

COTTON COLLEGE STATE UNIVERSITY

DEPARTMENT OF GEOLOGY

Postgraduate Geology Syllabus

DISTRIBUTION OF PAPERS/CREDITS (L+T+P format)

Semester – I

| Paper Code | Paper Name | Credits |
|-------------------|---|----------------|
| GLY 701C | Geomorphology and Quaternary Geology | 3+0+1 |
| GLY 702C | Structural Geology and Geotectonics | 3+0+1 |
| GLY 703C | Part I: Mineralogy and Crystal Chemistry Part II: Remote Sensing | 3+0+1 |
| GLY 704C | Seminar and Fieldwork (Geological Mapping) with Viva-voce | 0+2+2 |
| GLY 705E | Earth and Climate and Climate Change Studies | 2+1+0 |

Semester – II

| Paper Code | Paper Name | Credits |
|------------|---|---------|
| GLY 801C | Part I: Igneous Petrology Part II: Metamorphic Petrology | 3+0+1 |
| GLY 802C | Hydrogeology | 3+0+1 |
| GLY 803C | Part I: Geochemistry and Isotope Geology Part II: Statistics in Geology | 3+0+1 |
| GLY 804C | Seminar, Group Discussion and Fieldwork (Geomorphology/Soil Profile / Recent Sediment) with Viva-voce | 0+2+2 |
| GLY 805E | Disaster Management | 2+1+0 |

Semester – III

| Paper Code | Paper Name | Credits |
|------------|---|---------|
| GLY 901C | Part I: Sedimentary Petrology Part II: Palaeontology | 3+0+1 |
| GLY 902C | Part I: Engineering Geology Part II: Environmental Geology | 3+0+1 |
| GLY 903C | Fuel Geology (Petroleum, Coal, Nuclear and Geothermal Energy) | 3+0+1 |
| GLY 904C | Seminar and Fieldwork (Economic/Stratigraphic importance) with Viva-voce | 0+2+2 |
| GLY 905E | GIS and GPS | 1+1+1 |

Semester - IV

| Paper Code | Paper Name | Credits |
|-------------------|--|----------------|
| GLY 1001C | Part I: Exploration and Mining Geology and Mineral Economics Part II: Paleoseismology, Seismology and Interior of the Earth | 3+1+0 |
| GLY 1002C | Part I: Principles of Stratigraphy Part II: Indian Stratigraphy | 3+1+0 |
| GLY 1003C | Part I: Economic Geology (Principles) Part II: Economic Mineral Deposits of Indian and World | 3+1+0 |
| GLY 1004C | Project Work | 0+0+4 |
| GLY 1005E | Oceanography | 2+1+0 |

SEMESTER I
PAPER: GLY 701C

GEOMORPHOLOGY AND QUATERNARY GEOLOGY
CREDITS: 3+0+1

THEORY

GEOMORPHOLOGY

Unit-1:

Time scales of landscape analysis, landform as the unit of systematic analysis, energy flow in geomorphic systems, models of landform evolution, consideration of structure process and time. Mass wasting – mechanism and classification, hill slope morphology and processes, models of hill slope evolution.

Unit-2:

Weathering and soil formation process, soil horizon, soil profile, physical properties of soil, soil classification (taxonomic), soil chemistry and mineralogy, climate control and soil formation, palaeosol, laterite, laterisation and their geological significance.

Unit-3:

Fluvial geomorphic system, channel geometry and drainage patterns and their significance, processes of transport, drainage basin evolution, structural control of fluvial erosion, aggradation in fluvial cycle – floodplain, fans and deltas.

Unit-4:

Tectonic geomorphology: geomorphic markers, Holocene deformation and landscape responses, geomorphic indices of active tectonics. Coastal geomorphology: shore zone processes, wind generated waves and tsunamis, coastal erosional and depositional landforms.

QUATERNARY GEOLOGY

Unit-5:

Significance of Quaternary studies, Quaternary classification based on climate, sea level fluctuation and magnetic polarity events.

Unit-6:

Quaternary climate and uplift – climate connection, glacial/interglacial cycles, Milankovitch hypothesis, Quaternary climate and sea level changes, climate records in sediments

Unit-7:

Quaternary stratigraphy: basic principles, morphostratigraphy, pedostratigraphy, oxygen isotope stratigraphy and Quaternary palaeoecology, Pliocene-Pleistocene and Pleistocene-Holocene boundary problems.

Unit-8:

Establishing timing in Quaternary landscape: Dating methods – radiocarbon dating, luminescence dating, AMS dating, cosmogenic radionuclide dating, dating from artefacts, human evolution and cultural evolution of human, limitations of dating techniques

Unit-9:

Quaternary stratigraphy and evolution of Indo-Gangetic plain, Brahmaputra plain and Narmada plain

PRACTICAL

1. Interpretation of topographic maps, topographic profiles, drainage basin morphometry, hypsometric analysis, J.T. Hack profile study.
2. Estimation of incision deficit, rate of sedimentation and erosion, sediment rating curve.
3. Laboratory study of oriented samples of river sediment, preparation of litholog from vertical section, electrical log interpretation, detection of ideal cycles from detail vertical logs using Markov chain analysis, vector analysis of paleocurrent data.
4. Problems on Quaternary chronological data. Preparation of geomorphological maps from remote sensing data.

Reading List

1. Bloom, A. L., *Geomorphology: A systematic analysis of late Cenozoic landform*, Pearson Ed.
2. Burbank, D.W. and Anderson R.S., *Tectonic Geomorphology*, Blackwell Science.
3. Singh, S., *Geomorphology*, Prayag Pustak Bhawan.
4. Keller, Edward A. and Pinter Nicholas, *Active Tectonics*, Prentice Hall.
5. Mathur, U. B., *Quaternary Geology: Indian Perspective*, Geological Society of India.
6. Goswami, A. B., *Principles of Quaternary Geology and Environmental Study*, Pub. Book Way, Kolkata.

SEMESTER I

PAPER: GLY 702C

STRUCTURAL GEOLOGY AND GEOTECTONICS

CREDITS: 3+0+1

THEORY**STRUCTURAL GEOLOGY****Unit-1:**

Definition of geological structures, structural geology and tectonics; Primary, secondary & pen contemporaneous structures; Non-diastraphic/non-tectonic and diastraphic/ tectonic structures; Geometric, kinematic, dynamic/mechanical analysis and evolutionary history of structures;

Definition of tectonites; Penetrative and non-penetrative structures, fabric of a tectonite; Symmetry of structures; Scale of structures; Geological and structural map; Structural elements and their attitudes; Stereographic projections of structural elements.

Unit-2: Stress:

Force (body force and surface force), traction and stress; Normal stress and shear stress; Two dimensional and three dimensional stress at a point; Stress tensor; Mohr diagram for two dimensional stress (Mohr diagram, principal stresses, surface stress and orientation of planes, conjugate planes of maximum shear stress, scalar invariants of the stress, equations of the Mohr circle); Elementary idea of the Mohr diagram for three dimensional stress; Terminology for states of stress in terms of their respective Mohr stress circles (hydrostatic stress/pressure, uniaxial stress, axial stress, triaxial stress, pure shear stress, Deviatoric stress, differential stress and effective stress).

Unit-3: Strain/Deformation:

Translation, rotation and deformation/strain; Measurement of strain (linear or longitudinal, volumetric and shear strains); State of strain (strain ellipsoid and strain tensor); Homogeneous and inhomogeneous deformations/strains; Finite and infinitesimal strain/deformation; Finite homogeneous deformation/strain (plane strain, flattening and constriction); Examples of homogeneous deformation/strain [non-rotational or pure strain (uniform dilation, pure shear, simple extension and uniaxial strain) and rotational strain (simple shear)]; Elementary concept of progressive deformation/strain and deformation/strain path; Measurement of finite strain (strain markers, spherical strain markers, Fry method); Graphical representation of strain states and strain histories (Flinn diagram).

