

Kazi Nazrul University



Curriculum and Credit Framework for Post Graduate Program (CCFPP)

Syllabus for M.Sc. in Applied Geology

2-Year PG Degree (with effect from Academic Session 2026-27) /

1-Year PG Degree (with effect from Academic Session 2027-28)

M.Sc. in Geology
COURSE STRUCTURE

2 Year PG	Semester	Course Type	No. of Courses	Course Details	Course Credit (each course)	Course Credit	Total Credit
	I	MAJOR COURSEWORK	4	MC-1, MC-2, MC-3, MC-4	5	20	90
		MINOR COURSEWORK	1	MNC-1	5	5	
		Total Credit (Semester I)				25	
	II	MAJOR COURSEWORK	4	MC-5, MC-6, MC-7, MC-8	5	20	
		MINOR COURSEWORK	1	MNC-2	5	5	
		Total Credit (Semester II)				25	
	III	MAJOR RESEACH COURSEWORK ELCTIVE	3	MCE-1, MCE-2, MCE-3	5	15	
		RESEARCH METHODOLOGY	1	RMC-1	5	5	
		Total Credit (Semester III)				20	
	IV	DISSERTATION	2	RDC-1, RDC-2	5 (RDC-1) 15 (RDC-2)	20	
		Total Credit (Semester IV)				20	

1 Year PG	Semester	Course Type	No. of Courses	Course Details	Course Credit (each course)	Course Credit	Total Credit
	I	MAJOR RESEACH COURSEWORK ELCTIVE	3	MCE-1, MCE-2, MCE-3	5	15	40
		RESEARCH METHODOLOGY	1	RMC-1	5	5	
		Total Credit (Semester I)				20	
	II	DISSERTATION	2	RDC-1, RDC-2	5 (RDC-1) 15 (RDC-2)	20	
		Total Credit (Semester II)				20	

Semester-wise Course Structure

Semester I (2yr PG)

Course Name	Course Type	Course Code	Course Details	L - T - P	Course Credit	CA Marks		ESE Marks		Total Marks
						Pr	Th	Pr	Th	Pr+Th
Exploration Geology	MAJOR COURSEWORK	MSCAGLMC701	MC-1	3 - 0 - 4	5	30	15	20	35	100
Engineering Geology	MAJOR COURSEWORK	MSCAGLMC702	MC-2	3 - 0 - 4	5	30	15	20	35	100
Fuel Geology	MAJOR COURSEWORK	MSCAGLMC703	MC-3	5 - 0 - 0	5		30		70	100
Geostatistics	MAJOR COURSEWORK	MSCAGLMC704	MC-4	5 - 0 - 0	5		30		70	100
Choose from the Pool of Minor Courses offered in 1 st Semester by other Disciplines within the faculty	MINOR	See Pool	MNC-1	5 - 0 - 0	5		30		70	100
Semester I	Total Credit				25	Total Marks				500

Semester II (2yr PG)

Course Name	Course Type	Course Code	Course Details	L - T - P	Course Credit	CA Marks		ESE Marks		Total Marks
						Pr	Th	Pr	Th	Pr+Th
Oceanography	MAJOR COURSEWORK	MSCAGLMC801	MC-5	5 - 0 - 0	5	30	15	20	35	100
Climatology	MAJOR COURSEWORK	MSCAGLMC802	MC-6	5 - 0 - 0	5	30	15	20	35	100
Mineral Beneficiation and Mineral Economics	MAJOR COURSEWORK	MSCAGLMC803	MC-7	5 - 0 - 0	5		30		70	100
Environmental Geology	MAJOR COURSEWORK	MSCAGLMC804	MC-8	5 - 0 - 0	5		30		70	100
Choose from the Pool of Minor Courses offered in 2 nd Semester by other Disciplines within the faculty	MINOR	See Pool	MNC-2	5 - 0 - 0	5		30		70	100
Semester II	Total Credit				25	Total Marks				500

Semester III (2yr PG)/ Semester I (1yr PG)

Course Name		Course Type	Course Code	Course Details	L - T - P	Course Credit	CA Marks		ESE Marks		Total Marks
							Pr	Th	Pr	Th	Pr+Th
Advanced Petrology	Group A	Major Research Coursework Elective (Any one group to be opted)	MSCAGLMCE901	MCE-1	3 - 0 - 4	5	30	15	20	35	100
Medical Geology and Forensic Geology			MSCAGLMCE902	MCE-2	5 - 0 - 0	5		30		70	100
Remote Sensing in Geology			MSCAGLMCE903	MCE-3	3 - 0 - 4	5	30	15	20	35	100
Advanced Ore Geology	Group B		MSCAGLMCE904	MCE-1	3 - 0 - 4	5	30	15	20	35	100
Advanced Structural Geology			MSCAGLMCE905	MCE-2	3 - 0 - 4	5	30	15	20	35	100
Remote Sensing and GIS			MSCAGLMCE906	MCE-3	3 - 0 - 4	5	30	15	20	35	100
Palaeobiology	Group C		MSCAGLMCE907	MCE-1	3 - 0 - 4	5	30	15	20	35	100
Advanced Stratigraphic Principles and Basin Analysis			MSCAGLMCE908	MCE-2	3 - 0 - 4	5	30	15	20	35	100
Geoheritage and Geotourism			MSCAGLMCE909	MCE-3	3 - 0 - 4	5	30	15	20	35	100
Research Methodology with AI		Research Methodology	MSCAGLRMAI901	RMC-1	3 - 0 - 4	5	30	15	20	35	100
Semester III (2yr PG)/ Semester I (1yr PG)		Total Credit				20	Total Marks				400

Semester IV (2yr PG)/ Semester II (1yr PG)

Course Name	Course Type	Course Code	Course Details	L - T - P	Course Credit	CA Marks		ESE Marks		Total Marks
						Pr	Th	Pr	Th	Pr+Th
Literature Review	Dissertation	MSCAGLRD1001	RDC-1	0 - 3 - 4	5	60		40		100
PG Dissertation	Dissertation	MSCAGLRD1002	RDC-2	0 - 10 - 10	15	180		120		100
Semester IV (2yr PG) / Semester II (1yr PG)	Total Credit				20	Total Marks				400

Semester-I (2yr PG)

Course Name: **EXPLORATION GEOLOGY**

Course Code: **MSCAGLMC701**

COURSE OBJECTIVES:

To understand the concept of exploration, different techniques used to find out a hidden mineral treasure, advantages and disadvantages of these techniques and to estimate the content of the treasure.

COURSE LEARNING OUTCOMES:

The students will be able to judge the suitability of a technique for a particular type of deposit and its limitation. They will be aware of the required information that to be collected for reserve estimation.

Theory

Unit 1

5 Lectures

Concept of mineral exploration, stages of mineral exploration and tasks accomplished under them. Surface and subsurface methods of exploration.

Unit 2

10 Lectures

Introduction of various methods of geophysical prospecting – magnetic, gravity, electrical, seismic and radiometric methods. Brief outline of various well logging techniques.

