
DHANAMANJURI UNIVERSITY
IMPHAL, MANIPUR



MASTER OF SCIENCE IN GEOLOGY
(One-Year Programme)



DEPARTMENT OF GEOLOGY
School of Human and Environmental Sciences
D. M. COLLEGE OF SCIENCE, D. M. UNIVERSITY
Imphal – 795001, Manipur.
2026

M. Sc. 1st SEMESTER (M.Sc. One Year Programme)
THEORY PAPERS & PRACTICAL PAPERS:

<i>Paper Code</i>	<i>Paper Title</i>	<i>Internal Assessment</i>	<i>End Semester Assessment</i>	Total Marks	<i>No. of Credits</i>
GEL – 601	Economic Geology, Mineral Economics & Mining Geology	20	80	100	4
GEL – 602	Geo-Engineering and Hydrogeology	20	80	100	4
GEL – 603	Fuel and Environmental Geology	20	80	100	4
GEL – 604	Remote Sensing and Application of GIS	20	80	100	4
GEL – 605	Practical related to GEL – 601 & GEL- 602			100	4
GEL – 606	Practical related to GEL – 603 & GEL- 604			100	4
Total		80	520	600	24

Total Marks of First Semester = 600

Total Credits = 24

M. Sc. 2nd SEMESTER (M.Sc. One Year Programme)
THEORY PAPERS & PRACTICAL PAPERS:

<i>Paper Code</i>	<i>Paper Title</i>	<i>Internal Assessment</i>	<i>End Semester Assessment</i>	Total Marks	<i>No. of Credits</i>
GEL – 607	Geodynamics & Geotectonics	20	80	100	4
GEL – 608	Exploration Geology	20	80	100	4
GEL – 609	Atmosphere, Ocean & Climate Dynamics	20	80	100	4
GEL – 610	Dissertation			150	6
GEL – 611	Practical related to GEL – 607 & GEL- 608			100	4
GEL – 612	Field Work			50	2
Total		60	540	600	24

Total Marks of Second Semester = 600

Total Credits = 24

DETAILED CONTENTS OF M.Sc. 1 YEAR COURSE IN GEOLOGY PAPERS

FIRST SEMESTER

THEORY

Paper Code: GEL – 601 (ECONOMIC GEOLOGY, MINERAL ECONOMICS & MINING GEOLOGY)

Credits: 4

Full Marks: 100

Course Objectives

1. This course introduces the fundamental principles of ore geology, emphasizing the origin, occurrence, and classification of mineral deposits in relation to geological processes and tectonic settings.
2. It provides a comprehensive understanding of the physicochemical principles governing ore formation, including the roles of ore-forming fluids, magmatism, metamorphism, and surface processes in mineralization.
3. The course highlights the relationship between plate tectonics, structural controls, and metallogeny, with special reference to mineralization associated with different rock types and tectonic environments.
4. Students will study the mineralogy, geochemistry, genesis, and economic importance of metallic and non-metallic mineral deposits of India and the world, as well as marine mineral resources and the legal frameworks governing them.
5. It also covers the fundamentals of mineral economics and mining geology, focusing on mineral exploration, extraction techniques, resource management, and the role of mineral resources in the national economy.

Economic/Ore Geology:

Unit-1

20 Marks

Historical background to the development of Ore Geology. Scope and application of economic geology. Classification of ore deposits: Forms and modes of occurrence of ore deposits – morphology and relationship of host rocks. Concept of the terms ore, gangue, grade, tenor, metallic, non-metallic minerals deposits, resources, reserves, renewable and non-renewable resources, etc. Textures, Paragenesis and Zoning of ores and their significance. Global tectonics and metallogeny.

Unit-2

25 Marks

Ore forming processes. Physicochemical principles of minerals deposits and ore-genesis. Ore forming fluids: origin, types, nature and migration. Primary and secondary ore forming processes. Endogeneous processes: Magma as ore forming fluids and related mineralization through geological time. Contact metasomatism, Hydrothermal deposits, Sublimation. Exogeneous processes: Sediment hosted ore deposits. Chemical and biological precipitation. Residual and mechanical concentration. Oxidation and supergene enrichment. Evaporation of brine and metamorphism related ore forming processes.

Plate tectonic and ore deposits: Mineralization related to plate tectonic. Structural and physicochemical controls on ore localization. Broad tectonic setting and magmatism associated with various types of ore deposits. Mineralisation associated with ultramafic, mafic and acidic rocks, greenstone belts and komatiites, anorthosites and kimberlites

Unit-3

25 Marks

Economic minerals deposits of India and world: Mineralogy, geochemistry, genesis, mode of occurrence, geographic distribution and uses of Metalliferous deposits of India - base metals,

iron, manganese, aluminium, chromium, nickel, gold, silver, molybdenum. Non-metalliferous deposits of India: mica, asbestos, barytes, gypsum, graphite, apatite and beryl. Gemstones, refractory minerals, abrasives and minerals used in glass, fertilizer, paint, ceramic and cement industries. Building stones. Phosphorite deposits. Placer deposits, rare earth minerals. Industrial minerals of India - Iron and Steel industry, refractory industry, fertilizer industry, cement industry, chemical industry and abrasives. Major ore deposits of world.

Marine minerals resources and law of sea:

Introduction to the Science of Marine Minerals. Seafloor Settings of Marine Mineral Deposits. Sources of Marine Minerals. Marine Mineral Deposits: Metalliferous Sediments, Seafloor Polymetallic Massive Sulphides and Related Deposits: Polymetallic Manganese Nodules, Cobalt-Rich Ferromanganese Crusts, Placer Deposits, Lime, Phosphorite, Gas hydrates and Salt Deposits. ISBA guidelines on law of sea

Unit-4

30 Marks

Introduction to mineral economics:

Importance of Minerals in National Economy. Atomic, Strategic, essential and critical minerals. National mineral policy. Conservation and utilization of mineral resources. India's status in mineral production. Changing patterns of mineral consumption. Mineral Concession Rules.

