). Optical Mineralogy. McGraw- Hill.
- Klein, C., Dutrow, B., Dwight, J.: The 23rd Edition of the Manual of Mineral Science (after James D. Dana). J. Wiley & Sons.
- Verma, P. K. (2010). Optical Mineralogy. Ane Books Pvt. Ltd.

Course Code: GEOL -301

Course Name: Igneous Petrology

Credit: 03

Unit 1: Introduction to Igneous petrology: Heat flow, geothermal gradients through time, origin and nature of magma, magmatic differentiation and assimilation.

Unit 2: Classification of igneous rocks: mineralogical and chemical classification, Textures and structures of igneous rocks, Mode of occurrence of Igneous rocks.

Unit 3: Phase diagrams and petrogenesis. Unary, Binary (forsterite-silica and albite-anorthite) and Ternary (diopside-albite-anorthite and orthoclase-albite-silica) Phase diagrams in understanding crystal-melt equilibrium in basaltic and granitic magmas. Magma generation in crust and mantle, their emplacement and evolution.

Unit 4: Magmatism in different tectonic settings. Magmatism in the oceanic domains (MORB, OIB).Magmatism along the plate margins (Island arcs/continental arcs)

Unit 5: Petrogenesis of Felsic, Mafic and Ultramafic igneous rocks: granite, pegmatite, syenite, gabbro, basalt, komatiite, peridotite and pyroxenite.

Course Code: GEOL -302

Course Name: Practical on Igneous Petrology

Credit: 01

Study of important igneous rocks in hand specimens and thin sections- granite, pegmatite, syenite, diorite, gabbro, anorthosite, peridotite, pyroxenite, basalt, andesite, trachyte, rhyolite, dacite. Modal analysis and Niggli value calculations of important igneous rocks.

Suggested readings:

- Bose M.K. (1997). Igneous Petrology.
- Cox, K.G., & Bell, J.D. (1979). The Interpretation of Igneous Rocks. Springer/Chapman & Hall.
- McBirney, A. R. (1984). Igneous Petrology. San Francisco (Freeman, Cooper & Company) and Oxford (Oxford Univ. Press).
- Myron G. Best (2001). Igneous and Metamorphic Petrology,
- Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
- Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
- Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.
- Tyrrell, G.W. (1926). Principles of Petrology. Springer.
- Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.

Course Code: GEOL-303**Course Name: Metamorphic Petrology****Credit: 03**

Unit 1: Metamorphism: Definition of metamorphism. Factors controlling metamorphism. Types of metamorphism- contact, regional, fault zone metamorphism, impact metamorphism.

Unit 2: Metamorphic facies and grades: Index minerals, Concept of metamorphic facies and grade, Chemographic projections, Mineralogical phase rule, Structure and textures of metamorphic rocks.

Unit 3: Metamorphism and Tectonism: Relationship between metamorphism and deformation. Prograde and retrograde metamorphism.

Unit 4: Brief idea of anatexis and origin of migmatites. Metasomatism and role of fluids in metamorphism. Ocean floor metamorphism

Unit 5: Petrological study of the following metamorphic rocks- schist, gneiss, khondalite, charnockite, slate, quartzite and marble.

Course Code: GEOL-304**Course Name: Practical on Metamorphic Petrology****Credit: 01**

Megascopic and microscopic study (textural and mineralogical) of the following metamorphic rocks: low grade metamorphic rocks- serpentinite, schist, slate; medium to high grade metamorphic rocks- Gneiss, amphibolite, garnetiferous schist, sillimanite-kyanite-bearing rocks, granulite, eclogite, marble.

Laboratory exercises in graphic plots for petrochemistry and interpretation of assemblages.

Suggested readings:

- Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
- Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.

- Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.
- Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
- Yardley, B. W., & Yardley, B. W. D. (1989). An introduction to metamorphic petrology.
- Longman Earth Science Series.

Course Code: GEOL-401

Course Name: Sedimentary Petrology

Credit: 03

Unit 1: Physical and chemical weathering and origin of sediments, their transportation (laminar and turbulent flow) and deposition. Tectonic control on sediment generation.

Unit 2: Classification of sedimentary rocks: clastic and non-clastic. Textures in sedimentary rock: Grain size scale, particle size distribution, particle shape and fabric.

Unit 3: Sedimentary structures: Ripple marks, cross beds, mud-cracks, graded bedding, flute marks, loadcast, tracks, trails and related structures. Paleocurrent analysis.

