Syllabus and Curriculum

Four Semester M. Sc. Course in Geology

2016

Gauhati University
Guwahati- 781 014, Assam

PROGRAMME SPECIFIC OUTCOMES
(M.Sc. in Geology)

Upon satisfactory completion of M.Sc. degree in geology, the graduates will be able to:

- Demonstrate sound knowledge in interpreting petrological processes that operates in the lithosphere.
- Carry out exploration activities for hydrocarbon and other ore and mineral deposits in scarcely known terrains.
- Explore and analyze groundwater system to ensure safe and trouble-free withdrawals.
- Understand the earth's surface process and the process-form relationship, the linkages between the interdisciplinary components of earth systems science and the Quaternary geological history and associated issues of concern like climate change, active tectonics.
- Understand the key environmental issues of regional concern viz., flood, erosion, earthquake etc.
- Carry out technical analysis of earth material and geological structures for site selection of large civil engineering structures like tunnel, dam, road etc.
- Demonstrate sound knowledge in identifying and interpreting fossil assemblage of sedimentary rocks in constructing and dating the stratigraphic column in a scarcely known geological terrain.
- Carry out geological mapping in an unknown/project specific terrain.
- Apply the techniques of Geoinformatics in solving problems not only in the field of earth sciences but also in other fields that require analysis of spatial data, such as environmental science, social science, public administration, economics etc.
- Develop skills in creative and critical thinking, analytical methods and integration of knowledge in multiple branches and will be able to formulate a scientific problem and strategies to solve it.

Section-A

1.1 Distribution of marks and general rules

Semester	Assessment					
	Course	Credit	Contact hours	External	Internal	Total Marks
First Semester	Theory	18	216	240	60	300
	Practical	10	240	136	34	170
	Fieldwork	2	60		30	30
	Total	***30***	***516***	***376***	***124***	***500***
Second Semester	Theory	19	228	256	64	320
	Practical	11	264	144	36	180
	Total	***30***	***492***	***400***	***100***	***500***
Third Semester	Theory	16	192	296	74	370
	Practical	6	144	80	20	100
	Fieldwork	2	60		30	30
	Open Course [Theory]	6	72			
	Total	***30***	***468***	***376***	***124***	***500***
Fourth Semester	Theory	10	120	216	54	270
	Practical	6	144	80	20	100
	Project work	8	150			
	or			65	65	130
	Elective Paper					

	Theory	6	72			
	Practical	2	48	80	20	100
	Open Course [Theory]	6	72	24	6	30
	Total					
	With Project Work	***30***	***486***	***361***	***139***	***500***
	With Elective Paper	***30***	***456***	***400***	***100***	
Grand Total						
With Project Work		**120**	**1962**	**1513**	**487**	**2000**
With Elective Paper		**120**	**1932**	**1552**	**448**	

1.2.1 First Semester

Code	***Course***	***Credit***	***Contact hour***	***Total marks (External + Internal)***	***Type of the Course***
GLG-1016	Group-A: Structural Geology Group-B: Seismology	4 2	48 24	70(56+14) 30(24+6)	Core (Theory)
GLG-1026	Group-A: Mineralogy & Crystal Chemistry Group-B: Thermodynamics in Geology	3 3	36 36	50(40+10) 50(40+10)	Core (Theory)
GLG-1036	Group-A: Geoinformatics Group-B: Geomorphology & Quaternary Geology	3 3	36 36	50(40+10) 50(40+10)	Core (Theory)
GLG-1044	Group-A: Structural Geology Group-B: Seismology	3 1	72 24	50(40+10) 20(16+4)	Core (Practical)
GLG-1052	Mineralogy	2	48	30(24+6)	Core (Practical)
GLG-1064	Group-A: Geoinformatics Group-B: Geomorphology & Quaternary Geology	2 2	48 48	35(28+7) 35(28+7)	Core (Practical)
GLG-1072	Field Mapping #	2	60	30 (Internal)	Core (Fieldwork)
Total		30	516	500	

Field mapping is of one week duration with about 60 contact hours.

1.2.2 Second Semester

Code	***Course***	***Credit***	***Contact hour***	***Total marks (External + Internal)***	***Type of the Course***
GLG-2016	Group-A: Hydrogeology Group-B: Climatology and Oceanography	4 2	48 24	70(56+14) 30(24+6)	Core (Theory)
GLG-2026	Group-A: Igneous Petrology Group-B: Metamorphic Petrology	3 3	36 36	50(40+10) 50(40+10)	Core (Theory)
GLG-2035	Group-A: Geochemistry and Isotope Geology Group-B: Application of Statistics in Geology	3 2	36 24	45(36+9) 35(28+7)	Core (Theory)
GLG-2042	Engineering Geology	2	24	40(32+8)	Core (Theory)
GLG-2052	Hydrogeology	2	48	40(32+8)	Core (Practical)
GLG-2064	Group-A: Igneous Petrology Group-B: Metamorphic Petrology	2 2	48 48	35(28+7) 35(28+7)	Core (Practical)
GLG-2073	Group-A: Geochemistry and Isotope Geology Group-B: Application of Statistics in Geology	1 2	24 48	20(16+4) 30(24+6)	Core (Practical)
GLG-2082	Engineering Geology	2	48	20(16+4)	Core (Practical)
Total		30	492	500	

1.2.3 Third Semester

Code	*Course*	*Credit*	*Contact hour*	*Total marks (External + Internal)*	*Type of the Course*
GLG-3016	Group-A: Economic Geology – Genesis Group-B: Economic Geology – Indian deposits Group-C: Exploration and Mining	3 2 1	36 24 12	50(40+10) 30(24+6) 20(16+4)	Core (Theory)
GLG-3024	Group-A: Sedimentology Group-B: Surveying and Mapping	3 1	36 12	50(40+10) 20(16+4)	Core (Theory)
GLG-3036	**Stratigraphy** Group-A: Principles of Stratigraphy Group-B: Indian Stratigraphy Group-C: Stratigraphy of North-East India	 2 3 1	 24 36 12	 30(24+6) 50(40+10) 20(16+4)	Core (Theory)
GLG-3044	Group-A: Economic Geology Group-B: Sedimentology	2 2	48 48	25(20+5) 25(20+5)	Core (Practical)
GLG-3052	Group-A: Stratigraphy Group-B: Surveying and Mapping	1 1	24 24	30(24+6) 20(16+4)	Core (Practical)
GLG-3062	Fieldwork#	2	60	30 (Internal)	Core (Fieldwork)
GLG-3073	Open Course-1: Geodynamics	3	36	50(40+10)	Open (Theory)
GLG-3083	Open Course-2: Planetary Geology	3	36	50(40+10)	Open (Theory)
Total		30	468	500	

Fieldwork is of one week duration with about 60 contact hours.

1.2.4 Fourth Semester

Code	*Course*	*Credit*	*Contact hour*	*Total marks (External + Internal)*	*Type of the Course*
GLG-4014	Palaeontology	4	48	70(56+14)	Core (Theory)
GLG-4026	**Fuel Geology** Group-A: Coal Group-B: Petroleum	 3 3	 36 36	 50(40+10) 50(40+10)	Core (Theory)
GLG-4034	**Fuel Geology** Group-A: Coal Group-B: Petroleum	2 2	48 48	35(28+7) 35(28+7)	Core (Practical)
GLG-4042	Palaeontology	2	48	30(24+6)	Core (Practical)
GLG-4056	Elective*1 (Mandatory)	6	72	100(80+20)	Elective (Theory)
GLG-4062	Elective*1 (Mandatory)	2	48	30(24+6)	Elective (Practical)
GLG-4078	Project Work*2 (in lieu of the mandatory Elective Course)	8	150	130	Core (Project)
GLG-4083	Open Course-3: Fluvial System	3	36	40+10=50	Open (Theory)
GLG-4093	Open Course-4: Environmental Geology	3	36	40+10=50	Open (Theory)
Total		30	486 (with project) 456 (with elective)	500	

*1: The students will have to opt for a compulsory elective course out of the offered two elective courses by the department annually for their choice, which will be notified from the list of the following courses –

1. Petroleum Exploration
2. Basin Analysis
3. Coal and Organic Petrology

4. Advanced Geoinformatics
5. Geo-Exploration
6. Advanced Sedimentology
7. Advanced Geochemistry and Thermodynamics

*2: The project work will be offered to students in lieu of the Elective Course and to how many students the Project Works will be offered shall be decided by the DAC. Project work will be offered only to those students with average score of 70% and above in the M. Sc. 1st and 2nd End Semester examinations.

N.B.: ***Seminar, Home Assignment, Sessional / Unit Tests will be part of the continuous evaluation in each of the Theory Paper within the given internal marks.***

1.3 General rules
1.3.1 Criteria for admission

Students having combination of mathematics/ physics/ chemistry/ statistics along with geology (Major) at degree level will be preferred for admission into the two year, 4 semesters M.Sc. course in Geology.

1.3.2 Minimum pass marks
As per the university rules.

1.3.3 Project Work
Project work will be allotted to the students at the beginning of the 3rd semester just after declaration of 2nd semester examination results. The project work will have to be submitted by the students before the commencement of the theory examination of the 4th semester.

Evaluation of Dissertation: Average of the evaluation mark by the external and internal examiner.
Open viva-voce on the project work will be jointly conducted by both the External and the concerned guide.

Section -B: Detail Syllabus

2.1 First Semester

2.1.1 GLG -1016: Structural Geology and Seismology (Theory)

Course Outcomes

- Lithological and structural mapping of a terrain and correlate with available deformation sequence obtained from physical and microstructural analyses.
- Identify basic structural elements and able to interpret the complex geometry in a repeatedly activated crustal terrain.
- Investigate the deformation structures within rocks from mesoscopic to microscopic scale.
- Interpret importance of structures and their developments which are directly related with the formation of ore and hydrocarbon deposits within the earth crust.
- Interpret importance of structures and their developments which are directly related with the formation of ore and hydrocarbon deposits within the earth crust.
- Correlate spatial distribution of earthquakes in the light of plate tectonics
- Interpret seismic waves and crustal velocity structures.