Mining Geology:

Application of rock mechanics in mining. Planning, exploration and exploratory mining of surface and underground mineral deposits involving diamond drilling, shaft sinking, drifting, cross cutting, winzing, stoping, room and pillaring, top-slicing, sub-level caving and block caving. Cycles of surface and underground mining operations. Exploration for placer deposits. Open pit mining. Ocean bottom mining. Types of drilling methods. Mining hazards: mine inundation, fire and rock burst.

Course Learning Outcomes

1. By the end of this course, students should have a thorough understanding of the formation, classification, and global distribution of ore deposits, and their association with geological and tectonic processes.
2. Be able to explain the physicochemical and geodynamic factors influencing ore genesis and evaluate different ore-forming environments such as magmatic, hydrothermal, sedimentary, and metamorphic systems.
3. Acquire detailed knowledge of India's major metallic and non-metallic mineral deposits, their genesis, mode of occurrence, and industrial significance, as well as an understanding of global metallogenic provinces.
4. Understand the occurrence, extraction potential, and legal aspects of marine mineral resources in the context of the International Seabed Authority (ISBA) guidelines and the Law of the Sea.
5. Develop the ability to apply geological and economic principles in mineral exploration, mining operations, and sustainable resource management, considering national mineral policies and conservation strategies.

Books Recommended:

1. Craig, J.M. & Vaughan, D.J., 1981: *Ore Petrography and Mineralogy*. John Wiley.
2. Evans, A.M., 1993: *Ore Geology and Industrial Minerals*. Blackwell.
3. Sawkins, F.J., 1984: *Metal deposits in relation to plate tectonics*. Springer Verlag.

4. Stanton, R.L., 1972: ***Ore Petrology***, McGraw Hill.
5. Torling, D.H., 1981: ***Economic Geology and Geotectonics***. Blackwell Sci Publ.
6. Barnes, H.L., 1979: ***Geochemistry of Hydrothermal Ore Deposits***. John Wiley:
7. Klemm, D.O. and Schneider, H.J., 1977: ***Time and Strata Bound Ore Deposits***. Springer Verlag.
8. Guilbert, J.M. and Park, Jr. C.F., 1986: ***The Geology of Ore Deposits***. Freeman.
9. Mookherjee, A., 2000: ***Ore genesis -a Holistic Approach***. Allied Publisher.
10. McKinstry, H.E., 1962: ***Mining Geology***. II Ed. Asia Publishing House.
11. Clark, G.B., 1967: ***Elements of Mining***. III Ed. John Wiley.
12. Arogyaswamy, R.P.N., 1996: ***Courses in Mining Geology***. IV Ed. Oxford IBH.
13. Sinha, R.K and Sharma, N.I. ***Mineral Economics***.
14. Wolfe, J.A. ***Mineral Resources: A world review***.
15. Smirnov, V.I. ***Geology of Ore Deposits***.

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FIRST SEMESTER

THEORY

Paper Code: **GEL – 602 (ENGINEERING GEOLOGY & HYDROGEOLOGY)**

Credits: 4

Full Marks: 100

Course Objectives

1. This course introduces the principles and applications of engineering geology in civil and geotechnical projects, emphasizing the geological factors that influence the design, construction, and maintenance of engineering structures.
2. It aims to provide a comprehensive understanding of soil and rock mechanics, engineering properties of construction materials, and the geological considerations for large-scale projects such as dams, tunnels, and reservoirs.
3. The course highlights the geological causes of structural failures, landslides, earthquakes, and hill slope instability, along with aseismic design and seismic zonation of India.
4. It also provides fundamental knowledge of hydrogeology, including the occurrence, movement, and distribution of groundwater in different geological settings and aquifer systems.
5. Students will gain practical insights into groundwater exploration, artificial recharge, water well technology, and the sustainable management of groundwater resources using geological, geophysical, and remote sensing methods.

Engineering Geology:

Unit-1

25 Marks

Role of engineering geology in civil constructions. Various stages of engineering geological investigation for civil engineering projects. Soil mechanics – three phases of soil, consistency limits, particle size distribution, soil classification, consolidation and compaction, and shear strength of soil. Engineering properties of rocks; rock discontinuities. Physical characters of building stones: mechanical strength and classification. Metal and concrete aggregates.

Unit-2

25 Marks

Geological consideration for evaluation of dams and reservoir sites. Dam foundation rock problems. Geotechnical evaluation of tunnel alignments and transportation routes, method of tunneling; classification of ground for tunneling purposes; various types of support. Mass movements with special emphasis on landslides and causes of hill slope instability. Earthquakes and seismicity, seismic zones of India. Aseismic design of building. Influence of geological conditions on foundation and design of buildings. Case history of engineering projects and geological causes for mishaps and failures of engineering structures.

Hydrogeology:

Unit-3

25 Marks

Role of groundwater in the hydrological cycle; Controls of geology on groundwater occurrence and distribution; Classification of aquifers and aquifer systems, geological formations as aquifers; Mode of occurrence of groundwater in different geological terrains of India; Bernoulli's equation and hydraulic head; Darcy's law and Reynolds number; Hydraulic conductivity, transmissivity, storage coefficient and specific capacity; Water table contour maps and flow net analysis

Unit-4**25 Marks**

Artificial recharge of groundwater, Consumptive and conjunctive use of surface and groundwater, problem of overexploitation, groundwater legislation. Water well technology: well types, drilling methods, construction., design, development and maintenance of wells. Water management in rural and urban areas, salt water intrusion in coastal aquifers, remedial measures. Surface and subsurface geophysical and geological methods of groundwater exploration, hydrogeomorphic mapping using various remote sensing techniques. Radio isotopes in hydrogeological studies.

