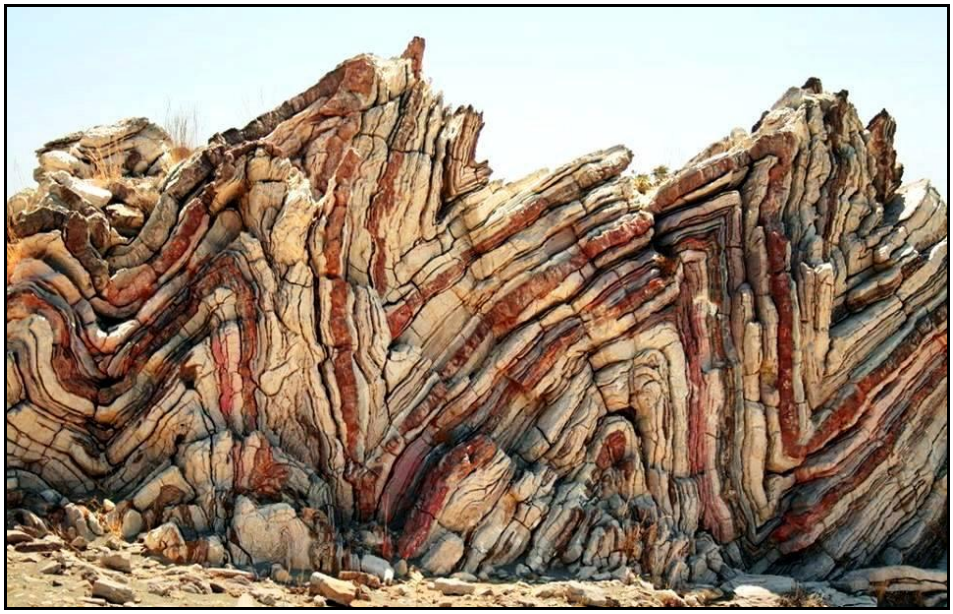
DHANAMANJURI UNIVERSITY
IMPHAL, MANIPUR

MASTER OF SCIENCE IN GEOLOGY
(Two Years Full Time Programme)



DEPARTMENT OF GEOLOGY
School of Human and Environmental Sciences
D. M. COLLEGE OF SCIENCE, D. M. UNIVERSITY
Imphal – 795001, Manipur.
2023

M. Sc. 1ST SEMESTER
THEORY PAPERS & PRACTICAL PAPERS:

Paper Code	*Paper Title*	*Internal Assessment*	*End Semester Assessment*	**Total Marks**	*No. of Credits*
GEL – 501	Structural Geology	**20**	**80**	**100**	**4**
GEL – 502	Crystallography & Mineralogy	**20**	**80**	**100**	**4**
GEL – 503	Palaeontology	**20**	**80**	**100**	**4**
GEL – 504	Principles of Stratigraphy & Indian Stratigraphy	**20**	**80**	**100**	**4**
GEL – 505	Practical related to **GEL – 501 & GEL- 502**			**100**	**4**
GEL – 506	Practical related to **GEL – 503 & GEL- 504**			**100**	**4**
	Total	**80**	**520**	**600**	**24**

Total Marks of First Semester = 600 **Total Credits = 24**

M. Sc. 2ND SEMESTER
THEORY PAPERS & PRACTICAL PAPERS:

Paper Code	*Paper Title*	*Internal Assessment*	*End Semester Assessment*	**Total Marks**	*No. of Credits*
GEL – 507	Igneous & Metamorphic Petrology	**20**	**80**	**100**	**4**
GEL – 508	Geochemistry & Thermodynamics	**20**	**80**	**100**	**4**
GEL – 509	Sedimentology	**20**	**80**	**100**	**4**
GEL – 510	Geomorphology & Quaternary Geology	**20**	**80**	**100**	**4**
OPE – 014 **OPE-OPEN ELECTIVE PAPER**	Natural Hazards & Disaster Management	**20**	**80**	**100**	**4**
GEL – 511	Practical related to **GEL – 507 & GEL- 508**		**100**	**100**	**4**
GEL – 512	Practical related to **GEL – 509 & GEL- 510 + Field Work**		**100**	**100**	**4**
	Total	**100**	**600**	**700**	**28**

Total Marks of Second Semester = 700 **Total Credits = 28**

M. Sc. 3RD SEMESTER
THEORY PAPERS & PRACTICAL PAPERS:

Paper Code	*Paper Title*	*Internal Assessment*	*End Semester Assessment*	**Total Marks**	*No. of Credits*
GEL – 613	Economic Geology, Mineral Economics & Mining Geology	**20**	**80**	**100**	**4**
GEL – 614	Geo-Engineering and Hydrogeology	**20**	**80**	**100**	**4**
GEL – 615	Fuel and Environmental Geology	**20**	**80**	**100**	**4**
GEL – 616	Remote Sensing and Application of GIS	**20**	**80**	**100**	**4**
GEL – 617	Practical related to **GEL – 613 & GEL- 614**			**100**	**4**
GEL – 618	Practical related to **GEL – 615 & GEL- 616**			**100**	**4**
	Total	**80**	**520**	**600**	**24**

Total Marks of Third Semester = 600 **Total Credits = 24**

M. Sc. 4TH SEMESTER
THEORY PAPERS & PRACTICAL PAPERS:

Paper Code	*Paper Title*	*Internal Assessment*	*End Semester Assessment*	**Total Marks**	*No. of Credits*
GEL – 619	Geodynamics & Geotectonics	**20**	**80**	**100**	**4**
GEL – 620	Exploration Geology	**20**	**80**	**100**	**4**
GEL – 621	Atmosphere, Ocean & Climate Dynamics	**20**	**80**	**100**	**4**
GEL – 622	**Dissertation**			**150**	**6**
GEL – 623	Practical related to **GEL – 619 & GEL- 620**			**100**	**4**
GEL – 624	**Field Work**			**50**	**2**
	Total	**60**	**540**	**600**	**24**

Total Marks of F0urth Semester = 600 **Total Credits = 24**

DETAILED CONTENTS OF M.Sc. COURSE IN GEOLOGY PAPERS

FIRST SEMESTER

THEORY

(a). Paper Code: **GEl – 501 (STRUCTURAL GEOLOGY)**

Credits: 4 Full Marks: 100

Course Objectives:

1. To teach the stress field that resulted in the observed strain and geometries in order to understand the dynamics of the stress field, which can be linked to important events in the regional geologic past.
2. To teach the three-dimensional distribution of rock units with respect to their deformational histories.
3. To provide the ideas of the importance of structural geology in the economic, petroleum, and mining industries.
4. To teach the architecture of the solid Earth and other planets.