Unit 4: Siliciclastic rocks: Conglomerates, sandstones, mudrocks. Carbonate rocks: limestone and its classification, dolomite and dolomitisation.

Unit 5: Diagenesis: Concepts and stages of diagenesis. Compaction, cementation and authigenesis/ neomorphism. Soils and paleosols.

Course Code: GEOL-402

Course Name: Practical on Sedimentary Petrology

Credit: 01

Exercises on sedimentary structures. Particle size distribution and statistical treatment. Paleocurrent analysis. Petrography of clastic and non-clastic rocks through hand specimens and thin sections.

Suggested readings:

- Collinson, J. D. & Thompson, D. B. (1988) Sedimentary structures, Unwin- Hyman, London.
- Nichols, G. (2009) Sedimentology and Stratigraphy Second Edition. Wiley Blackwell.
- Prothero, D. R., & Schwab, F. (2004). Sedimentary geology. Macmillan.
- Tucker, M. E. (2006) Sedimentary Petrology, Blackwell Publishing.

Course Code: GEOL-403

Course Name: Palaeontology

Credit: 03

Unit 1: Fossilization and fossil record: Nature and importance of fossil record; Fossilization processes and modes of preservation, Introduction to Palaeobotany, Gondwana Flora and Ichnology.

Unit 2: Species concept with special reference to palaeontology, Taxonomic hierarchy. Theory of organic evolution interpreted from fossil record. Growth strategies.

Unit 3: Brief introduction to important invertebrate groups (bivalvia, gastropoda, brachiopoda and echinoidea) and their biostratigraphic significance. Significance of ammonites in Mesozoic biostratigraphy. Functional adaptation in trilobites and ammonoids.

Unit 4: Mesozoic reptiles with special reference to origin, diversity and extinction of dinosaurs. Evolution of horse and intercontinental migrations. Human evolution.

Unit 5: Application of Fossils in stratigraphy: Biozones, index fossils and correlation. Fossils and paleoenvironmental analysis. Application of palaeontology in paleoecology.

Course Code: GEOL -404

Course Name: Practical on Palaeontology

Credit: 01

Study of fossils showing various modes of preservation. Study of diagnostic morphological characters, systematic position, stratigraphic position and age of various invertebrate, vertebrate and plant fossils.

Suggested readings:

- Brasier, M.D. (2005) Microfossils. Blackwell Publishing.
- Benton, M. (2009). Vertebrate palaeontology. John Wiley & Sons.
- Clarkson, E. N. K. (2012) Invertebrate palaeontology and evolution 4th Edition by Blackwell Publishing.
- Raup, D. M., Stanley, S. M., Freeman, W. H. (1971) Principles of Palaeontology.
- Shukla, A. C. And Misra, S. P. (1975). Essentials of palaeobotany. Vikas Publisher.

Course Code: GEOL-501

Course Name: Geomorphology

Credit: 03

Unit 1: Introduction to Geomorphology, Historical development of geomorphological concepts and scales in geomorphology. Endogenic and exogenic processes- diastrophism, orogenesis, degradational, aggradational and anthropogenic processes.

Unit 2: Geoid, topography, hypsometry. Topography of ocean basins and mountain ranges (with emphasis on Himalaya). Concept of plate tectonics.

Unit 3: Surficial processes, weathering and erosion. Glacial, periglacial, fluvial, coastal and eolian processes and associated landforms. Landforms associated with igneous activity.

Unit 4: Rates of uplift and denudation. Tectonics and drainage development. Sea-level changes. Long-term landscape development.

Unit 5: Overview of Indian Geomorphology: Northern mountains, the Great Plains, Central Highlands, Peninsular Plateau, Coastal Plains and the Islands. Extraterrestrial landforms. Hill slopes. Surface processes and natural hazards.

Course Code: GEOL-502

Course Name: Practical on Geomorphology

Credit: 01

Reading topographic maps. Concept of scale in preparation of a topographic profile. Preparation of longitudinal profile of a river; Preparing Hack Profile; Calculating Stream length gradient index. Morphometry of a drainage basin. Calculating different morphometric parameters. Preparation of geomorphic map, Interpretation of geomorphic processes from the geomorphology of the area.

Suggested readings:

- Robert S. Anderson and Suzanne P. Anderson (2010): Geomorphology - The Mechanics and Chemistry of Landscapes. Cambridge University Press.
- Summerfield, M.A. (1991) Global Geomorphology. Wiley & Sons.
- Thornbury, W.D. (1996) Principles of Geomorphology. John Wiley.