Course Learning Outcomes

1. By the end of this course, students will understand the essential role of geology in civil engineering, site investigation, and infrastructure development.
2. Be able to analyze the engineering properties of soils and rocks, interpret discontinuities, and assess their suitability as foundation and construction materials.
3. Develop the ability to evaluate geological conditions for dam, reservoir, and tunnel projects, identify potential hazards such as landslides and seismic risks, and propose appropriate engineering solutions.
4. Demonstrate a strong grasp of groundwater hydrology, including aquifer classification, flow dynamics, and the application of Darcy's law and related hydraulic principles in hydrogeological analysis.
5. Apply techniques for groundwater exploration, artificial recharge, and well construction, integrating geophysical, geological, and remote sensing data for water resource assessment and management.

Books Recommended:

1. Bell, F.G., 1992: Fundamentals of Engineering Geology. Aditya Books Pvt. Ltd. Indian Edition
2. Jaeger & Cook: Fundamentals of Rocks Mechanics.
3. Punmia, Soil Mechanics and Foundation
4. Krynine, D.H. and Judd, W.R., 1998: Principles of Engineering Geology. CBS Edition
5. Todd, O.K., 1980: Groundwater Hydrology. John Wiley.
6. Davies, S.N. & De Wiest, A.J.M., 1966: Hydrogeology. John Wiley.
7. Freeze, A.A. & Cherry, J.A., 1979: Ground Water. Prentice Hall.
8. Fetter, C. W., 1990: Applied Hydrogeology, Merrill Publishing.
9. Raghunath, N.M., 1982: Ground Water. Wiley Eastern.
1. 10. Karanth, K.R., 1987: Groundwater Assessment-Development and Management. Tata McGraw Hill.
10. Alley, W.M., 1993: Regional Ground Water Quality. VNR, New York.
11. Subramaniam, V., 2000: Water. Kingston Publ. London.

FIRST SEMESTER

THEORY

Paper Code: **GEL – 603 (FUEL AND ENVIRONMENTAL GEOLOGY)**

Credits: 4

Full Marks: 100

Course Objectives

1. This course introduces students to the major environmental and geological processes that shape the Earth's ecosystems and climate, with a focus on geological time scales and human impacts.
2. It examines the influence of atmospheric and oceanic circulation on global climate, the geological record of climatic changes, and modern issues such as global warming and pollution.
3. The course emphasizes the geologic and environmental aspects of groundwater and surface water degradation, soil quality, seismic hazards, and climate extremes in the Cenozoic.
4. It also provides a thorough understanding of the formation, classification, and exploration of coal, petroleum, and atomic fuels as natural energy resources.
5. Students will gain knowledge about the distribution of energy resources in India and the world, along with techniques of exploration, reserve estimation, and their environmental implications.

Environmental Geology:

Unit-1

20 Marks

Time scales of global changes in the ecosystems and climate. Impact of circulations in atmosphere and oceans on climate, rainfall and agriculture. Carbon dioxide in atmosphere, limestone deposits in the geological sequences, records of palaeo temperatures in ice cores of glaciers. Global warming caused by CO₂ increase in present atmosphere due to indiscrete exploitation of fossil fuels, volcanic eruptions and afforestation.

Unit-2

20 Marks

Cenozoic climate extremes, evolution of life, especially the impact on human evolution. Impact assessment of degradation and contamination of surface water and ground water quality due to industrialization and urbanization. Water logging problems due to the indiscrete construction of canals, reservoirs and dams. Soil profiles and soil quality degradation due to irrigation, use of fertilizers and pesticides. Influence of neotectonics in seismic hazard assessment. Preparation of seismic hazard maps. Distribution, magnitude and intensity of earthquakes.

Fuel Geology:

Unit-3: Coal

30 Marks

Definition and origin of kerogen and coal. Rank, grade and type of coal. Classification of coal. Proximate and ultimate analyses of coal. Macroscopic ingredients and microscopic constituents, concept of 'maceral' and 'microlithotypes'. Preparation of coal for industrial purposes. Maturation of coal and generation of methane in coalbeds. Fundamentals of coalbed methane exploration and production. Geological and geographical distribution of coal deposits in India. Detailed geology for some important coalfields of India. Methods of coal prospecting and estimation of coal reserves.

Unit-4: Petroleum and Atomic Fuel

30 Marks

Transformation of organic matter into kerogen, thermal cracking of kerogen. Composition and different fractions of hydrocarbons. Origin and Habitat of petroleum (quantity of organic matter, Quality of organic matter, Maturation of organic matter). Migration (primary and secondary). Characteristics of Reservoir rocks and Traps (structural, stratigraphic and combination). Prospecting for oil and gas, drilling and logging procedures. Oil bearing basins of India and the world. Geology of the productive oilfields of India. Future prospects and the economic scenario. Mode of occurrence and association of atomic minerals in nature. Atomic minerals as source of energy. Methods of prospecting and productive geological horizons in India. Nuclear power stations of the country and future prospects. Atomic fuels and environment.

Course Learning Outcomes

1. By the end of this course, students should be able to apply geological principles to understand environmental changes, natural hazards, and resource-related environmental problems.
2. Evaluate the environmental impacts of anthropogenic activities such as industrialization, urbanization, and fossil fuel exploitation on water resources, soils, and climate.
3. Understand the origin, classification, and exploration techniques of coal, petroleum, and atomic minerals, and assess their geological distribution and industrial significance.
4. Analyze and interpret seismic data, prepare seismic hazard maps, and understand the role of neotectonics in hazard assessments.
5. Be capable of formulating research questions and designing practical approaches in environmental and fuel geology, with emphasis on sustainable resource management.