Unit 3

10 Lectures

Geochemical methods for mineral exploration- lithogeochemical, pedogeochemical, hydrogeochemical, biogeochemical and atmogeochemical methods

Unit 4

4 Lectures

Geobotanical and photogeochemical methods.

Unit 5

10 Lectures

Drilling, sampling methods and estimation of reserves.

PRACTICAL (Lectures – 52)

1. Concept of weighted average, calculation of average grade from sampling data.
2. Calculation of grade from groove sampling.
3. Calculation of grade and reserve from exploratory mining, models of reserve estimation.

SUGGESTED READINGS:

- Brooks, R.R., Geobotany and Biogeochemistry in Mineral Exploration, Harper and Row., New York.
- Ginzburg, I.I., Principles of Geochemical Prospecting, Pergamon Press, London
- Hawkes, H.E. and Webb. J.S.: Geochemistry in Mineral Exploration, Harper and Row, New York.
- Levinson, A.A.: Introduction to Exploration Geochemistry, Applied Publishing Ltd. Calgary
- Malyuga, D.P: Biochemical Methods of prospecting. Consultants Bureau. New York
- Reedman, J.H.: Techniques in Mineral Exploration, Applied Science Publishers Ltd. London
- Benjamin F., Howell, JR.: Introduction to Geophysics, McGraw-Hill Book Co., New York
- Dobrin, M.B.: Introduction to Geophysical Prospecting, McGraw-Hill Book Co., New York
- Kearey, P. and Brooks, M. An Introduction to Geophysical Exploration, ELBS, Blackwell Scientific Publication
- Nettleton, L.L., Geophysical Prospecting for Oil. Mc-Graw-Hill Book Co., New York
- Parasnis, D.S. Principles of Applied Geophysics. Methuen and Co, London.
- Telford, W.M. AG Ltd., Sheriff, R.E. and Keys, D.A.: Applied Geophysics. Cambridge University Press.
- William Lawrie. Fundamentals of Geophysics, Cambridge University Press.

Course Name: ENGINEERING GEOLOGY

Course Code: MSCAGLMC702

COURSE OBJECTIVES:

The objectives of the course are to study and identify different types of natural materials like rocks and minerals and soil, to understand the various natural dynamic processes their influence on the surficial features, natural material and their consequences and to know the physical properties of rocks and minerals.

COURSE LEARNING OUTCOMES:

- Ability to categorize rocks and minerals by their origin and engineering properties.
- Ability to apply geological principles to rock masses and discontinuities for use in engineering design. e. g. rock slopes, foundation.

THEORY

Unit 1: Introduction

(Lectures – 03)

Role of engineering geologists in planning, design and construction of major man-made structural features.

Unit 2: Applications of Engineering Geology

(Lectures – 03)

Geological considerations in civil constructions like Dam, reservoirs, tunnels, bridges etc.

Unit 3: Foundation treatment

(Lectures – 03)

Grouting, rock bolting and other support mechanisms; slope stability and mass wasting; types of block failure, factor of safety.

Unit 4: Intact Rock and Rock Mass properties

(Lectures – 08)

Significance as construction material; properties of building materials: physical properties; compositions and structures of materials; significance of building or dimension stone: roofing and facing materials; armour-stone; crushed rock – concrete aggregate; road aggregate; gravels and sands; lime; cement and plaster; clays and clay products.

Unit 5: Rock Quality Designation (RQD) (Lectures – 06)

Concept, Mechanism and Significance of: Rock Structure Rating (RSR), Rock Mass Rating (RMR), Tunnelling Quality Index (Q)

Unit 6: Dams and Reservoirs

(Lectures –08)

Geological conditions for the selection of dam and reservoir sites; terminology associated with dams; types of dams – masonry, gravity, buttress, arch and earth dams; types of spillway; causes of dam failures. Problems affecting dams and their remedial measures; case studies of dam construction and failures; geological, geotechnical and environmental considerations for dams and reservoirs.

Unit 7: Tunnel

(Lectures – 05)

Tunnel: different parts; types; geological investigations for site selection for tunnel; tunnelling problems; factors effecting excavation of rocks while tunnelling; effects of fold, fault, bed attitude on tunnelling.

Unit 8: Landslides

(Lectures – 03)

Different parts of landslide body; inducing factors for landslides; role of gravity and water

Unit 9: Earthquakes

(Lectures – 03)

Causes, Factors and corrective / preventive measures

PRACTICAL (Lectures –52)

1. Selecting sites using topographic maps for dams, tunnels, bridges and similar civil structures.
2. Computation of reservoir area, catchment area, reservoir capacity and reservoir life.
3. Merits, demerits and remedial measures based upon geological cross sections of project sites;
4. Calculation of Index properties of rocks;
5. Evaluating mechanical properties of concrete aggregates;
6. Survey related exercises;
7. Computation of RQD, RSR, RMR and 'Q'

SUGGESTED READINGS:

1. Bell, Fred G, (2007) Engineering Geology (Second Edition), Elsevier.
2. Bell, Fred G. (2007) Basic Environmental and Engineering Geology, Whittles Publishing.
3. Blyth, F.G.H. and de Freitas, M. (1984) A Geology for Engineers, Elsevier.
4. Fletcher, Chris J.N. (2016) Geology for Ground Engineering Projects, CRC Press.
5. Gangopadhyay, S. (2013) Engineering Geology, Oxford India.
6. Goodman, R.E., 1993. Engineering Geology: Rock in Engineering constructions. John Wiley & Sons, N.Y.
7. Johnson, R.B. and De Graf, J.V. 1988. Principles of Engineering Geology, John Wiley.
8. Krynine, D.P. and Judd W.R. 1957. Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).
9. Smith, M.R. (1999) Stone – Building Stone, Rock Fill and Armourstone in Construction, Geological Society of London.
10. Waltham, T., (2009) Foundations of Engineering Geology (Third Edition) Taylor & Francis.
11. Waltham, T., 2009. Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.
12. Zhang, H. (2011) Building Materials in Civil Engineering, Woodhead Publishing.

Course Name: FUEL GEOLOGY

Course Code: MSCAGLMC703

COURSE OBJECTIVES:

The objectives of this course are to: (a) To introduce conventional and non-conventional geological energy sources; (b) To understand formation, classification, distribution of energy sources especially in India; (c) To familiarize with the fundamentals of petroleum prospecting.

COURSE LEARNING OUTCOMES:

- Characterization of each type of fuel deposit
- Demonstrate the occurrence, setting and components of different fuels
- Apprehend the distribution of fuel in India

THEORY

Unit 1: Coal

10 Lectures

Definition and origin of Coal

Classification of coal on the basis of Type, Grade, Rank, and Seyler's, ASTM, Indian classification

Fundamentals of Coal Petrology - Introduction to lithotypes, microlithotypes and macerals in coal Proximate and Ultimate analysis, chemical properties of coal

Unit 2: Coal Bed Methane

5 Lectures

Coal Bed Methane (CBM): global and Indian scenario, Underground coal gasification; UCG and SCG: advantages and disadvantages; Coal liquefaction

Unit 3: Petroleum

5 Lectures

Chemical composition and physical properties of crudes in nature. Origin of petroleum: favourable geological conditions, source material, maturation of organic matter - Biogenic and Thermal effect; Kerogen: types and relation to the origin of petroleum hydrocarbons

Unit 4: Petroleum system

5 Lectures

Source rock, reservoirs and cap rock. Source rock: general attributes. Reservoir rocks: general attributes and petrophysical properties. Cap rocks: definition and general properties. Migration of

petroleum hydrocarbons. Hydrocarbon traps: definition, anticlinal theory and trap theory.