Unit-4: Behaviour of rocks under stress (Rheological behaviour of rocks):

Continuum models of material/rock behaviour; Elastic, viscous and plastic substances; Brittle, transitional and ductile behaviours of rocks; Influence of confining pressure or depth, temperature and time in behaviour of rocks under stress; Ductile flow; Cataclastic flow and friction; Steady-state creep

Unit-5: Brittle deformations:

Fractures (extension and shear fractures); Definition and classification of joints; Definition of faults; Elements of faults; Types of faults on the basis of attitude of the fault surface; Types of faults on the basis of the orientation of relative displacement; Recognition of faults (fault or fault zone rocks, geologic or stratigraphic criteria, physiographic criteria); blind faults, Mechanics of faulting; Normal faults : horst and graben structure; synthetic faults; antithetic faults; listric faults; detachment faults; imbricate faults (half grabens); fault-ramp syncline; fault-bend anticline. Thrusts : overthrust and underthrust; allochthonous, autochthonous and parautochthonous units; thrust sheet or nappe; thrust nappe and fold nappe; window/fenster and klippe; ramp and flat geometry of thrust plane; hanging wall anticline and syncline; fault propagation folds; thrust system (foreland fold and thrust belts, salient or vigation, reentrant or syntaxis, imbricate fan or schuppen zone/belt, thrust duplex, Schuppen belt of NE India). Strike slip faults : transform, transcurrent and tear faults; shear fractures, folds, normal faults and thrusts associated with strike slip faults; displacement along strike slip faults [bends or jogs and step over or offsets, strike slip duplexes (negative and positive flower structures)].

Unit-6: Ductile deformations:

Definition of folds; Geometric parts of folds (single folded surface, folded layers and multi layers); Scale of folds; Attitude of folds and Fleuty's classification of folds; Elements of fold style [cylindricity, symmetry, style of a folded surface, style of a folded layer (geometrical or morphological classification of folds by Ramsay, 1967), style of a folded multilayer]; Order of folds; Common styles and structural association of folding; Fold superposition and interference structures; Mechanics of folding; Kinematics of folding.

Definition of boudinage; Types of boudinage; Geometry of boudinage; Boudin shape in transverse section; Aspect ratio of boudins in cross-section; Geometrical relationship of boudinage with folds; Boudinage in superposed deformations.

Definition of foliations and lineations; Tectonites (S-, L- and LS- tectonites); Morphological classification of foliations; Relationship of foliations to other structures; Morphological classification of secondary lineations; Associations of lineations with other structures.

Unit-7: Shear zones:

Definition and types of shear zones; Shear zone rocks; Types of ductile shear zones; Mylonite; Mylonitization in relation to metamorphism; Patterns of ductile shear zones; Shear sense indicators in ductile shear zones; Major shear zones in India.

GEOTECTONICS

Unit- 8:

Introduction; Internal structure of the earth; Historical perspective of plate tectonics; Continental drift hypothesis; Palaeomagnetism, Sea floor spreading and plate tectonics; Divergent plate boundaries; Convergent plate boundaries; Obduction principle and emplacement of ophiolites; Evolution of Himalaya and structure and tectonics of Himalayan mountain belt; Structure and tectonics of Indo-Myanmar mobile belt; Transform fault boundaries; Triple point junctions; Mantle plumes and hotspots; Seismic belts of the world; Mechanism of plate tectonics; Plate movement over geologic time; Palaeozoic plate tectonics; Precambrian plate tectonics.

PRACTICAL

1. Stereographic (cyclographic and π -pole) projection of planar and linear structures and their structural analysis both manually as well as using computer software.
2. Preparation of structural and geological map of an area using data on planar and linear structures.
3. GPS (hand-held) survey
4. Balancing of Closed Traverse
5. Construction of dip isogons and t'_α - α plot of fold profile sections.
6. Strain analysis in rocks using Fry method.

Reading List

Structural Geology:

1. Davis, G.H., *Structural Geology of Rocks and Regions* (2nd Edition), John Wiley and Sons, Inc

2. De Paor, D.G., *Structural Geology and Personal Computers*, Pergamon Press
3. Fossen, H., *Structural Geology*, Cambridge University Press
4. Ghosh, S.K., *Structural Geology*, Pergamon Press
5. Hobbs, B.E., Means, W.D. & Williams, P.F., *An outline of Structural Geology*, John Wiley and Sons, Inc
6. Lisle, R.J. & Leyshon, P.R., *Stereographic Projection Techniques for Geologists and Civil Engineers*, Cambridge University Press
7. Marshak, S. & Mitra, G., ***Basic methods of structural geology, Parts 1-2***; Prentice Hall
8. Price, N. J. & Cosgrove, J.W., *Analysis of Geol Structures*, Cambridge University Press.
9. Ragan, D.M., *Structural Geology: An Introduction to Geometrical Techniques*, Cambridge University Press
10. Ramsay, J.G., *Folding and fracturing of rocks*, McGraw Hill Book Company, New York
11. Ramsay, J.G. & Huber, M.I., *The Techniques of Modern Structural Geology*, volume 1 & 2; Academic Press, Inc., London
12. Twiss, R.J. & Moores, E.M., *Structural Geology*, W.H. Freeman and Company

Geotectonics:

1. Belousov, V.V., *Geotectonics*, Springer Berlin Heidelberg
2. Condie, K.C., *Plate Tectonics and Crustal Evolution*, Pergamon Press
3. Gubbins, D., *Seismology and Plate Tectonics*, Cambridge University Press
4. Johnson, R.L., *Plate Tectonics*, Twenty-First Century Books
5. Keary, P. & Vine, F.J., *Global Tectonics*, Blackwell Scientific Publications
6. Tomecek, S.M., *Plate Tectonics*, Infobase publishing
7. Valdiya, K.S., *Aspects of Tectonics*, Tata McGraw-Hill Publishing Company Ltd.
8. Windley, B.F., *The Evolving Continents*, John Wiley and Sons, Inc.
9. Compton, Robert R., *Geology in the Field*, John Wiley and Sons
10. Ghilani, Charles D. and Wolf, Paul R., *Elementary Surveying: An Introduction to Geomatics* (12th Edition), Pearson Prentice Hall

SEMESTER I

PAPER: GLY 703C

PART I: MINERALOGY AND CRYSTAL CHEMISTRY

PART II: REMOTE SENSING

CREDITS: 3+0+1

THEORY

PART I: MINERALOGY AND CRYSTAL CHEMISTRY

Unit-1:

Chemical composition and compositional variation in minerals: solid solution, Compositional classification of minerals into groups. Transformation processes in Minerals: exsolution, transient and structural phase transformations. Examples from Natural rocks: exsolution in augite-pigeonite solid solution, exsolution in feldspars.

Unit-2:

Principles of X ray crystallography: The Laue equations, the Bragg's equation. Single crystal methods and powder method. Mineral identification by X ray diffractometry.

Unit-3:

Crystal chemistry: principles of crystal chemistry. Ionic properties - chemical bond, size, ionic charge, ionisation potential, electro negativity, radius ratio and coordination numbers, Pauling's rule, ionic substitution, isomorphism, polymorphism, structural defects

PART II: REMOTE SENSING

Unit-1:

Remote Sensor and their classification

Digital Imaging Sensor: Working principle and components, Concept of Digital Image, Sensor Resolution, Types scanning system (Cross-track scanner, Along track scanner, Side scanning system, Circular scanner), Digital imaging by non-scanning system, Multispectral imaging system, Colour Composite Image, Satellite orbits, Orbital parameters of Remote Sensing Satellite, Space Remote Sensing missions (Land sat, SPOT, IRS, Geo Eye, Digital Globe), Types of Satellite Data Products. Concept of hyper spectral data and their importance

Photographic Sensor: Definition and history of Aerial Photography. Geometric types of Aerial Photograph, Photographic flight mission and layout, Characteristics of Aerial Photographs (Resolving power, Ground Resolution, Scale, Relief Displacement), Types of photographic distortion and Displacement Theory of Stereoscopy, Vertical Exaggeration, Principles and basic aspects of Photogrammetry, Image Parallax, Measuring heights from Relief Displacement and Parallax measurement, Instruments used in photo interpretation.

Unit-2: Microwave Remote Sensing:

Radar development, SLAR System, Spatial Resolution of SLAR Systems, Synthetic Aperture Radar (SAR), Geometric characteristics of Radar imagery, Transmission characteristics of Radar signals, Interpretation of radar image. Advantages of Radar Imagery for Geological Applications, Microwave Remote Sensing Satellite

Unit-3: Thermal Remote Sensing:

Thermal Infrared radiation, Kinetic and Radiant Temperature, Thermal properties of materials, characteristics of thermal images, Thermal image interpretation
Concept of LiDER remote sensing

Unit-4: Digital Image Processing:

Image rectification and restoration (Geometric corrections, Radiometric corrections and Noise removal), Image Enhancement (Contrast manipulation and Spatial feature Manipulation), Multi-image manipulation (Spectral ratioing, Principal and Canonical Components and Vegetation Components), Multispectral classification – Supervised and Unsupervised

Unit-5:

Application of Remote Sensing in Geomorphology, Structure and Lithology Mapping, Mineral exploration, Groundwater investigation, Engineering geology, Environmental surveillance and Natural hazard mitigation.