Books Recommended:

1. Taylor, G.H., Teichmuller, M., Davis, A., Diessel, C.F.K., Littke, R. and Robert, P, 1998: **Organic Petrology**. GebruderBorntraeger, Stuttgart.
2. Chandra, D., Singh, R.M. and Singh, M.P., 2000: **Textbook of Coal (Indian Context)**. Tara Book Agency, Varanasi.
3. Singh, M.P. (Ed.), 1998: **Coal and Organic Petrology**. Hindustan Publ. Corp., New Delhi.
4. Stach, E., Mackowsky, M.T.H., Taylor G.H., Chandra, D., Teichmuller, M., and Teichmuller, R., 1982 :**Stach's Text Book of Coal Petrology**, GebruderBorntraeger, Stuttgart.
5. Holson, G.D. and Tiratsoo, E.N., 1985: **Introduction to Petroleum Geology**. Gulf Publ. Houston, Texas.
6. Tissot, B.P. and Welte, D.H., 1984: **Petroleum Formation and Occurrence**. Springer-Verlag.
7. Selley, R.C., 1998: **Elements of Petroleum Geology**. Academic Press.
8. Durrance, E.M., 1986: Radioactivity in Geology. **Principles and Application**. Ellis Hoorwool
9. Dahlkamp, F.J., 1993: **Uranium Ore Deposits**. Springer Verlag.
10. Boyle, R.W., 1982: **Geochemical Prospecting for Thorium and Uranium Deposits**. Elsevier.
11. Hunt, J.M. (1996). **Petroleum geochemistry and geology**. W.H. Freeman and Company, New York.
12. Peters, K.E., Walters, C.C. and Moldowan, J.M. (2005). **The Biomarker Guide volume 1 & 2**. Cambridge.

13. Tyson, R.V. (1995). *Sedimentary organic matter*. Chapman and Hall.
14. Valdiya, K.S., 1987: *Environmental Geology -Indian Context*. Tata McGraw Hill
15. Keller, E.A., 1978: *Environmental Geology*, Bell and Howell, USA
16. Bryant, E., 1985: *Natural Hazards*, Cambridge University Press.
17. Patwardhan, A.M., 1999: *The Dynamic Earth System*. Prentice Hall
18. Subramaniam, V., 2001: *Textbook in Environmental Science*, Narosa International.
19. Bell, F.G., 1999: *Geological Hazards*. Routledge, London.
20. Smith, K., 1992: *Environmental Hazards*. Routledge, London.

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FIRST SEMESTER

THEORY

Paper Code: **GEL – 604 (REMOTE SENSING & APPLICATION OF GIS)**

Credits: 4

Full Marks: 100

Course Objectives

1. It also introduces the basic principles of remote sensing, including the electromagnetic spectrum, aerial photography, photogrammetry, and the characteristics of various satellite missions such as LANDSAT, IRS, and SPOT.
2. The course further focuses on the application of remote sensing and Geographic Information System (GIS) techniques in terrain analysis, groundwater exploration, and geological and tectonic interpretation.

Remote Sensing:

Unit 1:

30 marks

Principles of Remote Sensing: general idea about electromagnetic spectrum, aerial photographs and their geometry, photogrammetry: recent advancements and applications. Satellite remote sensing. Global and Indian space missions. Different satellite exploration programs and their characteristics: LANDSAT, METEOSAT, MODIS, SPOT, IRS. Image interpretation and digital processing techniques. Geological Studies: image characters and their relations with ground objects based on tone, texture and pattern; principles of terrain analysis, evaluation of groundwater potential, rock type identification; and interpretation of topographic and tectonic features. Principles and applications of Geographic Information System.

Unit 2:

25 Marks

Introduction to GIS; components of GIS; conceptual workflow of GIS; properties of spatial data; modeling in GIS; geotechnology; basic functional requirements of GIS; advantages and limitations of GIS; GPS; working of GPS and its application. GIS data model-types and structure; data types and model; basic data elements of a map; spatial data model; data structure- raster data structure and vector data structure; advantages and disadvantages of raster data; spatial relationships; temporal relationships.

Unit 3:

25 Marks

Image preprocessing-introduction; digital image; image processing systems; digital image processing; pre-processing-radiometric corrections; atmospheric correction; geometric correction; subsetting and mosaicking; image enhancement techniques; image classification; unsupervised and supervised classification; accuracy assessment.

Unit 4:

20 Marks

Applications of GIS models; topographic analysis; vector data analysis; spatial data editing; concept of geodatabase; raster/GRID data analysis; visualization techniques; applications of GIS in studying various natural hazards- land degradation, landslides, earthquakes.

Course Learning Outcomes

1. Develop the ability to interpret aerial photographs and satellite imagery, and understand the fundamentals of remote sensing platforms, sensors, and data analysis techniques.

2. Apply remote sensing and GIS tools in geological, geomorphological, and environmental investigations such as terrain evaluation, groundwater potential assessment, and mapping of tectonic and lithological features.

Books recommended:

1. **A practical guide to Geostatistical Mapping** by Tomislav Hengl | 291 p. | ISBN 978-90-9024981-0. eusoils.jrc.ec.europa.eu/esdb_archive/eusoils_docs/.../eur22904en.pdf
2. Burrough, P.A. and McDonnell, R.A., 1998. **Principles of Geographic Information System**, Oxford University Press, Oxford.
3. Campbell, J.B. 2002. **Introduction to remote sensing**, 3rd ed., The Guilford Press. ISBN 1-57230-640-8
4. Chandra, A.M. and Ghosh, S.K. 2000. **Remote Sensing and GIS**. Narosa Publishing House, New Delhi.
5. **Geographical Information Systems - Principles and Applications**, Volume 1 edited by David J. Maguire, Micheal F Goodchild and David W Rhind, John Wiley Sons. Inc., New York 1991.
6. Pratt, William K. (1978). **Digital Image Processing**. ISBN 0-471-01888-0.
7. **Remote Sensing of the Environment - An Earth Resource Perspective**, 2nd edition, J. Jensen, Prentice Hall.
8. **Remote Sensing: Principles and Interpretation**, 3rd edition, by: F. F. Sabins (W. H. Freeman & Co.; 1996, ISBN: 0-71-672442-1).