Classification of hydrocarbon traps - structural, stratigraphic and combination . Time of trap formation and time of hydrocarbon accumulation. Plate tectonics and global distribution of hydrocarbon reserves; Petroliferous basins of India.

Unit 5: Nuclear fuel

6 Lectures

Nuclear fuel: types of nuclear reactions; fuel types – uranium and thorium; important minerals and types of uranium deposits, nuclear raw material resources of India; usage of nuclear energy.

Unit 6: Other fuels

7 Lectures

Shale Gas: introduction, advantages and disadvantages; Gas hydrate: introduction, occurrence, stability of gas hydrates; advantages and disadvantages;

Unit 7: Indian scenario of fuel

2 Lectures

Indian scenario.

PRACTICAL (Lecture s – 52)

1. Petrographic study of coal, reserve estimation of coal, outcrop completion, fault and borehole problems.
2. Seismic profile interpretation.
3. Panel and fence diagrams, section correlation and identification of hydrocarbon prospect

SUGGESTED READINGS:

1. Thomas, L., 2020. Coal Geology (Third Edition), Wiley-BlackwelSuarez-Ruiz, I. and Crelling, J.C., 2008.
2. Demirbas, A., 2010. Methane Gas Hydrate. Springer
3. Chandra D., 2007. Chandra's Textbook on Applied Coal Petrology. Jijnasa Publishing House.
4. Chandra, D., Singh, R.M. and Singh, M.P., 2000. Textbook of Coal (Indian Context). Tara Book Agency, Varanasi
5. Diessel, C.F.K., 1992. Coal-Bearing Depositional Systems. Springer
6. Francis, W., 1964. Coal its Formation and Composition. Edward Arnold
7. Singh, M.P., 1998. Coal and Organic Petrology. Hindustan Publ. Corp., New Delhi.
8. Ward, C.R., 1984. Coal Geology and Coal Technology. Blackwell Science
9. Thakur, P., Schatzel, S.J., Aminian, K., Rodvelt, G., Mosser, M.H., D'Amico, J.S., 2020. Coal Bed Methane – Theory and Applications (Second Edition), Elsevier
10. Flores, R.M., 2014. Coal and Coalbed Gas – Fueling the Future. Elsevier

11. Singh, Ajay Kumar and Hajra, Partha Narayan, 2018. Coalbed Methane in India – Opportunities, Issues and Challenges for Recovery and Utilization. Springer
12. Letcher, T.M., 2020. Future Energy – Improved, Sustainable and Clean Options for our Planet (Third Edition). Elsevier
13. Bell, D.A., Towler, B.F. and Fan, M., 2011. Coal Gasification and Its Applications. Elsevier
14. Massey L.G., 1973. Coal Gasification. American Chemical Society
15. Whitehurst, D.D., 1980. Coal Liquefaction Fundamentals. American Chemical Society
16. Shelly R.C., 2014. Elements of Petroleum Geology (Third Edition). Academic Press
17. Bjorlykke, K., 1989. Sedimentology and Petroleum Geology. Springer
18. Tissot, B.P. and Welte, D.H., 1984. Petroleum Formation and Occurrence. Springer
19. Levorsen, A.I., 2004. Geology of Petroleum; CBS Publishers and Distributors, India
20. North, F.K., 1986. Petroleum Geology, Allen & Unwin
21. Bastia, R. and Radhakrishna, M., 2012. Basin Evolution and Petroleum Prospectivity of the Continental Margins of India. Elsevier
22. Doveton, J.H., 1986. Log Analysis of Subsurface Geology. Wiley-Interscience
23. Hobson, G.D., 1977. Developments in Petroleum Geology. Applied Science Publishers
24. Aswathanarayana, U., 1985. Principles of Nuclear Geology. Oxford
25. Boyle, R.W., 1982. Geochemical Prospecting for Thorium and Uranium Deposits. Elsevier

Course Name: GEOSTATISTICS

Course Code: MSCAGLMC704

COURSE OBJECTIVES:

This course helps to introduce the learners different statistical and mathematical tools used in geological studies. It aims to develop proficiency in data interpretation, probability theory, multivariate statistical techniques, with applications in spatial data analysis and geostatistical modelling.

COURSE LEARNING OUTCOMES:

- Apply basic statistical tools to analyse and interpret geological data.
- Use probability distributions and statistical tests to solve geological problems.
- Analyse spatial data using geostatistical techniques such as kriging and Semivariograms.
- Employ multivariate techniques like cluster analysis and discriminant functions in geological studies.

Unit 1: Introduction to Geostatistics (Lectures – 04)

Definition, scope and objectives of Geostatistics; Types of geological data; Population and sample; Variables and scales of measurement; Data collection, sampling strategies and sources of geological uncertainty.

Unit 2: Descriptive Statistics (Lectures – 08)

Graphical representation of geological data; Frequency distributions; Measures of central tendency (mean, median and mode); Measures of dispersion (range, variance, standard deviation and coefficient of variation); Skewness and kurtosis; Data transformation; Geological interpretation of statistical parameters.

Unit 3: Probability and Statistical Inference (Lectures – 10)

Concept of probability; Random variables and probability distributions; Sampling distributions and Central Limit Theorem; Confidence intervals; Statistical significance and *p*-values.

Unit 4: Statistical Tests and Analysis of Variance (Lectures – 10)

Concept of statistical hypothesis testing; Parametric and non-parametric statistical tests; Student's *t*-test; Chi-square test; *F*-test; Analysis of Variance (ANOVA); Assumptions of ANOVA; Type I and Type II errors; Geological applications of hypothesis testing.

Unit 5: Correlation, Regression and Time-Series Analysis (Lectures – 18)

Pearson correlation coefficient; Linear regression; Least-squares estimation; Model assumptions and goodness of fit; Trend surface analysis; Time-series data; Moving average method; Autocorrelation and cross-correlation; Applications in geological and environmental datasets.

Unit 6: Spatial and Multivariate Analysis (Lectures – 14)

Spatial characteristics of geological variables; Spatial autocorrelation; Distance-based interpolation methods; Semivariograms and variogram modelling; Kriging; Introduction to geostatistical interpolation; Applications of geostatistical estimation to mineral resource evaluation, including cut-off grade, grade–tonnage relationships and ore–waste classification; Introduction to multivariate methods (Principal Component Analysis (PCA), Cluster analysis, Discriminant analysis and Factor analysis); Geological applications of multivariate and spatial analysis.

