

**DEPARTMENT OF APPLIED GEOLOGY
INDIAN SCHOOL OF MINES, DHANBAD**



COURSE STRUCTURE AND SYLLABUS

FOR

2-YEAR M. TECH.

IN

MINERAL EXPLORATION

(2012-13 Session onwards)

**Course structure for Two-year M. Tech. in Mineral Exploration
(2012-13 Session onwards)**

I - SEMESTER

Sl. No.	Course No.	Name of the Course	L T P	Credit
1	GLC 51111	Exploration Techniques & Environmental Planning for Exploration/Mining	3 0 0	6
2.	GLC 51112	Tectonics and Structural Methods for Exploration	3 0 0	6
3	GLC 51113	Resource Evaluation and Geostatistics	3 0 0	6
4	GLC51114	Coal, Coal Bed Methane and Shale Gas Exploration	3 0 0	6
5	MER511XX*	Mining Operations and Methods	3 0 0	6
6	GLC 51211	Exploration Techniques Practical	0 0 3	3
7	GLC51212	Tectonics and Structural Methods for Exploration Practical	0 0 3	3
8	GLC 51213	Resource Evaluation and Geostatistics Practical	0 0 3	3
9	GLC51214	Coal, Coal Bed Methane and Shale Gas Exploration Practical	0 0 3	3
TOTAL			15 0 12	42

*Subject code to be provided by the Department of Mining Engineering

II – SEMESTER

Sl. No.	Course No.	Name of the Course	L T P	Credit
1	GLC52115	Exploration Geochemistry	3 0 0	6
2	GLC52116	Advanced Geostatistics and Mineral Economics	3 0 0	6
3		ELECTIVE (Any One)	3 0 0	6
	GLE52117	Petroleum and Gas Hydrate Exploration		
	GLE52118	Remote Sensing & GIS in Mineral Exploration		
	GLE52119	Nanotechnology in Mineral and Hydrocarbon Exploration		
	GLE52120	Groundwater Exploration		
	GLE52121	IT Applications in Mineral Exploration		
	GLE52122	Marine Mineral Resources and Exploration		
4	GPC52151	Engineering Geophysics	3 0 0	6
5	MSC52104	Project Management	3 1 0	7
6	GLC52215	Exploration Geochemistry Practical	0 0 3	3
7	GLC52216	Advanced Geostatistics Practical	0 0 3	3
8	GPE52251	Engineering Geophysics Practical	0 0 3	3
9	GLC52556	Composite Viva Voce	0 0 0	2
TOTAL			15 1 9	42

III – SEMESTER

Sl. No.	Course No.	Name of the course	L T P	Credit
1.	GLC53601	Industrial Training / Minor Project	0 0 0	4
2.	GLC53402	Seminar / viva-voce on Industrial Training / Minor Project	0 0 0	2
3.	GLC53503	Composite Viva-voce	0 0 0	4
4.	GLC53804	Interim Dissertation (Field Work / Lab Work)	0 0 0	15
5.	GLC53405	Seminar and Viva-voce on Dissertation	0 0 0	10
6.	GLC53006	Evaluation of teaching assignment / Lab. Development work	0 0 0	5
TOTAL			0 0 0	40

IV SEMESTER

Sl. No.	Course No.	Name of the course	L T P	Credit
1.	GLC54801	Dissertation	0 0 0	20
2.	GLC54402	Seminar on Dissertation	0 0 0	5
3.	GLC54503	Viva-Voce on Dissertation	0 0 0	10
4.	GLC54004	Evaluation of teaching assignment / Lab development work	0 0 0	5
TOTAL			0 0 0	40

FIRST SEMESTER

GLC 51111	Exploration Techniques & Environmental Planning for Exploration/Mining	3 0 0
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EXPLORATION TECHNIQUES

Advances in mineral exploration concepts. Concept-based exploration. Application of remote sensing in mineral exploration. Geological methods of prospecting and exploration. Different stages of exploration: objectives and tasks involved; preliminary studies and reconnaissance surveys. Surface and subsurface mapping for exploration. Regional and detailed exploration programmes: their planning and organizational set-up. Systematic collection and documentation of geological data.

