FOUR-YEAR UNDERGRADUATE PROGRAMME (FYUP)

Date of Approval by Academic Council -30th May and 21st June 2024

DEPARTMENT OF GEOLOGY
NORTH-EASTERN HILL UNIVERSITY
SHILLONG-793022

PREFACE

About the FYUG Programme of Geology:

The Department of Geology offers a three/ four years Bachelor of Sciences (B.Sc.) in Geology. The course content of B.Sc. in Geology has been designed to impart knowledge in pure and applied aspects of Geology. The programme will help students to extract valuable information stored in rocks, minerals, and fossils.

Under this programme, the students will gain in-depth knowledge on successive advancements in the subject of geology. Focus of this programme is to inculcate in the students the spirit of researching, identifying the knowledge-gaps in the specific core branches of geology, and motivating them to take up and address such geo-scientific problems in future. The programme will enable the students to understand the intricacies of various mineral, rock, and terrain forming processes resulting from spatio-temporal variations under the prevailing physico-chemical conditions. Such a knowledge will make them able to locate, explore, and judiciously utilize the Earth's resources, solving the complex geological problems, providing the geo-engineering solutions to sundry geo- environmental problems, including the hazard vulnerability, and safety and stability of civil engineering structures, as well as fill-up the knowledge-gaps pertaining to core branches of geology.

After completing this programme, the students will have wide-spectrum, in-depth knowledge in the subject of geology, covering basic principles, gradual advancements, and classical and recent concepts. The students will be able to identify, analyze, and solve different types of geological problems, to ensure developmental activities and optimum harnessing of the earth resources without adversely affecting the geo-environment or endangering the terrain stability, and to analyze the vulnerability of any terrain to various types of geo-hazards. It will also install in them the quest for better understanding of the subject through incessant pursuance and research.

PROGRAMME OUTCOMES

The Undergraduate programme in Geology aims to:

1.	Enabling the students to understand the age, composition, structure, processes, and Evolutionary history of the Earth.
2.	Enabling the students to identify, locate, explore, judiciously exploit, and manage various Earth resources like minerals, fossil fuel and natural gas, coal, building stones, weathered Crust and soils, underground and surface water etc.
3.	Enabling the students to understand and assess the potential of natural processes in causing hazards and disasters.
4.	To enhance knowledge of geological science with more sophisticated tools and techniques.
5.	Enabling the students to assess the suitability of terrain for various civil engineering constructions such as dams, reservoirs, bridges, tunnels, roads, railway lines, cable-cars, and buildings etc.
6.	Enabling the students to formulate and execute guidelines for safe developmental activities in diverse geological terrains.
7.	Motivating the students to take up higher studies and research to bring out new knowledge. Yet to be understood the geological aspects of the Earth.
8.	Understand and uphold professional ethics and standards in geology, such as the prudent use of geological resources, the preservation of the environment, and the encouragement of safety during geological studies.
9.	Students will gain the ability to adapt to cutting-edge technological developments in order to pursue employment in geology-related industries, such as mineral exploration, environmental consultancy, geological surveys, academia, and research institutes.
10.	This programme will ensure a strong foundation in geology and the fundamental abilities students need to succeed professionally and make contributions to the geosciences industry.

Structure of Geology Syllabus

1st Semester					
Course Code	**Title of the Course**	**Credit**			**Contact Hours**
		Theory	**Practical**	**Total**	
GEL 100	Introduction to Geology (Major)	3	1	4	75
GEL 100	Introduction to Geology (Minor)	3	1	4	75
MDC-110…119	Any one of the available courses as notified by the University from time to time.	3	-	3	45
AEC-120…129	Any one of the available courses as notified by the University from time to time.	3	-	3	45
SEC-130…139	Any one of the available courses as notified by the University from time to time.			3	45-90
VAC -140	Environmental Science	3	-	3	45
				20	
2nd Semester					
Course Code	**Title of the Course**	**Credit**			**Contact Hours**
		Theory	**Practical**	**Total**	
GEL -150	Minerals and Rocks (Major)	3	1	4	75
GEL -150	Minerals and Rocks (Minor)	3	1	4	75
MDC-160…..169	Any one of the available courses as notified by the University from time to time.	3	-	3	45
AEC-170…..179	Any one of the available courses as notified by the University from time to time.	3	-	3	45
SEC-180……189	Any one of the available courses as notified by the University from time to time.			3	45-90
VAC-190… ..199	Any one of the available courses as notified by the University from time to time.	3	-	3	45
				20	

3rd Semester					
Course Code	**Title of the Course**	**Credit**			**Contact Hours**
		Theory	**Practical**	**Total**	
GEL - 200	Crystallography and Mineralogy	3	1	4	75
GEL - 201	Structural Geology	3	1	4	75
MDC-210... ...219	Any one of the available courses as notified by the University from time to time	3	-	3	45
AEC-220… …229	Any one of the available courses as notified by the University from time to	2	-	2	30