Sl. No.	*Topic*	*Teaching hours*
1.	**GROUP-A: Structural Geology** **Stress and Strain** Definition of stress. Types of stress (hydrostatic, uniaxial, compressional, tensional, triaxial, deviatoric, differential and effective stress). Sign convention of shear stress; Mohr stress circle; Determination of direction of shearing stress. Definition of strain. Types of strain; Principal axes of strain, measurement of strain, Flinn's diagram and Fry's methods of strain measurement and other strain markers.	48

2.	**Ductile deformation** Morphological classifications of fold following Ramsay (1964) and Fleuty (1964). Kinematics of folding. Buckle folds and shear folds. Determination of sense of shear from fold geometry. Superposition of folds. Boudinage: origin and its relationship to fold.	
3.	**Brittle deformation** Faults: Classification of faults, mechanism of faulting. Normal faulting: extensional, synthetic, antithetic, horst and graben, half graben, relay fault, duplex, detachment fault, ramp and flat geometry. Fault nucleation and propagation; geometry of fault propagation. Thrust: allochthonous, autochthonous, klippe, windows, overthrust, under thrust, nappe, decollement, blind thrust, splay, ramp and flat geometry; thrust related folds; listric thrust, duplex, schuppen structure, imbricate structure, thrust duplex, en echelon thrust; foreland, hinterland; sinistral- dextral geometry - palm tree, tulip, negative flower and positive flower structures. Strike slip fault: tear fault, transcurrent fault, transfer fault and their characteristic features. Mechanism of faulting with reference to stress and strain.	
4.	**Foliation and lineation in deformed rocks** Morphological classification. Geometric relationship of foliation and lineation with folds. Interference patterns of lineations. Relation of foliations and lineations to strain directions.	
5.	**Shear zone** Ductile, brittle and brittle-ductile shear zone. Characteristic features of sheared rocks. Strain variation within the shear zone. Mylonite. Determination of shear sense.	
6.	**Rheology** Rheology. Rheological equations and importance of temperature in rheology. Geomagnetism. Thermal history of the Earth.	
7.	**Graphical interpretation of structures** Symmetry of structures; Graphic representation of spherical, stereographical plots, rose diagram and histogram. Introductory ideas on softwares used in structural geology.	
8.	**GROUP-B : Seismology** Seismology- introductory terminology and basic principles, crustal phases, travel time and magnitude of earthquake. Earthquake as natural hazard- prediction and seismic hazard management, seismic gap, Seismic waves, Snell's law, travel time curve, velocity model, b-value.	24
9.	Focal depth, earthquake-fault relation in tectonic domain. M, Mb, Ms, Mw, MM scale. Peaked ground acceleration (PGA) and peaked ground velocity (PGV), focal plane solution, Benioff zone.	
10.	Palaeoseismology- concept of paleoseismology and its importance, active faults, identification of seismogenic active faults, paleoseismological structures, identification of paleoseismic deformational features and structures from syn-sedimentary and other deformational structures, use of dating techniques for paleoseismic features and their reliability, materials suitable for dating, interpretation of dates, use of historical and archaeological data in paleoseismic data interpretation.	

2.1.2 GLG -1026: Mineralogy & Crystal Chemistry, and Thermodynamics in Geology (Theory)

Course Outcomes

- Study solid solution chemistry, exolution and structural inversion of important rock forming minerals.
- Identify mineral species using X-Ray crystallographic methods.
- Analyse importance of ionic radii, coordination number and Pauling rule and bonding in crystals.
- Study transformation processes in minerals, viz. exolution, transient phase in exolution and structural transformations (polymorphism).
- Learn role of fundamental thermodynamic equation, laws of thermodynamics in geological processes.
- Study P-T-X dependence of Gibbs free energy and Clausius-Clapeyron equation in determining slop of a mineral reaction.

Sl. No.	*Topic*	*Teaching hours*
	GROUP-A : Mineralogy & Crystal Chemistry	36
1.	Chemical composition and compositional variation of minerals, solid solution, compositional classification of minerals; detail classification and structural features of silicate minerals.	
2.	Principles of X-ray crystallography, mineral identification by X- ray diffractometry. Impact of X-ray crystallography. Crystal structure: CCP and HCP packing. Defect in minerals: Point Defects, Line defects and Planar defects.	
3.	Ionic crystal, ionic radii, coordination number, Pauling rule. Bonding in crystals: Ionic -, covalent- and metallic bonding.	
4.	Transformation process in minerals: Exsolution, example of transition phase in mineral exsolution. Structural transformation: Polymorphism.	
5.	Classification, structural inversion, solid solution behavior and exsolution in rock forming silicate minerals with the examples of feldspar, olivine, pyroxene, amphibole, garnet and mica; their optical behaviour and importance as rock forming minerals.	
	GROUP-B : Thermodynamics in Geology	36
6.	Forms of energy, transformation and conservation of energy, global energy budget. Geologic process and energy flow; state properties; direction of changes in state.	
7.	Fundamental thermodynamic equation, First Law of Thermodynamics; work done in volume expansion, Second and Third Law of Thermodynamics.	
8.	Chemical potential, Gibbs Free Energy function; Enthalpy, entropy and activity, Free Energy change as a function of activity; variation of enthalpy, entropy and Gibbs Free Energy with temperature and pressure, Clausius-Clapeyron equation.	
9.	Compositional dependence of Gibbs Free Energy and Gibbs-Duhem equation.	
10.	Mixing components, Raoults Law and Henrys Law, standard state and activity, ideal and non ideal solution behaviour and equilibrium constant.	

2.1.3 GLG -1036: Geoinformatics; Geomorphology & Quaternary Geology (Theory)

Course outcomes

- Learn the techniques of digital image processing and GIS and apply them in solving processes that operate on the surface of the earth.
- Learn the techniques of mapping using GPS and GIS.
- Understand the earth's surface process and the form -process relationship, the linkages between the interdisciplinary components of earth systems science and the Quaternary geological history and associated issues of concern like climate change, active tectonics. Various tectonic forcing on climate and the consequent changes.
- Imparts knowledge on the thick repository of Quaternary sediments and their stratigraphic framework in NE India.

Sl. No.	*Topic*	*Teaching hours*
	GROUP-A: Geoinformatics	36
1.	Spectral response curve. Sensors. Resolution properties of sensors. Resolution properties of Indian remote sensing satellites and sensors. Elements of photo and image interpretation. Remote sensing and geology.	
2.	Stereoscopy and vertical exaggeration. Basic elements of photogrammetric measurements of aerial photographs / digital stereo image. Digital photogrammetry: Concept of digital elevation model (DEM) and digital terrain model (DTM) and their uses. Advantages of digital photogrammetry over traditional optical photogrammetry. Orthophoto.	
3.	Thermal remote sensing; Thermal properties of materials; Characteristics of thermal images; thermal image processing and interpretation. Concept of LiDER remote sensing.	
4.	Microwave remote sensing; SLAR system; Spatial resolution of SLAR systems; Synthetic Aperture Radar (SAR); microwave remote sensing satellites; microwave image characteristics; Processing of	

	microwave digital data; Geologic interpretation of radar image.	
5.	Image processing methods: Image restoration, image enhancement, False colour composite (FCC). ratio images, multispectral classification - supervised and unsupervised, change detection images, accuracy assessment. Concept of hyperspectral data and their importance.	
6.	Introduction to GIS and its components, vector and raster data, georeferencing, planning needed to develop a GIS based project in earth science, analysis of spatial and attribute data in GIS platform.	
	GROUP-B : Geomorphology & Quaternary Geology	36
7.	The Quaternary Period and its divisions, Neogene-Quaternary and Pleistocene-Holocene boundary, the Anthropocene, Quaternary dating dating methods-cosmogenic radionuclides- C^{14}, Be^{10}, Al^{26}, luminescence chronology, dendrochronology (principles, applications and limitations), low temperature thermochronology and exhumation/denudation history	
8.	Quaternary climate and tectonics- the ice age, Milankovitch theory, glacial-interglacial cycles, LGM, Little Ice Age, Quaternary sea level changes, uplift-climate connection, climate proxies and Quaternary paleoclimate, $^{87}Sr/^{86}Sr$ as proxy for silicate weathering, duricrusts-calcrete, fericrete, alcrete and spleothems, application of stable isotopes in Quaternary climate,	
9.	Quaternary geomorphology- the earth as a system, energy flow in the geomorphic system, spatial and temporal scales of landscape analysis, role of structure, tectonics and climate in landform development, neotectonics and active tectonics and landscape response	
10.	Quaternary stratigraphy- oxygen isotope stratigraphy, magnetic stratigraphy –principles and application in Quaternary sequences-Indian examples, pedostratigraphy, soil profile and paleosol, Quaternary records from marine and continental settings, event stratigraphy	
11.	Quaternary sedimentary records from India- Himalayan foreland, Son-Narmada valley, Gangetic plains, coastal plains, Brahmaputra plains and other parts of NE India	

2.1.4 GLG -1044: Structural Geology and Seismology (Practical)

Course outcomes

- Prepare geological map after extensive field work and interpret structures from an available geological map.
- Plot planar and linear fabric elements within stereo net and used to solve complex structural problems in a reactivated geological terrain.
- Identify seismic waves in seismograms during pre-, syn- and post-seismic activities.
- Determine earthquake epicentres.
- Carry out fault plane solution.
- Interpret paleoseismological data.

Sl. No.	*Topic*	*Teaching hours*
	GROUP-A : Structural Geology	72
1.	Stereographic projection of planar, linear and fold structures and their statistical analyses with the help of stereo net and structural geology softwares.	
2.	Construction of dip isogons in folds (both manual and software based). Interpretation for interference of fold and lineation from hand specimens and field photographs.	
3.	Study of geological maps, profile sections and interpretation of structures.	
	GROUP-B : Seismology	24
4.	Identification of P and S waves from seismogram, determination of epicenter, determination of magnitude of earthquake, focal depth and PGA value.	
5.	Fault plane solution, determination of slip. Interpretation of co-seismic paleoseismological data.	

2.1.5 GLG -1052: Mineralogy (Practical)

Course outcomes

- Identify minerals in hand specimens and thin sections.
- Prepare samples for XRD analysis.
- Interpret X-Ray defractograms.

Sl. No.	*Topic*	*Teaching hours*
	Mineralogy	48
1.	Identification of major, minor and accessory minerals in thin sections and hand specimens.	
2.	Preparation of sample for XRD and interpretation of XRD data for mineral identification.	

2.1.6 GLG -1064: Geoinformatics, and Geomorphology & Quaternary Geology (Practical)

Course outcomes

- Classify satellite images using various techniques.
- Digitize vector data from various sources in GIS
- Perform spatial analysis in GIS
- Identify landforms, geological and geomorphic features.
- Understand topographic analysis the relation between landform and their controlling factors, drainage behaviour, discharge hydrograph, morphometric parameters, Quaternary chronology and tectonics

Sl. No.	*Topic*	*Teaching hours*
	Group-A: Geoinformatics	48
1.	Stereo vision test, use of pocket stereoscope and mirror stereoscope. Determination of height from aerial photographs using parallax bars.	
2.	Study of satellite imagery. Visual interpretation of satellite imagery for lineament analysis, demarcation of litho-units and structures, delineation of landforms and land use.	
3.	Digital image processing – image enhancement, on-screen digitization, ratio image and image classification.	
4.	Hands on exercise on GIS - Preparation of geological map of a given terrain in GIS.	
	Group-B: Geomorphology & Quaternary Geology	48
5.	Study of topographic maps and profiles for landscape analysis.	
6.	Hypsometry and hack profile analysis.	
7.	Estimation of rate of erosion and sedimentation, deformation.	
8.	Quaternary chronology.	
9.	Application of remote sensing in Quaternary landscape analysis.	
10.	Preparation of litholog in Quaternary stratigraphic sections/fluvial sequences.	
11.	Soil profile/weathering profile analysis.	

2.1.7 GLG -1072: Field Mapping (Fieldwork)

Course outcomes

- Carry out geological mapping in a hard rock terrain.

Sl. No.	*Topic*	*Teaching hours*
1.	Field Mapping	60

2.2.1 GLG -2016: Hydrogeology, Climatology & Oceanography **(Theory)**

Course outcomes

- Interpret hydrological cycles and occurrence of groundwater in aquifers.
- Analyze movement of groundwater through various rocks.
- Interpret Darcy's law and its validity and limitations.
- Analyze different types and factors of groundwater fluctuation.
- Carry out geological work for choosing a site for a groundwater well and a suitable method for drilling the well.
- Understand the energy budget, the latitudinal and altitudinal thermal gradients, the pressure belts and wind system, monsoon phenomena, storms, cloud and precipitation.
- Understand the mechanism of formation of the surface ocean currents , thermohaline circulation, subtropic gyres, El-Nino phenomena.