Course Learning Outcomes:

After the completion of the course, the students are:

1. Able to think about the 3D distribution and their geometries during the deformation of rocks.
2. Able to analyze and describe the 3D structures and microstructures resulting from the deformation of the Earth's crust.
3. Able to link the theoretical studies to the field.
4. Able to identify the geological event that occurred in the past.
5. Able to interact with a large range of geoscientists over a wide range of geological and environmental problems

Unit-1 25 marks

Stress and analysis of stress in two and three dimension. Plane stress analysis and Mohr stress circle, and its relationship with faulting and fracture mechanics. Mechanical principle, properties of rocks and their controlling factors. Theory of rock failure: brittle failure – shear and tensile failures. Role of fluid pressure and effective pressure in brittle failure. Strain and analysis of strain – finite and infinitesimal, homogeneous and inhomogeneous strains. General transformations and graphic representation of two and three dimensional strains. Strain and deformation paths. Determination of strain in naturally deformed rocks.

Unit-2 25 marks

Description and geometric classification of folds. Mechanisms and mechanics of folding and buckling. Buckling of single layer, multilayer and anisotropic materials. Fold development and distribution of strain in folds. Analysis and interpretation of superimposed folding. Fault bent folds, gravity induced structures and salt diapirs.

Unit-3 **25 marks**

Description and classification of faults and joints. Mechanics of faulting and jointing, and stress conditions for thrust, normal and strike-slip faults. Mechanics and geometric aspects of thrust, normal and strike-slip faults, and associated structural features. Use of faults in estimating crustal stretching and shortening. Concept of balanced section. Analysis of joints with reference to major structures and paleostress studies.

Unit-4 **25 marks**

Planar and linear fabrics (Foliation and Lineation): description, classification, genesis and significance. Petrofabric analysis: concept, preferred orientation developed under various geologic conditions. Study and interpretation of petrofabric data, use of universal stage. Stereographic and equal area projections for fabric data, π, β and contour diagrams. Nondiastrophic structures: significance in the study and analysis of deformed rocks.

Books Recommended:

1. Badgley, P.C., 1965: ***Structural Methods for Exploration Geologists***. Harper and Row.
2. Ramsay, J.G., 1967: ***Folding and Fracturing of Rocks***. McGraw Hill.
3. Hobbs, B.E., Means, W.O. and Williams, P.F., 1976: ***An Outline of Structural Geology,*** John Wiley.
4. Davis, G.R., 1984: ***Structural Geology of Rocks and Region***. John Wiley.
5. Ramsay, J.G. and Huber, M.I., 1987: ***Modern Structural Geology, Vol. I & II***. Academic Press.
6. Price, N.J. and Cosgrove, J.W., 1990: ***Analysis of Geological Structure***. Cambridge Univ. Press.
7. Bayly B., 1992: ***Mechanics in Structural Geology***. Springer Verlag.
8. Ghosh S.K., 1995: ***Structural Geology: Fundamentals of Modern Developments***. Pergamon Press.
9. Twiss, R.J. and Moores, E., 1992: ***Structural Geology***.
10. Park, R.G., 1989***: Foundation of Structural Geology***.
11. Billings, M.P: ***Structural Geology***.
12. Suppe, John: ***Principles of Structural Geology***.

……..

THEORY **FIRST SEMESTER**

(b). Paper Code: **GEL – 502 (CRYSTALLOGRAPHY & MINERALOGY)**

Credits: 4 **Full Marks: 100**

Course Objectives:

1. To learn about the structure and chemical makeup of Earth materials, focusing on the physical and chemical properties of minerals.
2. To understand the different rock-forming minerals and perceive their implications.
3. Comprehension of the optical behavior of minerals.

Course learning outcomes:

After studying this course, one should be able to:

1. Describe and recognize, giving examples, various physical properties of minerals, including lustre, cleavage, hardness, and density
2. Describe, giving mineral examples, the main differences between metallic, ionic, and covalent structures and their type of bonding
3. Explain the significance of various types of defects in crystals
4. Explain the meaning of the terms lattice, unit cell, reflections, and rotational symmetry, and how these relate to crystal systems.
5. Give, with an appropriate example, the meaning of the terms phase, phase boundary, and phase transformation, and interpret stability fields in terms of pressures and/or temperatures using a phase diagram

Crystallography:

Unit-1 **40 marks**

Crystallography and its importance in mineralogy. Introduction to 32 crystal classes of symmetry, description of holosymmetric class of various crystal systems, international system of crystallographic notation; Different types of crystal projections-spherical and stereographic, and their uses. Symmetry of internal structures – concept of point group, space group, Bravais lattices and lattice defects; Twinning and twin laws, common types of twins and their examples in minerals; Liquid crystals and their applications.

Development of X-ray crystallography and Bragg's equation, powder method in X-Ray crystallography; Electron probe micro analysis and scanning electron microscopy - principle, application and their utility in mineral sciences; Introduction to ion microprobe analysis and infra-red spectroscopy; Introduction to mineral formulae calculation of important rock forming minerals.

Mineralogy:

Unit-2 **15 marks**

Introduction to crystal chemistry, bonding in minerals, radius ratio, co-ordination number, solid solution, exsolution, polymorphism, isomorphism, pseudomorphism; Pauling's rules governing the ionic structures.

Unit-3 **25 marks**

A detailed study of following mineral groups with reference to their general formulae,

classification, atomic structure, chemistry, experimental work with special references to P-T stability and mode of occurrence and paragenesis:

a) Nesosilicates - Olivine group; Garnet group; Aluminosilicate group (kyanite, andalusite and sillimanite).
b) Cyclosilicates - Beryl
c) Inosilicates - Pyroxene group; Amphibole group.
d) Phyllosilicates - Kaolinite group; Serpentine group; Pyrophyllite, talc; Mica group; Chlorite group.
e) Tektosilicates - Feldspar group; Cordierite.
f) Sulfides, Halides, Sulfo-salts, Oxides, Hydroxides, and Carbonates

Optical Mineralogy:

Unit-4 **20 marks**

Nature of light, Polarisation, Double refraction, Nicol prism, Isotropic, uniaxial and biaxial indicatrices, Extinction: nature and types, Pleochroism and pleochroic schemes. Interference colors and interference figures, Determination of optic sign of uniaxial and biaxial minerals, optic angle (2V).

Books Recommended:

1. Berry, L.G., Mason, B. and Dietrich, R.V. (1982): ***Mineralogy,*** CBS Publ.
2. Dana, E.S. and Ford, W.E. (2002): ***A Textbook of Mineralogy (Reprint).***
3. Kerr, P.F. (1977): ***Optical Mineralogy***, McGraw Hill.
4. Moorhouse, W.W. (1951): ***Optical Mineralogy***, Harper and row Publ.
5. Nesse, D.W. (1986): ***Optical Mineralogy***, McGraw Hill.
6. Perkins, D. (1998): ***Mineralogy***, Prentice Hall.
7. Phillips, F.C (1971): ***Introduction to Crystallography***, Longman Group Publ.
8. Winchell, E.N. (1951): ***Elements of Optical Mineralogy***, Wiley Eastern.
9. Deer, W.A., Howie, A.A. and Zussman, J., 1996: ***The Rock Forming Minerals***. Longman.
10. Klein, C. and Hurlbut, Jr., C.S., 1993: ***Manual of Mineralogy***. John Wiley.
11. Putnis, Andrew, 1992: ***Introduction to Mineral Sciences***. Cambridge University Press.
12. Spear, F.S. 1993: ***Mineralogical Phase Equilibria and Pressure -Temperature-Time Paths***. Mineralogical Society of America Publ.
13. Phillips, Wm, A. and Griffen, D.T., 1986: ***Optical Mineralogy***, CBS Edition.
14. Hutchinson, C.S., 1974: ***Laboratory Handbook of Petrographic Techniques***. John Wiley.