PRACTICAL

1. Identification of major, minor and accessory minerals in thin sections and hand specimens. Preparation of sample for XRD and interpretation of XRD data for mineral identification.
2. Visual interpretation of satellite image and aerial photograph for interpretation of geomorphology, landform, lineament, lithology, structure and landuse.
3. Use of Image Processing Software for Image Enhancement, Multi-image manipulation and image classification.

Reading List

Mineralogy and Crystal Chemistry:

1. Berry, L. G., Dietrich, R. V. And Mason, B., *Mineralogy*, CBS Pub. and Dist.
2. Conelis, K., *Mineral Science*, John Wiley & Sons, Inc.
3. Dana, J. D., *Manual of Mineralogy*, John Wiley & Sons
4. Evans, R. C., *An Introduction to Crystal Chemistry*, Cambridge Univ. Press
5. Mason, B. and Moore, C. B., *Principles of Geochemistry*, Wiley Eastern Ltd
6. Putins, A., *Introduction to Mineral Sciences*, Cambridge Univ. Press
7. William, D. N., *Introduction to Mineralogy*, Oxford Univ. Press

Remote Sensing:

1. Bhatta, B., *Remote Sensing and GIS*, Oxford University Press
2. Sabins, F.F., *Remote Sensing – Principles and Interpretation*, W.H. Freeman and Company
3. Lillesand, T. M. and Kiefer, R. W., *Remote Sensing and Image Interpretation*, John Wiley & Sons, Inc
4. Drury, S. A., *Image Interpretation in Geology*, Allen & Unwin (Publishers) Ltd.
5. Pandey, S. N., *Principles and Applications of Photogeology*, New Age International (P) Ltd., Publishers
6. Jensen, J. R., *Remote Sensing of the Environment – An Earth Resource Management*, Pearson Education, Singapore
7. Miller, V. C. and Miller, C. F., *Photogeology*, McGraw-Kill Book Company, Inc.

SEMESTER I PAPER: GLY 704C

SEMINAR AND FIELDWORK (GEOLOGICAL MAPPING) WITH VIVA-VOCE

CREDITS: 0+2+2

SEMESTER I
PAPER: GLY 705E

EARTH AND CLIMATE AND CLIMATE CHANGE STUDIES
CREDITS: 2+1+0

THEORY

Unit-1: Climatology:

Definition and Scope; sub-divisions of climatology; Meteorology and Climatology; Climatic Controls; Layered structure of the atmosphere; Heat and Temperature, Controlling factors of temperature; Air pressure and Winds, Atmospheric circulation; Weather disturbances.

Unit-2: Climatic Classification:

Need and objectives, basis of classification; Koeppen's Classification; Thornthwaite's classification; Climatic regions of the world; Climatic time scales; Concepts of origin of Monsoons and its variation through time; Climatic significance of monsoon; Types of precipitation, factors controlling distribution of precipitation.

Unit-3: Climate Change:

Climatic Cycles; Theories of climate change; Role of geology in understanding atmospheric change; Climatic influences on geomorphic processes; Climate and water resources: Soil moisture and Groundwater, Climatic causes of flood; Role of climate in soil formation and soil erosion; Predictions of climate change.

Reading List

1. Aguado, E., and Burt, J., *Understanding weather and climate*, Prentice Hall.
2. Critchfield, H. J., *General Climatology*, 4th Edition, 2013, PHI Learning Pvt. Ltd., Delhi.
3. Lal, D. S., *Climatology*, Sharda Pustak Bhawan, Allahabad
4. Lutgens, F., Tarbuck, E., and Tasa, D., *The Atmosphere: An Introduction to Meteorology*, Pearson Publisher
5. Rohli, R. Y., and Vega, A Ll., *Climatology*, Jones and Barlett
6. Ruddiman, W. F., *Earth's climate: past and future*, 2nd Edition, Freeman Publisher

SEMESTER II
PAPER: GLY 801C

PART I: IGNEOUS PETROLOGY

PART II: METAMORPHIC PETROLOGY

CREDITS: 3+0+1

THEORY

PART I: IGNEOUS PETROLOGY

Unit-1:

Magma, their generation in the crust and mantle and their relation to plate tectonics. Present day magmatism and global tectonic processes. Magmatic crystallisation, differentiation and assimilation. Role of partial melting of rocks in igneous petrology

Unit-2:

Phase equilibria study in igneous system: binary, ternary and quaternary silicate system with reference to petrogenesis. Role of volatiles in petrogenesis.

Unit-3:

Geochemical characteristics of igneous rocks: major, trace and isotopic composition of igneous rocks in the context of petrogenesis. Compatible and incompatible trace elements. Geochemical criteria for identification of palaeotectonic settings.

Unit-4:

Igneous rocks in different tectonic settings: Mid-oceanic Ridge, Oceanic Intraplate, Subduction related settings.

Unit-5:

Petrogenetic aspects of different igneous rocks: Deccan trap, Anorthosite, Ophiolites, carbonatites, alkaline rocks.

Unit-6:

Characteristics of layered mafic-ultramafic igneous complex: Bushveld, Skaergaard, Stillwater and Sittampudi-complex, ultramafic volcanic rocks –Komatites, Kimberlites.

PART II: METAMORPHIC PETROLOGY

Unit-1: Nomenclature of metamorphic rocks and metamorphic textures and structures:

Foliated and lineated, Non foliated and non lineated and specific types, additional modifying terms and high-strain rocks. Solid-state metamorphic textures. Processes involved. Deformation, recovery, and recrystallization. metamorphic textures for interpretation of metamorphic conditions using solid state metamorphic textures. Textures of contact metamorphism, textures of fault zones (cataclastic metamorphism), regional orogenic metamorphic textures. Replacement textures and reaction rims.

Unit-2: Introduction to Thermodynamics:

Energy, Gibbs Free energy, Enthalpy and entropy. The Gibbs free energy for a phase, Variation of Gibbs free energy for a phase with Pressure and temperature. Gibbs Free energy for a reaction,

Gibbs Free energy for a reaction with Pressure and temperature. The equilibrium state. Le Chatelier's principle. Thermodynamic evaluation of Phase Diagrams Clapeyron equation

Unit-3: Metamorphic assemblages and reactions:

Equilibrium mineral assemblages. The phase rule. Chemographic diagrams: ACF, AKF and AKFM diagrams. Polymorphic transformations, Exsolution reactions, solid-solid reactions, devolatilization reactions, continuous reactions, ion exchange reactions, oxidation reduction reactions, petrogenetic grids.

Unit 4: Metamorphism of Basic igneous rocks and pelitic sediments:

Metamorphic reactions involved and metamorphic assemblages developed during regional metamorphism of pelitic sediments and basic igneous rocks.

PRACTICAL

1. Hand specimen for physical characteristics
2. Thin section study
3. Variation diagrams
4. Use of chemical analysis in classification of igneous rocks and in determining paleotectonic settings of igneous rocks.
5. Identification of textures and structures of the following rocks in hand specimens: Slate, phyllite, various types of schists, gneiss, amphibolite, hornblende schist, granulite, Calc-silicate rocks, marble, quartzite, hornfels, augen gneiss, mylonite, migmatite, eclogite.
6. Identification of slate, phyllite, various types of schists, gneiss, amphibolite, hornblende schist, granulite, Calc-silicate rocks, marble, quartzite, Chlorite schist, Biotite schist, Garnetiferous schist, Sillimanite schist, Amphibolite / Hornblende schist, Quartzite, Granulite.
7. Study & identification of following rocks in thin sections under microscope: Chlorite schist, Biotite schist, Garnetiferous schist, Sillimanite schist Amphibolite / Hornblende schist, Quartzite, Granulite
8. Plots of minerals and rock compositions in ACF and AKF diagrams.