Course Code: GEOL -503

Course Name: Economic Geology

Credit: 03

Unit 1: Ore and gangue minerals, tenor. Resources and reserves. Classification of Economic minerals: metallic and non-metallic. Metallogenic Provinces and Epochs. Textures and structures of ores.

Unit 2: Processes of formation of ore deposits: Magmatic, hydrothermal, metamorphic, sedimentary, residual and mechanical concentration; oxidation and supergene enrichment. Classification of ore deposits.

Unit 3: Chemical composition, occurrence, origin, uses and distribution of the following economic mineral deposits in India: iron, manganese, chromium, copper, aluminium, lead & zinc and gold.

Unit 4: Chemical composition, occurrence, origin, uses and distribution of the following industrial mineral deposits in India: magnesite, graphite, mica, asbestos, sillimanite and kyanite.

Unit 5: Brief account on the following economic deposits in the North East India: coal, petroleum, limestone, chromite and uranium. Introduction to gemstones.

Course Code: GEOL -504

Course Name: Practical on Economic Geology

Credit: 01

Megascopic identification of ores. Study of microscopic properties of ore forming minerals (Oxides and sulphides). Distribution of important ores and other economic minerals in India.

Suggested readings:

- Bateman, A.M. and Jensen, M.L. (1990) Economic Mineral Deposits. John Wiley.
- Deb, S. (1980) Industrial minerals and rocks of India. Allied Publishers.
- Evans, A.M. (1993) Ore Geology and Industrial minerals. Wiley.

- Guilbert, J.M. and Park Jr., C.F. (1986) The Geology of Ore deposits. Freeman & Co.
- Gokhale, K.V.G.K. and Rao, T.C. (1978) Ore deposits of India their distribution and processing, Tata-McGraw Hill, New Delhi.
- Laurence Robb. (2005) Introduction to ore forming processes. Wiley.
- Sarkar, S.C. and Gupta, A. (2014) Crustal Evolution and Metallogeny in India. Cambridge Publications.

Course Code: GEOL -505

Course Name: Stratigraphic Principles and Indian Stratigraphy

Credit: 03

Unit 1: Concept of facies in stratigraphy. Walther's law of facies. Concepts of litho-, bio- and chrono-stratigraphy. Dynamic stratigraphy: chemostratigraphy, seismic stratigraphy, sequence stratigraphy. Magnetostratigraphy.

Unit 2: International Stratigraphic Code – development of a standardized stratigraphic nomenclature. Concepts of stratotypes. Global stratotype section and point (GSSP). Concept of paleogeographic reconstruction.

Unit 3: Brief introduction to tectonic and physiographic subdivisions of India. Introduction to Indian Shield. Introduction to Proterozoic basins of India: Geology of Vindhyan and Cuddapah basins.

Unit 4: Palaeozoic succession of Kashmir and its correlatives from Spiti and Zaskar Stratigraphy. Mesozoic stratigraphy of India: Triassic successions of Spiti, Jurassic of Kutch, Cretaceous of Trichinopoly. Cenozoic stratigraphy of Assam.

Unit 5: Important Stratigraphic boundaries in India: Precambrian-Cambrian boundary, Permian-Triassic boundary and Cretaceous-Tertiary boundary. Volcanic provinces of India: Deccan, Rajmahal and Sylhet Trap.

Course Code: GEOL-506

Course Name: Practical on Stratigraphic Principles and Indian Stratigraphy

Credit: 01

Study of geological map of India and identification of major stratigraphic units. Study of rocks in hand specimens from known Indian stratigraphic horizons. Drawing various paleogeographic maps of Precambrian time. Study of different Proterozoic supercontinent reconstructions.

Suggested readings:

- Doyle, P. & Bennett, M. R. (1996). Unlocking the Stratigraphic Record. John Wiley.
- Krishnan, M. S. (1982). Geology of India and Burma, CBS Publishers, Delhi.
- Ramakrishnan, M. & Vaidyanadhan, R. (2008). Geology of India Vol. 1 & 2, Geological Society of India, Bangalore.
- Valdiya, K. S. (2010). The making of India, Macmillan India Pvt. Ltd.
- Ravindra Kuman (1986). Fundamentals of Historical Geology and Stratigraphy of India.