ENVIRONMENTAL PLANNING FOR EXPLORATION/MINING

Environmental baseline data needed for mine planning – its acquisition and documentation during different stages of mineral exploration. Nature and extent of environmental problems due to surface and underground mining – Air pollution, water pollution, visual impact, noise pollution, vibrations. Reclamation of mined land. Legislation and control measures. Mine waste management.

GLC 51211	Exploration Techniques Practical	0 0 3
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Megascopic identification of ore minerals; Ore microscopic studies; Studies on fluid inclusions.

GLC 51112	Tectonics and Structural Methods for Exploration	3 0 0
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Mapping of structural geometry: using of fence diagram, stratum contour, isopach and isochore maps. Projection of ore body geometry; cross-section using kink-style, concentric arc geometry. Balanced cross-section. Development of gravity induced and diapiric structures, Fracture analysis.

Brittle and Ductile deformation of rocks. Techniques of strain analysis. Concepts of plate tectonics and plate motion. Evolution of divergent boundary basins and their petro-tectonic assemblages. Evolution of convergent basins and their petro-tectonic assemblages. Evolution of strike-slip boundaries and their petro-tectonic assemblages. Plate Tectonics and mineral / Hydrocarbon accumulation.

GLC 51212	Tectonics and Structural Methods for Exploration Practical	0 0 3
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Construction of isopach, isochore, structure contour maps and cross sections; Studies on joint analysis. Stereoscopic projections involving tilt and rotation problems, and bore-hole data; Fault-slip analysis. Maps of superposed deformation and mineralization.

GLC 51113	Resource Evaluation and Geostatistics	3 0 0
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Resource Evaluation

Sampling: Theory, Patterns, Methods, Sample optimisation, Errors, Statistical Tests; Core logging and Core sampling. **Resources and Reserves:** Terminology, *viz.* Identified and Unidentified Resources, Measured, Indicated and Inferred Reserves, Paramarginal, Submarginal, Hypothetical and Speculative Resources; Classification Schemes, *viz.* USGS and UNFC Schemes. **Plans and Sections for Ore Evaluation:** Structure Contour Plans, Isopach Map, Isograd Plan, Assay Plan, Ore Distribution Plan, Transverse and Longitudinal Vertical Sections, Slice Plan and Isometric Projection. **Conventional Methods of ore Evaluation:** Polygonal, Triangular, Sectional, Random Stratified Grid, Contouring, Distance weighting and Trend Surface.

Geostatistics

Overview of Deterministic and Probabilistic models of Estimation; Exploratory data analysis. **Classical Statistics:** Theoretical models of Statistical distributions, *viz.* Normal (Gaussian), Lognormal, Binomial, Negative Binomial, Exponential and Poisson; Characteristics and properties of Normal (Gaussian) and Lognormal Probability Distributions, Graphical and Numerical Techniques of Model Fitting, Estimation of Distribution Parameters and their applications in Ore Evaluation. **Geostatistical Concepts and Theories:** Regionalized Variable Theory, Geostatistical Schools of Thought, *viz.* American, South African and French; Stationarity assumptions – Strict Stationarity, Second Order Stationarity and Intrinsic Hypothesis.

Geostatistical Semi-variogram Analysis: Definition, Characteristics, Properties, Relation with Covariogram; Calculation of Experimental Semi-variograms in One, Two and Three- Dimensions. **Mathematical Models of Semi-variogram:** Models with Sill and Models without Sill, Nested Models and Trend Models.

GLC 51213	Resource Evaluation and Geostatistics Practical	0 0 3
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Problems on Channel Sampling, Drill Hole Sampling, Construction of Sections and plans for ore evaluation, Conventional methods of ore evaluation, Normal and Lognormal Distribution modelling and constructions of One, Two and Three-dimensional experimental semi-variograms and their interpretations.

GLC 51114	Coal, Coal Bed Methane and Shale Gas Exploration	3 0 0
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Coal Exploration

Varieties of coal and origin, Analyses of coal, coal petrography, Coal classification, Organisation of coal exploration project. Different methods of coal exploration: Photogeological and remote sensing, geological, sedimentological and coal petrological. 4.Geophysical methods: Geophysical logging, in-seam seismic survey, In-seam drilling. Methodology involved in the preparation of geological cross sections, floor and roof contours, isopach and isochore of coal seams and partings, seam-folio maps, seam-structure map, statistical diagrams, panel diagrams. Detailed studies of cleat and joints. Assessment of reserve potential and standard procedure of coal reserve estimation. Economics of coal exploration.