	time				
SEC-230..239	Any one of the available courses as notified by the University from time to time			3	45 -90
VTC-240 … … 249	Any one of the available courses as notified by the University from time to time	1	3	4	105
				20	
4th Semester					
GEL - 250	Sedimentary Petrology	4	-	4	60
GEL - 251	Igneous Petrology	4	-	4	60
GEL - 252	Metamorphic Petrology	4	-	4	60
GEL - 253	Practical and Field work	-	4	4	120
VTC-260……269	Any one of the available courses as notified by the University from time to time	1	3	4	105
				20	
5th Semester					
GEL - 300	Stratigraphy and Palaeontology	4	-	4	60
GEL - 301	Practical and Field work	-	4	4	120
GEL - 302	Economic and Fuel Geology (Major)	4	-	4	60
GEL - 302	Disaster Risk Reduction (Minor)	4	-	4	60
GEL -303	Internship	-	4	4	120
				20	
6th Semester					
GEL - 350	Remote Sensing and GIS	4	-	4	60
GEL - 351	Hydrogeology and Engineering Geology	4	-	4	60
GEL - 352	Exploration and Mining Geology	4	-	4	60
GEL - 352	Practical and Field work	-	4	4	120
VTC-360…369	Any one of the available courses as notified by the University from time to time.	1	3	4	105
				20	

SEMESTER 1

GEOL-100: INTRODUCTION TO GEOLOGY

Credits: 3+1 / Total marks: 100 / Total Contact Hours: 75 (45 T + 30 P)

Course Objective: To understand the Solar System, the Earth and various features of the Earth's surface.

Learning Outcome: Students will gain knowledge about the Solar System and position of the Earth in the solar system along with the concept behind movements of the tectonic plates.

Theory (3 Credits, Contact Hours 45)

UNIT I: Introduction and scope of geology. The Solar System – planets, Meteorites and Asteroids. Earth – its position in the solar system. Internal structure of the Earth. Interacting Earth systems: Lithosphere, Hydrosphere, Atmosphere and Biosphere. Standard Geological time scale and introduction to the concept of time in geological studies. **(15 hours)**

UNIT II: Weathering and erosion, its resultant product. Mass wasting. Erosional and depositional landforms associated with water, wind and glacier. Drainage: types and patterns. **(15 hours)**

UNIT III: Continental drift. Seafloor spreading. Plate and plate tectonics; Plate motions: causes, rate and Wilson cycle; Plate boundaries. Rock deformation: folds faults, joints, and unconformities. Landform related to active folding and faulting. Earthquakes – mechanism and distribution. Volcanoes- types, products and their distribution. **(15 hours)**

Practical (1 Credit, Contact Hours 30)

UNIT IV: Study of topographic maps and geomorphic features. Drawing of contours and profile. Study of models: Physiographic, Landforms, Structures. *****The students shall be exposed to the field for using the geological equipment's and collecting the samples in the field. **(30 hours)**

Suggested Readings: (Updated Version)

Duff, P. M. D., & Duff, D. (Eds.). (1993). Holmes' principles of physical geology. Taylor & Francis
Emiliano, C. (1992). Planet earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press.
Thompson G.R.R., Turk J. (1997) Introduction to Physical Geology. Brooks Cole.
Tarbuck, E. J. &Lutgens, F. K. (1998). Earth: An Introduction to Physical Geology. Pearson
Thornbury W. D., (1958) Principles of Geomorphology John Wiley and Sons.

SEMESTER 2

GEOL-150: MINERALS AND ROCKS

Credits: 3+1 / Total marks: 100 / Total Contact Hours: 75 (45 T + 30 P)

Course Objective: To study the basic principles about minerals and rocks**.**

Learning Outcome: Students will gain knowledge about minerals and rocks such as Igneous, Sedimentary and Metamorphic rocks.

Theory (3 Credits, Contact Hours 45)

UNIT I: Minerals – Definition, perspective, scope and significance. Physical properties of minerals: Properties based on interaction with light (Colour, lustre, streak, play of colours, Chatoyancy and Asterism, Luminescence), Mechanical properties of mineral (cleavage, parting, fracture, hardness, tenacity) and Mass related properties of minerals (density and specific gravity). **(15 hours)**

UNIT II: Optical properties of minerals (Pleochroism, double refraction, birefringence, extinction, and interference colour. Gemstones. Rock cycle: Processes of rock formation. **(15 hours)**

UNIT III: Rocks- Definition, types. Textures and structures.
Igneous rock- magma generation, differentiation and crystallisation.
Sedimentary rock- surface processes and sedimentary environments.
Metamorphic rock- factors and types of metamorphism. **(15 hours)**

Practical (1 Credit, Contact Hours 30)

UNIT IV: A. Identification of common rock forming minerals in hand specimens: Quartz, Plagioclase, microcline, calcite, garnet, hornblende, biotite, augite, sillimanite. B. Identification of some common Igneous, Sedimentary and Metamorphic rocks under hand specimen: granite, basalt, sandstone, limestone, marble, gneiss. C. Reading topographical maps of the Survey of India; Identification of some common landforms on topographical maps. D. The students shall be exposed to the field for using the inclinometer and Brunton Compass and to collect the rock and mineral specimens in the field at least for two days. **(30 hours)**

Suggested Readings: (Updated Version)

Dexter Perkins., Mineralogy, 3rd edition, 2015.
Homes A., (1993) Principle of Physical Geology 4th Ed., Chapman and Hall, London.
Rutley's Elements of Mineralogy 27th Edition- revised by CD Gribbek.
Verma, V.K., Walia, D. and Deshmukh, B. (2023) Geomorphology with Indian Examples, Rawat Publications, New Delhi.