SUGGESTED READINGS:

1. Armstrong, M. (1998) Basic Linear Geostatistics, Springer Verlag, Berlin.
2. Cooley, W.W. and Lohnes, P.R. (1971) Multivariate data analysis, John Wiley and Sons.
3. Creighton, J.H.G. (1994) First course in probability models and statistical inference, Springer Verlag.
4. Davis, J.G. (1986) Statistics and data analysis in geology, John Wiley.
5. Journel, A.G. and Huijbregts, Ch. (1978) Mining Geostatistics, Academic Press.
6. Kubackova, L., Kubacek, L. and Kukuca, J. (1987) Probability and Statistics in Geology and Geophysics, Elsevier.
7. Pitman, J. (1993) Probability, Springer Verlag, (also Narosa Publishers).
8. Saals, E.A. and Srovastav, R.M. (1990) An Introduction to Geostatistics, Oxford University Press.
9. Spiegel, M.R. (1982) Probability and Statistics, Schaums Outline Series, McGraw-Hill Int., Singapore, Asian Students Edn.

9. Walpole, R.E. and Myers, R.H. (1982) Applied multivariate statistical analysis, Prentice Hall Inc., New Jersey.

Semester-II (2yr PG)

Course Name: OCEANOGRAPHY

Course Code: MSCAGLMC801

COURSE OBJECTIVE:

The objective of this course is to provide students with a wide-ranging understanding of the physical, chemical, biological, and geological aspects of the ocean and its interactions with the atmosphere. It aims to develop introductory knowledge of oceanographic processes. Students will learn topics such as ocean currents, waves, tides, marine ecosystems, climate variability, global climate change, sea water chemistry, activities on shore, marine resources and the tools used in ocean and climate studies

COURSE LEARNING OUTCOME:

- Explain the essential principles of oceanography, including the structure and composition of the ocean.
- Describe the important physical, chemical, biological, and geological processes in the ocean and how they interact with atmospheric systems.
- Gain fundamental knowledge about the role of oceanic circulation in global climate regulation and weather patterns.
- Discuss the significance of ocean-atmosphere interactions in phenomena such as El Niño, LaNiña, monsoons, and hurricanes.
- Understand and address the contemporary environmental challenges and policy issues from their knowledge of ocean.
- Understanding the geology and resources of marine environment.

Unit 1: Introduction to the Oceans (Lectures – 10)

The concept of oceanography, brief historical review; origin of ocean basins; physiography of the ocean floor.

Unit 2: Ocean Circulation(Lectures – 06)

Oceanic circulation, Oceanic currents – types and controlling factors.

Unit 3: Waves and Tides in the Ocean (Lectures – 15)

Properties of Ocean Waves; Wave Motions; Standing Waves, Internal Waves, Tsunamis, Origin of the Tides, Equilibrium Model of Tides, Dynamic Model of the Tides; Tidal Currents.

Unit 4: Sea water chemistry(Lectures – 12)

Major and minor constituents of sea water and their residence times; Processes controlling the composition of sea water, Dissolved gases in sea water-their sources and sinks; Interrelationships between ocean circulation, primary productivity and chemical composition of the atmosphere and ocean.

Unit 5: The Dynamic Shoreline (Lectures – 12)

Coastal Water Movement, Shoaling Waves and Refraction, Circulation in the Surf Zone; Beaches; Coastal Dunes; Barrier Islands; Deltas; Estuaries; Lagoons; Mangrove swamps; Anthropogenic impact on the Coastline.

Unit 6: Marine Geology(Lectures – 10)

Morphological and tectonic domains of the ocean floor; Mid oceanic ridge systems; Hydrothermal vents and seawater — basalt interaction; Modes and rates of sedimentation in the oceans; Nature of deep sea sediments and processes regulating sedimentary composition.

Unit 7: Marine Resources (Lectures – 06)

Types of marine resources; Physical, energy, biological and non-extractive resources; Mineral resources; Laws of the sea.

SUGGESTED READINGS:

1. Alan P. Trujillo & Harold V. Thurman. (2011). Essentials of Oceanography, 10th ed. Pearson
2. Gross, M. G., 1977. Oceanography: A view of the earth. 12. Lal, D. S., 2001. Climatology and oceanography: ShardaPustakBhawan
3. Pinet, Paul R. (2016). Invitation to Oceanography, Seventh edition. Jones & Bartlett Learning.

Course Name: CLIMATOLOGY

Course Code: MSCAGLMC802

COURSE OBJECTIVE:

The objective of this course is to provide students with a wide-ranging understanding of the physical, chemical, biological, and geological aspects of the atmosphere. It aims to develop introductory knowledge of climatological processes and their roles in Earth's climate system. Students will learn topics such as atmospheric currents, heat budget, orbital cyclicity, climate variability, global climate change, and the tools used in climate studies

COURSE LEARNING OUTCOME:

- Explain the essential principles of climatology, including the structure and composition of the atmosphere.
- Describe the important physical, chemical, biological, and geological processes in the atmospheric systems.
- Gain fundamental knowledge about the role of atmospheric circulation in global climate regulation and weather patterns.
- Understand and address the contemporary environmental challenges and policy issues from their knowledge of climate.
- Understanding heat budget and orbital cyclicity.

THEORY

Unit 1: Atmosphere and Atmospheric Dynamics (Credit Hours – 06)

Composition and structure of the atmosphere; atmospheric properties; air pressure and pressure systems; Coriolis force and its effects; atmospheric circulation; global wind systems; atmospheric stability and circulation patterns.

Unit 2: Atmosphere–Ocean Interactions (Credit Hours – 10)

Atmosphere–ocean interactions and their role in the Earth's climate system; heat exchange between the atmosphere and oceans; surface and deep ocean circulation; thermohaline circulation (global ocean conveyor belt) and its influence on global climate; sea ice and glacial ice; monsoon systems with special emphasis on the Indian monsoon, its mechanism, variability, and climatic significance.

Unit 3: Climate System: Components, Forcing and Feedbacks (Credit Hours – 10)

Components of the climate system (atmosphere, hydrosphere, cryosphere, lithosphere, and biosphere); climate forcing (external and internal); climate-controlling factors; climate system responses and response times; interactions among climate system components; positive and negative feedback mechanisms.

Unit 4: Earth's Energy Budget and Heat Balance (Credit Hours – 10)

Solar radiation and the solar spectrum; incoming and outgoing radiation; absorption, reflection, and scattering of radiation; storage and redistribution of heat; latent and sensible heat transfer; Earth's global heat budget; interactions among different sources of terrestrial heat and their role in climate regulation.

Unit 5: Climate Variability Through Geological Time (Credit Hours – 10)

Orbital forcing and Milankovitch cycles; natural climate variability; glacial–interglacial cycles; Last Glacial Maximum (LGM); Pleistocene glacial–interglacial oscillations; Younger Dryas event; Snowball Earth hypothesis; geological controls on long-term climate evolution.

Unit 6: Climate Change, Biosphere and Earth System Response (Credit Hours – 12)

Climate classification systems; natural and anthropogenic climate change; interactions between climate and the biosphere; climate impacts on ecosystems and biodiversity; changes in atmospheric chemistry; archives and proxies of climate change; palaeoclimate records from the Indian subcontinent; future climate projections, mitigation, and adaptation strategies.