Coal Bed Methane Exploration

Coal bed methane generation and accumulation Geological and petrographic influences on coal, Pore geometry, Micropore, Mesopore and macropore, cleat system Sorption – principles, sorption isotherms – types and interpretation. CO₂, CH₄ and N₂ adsorption – desorption, hysteresis, Langmuir isotherm, Swelling of coal matrix isotherm construction. CH₄ content determination in coal seams. Coal bed methane reservoir analysis, comparison between conventional gas reservoir and coal bed methane reservoir, Permeability klinkenberg, shrinkage, stress and depth effects on permeability, water composition as permeability indicator, gas flow diffusion in micropores, Darcy flow in cleats, sorption time, CBM reservoir characterization methods, enhanced recovery. Water production and disposal, injection wells, carbon dioxide sequestration. Characterization of various shales for shale gas exploration. Potential CBM and shale gas basins and production, hydraulic fracturing of coal seams and shales , CBM and shale gas exploration. In-situ gasification; carbon dioxide sequestration

GLC 51214	Coal, Coal Bed Methane and Shale Gas Exploration Practical	0 0 3
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Preparation of geological cross sections, seam-structure map. Statistical diagrams; Panel diagrams. Gassiness studies. Studies of cleat and joints, Reflectogram, Petrographic analyses of coal. Analyses of coal, Coal reserve estimation; CBM estimation; Cellulose content in coal; Solvent extraction of coal. Organo-geochemical analyses of coal, lignite and soils.

MER511XX*	MINING OPERATIONS AND METHODS	3 0 0
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Introduction to mining, elements of mining, definitions and explanation of different mining terms.

Introduction to surface mining; Deposits amenable to surface mining; Concept of stripping and stripping ratios. Box cut – definition, objectives, types and their applicability; Production benches – objectives, formation and parameters. Unit operations vis-a-vis equipments; Classification of surface mining systems. Rippling, drilling and blasting. Shovel-dumper and dragline operation.

Introduction to underground coal mining: Broad classification of underground coal mining methods. Bord and Pillar method – general description, panel system of mining and its advantages and disadvantages, determination of size of panel, development by SDL/LHD, Rib & Slice method of depillaring in one lift with

caving in flat/moderately inclined seams. Longwall method – general description and application, Longwall advancing and Longwall retreating methods and their advantages and disadvantages, factors governing length of panel and length of Longwall face, introduction to PSLW technology with shearer.

Introduction to underground metal mining; Deposits amenable to underground metal mining. Modes of entry to underground mineral deposits. Mine development: drifting, raising and winzing; Classification of underground metal mining methods. General description, applicability and operations involved in different methods.

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SECOND SEMESTER

GLC 52115	Exploration Geochemistry	3 0 0
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Role of geochemistry in mineral exploration. Geochemical mobility and association of elements. Geochemical traces. Geochemical anomalies – primary and surficial dispersion patterns. Evaluation of different terrains for geochemical exploration with special reference to India. Reconnaissance and detailed geochemical exploration.

Rock geochemistry in mineral exploration. Geochemical soil surveys, drainage and hydrogeochemical surveys, geobotanical and biogeochemical prospecting. Non-conventional methods – mercury vapour and other volatile components in ore soil, gas and air as ore-guides, electrochemical methods, etc.

Instrumental analytical techniques. Statistical analysis and interpretation of geochemical prospecting data. Selected Indian case studies.

GLC 52215	Exploration Geochemistry Practical	0 0 3
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Usage of various analytical instruments and analytical techniques-AAS, XRF
Statistical analysis and interpretation of geochemical prospecting data.

GLC 52116	Advanced Geostatistics and Mineral Economics	3 0 0
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Advanced Geostatistics

Practical difficulties associated with semi-variography, viz. anisotropy, non-stationarity, regularisation, presence of nugget effect and presence of trend. Extension, Estimation and Dispersion variances: definitions, methods of calculations and applications; Screen Effect.

Ordinary Kriging: definition, point/block estimation procedures, techniques of semi-variogram model fitting; Geostatistical evaluation scheme; Effect of Nugget variance on kriged weights.

Brief capsule on Non-linear and Non-parametric Geostatistics: Lognormal, Disjunctive and Multi-Gaussian, Indicator and Probability Kriging.