Sl. No.	*Topic*	*Teaching hours*
	Group-A: Hydrogeology	48
1.	Definition of hydrology and hydrogeology. Hydrologic cycle - precipitation and run-off Analysis of hydrograph, base flow separation, factors governing shape of hydrograph.	
2.	Occurrence of ground water- openings in rocks, types of openings. Porosity and void ratio. Definition of aquifers, aquiclude, aquitard and aquifuge. Subsurface distribution of water, vadose water and ground water. Specific yield and retention. Estimation of specific yield. Aquifers and their classification. Ground water recharging.	
3.	Ground water movement. Darcy's law - its range of validity and limitation. Hydraulic conductivity, permeability, effective stress, specific storage, transmissivity and storativity.	
4.	Physical and chemical characteristics of ground water. Chemical classification of ground water. Quality criteria for drinking, irrigation, and industrial uses.	
5.	Occurrence of ground water in different rock types- igneous, metamorphic, sedimentary and non-indurated sediments. Ground water provinces of India.	
6.	Ground water levels and fluctuations - secular, seasonal and diurnal variation. Factors governing ground water level fluctuation. Fresh and salt water relationship in coastal area. Ghyben-Herzberg principle. Prevention and control of sea water intrusion.	
7.	Basic principles of well hydraulics- drawdown and cone of depression. Steady state and none steady state flow. Equation for pumping tests. Step drawdown test and aquifer performance test. Analysis of pumping test data.	
8.	Surface and subsurface investigation of ground water. Hydrogeological mapping. Systematic and reappraisal survey by well inventory method. Geophysical methods of exploration - gravity, magnetic, electrical and seismic methods. S.P., resistivity, gamma and neutron gamma logging. Ground water exploration by test drilling.	
9.	Methods of construction of shallow wells. Methods of drilling, design criteria and development of deep tube wells.	
10.	Ground water assessment, development and management. Concept of ground water reserve - static and dynamic reserve. Safe yield and overdraft. Factors governing safe yield. Equation of hydrologic equilibrium. Ground water budgeting.	
	Group-B: Climatology & Oceanography	24
11.	Definition of climate, composition of atmosphere, vertical and horizontal distribution of temperature, insolation, Clouds: their formation and classification. Precipitation: Causes, forms, processes and types. Atmospheric pressure and air circulation, factors affecting wind direction and speed, upper-level waves and jet streams, the Monsoons.	
12.	Weather disturbances: Properties of air masses, extratropical cyclone, fronts, anticyclones, tropical weather, thunderstorms, tornadoes and waterspouts. Climates dominated by equatorial and tropical air masses.	

13.	Classification of oceans and seas, general features of ocean floor, sea waves, tides, ocean currents, giant deep ocean circulations, physical properties of sea water.	

2.2.2 GLG -2026: Igneous and Metamorphic Petrology (Theory)

Course outcomes

- Understand the process of generation of magma in the crust and mantle and correlate it with the global tectonic processes.
- Apply the principles of phase equilibria in studying igneous systems.
- Classify igneous rocks.
- Describe metamorphic processes and role of structures and textures in the identification of poly-deformational and poly-metamorphic rocks.
- Identify spatial mineral reactions in reconstructing PTt path of metamorphism.
- Study types of mineral reaction and their application in geothermobarometry and petrogenetic grid.

Sl. No.	*Topic*	*Teaching hours*
	Group-A: Igneous Petrology	36
1.	Magma, their generation in the crust and mantle. Present day magmatism and global tectonic processes. Magmatic process- concept and models (batch melting and Rayleigh fractionation). Quantitative approach to partial melting, fractional crystallization and source characterization.	
2.	Geochemical characteristics of igneous rocks: chemical analyses, major, trace and isotopic composition of igneous rocks in the context of petrogenesis. Compatible and incompatible elements. Geochemical criteria for the identification of palaeo-tectonic settings of igneous rocks.	
3.	Phase equilibria study in igneous system: binary, ternary and quaternary silicate system with reference to petrogenesis. Role of volatile H_2O and CO_2 in petrogenesis.	
4.	IUGS Classification schemes of Igneous rocks. Plume magmatism and hot spots. Concepts of mantle metasomatism.	
5.	Petrology and petrogenesis of major igneous rock types: Ultramafic rocks (Komatite, Kimberlite, Alkaline rocks, Ophiolites, Carbonatites, Flood basalts (Deccan Trap, Sylhet Trap), Anorthosites, Granitoids and Layered igneous rocks.	
	Group-B: Metamorphic Petrology	36
6.	Regional orogenic metamorphic textures: Tectonites, foliation, lineation; mechanism of tectonic development; Analyses of poly-deformed and poly-metamorphic rocks; other regional metamorphic textures; replacement textures and reaction rim and their role in reconstructing P-T-t history of metamorphism.	
7.	Sources of plate tectonic metamorphic heat for crustal metamorphism, geothermal gradient, crustal thickening processes and P-T-t path of metamorphism.	
8.	Mineral assemblages and their graphical representation: ACF, AKF and AFM and compositional phase diagrams. Chemical equilibrium in metamorphism, solid-solid reaction, continuous and discontinuous metamorphic reaction.	
9.	Cation exchange partitioning relationship among coexisting phases, application of geothermometry and geobarometry, and petrogenetic grid	
10.	Regional metamorphism of pelitic and basic metamorphic assemblages: metamorphic reaction involved during regional metamorphism of the rocks.	

2.2.3 GLG -2035: Geochemistry & Isotope Geology, and Application of Statistics in Geology (Theory)

Course outcomes

- Interpret abundance of elements in the interior of the earth.
- Use appropriate techniques for determining abundance of major, trace and rare earth elements in rocks.

- Describe the application of radiogenic isotopes in geochronology.
- Interpret the processes of fractionation of stable isotopes and their application.
- Apply statistical methods in solving geological problems.

Sl. No.	*Topic*	*Teaching hours*
	Group-A: Geochemistry and Isotope Geology	36
1.	Origin, abundance, classification and distribution of elements. Chemical differentiation of earth. Crust and mantle as a geochemical system (composition of the crust, composition of mantle, interaction between crust and mantle). Ocean and atmosphere as a geochemical system (composition of ocean, composition of atmosphere, evolution of sea water and air, the rise of oxygen). Geochemical cycle.	
2.	Principles and application of analytical instruments in geochemistry and isotope studies. Meteorites-classification, composition and origin. Type and composition of Martian and Lunar meteorites.	
3.	Stability and abundance of radionuclides, decay mechanism, decay and growth rate of radiogenic decay, decay series.	
4.	Radiogenic isotopes: Radiogenic isotopes in geochronology (Rb-Sr, Sm-Nd,K-Ar, U-Th-Pb method of age dating). Extinct radionuclides in geochronological studies. Promordial ^{87}Sr –^{86}Sr ratios. Isotopic evolution of Sr and Nd in the Earth.	
5.	Stable isotopes: Stable isotopes of O, C and S. Control, application and fractionation of stable isotopes. Oxygen isotope thermometry. Distribution of sulphur isotopes in nature.	
	Group-B: Application of Statistics in Geology	24
6.	Binomial and Normal Distributions. Standardization of normal distribution, Joint distribution.	
7.	Correlation and regression, variance and covariance, standard and probable error of correlation coefficient.	
8.	Sampling distributions : Estimators, sampling distribution of mean, confidence limits, Student t-distribution. Test of significance, setting up a hypothesis, null and alternative hypothesis, z-test, t-test, F-test, Chi-square test.	
9.	Factor and principal component analysis. Gumbel and Log-Pearson distributions - their applications in flood frequency analysis.	

2.2.4 GLG -2042: Engineering Geology (Theory)

Course outcomes

- Determine engineering properties of soil and rocks.
- Interpret geological structures and their role in stability of large engineering structures.
- Assess groundwater condition and its effect in stability rock masses.
- Apply your knowledge in geology to suggest suitable techniques of blasting and improvement of rock mass properties.
- Carry out geotechnical investigation in selecting sites of large engineering structures like tunnel, dam etc.

Sl. No.	*Topic*	*Teaching hours*
1.	Soil: Engineering properties of soil, definition of unit weight, specific gravity, porosity and void ratio, water content, degree of saturation, elementary knowledge of compressibility, consolidation, compaction and shear strength. Importance of clay mineralogy, Atterberg units and soil classification, soil and engineering structures.	24
2.	Rocks: Strength of rocks, hardness, elasticity, porosity, specific gravity. Rock masses: discontinuity in rock masses, weathering of rock masses, rock mass deformation. Engineering classification of rocks, classification of rock masses in the field according to R.Q.D. (rock quality designation), Bieniswaki and Q-system. Quarrying with special reference to rock blasting. Rock as construction materials. Improvement of rock mass properties - grouting, bolting and anchoring.	
3.	Dams and Reservoirs: Classification and parts of dams; geological and geophysical investigation of dam sites, foundation and abutment problems, forces acting on them; Seepage, bearing strength and	

	rebound problem; Treatment of weak zones - grouting. Investigation of reservoir area, control of leakage and silting.	
4.	Geotechnical investigation for tunnel construction: General geotechnical consideration for site locations, geology of the area, importance of structural discontinuities on tunnel and bridge alignment, groundwater conditions, rock stress condition. Methods of tunnel excavation.	

2.2.5 GLG -2052: Hydrogeology (Practical)

Course outcomes

- Analyze rainfall data and well hydrographs.
- Interpret geological maps and satellite imagery for groundwater prospect evaluation.
- Estimate groundwater reserves.
- Compute aquifer and well characteristics from aquifer tests and Step Draw Down tests.

Sl. No.	*Topic*	*Teaching hours*
		48
1.	Analysis of rainfall data and well hydrograph. Estimation of average annual rainfall.	
2.	Interpretation of topographic map, geologic map, aerial photograph and satellite imagery for ground water prospect evaluation.	
3.	Determination of porosity, permeability, effective size, uniformity coefficient and design of well screen and gravel pack from mechanical analysis data of aquifer materials.	
4.	Preparation and interpretation of depth to water map, water table map, piezometric surface map,. isolith map, chemical quality map and diagrams, hydrogeological sections, panel diagram and hydrogeological map.	
5.	Estimation of ground water reserve.	
6.	Computation of aquifer and well characteristics from aquifer tests (APT) and Step Draw Down Test.	

2.2.6 GLG -2064: Igneous and Metamorphic Petrology (Practical)

Course outcomes

- Identify igneous rocks in thin sections and hand specimens and interpret textures and structures.
- Interpret variation diagrams.
- Identify metamorphic rocks in thin sections and hand specimens and interpret metamorphic mineral assemblages, textures and structures.
- Carryout geothermo-barometric calculations from mineral chemistry data.

Sl. No.	*Topic*	*Teaching hours*
	Group-A: Igneous Petrology	48
1.	Hand specimen for physical characteristics.	
2.	Thin section study for mineralogy and texture.	
3.	Variation diagrams.	
4.	Use of chemical analysis in determination of palaeotetonic settings of igneous rocks.	
	Group-B: Metamorphic Petrology	48
5.	Hand specimen and thin section study of major Indian metamorphic rocks.	
6.	Plots of mineral and rock composition in ACF, AKF and AFM diagram.	
7.	Study of metamorphic texture.	