SUGGESTED READINGS:

1. Aguado, E., and Burt, J., (2009). Understanding weather
2. Lutgens, F., Tarbuck, E., and Tasa, D. (2009). The Atmosphere: An Introduction to Meteorology. Pearson Publisher
3. Rohli, R. V. and Vega, A. J. (2007). Climatology. Jones and Barlett

4. Rudiman, W.F. (2001). Earth's climate: past and future: 2nd ed., Freeman Publisher.

Course Name: MINERAL BENEFICIATION AND MINERAL ECONOMICS

Course Code: MSCAGLMC803

COURSE OBJECTIVES:

The course objective is to provide a possibility to understand mineral processes for ores, industrial minerals, recycling products and mineral fuel. The theoretical aspects of common mineral processing techniques are covered. Students will have an idea about equipment utilized nowadays in mining and extractive metallurgy practices. They will be acquainted with the solid separation principles when applied to ores and minerals, from the mine down to concentrates production.

COURSE LEARNING OUTCOMES:

After completion of the course, the student will be able to:

- Understand the basic principles of mineral separation processes and the respective equipment used.
- Analyze reasons for selection of processes based on raw material properties.
- Make a logical link between applied mineralogy, mineral processing and economics of metal production.

Unit 1	5 Lectures
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Beneficiation- necessity, importance, advantages;

Unit 2	10 Lectures
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Crushing- Construction and operational features of primary and secondary crushers. Jaw and Gyratory crushers, cone and roll crushers.

Unit 3	10 Lectures
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Grinding theory, Ball and Rod mills- construction and operation.

Unit 4	12 Lectures
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Laboratory sizing and industrial screening, rake, spiral and hydrocyclone classifiers.

Unit 5	12
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Lectures

Size, specific gravity and surface property dependent beneficiation processes- gravity concentration-theory and practice of Jigging, heavy media separation and flowing film concentration. Froth flotation. Drying and dewatering.

Unit 6	15
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Lectures

Mineral economics and its concept. Specialities inherent in mineral industry. Strategic, critical and essential minerals. Reserve- resources classification; Conservation and

substitution, National Mineral Policy. Marine mineral resources: Territorial jurisdiction; law of the sea. Exclusive Economic Zone. Management of resources of international sea bed. Marine pollution. Rights of landlocked countries.

SUGGESTED READINGS:

Mineral Beneficiation

1. Gaudin, A.M., Principles of Mineral Dressing. McGraw-Hill, London.
2. Gokhale, K.V.G.K. and Rao, T.C. (1973): Ore deposits of India-their distribution and processing. Thompson press (India) ltd., Delhi.
3. Jain, S.K. (2008): Mineral processing. CBS publishers and distributors, New Delhi.
4. Lele, A, Palet, S and Rao, V (2017): Mineral processing (including mineral dressing, experiments and numericals). I.K. international publishing house.
5. Richards, R.H. (2022): A text book of ore dressing. Legare street press.
6. Taggart A.F., Handbook of Mineral Dressing. Wiley, New York

Mineral Economics

1. Gupta, V. (2018): The mines and minerals (Developments and Regulations) act 1957. 2nd edition. Commercial Law House publishers.
2. Halder, S.K. (2013): Mineral exploration – principles and applications. Elsevier publications.
3. Ray, S.C. and Sinha, I.N.: Mine and mineral economics. PHI Learning Publishers. E-Book ISBN: 9789354436819.
4. Seshagiri Rao, P. (2023): Law of mines and minerals (in 2 volumes). 23rd edition. Asia Law House publishers.
5. Sinha, R. K. and Sharma, N. L. (1988) : Mineral Economics, fourth edition. Oxford and IBH Publishing Co. Private Ltd.
6. Barry A. Wills, Mineral Processing Technology, Pergamon Press, New York.
7. Chatterjee, K.K. An Introduction to Mineral Economics, Wiley Eastern Limited, Calcutta.
8. Hussain, A.M.: The Economics and Economic Geology of the Mineral Industries, Applied Publishers.
9. Sinha, R.K. and Sarma, N.L., Mineral Economics. Oxford and IBH Publishing Co.

Course Name: ENVIRONMENTAL GEOLOGY

Course Code: MSCAGLMC804

COURSE OBJECTIVES:

This course aims to investigate the interaction between geologic principles, environments, humans, and the Earth. The course is designed to provide the students with the tools necessary

to interpret change in global environments. The use of fundamental geologic knowledge is investigated to encourage critical thinking & effective problem-solving methodologies for sustainability in human-landscape interactions.

COURSE LEARNING OUTCOMES:

- Describe the scientific method as applied in the earth sciences;
- Demonstrate about common earth materials and their relationship to environmental hazards;
- Explain how the occurrence and formation of earth resources and significant environmental effects caused by their extraction, processing, and use;
- Describe the major sources of water, soil, and sediment pollution and methods for their management;
- Explain the causes and effects of global climate change;
- Demonstrate an understanding of data collection, interpretation, and concluding specific to natural and anthropogenic processes that are relevant to humans and the environment;
- Scrutinize how the earth system process is instrumental in formulating public policy or law to deal with a variety of environmental problems and the delineate role of geoscientist in management of solving environmental problems.

THEORY

Unit 1: Introduction (Lectures – 1)

Concepts of Environmental Geology. Domains of Environmental Geology. Time scales of global changes in the ecosystem and climate. Impact of circulations in atmosphere and oceans on climate and rain fall. Levels of Present and past atmospheric carbon-dioxides. Global warming caused by CO₂ increase in the present atmosphere.

Unit 2: Carbon Sequestration (Lectures – 06)

Brief introduction on carbon sequestration and its various processes

Unit 3: Different factors influencing environment (Lectures – 10)

Role of physical, chemical and biological parameters influencing environment. Riverine and marine environments and their important characteristics.

Unit 4: Environmental pollution (Lectures – 10)

Air, water and noise pollution and their major causes. Pollution in the mining areas. Parameters influencing weathering, development of soils and soil profiles.

Unit 5: Natural and Anthropogenic Hazards (Lectures – 12)

Distribution, magnitude and intensity of earthquakes. Seismic hazard zones. Neotectonics in seismic hazard assessment. Landslide, Floods and volcanic hazards their causes and control. Coastal erosion its causes and control. Anthropogenic effects.

Unit 6: Urban Environment (Lectures – 10)

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

SUGGESTED READINGS:

1. Bell, F.G. (1999) Geological Hazards, Routledge, London
 2. Bryant, E. (1985) Natural Hazards, Cambridge University Press
 3. Keller, E.A. (1978) Environmental Geology, Bell and Howell, USA
 4. Patwardhan, A.M. (1999) The Dynamic Earth System. Prentice Hall
 5. Smith, K. (1992) Environmental Hazards. Routledge, London
 6. Subramaniam, V. (2001) Textbook in Environmental Science, Narosa International
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Semester-III (2yr PG)/ Semester-I (1yr PG)

Group A

Course Name: ADVANCED PETROLOGY

Course Code: MSCAGLMCE901

COURSE OBJECTIVES:

This course aims to provide an advanced understanding of the mineralogical, petrographical, geochemical, and thermodynamic processes governing the formation, evolution and transformation of igneous, sedimentary, and metamorphic rocks. The course introduces modern analytical techniques and quantitative approaches used in petrological investigations to interpret mineral assemblages, phase equilibria, pressure–temperature conditions and petrogenetic evolution. It is designed to develop analytical and research skills required for advanced studies in petrology and related geoscientific disciplines.