Reading List

Igneous Petrology:

1. Phillpotts, A. R., *Igneous and Metamorphic Petrology*, Prentice Hall of India Private Ltd., New Delhi
2. Winter, J. D., *An Introduction to Igneous and Metamorphic Petrology*, Prentice Hall
3. Moorhouse, W. W., *The Study of Rocks in Thin Sections*, CBS Publishers & Distributors
4. Blatt, H. and Ehlers, E. G., *Petrology: Igneous and Metamorphic*, CBS Publishers & Distributors
5. Best, M. G., *Igneous and Metamorphic Petrology*, CBS Publishers & Distributors
6. Bell, J. D., Cox, K. G, and Pankhurst, R. J., *The Interpretation of Igneous Rocks*, George Allen and Unwin

Metamorphic Petrology:

1. Barth, T.F.W., *Theoretical Petrology*, John Wiley and Sons, Inc.
2. Best, M.G., *Igneous and Metamorphic Petrology*, CBS Publishers & Distributors
3. Blatt, H & Ehlers, E.G., *Petrology*, CBS Publishers & Distributors

4. Chatterjee, S.C., *Petrography of the Igneous and Metamorphic Rocks of India*, The Macmillan Company of India Ltd.
5. Gilbert, C.M, Turner, F.J & Williams, H., *Petrography*, CBS Publishers & Distributors
6. Huang, W.T., *Petrology*, McGraw-Hill Book Company
7. Hyndman, D.W., *Petrology of Igneous and Metamorphic Rocks*, McGraw-Hill Book Company
8. Miyashiro, A., *Metamorphism and Metamorphic Belts*, George Allen & Unwin Ltd.
9. Moorhouse, W.W., *The Study of Rocks in Thin Section*, CBS Publishers & Distributors
10. Philpotts, A.R., *Principles of Igneous and Metamorphic Petrology*, Prentice-Hall of India Pvt. Ltd. Turner, F.J., *Metamorphic Petrology*, McGraw Hill Book Company
11. Turner, F.J. & Verhoogen, J., *Igneous and Metamorphic Petrology*, McGraw-Hill Book Company
12. Tyrrell, G.W., *Principles of Petrology*, B.I. Publications Pvt. Ltd.
13. Winkler, H.G.F., *Petrogenesis of Metamorphic Rocks*, Springer Verlag, New York Inc.
14. Winter, John ., *Principles of Igneous and Metamorphic Petrology*, PHI learning Pvt. Ltd.
15. Yardley, B.W.D., *Metamorphic Petrology*, ELBS/Longman

SEMESTER II
PAPER: GLY 802C

HYDROGEOLOGY
CREDITS: 3+0+1

THEORY

Unit-1:

Definition of hydrology and hydrogeology, Hydrologic cycle – precipitation and run-off, Analysis of hydrograph, base flow separation, factors governing shape of hydrograph.

Unit-2:

Occurrence of groundwater – openings in rocks, types of openings. Porosity and void ratio, Definition of aquifers, aquiclude, aquitard and aquifuge. Subsurface distribution of water – vadose water and groundwater, Specific yield and retention, Estimation of specific yield, Aquifers and their classification, Groundwater recharging

Unit-3:

Groundwater movement, Darcy's law – its range of validity and limitation, Hydraulic conductivity, permeability, effective stress, specific storage, transmissivity and storativity

Unit-4:

Physical and chemical characteristics of groundwater, Chemical classification of groundwater. Quality criteria for drinking, irrigation and industrial uses

Unit-5:

Occurrences of groundwater in different rock types – igneous, metamorphic, sedimentary and non-indurated sediments. Groundwater provinces of India.

Unit-6:

Groundwater levels and fluctuations – secular, seasonal and diurnal variation, Factors governing groundwater level fluctuations, fresh and salt water relationship in coastal area, Ghyben-Herzberg principle, Prevention and control of sea water intrusion

Unit-7:

Basic principles of well hydraulics-drawdown and cone of depression, Steady state and non-steady state flow, Non-equilibrium equation for pumping tests, Step drawdown test and aquifer performance test, Analysis of pumping test data

Unit-8:

Surface and sub-surface investigation of groundwater. 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. Groundwater exploration by test drilling.

Unit-9:

Methods of construction of shallow wells, Methods of drilling, design criteria and development of tube wells.

Unit-10:

Groundwater assessment, development and management. Concept of groundwater reserve – static and dynamic reserve. Safe yield and overdraft. Factors governing safe yield. Equation of hydrologic equilibrium. Groundwater budgeting.

PRACTICAL

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 groundwater 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 groundwater reserve.
6. Computation of aquifer and well characteristics from aquifer tests (APT) and Step Drawdown Test.

Reading List

1. Pitchaiah, P. S., *Ground water*, Scientific Publishers
2. Raghunath, H. M., *Ground water*, Wiley Eastern Ltd.

3. Todd, D. K., *Groundwater Hydrology*, John Wiley and Sons

SEMESTER II
PAPER: GLY 803C

PART I: GEOCHEMISTRY AND ISOTOPE GEOLOGY
PART II: STATISTICS IN GEOLOGY
CREDITS: 3+0+1

THEORY

PART I: GEOCHEMISTRY AND ISOTOPE GEOLOGY

Unit-1:

Chemical differentiation of the earth, Composition of crust, mantle and core, Composition of the earth as a whole, Geochemical classification of the elements, Composition of ocean, composition of atmosphere, evolution of sea water and air, the rise of oxygen. Geochemical cycle, Geochemistry of meteorites, lunar and Martian rocks

Unit-2: Principles and application of analytical instruments in geochemistry and isotope studies- XRF, ICP-AES, ICP-MS, TIMS, EPMA, SHRIMP. Mass spectrometer –fundamentals, principles and application in geochronological study

Unit-3: Stability and abundance of radionuclides, decay mechanism of radionuclides, radioactive decay and growth rate of radiogenic decay, decay constant, half-life, and decay of radioactive parents to stable daughters.

Unit-4: Principle and methodology of isotope dating – Rb-Sr, Sm-Nd, K-Ar, U-Th-Pb systematics in geochronological studies, primordial ^{87}Sr - ^{86}Sr ratios, Application and fractionation of stable isotopes, oxygen isotope geothermometry.

PART II: STATISTICS IN GEOLOGY

Unit-1: Introduction to statistics, Geostatistics, Population and Sample, Variables and Constant, Frequency and cumulative frequency distribution, Sturge's formula, Histogram, Frequency polygon / curve, Ogive, Examples of geological population.

Unit-2: Measures of Central Tendency, Measures of Dispersion, Skewness and Kurtosis, Moments.

Unit-3: Probability: Concept of Set, Venn Diagram, Experiment, Sample space, Types of event, Empirical and theoretical / statistical probability, Additive law, Multiplicative law, Conditional probability, Bayes' theorem, Mathematical expectation.

Unit-4: Binomial Distribution, Poission Distribution and Normal Distribution, Standardized Normal Distribution, Examples of the distribution in Geological population.

Unit-5: Correlation and Regression, Scatter diagram, Graphical method of correlation, Karl's Pearson coefficient of Correlation, Rank correlation, Linear curve fitting, Standard error of estimate, Coefficient of determination, Geological data analysis.

Unit-6: Sampling distributions: Sampling unit and sample, Parameter and Statistics, Estimators, Sampling with and without replacement, Sampling distribution of mean, Standard errors, Confidence limits, Student t-distribution, Test of significance, Setting up a hypothesis, Null and Alternative hypothesis, z-test, t-test. Geological data analysis

Unit-7: Basic concepts of Principal component analysis, Gumbel and Log-pearson distribution – their use in Geological data analysis. Moving average method.\

PRACTICAL

1. Calculation of mineral formula from EPMA data of minerals: pyroxenes, plagioclase, mica.
2. Estimation of Fe^{+3} and Fe^{+2} from pyroxenes and amphiboles from EPMA data.
3. Norm calculation from major oxide data, classifying granite using major oxide data.
4. Tectonic discrimination diagram using major, minor and trace elements.
5. Problems related to the use of statistical concepts in Geological data analysis.