8.	Geothermobarometric calculation and estimation of XH_2O, XCO_2 from mineral chemistry data of metamorphic rocks.	

2.2.7 GLG -2073: Geochemistry & Isotope Geology, Statistics in Geology (Practical)

Course outcomes

- Calculate mineral formula from EPMA data.
- Calculate norms from major oxide data and classify metamorphic rocks.
- Apply tectonic discrimination diagrams based on major, minor and trace elements.
- Carryout computer-based correlation and regression analysis.
- Carryout factor and principal component analysis using computer.
- Carry out flood frequency analysis using Gumbel and Log-Pearson Type-III distributions.

Sl. No.	*Topic*	*Teaching hours*
	Group-A: Geochemistry and Isotope Geology	24
1.	Calculation of mineral formulae from EPMA data of minerals: pyroxenes, plagioclase, mica; Estimation of Fe^{3+} and Fe^{2+} from pyroxenes and amphiboles from EPMA data.	
2.	Norm calculation from major oxide data, classifying igneous rock using norm- Basalt classification using Ab-An-Or diagram. Granite classification using Ab-An-Or diagram.	48
3.	Tectonic discrimination diagram using major, minor and trace element. Discrimination diagram for clastic sediments.	
	Group-B: Statistics in Geology	
4.	Test of hypothesis, computer based correlation and regression analysis. Factor and Principal analyses using computer.	
5.	Flood frequency analysis using Gumbel and Log-Pearson Type-III distribution. Determination of moving average. Linear curve fitting.	

2.2.8 GLG -2082: Engineering Geology (Practical)

Course outcomes

- Determine shear strength parameters of rocks and soils.
- Determine Poisson ration, modulus of elasticity and Point Load Index and uniaxial compressive strength of rocks.
- Carryout numerical and graphical analysis of stability problems.

Sl. No.	*Topic*	*Teaching hours*
1.	Determination of Specific Gravity and Consistency Limits of soil.	48
2.	Determination of shear strength parameters of soil by Direct Shear Test and Triaxial Test.	
3.	Determination of Poissons ratio, Modulus of Elasticity, Point Load Index, Uniaxial Compressive Strength of rock samples.	
4.	Numerical and graphical solution of slope stability problems. Determination of RQD and RMR.	

2.3.1 GLG -3016: Economic Geology – Genesis and Indian deposits, Exploration and mining (Theory)

Course outcomes

- Interpret structural and textural features of ores.
- Analyze critically genesis of hydrothermal, magmatic, volcanogenic, submarine exhalative, metasomatic and pegmatitic ore deposits.
- Describe the techniques of geothermometry and geobarometry and their application in ore geology.

- Interpret the roles of plate tectonics in localization of ore deposits.
- Analyze the metallogeny of Archean Greenstone Belts and Proterozoic mobile belts.
- Describe distribution and genesis of ore deposits in India.
- Describe distribution and genesis of major ore and none metallic deposits of Northeast India.
- Assess the applicability of different geophysical, geochemical and radioactive techniques in exploration of mineral deposits.
- Describe the methods of mining and assess the applicability of different methods in different geological conditions.

Sl. No.	*Topic*	*Teaching hours*
	Group-A: Economic Geology – Genesis	36
1.	Morphology of ore bodies, textural and structural features of ores, chemical composition of ire, classification of ore deposits. Metallogeny and its relation to crustal evolution.	
2.	Genesis of ore deposits: Magmatic, Hydrothermal, Metasomatic, pegmatitic, submarine exhalation and volcanogenic.	
3.	Sedimentary type ore deposits: chemical sedimentary and detrital sedimentary ore deposits: stratabound and stratiform deposits; evaporates, metamorphic type ore deposits.	
4.	Organic matter in ore, fluid inclusion in ore; Geothermometry, Geobarometry and dating of ore deposits. Metallogeny of Archaean greenstone belts and Proterozoic mobile belts	
5.	Structural and chemical control of ore deposits. Plate tectonic and global ore localization. Ore mineralization through geological time.	
	Group-B: Economic Geology – Indian deposits	24
6.	Metallic mineral deposits of India, their distribution, mode of occurrence, mineralogy and genesis: iron, manganese, chromium, copper, lead and zinc, gold, silver, aluminum, nickel and molybdenum.	
7.	Non- metallic mineral deposits: Diamond, limestone and dolomite, magnesite, phosphates, asbestose, gemstone, refractory minerals. Clay mineral deposits of Northeast India. Critical and essential minerals.	
8.	Radioactive minerals: uranium, thorium: their distribution, mode of occurrence, mineralogy and genesis. Uranium mineralization in north eastern part of India. Rare Earth minerals.	
	Group-C: Exploration and mining	12
9.	Methods of mineral prospecting and exploration. Classification of mineral reserve.	
10.	Different methods of surface and subsurface mining for metallic and non-metallic minerals; mining of coal; alluvial mining.	

2.3.2 GLG -3024: Sedimentology, and Surveying & Mapping (Theory)

Course outcomes

- Interpret textures and structures of sedimentary rocks.
- Critically analyse the physical and chemical parameters of sedimentary environments and classify them.
- Analyze diagenetic environments and classify the sedimentary rocks genetically.
- Correlate sedimentation with tectonics and classify sedimentary basins.
- Describe various methods of surveying and their advantages and disadvantages.
- Formulate a method of geological mapping in an unknown terrain.

Sl. No.	*Topic*	*Teaching hours*
	Group-A: Sedimentology	36
1.	Texture of sedimentary rocks -, textural elements - size, roundness, sphericity, fabric, form and surface textures, their measurement. Statistical treatment and interpretation of grain-size analysis data.	
2.	Structures of sedimentary rock - genesis and significance of sedimentary structures. Paleocurrent	

	analysis.	
3.	Sedimentary environments - classification of sedimentary environments, physical and chemical parameters of depositional environments, lithofacies assemblages from fluvial, deltaic, lacustrine, marine, glacial and arid environment.	
4.	Genetic classification of sedimentary rocks; clastics (sandstone and shale), mineralogy of the clastic sediments Diagenesis and lithification. Sedimentology of clay.	
5.	Provenance determination using heavy minerals, quartz, feldspars and rock fragments.	
6.	Origin, mineralogy, classification (Dunham and Folk) of limestone; Diagenesis and neomorphism of carbonate rocks.	
7.	Sedimentary basins: classification of sedimentary basins, Sedimentation and tectonics (tectonic control of sedimentation, plate tectonics and sediment accumulations).	
8.	Sedimentation as a geochemical process; Physico-chemical factors in sedimentation, Eh-pH diagrams, Geochemistry of natural water, geochemical analysis of sediments and their graphical plots to decipher their chemical maturity, weathering index of the source rocks, determination of provenance and tectonic settings, classification of sediments.	
9.	**Group-B: Surveying and Mapping** Maps - types and basic elements, projection system, datum and datum transformation, digital mapping techniques, GPS/GNSS and mapping. Surveying: Basic principles, types and procedures of field survey. Closed loop and open traverse, principles of theodolite, dumpy level and total station survey, RL transfer.	12
10.	Geologic surveying: Definition and scope, study of outcrops, use of compass and clinometers. Base maps: Locating field data on base map, geologic traverses, detail and reconnaissance mapping; Geological field mapping in sedimentary and hard rock terrain.	

2.3.3 GLG -3036: Stratigraphy (Theory)

Course outcomes

- Assess the existing knowledge, concepts, techniques, and methodology appropriate for classification and correlation of stratigraphic units.
- Knowledge on the sequence, event and magnetostratigraphy and their application.
- Identify and model sedimentary facies based on available information.
- Describe the stratigraphic horizons from different parts of India- Precambrian to Recent.
- Identify the sedimentary basins of India and analize basin configurations, sedimentation history and paleoclimate therein.
- Understand the tectonosedimentrary framework and evolution of the sedimentary basins of the Northeast India and classification and correlation of the sedimentary sequences.

Sl. No.	*Topic*	*Teaching hours*
1.	**Group-A: Principles of Stratigraphy** Stratigraphy and its relation with sedimentation. Components of stratigraphy. Geological disposition of the Indian stratigraphic sequences; geological history of India. Geological time scale. Stratigraphic units –International and Indian stratigraphic codes.	24
2.	Principles and methods of correlation of stratigraphic units, stratigraphic relationships -vertical and lateral. Concepts of sequence stratigraphy, magnetostratigraphy and seismo-stratigraphy.	
3.	Sedimentary facies - facies concept, lateral and vertical facies variation, facies modeling, palaeogeographic reconstruction.	
4.	**Group-B: Indian Stratigraphy** Precambrian formations of India : Dharwar Province, Eastern Ghats Province, Central Indian Province, Singhbhum-Orissa Province and Aravalli-Bundelkhand Province. Archaean-Proterozoic boundary.	36

5.	Proterozoic formations of Indian Peninsula : Cuddapah Supergroup, Vindhyan Supergroup, Kurnool Group.	
6.	Palaeozoic formations of India, Himalayan Palaeozoics, marine Palaeozoics in Peninsular India, Precambrian-Cambrian boundary.	
7.	Mesozoic formations of India, Triassic of Spiti and Himalayan range; Jurrasic of Kutch region, Cretaceous of Peninsular India. Deccan Traps and associated infra, inter and intra-trappean beds.	
8.	Gondwana Sequence of India: Basin configuration, sedimentation and palaeoclimates, Gondwana deposits of Peninsular India, marine intercalations.	
	Group-C: Stratigraphy of North-East India	12
9.	Precambrians and all igneous activities of Shillong Plateau and Arunachal Himalayas.	
10.	Gondwana and Paleozoic stratigraphy in the Northeastern region of India. Cretaceous deposits of the Northeast India, Cretaceous-Tertiary boundary, Sylhet traps and other Mesozoic intrusives of the Northeast India. Cenozoic stratigraphy of Assam-Arakan region.	

2.3.4 GLG -3044: Economic Geology and Sedimentology (Practical)

Course outcomes

- Identify ore minerals in polished blocks and hand specimens.
- Identify the textures and structures of ore minerals under microscope and in hand specimen.
- Identify industrial minerals for different mineral-based industries.
- Study different sedimentary rocks in thin sections.
- Isolate and identify heavy minerals.
- Carry out textural analysis of sedimentary rocks.
- Prepare facies maps and fence diagrams from bore-hole data.

Sl. No.	*Topic*	*Teaching hours*
	Group-A: Economic Geology	48
1.	Identification of opaque metallic minerals under ore microscope - galena, sphalerite, pyrite, pyrrhotite, chalcopyrite, arsenopyrite, magnetite, haematite, ilmenite, goethite, chromite, cassiterite, covellite, cobaltite, nicolite.	
2.	Study of common textures in ores and their significance-granular, collomorphic, replacement exsolution and nodular textures.	
3.	Study of different structures of ores in hand specimen, their genetic significance.	
4.	Identification of industrial minerals in hand specimen for cement, steel, refractory, glass and ceramic industry.	
5.	Identification of minerals in hand specimen (non-opaque, opaque and gemstones).	
6.	Ore reserve estimation.	
7.	**Group-B: Sedimentology**	48
	Thin section petrography of shale, sandstones and limestone, modal analysis, measurement of porosity.	
8.	Separation of heavy mineral and their study under microscope.	
9.	Study of sedimentary structures in hand specimen, determination of sphericity and roundness.	
10.	Granulometric analysis and their interpretation.	
11.	Paleocurrent analysis-field measurement procedures and laboratory techniques.	
12.	Chemical analysis of limestone. Staining for carbonate minerals.	