COURSE LEARNING OUTCOMES:

- Explain advanced concepts of mineralogy and petrology related to the origin and evolution of igneous, sedimentary and metamorphic rocks.
- Describe the principles and applications of modern analytical techniques, including optical microscopy, Electron Probe Micro-Analyzer (EPMA), Scanning Electron Microscopy (SEM) and Raman spectroscopy, in petrological investigations.
- Apply concepts of crystal chemistry, mineral chemistry, stoichiometry, and structural formula calculations to characterize rock-forming minerals.
- Interpret magmatic, sedimentary and metamorphic processes using phase equilibria, mineral assemblages, and geochemical data.
- Evaluate pressure–temperature–time (P–T–t) evolution, fluid–rock interactions, and metamorphic conditions using geothermobarometry and phase equilibrium modelling.
- Explain the principles of isotope geochemistry, thermodynamics and element partitioning in understanding petrogenetic processes.
- Integrate petrographic, mineralogical, and geochemical observations to reconstruct the geological history and evolution of rocks.
- Develop scientific, analytical, and research skills for solving advanced problems in petrology and Earth sciences.

THEORY

Unit 1: Advanced Mineralogy and Petrological Principles

(Lectures – 10)

Advanced concepts in mineralogy and petrology. Crystal chemistry, mineral structures, mineral stability. Modern analytical techniques in petrology: optical microscopy, Electron Probe Micro-Analyzer (EPMA), Scanning Electron Microscopy (SEM), Raman spectroscopy and their applications.

Unit 2: Igneous Petrology and Magmatic Processes (Lectures – 08)

Phase equilibria in binary and ternary systems. Experimental petrology. Evolution of basaltic magmas. Mid-ocean ridge, hotspot and subduction-related magmatism. Large Igneous Provinces. Alkaline rocks, carbonatites, kimberlites, anorthosites and komatiites.

Unit 3: Sedimentary Petrology (Lectures – 04)

Provenance analysis, sediment maturity, sedimentary geochemistry and post-depositional alterations.

Unit 4: Metamorphic Petrology (Lectures – 06)

Phase equilibria and metamorphic transformations. Pressure–temperature–time (P–T–t) paths. Role of fluids in metamorphism. Geothermobarometry and pseudosection modelling.

Unit 5: Quantitative Petrology and Geochemistry (Lectures – 12)

Mineral chemistry and stoichiometry. Structural formula calculations. Chemographic methods. Partitioning of elements between coexisting phases. Introduction to isotope geochemistry. Application of thermodynamics in petrology. Quantitative interpretation of petrological data and reconstruction of petrogenetic evolution.

PRACTICAL(Lectures – 52)

1. Mineral chemical calculations and structural formula determination.
2. Calculation and application of mineral geothermometers and geobarometers.
3. Demonstration and interpretation of data obtained from EPMA, SEM and Raman spectroscopy.
4. Independent petrological investigation and presentation based on petrographic, mineralogical and geochemical datasets.

SUGGESTED READINGS:

1. Winter, John DuNann. *Principles of igneous and metamorphic petrology*. Vol. 2. Harlow, UK: Pearson education, 2014.
2. Sen, Gautam. *Petrology: Principles and practice*. Springer Science & Business Media, 2013.

Course Name: MEDICAL GEOLOGY AND FORENSIC GEOLOGY

Course Code: MSCAGLMCE902

COURSE OBJECTIVES:

- To introduce the relationship between geological processes, earth materials and human health.
- To understand the occurrence, mobility and bioavailability of naturally occurring and anthropogenic toxic elements in the environment.

- To examine the role of geological factors in the distribution of diseases and environmental health hazards.
- To develop knowledge of modern analytical techniques and geospatial tools used in medical geology for hazard assessment and mitigation.
- Understand the role of soil, minerals and microfossils as physical trace evidence.
- Master analytical techniques used to characterize geological evidence.
- Learn the legal frameworks, evidence collection protocols and expert witness standards under the **Bharatiya Nyaya Sanhita (BNS)** and **Bharatiya Sakshya Adhiniyam (BSA)**.

COURSE LEARNING OUTCOMES:

- Explain the principles and scope of Medical Geology and its significance in public health.
- Evaluate the health impacts of essential and toxic trace elements in geological environments.
- Assess geological factors controlling contamination of air, water and soil and their effects on human health.
- Apply analytical and GIS-based techniques for environmental health assessment and mitigation of geogenic hazards.
- Application of earth science techniques to legal investigations, environmental crimes, and law enforcement in India.

Medical Geology

Unit 1: Introduction to Medical Geology (Lectures – 07)

Definition, scope and significance of Medical Geology; history and development of Medical Geology; interaction between geological environments and human health; principles of environmental health; exposure pathways; epidemiological concepts; environmental risk assessment.

Unit 2: Environmental Geochemistry and Trace Elements (Lectures– 09)

Geochemical cycling of elements; bioavailability and biogeochemical pathways; transfer of elements through rocks, soils, water, plants and food chain; health effects of deficiencies and excesses of iodine, selenium, arsenic, fluoride and other trace elements.

Unit 3: Geogenic Hazards and Human Health (Lectures– 08)

Natural dusts and aerosols; volcanic emissions; particulate matter and respiratory diseases; pneumoconiosis; geological occurrence of radon gas and associated health risks; mineralogical characteristics and health impacts of asbestos and fibrous minerals.

Unit 4: Water Resources and Environmental Health (Lectures– 08)

Groundwater quality and hydrogeochemistry; natural groundwater contamination; water hardness and human health; geogenic contaminants in drinking water; geological controls on waterborne diseases; assessment of water quality for public health.

Unit 5: Anthropogenic Impacts on Human Health (Lectures– 08)

Mining and industrial contamination; release and transport of potentially harmful elements (PHEs); soil degradation; soil chemistry and nutrient availability; food security and malnutrition.

Unit 6: Analytical Techniques and Mitigation Strategies (Lectures– 08)

Geochemical sampling and analysis; spectroscopy; X-ray analytical techniques; GIS applications in Medical Geology; spatial mapping of disease distribution and geogenic hazards; remediation and mitigation strategies; environmental management and sustainable practices.

Forensic Geology

Unit 1: Introduction to Forensic Geology (Lectures- 06)

- **Foundations:** Scope, history, and development of forensic geology (from Sherlock Holmes to modern geo-forensics). Locard's Exchange Principle applied to earth materials.
- **Indian Context:** The role of the Central Forensic Science Laboratories (CFSLS) and State FSLs. Overview of geologists as expert witnesses.