……..

PRACTICAL (GEL-501 + GEL-502) **FIRST SEMESTER**
Paper Code: **GEL – 505 (STRUCTURAL GEOLOGY, CRYSTALLOGRAPHY & MINERALOGY) Credits: 4 Full Marks: 100**

STRUCTURAL GEOLOGY:

Preparation and interpretation of geological maps and sections.

Structural problems concerning economic mineral deposits.

Recording and plotting of field data, and construction of a traverse map.

Problems on stereographic and orthographic projections.

Plotting and interpretation of petrofabric data and resultant diagrams: π, β and contour diagrams.

Determination of stress and strain in deformed rocks, based on given data.

Construction of balanced sections.

CRYSTALLOGRAPHY & MINERALOGY

Identification and sketching of symmetry elements (planes, axes, centers) in given crystal models. Determination of crystal class and system from crystal models (Cubic, Tetragonal, Orthorhombic, Hexagonal, Trigonal, Monoclinic, Triclinic). Preparation of crystal projection diagrams for selected crystal forms (e.g., cube, octahedron, prism, pyramid). Construction of stereographic and spherical projections for given crystal forms. Interpretation of pole plots and symmetry elements using the stereographic net. Demonstration of projection methods using modern software (optional digital component). Identification and sketching of common twins in minerals (e.g., Carlsbad, Albite, Spinel, and Contact twins). Construction of Axial Ratio of Cubic System. Clinographic Projection of crystal models belonging to normal classes.

To find out the chemical formula from the given chemical data and name.

Study of important rock forming minerals with reference to their diagnostic physical properties. Determination of pleochroic scheme of certain minerals, extinction angle and birefringence of minerals using accessory plates. Interference figures and determination of optic signs of uniaxial and biaxial minerals. Determination of optic axial angle - 2V of important minerals.

Identification of important rock-forming minerals in thin section using diagnostic optical properties. Identification of minerals and calculation of cell parameters using XRD data.

……

FIRST SEMESTER

THEORY

(a). Paper Code: **GEL – 503 (PALAEONTOLOGY)**

Credits: 4 **Full Marks: 100**

Course Objectives:

1. To show how life, landscapes, and climate have changed over time and how living things responded to those changes.
2. Identification and classification of body or trace fossils which provides a list of ancient plants and animals that lived in a particular place in particular geological time period.
3. To provide knowledge of past life to develop new concepts and principles of evolution and ecology and perhaps even develop new theories about how our world has changed over time.
4. To determine depositional environment and hydrocarbon evolution.
5. To describe the world's past biodiversity: all of the micro-organisms, plants and animals that have existed since the origin of life.

Course Learning Outcomes:

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

1. Understand the uses of fossils found in the rock in order to find out the evolutionary history of different organism groups.
2. Examine the information for consistencies and similarities that reveal the processes of evolution and ecology that have governed the pattern of life's history
3. Develop temporal maps and scenarios of the changes that have taken place in ecological communities.
4. Interpret the habits and adaptive features of past plants and animals and their ecological roles within ancient communities.
5. Learn how climate change has effected past organisms as well as how organisms have changed the physical world.

Unit-1 **25 marks**

General principles of palaeontology: Origin of life through time and space; Nomenclature of organisms; Organic evolution-Punctuated equilibrium and Phyletic gradualism models. Trace fossils, their classification and palaeo-environmental significance. Oxygen and carbon stable isotopes studies of microfossils and their use in palaeoclimate interpretation. Biodiversity and mass extinction events. Evidence of life in Precambrian times.

Unit-2 **25 marks**

Invertebrate Palaeontology: Functional morphology, classification, evolutionary trends and distribution of Bivalves, Cephalopoda and Gastropods, Echinoids, Trilobites and Brachiopods. Vertebrate Palaeontology: Brief study of vertebrate life through ages. Mesozoic reptiles and Evolution of Man; Vertebrate fossil records of Siwaliks.

Unit-3 **25 marks**

Micro-Palaeontoloy:

Calcareous microfossils: Classification, morphology and palaeoecological significance of Foraminifers, Ostracods and Conodonts. Morphology and application of Calcareous

nannoplankton and Calcareous algae. *Siliceous microfossils*: Morphology, classification and biogeography of Radiolarians. *Phosphatic microfossils*: Classification, morphology and palaeoecological significance of
Conodonts.

Unit-4 **25 marks**

Organic-Walled microfossils: Morphology and application of fossil pollen and spores. Morphology, Environmental application and stratigraphic significance of Dinoflagellate cysts. *Type of Organic matters:* Palynofacies and its application in palaeoenvironment interpretation. *Application of microfossils:* Application of micropaleontology in hydrocarbon exploration.

Books Recommended:

1. Clarkson, E.N.K., 1998: ***Invertebrate Palaeontology and Evolution***. IV Ed. Blackwell.
2. Stearn, C.W. & Carroll, R.L., 1989: ***Palaeontology -the Record of Life***. John Wiley.
3. Smith, A.B., 1994: ***Systematics and the Fossils Record-Documenting Evolutionary Patterns***. Blackwell.
4. Prothero, D.R., 1998: ***Bringing Fossils to Life -An Introduction to Palaeobiology***. McGraw Hill.
5. Pomerol, C., 1982: ***The Cenozoic Era: Tertiary and Quaternary***. Ellis Harwood Ltd.
6. Bignot, G. (1985). ***Elements of Micropalaeontology***. Graham&Trotman, Paris.
7. Kethal, P.K. (1998). ***Microfossils and Their Applications.*** CBS Publishers & Distributors.
8. Jones, R.W. (1998). ***Micropalaeontology in Petroleum Exploration***. Oxford University Press.
9. Brooks, J. (1981). ***Organic Maturation Studies and Fossil Fuel Exploration***. Academic Press.
10. Traverse, A. (1994) ***Sedimentation of Organic Particles***. Cambridge University Press.
11. Foote, M & Miller, A.I. (2001). ***Principles of Palaeontology***. W.H. Freeman & Company.
12. Doyle, P. (2002). ***Understanding fossils an Introduction to Invertebrate Palaeontology.*** Wiley
13. Jones, R.W. (2006). ***Applied Palaeontology***. Cambridge University Press.
14. Brasier, M.D. (1980). ***Microfossils***. Unwin Hyman, London.
15. Traverse, A (2007). ***Palaeopalynology***. Springer.
16. Haslett, S.K. (2002). ***Quaternary Environmental Micropalaeontology***. Arnold.
17. Ray, A.K. (2008). ***Fossils in Earth Sciences***. Prentice Hall of India Private Limited, New Delhi.
18. Skelton, P.W., Spicer, R.A., Keller, S.P. and Gilmour, L. (2003). ***The Cretaceous World***. Cambridge University Press.
19. Billal U. Haq and Anne Boersma (1998). ***Introduction to Marine Micropalaeontology.*** Elsevier.
20. Fensome, R.A., Taylor, F.J.R., Norris, G., Sarjeant, W.A.S., Wharton, D.I. and Williams, G.L. 1993. ***A Classification of Fossil and Living Dinoflagellates. Micropalaeontology*** Press Special Paper, 7: 351p.
21. Tyson, R.V. (1995). ***Sedimentary organic matter.*** Chapman and Hall.
22. Benton, M.J. 2008. ***Introduction to Paleobiology and the Fossil Record***.Wiley-Blackwell.