SEMESTER 3

GEOL-200: CRYSTALLOGRAPHY AND MINERALOGY

Credits: 3+1 / Total marks: 100 / Total Contact Hours: 75 (45 T + 30 P)

Course Objective: The course introduces fundamentals of crystallography and mineralogy to enable students understands and acquires basic knowledge in this respect. Students will understand the nature and characteristics of various rock-forming minerals and their systematic characteristics. It also includes the relationship of behaviour of light and the crystals.

Learning Outcome: The students will develop capacity to study the diagnostic and optical properties of common rock forming minerals under microscope. The course provides better understanding to students in the fundamentals of Crystallography, Mineralogy and Optical Mineralogy and its application involved during the origin and evolution of the rocks.

Theory (3 Credits, Contact Hours 45)

UNIT I: Introduction to crystallography, Morphology of crystals; face, edge and solid angle. Laws of constancy of interfacial angles, axial systems and axial ratio, (Miller Indices and HM symbol). Crystal symmetry and classification of crystals; Crystal projections; Elements of crystal chemistry and aspects of crystal structures; CCP and HCP structures. **(15 hours)**

UNIT II: Silicate structures. Rock-forming minerals. Silicate, and Non-Silicates – Sulphates, Oxides, Carbonates and Phosphates. **(15 hours)**

UNIT III: Properties of light and optical microscopy; Nature of light and principles of optical mineralogy, Nicol Prism. Introduction to the petrological microscope. **(15 hours)**

Practical (1 Credit, Contact Hours 30)

UNIT IV: Study of crystals and symmetry elements of crystal-models; Stereographic projections of crystal models of different systems. Study of physical properties of minerals in hand specimen; Study of optical properties of quartz, microcline, orthoclase, plagioclase, mica, amphibole, clinopyroxene, orthopyroxene, garnet, olivine, aluminosilicate, calcite, zircon, apatite, magnetite. **(30 hours)**

Suggested Readings: (Updated Version)

Berry, L.G., Mason, B. and Dietrich, R.V. (1985): Mineralogy: Concepts, Descriptions and determinations. CBS

Deer, W.A., Howie, R.A. and Zussman, J. (2013): An Introduction to the rock forming minerals, ELBS and Longman

Gribble, C.D. (2005): Rutley's elements of Mineralogy, Springer.

Perkins, D. (2013): Mineralogy, Prentice Hall

Phillips, F.C. (1971): Introduction to Crystallography. Longman Group Publication.

GEOL-201: STRUCTURAL GEOLOGY

Credits: 3+1 / Total marks: 100 / Total Contact Hours: 75 (45 T + 30 P)

Course Objective: The primary goal of structural geology is to uncover the history of deformation in the rocks. The deformation of the lithospheric rocks by tectonic forces can be learnt through this subject. Structural geology also helps to understand the geodynamics of regional to global dimension. Structural control on ore localization and landscape evolution are learnt through this subject. Application of structural geology in the engineering geology project is enormous.

Learning Outcome: Students will be exposed to complexities of nature to understand the forces involved in the formation of various features present in the rocks and the instruments used to record the attitude of the rock beds. Hence will get the exposure of working in the field to identify the structures and plot them.

Theory (3 Credits, Contact Hours 45)

UNIT I: Stress: Definition, units and dimension; types of stress, principle stress axes, stress ellipsoid, traction. Strain: Definition, units strain, types of strain, elasticity, plasticity, rigidity in rocks; ductile and brittle behaviour of rocks; Stress-strain relationships. Factors controlling mechanical behaviour of rocks. Strain Ellipse and strain ellipsoid. Mohr's circle. **(15 hours)**

UNIT II: Planar and linear structures. Concept of dip, strike, pitch and plunge. Fold morphology; Geometric classification of folds. Introduction to the mechanics of folding: Buckling, Bending, Flexural slip and flow folding. Ramsay's classification based on the dip isogons. Superimposed folds. Foliation and lineation: description, classification and origin. Relationship of lineation and foliation with the major structures. **(15 hours)**

UNIT III: Fracture and fault: Geometric and genetic classification of fractures and faults. Effects of faulting on the outcrops. Geologic/geomorphic criteria for recognition of faults and fault plane. Joints: Definition, classification and origin. Relation of joints with major geological structures. Unconformity: Definition and types of unconformity; criteria for recognition of unconformities. **(15 hours)**

Practical (1 Credit, Contact Hours 30)

UNIT IV: Use of clinometer and Brunton compass for structural measurements. Drawing profile sections, cross-section and interpretation of geological maps of different complexities. Study of structure contour map; 3-point problems of dip and strike. Exercises of stereographic projections of mesoscopic structural data (planar, linear, folded etc.) Demonstration of various Linear & Planner structure in the field. The students shall be exposed to the field for using the geological equipment to collect the structural data and plot it in the topographic sheets/stereographic projection/diagrams. **(30 hours)**

Suggested Readings: (Updated Version)

Billings, M. P. (1992): Structural Geology, Prentice-Hall India Pvt. Ltd., New Delhi.
Fossen, H. (2010): Structural Geology, Cambridge University Press:
Gass, I.G., Smith, Peter, J. and Wilson, R.C.L. (1972): Understanding the Earth. Artemis Press Ltd. U.K.
Ghosh, S.K. (1993): Structural Geology: Fundamental and Modern Developments. Pergamon Press.

Twiss, R.J. and Moores, E.M. (2006): Structural Geology Second Edition, W. H. Freeman.