Unit 2: Soil as Forensic Evidence (Lectures- 08)

- **Soil Stratigraphy & Dynamics:** Soil horizons, soil formation across Indian climatic zones (e.g., Alluvial, Black Cotton, Laterite soils).
- **Trace Evidence Collection:** Sampling protocols at crime scenes, alibi locations, and control sites. Preventing cross-contamination.
- **Physical Analysis:** Color matching (Munsell charts), particle size distribution (sieving, laser diffraction), and density gradient analysis.

Unit 3: Geo-Analytical Instrumentation (Lectures- 08)

- **Mineralogical Fingerprinting:** Polarizing microscopy for heavy mineral analysis; X-Ray Diffraction (XRD) for clay mineralogy.
- **Chemical Characterization:** Scanning Electron Microscopy with Energy Dispersive Spectroscopy (SEM-EDS) for gunshot residue (GSR) vs. environmental dust; X-ray Fluorescence (XRF) and ICP-MS for trace element sourcing.
- **Organic Evidence:** Palynology (forensic botany) and micropaleontology (diatoms in drowning cases, foraminifera in coastal crimes).

Unit 4: Geo-Exploration & Crime Scene Mapping (Lectures- 12)

- Subsurface Search Techniques: Use of Ground Penetrating Radar (GPR), electrical resistivity, and magnetometry to locate clandestine graves, buried caches, or weapons.
- Remote Sensing & GIS: Utilizing ISRO's Bhuvan data, Google Earth, and GIS mapping to track illegal mining, land encroachment, or cross-border smuggling routes.

Unit 5: Environmental Forensic Geology & Indian Law (Lectures- 07)

- Geo-Crimes in India: Investigating illegal sand mining (mafia operations) in riverbeds, illegal groundwater extraction, and adulteration of gemstone/mineral reserves.
- Legal Frameworks: Overview of the Mines and Minerals (Development and Regulation) Act, National Green Tribunal (NGT) mandates, and presenting geological evidence under the Bharatiya Sakshya Adhiniyam (BSA).

SUGGESTED READINGS

Medical Geology

1. Dissanayake, C.B. and Chandrajith, R., 2009. *Introduction to medical geology*. Springer science & business media.
2. Alloway, Brian, Jose A. Centeno, Robert B. Finkelman, Ron Fuge, Ulf Lindh, and Pauline Smedley. *Essentials of medical geology*. Edited by Olle Selinus. Academic Press, 2005.
3. Prasad, Majeti Narasimha Vara, and Meththika Vithanage, eds. *Medical geology: en route to one health*. John Wiley & Sons, 2023.

Forensic Geology

1. **Ruffell, A., & McKinley, J. (2008).** *Geoforensics*. Wiley-Blackwell. (*The definitive textbook on geological trace evidence*).
2. **Pye, K. (2007).** *Geological and Soil Evidence: Forensic Applications*. CRC Press.
3. **Murray, R. C. (2011).** *Evidence from the Earth: Forensic Geology and Criminal Investigation*. Mountain Press Publishing.
4. **Sharma, B. R. (2020).** *Forensic Science in Criminal Investigation and Trials* (6th ed.). Universal Law Publishing. (*Crucial for understanding the legal landscape of forensic evidence in India*).
5. **Geological Survey of India (GSI).** *Miscellaneous Publications / Training Manuals on Environmental Geoscientific Investigations*.
6. Selected research papers from the *Journal of Forensic Sciences* and *Forensic Science International* regarding soil provenance.

Course Name: REMOTE SENSING IN GEOLOGY

Course Code: MSCAGLMCE903

COURSE OBJECTIVES:

This course aims to provide a comprehensive understanding of the principles and applications of Remote Sensing (RS) and Geographic Information System (GIS) in geosciences. The course introduces the theoretical foundations of electromagnetic radiation, aerial photography, image interpretation, spatial database management and satellite data acquisition. It also emphasizes the integration of RS and GIS for solving geological, environmental, natural resource and socio-economic problems through modern geospatial technologies.

COURSE LEARNING OUTCOMES:

Upon successful completion of this course, students will be able to:

- Explain the fundamental principles, scope and applications of Remote Sensing and GIS.
- Describe the characteristics of the electromagnetic spectrum and its significance in remote sensing data acquisition.
- Interpret the interaction of electromagnetic radiation with the atmosphere and Earth's surface for different wavelength regions.
- Understand the principles of aerial photography, photogrammetry, stereoscopic vision, and aerial photo interpretation.
- Develop and manage spatial databases using raster and vector GIS techniques.
- Perform spatial analysis, data integration, updating, and multilayer analysis in GIS.
- Explain the principles of GPS positioning and geodetic applications.
- Integrate Remote Sensing, GIS, and GPS datasets for geoscientific investigations and decision-making in environmental and socio-economic applications.

THEORY

Unit 1: Fundamentals of Remote Sensing (Lectures – 08)

Definition, scope and purpose of Remote Sensing. Types of Remote Sensing. Digital imagery versus conventional photography. Introduction to remote sensing systems and applications in geosciences.

Unit 2: Aerial Photography and Photogrammetry (Lectures– 02)

Aerial photography: air photographs, scales, photomosaics and stereo-pairs. Types and geometry of aerial photographs. Fundamentals of photogrammetry. Aerial photo interpretation techniques. Recognition of photo elements and terrain elements.

Unit 3: Electromagnetic Radiation and Interaction with Matter (Lectures– 10)

Electromagnetic (EM) spectrum: fundamental concepts and theories. Subdivisions of the electromagnetic spectrum. Basic laws governing electromagnetic radiation and their interrelationships in remote sensing. Common wavelength bands used in remote sensing and their characteristic applications. Role of atmosphere in remote sensing. Atmospheric windows and their significance.

Unit 4: Earth Observation Systems and Data Acquisition (Lectures – 10)

Earth observation platforms and data types; Satellite, airborne and UAV platforms; Passive and active remote sensing; Optical, thermal, microwave sensors; Remote sensing data acquisition; Data products; Geometric and radiometric corrections; Data repositories; Major Earth observation missions and datasets used in Earth Sciences (LANDSAT, MODIS, RESOURCESAT, Sentinel, IRS Series, LISS III & IV, RISAT).

Unit 5: Thermal and Microwave Remote Sensing (Lectures – 10)

Concepts and principles of thermal and microwave remote sensing; Thermal radiation and microwave interaction with vegetation, soil, snow and water; Fundamentals of thermal and microwave data processing; Applications of thermal and microwave and SAR remote sensing in Earth Sciences.

Unit 6: Geographic Information System (GIS) (Lectures– 08)

Introduction to Geographic Information System (GIS). Components of GIS. Data representation. Digitization and scanning. Raster and vector data models. Input and output devices. GIS software and hardware. Database design and structure. Spatial data analysis and cartographic modelling. Data representation and integration techniques. Integrated GIS applications. Data updating, merging and multilayer data products.

Unit 7: Global Positioning System (GPS) and Geospatial Integration (Lectures– 04)

Definition, scope and purpose of GPS. Advantages of GPS. Principles of GPS position determination. GPS receiver types and survey techniques. Geodetic implications. Integration of Remote Sensing, GIS and GPS; Applications of geospatial technologies in geosciences and socio-economic sectors; Remote sensing applications in lithological and structural mapping, mineral and groundwater exploration (case studies).