……..

FIRST SEMESTER

THEORY

(a). Paper Code: **GEL – 504 (PRINCIPLE OF STRATIGRAPHY & INDIAN STRATIGRAPHY)**

Credits: 4 Full Marks: 100

Course Objectives

1. This course introduces the fundamental principles and methodologies of stratigraphy, emphasizing the controls on the development of stratigraphic records and the application of standard stratigraphic nomenclature.
2. It provides an in-depth understanding of lithostratigraphic, biostratigraphic, and chronostratigraphic codes, including global standards such as the Global Boundary Stratotype Sections and Points (GSSP).
3. The course emphasizes various correlation techniques such as chemostratigraphy, magnetostratigraphy, event, seismic, cyclo-, and sequence stratigraphy to interpret geological records.
4. It focuses on understanding the stratigraphic framework of India, including the major Precambrian cratons and Proterozoic basins, as well as the Palaeozoic, Mesozoic, and Cenozoic successions.
5. Students will also explore significant stratigraphic boundary problems in Indian geology and their implications for Earth's geological history and palaeogeographic reconstruction.

Course Learning Outcomes

1. By the end of this course, students should have a clear understanding of the principles and classification systems used in modern stratigraphy and their applications in geological correlation and basin analysis.
2. Be able to apply various stratigraphic techniques—such as lithostratigraphic, biostratigraphic, chronostratigraphic, and chemostratigraphic methods—for interpreting and correlating sedimentary successions.
3. Demonstrate a sound knowledge of the major Precambrian, Palaeozoic, Mesozoic, and Cenozoic stratigraphic successions of India, including their lithological, palaeontological, and tectonic characteristics.
4. Understand the role of sequence, event, and magnetostratigraphy in reconstructing Earth's geologic and palaeogeographic history.
5. Critically evaluate stratigraphic boundary problems within the Indian geological framework (e.g., Archaean–Proterozoic, Cretaceous–Tertiary, and Paleogene–Neogene boundaries) using integrated geological and geochronological data.

Principles of Stratigraphy:

Unit-1 **25 marks**

Controls on the development of stratigraphic records; Code of stratigraphic nomenclature; Study of standard stratigraphic code (Lithostratigraphic, Biostratigraphic, Chronostratigraphic and Geochronology); Global Boundary Stratotype Sections and Points (GSSP). Stratigraphic correlations including Shaw's Graphic; Chemostratigraphic correlation; Concept of Magnetostratigraphy, event stratigraphy, seismic stratigraphy, cyclostratigraphy and sequence stratigraphy; Concept of Strontium isotope stratigraphy and palaeogeography.

Indian Stratigraphy:

Unit-2: Precambrian stratigraphy **25 marks**

Precambrian of Rajasthan, Dharwar craton, Eastern Ghat belt and Singbhum-Orissa belt; Proterozoic stratigraphy of Vindhyan, Cuddapah and Kurnool basins.

Unit-3: Marine Palaeozoic and Gondawana stratigraphy **20 marks**

Stratigraphy, facies, and fossil contents of the Palaeozoic rock formations of Himalaya. Classification, fauna, flora and age limits of Gondwana Supergroup and palaeoclimate.

Unit-4: Mesozoic and Cenozoic Stratigraphy **30 marks**

Triassic of Spiti; Jurassic of Kutch; Cretaceous of Trichinopoly; Bagh and Lameta Groups; Himalayan Palaeogene and Neogene Successions; Tertiary deposits of Assam and its equivalent in North East India (Manipur, Nagaland, Mizoram, Meghalaya, Arunachal Pradesh and Tripura); Brief study of Quaternary stratigraphy of India.

Stratigraphic boundary problems in Indian geology (Archaean-Proterozoic, Precambrian-Cambrian, Permian-Triassic, Jurassic-Cretaceous Cretaceous-Tertiary, Paleogene-Neogene)

Books Recommended:

1. Pomerol, C., 1982: ***The Cenozoic Era: Tertiary and Quaternary***. Ellis Harwood Ltd.
2. Goodwin, A.M., 1991***: Precambrian Geology: The Dynamic Evolution of Continental Crust.*** Academic Press.
3. Boggs, Sam Jr., 1995: ***Principles of Sedimentology and Stratigraphy***, Prentice Hall
4. Doyle, P. and Bennett, M.R., 1996: ***Unlocking the Stratigraphic Record***. John Wiley.
5. Brenner, R.E. and McHargue, T.R., 1988: ***Integrative Stratigraphy: Concepts and Applications***. Prentice Hall.
6. Naqvi, S.M. and Rogers, J.J.W., 1987: ***Precambrian Geology of India***, Oxford Univ. Press.
7. Pascoe, E.H., 1968. ***A Manual of Geology of India and Burma***, Vol. I-IV, Govt. of India Press.
8. Krishnan, M.S. ***Geology and India and Burma***
9. Kumar, R. ***Fundamental of Historical Geology and Stratigraphy of India***
10. Wadia, D.N. Geology of India
11. GSI Miscellaneous Publication: ***Indian Committee on Stratigraphic Nomenclature of India.***
12. Ramakrishnan, M and Vaidyanadhan, R (2008). ***Geology of India***. GSI, Banglore, Vol. 1&2.
13. Prothero, D.R. and Schwab, F (1996). ***Sedimentary Geology: An introduction to Sedimentary Rocks and Stratigraphy***. W.H. Freeman.
14. GSI (1990) ***Stratigraphic Boundary Problem in India***. Geological Society of India, Memoir-16.
15. Brookfield, M.E. (2004) ***Principles of Stratigraphy***. Blackwell.
16. Lele, K.M. (1976). ***Palaeoclimatic implications of Gondwanafloras. Geophytology*** 6(2): 207- 229.
17. D.Q. Bowen (1983). ***Quaternary Geology***.Pergamon Press.
18. Gunter Faure and Teresa M. Mensing ***Isotopes-Principal and Application***. Third Edition, Wiley.