SEMESTER 4

GEL-250: SEDIMENTARY PETROLOGY

Credits: 4 / Total marks: 100 / Total Contact Hours: 60

Course Objective: To impart requisite knowledge about the processes of formation of sediments and their transformation into sedimentary rock as well as their depositional environment. The course also puts emphasis on the classification and petrographic description of sedimentary rocks.

Learning Outcome: Students can visualize the processes of transportation, deposition of sediments and generation of bedforms. The course also provides better understanding about diagenetic processes and depositional sedimentary environments.

Theory (4 Credits, Contact Hours 60)

UNIT I: Weathering: Physical and chemical weathering, soils and paleosols. Fluid flow, Transportation and Deposition of sediments. Sediment texture (grain size scale, particle size distribution, particle shape and fabric), textural parameters and their significance. Heavy minerals and their significance. Classification of sedimentary rocks. **(15 hours)**

UNIT II: Sedimentary structures – primary and secondary structures and their significance. Paleocurrent analysis. Sedimentary Facies; Characteristics of Depositional sedimentary environments: Fluvial, Deltaic, Tidal flat and Deep-Sea environments. **(15 hours)**

UNIT III: Diagenesis: compaction, cementation, lithification, authigenesis, replacement and recrystallization. Physico – chemical factors of sedimentation. **(15 hours)**

UNIT IV: Petrographic description of the following rock types: Sandstone, Mudstone, limestone, breccia, conglomerate, evaporites and volcaniclastics. **(15 hours)**

Suggested Readings: (Updated Version)

Boggs S., (2009): Principles of Sedimentology and Stratigraphy, 4th Ed., Prentice Hall
Nichols, G. (2009): Sedimentology and Stratigraphy Second Edition. Wiley Blackwell
Pettijohn, F.J., (2004): Sedimentary Rocks 3rd Ed., CBS
Sengupta S.M., (2018): Introduction to Sedimentology, 2nd Ed., CBS
Selby, M.J., Earth's Changing Surface
Tyrell G.W., 1926. The principal of Petrology.
Tucker, M. E. (2006). Sedimentary Petrology, Blackwell Publishing.
Williams, H., Turner, E.J., and Gilbert, C.M., (1954): Petrography: An Introduction to the Study of Rocks in Thin Section.

GEOL-251: IGNEOUS PETROLOGY

Credits: 4 / Total marks: 100 / Total Contact Hours: 60

Course Objective: This course will provide in-depth knowledge about the origin and evolution of igneous rocks in diverse tectonic environments through several major and subsidiary magmatic processes. The petrogenesis of igneous rocks can be very well demonstrated in the light of modern phase equilibria experimental works. Igneous rocks, also called primary rocks, are most abundant and were formed throughout the Earth's evolutionary history that essentially make-up the continents as a stable platform to live on it. Students will come to know about the igneous processes and world class examples of igneous provinces, complexes, and suites of India.

Learning Outcome: Students will develop capability to understand the processes, origin, mode of occurrence and Petrogenesis of common felsic and mafic igneous rock.

Theory (4 Credits, Contact Hours 60)

UNIT I: Classification of Igneous rocks; Petrography and genetic interpretation of igneous textures in terms of rate of nucleation and crystal growth; IUGS classification schemes and nomenclature of igneous rocks: Ultramafic, mafic and felsic igneous rocks; Mode of occurrence of Igneous rocks: concordant and discordant; intrusive and extrusive structures. **(15 hours)**

UNIT II: Origin and nature of Magma; Evolution of Magma, Magmatic differentiation, Mixing and Assimilation. Role of volatiles in magma. Magmatic processes: Partial melting, fractional crystallization, magma mixing, assimilation, liquid immiscibility, and other subsidiary processes. **(15 hours)**

UNIT III: Binary and Ternary Phase diagrams in understanding crystal-melt equilibrium in basaltic and granitic magmas. Binary; Diopside-Anorthite, Forsterite-Silica, Nepheline-Silica, Forsterite-Fayalite; Albite-Anorthite. Ternary Diopside-Albite-Anorthite, Anorthite- Forsterite-Silica. **(15 hours)**

UNIT IV: Magmatism in relation to tectonism: oceanic domains (MORB, OIB); plate margins (Island arcs/continental arcs). Petrogenesis of igneous rocks: Komatiite, Basalt, Gabbro, Dolerite, Granite, Dunite, Pyroxenite, Alkaline rocks and Kimberlite. **(15 hours)**

Suggested Readings: (Updated Version)

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.

Tyrell G.W., 1926. The principal of Petrology.

Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.

GEL-252: METAMORPHIC PETROLOGY

Credits: 4 / Total marks: 100 / Total Contact Hours: 60

Course Objective: This course will allow students to gain in-depth knowledge about the origin of metamorphic rocks from different protoliths. The identification of structures, textures and mineral assemblages provide information on involved reactions under different pressures and temperature regimes, and its implication on understanding the metamorphic evolutionary history and geodynamics of mobile belts thorough time. Some noted Indian examples will be demonstrated.

Learning Outcome: Students will gain in-depth understanding of P-T limits of metamorphism, metamorphic grade, facies and idea about various phase diagrams.