Geostatistical applications: optimisation of exploration drilling, calculation of mineral inventory, establishment of grade-tonnage relations, calculation of planning cut-off grade; misclassified tonnages; geostatistical grade control plan.

Geostatistical Conditional Simulation – Theory, techniques and applications with special reference to Simulated Annealing Simulation.

Mineral Economics

The study of mineral economics, Classifications of mineral resources – IMM, JORC, SAMERC, ISP and UNFC schemes. National Mineral policies. Economics of mineral Exploration. Economic evaluation of mineral deposits.

GLC 52216	Advanced Geostatistics Practical	0 0 3
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Computation of estimation variance; Point Kriging and Block Kriging Exercises; Computer based modeling for Univariate and Bivariate data; Computer based semi-variogram modeling, Point Kriging Cross-validation and Block Kriging.

GLE52117	Petroleum and Gas Hydrate Exploration	3 0 0
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Petroleum Exploration:

Transformation of organic matter to petroleum, organic geochemical indicators, Agents in transformation, Optical parameters in source maturity studies

Source sediments, Oilfield water; Varieties of petroleum

Well Logs

Migration and Trapping Mechanism

Exploration of petroleum- surface and direct indications, geological and geophysical methods.

Gas Hydrate Exploration:

Gas hydrate, occurrence and origin; structure of gas hydrate, Types of gas hydrate; Kinetics of gas hydrate

Formation

Geological setting of Hydrate; Stability of gas hydrates; Gas hydrate reservoir;

Volume of gas in hydrate; inhibitors.
 Geological and geophysical exploration of gas hydrate
 Prospect and potentialities of gas hydrate in India.

GLE52118	Remote Sensing and GIS in Mineral Exploration	3 0 0
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Remote Sensing

Fundamental of Remote Sensing: History and Development, Definition, Concept and Principles; Energy Resources, Radiation Principles, EM Radiation and EM Spectrum; Black Body Radiation, Laws of Radiation; Interaction of EMR with Atmosphere and Earth Surface; Platforms-Type and their Characteristics, Sensor-Type and their Characteristics; Earth Resource Satellite- LANDSAT, SPOT, IRS, IKONOS satellite Series ;Concept of Resolution: Spatial, Spectral, Temporal and Radiometric ; Basic Concept and Principle of Thermal, Microwave and Hypersectral Remote Sensing.

Techniques of interpretation of aerial photographs and satellite imageries with case studies; Application of Remote Sensing technology in Geological mapping; Hyperspectral Remote Sensing and it's application in mineral exploration; Case histories of application of Remote Sensing in Mineral Exploration.

GIS

Fundamentals of GIS: Theory, Concepts, Developments and Components. Capabilities of GIS: Data input, Projection and Registration, Topology building, Data integration, Map making and Spatial interpolation. Data Models: Vector model, Raster model and TIN model; Formats of feature data. Spatial Data Analysis and Modelling: DEM, DTM, Overlaying and Integration. GIS Applications: Geological map production, Mineral potential mapping, Geological hazard zonation, viz. Volcanic, Landslide and Earthquake. Introduction to GIS packages.

GLE52119	Nanotechnology in Mineral and Hydrocarbon Exploration	3 0 0
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Introduction, New forms of matter, Nanopowders and nanomaterials, nanopores and their properties, Structure of nanomaterials, Fullerene structures, New forms of carbon, carbon nanotubes (CNT), Nanomaterials in Earth Science; Properties of Nanotubes; Analytical methods for studying nanomaterial: Scanning Tunneling Microscope, Atomic Force Microscope (AFM), Raman Spectroscopy, Nanomanipulator, Nanotweezers, Dip Pen Nanolithography, Processes for CNT production; Utilization of coal for production of CNT; Application of CNT- vacuum microelectronics, energy storage, Nanotubes from inorganic materials and their applications, Enhanced diamond synthesis, New chemicals; Dynamics of natural gas adsorption dynamics; Application of Nanotechnology: gas separation and storage; Removal of SO_x and NO_x, Coalbed Methane, Petroleum exploration; CO₂ sequestration and CO₂ adsorption dynamics of nanopores; Molecular sieves; Nanoprobes and sensors.