Course Code: GEOL-601

Course Name: Engineering and Exploration Geology

Credit: 03

Unit 1: Role of Engineering geologists in planning, design and construction of major man-made structural features. Site investigation and characterization (relief, lithology, structures, ground water conditions). Foundation treatment; grouting, rock bolting and other support mechanisms.

Unit 2: Geological, geotechnical and environmental considerations for dams and reservoir, highways and bridges. Tunnels and tunnelling methods.

Unit 3: Landslides: Causes, effects and mitigation/preventive measures. Earthquakes: Causes, effects and mitigation measures.

Unit 4: Resource and reserve - definitions. Prospecting and exploration - conceptualization, methodology and stages. Principles of mineral exploration. Sampling, Geochemical exploration, Remote sensing, Geophysical prospecting. Ore grade and its assessment.

Unit 5: Principles of reserve estimation, density and bulk density. Factors affecting reliability of reserve estimation. Reserve estimation based on geometrical models (square, rectangular, triangular and polygon blocks). Principles of Mineral economics: strategic, critical and essential minerals. National and domestic mineral policies

Course Code: GEOL-602

Course Name: Practical on Engineering and Exploration Geology

Credit: 01

Computation of reservoir area, catchment area, reservoir capacity and reservoir life. Merits, demerits & remedial measures based upon geological cross sections of project sites. Computation of Index properties of rocks.

Identification of anomaly. Concept of weighted average in anomaly detection. Geological cross-section. Models of reserve estimation.

Suggested readings:

- Bell, F.G. (2006) Basic Environmental and Engineering Geology Whittles Publishing.
- Bell, F.G. (2007) Engineering Geology, Butterworth-Heinemann.
- Goodman, R.E. (1993) Engineering Geology: Rock in Engineering constructions. John Wiley & Sons, N.Y.
- Johnson, R.B. and De Graf, J.V. (1988) Principles of Engineering Geology, John Wiley.
- Krynin, D.P. and Judd W.R. 1957. Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).
- Waltham, T., 2009. Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.
- Arogyaswami, R.P.N. (1996) Courses in Mining Geology. 4th Ed. Oxford-IBH.
- Clark, G.B. (1967) Elements of Mining. 3rd Ed. John Wiley & Sons.
- Moon, C.J., Whateley, M.K.G., Evans, A.M. (2006) Introduction to Mineral Exploration, Blackwell Publishing.

Course Code: GEOL -603

Course Name: Remote Sensing and GIS

Credit: 03

Unit 1: Types and acquisition of aerial photographs. Scale and resolution. Principles of stereoscopy, relief displacement, vertical exaggeration and distortion. Elements of air photo interpretation. Identification of sedimentary, igneous, metamorphic rocks and geomorphic landforms.

Unit 2: Concepts in remote sensing and EM radiations and its interaction with atmosphere. Platforms, sensors and scanners. Satellites and their characteristics.

Unit 3: Data formats- raster and vector. Digital image processing, image errors, rectification and restoration, image enhancement, filtering, image rationing. Image classification - supervised and unsupervised classification. Accuracy assessment.

Unit 4: Introduction to GIS. Datum, coordinate systems and projection systems. Spatial data models and data editing: attribute data input and management, data editing, exploration and analysis. Applications of GIS. Introduction to DEM analysis.

Unit 5: Concepts of GPS. Components of GIS-GPS receivers. GPS position modes- Point positioning and relative positioning, accuracy and error sources. Integrating GPS data with GIS, Applications in earth system sciences.

Course Code: GEOL-604

Course Name: Practical on Remote Sensing and GIS

Credit: 01

Aerial photo interpretation, identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms. Creating a FCC from raw data. Registration of satellite data with a toposheet of the area. Enhancing the satellite images; Generating NDVI images and other image ratio and its interpretation. DEM analysis: generating slope map, aspect map and drainage network map and its applications.

Suggested readings:

- Demers, M.N.(1997)Fundamentals of Geographic Information System, John Wiley & sons. Inc.
- Hoffmann-Wellenhof, B., Lichtenegger, H. and Collins, J. (2001)GPS: Theory &Practice, Springer Wien New York.
- Jensen, J.R. (1996) Introductory Digital Image Processing: A Remote Sensing Perspective, Springer- Verlag.
- Lillesand, T. M. & Kiefer, R.W. (2007) Remote Sensing and Image Interpretation, Wiley.
- Richards, J.A. and Jia, X. (1999) Remote Sensing Digital Image Analysis, Springer-Verlag.