Reading List

Geochemistry and Isotope Geology:

1. Faure, G., *Principles of Isotope Geology*, Wiley
2. Krauskopf, K. B., *Introduction to Geochemistry*, McGraw-Hill
3. Mason, B. and Moore, C. B., *Principles of Geochemistry*, Wiley Eastern Ltd.
4. Rollinson, H., *Using Geochemical Data Evaluation, Presentation, Interpretation*, Prentice Hall

Geostatistics

1. Agarwal, B. L., *Basic Statistics*, New Age International Publishers
2. Davis, J. C., *Statistics and Data Analysis in Geology*, John Wiley and Sons Inc
3. Gupta., S. C. and Kapoor, V. K., *Fundamentals of Mathematical Statistics*, Sultan Chand and Sons
4. McCammon, R. B. (Ed.), *Concept in Geostatistics*, Springer-Verlag, New York Inc.
5. Miller, R.L. and Kahn, J. S., *Statistical Analysis in Geological Sciences*, John Wiley and Sons, New York
6. Reyment, R. A. and Savazzi, E., *Aspect of Multivariate Statistical Analysis in Geology*, Elsevier
7. Spiegel, M. R., *Schaum's Outline Series - Theory and Problems of Probability and Statistics*, McGraws-Hill International Book Company
8. Spiegel, M. R., *Schaum's outline of Statistics*, McGraws-Hill International Book Company

SEMESTER II
PAPER: GLY 804C

**SEMINAR, GROUP DISCUSSION AND FIELDWORK (GEOMORPHOLOGY/SOIL PROFILE
/ RECENT SEDIMENT) WITH VIVA-VOCE**
CREDITS: 0+2+2

SEMESTER II
PAPER: GLY 805E

DISASTER MANAGEMENT
CREDITS: 2+1+0

THEORY

Unit-1: Understanding disaster

Disaster: Meaning, Factors and significance; Understanding Disasters: Causes and Effects;
Disasters: A Global View; Disaster Profile of India- Regional and Seasonal

Unit-2: Understanding natural Disasters and Man-made Disasters

Natural Disasters: Earthquake, Landslide, Tsunami, Flood, Droughts, Cyclone
Man-made Disasters: Nuclear Disasters, Chemical Disasters, Biological Disaster

Unit-3: Disaster Preparedness, Mitigation and Response

Disaster management cycle: Prevention, Preparedness and Mitigation; Concepts of risk
management and crisis management; Disaster management Act and Policy in India;
Organizational structure for disaster management in India; Disaster Preparedness: Conception
and Nature

Reading List

1. Bose, B. C., *Introduction to Disaster Management*, Rajat Publications.
2. Kapoor, M., *Disaster Management*, Saurabh Publishing House
3. Publications from NDMA and SDMA

SEMESTER III
PAPER: BOT 901C

PART I: SEDIMENTARY PETROLOGY

PART II: PALAEOONTOLOGY

CREDITS: 3+0+1

THEORY

PART I: SEDIMENTARY PETROLOGY

Unit-1: Sedimentary Textures:

Textural elements of sedimentary rocks - Concept of size, shape, roundness, sphericity, form, surface textures, fabric- their measurement, statistical treatment and interpretation.

Unit-2: Sedimentary structures:

Genesis and significance of sedimentary structures - Syndepositional and Post-depositional, Principles of statistical treatment of palaeocurrent analysis

Unit-3: Lithification and Diagenesis:

Definition, principles, major stages in lithification and diagenesis of clastic and nonclastic rocks with reference to sandstones and limestones

Unit-4: Classification of sedimentary rocks, Sandstones:

Classification, light and heavy minerals, tectonic setting; Limestones: Classification, mineralogy, environment of deposition.

Unit-5: Provenance:

Introduction, definition and concepts, Minerals and source rocks; Mineral stability during transit, intrastratal mineral stability, Heavy mineral zones, Reading provenance history

Unit-6: Sedimentary Environments:

Classification of environments- continental, marine and transitional; their physical and chemical parameters, Processes and Characteristics of fluvial, deltaic, lacustrine, marine, glacial and aeolian environments, Concept of sedimentary facies, their analysis and interpretation of depositional environments.

Unit-7: Sedimentation and Tectonics:

Tectonic controls of sedimentation, diastrophic cycle, Basin classification in relation to plate tectonic setting.

PART II: PALAEOONTOLOGY

Unit-1:

Principles of palaeontology; Origin and evolution of fossils; Major causes of Mass Extinction; Application of fossils in the study of palaeoecology, palaeobiogeography and palaeoclimate.

Unit-2: Micropaleontology:

Sampling methods and sample processing techniques. Types of microfossils. Calcareous Microfossils - Foraminifera – morphology and applications; Ostracod -outline morphology, paleoecology & geological history. Siliceous Microfossils: Radiolaria-outline morphology,

classification and application. Brief account of marine diatoms and silicoflagellates. Phosphatic Microfossils: Conodont - outline morphology, paleoecology and geologic significance. Organic Walled Microfossils: Brief account of dinoflagellates and acritarchs.

Applications of Micropaleontology in petroleum exploration, Environmental significance of microfossils

Nanno fossils and their applications in geology, Ichnology-classification of trace fossils and their utility in palaeoenvironmental reconstructions.

Unit-3: Palynology:

General morphology of spores and pollen, and their geological significance; Application of palynology in hydrocarbon exploration.

Gondwana flora and role of climate in its evolution; role of plant fossils in palaeoclimatic reconstructions.

Unit-4: Invertebrate paleontology:

Functional morphology and evolutionary history of Brachiopoda, Mollusks, Echinoids, Corals and Trilobita. Vertebrate paleontology: Major subdivisions of vertebrates; Succession of vertebrate life through geologic time. Broad classification and study of some characteristic Indian vertebrate genera

PRACTICAL

1. Study of hand specimens of different types of sedimentary rocks.
2. Study of hand specimens of different types of sedimentary structures.
3. Determination of mean, mode, median, sorting, skewness, and kurtosis from grain size data.
4. Thin section petrography of sandstones and limestone.
5. Separation of heavy mineral and their study under microscope.
6. Paleocurrent analysis-field measurement procedures and laboratory techniques.
7. Study of diagnostic morphological characters, stratigraphic position and age of some important genera of Lamellibranchs, Gastropods Cephalopods, Brachiopods Echinoids, Trilobites.
8. Megascopic study of important fossils from Gondwana Flora.
9. Microscopic study of Foraminifera, Radiolarian, Ostracods.
10. Microscopic study of the morphology of Pollen and Spores, Dinoflagellate.
11. Construction of range charts.

Reading List

Sedimentary Petrology:

1. Blatt, H., Middleton, G.V. and Murray, R.C., *Origin of Sedimentary Rocks*, Prentice-Hall Inc.
2. Boggs Sam Jr., *Principal of Sedimentary and Stratigraphy*, Prentice Hall
3. Collins, J.D., and Thompson, D.B., *Sedimentary Structures*, George Allen and Unwin, London
4. Einsele, G., *Sedimentary Basins*. Springer Verlag
5. Friedman, G.M. and Sander, J.E., *Principles of Sedimentology*, John Wiley
6. Lindholm, R.C., *A Practical Approach to Sedimentology*, Allen and Unwin, London

7. Miall, A.D., *Principles of Basin Analysis*, Springer-Verlag
8. Nichols, G., *Sedimentology and Stratigraphy*, Blackwell
9. Pettijohn, F.J., Potter, P.E. and Siever, R., *Sand and Sandstone*, Springer Verlag
10. Pettijohn, F.J., *Sedimentary Rocks* (3rd Ed.), Harper and Row Publ., New Delhi
11. Prothero, D.R. and Schwab, F., *Sedimentary Geology*, Freeman
12. Reineck, H.E. and Singh, I.B., *Depositional Sedimentary Environments*, Springer Verlag
13. Selley, R.C., *Applied Sedimentology*, Academic Press
14. Sengupta, S., *Introduction to Sedimentology*, Oxford – IBH
15. Tucker, M.E., *Sedimentary Petrology: An Introduction*, Wiley and Sons, New York
16. Tucker, M.E., *Carbonate Sedimentology*, Blackwell Scientific Publication

Paleontology:

1. Alfred R. Loeblich, Jr. and Helen Tappan, *Foraminiferal Genera and their classification*, Van Nostrand Reinhold Company, New York
2. Benton, M. J., *Vertebrate Paleontology*. Unwin Hyman, London
3. Bignot, G., Graham and Trotter, *Elements of Micropaleontology*, London
4. Clarkson, E. N. K. *Invertebrate Paleontology and Evolution*, Allen and Unwin, London
5. Colbert, E. H., *Evolution of Vertebrates*, Wiley Eastern Ltd.
6. Glaessner, N., *Principles of Micropaleontology*, Melbourne
7. Haynes, J. R., *Foraminifera*, John Wiley
8. Jones, D. J., *Introduction to Microfossils*, Cambridge University press
9. Jones, R. W., *Micropaleontology in Petroleum Exploration*, Clarendon Press
10. Kathal, P. K., *Microfossils and Their Applications*, CBS Publ. & Dist., New Delhi
11. Brasier, M.D., *Microfossils*, George Allen & Unwin, London.
12. Prothero, D. R., *Bringing Fossil to Life An Introduction to Palaeontology (2nd Ed.)*, McGraw Hill
13. Raup & Stanley, *Principles of paleontology*, CBS Publ. & Distributors, New Delhi
14. Romer, A. S., *Vertebrate Palaeontology (3rd Edn.)*, The University of Chicago Press
15. Sengupta B. K., *Modern Foraminifera*
16. Swinnerton, H. H., *An outline of palaeontology*, Edward Arnold and Co.
17. Weller, J. M., *The Course of Evolution*, McGraw-Hill Book Company
18. Walton, J., *An introduction to the study of fossil plants*, Adam & Charles Black, London.