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Paper Code: GEL – 605 (ECONOMIC GEOLOGY, MINERAL ECONOMICS & MINING GEOLOGY AND ENGINEERING GEOLOGY & HYDROGEOLOGY)

Credits: 4

Full Marks: 100

Megascopic study of structures and fabrics of different ores and their associations. Mineralogical and textural studies of common ore minerals under ore-microscope and petrological study of other industrial and non-metallic minerals. Exercises in the determination of reflectivity and micro hardness of common ore minerals. Geographical distribution of mineral deposits on the outline map of India and world.

Study of properties of common rocks with reference to their utility in engineering projects. Study of maps and models of important engineering structures as dam sites and tunnels. Interpretation of geological maps for landslide problems. Various problems of soil and rock mechanical properties. Diagrammatic representation of open cast and underground mining. Methods of mining survey. Exercises on mine sampling and determination of tenor, cut-off grades and ore reserves.

Delineation of hydrological boundaries on water-table contour maps and estimation of permeability. Analysis of hydrographs and estimation of infiltration capacity. Chemical analysis of water in conjunction with practicals for Paper-V. Pumping test: time-drawdown and timerecovery tests and evaluation of aquifer parameters. Step drawdown tests, Electric resistivity sounding for delineation of fresh and saline aquifers. Study of geophysical well logs. Estimation of TDS using resistivity and SP logs. Exercises on groundwater exploration using remote sensing techniques in conjunction with practicals given for Remote Sensing.

Study of seismic and flood-prone areas in India. Analyses for alkalinity, acidity, pH and conductivity (electrical) in water samples. Classification of ground water for use in drinking, irrigation and Industrial purposes. Presentation of chemical analyses data and plotting chemical classification diagram. Evaluation of environmental impact of air pollution groundwater, landslides, deforestation, cultivation and building construction in specified areas.

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Study of seismic and flood-prone areas in India. Analyses for alkalinity, acidity, pH and conductivity (electrical) in water samples. Classification of ground water for use in drinking, irrigation and Industrial purposes. Presentation of chemical analyses data and plotting chemical classification diagram. Evaluation of environmental impact of air pollution groundwater, landslides, deforestation, cultivation and building construction in specified areas.

Megascopic characterization of banded coals. Proximate analysis of coal. Completion of outcrops in the given maps and calculation of coal reserves. Preparation of polished particulate mounts of coal. Microscopic examination of polished coal pellets (identification of macerals in coal). Megascopic and microscopic study of cores and well cuttings. Study of geological maps and sections of important oilfields of India and world. Calculation of oil reserves.

Study of nature of aerial photographys: resolution, mosaics, symbols, gully pattern and drainage analysis, image parallax. Determination of scale, height, dip, slope, vertical exaggeration and image distortion. Exercises on MSS, TM, FCC, IR, Thermal IR, Radar and SPOT images for geological and geomorphological mapping and in (georesources) vegetation, water and mineral resources evaluation. Making false colour composites, and study of multi-spectral scans and spectral patterns. Exercises on digital image processing. Study of environmental hazards maps.

Introduction to ArcGIS software; map projection; georeferencing- map to image, image to image; shapefile creation; spatial data editing; image digitization; DEM- slope generation, curvature, aspect; false color composite; true color composite; image preprocessing; atmospheric correction; image classification- supervised, unsupervised classification.

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SECOND SEMESTER

THEORY

Paper Code: GEL – 607 (GEODYNAMICS & GEOTECTONICS)

Credits: 4

Full Marks: 100

Course Objectives

1. This course introduces the structure and origin of the Earth within the context of the universe and the solar system, with a focus on its internal constitution, age, and evidence from meteorites and palaeoclimate records.
2. It provides a comprehensive understanding of geophysical properties such as gravity, heat flow, and seismicity, including the study of earthquakes, seismic belts, and instruments like seismographs.
3. The course explores the Earth's magnetic field, paleomagnetism, and the geodynamic processes underlying sea-floor spreading, magnetic reversals, and polar wandering.
4. A strong emphasis is placed on the theory of plate tectonics, the geometry and mechanism of plate motion, and crustal evolution through orogenic and epirogenic processes.
5. Students will investigate the geotectonic history and structural features of major mountain belts and tectonic regions, including the Himalayas, Indo-Myanmar Range, Cordilleras, and Alpines.

Unit-1

25 Marks

Earth in the Universe and Solar System, age of the Earth. Internal constitution and structure of the Earth based on pressure, temperature, density, seismic wave velocity, mineralogical and chemical composition. Meteorites and other extra-terrestrial materials. Paleoclimate: causes and consequences.

Unit-2

25 Marks

Gravity, gravity anomaly and isostasy. Thermal energy and internal heat of the Earth. Thermal gradient, heat flow, source and origin, and structure of the internal heat of the Earth. Seismology, seismic waves and seismotectonics. Seismic intensity, magnitude and seismic belts. Seismographs and seismograms.

Unit-3

20 Marks

Geomagnetism and paleomagnetism: concept, principle and method of study. Polar wandering, sea-floor spreading and polarity reversal. Various tectonic features of mid-oceanic ridges, island arcs, ocean trenches and transform faults.

Unit-4

30 Marks

Plate tectonics: concept, pros and cons, various types of plate margins and their tectonic features. Geometry and mechanism of plate motion, and computing plate motion on spherical earth. Orogenic and epirogenic processes of crustal evolution and mountain building. Geotectonic evolution and features of the North and South American Cordilleras (Rockies and Andes), the Alpines of Europe. Geotectonic evolution of the Indian peninsula, Himalaya and the Indo-Myanmar (Burma) Range.