Course Code: GEOL-605

Course Name: Hydrogeology

Credit: 03

Unit 1: Scope of hydrogeology. Hydrologic cycle: precipitation, evapotranspiration, run-off, infiltration and subsurface movement of water. Origin of groundwater. Vertical distribution of subsurface water. Rock properties affecting groundwater; aquifer parameters. Types of aquifer.

Unit 2: Darcy's law and its validity; intrinsic permeability and hydraulic conductivity; laminar and turbulent groundwater flow. Determination of hydraulic conductivity in the laboratory and field. Groundwater table contour maps. Water level fluctuations.

Unit 3: Basic concepts of well hydraulics and groundwater exploration. Surface-based groundwater exploration methods. Introduction to subsurface borehole logging methods.

Unit 4: Physical and chemical properties of water and water quality. Introduction to methods of interpreting groundwater quality data using standard graphical plots. Conjunctive and consumptive uses of surface and ground water. Sea water intrusion in coastal aquifers.

Unit 5: Surface and subsurface water interaction. Basic concepts of water balance studies. Groundwater pollution. Issues related to groundwater resources development and management. Rainwater harvesting.

Course Code: GEOL-606

Course Name: Practical on Hydrogeology

Credit: 01

Preparation and interpretation of water level contour maps and depth to water level maps. Study, preparation and analysis of hydrographs for differing groundwater conditions. Water potential zones of India (map study). Graphical representation of chemical quality data and water classification (C-S and Trilinear diagrams). Simple numerical problems related to: determination of permeability in field and laboratory, Groundwater flow, Well hydraulics etc.

Suggested readings:

- Davis, S.N. and De Weist, R.J.M. (1966) Hydrogeology, John Wiley & Sons Inc., N.Y.
- Karanth K.R. (1987) Groundwater: Assessment, Development and management, Tata McGraw-Hill Pub. Co. Ltd.
- Todd, D. K. (2006) Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.

Course Code: GEOL-607

Course Name: Geological Field Work

Credit: 04 (Minimum 7 Working Days)

Basic Field Training (Compulsory): 2 Credits

Orientation of Topographic sheet in field, marking location in toposheet, reading contours and topography. Bearing (Front and back). Concepts of map reading, distance, height and pace approximation. Identification of rock types in field; structures and texture of rocks, Use of hand lens. Basic field measurement techniques: Bedding dip and strike, Litho-log measurement. GPS handling.

In addition to the above compulsory basic field training, the students should undergo any ONE of the following field training programmes:

(i) Precambrian Geology Field (2 Credits)

Field transect in any Precambrian terrain. Study of craton ensemble including basic intrusive suites. Precambrian sedimentary basins. Basement-Cover relation in old belts and sedimentary successions.

(ii) Tertiary Geology Field (2 Credits)

Field training along Tertiary terrain. Documentation of stratigraphic details in the field. Collection of sedimentological, stratigraphic and structural details.

OR

Visit to any Oil Field of Northeast India and preparation of detailed report.

(iii) Economic Geology Field (2 Credits)

Module I: Visit to any Economic mineral deposit: mode occurrence of ore and ore mineralogy, ore formation process. Basic techniques of surveying, concept of outcrop mapping.

OR

Module II: Visit to underground or open cast mine: practical experience of mining methods. Underground mapping/ Bench mapping.

Course Code: GEOL -701

Course Name: Geology of Nagaland

Credit: 03

Unit 1: Introduction to Geology of Nagaland: physiography, stratigraphy, fossil content and tectonic setting.

Unit 2: Belt of Schuppen: stratigraphy, structure and petrology of the litho-units. Geological characteristics of thrusts with special reference to the Naga and Disang thrusts.

Unit 3: Inner Fold Belt: stratigraphy, structure and petrology of the various litho-units.

Unit 4: Naga Ophiolite Belt: major litho-units, structure, tectonic setting and evolution.

Unit 5: Mineral resources of Nagaland with special reference to coal, petroleum, limestone, chromite and serpentinite.

Course Code: GEOL -702

Course Name: Practical on Geology of Nagaland

Credit: 01

Megascopic studies of Disang shale, Barail sandstone, Surma sandstone, Tipam sandstone, Girujan clay, Dihing pebbles and boulders, vesicular basalt, spilite, gabbro, pyroxenite, peridotite, serpentinite, dolerite, plagiogranite, blue schist, phyllite, marble, limestone and conglomerate. Study of the following minerals: asbestos, coal, chert, chromite, magnetite, talc and jadeite. Study of available fossils of Nagaland.