Theory (4 Credits, Contact Hours 60)

UNIT I: Metamorphism: definition and controlling factors. Structure and textures of metamorphic rocks. Types of metamorphism - contact, regional, burial, cataclastic, shock metamorphism. Regional metamorphism of argillaceous, calcareous and mafic igneous rocks. Index minerals. **(15 hours)**

UNIT II: Phase rule of closed and open systems. General idea about the thermodynamic consideration in metamorphic rock. Univariant and bivariant reactions and their significance. Graphical representation of minerals in ACF, AKF and AFM diagrams. **(15 hours)**

UNIT III: Relationship between metamorphism and deformation, Metamorphic mineral reactions (prograde and retrograde). Metamorphic zones and isograde. Concept of metamorphic facies and grade: description of each facies of low, medium to high pressure and very high pressure with special reference to characteristics minerals. **(15 hours)**

UNIT IV: Petrogenesis of following rock types: slate, phyllite, schist, gneiss, quartzite, marble, amphibolite, granulite, hornfels, eclogites, charnockite and khondalite. Migmatites and their origin. **(15 hours)**

Suggested Readings: (Updated Version)

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.
Tyrell G.W., 1926. The principal of Petrology.
Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
Yardley, B. W., & Yardley, B. W. D. (1989). An introduction to metamorphic petrology. Longman Earth Science Series.

GEL-253: PRACTICAL AND FIELD WORK

Credits: 4 / Total marks: 100 / Total Contact Hours: 120

Course Objective: Geology is field and observational science. Geo-scientific hypothesis is framed in the field that can be tested through field data and laboratory investigations.

Learning Outcome: This course will enable the students to explore practical aspect of geology such as to identify the various rocks in hand specimens as well as under microscope, to know Petrogenesis and provenance etc.

Practical (4 Credits, Contact Hours 120)

UNIT I: Sedimentary Petrology: Detailed study of clastic and non- clastic rocks in hand specimen: Sandstone, Limestone, Mudstone, Conglomerate, Breccia. Study of sedimentary structures in hand specimen. Petrography of important sedimentary rock types (Sandstone, Limestone, Mudstone) with emphasis on depositional setting, provenance, and diagenesis. **(30 hours)**

UNIT III: Igneous Petrology: mesoscopic study of major igneous rock types: Gabbro, Rhyolite, Dolerite, Pyroxenite, Dunite, Peridotite, Pegmatite, Granodiorite, Syenite, Nepheline Syenite, Trachyte; and microscopic study of major igneous rock types: Granite, Basalt, Granodiorite, Gabbro, Dolerite, Anorthosite, Diorite, Syenite, Pyoxenite, Dunite, Rhyolite. CIPW normative mineral calculation. **(30 hours)**

UNIT III: Metamorphic Petrology: Study of metamorphic rocks of different metamorphic facies in hand specimens. Study of metamorphic rocks in thin sections: Schists, Gneisses, Marble, Quartzite Calculation of ACF, AKF, AFM and A'F'M values from the given chemical data / structural formula of minerals and their graphical representation. **(30 hours)**

UNIT IV: Field work along with geological field training including geological mapping techniques, understanding the interaction between topography and geologic structures. **(30 hours)**

SEMESTER 5

GEL-300: STRATIGRAPHY AND PALEONTOLOGY

Credits: 4 / Total marks: 100 / Total Contact Hours: 60

Course Objective: To provide a comprehensive knowledge about the principles and fundamentals of stratigraphy as well as distribution of different stratigraphic horizons in India. The course also puts emphasis on the scopes and applications of palaeontology as well as morphology, geological distribution and biostratigraphic significance of flora, vertebrates, invertebrates and microfossils.

Learning Outcome: The students will develop capability to visualize the principles of stratigraphy, stratigraphic subdivisions of India. It also gives insight as to how earth has behaved during Precambrian, Palaeozoic, Mesozoic and Cenozoic era. Student will be able to understand the morphology, geological distribution and biostratigraphic significance of flora, vertebrates, invertebrates, and microfossils.

Theory (4 Credits, Contact Hours 60)

UNIT I: Principles of stratigraphy. Codes of stratigraphic nomenclature: Fundamentals of litho-, bio-, magneto- and chrono-stratigraphy; Introduction to Global Stratotype Section and Point (GSSP). Precambrian Stratigraphy of Dharwar Craton, Singhbhum Craton, and Assam-Meghalaya Gneissic Complex (AMGC). Proterozoic basins of India: Vindhyan and Cuddapah basins. Gondwana Supergroup. **(15 hours)**

UNIT II: Mesozoic stratigraphy of India: Triassic of Spiti, Jurassic of Kutch, Cretaceous of Tiruchirappalli. Deccan, Rajmahal and Sylhet Trap. Cenozoic stratigraphy of India: Siwalik successions, Tertiary successions of North-East India. Lithostratigraphy of Meghalaya. Meghalayan Age. **(15 hours)**

UNIT III: Palaeontology: definition, branches and applications. Fossil: definition, types, process of fossilization, modes of preservation. Morphology, geological distribution and biostratigraphic significance of invertebrate groups and microfossils: Brachiopoda, Pelecypoda, Gastropoda, Cephalopoda, Trilobite, Echinoidea and Foraminifera. **(15 hours)**

UNIT IV: Evolution of Equus and Trilobites. Morphology and distribution of Gondwana flora: Glossopteris, Gangamopteris, Vertebraria and Ptilophyllum. Stratigraphic Boundary Problems: Precambrian- Cambrian; Permo-Triassic; K-T/Pg boundary **(15 hours)**

Suggested Readings: (Updated Version)

Clarkson, E.N.K. (2012): Invertebrate Paleontology and Evolution. 4th Edition by Blackwell Publishing.
Doyle, P. & Bennett, M. R., (1996): Unlocking the Stratigraphic Record. John Wiley
Manivannan. V, and Subramani. K., (2014): Palaeontology Practical Manual.
Jain, P.C. and Anantharaman, M.S., (2016): Palaeontology (Palaeobiology) - Evolution and Animal Distribution.
Ramakrishnan, M. & Vaidyanadhan, R., (2008): Geology of India Volumes 1 & 2, Geological society of India, Bangalore.