…….

PRACTICAL (GEL-504 + GEL-505) **FIRST SEMESTER**

Paper Code**: GEL – 506 (PALAEONTOLOGY AND PRINCIPLE OF STRATIGRAPHY & INDIAN STRATIGRAPHY)**

Credits: 4 **Full Marks: 100**

PALAEONTOLOGY:

Recognition of fossil groups in an assorted assemblage and their identification.

Study of important fossils from Indian Stratigraphic horizons.

Techniques of separation of microfossils and spore and pollen grains from matrix.

Study of morphological features, systematic classification and stratigraphic age of Mollusks, Brachiopods, Echinoderma and Trilobites.

Identification of important calcareous, siliceous, phosphatic and organic walled microfossils, plant fossils and vertebrate fossils.

STRATIGRAPHY:

Study of rocks in hand specimens from known Indian stratigraphic horizons and type localities and Order of Superposition;

Exercises on stratigraphic classification and correlation.

Study of palaeogeographic maps of important geological periods.

……..

SECOND SEMESTER

THEORY

(a). Paper Code: **GEL – 507 (IGNEOUS & METAMORPHIC PETROLOGY)**

Credits: 4 **Full Marks: 100**

Course Objectives

1. This course introduces the fundamental principles of igneous and metamorphic petrology with emphasis on phase equilibria, magma genesis, and metamorphic processes operating within the Earth's crust and mantle.
2. It provides a comprehensive understanding of phase rule applications to unary, binary, and ternary systems, and their relations to crystallization and melting processes in the light of modern experimental petrology.
3. The course emphasizes the interpretation of igneous textures, magma chemistry, and mechanisms of partial melting, fractional crystallization, and magma evolution in various tectonic settings.
4. It focuses on the classification, mineralogy, and petrogenesis of major igneous and metamorphic rock types, including Indian examples and their tectonic associations.
5. The course also introduces the concept of metamorphic facies, reactions, and pressure–temperature (P–T) relationships in understanding the evolution of metamorphic terrains and crustal processes.

Course Learning Outcomes

1. By the end of this course, students should have a clear understanding of the processes governing the generation, evolution, and crystallization of magmas, as well as the principles underlying phase equilibria in igneous systems.
2. Be able to identify and classify igneous and metamorphic rocks using mineralogical, textural, and chemical criteria, and interpret their petrogenesis with reference to plate tectonic settings.
3. Understand the role of pressure, temperature, fluids, and bulk composition in metamorphic transformations and facies development, and interpret metamorphic P–T–t paths in relation to crustal evolution.
4. Apply thermodynamic and experimental data to explain magma formation, metamorphic reactions, and the origin of migmatites and ultrahigh-pressure/temperature assemblages.
5. Demonstrate competence in using phase diagrams, petrogenetic grids, and reaction isograds for interpreting the evolution of igneous and metamorphic rocks in regional and global geological contexts.

Igneous Petrology:

Unit-1 **30 marks**

Plate tectonics and generation of magmas; Phase rule and phase equiliba study of uninary (SiO_2, etc.) and binary systems (Ab-An, Ab-Or, Di-An, Fo-Si) and their relations to magma genesis and crystallization in the light of modern experimental works.

Phase equilibria study of Ternary systems (Di-Ab-An, Di-Fo-Si, Di-Fo-An, Ne-Ks-Si, Fo-An-Si) and their relations to magma genesis and crystallization in the light of modern experimental works; Effects of fluids/volatiles on melt equilibria. Interpretation of igneous textures in terms of rate of nucleation and crystal growth. Chemical compositions and physical properties of magmas. Mechanisms of partial melting and magma generation in the Earth, fractional and batch melting.

Unit-2 **20 marks**

IUGS classification of the igneous rocks and CIPW norm; Petrology and petrogenesis of major igneous rock types with Indian examples; basalt, andesite, granite, rhyolite, alkaline rocks: carbonatite, lamprophyre, lamproite, and kimberlite, anorthosite, ultramafic, komatiite, ophiolite, bornite.

Metamorphic Petrology:

Unit-3 **20 marks**

Concept of metamorphism and role of pressure, temperature and other factors in metamorphism. Protolith types and characteristic metamorphic, Nature of metamorphic reactions; Concept of metamorphic facies and facies series; Different type of metamorphism; Introduction to ultrahigh temperature and ultrahigh pressure metamorphism.

Unit-4 **30 marks**

Metamorphic facies: description of each facies of low, medium to high pressure and very high pressure with special reference to characteristic minerals and P/T conditions, subdivision into zones/subfacies, mineral assemblages; Metamorphic reactions and pressure – temperature conditions of metamorphism.

Isograds and reaction isograds; Schrienemakers rule and construction of petrogenetic grids; Metamorphic differentiation, anatexis and origin of migmatites in the light of experimental studies; Regional metamorphism and paired metamorphic belts with reference to the theory of plate tectonics; Pressure – temperature – time paths.

Books Recommended:

1. Turner, F.J. 1980: ***Metamorphic Petrology***, McGraw Hill, New York.
2. Yardley, B. W. 1989: ***An Introduction to Metamorphic Petrology***. Longman New York.
3. Bucher, K. and Frey, M. 1994: ***Petrogenesis of Metamorphic Rocks***, Springer -Verlag.
4. Blatt, H. and Tracy, R.J. (1996): ***Petrology (Igneous, Sedimentary, Metamorphic)***, W.H. Freeman and Co., NewYork.
5. Philpotts, A.R. (1994): ***Principles of Igneous and Metamorphic Petrology***, Prentice Hall.
6. Spry, A. (1976): ***Metamorphic Textures***, Pergamon Press.
7. Winter, J.D. (2001): ***An introduction to Igneous and Metamorphic Petrology***, Prentice Hall.
8. Wood, B.J. and Fraser, D.G. (1976): ***Elementary Thermodynamics for Geologists***, Oxford University Press, London.
9. Yardley, B.W.D., Mackenzie, W.S. and Guilford, C. (1995): ***Atlas of Metamorphic Rocks and their textures***, Longman Scientific and Technical, England.
10. Best,M.G., 1986: ***Igneous Petrology***, CBS Publ.
11. McBirney, A.A., 1993: ***Igneous Petrology***. Jones &Bartlet Publ.
12. Kretz, A., 1994: ***Metamorphic Crystallization***, John Wiley.
13. Bose, M.K., 1997; ***Igneous Petrology***. World Press.

…….