2.3.5 GLG -3052: Stratigraphy, Surveying and Mapping (Practical)

Course outcomes

- Identify rocks of different stratigraphic horizons of India.
- Prepare and interpret geological maps.
- Carry out close and open traverse using theodolite and total station.
- Carry out topographical survey using GPS.

Sl. No.	*Topic*	*Teaching hours*
	Group-A: Stratigraphy	24
1.	Study of important rocks of India in hand-specimen and in thin section.	
2.	Study of geological maps of geologically important areas of India.	
3.	Facies maps (sand-shale ratio map, carbonate and sand & shale ratio map)	
4.	Preparation of fence diagram.	
	Group-B: Surveying and Mapping	24
5.	Use of Brunton Pocket Transit for bearing, estimation of height of objects, Plane table survey. Traverse using theodolite-close loop and open end survey, use of Dumpy level.	
6.	Topographic mapping/contouring; GPS (Hand held) based survey and mapping. Contouring from DEM.	

2.3.6 GLG -3062: Field Work

Course outcomes

- Carry out geological mapping in an unknown geological terrain, prepare geological map and collect samples.

Sl. No.	*Topic*	*Teaching hours*
1.	Field work	60

2.3.7 GLG -3073: Open Course-1:: Geodynamics (Theory)

Course outcomes

- Describe the theories of formation of continents, ocean basins and mountains.
- Analyze the role of plate tectonics in evolution of Himalaya.
- Provide broad overview of the tectonic divisions of India.

Sl. No.	*Topic*	*Teaching hours*
1.	Continents, Oceans and Mountains. Development of theories from geosynclines to plate tectonics.	36
2.	Sea-floor spreading, island arc, mid-oceanic ridge, emplacement of ophiolites. Earthquake and seismic belts of the world. Measurements of plate dynamics.	
3.	Broad overview of tectonic settings of India. Evolution of the Himalayas and Himalayan tectonics, Indo-Myanmar mobile belt.	

2.3.8 GLG -3083: Open Course-2:: Planetary Geology (Theory)

Course outcomes

- Impart basic understanding on evolution of the solar system, morphology and classification of meteorites.
- Planetary remote sensing.

Sl. No.	*Topic*	*Teaching hours*
1.	Introduction and history of planetary geology: Universe; introduction to solar system: origin and age of the solar system, formation of the Sun and the planets.	36
2.	Cosmic dust. Asteroidal parent body. Morphology and classification of meteorites.	
3.	Primitive meteorites: Ordinary Chondrites and Carbonaceous Chondrites.	
4.	Differentiated meteorites: Achondrites, Lunar meteorites and Martian meteorites, iron and stony –iron meteorites.	
5.	Planetary remote sensing: Planetary topography and surface study. Surface, asmospheric, mineral and chemical composition study. Thermal remote sensing for planets. Gravity, Gamma and X-ray spectroscopy.	

2.4.1 GLG -4014: Palaeontology (Theory)

Course outcomes

- Carry out taxonomic identification of foraminifers in sedimentary rocks and interpret their significance in geological studies and hydrocarbon explorations.
- Study evolution of some of vertebrates based on fossil records in the context of changing pattern of paleoclimate and paleoecology.
- Learn and understand separation techniques and taxonomic identification of palynomorphs from sedimentary rocks and significance of palynological studies.
- Analyze application of Gondwana flora in deciphering paleoclimate of the Permian Period.

Sl. No.	*Topic*	*Teaching hours*
1.	Micropalaeontology - definition, types of microfossils and their importance. Nannofossils and their importance in geology; Trace fossils and their classification,	48
2.	Foraminifers - their morphology and evolution, geological distribution and their applications in palaeoecology, correlation, biostratigraphy and hydrocarbon exploration.	
3.	Conodonts, ostracods and radiolaria - morphology, stratigrapohic distribution and application.	
4.	Vertebrate palaeontology - Evolution of man, equidae and proboscidae in the context of palaeoclimate and palaeoecology. Changing pattern of dentition during evolution of the above vertibrates.	
5.	Palynology and its stratigraphic and palaeoclimatic significance. Study of pollens and spores, diatoms, dianoflagellate. Palynological organic matters.	
6.	Detail account of Gondwana flora in the World and in the Indian context in the context of palaeoclimate and palaeoecology.	

2.4.2 GLG -4026: Fuel Geology (Theory)

Course outcomes

- Analyze coal samples for proximate and ultimate analysis and classify them.
- Carry out petrological study of coal samples under microscope and write about origin of macerals and their applications in hydrocarbon exploration.
- Analyze the properties and assess utilization prospects of Indian coal deposits.
- Assess reservoir properties of sedimentary rocks for petroleum deposits.
- Explore petroleum systems in a sedimentary basin and identify source, reservoir, trap and seal components in it.
- Describe the techniques of exploration and geophysical logging and assess their application.

Sl. No.	Topic	Teaching hours
	Group-A: Coal	36
1.	**Origin of coal:** Evolutionary development of flora; climatic, paleogographic and tectonic requirements for origin of peat swamps; sedimentation of coal and coal bearing sequence, geological features of coal seams; age and geographical distribution of coal; diagenesis of peat and coalification, physical and chemical changes of coal associated with progressing coalification; Causes of coalification.	
2.	**Coal sampling and analysis:** Coal sampling; coal analysis, chemical properties of coal, proximate analysis and ultimate analysis; physical properties of coal; trace elements in coal; coal classification.	
3.	**Petrography of coal:** Macroscropic description of coal; microscopic description of coal, macerals- classification, properties, origin and application, microlithotypes.	
4.	**Coal utilization and coal as alternative energy source:** Combustion, gasification, carbonization and coke; gas in coal, underground coal gasification, coal as liquid fuel, coal as an oil prone source rock; coal and environment	
5.	**Geology of Indian coal deposits:** Geological and geographical distribution of Indian coal deposits; geology of coal deposits of Northeast India.	
	Group-B: Petroleum	36
6.	Nature and origin of petroleum: Basic components of petroleum, Physical properties of oil, Origin of petroleum, theories of organic and inorganic origin. Migration of hydrocarbon – primary and secondary. Trapping mechanisms for oil and gas.	
7.	Reservoir properties: Porosity, permeability (absolute, effective and relative), Fluid saturation, relative permeability and fluid saturation.	
8.	Reservoir rocks : Sandstone reservoir, carbonate reservoir, fractured reservoirs, Petrophysical studies of reservoir rocks, Pressure condition in reservoirs – reservoir pressures, normal and abnormal formation pressure.	
9.	Oil well drilling and drilling fluids – parameters, usefulness types, vertical, deviated and horizontal drilling, Duties of well site geologists; Well logging : Basic of well logging, Different well logging – SP, GR, Resistivity log, neutron log, Density logs, sonic log, conventional electric log. Resistivity and water saturation.	
10.	Exploration of hydrocarbon – geological, geochemical and geophysical exploration. Geophysical exploration of hydrocarbon – seismic survey, gravimetric survey, geological interpretation of seismic data. Petroliferous basins of India. Oil and gas fields of Assam, Arunachal Pradesh, Nagaland, Tripura, Mizoram, Cambay basins, Bombay Off-shore and Krishna-Godaveri basins.	

2.4.3 GLG -4034: Fuel Geology (Practical)

Course outcomes

- Carry out proximate analysis in the laboratory.
- Identify macerals in polished pellets of coal.
- Interpret organic geochemical data for characterizing source rocks.
- Interpret geophysical logs.
- Prepare structure contour, isopay and isopach maps.
- Prepare master logs from well data.

Sl. No.	Topic	Teaching hours
	Group-A: Coal	48
1.	Study of coal in hand specimen.	
2.	Identification of different types of coal, lithotypes, cokes and structures associated with coal seams.	

3.	Proximate analysis of coal- determination of moisture, ash and volatile matter.	
4.	Petrography of coal- polished block study under microscope.	
5.	Analysis and interpretation of elemental analysis and Rock-Eval pyrolysis.	
	Group-B: Petroleum	48
6.	Preparation of lithostratigraphic and geophysical sections from geophysical well logs and well data.	
7.	Study of wireline logs (SP, IEL, Porosity, Neutron, Gamma ray, CBL and dipmeter log).	
8.	Determination of porosity and water saturation (for clean sand) from well log data.	
9.	Structure contour, isopay and isopach maps.	
10.	Estimation of oil and gas reserves.	
11.	Preparation of Geo Technical Orders (Drilling policy) for exploratory and development wells.	
12.	Preparation of master logs from well data.	
13.	Evaluation of high pressure zones and calculation of mud density.	

2.4.5 GLG -4042: Palaeontology (Practical)

Course outcomes

- Identify different invertebrate fossil forms.
- Identify plant fossils of Gondwana seqence rocks.
- Identify foraminifera and palynoforms under microscope.
- Carryout biostratigraphic zonation based on foraminiferal fossil assemblages.

Sl. No.	*Topic*	*Teaching hours*
1.	Megascopic study of important fossil forms - lamellibranchs, cephalopods, gastropods, trilobites, brachiopods and echinoids.	48
2.	Megascopic study of important fossils from Gondwana flora.	
3.	Microscopic study of foraminifera, radiolarian, ostracoda.	
4.	Microscopic study of spores and pollens, dianoflagallete	
5.	Problems on biostratigraphic zonations.	

2.4.6 GLG -4056*: Elective (Theory)

Sl. No.	*Topic*	*Teaching hours*
1.	Elective papers are listed at 2.4.10.	72

2.4.7 GLG -4062*: Elective (Practical)

Sl. No.	*Topic*	*Teaching hours*
1.	Elective papers are listed at 2.4.10.	48

2.4.7 GLG -4078: Project work (Theory)

Course outcomes

- Formulate a research problem from a geological terrain and prepare a model to address it.
- Carry out Lab analysis and interpret them to address the problem.
- Write the dissertation.

Sl. No.	*Topic*	*Teaching hours*
1.	Project work will be allotted by the Departmental Advisory Committee.	150

2.4.8 GLG -4083: Open Course-3:: Fluvial System (Theory)

Course outcomes

- Gives a source to sink overview of the fluvial system, fluvial landforms and their significance, fluvial sedimentary sequence
- Understand the fluvial landform features in Northeast India.

Sl. No.	*Topic*	*Teaching hours*
1.	**Fluvial processes**: Evolution of drainage basin, drainage patterns and their significance, hydraulic geometry, classification of fluvial systems, the processes of erosion, transportation and deposition. Stream power, competence and capacity, base level control, structural and active tectonic control on rivers.	36
2.	**Fluvial landforms:** The form - process relationship, erosional and depositional landforms, evolution of floodplains and their types, alluvial terraces, alluvial fan and delta, concept of peneplain and fluvial cycle of erosion.	
3.	Fluvial depositional environments and sedimentation, depositional models, lithofacies and lithofacies assemblages, genesis of facies, architectural element analysis in facies.	
4.	Fluvial landforms in NE India, records of Phanerozoic fluvial sequences, economic potential of fluvial depositional systems.	