Valdiya, K. S., (2010): The Making of India, Macmillan India Pvt. Ltd

GEL-301: PRACTICAL AND FIELD WORK

Credits: 4 / Total marks: 100 / Total Contact Hours: 120

Course Objective: Geology is field and observational science. Geo-scientific hypothesis is framed in the field that can be tested through field data and laboratory investigations.

Learning Outcome: This course will enable the students to explore practical aspect of geology such as lithological variation from basin to basin and dome to dome, and also their correlation; identify various fossils; preparation of geological maps, cross-section, and reconnaissance and detailed surveys for geo-resource exploration and environmental purposes etc.

Practical (4 Credits, Contact Hours 120)

UNIT I: Stratigraphy: Study of lithostratigraphic maps of India showing distribution of important geological formations. Study rocks from different stratigraphic horizons in hand specimens: Meghalaya, Assam, Peninsular- Dharwar, Singhbhum, Kutch and Gondwana from known Indian stratigraphic horizons and type localities. Exercises on stratigraphic classification and correlation of: Dharwar, Cuddapah, Deccan Traps, Spiti, Kutch, Siwalik, Gondwana, Northeast India. **(30 hours)**

UNIT I: Paleontology: Study of the morphological characters of some important invertebrate fossils belonging to Brachiopoda, Bivalvia, Gastropoda, Cephalopod, Trilobita, Echinoidea and Foraminifera. **(30 hours)**

UNIT I: Economic & Fuel Geology: Hand specimen study of Indian metallic, non-metallic, and industrial minerals; Study of optical properties and identification of important ore minerals under ore- microscope; Study of maps of India showing distribution of metallic, non- metallic and industrial minerals. Macroscopic characterization of banded coals. Microscopic examination of polished particulate mounts (identification of macerals). Proximate analysis of coal. Study of geological maps and sections of important oilfields of India. **(30 hours)**

UNIT I: Field work: The paper will be based on geological field training, in which the students will be trained for the geological mapping techniques, understanding the interaction between topography and geologic structures. **(30 hours)**

GEL-302: ECONOMIC AND FUEL GEOLOGY

Credits: 4 / Total marks: 100 / Total Contact Hours: 60

Course Objective: To impart requisite knowledge of ore deposits, controls on ore localization, their classification and familiarise the students about the origin, occurrence, classification, composition and accumulation of fossil fuels especially Coal, Petroleum and Atomic minerals.

Learning Outcome: The student will be able to understand the basic concepts of ore forming processes, and distribution in India. The students will also develop capability to understand the origin, classification, composition, occurrence, accumulation, and preservation of organic matter in sediments and habitat of Coal, Petroleum and Atomic minerals.

Theory (4 Credits, Contact Hours 60)

UNIT I: Ore, gangue minerals, tenor, grade and specification. Structural, Physico-Chemical and stratigraphic controls of ore localization. Classification of ore deposits. Endogenous processes and types: Magmatic concentration, skarns, greisens, and hydrothermal deposits. Exogenous processes and types: weathering products and residual deposits, oxidation and supergene enrichment, placer deposits. **(15 hours)**

UNIT II: Origin, mode of occurrence, mineralogy and distribution of gold, copper, lead-zinc, aluminium, iron, chromium, mica, limestone, diamond. Metallogenic Provinces and Epochs. **(15 hours)**

UNIT III: Origin and occurrence of coal. Rank & Grade of coal. Chemical and Physical properties of coal. Proximate and ultimate analysis of Coal. Coal Petrology – concept of 'Lithotype', 'Maceral' and 'Microlithotype'. Geological, geographical distribution of coal and lignite deposits in India. Coalbed methane – a new energy resource. **(15 hours)**

UNIT IV: Physical properties and chemical composition of Petroleum, crude oil and natural gas. Introduction to gas hydrates, shale gas and shale oil. Concept of source rock, reservoir rock and cap rock. Origin, migration and entrapment of petroleum. Onshore and offshore petroliferous basins of India with special reference to NE India and Bombay High. Atomic minerals as fuels, Origin, mode of occurrence, mineralogy and distribution of uranium and thorium. **(15 hours)**

Suggested Readings: (Updated Version)

Bateman, A.M., (1962): Economic Mineral Deposits, Wiley.
Cuilbert, J.M. and Park, Jr. C.F., (1986): The Geology of Ore Deposits, Freidman.
Chandra, D., Singh, R.M. Singh, M.P., (2000): Textbook of Coal (Indian context).
Evans, A.M., (1993): Ore Geology and Industrial Minerals, Blackwell.
Jenson and Bateman, A.M., (1962): Economic Mineral Deposits, 111 edition, John Wiley
James R. Craig and David J.Vaughan, (1994): Ore Microscopy and Petrography.
Mookherjee, A., (2000): Ore Genesis-A Holistic Approach, Allied Publisher.
Levorsen, AI., (2004): Geology of Petroleum, WH Freeman & Co.
Selley, R.C., (1998): Elements of Petroleum Geology. Academic press.