Suggested readings:

- Geology of Nagaland Ophiolite (1982) Geological Survey of India Memoirs, v. 119.
- Ghose, N.C. Phanerozoic Ophiolites of India Sumna Publishers & Distributors, Patna.
- Krishnan, M.S. (1982) Geology of India and Burma. CBS Publishers & Distributors.
- Kumar, R. (1985) Fundamental of Historical Geology and Stratigraphy of India (3rded) Wiley Eastern.
- Nandy, D.R. (2001) Geodynamics of North-eastern India and the Adjoining Region. ACB Publications.

- Srivastava, S.K. (2016) Recent trends in Earth Science Research with special reference to NE India, (Ed) Today's and Tomorrow's Printers and Publishers.
- Mekro, Vizovol (2014) Rocks of Nagaland, Mittal Publications.
- Wadia, D.N. (1957) Geology of India (3rd ed).

Course Code: GEOL -703

Course Name: Environmental Geology

Credit: 03

UNIT 1: Introduction to environmental geology; cultural and environmental awareness, geology as a basic environmental Science. Earth as a system, Sustainability and limitation of resources.

UNIT 2: Environmental pollution: causes, impacts, remediation/mitigation measures of air and water pollution. Vehicular pollution.

UNIT 3: Geological hazards: Primary and secondary hazards, Seismic engineering, early warning systems, Planning and education. Stabilizing hill slopes and controlling landslides, Vulnerability zone, types and mitigation measures.

UNIT 4: Anthropogenic hazard: causes, impact and preventive measures on deforestation. Soil sickness, soil loss equation, conservation method.

UNIT 5: Geo-environmental Problems of NE India: Geological and topographic characteristics, climate, drainage, groundwater, soil, land use, land capability, forest cover and their mitigation.

Course Code: GEOL -704

Course Name: Practical on Environmental Geology

Credit: 01

Case studies on population growth, deforestation, water and air pollution, earthquake zones of the world, landslide zonation maps and geoenvironmental problems of North east India.

Suggested readings:

- 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.
- Asthana, D.K. (2006) Environmental Problems and Solutions. S. Chand Publications.
- Sivakumar, R. (2013) Environmental Science and Engineering. Sri Krishna Hitech Publishing Company Pvt. Ltd.
- Sharma, P.D. (2012) Ecology and Environment. Rastogi Publications.
- Keller, E.A. (1978) Environmental Geology. Bell & Howell.
- 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.
- Valdiya, K.S. (1987) Environmental Geology - Indian Context. Tata McGraw Hill.

Course Code: GEOL -705
Course Name: Fuel Geology
Credit: 03

Unit 1: Definition and origin of Coal. Basic classification of coal. Introduction to lithotypes, micro lithotypes and macerals in coal, Proximate and Ultimate analysis.

Unit 2: Coal Bed Methane (CBM) - introduction, reservoir properties, storage and transport. Underground coal gasification and liquefaction.

Unit 3: Chemical composition and physical properties of petroleum. Origin and migration of oil. Properties of reservoir rocks. Drilling methods.

Unit 4: Reservoir rocks - clastic and chemical, hydrocarbon traps - structural, stratigraphic and combination, Cap rocks - definition and general properties.

Unit 5: Gas Hydrates. Radioactive minerals: Occurrence and origin of Uranium and Thorium bearing minerals, reserves in India. Nuclear waste disposal.

Course Code: GEOL -706
Course Name: Practical on Fuel Geology
Credit: 01

Study of hand specimens of coal. Reserve estimation of coal. Section correlation and identification of hydrocarbon prospect. Panel and Fence diagrams.

Suggested readings:

- Bastia, R. and Radhakrishna, M. (2012). Basin evolution and petroleum prospectivity of the continental margins of India (Vol. 59). Newnes.
- Bjorlykke, K. (1989). Sedimentology and petroleum geology. Springer-Verlag.
- Chandra D. (2007). Chandra's Textbook on applied coal petrology. Jijnasa Publishing House.
- Shelly R. C. (2014). Elements of Petroleum geology: Third Edition, Academic Press.

Course Code: GEOL -707
Course Name: Research Methodology
Credit: 04 (Common Course for all Under-Graduate Departments)