Course Learning Outcomes

1. By the end of this course, students will be able to explain the Earth's position in the universe and describe its internal structure based on geophysical and geochemical evidence.
2. Understand the principles of gravity, heat flow, and seismology, and analyze data related to seismic waves, magnitude, and tectonic activity.
3. Apply concepts of geomagnetism and paleomagnetism to interpret tectonic processes such as sea-floor spreading, polar wandering, and magnetic reversals.
4. Evaluate the theory of plate tectonics, identify types of plate boundaries, and understand their role in the evolution of Earth's surface features.
5. Interpret the tectonic history and evolution of major global and regional orogenic belts, with a specific focus on the Indian subcontinent and surrounding tectonic provinces.

Books Recommended:

1. Holmes, Arthur (1992): *Principles of Physical Geology*, Vol. 1, Chapman and Hall, London.
2. Leet, L.D. and Judson, S. (1969): *Physical Geology*, Prentice Hall.
3. McBride, N. and Gilmour, I (2003): *An Introduction to the Solar System*, Cambridge Univ. Press.
4. Ruhe, R.V. (1975): *Geomorphology*, Houghton Mifflin Co., Boston.
5. Sparks (1960): *Geomorphology*, Longmans.
6. Moores, E and Twiss, R.J., 1995: *Tectonics*. Freeman.
7. Keary, P. and Vine, F.J, 1990: *Global Tectonics*. Blackwell.
8. Storetvedt, K.N., 1997: *Our Evolving Planet: Earths History in New Perspective*. Bergen (Norway), Alma Mater Forlag.
9. Valdiya, K.S., 1998: *Dynamic Himalaya*. Universities Press, Hyderabad.
10. Summerfield, M.A., 2000: *Geomorphology and Global Tectonics*. Springer Verlag.
11. Fowler, C.M.R., 1990: *The Solid Earth: an Introduction to Global Geophysics*.
12. Lowrie William, 1997: *Fundamentals of Geophysics*
13. Verma, R.K., 1991: *Geodynamics of the Indian Peninsula and the Indian Plate Margin*.

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SECOND SEMESTER

THEORY

Paper Code: GEL – 608 (EXPLORATION GEOLOGY)

Credits: 4

Full Marks: 100

Course Objectives

1. This course introduces the fundamental principles and field techniques used in gravity, magnetic, electrical, and seismic methods of geophysical exploration, emphasizing their applications in mineral, groundwater, and petroleum prospecting.
2. It aims to provide a comprehensive understanding of the theoretical basis of geophysical measurements, data corrections, and interpretation of gravity and magnetic anomaly maps in relation to subsurface structures.
3. The course further develops knowledge of electrical resistivity and seismic survey techniques, including field procedures, data acquisition, processing, and interpretation for solving subsurface geological problems.
4. It also familiarizes students with the concepts and methods of geochemical prospecting, emphasizing the significance of indicator and pathfinder elements, geochemical anomalies, and dispersion patterns in exploration.
5. Finally, the course integrates geological, geophysical, and geochemical data interpretation for locating and evaluating mineral and energy resources, fostering a holistic approach to exploration geoscience.

Unit-1

30 Marks

Variation of gravity over the surface of the earth. Principle of gravimeters. Gravity field surveys. Various types of corrections applied to gravity data. Preparation of gravity anomaly maps and their interpretation in terms of shape size and depth. Geomagnetic field of the earth. Magnetic properties of rocks. Working principle of magnetometers. Field surveys and data reductions. Preparation of magnetic anomaly maps and their quantitative interpretation. Magnetic anomalies due to single pole and dipole. Introduction to Aeromagnetic survey. Three dimensional current flow, potential due to a point current source.

Unit-2

30 Marks

Resistivity method: basic principles, various types of electrode configurations, Field procedure: profiling and sounding. Application of electrical methods in ground water prospecting and civil engineering problems. Seismic methods: fundamental principles of wave propagation, refraction and reflection surveys for single interface, horizontal and dipping cases. Concept of seismic channel and multi-channel recording of seismic data. End-on and split spread shooting techniques. COP method of data acquisition, sorting, gather, stacking and record section. Seismic velocity and interpretation of seismic data. Application in mineral and petroleum exploration. Description of borehole environment. Brief outline of various well-logging techniques. Principles of electrical logging and its application in petroleum, groundwater and mineral exploration.

Unit-3

20 Marks

Controls on localization of ore bodies. Prospecting criteria and guides, and their uses in mineral prospecting. Traditional methods of prospecting – panning, float tracing etc. Fundamentals of exploration. Estimation and classification of ore reserves and resources.

Unit-4

20 Marks

Bases and methods of geochemical prospecting. Indicator and pathfinder elements. Anomalies – background and threshold values. Primary and Secondary dispersions. Pedogeochemical, lithogeochemical, biogeochemical and geobotanical surveys. Heavy mineral prospecting. Uses and appraisal of data.

Course Learning Outcomes

1. Understand the variations in the Earth's gravity and magnetic fields and apply principles of gravimetry and magnetometry in interpreting subsurface geological features.
2. Demonstrate proficiency in conducting field surveys using electrical and seismic methods, analyze data, and interpret subsurface structures for groundwater, mineral, and petroleum exploration.
3. Identify and evaluate the controlling factors for ore localization, and apply prospecting criteria and reserve estimation techniques in mineral exploration.
4. Explain the principles and methodologies of geochemical prospecting, and interpret geochemical data to recognize anomalies, dispersion patterns, and potential mineralization zones.
5. Integrate geophysical and geochemical information for solving real-world exploration problems, thereby developing practical skills essential for environmental, engineering, and resource geoscience applications.