2.4.9 GLG -4093: Open Course-4:: Environmental Geology (Theory)

Course outcomes

- Write about causal factors of pollution and hazards related to mining.
- Analyze impact of landslides on environment.
- Write about the causal factors of flood in fluvial systems and their management.
- Identify the sources of water pollution and suggest remedial measures.

Sl. No.	*Topic*	*Teaching hours*
1.	Definition, fundamental concepts and scope of environmental geology, pollution and hazards due to mining activities, pollution due to radioactive mineral mining.	36
2.	Landslides, causal factors, impact of landslides on environment, landslide hazard zonation, preventive measures. Soil erosion.	
3.	Flood – definition, causes, flood in fluvial systems, flood management, structural and non-structural methods of flood management, dams and flood, method of flood frequency analysis, flood in Assam	
4.	Water pollution - sources of pollution of surface and ground water, water pollution parameters, types of water pollution, causal factors, case studies. Parameters of potable water as per Indian and WHO's standards.	

2.4.10 GLG-4056 Elective Paper (Theory) and GLG-4062 Elective Paper (Practical)

or

GLG-4078 Project work (in lieu of paper GLG-4056 and GLG-4062)

Elective papers offered:

(Any one should be chosen by the student. Students may not be accommodated in all the papers given below. It depends on the capacity and man-power of the department and will be decided by the department.)

1. Petroleum Exploration
2. Basin Analysis
3. Coal and Organic Petrology
4. Advanced Geoinformatics
5. Geo-Exploration
6. Advanced Sedimentology
7. Advanced Geochemistry and Thermodynamics

GLG-4056A :: Petroleum Exploration [Theory]

Course outcomes

- Characterize organic matters in source rocks on the basis of organic geochemical and petrographical data.
- Enumerate characteristics of siliciclastic and carbonate reservoirs.
- Write about the techniques of hydrocarbon migration and role of cap rocks and traps.
- Explain the importance of geophysical logs in petroleum exploration.
- Design a model of geophysical exploration for hydrocarbon in an unexplored sedimentary basin.
- Write about the criteria for oilfield development and role of a petroleum geologist in it.
- Classify sedimentary basins on the basis of tectonics and hydrocarbon potential with special reference to Indian sedimentary basins.

Sl. No.	*Topic*	*Teaching hours*
1.	Source rock-definition, nature and type of source rock. Process of diagenesis, catagenesis and metagenesis in the formation of source rocks. Evaluation of petroleum source rock potential. Condition for generation of oil and gas from the source sediments, Oil window.	72
2.	Characteristics of reservoir rocks. Clastic reservoir rock, Carbonate reservoir rock, Fractured and miscellaneous reservoir rock, Marine and non marine reservoir rock. Porosity and permeability of reservoir rocks. Effects of diagenesis on the reservoir quality.	
3.	Hydrocarbon migration and accumulation. Hydrocarbon migration from the source rock to the reservoir rock, short distance and long distance migration, Primary and secondary migration.	
4.	Entrapment of hydrocarbon. Traps in the path of migration, entrapment and accumulation of hydrocarbon, classification and types of traps: structural, stratigraphic and combination type of traps, Trap mechanism in the different oil field of India. Primary and secondary stratigraphic traps.	
5.	An overview of the geophysical methods of exploration. Physical properties of rock- density, susceptibility, resistivity, and elastic wave velocities, factors controlling the properties. Principle of gravity exploration, concept of gravity anomaly, reduction of data, interpretation of anomaly maps, identification of folds, faults and contacts. Principles of seismic reflection and refraction methods. Seismic data acquisition on land and sea and interpretation of results. Bright spots.	
6.	Types of wells-exploration, appraisal and development wells. Vertical, deviated, horizontal and multilateral wells. Type of drilling fluid, properties and functions. Drilling rigs and its components. Conventional and side wall coring. Duties of well site geologists. Mud loss and mud circulation, well kicks and blowouts. Perforation and testing of the promising horizons.	
7.	Well log presentation-log head scales. Drilling fluids and invasion profile. Principles and utilities of the different logs such as self potential log, resistivity logs, calliper log, sonic log, compensated	

	density logs, compensated neutron logs, natural gamma ray log, spectral gamma ray logs, casing collar locator, cement bond tool, Log interpretation and formation evaluation. Oil water contacts and gas oil contacts. Interpretation in clean and shaly formation.	
8.	Reservoir drives mechanisms- depletion drive, displacement drive, combination drive. Efficiency of the individual drives. Estimation of oil and gas reserve: volumetric estimation, decline-curve method, material balance method and simulation method. Enhanced/Improved oil recovery methods: water flooding method, thermal methods, chemical flooding methods, miscible gas flooding methods.	
9.	Criteria for oil field development- basic geological data for development planning. Delineation of the field limits, volumetric estimation of in place reserve, planning development wells based on the reservoir parameters and economic criteria, well spacing, final development plan, rate of production, oil recovery factor, water injection and pressure maintenance.	
10.	Tectonic classification, stratigraphic evolution and hydrocarbon accumulations in the following basins of India-Cambay basin and Gulf of Cambay, Bombay offshore, Cauvery basin, Krishna – Godavari basin, Mahanadi and Mahanadi offshore, upper Assam, Naga hills, Tripura, Cachar and Rajasthan basins.	

GLG-4062A :: Petroleum Exploration [Practical]

Course outcomes

- Prepare structure contour map and determine the location of gas-oil and oil-water contacts.
- Prepare isopach maps and postulate depositional model.
- Characterize organic matters of source rocks based on interpretation of organic geochemical data.
- Interpret 2D seismic sections.

Sl. No.	*Topic*	*Teaching hours*
1.	Preparation of structure contour map and location of Gas Oil contact and Oil water contacts.	48
2.	Interpretation of structure contour maps.	
3.	Interpretation of Isopach map and depositional model.	
4.	Evaluation of Organic matter (Kerogen) type and maturity of source rocks.	
5.	Study of source rock maturity and genetic potential by Rock-Eval Method.	
6.	Plotting of inclinometer data and computation of vertical shortening and horizontal drift.	
7.	Calculation of cement slurry volume.	
8.	Interpretation of seismic section.	
9.	Reserve calculation.	

GLG-4056B :: Basin Analysis [Theory]

Course outcomes

- Carry out an integrated study of the sedimentary basins as geodynamic entities.
- Write about surface and subsurface methods employed for characterizing a sedimentary basin.
- Analyze the role of plate tectonics in formation of a sedimentary basin and functioning of sedimentary routing systems.
- Define a model of establishment of stratigraphy and thermal history of a sedimentary basin.
- Write about application of sequence stratigraphy in drawing tectonic and sedimentation history of a sedimentary basin and its petroleum potential.

Sl. No.	*Topic*	*Teaching hours*
1&2.	**Introduction:** Basin analysis - the integrated study of sedimentary basins as geodynamic entities; Basins in their plate tectonic environment. Compositional and rheological zonations of the earth; Classification of the sedimentary basins; scope of sedimentary basin analysis study. Physical state of the lithosphere – stress-strain, isostasy, heat flow, rheology.	72
3&4.	**Tools and methods of basin analysis:** Surface and subsurface investigation methods – outcrop section, field measurement and documentation, sampling; subsurface stratigraphic sections from well cuttings and cores, petrophysical logs, preparation of structure contour, isopach, lithofacies, clastic ratio and paleocurrent maps; siliciclastic petrofacies. Remote sensing and basin analysis.	
5.	**Mechanics of basin formation:** Basins due to lithospheric stretching, basins due to flexure; Effects of mantle dynamics; Basins associated with strike-slip deformation.	
6.	**Sedimentary Basin fill:** Terrestrial sediments and solute yields, measurements of erosion rates, functioning of sediment routing systems	
7.	**Basin stratigraphy:** Stratigraphic cycles – definition and recognition, driving mechanism for stratigraphic pattern, numerical simulation of stratigraphy, depositional systems, relation of depositional style to basin setting; subsidence and thermal history, thermal maturity measurement and applications, factors influencing temperatures and paleotemperatures in sedimentary basins.	
8&9.	**Sequence stratigraphy:** Introduction, depositional systems and system tracts, sequence boundaries, system tracts and sequences in siliciclastic and carbonate deposits, sequence stratigraphy and petroleum exploration.	
10.	**Application to petroleum play assessment:** From basin analysis to play concept, the petroleum charge system, reservoir and trap.	

GLG-4062B :: Basin Analysis [Practical]

Course outcomes

- Prepare facies maps based on borehole data and interpret them.
- Correlation stratigraphical columns based on lithological, heavy mineral assemblage and paleontological data.
- Interpret and correlate geophysical logs.

Sl. No.	*Topic*	*Teaching hours*
1.	Preparation and interpretation of various types of facies maps.	48
2.	Interpretation and correlation of lithological, heavy mineral and palaeontological logs.	
3.	Interpretation and correlation of wireline, GR, SP, Neutron log.	
4.	Integration of various analyzed data to interpret the relationship of tectonics and sedimentation.	

GLG-4056C :: Coal and Organic Petrology [Theory]

Course outcomes

- Explain the geological basis of evolution of peat swamps and coal deposit through geological time.
- Write an account of the ICCP schemes of classification of coal macerals and their application hydrocarbon exploration and characterization of utilization prospects of coal deposits.
- Discuss about the dispersed organic matters present in sedimentary rocks and their thermal evolution.
- Write about different analytical tools of organic geochemistry and their applications.

Sl. No.	*Topic*	*Teaching hours*
1.	Definition and scope of organic petrology; evolutionary development of flora; coal depositional environments; coalification: its causes and effects; coal system analysis; sequence stratigraphic setting of coalfields; distribution of coal deposits through ages; coal deposits of the world and India with special reference to Northeast India.	72
2.	The coal petrology microscope; petrographic methods-sampling and sample preparation methods, reflectance and fluorescence measurements; macro- and microscopic constituents of coal-lithotypes, macerals and microlithotypes; maceral sub group and macerals; physical and chemical composition of macerals; origin of macerals.	
3.	Application of coal petrography; reflectance of vitrinite and its application; fluorescence of macerals and its application, coke petrology and application.	
4.	Preparation of coal for industrial purposes; combustion of coal; carbonization and coke manufacture; gasification; liquefaction; coal oxidation and weathering; coal combustion and coke petrology; environmental effects of coal utilization; coal-bed methane and its exploitation.	
5&6.	Introduction to dispersed organic matters in sedimentary rocks; transformation of organic matters into kerogen; organic maturation, thermal cracking of kerogen; diagenesis, ketagenesis and metagenesis; formation of petroleum in relation to geological processes: temperature, time, and pressure; timing of oil and gas generation; coal as source rock of petroleum; oil shales.	
7&8.	Sedimentological and tectonic aspects of coal mining; coal mining methods; Interpretation of petrographic results and their application to mining and beneficiation; environmental effects of coal mining	
9 & 10.	Elemental analysis; Rock Eval pyrolysis; biomarker analysis as indicators of depositional environments, age and maturity of source rocks; methods for measurement of maturity of kerogen – optical (Thermal Alteration Index, vitrinite reflectance), microscopic organic analysis (MOA) and physico-chemical (fluorescence spectroscopy) methods. Merits and demerits of these methods.	