SECOND SEMESTER

THEORY

(a). Paper Code: **GEL – 508 (GEOCHEMISTRY & THERMODYNAMICS)**

Credits: 4 **Full Marks: 100**

Course Objectives

1. This course introduces the fundamental principles of modern geochemistry, focusing on the atomic structure, distribution, and behavior of elements within the Earth and the Solar System.
2. It provides a comprehensive understanding of nucleosynthesis, geochemical classification of elements, and the isotopic systems used for determining the age and evolution of the Earth's crust, mantle, and core.
3. The course emphasizes the role of stable and radiogenic isotopes in tracing geological, environmental, and biological processes, as well as understanding fluid–rock interactions and elemental cycling.
4. It also introduces the basic principles of thermodynamics as applied to geological systems, covering energy transformations, equilibrium relations, and the thermodynamic basis of mineral stability.
5. Students will learn to apply thermodynamic and geochemical principles to interpret natural processes, including magma formation, metamorphism, weathering, and global biogeochemical cycles.

Course Learning Outcomes

1. By the end of this course, students will have a sound understanding of the atomic and isotopic foundations of geochemistry, the distribution of elements in the Earth and Solar System, and the processes that control their mobility and fractionation.
2. Be able to apply geochemical and isotopic principles to radiometric dating, elemental partitioning, and thermodynamic equilibrium problems in mineralogical and petrological systems.
3. Understand and utilize thermodynamic laws and parameters—such as Gibbs free energy, entropy, and equilibrium constants—to analyze phase relations and reaction equilibria in rocks and minerals.
4. Interpret Eh–pH diagrams, phase rule applications, and stability fields of minerals using thermodynamic and experimental data.
5. Develop the ability to integrate geochemical and thermodynamic approaches for solving problems related to the Earth's formation, crustal evolution, and environmentally relevant geochemical processes.

GEOCHEMISTRY:

Unit-1 **30 marks**

Structure and atomic properties of elements, the Periodic Table and special properties of transition and rare earth elements. Origin and components of the universe. Abundance and distribution of elements in the Solar system and its various components. Origin of elements: Nucleosynthesis and stellar evolution. Geochemical classification of elements. Composition and evolution of the crust, mantle and core. Age of the Earth. Radiogenic isotopes. Radioactive decay schemes of U-Pb, Sm-Nd, Rb-Sr, K-Ar, and growth of daughter isotopes. Radiometric dating of single minerals and whole rocks. Stable isotopes: nature, abundance, and fractionation. Fluid interactions and biological processes.

Unit-2 **25 marks**

Principles of ionic substitution in minerals; element partitioning in mineral/rock formation and concept of simple distribution coefficients and exchange reaction distribution coefficients; element partitioning in mineral assemblages and its use in the pressure-temperature estimation. Redox reactions and mineral stability in Eh-pH diagram. Rock weathering and soil formation. Elemental mobility in surface environment. Concept of geochemical-biogeochemical cycling and global climate.

THERMODYNAMICS:

Unit-3 **25 marks**

Laws of thermodynamics; Gibb's free energy, entropy; □G of metamorphic reactions (solid-solid and dehydration reactions); Clausius- Clapeyron equation; Geothermometry, geobarometry. Phase rule and application in mineral equilibrium studies.

Unit-4 **20 marks**

Fugacity and activity; Raoult's law and Henry's law; ideal and non-ideal solutions; equilibrium constant, Application of thermodynamics in mineralogical and petrological studies. Computation of stability fields of minerals and rocks using thermodynamic data, and comparison with experimental data.

Books Recommended:

1. Powell, R. (1978): ***Equilibrium thermodynamics in Petrology: An Introduction***, Harper and Row Publ., London.
2. Rastogy, R.P. and Mishra, R.R. (1993): ***An Introduction to Chemical Thermodynamics***, Vikash Publishing House.
3. Spear, F. S. (1993): ***Mineralogical Phase Equilibria and pressure – temperature – time Paths***, Mineralogical Society of America.
4. Wood, B.J. and Fraser, D.G. (1976): ***Elementary Thermodynamics for Geologists***, Oxford University Press, London.
5. Perchuk, L.L. and Kushiro, I. (eds), 1991: ***Physical Chemistry of Magmas***. Springer Verlag.
6. Bloss, F.D. (1971): ***Crystallography and Crystal Chemistry***, Holt, Rinehart, and Winston, New York.
7. Evans, R.C., (1964): ***Introduction to Crystal Chemistry***, Cambridge Univ. Press.
8. Hoefs, J. (1980): ***Stable Isotope Geochemistry***, Springer-Verlag.
9. Klein, C. and Hurlbut, C.S. (1993): ***Manual of Mineralogy***, John Viley and Sons, New York.
10. Krauskopf, K.B. (1967): ***Introduction to Geochemistry***, McGraw Hill.
11. Mason, B. and Moore, C.B. (1991): ***Introduction to Geochemistry***, Wiley Eastern.
12. Rollinson, H.R. (1993): ***Using geochemical data: Evaluation, Presentation, Interpretation***. Longman U.K.
13. Shikazono, N. (2003): ***Geochemical and Tectonic Evolution of Arc-Backarc Hydrothermal Systems -Implication for the Origin of Kuroko and Epithermal Vein-Type Mineralizations and the Global Geochemical Cycle***, Eslevier Science.

…….

PRACTICAL (GEL-507 + GEL-508) **SECOND SEMESTER**

Paper Code**: GEL – 511 (IGNEOUS & METAMORPHIC PETROLOGY AND GEOCHEMISTRY & THERMODYNAMICS)**
Credits: 4 Full Marks: 100

IGNEOUS & METAMORPHIC PETROLOGY

Megascopic and microscopic study of igneous rocks.
Calculation of CIPW Norms. Preparation of variation diagrams.
Megascopic and microscopic study of metamorphic rocks of different facies.
Calculation of ACF, AKF and AFM values from chemical and structural formulation of minerals and their graphical representation.
Graphic presentation of various petrographic and petrochemical data.

GEOCHEMISTRY & THERMODYNAMICS

Calculation of mineral formulae from the concentration of various oxides in minerals.
Calculation of normative minerals from rock composition. Presentation of analytical data.
Estimation of pressure and temperature from important models of geothermometry and geobarometry.
Calculation of stability fields based on thermodynamic data at various P/T conditions.

……

SECOND SEMESTER

THEORY

(a). Paper Code: **GEL – 509 (SEDIMENTOLOGY)**

Credits: 4 **Full Marks: 100**

Course Objectives

1. This course introduces the principles and methods of sedimentary petrology, emphasizing field data collection, textural analysis, and interpretation of sedimentary structures for palaeocurrent reconstruction.
2. It aims to provide an understanding of the origin, classification, and petrogenesis of clastic and non-clastic sedimentary rocks, including their mineralogical and geochemical characteristics.
3. The course emphasizes the processes of sediment transport, deposition, and diagenesis, and their roles in the formation and transformation of sedimentary rocks.
4. It highlights the relationships between tectonics and sedimentation, explaining the origin, evolution, and classification of sedimentary basins in the context of plate tectonics.
5. Students will gain insights into various depositional environments, sedimentary facies, and basin development processes, enabling interpretation of past sedimentary and tectonic settings.