GEL-302: DISASTER RISK REDUCTION* **(Minor- Course)**

Credits: 4 / Total marks: 100 / Total Contact Hours: 60

Course Objective: With recent increase in disasters, the courses is designed to understand the disaster causes, management of disaster and their related earth processes.

Learning Outcome: After completing the course, the student will study natural hazards such as landslides, floods, earthquakes, and tsunamis affecting the humanity to understand the controlling processes and mitigation strategies and understand the earth science behind natural disasters.

Theory (4 Credits, Contact Hours 60)

UNIT I: Introduction to Hazards, Vulnerability, disaster and risk. Hazards and Disasters: Definition and Characteristics, Contributing Factors, and capability; Concepts related to Earthquakes, Tsunami, Volcanic eruption, Cyclones, Floods, Drought, Landslides, and Fires. Rates of natural cycles and residence time. **(15 hours)**

UNIT II: Potential Impacts of Disasters, Approaches to Disaster Risk and Vulnerability Assessment; Vulnerability Atlas of India and its usage; Disaster Management; Disaster Management Act and Policy. **(15 hours)**

UNIT III: Disaster Management Cycle: Awareness, Response and Recovery. Disaster Management plan with key response functions: Emergency Response and Crisis Management. **(15 hours)**

UNIT IV: Conceptual Framework of Disaster Risk Reduction; International Frameworks: Yokhama Strategy, Hygo Framework for Action, Sendai Framework. DRR Measures; Climate variability and disaster risk. Rapid visual screening: Pre and Post disaster; Risk Resilience for Earthquakes, Landslides, Cyclones, Floods, Fires. Post Disaster Needs Assessment (PDNA). **(15 hours)**

Suggested Readings: (Updated Version)

Alexander, D., (1999): Natural Disasters, , Kluwer Academic London.
Bell, F.G., (1999): Geological Hazards, Routledge, London
Bhandari, R. K., (2011): An overview on natural & man-made disasters and their reduction, CSIR, New Delhi.
Bryant, E., (1985): Natural Hazards, Cambridge University Press
Coppola D. P., (2007): Introduction to International Disaster Management, Elsevier Science (B/H), London.
Disaster Management Act 2005, Publisher by Govt. of India
Goyal, S. L., (2006): Encyclopaedia of disaster management, Vol I, II and III with Disaster management policy and administration, , Deep & Deep, New Delhi.
Gupta, M. C., (2010): Manual on natural disaster management in India, NIDM, New Delhi.
National Disaster Management Policy, 2009, Government of India

GEL-303: INTERNSHIP/ APPRENTICESHIP/ COMMUNITY ENGAGEMENT AND SERVICE FIELD BASED LEARNING OR MINOR PROJECT

Credits: 4 / Total marks: 100 / Total Contact Hours: 120

SEMESTER 6

GEL-350: REMOTE SENSING AND GIS

Credits: 4 / Total marks: 100 / Total Contact Hours: 60

Course Objective: To impart requisite knowledge about Remote Sensing and GIS which is used as tools for geological investigation and various other purposes?

Learning Outcome: The students will develop capability to visualize the processes and principles involved in Remote Sensing and GIS and their integrated applications in different of fields of Geology.

Theory (4 Credits, Contact Hours 60)

UNIT I: Remote Sensing: Elements, Process, types and resolution; Electromagnetic radiation and their characteristics; platforms; sensors; Satellites and their characteristics; Indian remote sensing satellite; LANDSAT and SPOT. **(15 hours)**

UNIT II: Photogeology: types and geometry of aerial photographs; Scale and resolution, flight procedure; Relief displacement; Vertical exaggeration; photomosaics, Annotations; Principle of stereoscopy and stereoscopes. **(15 hours)**

UNIT III: Digital Image processing: concept and processes. Fundamental steps in image processing; Elements of satellite image interpretation; Identification of sedimentary, igneous and metamorphic rocks; drainage patterns, and various aeolian, glacial and fluvial landforms. **(15 hours)**

UNIT IV: Geographic Information System: Definition, Scope, Components and Functions; GIS data types: Raster and Vector Data; Spatial and non-spatial data; Georeferencing; Concept of Datum and coordinate system; Map projections; Global Positioning System: components and application. Indian Navigation System (NAVIC). **(15 hours)**

Suggested Readings: (Updated Version)

Demers, M.N., 1997. Fundamentals of Geographic Information System, John Wiley & sons. Inc.
Gupta, R.P., 2002. Remote Sensing Geology, Springer.
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.

GEL-351: HYDROGEOLOGY AND ENGINEERING GEOLOGY

Credits: 4 / Total marks: 100 / Total Contact Hours: 60

Course Objective: This course deals the types of surface and subsurface water and hydrologic properties of rocks as well as the techniques of groundwater explorations and water management. It also provides geological and geotechnical recommendations, geo-structural design and analysis associated with anthropogenic developments and constructions.

Learning Outcome: The course content will help to understand Hydrogeology, Well-hydroulics, Engineering Geology, and Geological, Geotechnical, and Environmental consideration for the major infrastructural projects.