GLG-4062C :: Coal and Organic Petrology [Practical]

Course outcomes

- Determine forms of sulphur based on gravimetric analysis.
- Interpret organic geochemical analysis data for typing of organic matters of sedimentary rocks.
- Identify macerals under microscope and write about their genesis.

Sl. No.	*Topic*	*Teaching hours*
1.	Determination of amount and forms of sulphur in coal.	48
2.	Interpretation of elemental composition of coal: identification of kerogen types using Van-Krevelen diagram.	
3.	Interpretation of Rock-Eval pyrolysis data: characterization of kerogens, thermal maturity and hydrocarbon potential of petroleum source rocks.	
4.	Study of macerals under ore microscope and interpretation of results.	
5.	Evaluation of depositional environment coal deposits from organo-geochemistry and petrpgraphic data.	

GLG-4056D :: Advanced Geoinformatics [Theory]

Course outcomes

- Define a digital image and explain the theoretical basis and applications of different image restoration and enhancement methods.
- Discuss the technical aspects and application of RADAR remote sensing.
- Write about the theoretical basis and design of a thermal remote sensing system.
- Explain the techniques of hyperspectral remote sensing and write about spectral libraries.
- Discuss about digital photogrammetry and techniques of creation of orthophoto and DEM from stereo satellite images.
- Write about structure and analysis of spatial data in GIS.
- Discuss the techniques of surveying using Differential and RTK GNSS receivers.

Sl. No.	*Topic*	*Teaching hours*
1.	Definition and Scope of Remote Sensing; Electromagnetic Radiation (EMR); interaction of the earth's atmosphere with electromagnetic radiation; platforms; spatial, temporal and radiometric resolution; spectral signatures; active and passive remote sensing; opto-mechanical and pushbroom scanners; microwave and thermal sensors; side looking RADAR; hyperspectral remote sensing; commonly used remote sensing satellite systems.	72
2&3.	Digital image; digital image data formats; digital image processing; image rectification and registration; image enhancement techniques; image elements; digital image classification: visual, supervised, unsupervised; knowledge based and object oriented image classification; probability and statistical methods used in image interpretation; image transformations: HIS, image fusion, Principal Component Analysis etc; Natural Indices.	
4.	Microwave remote sensing: plane waves; antenna systems; radiometry; microwave interaction with atmosphere and earth's surface; physical mechanisms and empirical models for scattering and emission - radiometric systems; sensors; data product and applications.	
5.	RADAR remote sensing: interaction of RADAR and earth's surface; surface scattering theory; geometry of RADAR images; resolution concept; SAR interferometry; application of RADAR remote sensing in geology, hydrology and land use mapping.	
6.	Thermal remote sensing: thermal radiation principles and interaction with the earth's surface; thermal sensors; thermal images; interpretation of thermal images.	
7.	Hyperspectral remote sensing: imaging spectroscopy; compound spectral curve; spectral library; characteristic and processing of hyperspectral images; derivative spectrometry, thermal remote sensing.	
8&9.	Introduction to digital photogrammetry; advantages of digital photogrammetry over analog photogrammetry; aerial Triangulation (ATM); block adjustment; DEM and orthophoto generation. Introduction to Geographical Information System; hardware and software requirements for GIS; map projection, ellipsoid and datum; GIS data structures: raster based and vector based structures; GIS data acquisition; overlay analyses; spatial analyses: vector and raster based; Digital elevation models and its interpretation; GIS projects; recent trends in GIS.	
10.	Introduction to GNSS: Fundamental concepts of GNSS; GNSS types: GPS, GLONASS, Galileo and BEIDOU; application of GNSS; mapping and surveying.	

GLG-4062D :: Advanced Geoinformatics [Practical]

Course outcomes

- Georeference satellite images by collecting GCPs from already georeferenced images.
- Enhance and classify optical images.
- Analyze and interpret SAR data.
- Carry out spatial analysis using GIS.

- Carry out surveying using GPS and integrate data in GIS.

Sl. No.	*Topic*	*Teaching hours*
1.	Georeferencing of satellite images; image filtering; image fusion; image classification: visual, supervised and object oriented; study of spectral and image characteristics of SAR data; interpretation of SAR data for land use studies; study of thermal image and interpretation: computing radiance image from satellite data; Interpretation of hyperspectral data; use of spectral libraries; preparation of DEM and orthophoto from stereo satellite images.	48
2.	Overview of GIS softwares; digitizing features from toposheet and satellite images; query and analyses of GIS data; map composition; creation of Geodatabase.	
3.	Surveying with GPS; integration of GPS data in GIS projects.	

GLG-4056E :: Geo-Exploration [Theory]

Course outcomes

- Write about techniques and application of seismic methods of exploration.
- Explain the theoretical bases of electromagnetic methods of exploration.
- Write about the techniques of gravimetric and magnetic surveys and their applications in mineral explorations.

Sl. No.	*Topic*	*Teaching hours*
	Group-A: Methodology	72
1.	Introduction: Scope and modern developments in data acquisition and processing tools, ambiguities and sources of error, anomaly, signal and noise, field procedures and plan for data acquisition, care of field equipments.	
2.	Seismic methods: Seismic waves used in seismic survey and their velocities in different rocks, basic principles of seismic wave reflection and refraction seismic methods, data acquisition, processing and interpretation.	
3.	Geo-electrical methods: Self potential and resistivity methods, basic principles, data acquisition, procedure, processing and interpretation, basic layouts, quantitative interpretation, induced polarisation method, Resistivity tomography.	
4.	Electromagnetic methods; Basic principles-EM spectrum, frequency and depth of penetration, electromagnetic methods and telluric current methods, Turam and VLF method, transient EM (TEM) method, GPR.	
5.	Gravity and magnetic methods; Basic concepts, gravity anomaly, density variation in rocks, Measurement of gravity- field procedures, equipments and layout, Data processing, corrections, interpreting gravity data, forward modeling and mass estimation, Magnetic field of the earth, magnetic susceptibility, induced magnetism and remnant magnetism, field procedures and measurements, processing and interpreting magnetic data.	
	Group-B: Application of geophysical methods	
6.	Application of gravity, magnetic, electrical and electro-magnetic methods for exploration of different types and deposits of metallic minerals. Data processing and interpretation for the deposits by the different methods in regional and deposit wise interpretation.	
7.	Exploration of the non-metallic minerals by integrated geophysical data, geophysical approach for the engineering construction and hazard detection.	
8.	Processing of the gravity and magnetic reconnaissance data for hydrocarbon exploration, 2D seismic surveys and interpretation of the seismic data for interpreting the structures favourable for oil accumulation, 3D seismic survey,	
9.	Geophysical surveys and data interpretation for exploration and detection of the ground water bodies.	
10.	Geophysical mapping: Igneous, metamorphic and sedimentary terrane mapping, delineation of lithological units and structural elements, satellite mapping-gravity, thermal and magnetic, bathymetric studies. Correlation of structural and gravity lineaments, Ground radiometry.	

GLG-4062E :: Geo-Exploration [Practical]

Course outcomes

- Interpret seismic, gravity and magnetic data.
- Analyse petrophysical properties of ore bearing horizon.
- Identify anomalies and delineate discontinuities.

Sl. No.	*Topic*	*Teaching hours*
1.	Data acquisition procedures in seismic, electrical, gravity and magnetic methods and their layout.	48
2.	Data processing and interpretation for ore body, structure and lithology by using different methods.	
3.	Lab-based analysis viz. petrophysical properties of ore bearing horizons.	
4.	Calibration procedures required for the methods mentioned in Unit-1 above.	
5.	Identification of anomalies, delineation of discontinuities and interpretation.	

GLG-4056F :: Advanced Sedimentology [Theory]

Course outcomes

- Discuss about genesis and significance of sedimentary structures.
- Write about tectonic evolution of sedimentary basins.
- Illustrate the petrographic methods that are used in characterizing clastic sediments.
- Discuss the textures, structures and diagenesis of carbonate sediments.
- Write about heavy mineral assemblage of sediments and applications of it in provenance analysis.

Sl. No.	*Topic*	*Teaching hours*
1.	**Sediment Texture and Mineralogy** Sediment Texture, their measurement and significance. Pore morphology. Types of porosity and their origin. Relationship between porosity, permeability and texture. Diagenesis and porosity of rocks.	72
2&3.	**Tectonics and Sedimentation** Tectonic control of sediment/sedimentary rock composition. Structural evolution of sedimentary basins – deformation mechanisms and types, paleostress and deformation dating, tectonics in reservoir geology.	
4&5	**Petrographic Methods** Preparation of laquer peels of non-indurated sediments and their analysis. Preparation of polished slabs of indurated rocks, their megascopic examination and measurements. Preparation of thin sections of non-indurated and indurated sediments and their petrographic analysis. The Gazzi-Dickinson Point Counting Method. Staining of slabs and slides. Heavy mineral separation and analysis. Petrographic analysis of organic matter. SEM in grain morphology and clay mineral study. Staining in sandstones.	
6&7.	**Carbonate Sedimentology** The Carbonate Cycle. Composition of rock forming carbonate minerals. Allochems, Ooids, Intraclasts, Peloids, Skeletals, Onkoids and Thromboids. Carbonate muds and carbonate cements. Porosity classification of carbonates. Carbonate environments and facies. Carbonate diagenesis. Staining in carbonate rocks.	
8.	**Heavy Minerals** Heavy mineral assemblage and factors controlling heavy mineral assemblage. Hydraulic control of heavy mineral assemblage. Weathering and diagenesis of heavy minerals. Geochemistry of heavy minerals. High resolution heavy mineral analysis (HRHMA). Provenance analysis. Use of heavy minerals in forensic science and geoarchaeology.	
9.	**Age measurements in sedimentology** Geochronology. Radiochronology and Isotopic Stratigraphy. Mineralogical and geochemical	

	markers. Chemostratigraphy. Paleomagnetism and Magnetostratigraphy.	
10	Evaporites, cherts, phosphatic sediments, iron rich sedimentary rocks, organic carbon rich sedimentary rocks.	

GLG-4062F :: Advanced Sedimentology [Practical]

Course outcomes

- Prepare thin section of sediments and sedimentary rocks and study them under microscope for analysis of diagenesis and cementation.
- Separate heavy minerals from sediments and identify the heavy mineral assemblage under microscope.
- Prepare lithologs from field data.
- Stain thin sections of carbonate and siliciclastic rocks and identify stained minerals.

Sl. No.	*Topic*	*Teaching hours*
1.	Preparation of thin sections of sediments and sedimentary rocks and their petrographic analysis including diagenesis, cementation and volumetric analysis.	48
2.	Heavy mineral separation, their petrographic examination and preparation of heavy mineral range table.	
3.	Measurement of porosity and permeability in sandstones / sediments.	
4.	Preparation of lithologs from field data. Paleocurrent analysis.	
5.	Staining of carbonate rock and sandstone thin sections and identification of stained minerals.	

GLG-4056G :: Advanced Geochemistry and Thermodynamics [Theory]

Course outcomes

- Discuss the geochemical characteristics of noble gas and their importance in studying mantle processes and aquifer systems.
- Illustrate the importance of thermodynamic systems in studying magmatic and metamorphic reactions.
- Discuss the thermodynamic properties of ideal and non-ideal solutions and their role in magmatic and metamorphic reactions.
- Discuss the distribution of trace elements in studying genesis of igneous and metamorphic processes.
- Write about the application of stable isotope geochemistry in studying processes of ore formation.