**SEMESTER III
PAPER: GLY 902C**

PART I: ENGINEERING GEOLOGY

PART II: ENVIRONMENTAL GEOLOGY

CREDITS: 3+0+1

THEORY

PART I: ENGINEERING GEOLOGY

Unit-1: Soil:

Engineering properties of Soil. Definition of unit weight, specific gravity, porosity and void ratio, water content, degree of saturation, Bulk density. Elementary knowledge of compressibility, consolidation, compaction and shear strength. Atterberg limits. Soil Water Characteristic Curve. Engineering classification of soil.

Unit-2: Rocks:

Strength, hardness, elasticity, porosity and specific gravity of rock. Engineering classification of rocks. Rock masses: Discontinuity in rock masses, weathering of rock masses, rock mass deformation. Classification of rock masses in the field according to Rock Quality Designation (R.Q.D.), Bieniswaki and Q-system. Quarrying with special reference to rock blasting, Rocks as construction material.

Improvement of rock mass properties – grouting, bolting and anchoring

Unit-3: Dam and Reservoir:

Types and parts of dam. Forces acting on dam. Geological and geophysical investigation for dam site selection. Foundation and abutment problem. Seepage, bearing strength and rebound problems. Treatment of weak zones. Investigation of reservoir area. Control of reservoir leakage and silting.

Unit-4: Tunnel and Bridge:

Geotechnical, geological and groundwater consideration for tunnel and bridge site selection. Importance of structural discontinuities in tunnel and bridge alignment. Rock stress condition in tunnel construction. Methods of tunnel excavation.

PART II: ENVIRONMENTAL GEOLOGY

Unit-1:

Definition, fundamental concepts and scope of environmental geology, pollution and hazards due to mining activities, pollution due to radioactive mineral mining

Unit-2:

Landslides, causal factors, impact of landslides on environment, landslide hazard zonation, preventive measures. Soil erosion.

Unit-3:

Flood – definition, causes, flood in fluvial systems, flood management, structural and non structural methods of flood management, method of flood frequency analysis, flood in Assam

Unit-4:

Seismology- introductory terminology and basic principles, crustal phases, travel time and magnitude of earthquake. Earthquake as natural hazard- prediction and seismic hazard management

Unit-5:

Water pollution-sources of pollution of surface and ground water, water pollution parameters, types of water pollution, casual factors, case studies

PRACTICAL

1. Determination of specific gravity, liquid limit, plastic limit (Casagrande and Cone penetrometer), hardness of rock by L-hammer.
2. Numerical problems and graphical solution of Angle of internal friction (Φ), cohesion factor (c) and pore pressure determination.

Reading List**Engineering Geology:**

1. Bell, F. G., *Fundamentals of Engineering Geology*, Butterworth & Co. (Publishers) Ltd.
2. Bell, F. G., *Engineering Geology*, Butterworth-Heinemann
3. Farmer, I.W., *Engineering Properties of Rocks*, E. and F. N. Spon Ltd., London
4. Johnson, R. B. and DeGraff, J. V., *Principles of Engineering Geology*, Wiley
5. Krynine, D. K. & Judd, W. R., *Principles of Engineering Geology and Geotectonics*, McGraw-Hill, New York
6. Punmia, B.C., *Soil Mechanics and Foundations*, Laxmi Foundations Private Ltd, New Delhi
7. Rangwala, K. S., *Engineering Materials*, Charotar Publishing House, Anand
8. Terzaghi, K., Peck, R. B. and Mesri, G., *Soil Mechanics in Engineering Practice*, John Wiley & Sons Inc
9. Verma, B.P., *Rock Mechanics for Engineers*, Khanna Publishers

Environmental Geology:

1. Murck, B. W., Spinner, B. J. and Porter, S. C., *Environmental Geology*, John Wiley & Sons, Inc.
2. Valdiya, K. S., *Environmental Geology: Indian Context*, Tata McGraw-Hill Pub. Comp. Ltd.
3. IGNOU, *Understanding Natural Disasters* (MPA-001)

**SEMESTER III
PAPER: GLY 903C****FUEL GEOLOGY (PETROLEUM, COAL, NUCLEAR AND GEOTHERMAL ENERGY)**

CREDITS: 3+0+1

THEORY

PETROLEUM

Unit-1:

Chemical composition and physical properties of crude oil; Origin of petroleum, Maturation of kerogen; Biogenic and Thermal effect; Oil window; Classification of reservoir rocks - fragmental reservoir rocks and chemical reservoir rocks; Petro-physical properties and Characteristics of reservoir rocks;

Unit-2:

Identification and characterisation of Source rocks; Trapping mechanisms for oil and gas, structural, stratigraphic and combination traps; Pressure condition in the reservoir; Migration of petroleum and natural gas; Oil shale, and Oil and Gas hydrates; Oil-well drilling and drilling fluids-parameters, usefulness, types; vertical, deviated and horizontal drilling; Mud logging, Duties of well-site geologists

Unit-3:

Geophysical exploration for hydrocarbon: Gravimetric surveys; Seismic surveys-principles and interpretation; Wireline logging: principles and interpretations of Spontaneous Potential log, Natural gamma ray log, Porosity logs-sonic, density, neutron logs, Resistivity log, Conventional electric log, Induction logging, Resistivity and water saturation; use of well logging in stratigraphic correlations.

Unit-4:

Onshore and Offshore petroliferous basins of India; Geology of productive oil and gas fields of India with special reference to NE India.

COAL

Unit-1:

Definition and origin of coal. Sedimentology of coal bearing strata, types of seam discontinuities and structures associated with coal seams.

Unit-2:

Types of coal, coal-rank, grade; physical properties of coal. Chemical analysis of coal (proximate and ultimate analysis).

Unit-3:

Classification of coal, Indian classification for coking and non-coking coals.

Unit-4:

Petrography of coal: lithotypes, macerals and microlithotypes.

Unit-5:

Elementary Idea about coal preparation, coal carbonization, coal gasification, coal hydrogenation, coal combustion

Unit-6:

Coal bed methane: new energy resource, maturation of coal and generation of methane in coal beds.

Unit-7:

Geological and geographical distribution of coal deposits in India.

NUCLEAR AND GEOTHERMAL ENERGY

Unit-1:

Concept of atomic energy, mode of occurrence and association of atomic minerals in nature, productive geological horizons of atomic minerals in India

Unit-2:

Concept of geothermal energy, geothermal energy and its potential in India

PRACTICAL

1. Study of wireline logs (SP, IEL, Porosity, Neutron, Gamma ray, CBL, Dipmeter logs).
2. Determination of porosity and water saturation (for clean sand) from well log data.
3. Structure contour, isopay and isopach maps.
4. Estimation of oil and gas reserve.
5. Study of coal in hand specimen.
6. Identification of different types of coal, lithotypes, coles and structures associated with coal seams.
7. Proximate analysis of coal- determination of moisture, ash and volatile matter.
8. Petrography of coal- thin section and polished block study under microscope.
9. Coal reserve estimation.
10. Determination of total organic carbon.