Course Learning Outcomes

1. By the end of this course, students should have a comprehensive understanding of sedimentary processes, textures, and structures, and be able to interpret field data from sedimentary terrains.
2. Be able to classify and describe the major types of clastic and non-clastic sedimentary rocks and interpret their petrogenesis in relation to provenance, tectonic setting, and depositional environment.
3. Understand the processes and evidences of diagenesis and their effects on sediment composition, porosity, and rock fabric.
4. Develop skills to analyze sedimentary structures and apply them in palaeocurrent analysis, environmental reconstruction, and basin interpretation.
5. Comprehend the concepts of sedimentary basins, their tectonic controls, and the characteristics of continental, coastal, and marine depositional systems, linking sedimentary processes with global tectonic evolution.

Unit-1 **25 marks**

Collection of field data from sedimentary terrain and their presentation. Origin of clastic and non-clastic sediments.Shape, size, and fabric of the clastic sedimentary particles and surface textures.Methods of textural analysis, textural parameters and their significance. Fluid flow mechanics, formation and classification of sedimentary structures and bed forms. Application of sedimentary structures in palaeocurrent analysis.

Unit-2 **25 marks**

Clastic sedimentary rocks: Rudaceous, Arenaceous, Argillaceous and Volcaniclastic.

Classification and petrogenesis of sandstones, Graywacke and graywacke problem; platetectonics and sandstones composition; Argillaceous rocks, their classification and genesis.

Unit-3 **25 marks**

Non-clastic sedimentary rocks: Limestone, Dolomite and Evaporites. Dolomites and dolomitization, their petrographic characteristics. Study of evaporites such as gypsum, anhydrite and halite. Detailed study of siliceous, phosphatic and ferruginous rocks. Diagenesis- physical and chemical, processes and evidences of diagenesis in sandstones, mud rocks and carbonate rocks.

Unit-4 **25 marks**

Geosynclinal concept and sedimentary basins. Origin and evolution of sedimentary basins in the light of plate tectonics. Tectonics and sedimentation Sedimentary environments and facies. Continental, alluvial-fluvial, lacustrine, desert-aeolian and glacial sedimentary systems. Shallow coastal clastics and carbonate deposits. Deep sea basins.

Books Recommended:

1. Allen, J.R.L., 1985: ***Principles of Physical Sedimentation***, George Allen &Unwin.
2. Allen, P., 1997: ***Earth Surface Processes***. Blackwell.
3. Nichols, G., 1999: ***Sedimentology and Stratigraphy***. Blackwell.
4. Readin.g, H.G. 1996: ***Sedimentary Environments***. Blackwell.
5. Davis, R.A. Jr., 1992: ***Depositional Systems***. Prentice Hall.
6. Einsele, G., 1992: ***Sedimentary Basins***. Springer Verlag.
7. Reineck, H.E. and Singh, I.B., 1980: ***Depositional Sedimentary Environments***. Springer-Verlag.
8. Prothero, D.R. and Schwab, F., 1996: ***Sedimentary Geology***. Freeman.
9. Miall, A.D., 2000: ***Principles of Sedimentary Basin Analysis***. Springer - Verlag.
10. Pettijohn, F.J., Potter, P.E. and Siever, R., 1990: ***Sand and Sandstone***. Springer Verlag
11. Blatt, H, Murray, G.V. and Middleton, R.C., 1980: ***Origin of Sedimentary Rocks***.
12. Bhattacharya, A and Chakraborti, C., 2000: ***Analyses of Sedimentary Successions***.Oxford-IBH.
13. Boggs Sam Jr., 1995: ***Principles of Sedimentology and Stratigraphy***, Prentice Hall.
14. Sengupta, S., 1997: ***Introduction to Sedimentology***, Oxford-IBH.
15. Maurice E. Tucker, 2003: ***Sedimentary Rocks in the Field***. John Wiley
16. Gary Nochols, 2009: ***Sedimentology and Stratigraphy***. Willy- Blackwell
17. Collinson and Thompson, 1982: ***Sedimentary Structures***. CBS Publishers & Distributors, Delhi
18. Adams, Mackenzie and Guilford, 1987: ***Atlas of Sedimentary Rocks under Microscope***. ELBS
19. Roy C. Lindholm, 1987: ***A Practical Approach to Sedimentology***, Allen & Unwin, London
20. Potter & Pettijohn 1977: ***Paleocurrent and Basin Analysis***. Springer-Verlag.

……

SECOND SEMESTER

THEORY

(a). Paper Code: **GEL – 510 (GEOMORPHOLOGY & QUATERNARY GEOLOGY)**

Credits: 4 **Full Marks: 100**

Course Objectives

1. This course introduces the fundamental principles of geomorphology, focusing on the study of landforms, geomorphic processes, and the dynamics shaping the Earth's surface.
2. It aims to provide a comprehensive understanding of drainage systems, drainage anomalies, and morphometric analysis for interpreting geomorphic evolution and landscape development.
3. The course emphasizes the concepts of morphochronology, morphotectonics, neotectonics, and active tectonics, with special reference to the geomorphology of India and its applied aspects in hydrogeology, mineral exploration, and environmental studies.

Geomorphology:

Unit-1 **25 marks**

Historical Development in geomorphology; Geomorphological Studies: dynamics of geomorphology, geomorphic processes and resulting landforms, Drainage Patterns, Drainage Anomaly and Morphometric analysis.

Unit-2 **25 marks**

An elementary idea about morphochronology; Morphotectonics, Neotectonics – Geomorphologic Thresholds, Active Tectonics, Paleoseismicity. Brief outline of Geomorphology of India; Application of geomorphology in mineral prospecting, civil engineering, military purposes, hydrogeology and environmental studies.

Unit-3 **25 marks**

Introduction to the Quaternary; Classification: the Quaternary and Pre-Quaternary compared, data presentation: Climatic curves, stratigraphic classification, Chronostratigraphic classification, Last interglacial, last glaciation, Holocene. Quaternary dating methods: radiocarbon dating, Uranium series, Luminescence, Potassium-Argon, Dendrochronology, Non-glacial annual deposits, Glacial varves, Fission Track dating, Palynological Dating; Quaternary stratigraphy-oxygen isotope stratigraphy, biostratigraphy and megnetostratigraphy.

Unit-4 **25 marks**

Quaternary Climate: Glacial - interglacial cycles, eustatic changes, proxy indicators of palaeoenvironmental/Palaeoclimatic changes; Responses of geomorphic systems to climate, sea level and tectonics on variable time scales in Quaternary. Quaternary stratigraphy of India-continental records (fluvial, glacial, aeolian, palaeosols); marine records; continental-marine correlation of Quaternary record; Fossil records-pollen analysis, Mammalian faunas, hominids; Tectonic geomorphology, neotectonic, active tectonic and their applications to natural hazard assessment.