Theory (4 Credits, Contact Hours 60)

UNIT I: Introduction to Hydrogeology, its societal relevance. Water cycle, rock properties, aquifer classification and vertical distribution of groundwater. Physics of water flow. Hydro-geochemistry and water quality. Surface water-groundwater interaction. **(15 hours)**

UNIT II: Well hydraulics. Concept of drawdown, cone of depression, specific capacity, specific yield, specific retention, storativity. Groundwater exploration methods. Water management techniques. **(15 hours)**

UNIT III: Engineering characteristics of rock and soil. Role of geoscientists in planning, design and construction of major man-made structural features. Site investigation and characterization. Foundation treatment. Intact Rock and Rock Mass properties. Concepts of Rock quality designation (RQD). Rock mass rating (RMR). Q-index. **(15 hours)**

UNIT IV: Geological, Geotechnical and Environmental considerations for Dams and Reservoirs; Tunnels and Tunnelling Methods; Landslides and earthquakes; Causes, Factors and corrective/Preventive measures. Geotechnical studies associated with: Bhakra Nangal dam, Kopili hydroelectric project, Sela tunnel. **(15 hours)**

Suggested Readings: (Updated Version)

Davis, S. N. and De Weist, R.J.M. 1966. Hydrogeology, John Wiley & Sons Inc., N.Y.
Goodman, R.E., (1993). Engineering Geology: Rock in Engineering constructions. John Wiley & Sons, N.Y.
Karanth K.R., 1987, Groundwater: Assessment, Development and management, Tata McGraw-
Schultz, J.R. & Cleaves, A.B. (1951): Geology in Engineering, John Willey & Sons, New York.
Todd, D. K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.
Waltham, T., (2009). Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.

GEOL-352: EXPLORATION AND MINING GEOLOGY

Credits: 4 / Total marks: 100 / Total Contact Hours: 60

Course Objective: To impart requisite knowledge of Exploration and Mining Geology and to familiarise the students with modern techniques used in mineral exploration.

Learning Outcome: The students learn to use the techniques, skills, and modern engineering tools necessary for geophysical and geochemical prospecting. They will understand different elements associated with mining geology, environmental impact of mining and associated legislations and will be able to provide consultancy for sustainable mining.

Theory (4 Credits, Contact Hours 60)

UNIT I: Prospecting and exploration: concepts, methodology and stages. Theory and methods of sampling; subsurface sampling including pitting, trenching and drilling. Principles of mineral exploration. Geophysical and Geochemical Methods of exploration. **(15 hours)**

UNIT II: Core and non-core drilling methods. Planning of bore holes and location of boreholes on ground. Core-logging. Principles of ore reserve estimation. Factors affecting reliability of ore reserve estimation. **(15 hours)**

UNIT III: Mining Methods and types: Open cast and Underground mining. Coal mining with special reference to Meghalaya. Methods of breaking rocks, Explosives used in mining; Mine hazards and safety measurements. **(15 hours)**

UNIT IV: Factors in evaluating a mineral deposit and recoverable values. Mine safety measures and mine legislations. MMDRA Act (1952, 2023), Prospecting Licence and Mining Lease. Mine closure plan, Environmental impact of mining. **(15 hours)**

Suggested Readings: (Updated Version)

Arogyaswami, R.P.N. 1996 Courses in Mining Geology. 4th Ed. Oxford-IBH.
Bagchi, T.C., Sengupta, D.K., Rao, S.V.L.N. (1979): Elements of Prospecting and Exploration
Clark, G.B. 1967. Elements of Mining. 3rd Ed. John Wiley & Sons.
McKinstry, H.E. Mining Geology, Prentice Hall, Englewood Clifts, N.J.
Moon, C.J., Whateley, M.K.G., Evans, A.M., 2006, Introduction to Mineral Exploration, Blackwell Publishing.
Roonwal, G.S., 2018. Mineral exploration: practical application.
Stevens, R., 2010. Mineral exploration and mining essentials. Port Coquitlam, British Columbia, Canada: Pakawau GeoManagement.
Young, G.J.: - Elements of Mining

GEL-353: PRACTICAL AND FIELDWORK

Credits: 4 / Total marks: 100 / Total Contact Hours: 120

Course Objective: Geology is field and observational science. Geo-scientific hypothesis is framed in the field that can be tested through field data and laboratory investigations.

Learning Outcome: This course will enable the students to explore practical aspect of geology such as lithological variation from basin to basin and dome to dome, and also their correlation; identify various fossils; preparation of geological maps, cross-section, and reconnaissance and detailed surveys for geo-resource exploration and environmental purposes etc.

Practical (4 Credits, Contact Hours 120)

UNIT I: Remote Sensing and GIS: Interpretation of aerial photo/satellite image for determination of drainage pattern and lithology and structural features (fold, faults and joints). Use of GPS and GIS for surveying and mapping. **(30 hours)**

UNIT II: Hydrogeology and Engineering Geology: Preparation and interpretation of water level contour maps and depth to water level maps. Preparation and interpretation of groundwater quality maps. Study of maps and models (with site visit) of important buildings, dam sites and tunnels. **(30 hours)**

UNIT III: Exploration and Mining Geology: Exercises on mine sampling and determination of Tenor, Cut-off grades and ore reserves. Mining terminology. **(30 hours)**

UNIT IV: Field work: Field work in a geologically important area / engineering project. Identification of rocks and their stratigraphic position in the field. Description of the lithology, structures and geotechnical characters on the field. **(30 hours)**