Sl. No.	*Topic*	*Teaching hours*
1.	Geochemistry of Noble Gas: Geochemical characteristics of noble gas, Solar noble gas, Planetary noble gas, noble gas in aquifer system, mantle noble gas, the mantle He flux.	72
2.	Thermodynamic system and variables and the Fundamental Relationships: Conservation of energy and First Law of Thermodynamics; Reversibility; Heat, Work, Internal Energy, Enthalpy; Heat Capacities. Second Law of Thermodynamics: Entropy; Expressions of the Second Law; Implications of the Second Law, Combined First and Second Laws, Enthalpy; Criteria for Spontaneity and Equilibrium; Temperature and pressure dependence of Gibbs free energy; Clapeyron equation and calculation of a reaction boundary.	
3.	Fugacity: Activity and Standard states. Excess function and activity coefficient. Activity of ideal and non- ideal Solution: Equilibrium constant and calculation of a reaction boundary involving a fluid phase.	
4.	Thermodynamics of solution: Vapour pressure and Gas mixtures: Roult's Law and Henry's Law. Partial molar properties and the chemical potential. Gibbs –Duhem equation and Phase rule. Thermodynamic properties of ideal and non-ideal solution.	
5.	Geochemistry of Aqueous phases: General information on structure and properties of water. Electrolytic nature of aqueous solutions. Activities and activity coefficient of electrolysis in	

	aqueous solution. Activity of dissolved neutral species. Activity of solvent in aqueous solution.	
6.	Trace element geochemistry: Assimilation of trace elements in crystals. Fractionation operated by crystalline solids, onuma diagram. Assimilation of trace elements in silicate melts. Trace elements distribution models for magma genesis.	
7.	Stable Isotope Geochemistry: Definitions and type of stable isotopes. Isotope in nature. Isotope fractionation. Isotope fractionation H, O, C and S. Role of stable isotope in ore deposits and hydrothermal system.	

GLG-4062G :: Advanced Geochemistry and Thermodynamics [Practical]

Course outcomes

- Classify igneous and sedimentary rocks based on geochemical data.
- Use REE and trace element diagrams for igneous rock, sea and river water and sediments.
- Determine mineral stability based on thermodynamic calculations.

Sl. No.	Topic	Teaching hours
1.	Rock classification: TAS for plutonic and volcanic rock; Classification of igneous rocks using cations; R_1-R_2 diagram; Chemical Classification of sedimentary rocks.	48
2.	REE diagram for igneous rock, sea and river water and sediments. Spider diagram for trace elements.	
3.	Thermodynamic calculations to estimate physical and chemical conditions of mineral stability.	

Section – 3 : Suggested readings

GLG-1016 :: Structural Geology and Seismology

1. *Structural Geology-Fundamentals and modern developments, S. K. Ghosh, 1993, Pergamon Press.*
2. *Structureal geology of rocks and regions, Davis, G H and Reynolds, S J, 1996, Wiley and Sons.*
3. *Structural geology, Price and Cosgrove, 1996.*
4. *Microtectonics C. W. Passchier and R. Trouw, Springer.*
5. *Structural Geology, R. J. Twiss and E M Moore, W H Freeman and Co.*
6. *Structural Geology, by Haakon Fossan, Cambridge University Press, 2010, 463pp.*
6. *Fundamentals of structural geology, David D. Pollard, Raymond C. Fletcher, Cambridge University Press, 2005*
7. *Earthquake Seismology, Treatise on Geophysics, by Hiroo Kanamari and Gerald Schubert, ELSIVIER Publishers, 2007.*
8. *Paleoseismology, 2nd edition, edited by Mc Calpin, Academic Press.*

GLG-1026 ::Mineralogy & Crystal Chemistry, Thermodynamics in Geology

1. *Fundamentals of optical, spectroscopic and X-ray mineralogy, Sachinath Mitra*
2. *Crystallography and crystal chemistry-Donald E Bloss*

GLG-1036 :: Geoinformatics, Geomorphology & Quaternary Geology

1. *Introduction to Remote Sensing, 5th Edition, James B. Campbell and Randolph H. Wynne, The Guilford Press, 2011, 666p.*
2. *Principles & Applications of Photogeology – S.N.Pandey; New Age International Publishers.*
3. *Remote Sensing & Image Interpretation – T.M. Lillesand & R.W. Kiefer; John Wiley & Sons, Inc.*
4. *Fundamentals of Geographic Information Systems, 3rd Edition, by Michael N. DeMers, Wiley India.*

1. *Geomorphology: A systematic analysis of late Cenozoic landform, Arthur L Bloom., Pearson Ed.*
2. *Tectonic Geomorphology, Douglas W. Burbank and Robert S. Anderson, Blackwell Science.*
3. *Active tectonics, by Edward A. Keller and Nicholas Pinter, Prentice Hall.*

GLG-2016 :: Hydrogeology, Climatology & Oceanography

1. *Groundwater Hydrology,3rd Edition, David Keith Todd and Larry W. Mays, John Wiley & Sons, 636pp.*
2. *Groundwater Hydrology – D.K.Todd (2nd Edition); John Wiley and Sons, Inc.*
3. *Earth's climate, past and future, by William F. Ruddiman, W H Freeman and Company.*
4. *General Climatology by Howard J. Critchfield, Eastern Economy Edition, Prentice-Hall of India Pvt.Ltd., New Delhi-110 001.*
5. *PALEOCLIMATOLOGY: Reconstructing Climates of the Quaternary, 2nd Edition, by Raymond S. Bradley, Academic Press.*
6. *Essentials of Meteorology: An Invitation to the Atmosphere, by C. Donald Ahrens.*

7. *Essentials of Oceanography, 10th Edition, Alan P. Trujillo and Harold V. Thurman, Prentice Hall, 551p.*
8. *A text book of Oceanography, by J. T. Jenkins, Constable and Co. Ltd., London.*

GLG-2026 :: Igneous and Metamorphic Petrology

1. *Igneous and metamorphic petrology, Anthony R. Phillipotts*
2. *Principles of Igneous and metamorphic petrology, Anthony R. Phillipotts*
3. *An introduction to igneous and metamorphic petrology, John, D Winter*
4. *Igneous and Metamorphic Petrology, by G. Myron Best.*
5. *The Interpretation of Igneous rocks, by K.G. Cox, J.D. Bell and R.J. Pankhvrst*
6. *The Study of Igneous, Sedimentary and Metamorphic Rocks, by L.A. Raymond.*
7. *Petrology: Igneous, Sedimentary and Metamorphic, by Ernest G. Ehlers and H. Blatt*
8. *Igneous Petrology, by Antony Hall.*
9. *Petrology of Igneous and Metamorphic Rocks, by D.W. Hyndman.*

GLG-2035 :: Geochemistry & Isotope Geology, Application of Statistics in Geology

1. *Principles of geochemistry, by Bryan Mason and Moore*
2. *Introduction to geochemistry, by Konrad B. Krauskpf*
3. *Principles of isotope geology, by Gunter Faure*
4. *Geochemistry: Pathways and Process by S.M. Richardson and H.Y. McSween Jr.*
5. *Statistics and Data analysis in Geology, Third Edition, by John C. Davis, Kansas Geological Survey; John Wiley and Sons, Inc., 2005.*
6. *Fundamentals of Mathematical Statistics, by S.C. Gupta and V.K. Kapoor, Sultan Chand ans Sons.*
7. *Concepts in Geostatistics, Ed. By Richard B. McCammon, Springer-Verlag, New York Inc.*
8. *Statistical analysis in the geological sciences, Miller and Kahn, John Wiley and Sons, New York*
9. *Aspects of Multivariate Statistical Analysis in Geology by Richard A. Reyment and Enrico Savazzi, Elsivier, 1999.*

GLG-2042 :: Engineering Geology

1. *Engineering Geology and Geotechniques by Krynine & Judd.*
2. *Engineering Geology by F.G. Bell, Wiley.*
2. *Engineering Materials by K.S. Raigwala, Charotar Publishing House, Anand, India.*
3. *Engineering Materials by R.K. Rajput. S. Chand & Company Ltd. Ram Nagar, New Delhi.*
4. *Rock Mechanics for Engineers, by Dr. B.P. Vema, Khanna Publishers.*
5. *Soil Mechanics in Engineering Practice by Terzaghi and Peck.*
6. *Engineering Geology by B.S. Sathyanarayanaswami, Dhanpat Rai & Co.*

GLG-3016 :: Economic Geology and Exploration & Mining

1. *Economic Mineral Deposits – M.L.Jensen & A.M.Bateman (3rd Edition); John Wiley and Sons, Inc.*
2. *Ore Deposits – C.F.Park,Jr. & R.A.MacDiarmid; W.H.Freeman and Company.*
3. *Ore Geology and Industrial Minerals: An Introduction, by A.M. Evans, 3rd Edition, Blackwell Science, 389pp.*
4. *An Introduction to Ore Geology, by A.M. Evans.*
5. *Hydrothermal Mineral Deposits, by F. Pirajno.*
6. *Ore Genesis: A Hollistic Approach, by Asoke Mookherjee.*
7. *Economic Geology (Economic Mineral Deposits) – U.Prasad; CBS Publishers & Distributors.*
8. *Ore Deposits of India – K.V.G.K. Gokhale & T.C. Rao; Affiliated East-West Press Pvt. Ltd.*
9. *Mineral Resources of India – by D. K. Banerjee.*
10. *Introductory Mining Engineering, 2nd Edition – by Howard L. Hartman and Jan M. Mutmansky*
11. *Geological Methods in Mineral Exploration and Mining – by Roger Marjoribanks; Springer, 2010, 233pp.*

GLG-3024 :: Sedimentology, Surveying & Mapping

1. *Petrology of Sedimentary Rocks, by Sam Boggs, Jr., Cambridge University Press, 2009, 600pp.*
2. *Applied Sedimentology, by Richard C. Selley, Academic Press, 521pp.*
3. *Heavy Minerals in Use, Developments in Sedimentology, 58, Mange, M. A. and Wright, D. T., Elsevier, 1283pp.*
4. *Diagenesis IV, Developments in Sedimentology 51, by K.H. Wolf and G.V. Chilingarian, ELSIVIER Publishers.*
5. *Quartz Cementation in Sandstones, by Richard H. Worden and Sadoon Morad (Editors), Blackwell Publishers, 2000, Special Publication Number 29 of the International Association of Sedimentologists, 342pp.*
6. *Introduction to Sedimentology by S. Sengupta, Oxford & IBH Publishing Co,*
7. *Sedimentary Structures by Thompson and Collison*

GLG-3036 :: Stratigraphy

1. *Stratigraphic Principles and Practices – J.M.Weller; Universal BookStall, Delhi.*
2. *Principles of Sedimentology and Stratigraphy, by Sam Boggs, Jr., 4th Edition, Pearson Prentice Hall, 2006, 662pp.*
3. *Principles of Sequence Startigraphy, by Octavian Catuneanu, ELSIVIER Publishers.*
4. *Principles of Sedimentary Basin Analysis, by A. D. Miall, 3rd Edition, Springer, 2000, 616pp.*
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