Books Recommended:

1. Sharma, P.V., 1986: *Geophysical Methods in Geology*. Elsevier.
2. Sharma, P.V., 1997: *Environmental and Engineering Geophysics*, Cambridge Univ. Press.
3. Vogelsang, D., 1995: *Environmental Geophysics -A Practical Guide*. Springer Verlag.
4. Dobrin, M.B., 1976: *Introduction to Geophysical Prospecting*. McGraw Hill.
5. Parasnis, D.S., 1975: *Principles of Applied Geophysics*. Chapman and Hall.
6. Stanislave, M., 1984: *Introduction to Applied Geophysics*, Reidel Publ!.
7. Kreiter – *Geological Prospecting and Exploration*
8. Maximov – *Geological prospecting and Exploration*
9. Mckinstry – *Mining Geology*
10. Parks – *Examination & Valuation of Mineral Property*
11. Ginzburg– *Principles of Geochemical Prospecting*
12. Hawkes and Wobb – *Geochemistry in Mineral Exploration*
13. Pacal, Z. (ed), 1977: *Geochemical Prospecting Methods*. Ustrendi
14. Brooks, A.R., 1972: *Geobotany and Biogeochemistry in Mineral Exploration*. Harper & Row.
15. Rose, A.W., Hawkes, H.E. and Webb, J.A., 1979: *Geochemistry in Mineral Exploration*. Academic Press.

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SECOND SEMESTER

Paper Code: **GEL – 609 (ATMOSPHERE, OCEAN & CLIMATE DYNAMICS)**

Credits: 4

Full Marks: 100

Unit 1

30 Marks

Hypsography: Morphology of the ocean floor – continental shelf, slope, rise, abyssal plains. Structure and composition of the atmosphere: Vertical structure, chemical constituents, lapse rate, scale height, geopotential. Physical and chemical properties of seawater: Temperature, salinity, density and spatial variations. Residence time of elements in seawater; conservative vs. non-conservative elements. Carbonate chemistry of seawater: CO₂-carbonate system, alkalinity, pH control, and biological pump. Biological productivity in the oceans.

Unit 2

35 Marks

Ocean circulation: Ocean currents, waves, tides, thermohaline circulation, and the global oceanic conveyor belt. Major water masses and their characteristics. Atmospheric circulation: General circulation, jet streams, monsoons, cyclones and anticyclones. ENSO (El Niño Southern Oscillation), Indian Ocean Dipole (IOD), and their impact on the Indian monsoon. Air-sea interactions on various spatial and temporal scales. Greenhouse gases and global warming. The Keeling Curve and rising atmospheric CO₂. Ocean acidification, deoxygenation, and circulation shifts in a warming climate. Sea level changes and their climatic implications. Marine and atmospheric pollution, ozone layer depletion.

Unit 3

35 Marks

Climate system components: Forcing factors, responses, and feedback mechanisms. Insolation and Earth's heat budget, radiation balance. Cloud formation, precipitation processes, and atmospheric boundary layer. Climate variability: Milankovitch cycles, climatic cyclicality, interplay of tectonics, weathering, and long-term climate evolution. Important climatic events in Earth history. Basics of palaeoclimatology: Natural archives of climate (ice cores, sediments, corals). Proxy interpretation: Isotopic and elemental geochemistry for reconstructing paleoclimate. Applications in identifying past environmental and climatic changes.

Books Recommended:

1. Millero, F. J. (2005). Chemical Oceanography (Vol. 30). CRC press.
2. Lamb, H. H. (2013). Climate: present, past and future (Routledge revivals): volume 2: climatic history and the future. Routledge.
3. Rohli, R.V., and Vega, A.J., 2007. Climatology.
4. Jones and Barlett Lutgens, F., Tarbuck, E., and Tasa, D., 2009. The Atmosphere: An Introduction to Meteorology. Pearson Publisher
5. Aguado, E., and Burt, J., 2009. Understanding weather and Climate. 5th Edition, Pearson Publisher
6. Dorothy Merritts, Kirsten Menking and Andrew deWet, 2014. Environmental Geology: An Earth Systems Science Approach. Edition 2,
7. W.H.Freeman and Co Ltd Paul R. Pinet (2009). Invitation to Oceanography. Jones and Barlett. Edition 5
8. Alan P. Trujillo and Harold V. Thurman, 2011. Essentials of Oceanography. 10th Edition

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Paper Code: GEL – 610
Credits: 6

SECOND SEMESTER
(DISSERTATION)
Full Marks: 150

Course Objectives

1. *This course aims to provide students with the opportunity to conduct independent and original research in a specialized area of Earth Science under the supervision of faculty members.*
2. *It is designed to develop the ability to formulate a clear research question, define objectives, and design an appropriate methodology for addressing the chosen problem.*
3. *The course encourages students to apply theoretical concepts, field techniques, laboratory methods, and computational tools to analyze and interpret scientific data effectively.*
4. *It also emphasizes the development of scientific writing, data presentation, and critical evaluation skills through the preparation of a dissertation report.*
5. *Finally, the course aims to enhance students' oral communication and defense skills by engaging them in a formal presentation and viva-voce examination before a board of examiners.*

Course Learning Outcomes

1. *Formulate a research problem and develop testable hypotheses relevant to the chosen field of specialization in Earth Science.*
2. *Design and execute a research plan incorporating appropriate experimental, field, laboratory, or computational methods.*
3. *Analyze, interpret, and synthesize data using scientific reasoning and suitable analytical or statistical techniques.*
4. *Prepare a comprehensive dissertation that effectively communicates the objectives, methodology, results, and conclusions of the research.*
5. *Demonstrate the ability to present and defend research findings confidently and critically before an academic panel.*
6. *Exhibit professional ethics, responsibility, and independent thinking in conducting and reporting scientific research.*