GLE52120	Ground Water Exploration	3 0 0
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Geological Aspects

Groundwater exploration techniques. Groundwater exploration in hard and soft rocks and in volcanic, lateritic, fractured and karstified rocks. Thermal, industrial and medicinal mineral waters. Artificial recharge. Groundwater inventory. Geological and geomorphic controls of groundwater occurrences. Geochemical aspects of groundwater. Groundwater pollution., Low temperature aqueous geochemistry, Sources of contamination; chemical evolution of soil water and ground water, Solute transport in ground water; transformation, retardation and attenuation.

Geophysical Aspects

Remote sensing and aerial-photo interpretation in groundwater exploration. Groundwater flow – Pre-water pressure, steady and unsteady flow, flow through unsaturated media. Well hydraulics and methods of determination of aquifer characteristics.

GLE52121	IT Applications in Mineral Exploration	3 0 0
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Basics of IT and its phase-wise emergence, Information Systems, Networking, Internet and Intranet, Information Superhighway, GIS, GPS, Role of IT in Mineral Exploration. **Database Systems:** Database, Data

organisation and Structure; Data warehouse and Data mining; Use of dBase and MS-Access; Mineral database. **Computer Graphics:** Definition and representative uses; CAD and its use in mineral exploration. **Computer Aided Orebody Modelling:** Algorithms and flow diagrams for Conventional and Geostatistical modelling. **IT Concepts :** Knowledge Based Expert System, Decision Support System, Neural Network, Virtual Reality, Fuzzy Logic and Genetic Algorithm and their role in mineral exploration. **Introduction to mineral exploration Software Packages,** viz. ISATIS, GEXSYS, GEO-EAS, GSLIB, MICROMINE, GEMCOM, SURPAC, DATAMINE, ArcGIS and SPANS.

GLE52122	Marine Mineral Resources and Exploration	3 0 0
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Introduction to marine geology: Geological and Geophysical oceanography. Physiographic provinces of the ocean floor, basins, etc. classification and potentials of marine mineral resources; metalliferous brines; Marine mineral resources of India; Offshore drilling operations and organization. Deep sea mining technology. Various Marine mineral exploration techniques; Research vessels and submersibles. International and national oceanographic institutions, agencies, organizations, etc. Data evaluation of exploration surveys. Marine mining and its impact on environment. Laws of the sea relevant to marine mineral exploration

GPC52151	Engineering Geophysics	3 0 0
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Seismic method: Huygens' Principle, elastic constants, reflection and refraction. Elastic constants, effect of depth and age. Snell's law. Seismic reflection and refraction, Seismic waves, Analysis of time and distance graphs, Parallel and non-parallel interface, multilayered models, correction, velocity inversion.

Gravity method: Fundamentals of gravity method, gravity data acquisition, processing, magnetic data correction, magnetic anomaly and its analysis.

Magnetic method: Fundamentals of magnetic method, magnetic data acquisition, processing, magnetic data correction, magnetic anomaly and its analysis.

Geo-electrical method: Fundamental concepts of electrical Resistivity method, Archie's law point current electrode on homogeneous Earth, Heterogeneous medium, Resistivity profiling and sounding, Resistivity data interpretation, Two layered structures, Curve matching, Fundamental concepts of Electromagnetic and Magnetotelluric method.

Application of geophysics in dome foundation and rock tunneling etc.

GPC52251	Engineering Geophysics Practical	0 0 3
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Calculation of elastic constants from the seismic velocity and critical angle from Snell's law. Interpretation of travel time – distance curve for a horizontal reflector. Calculation of intercept time and crossover distance for a horizontal refractor and travel – distance curve for a dipping refractor. Drawing of travel time – distance curve for three layered earth. Calculation of Normal Move Out and Dip Move Out from reflected travel time. Interpretation of ascending and descending sounding curve for layered earth. Interpretation of bell shaped and bowl shaped sounding curve for layered earth. To plot and interpret resistivity profiling data.

MSC 52104	Project Management	3 1 0
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Project Management – an Overview; Project Life Cycle, Feasibility Study; Market and Demand Analysis; Technical Analysis; Financial Analysis; Social Cost-Benefit Analysis; Detailed Project Report.

Project Planning and Scheduling; Planning Time Scales, Project Planning using Network techniques, Scheduling of Project with Limited Resources, Implementation and Control; Project Organization, Project Management Information Systems, Basics of Software Project Management.