Course Learning Outcomes

1. By the end of this course, students should have a sound understanding of geomorphic processes, landform development, and the relationship between surface processes and tectonic activity.
2. Be able to analyze drainage patterns, drainage anomalies, and morphometric parameters to infer the structural and tectonic evolution of a region.
3. Understand the principles of morphochronology, morphotectonics, and neotectonics, and their significance in interpreting past and present geomorphic and seismic activities.
4. Develop the ability to interpret aerial photographs and satellite imagery, and understand the fundamentals of remote sensing platforms, sensors, and data analysis techniques.
5. 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. Miller, V.C., 1961: ***Photogeology***. McGraw Hill
2. Sabbins, F.F., 1985: ***Remote Sensing -Principles and Applications***. Freeman. ,
3. Ray. R.G., 1969: ***Aerial Photographs in Geologic Interpretations***. USGS Prof. Paper 373.
4. Drury, S.A., 1987: ***Image Interpretation in Geology***. Allen and Unwin.
5. Moffitt, F. H. and Mikhail, E.M.,1980: ***Photogrammetry***, Harper and Row.
6. Lillesand, T.M. and Kieffer, R.W., 1987: ***Remote Sensing and Image Interpretation***. John Wiley.
7. Paine, D.P., 1981: ***Aerial photography and Image Interpretation for Resource Management.*** John Wiley.
8. Pandey, S.N., 1987: ***Principles and Applications of Photogeology***. Wiley Eastern, New Delhi.
9. Gupta, R.P., 1990: ***Remote Sensing Geology***. Springer Verlag.

……

PRACTICAL (**GEL**-510 + **GEL**-511) **SECOND SEMESTER**

Paper Code**: GEL – 512 (SEDIMENTOLOGY AND GEOMORPHOLOGY & REMOTE SENSING)**
Credits: 4 **Full Marks: 100**

Sedimentology:
Study of primary, secondary and biogenic sedimentary structures in hand specimens, and field photographs. Tilt corrections of palaeo current data and palaeo current analysis. Petrography of clastic and chemical sedimentary rocks. Microscopic study of heavy minerals. Exercises on mineralogical and geochemical data plots for environmental interpretations.

Geomorphology:
Drainage and slope morphology, hypsometry; Geomorphology through topo-sheets, aerial photos and satellite imagery; Terrain aspect mapping.

FIELD WORK: **50 Marks**
The students will camp in a selected area for a period of about three weeks during which the student will be imparted training on systematic geological and structural mapping. Collection of samples of minerals, rocks, fossils will be carried out wherever possible. Students shall submit a detailed field report based on the field work.

……

SECOND SEMESTER

THEORY: OPEN ELECTIVE PAPER

Paper Code: **OPE- 014 (NATURAL HAZARDS AND DISASTER MANAGEMENT)**

Credits: 4 Full Marks: 100

Unit -1 20marks

Concepts in Disaster Management: Hazards and Disasters, Vulnerability, Disaster Management, Disaster Cycle, risk, prevention, mitigation, relief and response, recovery and rehabilitation, etc. – Brief history of disaster management in India and world. The emerging field of disaster management – Role of social sciences and natural sciences and multidisciplinary nature of disaster management as applied disciplines.

Unit- 2 15marks

Different typologies and classification of disasters, cataclysmic- slow – onset, natural/manmade etc. Critique of different classifications, what magnitude constitutes a ―Disaster‖ for the government. Effects of hazards: Primary, Secondary and Tertiary.

Unit- 3 15marks

Problems of urbanization, human population and their impact on environment. Alternative source of energy. Waste disposal and related problems. Environmental legislation.

Unit- 4 10marks

Consequences and impact of disasters: Flood, Cyclones, Tsunamis, Earthquakes, Landslides, Volcanic Eruption, Drought, Salinity ingress – Overview through case studies.

Unit- 5 20marks

Climate change, environment stress, biological and technological disaster – Overview through case studies. Nature of challenges in disaster management for people and environment, Role of disaster management in contemporary times.

Books Recommended:

1. Edward A Keller and Robert H Blodgett. 2008. Natural hazards. Pearson Prentice Hall, 488p.
2. Denald Hyndman and David Hyndman,2009. Natural hazards and disasters, Brooks/ Cole,555p.
3. Bankoff, G., Frerks, G.and Hilhorst, D. 2004. (eds.) Mapping Vulnerability: Disasters,Development, and People, Earthscan, London.
4. Wisner, B., Blaikie, P., Cannon, T. and Davis, I. 2004. At Risks: Natural Hazards, People's Vulnerability and Disasters, Second Edition, Routledge, London.
5. Weichselgartner F (2001): Disaster Mitigation: The concept of Vulnerability Revisited, Disaster Prevention and Management, 10 (2), Pg. 85- 94

……

THIRD SEMESTER

THEORY

Paper Code: **GEL – 613 (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 physicchemical 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 hydratesand 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.***

……..

THIRD SEMESTER

THEORY

Paper Code: **GEL – 614 (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, Merill 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.

THIRD SEMESTER

THEORY

Paper Code: **GEL – 615 (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'sText 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.

…….

THIRD SEMESTER

THEORY

Paper Code: **GEL – 616 (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 Heng| | 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).

……..

PRACTICAL (**GEL**-613 + **GEL**-614) **THIRD SEMESTER**

Paper Code**: GEL – 617 (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.

……..

PRACTICAL (CGE-615 + CGE-616) **THIRD SEMESTER**

Paper Code**: GEL – 618 (ENVIRONMENTAL GEOLOGY & FUEL GEOLOGY AND REMOTE SENSING & APPLICATION OF GIS)**

Credits: 4 **Full Marks: 100**

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.

……..

FOURTH SEMESTER

THEORY

Paper Code: **GEL – 619 (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 Miffin 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 Fortag.
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 Geophysi***cs
13. Verma, R.K., 1991: ***Geodynamics of the Indian Peninsula and the Indian Plate Margin.***

……..

FOURTH SEMESTER

THEORY

Paper Code: **GEL – 620 (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 Pub!.
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.

……..

FOURTH SEMESTER

Paper Code: **GEL – 621 (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: CO_2-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 CO_2. 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 cyclicity, 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 Barlatt 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 Barlatt. Edition 5
8. Alan P. Trujillo and Harold V. Thurman, 2011. Essentials of Oceanography. 10th Edition

……..

FOURTH SEMESTER

Paper Code: **GEL – 622** **(DISSERTATION)**

Credits: 6 **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-619 + GEL-620) **FOURTH SEMESTER**

Paper Code: **GEL – 623 (GEODYNAMICS & GEOTECTINICS 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.

……..

FOURTH SEMESTER

Paper Code: **GEL- 624** **(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:

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

……

L. Debala Devi
22/9/26.

Head,
Department of Geology,
DM College of Science,
D.M. University, Imphal