Reading List

Petroleum:

1. Deshpande, B. C., *The World of Petroleum*, Wiley Eastern Ltd.
2. Levenson, A. L., *Geology of Petroleum*, CBS Pub. & Dist., Delhi
3. North F. K., *Petroleum Geology*, Unwin Hyman
4. Shelly, R.C., *Elements of Petroleum Geology*
5. Singh, L., *Oil and Gas Fields of India*, Indian Petroleum Publishers
6. Tissot, B.P. and Welte, D. H., *Petroleum Formation and Occurrences*

Coal:

1. Acharyya, S. K., *Coal and Lignite Resources of India: An overview*, Geological Society of India,
1. Bangalore

2. Chandra, D., Singh, R.M.and Singh, M.P., *Textbook of Coal*, Tara Book Agency, Varanasi
3. Krevelen, D. W. Van, *Coal*, Elsevier Pub.
4. Singh, M.P., *Coal and Organic Petrology*, Hindustan Pub. Corp.
5. Stach, E, Macknowsty, M.T.H; Taylor, H.H and others, *Stach's Textbook of Coal Petrology*, Gabruder Borntraegar, Berlin, W. Germany
6. Ward , C. R., *Coal Geology and Coal Technology*, Black Scientific Pub.

Nuclear and Geothermal Energy:

1. Tiwari, S. K, *Fuel Minerals and Other Energy Resources*, Atlantic Pub. & Dis. Ltd.
2. Durrance, E.M., *Radioactivity in Geology, Principles and Application*, Ellis Hoorwool
3. Aswathanarayana, U., *Principles of Nuclear Geology*, Oxford Press
4. Raj, G.D., *Non-conventional Energy Sources*, Khanna Publishers
5. Website of Ministry of New and Renewable Energy

**SEMESTER III
PAPER: GLY 904C**

SEMINAR AND FIELDWORK (ECONOMIC/STRATIGRAPHIC IMPORTANCE) WITH VIVA-VOCE

CREDITS: 0+2+2

**SEMESTER III
PAPER: GLY 905E**

**GIS AND GPS
CREDITS: 1+1+1**

THEORY

Unit-1: Basics Of GIS:

Introduction to GIS, Defining GIS, Elements of GIS, GIS operational workflow, Areas of GIS application

Unit-2: Map Generation In GIS:

Mapping Concepts, Map Features, Spatial Data Structure, Organization of Spatial Data in GIS

Unit-3: GIS Data Capture:

Introduction to Data Input, Data Sources for GIS, Entering Spatial and non-spatial Data, Data Conversion

Unit-4: Map Projection:

Concept of Projection, Geographic and Projected Coordinate System, Properties of Map Projections, Projection Types, Choosing a Map Projection, Georeferencing and Rectification

Unit-5: Spatial Modelling:

Introduction, Overlay Operations, Neighbourhood Operations, Connectivity Operations, Digital Terrain Model

Unit-6: Principles of GPS:

Introduction, Basic Principles of GPS, Information Provided by GPS, GPS segments, Contribution of Different Errors in GPS Observations, GPS Applications.

PRACTICAL

1. Preparation for GIS Database creation.
2. Georeferencing and Rectification of Satellite Images and Maps.
3. Creation of Vector and Raster data layers and Editing.
4. Creation of attribute database.
5. Linking external database.
6. Spatial data analysis vector database.
7. Map composition in GIS.
8. GPS data acquisition and linking with GIS Database.
4. Extraction of elevation contours from digital elevation models in GIS platform.

Reading List

1. Heywood, I., et al., *An Introduction to GIS*, Longman
2. Longley, P. A., et al., *Geographic Information System*, John Wiley & Sons, Inc.
3. Clarke, K. C., *Getting Started with GIS*, Prentice Hall of India
4. Worboys, M. F., *GIS - A Computing Perspective*, Taylor & Francis
5. Jones, C., *GIS & Computer Cartography*, Longman
6. Malczewski, J., *GIS & Multicriteria Decision Analysis*, John Wiley & Sons, Inc.
7. Burrough & McDonnell, *Principles of GIS*, Oxford University Press
8. Korte, G. B., *The GIS Book*, Onword Press
9. Ahmed El-Rabbany, *Introduction to GPS: The Global Positioning System*
10. Misra, P. and Enge, P., *Global Positioning System: Signals, Measurements and Performance*

**SEMESTER IV
PAPER: GLY 1001C**

PART I: EXPLORATION AND MINING GEOLOGY AND MINERAL ECONOMICS
PART II: PALEOSEISMOLOGY, SEISMOLOGY AND INTERIOR OF THE EARTH

CREDITS: 3+0+1

THEORY

PART I: EXPLORATION AND MINING GEOLOGY AND MINERAL ECONOMICS

Unit-1:

Principles of geological and geochemical prospecting for minerals.

Unit-2:

Principles of geophysical exploration for minerals; Gravity surveying; Magnetic surveying; Electrical surveying.

Unit-3:

Stages in life of a mine; unit operations in mining: drilling and rock penetration, blasting and rock fragmentation, loading and excavation, haulage and hoisting, auxiliary operations in mining.

Unit-4:

Different methods of surface and subsurface mining for metallic and non-metallic minerals, mining for coal.

Unit-5:

Policy and economics of mining, classification of mineral reserve, mineral legislation, National mineral policy, mines and minerals regulation and development acts.

PART II: PALEOSEISMOLOGY, SEISMOLOGY AND INTERIOR OF THE EARTH

Paleoseismology

Unit-1:

Concept of palaeoseismology and its importance, estimating the magnitude of Prehistoric earthquakes, active faults, distinguishing palaeoseismic features from nonseismic features, identification of palaeoseismic features and structures from syndepositional and other deformational structures, use of dating techniques for palaeoseismic features and their reliability, use of historical and archaeological data in palaeoseismic data interpretation

Seismology and Interior of the Earth

Unit-2: Seismology:

Introduction; Earthquake descriptor; Seismic waves; Earthquake locations; Mechanism of earthquakes; Focal mechanism solutions of earthquakes; Seismic tomography; Velocity structure of the earth; Plate tectonics and seismicity at plate boundaries; Earthquake hazards; Earthquake prediction.

Unit-3: Internal structure of the earth:

Composition of the earth; Crust (continental crust and oceanic crust); Ophiolites; Difference between continental and oceanic crust; Metamorphism of oceanic crust and upper mantle; Mantle (seismic structure of mantle, mantle composition, low velocity zone, transition zone); Deformation in crust and mantle; Convection in mantle; Lithosphere and asthenosphere; Terrestrial heat flow; Core (core temperature, composition, age and origin of core, generation of earth's magnetic field).

PRACTICAL

1. Identification of P and S waves from seismogram.
2. Determination of epicenter.
3. Determination of magnitude of earthquake, focal depth and PGA value.

Reading List

Exploration and mining geology and Mineral Economics:

1. Arogyaswamy, R. N. P., *Courses in Mining Geology*, Oxford & IBH Pub Co. Pvt. Ltd.
2. Charles J. Moon, Whateley, Michael K.G. & Evans, Anthony M., *Introduction to Mineral Exploration* (Second Edition), Blackwell Publishing
3. Calpin, James P. Mc., *Paleoseismology*, 2nd Ed. Edited, Elsevier
4. Hartman, H. L. and Mutmanský, J. M., *Introductory Mining Engineering*, Wiley
5. Kearey, P., Brooks, M. and Hill I., *An Introduction to Geophysical Exploration* (Third Edition), Blackwell Scientific
6. Robinson, E. S. and Coruh, C., *Basic Exploration Geophysics*, John Wiley and Sons

Paleoseismology:

1. Burbank, D. W. and Anderson, R. S., *Tectonic Geomorphology*, Blackwell Science
2. Caplin, M. and James, P., *Paleoseismology*, Academic Press

Seismology and Interior of the Earth:

1. Gubbins, D., *Seismology and Plate Tectonics*, Cambridge University Press
2. Lay, T. & Wallace, T.C., *Modern Global Seismology*, Academic Press
3. Shearer, P.M., *Introduction to Seismology* (2nd Edition), Cambridge University Press
4. Stein, S. & Wysession, M., *An Introduction to Seismology, Earthquakes and Earth Structures*, Blackwell Publishing
5. Vallina, A.U., *Principles of Seismology*, Cambridge University Press

SEMESTER IV PAPER: GLY 1002C

PART I: PRINCIPLES OF STRATIGRAPHY

PART II INDIAN STRATIGRAPHY

CREDITS: 3+0+1

THEORY

PART I: PRINCIPLES OF STRATIGRAPHY

Unit-1:

Lithostratigraphy: Types of Lithostratigraphic Units; Stratigraphic Relations - Contacts, Unconformities; Vertical and Lateral Successions of Strata; Cyclic Successions; Stratigraphic Cycles and their postulated causes; Sedimentary Facies; Relationship of lateral and vertical facies; Walther's Law of Succession of Facies; Transgressions and Regressions; Correlation of Lithostratigraphic Units.