Dissertation work opted by students in the 4th semester of M. Sc. final year may include an experimental investigation, field work and laboratory studies, a theoretical investigation accompanied by computational work, data processing and analysis, or a combination of these. The exact nature of the project and the problem to be studied shall be decided at the end of the first year by the Head of the department in consultation with the faculty members and students. After the project is completed, the student will submit a dissertation based on the results obtained in his/her investigation/work. Finally, the student is expected to defend his/her findings as embodied in his/her dissertation before a Board of Examiners and take an oral examination. The panel of examiners and scheme of evaluation shall be as follows:

Sl. No.	Evaluation Component	Assessment Parameter/Scope of Assessment	Marks	Total Marks
1	Research Planning and Design	Hypothesis and Selection of Topic	05	15
		Preparation of Synopsis of the Research/Project/Thesis/Dissertation/Field Work/Patent	10	
2	Critical Review and Plan of Work	Introduction and Review of Literature	10	35
		Justification and Likely benefits	05	
		Plan of Work/Methodology	20	
3	Research Execution and Writing	Data Collection, Data Analysis, Data Interpretation, and Originality	20	50
		Presentation of Results, Discussion, Summary, and Conclusion	25	
		Bibliography/References	05	
4	Scholarly Presentation and Evaluation	Seminar with PPT Presentation	25	50
		Viva-Voce by External & Internal Examiners/Supervisor	20	
		Publication in DMU approved Journals/Presentation (oral/poster) at Conference, Seminar, Workshop, etc./Invited Talk/Speech or contribution in public domain	05	
			Total	150

1. Board of Examiners:

- a) Chairman: Head of Department
- b) Expert: External Examiner
- c) Member: Supervisor/Internal Examiner

PRACTICAL (GEL-607 + GEL-608)**SECOND SEMESTER**

Paper Code: **GEL – 611 (GEODYNAMICS & GEOTECTONICS AND EXPLORATION GEOLOGY)**

Credits: 4

Full Marks: 100

Geodynamics & Geotectonics

2 Credits

Course Objective:

- 1. To teach the patterns of continental accretion and breakup of continent and supercontinents*
- 2. To understand the driving mechanisms behind plate tectonics.*
- 3. To calculate and model the brittle and ductile deformation of geologic materials.*
- 4. To determine the geometry of paleomagnetic, plate motion, and fault plane solution.*

Position of Earth in space as given by Titius-Bode's law. Computation of gravity, magnetic, heat flow, and mass, volume and density of different internal layers of the earth on the basis of given data. Preparation of charts and diagrams, and calculations of paleomagnetic data. Computation of plate motion, fault plane solution, etc. Study of various geologic and tectonic features of the Earth, and their presentation in the form of map, charts and diagrams.

Course Learning Outcomes:

After the completion of the course, the students are:

- 1. Able to predict patterns of tectonic movement and their deformation on rocks.*
- 2. Able to understand different internal layers of the earth on the basis of dynamic properties of Earth.*
- 3. Able to prepare and interpret paleomagnetic data in the form of graphical and diagrammatical presentation.*

Exploration Geology

2 Credits

Course Objective:

- 1. To familiarize with the different methods of geophysical investigation in exploration of natural resources.*
- 2. To determine the geometry and depth of covered geological structures including uplifts, subsiding basins, faults, folds, igneous intrusions and salt diapirs using geophysical anomalies.*
- 3. To map the subsurface distribution of stratigraphy and its structure, this can be used to delineate potential hydrocarbon accumulations, both stratigraphic and structural deposits.*
- 4. To produce a treatise on ore deposits focusing on their geochemistry and geological models for a complete understanding of their genesis and guides to their exploration*

Study of gravimeter, magnetometer and seismographs. Resistivity survey. Interpretation of underground structure on the basis of seismic data. Study of prospecting procedures of some important deposits. Study and interpretation of geological maps/mine plans and sections of mineral deposits. Calculation of assay values, ore and mineral reserves from maps and data. Study of geochemical and geophysical anomalies and their interpretation.

Course Learning Outcomes:

After the completion of the course, the students are expected:

1. To directly detect the target style of mineralization, via measuring its physical properties directly.
2. Able to interpret and analysis geophysical and geochemical anomalies and data for potentially economic concentrations of naturally occurring minerals.
3. Able to prepare map of subsurface distribution of stratigraphy and its structure using geophysical and geochemical data.

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SECOND SEMESTER

Paper Code: **GEL- 612**

(FIELD)

Credits: 2

Full Marks: 50

Field Training

Course Objective:

1. To expose the student and familiarize them with the geological setting of the different types of mineral deposits and of various mining methods.
2. To visualise and familiarize with the machineries and equipments used in mining activities.
3. To study tectonic setting and stratigraphic set up of the mining areas.
4. To teach them how to collect samples from the mining area.

Students will carry out studies of different mineral deposits and of various mining methods. Preparation of geological maps and sections of the mineral deposits etc. Geological study of some stratigraphic type areas. Visits to important Geological Organizations and related institutions. Students shall submit a detailed field report based on the field work.

Course Learning Outcomes:

After the completion of the course, the students are expected:

1. To learn and would able to identified how ore and minerals are deposited on the crust of the Earth and their associated geological structure.
2. To prepare and interpret the geological section of the mining area.
3. To learn and understand different process in mining industries.
4. Able to recognize and understand the application and need of geologist in mining industries.

1. Board of Examiners:

- a) Chairman: Head of Department
- b) Expert: External Examiner
- c) Member: Supervisor/Internal Examiner

2. Evaluation Scheme:

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| a) Contents, Presentation and Contribution | 50% |
| b) Field work / Laboratory work | 30% |
| c) Viva-voce | 20% |

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L. Debala Devi
22/9/26.