Unit-2:

Sequence Stratigraphy; Seismic sections; Exxon-Vail Curve; System Tracts; Methods and Applications of Sequence Stratigraphy.

Unit-3:

Magnetostatigraphy; Field Reversals and Polarity Time Scale; Magnetostatigraphic Correlation.

PART II: INDIAN STRATIGRAPHY

Unit-1:

Tectonic Framework of India- Cratons and Mobile belts, Archean-Proterozoic boundary

Unit-2:

Precambrian formations of India: Dharwar Province, Eastern Ghats Province, Central Indian, Singhbhum-Orissa Province, Aravalli-Bundelkhand Province.

Unit-3:

Proterozoic formations of Indian Peninsula: Cuddapah and Vindhyan Supergroup.

Unit-4:

Precambrians of Shillong Plateau and Arunachal Himalaya

Unit-5:

Palaeozoic formations of India, Himalayan Palaeozoics, marine Palaeozoics in Peninsular India, Precambrian-Cambrian boundary

Unit-6: Mesozoic formations of India, Triassic of Spiti and Himalayan range; Jurassic of Kutch region, Cretaceous of Peninsular India and Northeastern region of India. Permian-Triassic boundary.

Unit-7:

Gondwana Sequence of India: Basin configuration, sedimentation and palaeoclimates, Gondwana deposits of Peninsular India, marine intercalations, Gondwana deposits in the Himalayas.

Unit-8:

Cenozoic formations of India: Tectonic history, Cenozoic life, Cretaceous-Tertiary boundary, Himalayan Cenozoic formations, Cenozoic stratigraphy of Assam-Arakan region.

PRACTICAL

1. Study of Indian stratigraphic rocks in handspecimens
2. Construction and analysis of sea-level curve from vertical successions of strata
3. Interpretation of seismic sections; Recognizing sequences in seismic sections
4. Interpretation of geologic history from geologic maps
5. Bore-hole problems

Reading List

Principles of Stratigraphy:

1. Boggs, S. Jr., *Principles of Sedimentology and Stratigraphy* (Fourth Edition), Prentice Hall
2. Prothero, D. R. and Schwab, F., *Sedimentary Geology: An Introduction to Sedimentary Rocks and Stratigraphy* (Second Edition), W. H. Freeman and Company

Indian Stratigraphy:

1. Krishnan, M. S.: *Geology of India and Burma*, CBS Pub.
2. Kumar, R.: *Fundamental of Historical Geology and Stratigraphy of India*, New Age International Pub.
3. Naqvi, S. M. and Rogers, J. J. W.: *Precambrian Geology of India*, Oxford Univ. Press.
4. Vaidyanadhan, R and Ramakrishnan, R, *Geology of India (Volume -1 & 2)*, Geological society of India
5. Wadia, D. N.: *Geology of India*, Tata-McGraw-Hill Pub.
6. Published articles and records of GSI and research Journals

SEMESTER IV PAPER: GLY 1003C

PART I: ECONOMIC GEOLOGY (PRINCIPLES)

PART II: ECONOMIC MINERAL DEPOSITS OF INDIAN AND WORLD

CREDITS: 3+0+1

THEORY

PART I: ECONOMIC GEOLOGY (PRINCIPLES)

Unit-1:

Concept and Classification of ore deposits; Spatial and temporal distribution of ore deposits; Metallogenic Provinces and Metallogenic epochs; Paragenesis and Zoning; Concept of Geothermometry, Geobarometry and Dating of ore deposits;

Unit-2:

Concept of ore bearing fluids, their origin and migration; Wall rock alteration; Structural, physicochemical and stratigraphic controls of ore localization; Organic matters in ore; Fluid inclusions in ore – principles and applications

Unit-3:

Mineralogy, classification and genesis of ore deposits associated with orthomagmatic ores of ultramafic-mafic rocks; Ores of felsic-silicic igneous rocks; Ores of sedimentary affiliation - biochemical, chemical and clastic sedimentation, placers and residual concentration deposits; Ores of metamorphic affiliations; Mineralisation at plate boundaries

PART II: ECONOMIC MINERAL DEPOSITS OF INDIA AND WORLD

Unit-1:

Non-metallic minerals: limestone and dolomite, magnesite, phosphate, asbestos, gemstones, clay mineral deposits.

Unit-2:

Study of the following metallic deposits of India with special reference to their mineralogy, genesis, mode of occurrence, uses and distribution: Fe, Mn, Cr, Al, Cu, Pb, Zn, Au, Mg, Sn, W and atomic minerals.

Unit-3:

Geology of important type of mineral deposits of the world: disseminated type diamond deposits of South Africa, platform type chrome-magnetite deposits of Bushveld.

Unit-4:

Alpine type - Cuban chromite deposit, Injection type – magnetite deposit of Kirunavara, complex pegmatite, sulfide immiscible – hydrothermal type deposits of Sudbury, Canada. Cyprus and Kuroko type deposits, Japan. Polymetallic deposits of Mississippi type. Sedimentary-metamorphic iron ore deposits of Lake Superior region, USA.

PRACTICAL

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 economic minerals in hand specimen.
5. Identification of industrial minerals in hand specimen for cement, steel, refractory, glass and ceramic industry.
6. Ore reserve estimation.

Reading List

1. Banerjee, D. K., *Mineral Resources of India*, The World Press Pvt. Ltd., Calcutta
2. Barnes, J. W., *Ores and Minerals: Introducing Economic Geology*, Open University Press, Milton Keynes, U.K.
3. Craig, J. M. and Vaughan, D. J., *Ore Microscopy and Ore Petrography*, John Wiley
4. Evans, A.M., *Ore Geology and Industrial Minerals*, 4th Edn., Blackwell Scientific Pub., Oxford.
5. Gokhale, K. V. G. V. & Rao, T. C., *Ore deposits of India*, Affiliated East-West Press Pvt. Ltd.

6. Guilbert, J. M. and Park, C.F. Jr., *The Geology of Ore Deposits*, Freeman
7. Jensen, M. L. and Bateman, A. M., *Economic Mineral Deposits*, John Wiley
8. Klemm, D. D. and Schneider, H. J., *Time and Strata Bound Ore Deposits*, Springer Verlag
9. Misra, K. C., *Understanding mineral deposits*, Kluwer Academic Publishers
10. Mookherjee, A., *Ore Genesis A Holistic Approach*, Allied Publishers
11. Park, C. F., Jr. & MacDiarmid, R. A., *Ore Deposits*, W. H. Freeman and Company
12. Pirajno, F., *Hydrothermal Mineral Deposits*.
13. Sawkins, F. J., *Metal deposits in Relation to Plate Tectonics*, Springer Verlag
14. Stanton, R. L., *Ore Petrology*, McGraw Hill
15. Torling, D. H., *Economic Geology and Geotectonics*, Blackwell
16. Prasad, U., *Economic Geology (Economic Mineral Deposits)*, CBS Publishers & Distributors

SEMESTER IV
PAPER: GLY 1004C

PROJECT WORK
CREDITS: 0+0+4

Project work will be allotted to the students at the beginning of the 3rd semester. The Dissertation 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.

SEMESTER IV
PAPER: GLY 1005E

OCEANOGRAPHY
CREDITS: 2+1+0

THEORY

Unit-1:

Origin of ocean basins, general features of ocean floor, mid-oceanic ridges, ocean trenches, deep sea sediments, physical properties of sea water. Ocean and climatic change, sea-level changes in response to glaciations

Unit-2:

Wind-driven circulation of ocean, circulation model, temperature and salinity distribution of the model, currents of world ocean, deep circulation of ocean, sea waves, tides and tide generating force, tsunami.

Unit-3:

Marine ecology: Ocean habitats, classification of organisms, basic ecology – temperature, salinity, hydrostatic pressure. Ocean resources: oil and natural gas, gas hydrates, sand and gravel, manganese nodules, phosphate deposits

Reading List

1. Alan P. Trujillo & Harold V. Thurman, *Essentials of Oceanography*, 10th ed., Prentice Hall
2. Jenkins, J. T., *A Textbook of Oceanography*, Constable & Co. Ltd. London