PRACTICAL (Lectures– 52)

1. Georeferencing of published maps and spatial data.
2. Digitization of georeferenced maps using point, line and polygon vector layers, and spatial data editing.
3. Generation of True Colour Composite (TCC), False Colour Composite (FCC) and pan-sharpened satellite images.
4. Image enhancement, visual interpretation, and computation of spectral indices (NDVI, NDWI and NDSI).

5. GIS database creation using raster and vector data, including spatial analysis and data management.
6. GPS survey, waypoint collection and mapping.
7. Integration of Remote Sensing, GIS and GPS datasets for geoscientific applications.

SUGGESTED READINGS

1. Jensen, J. R. "Remote sensing of the environment: an earth resource perspective, Pearson Education Limited." (2014).
2. Lillesand, Thomas, Ralph W. Kiefer, and Jonathan Chipman. *Remote sensing and image interpretation*. John Wiley & Sons, 2015.
3. Gupta, Ravi P. *Remote sensing geology*. Springer, 2017.

Group B

Course Name: ADVANCED ORE GEOLOGY

Course Code: MSCAGLMCE904

COURSE OBJECTIVE:

The objectives of this course are to: (a) acquaint with common ore minerals and their identifying criteria at various scales of study; (b) demonstrate knowledge of the variety of ore-forming processes; understand the control of ore in different rock association with respect to time and space; (c) modelling ore bearing fluids and fluid rock interaction process; (d) application of geochemistry to derive ore genesis; (e) application of several geochronological methods to determine the ore formation age.

COURSE LEARNING OUTCOME:

- Recognize common ore minerals in hand samples and under microscope.
- To describe the mode of occurrence and paragenesis of ore deposits
- To classify ore deposits based on major ore forming processes
- To apprehend the pattern of distribution of mineral deposits in India.
- To apply geochemistry for explaining ore genesis.
- To apply several geochronological methods to determine the ore formation age.
- To understand different nuclear fuel

THEORY

Unit 1: Spatial and temporal distribution of ore (Lectures- 02)

Metaliogenic province, Metallogenic epoch, plate tectonics and mineral deposits.

Unit 2: Systematic study of ore deposits. (Lectures- 03)

Mode of occurrence of ore deposits, structures and textures in ores, fluid inclusions in ores.

Unit 3: Ore forming processes and ore deposits: (Lectures- 20)

Sedimentary ore forming processes:

Chemical sedimentary deposits; Fe-deposits, Mn-deposits, phosphorites and evaporites.

Clastic sedimentary deposits; placer deposits of Au, ilmenite, rutile, zircon, Sn.

Hydrothermal ore forming processes:

Magmatic hydrothermal ore deposits; pegmatitic ore deposit, porphyry Cu-Mo-W, skarns, epithermal Au deposits.

Sea water hydrothermal ore deposits; VMS-SEDEX continuum.

Metamorphic hydrothermal ore deposits; orogenic gold deposits, conglomerate hosted gold deposits.

Connate water hydrothermal ore deposits; stratiform sediment hosted Cu-deposits(SSC), Mississippi valley type Pb-Zn ores(MVT).

Meteoric water hydrothermal fluid; sandstone hosted U-deposits.

Surficial processes and weathering related ore deposits:

Lateritic ore deposits; bauxite, Ni, Au, PGE.

Supergene ore deposits; Cu-enrichment.

Unit 4: Sulfide and oxide phase equilibria: (Lectures- 08)

Concept of thermodynamic equilibrium and phase rule, standard states, entropy, enthalpy, activity, fugacity and heat capacity. Basic thermodynamic equations.

Sulfide phase equilibria; Fe—S, Fe—Zn—S, Cu—Fe—S systems.

Oxide phase equilibria; FeO—MnO system.

Sulfur isotope thermometry, sphalerite geobarometry.

Unit 5: Metamorphism and ore deposits: (Lectures- 02)

Metamorphogenic ore deposits; origin of aqua-carbonic fluid and related ore deposits.

Metamorphosed ore deposits; changes in texture and mineralogy of ore minerals and gangue minerals.

Unit 6: Non- metallic ore deposits: (Lectures- 02)

Mode of occurrence, lithoassociation and genesis of the following non-metallic minerals(with Indian examples); diamond, graphite, barite, gypsum, phosphorite, mica and asbestos.

Specification of raw materials in the following industry: iron and steel, glass and ceramic, cement and fertiliser.

Unit 7: Important Indian deposits: (Lectures- 03)

Singbhum Cu-U mineralisation, Sausar Mn-deposits, Malanjkhand Cu-deposit, Rajpura-Dariba Pb-Zn deposit, Jawar Pb-Zn deposit.

PRACTICAL (Lectures- 52)

Study of ores under microscope with emphasis on mineralogy, texture, structure and paragenesis

SUGGESTED READINGS:

1. Introduction to Ore-Forming Processes by **Laurence Robb**
2. Ore Deposit Geology by **John Ridley**
3. Economic Geology: Principles and Practice by **Walter L. Pohl**

4. Hydrothermal Ore Deposits: Geochemical Attributes by Biswajit Mishra and Dewashish Upadhyay.
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Course Name: ADVANCED STRUCTURAL GEOLOGY

Course Code: MSCAGLMCE905

COURSE OBJECTIVE:

The objectives of this course are to make students able to understand the rheology and microtectonics, concepts of stress analysis, strain analysis, deformation and rock mechanics; Significance of brittle, plastic and ductile deformation and their products, Origin and mechanisms of faults, fractures, and folds, Processes and fabrics that occur in shear zones and their kinematic significance; Deriving tectonic histories from analysis of geological maps.

COURSE LEARNING OUTCOME:

- Understand the structure of the rocks in the earth's crust and mantle.
- Determine the deformational history based on fabrics and geometric relationships.
- Quantitatively describe stress and strain transformation.

THEORY

Unit 1: Rheology and microtectonics (Lectures-08)

Behaviors of rocks under stress; Rheological models; Flow law for steady state creep; factors influencing flow of rocks; Deformation mechanism; Estimation of paleostress.

Unit 2: Stress and rock mechanics (Lectures- 08)

Basic concept of stress; Analysis of stress in three dimensions (3D); stress field description; equilibrium condition; trajectory patterns and boundary condition.

Unit 3: Quantitative strain analysis (Lectures- 08)

Infinitesimal strain; measurement of strain; progressive deformation; Role of fluid in deformation; Rheology; Stress –Strain curves for elastic, viscous and plastic; poro-elasticity

Unit 4: Mechanism of folding and superposed folding (Lectures-05)

Interpretations of ductile structures: foliation, lineation, boudinage; Structural analysis of deformed terrain

Unit 5: Fracture mechanics. (Lectures- 04)

Dynamics of faulting and jointing

Unit 6: Shear Zones (Lectures- 06)

Grain scale deformation mechanism and its manifestation in microstructure: Solid State Diffusion Creep. Granular flow and Superplasticity Granular flow and Superplasticity.

PRACTICAL (Lectures– 52)

- Interpretation of outcrop patterns of deformed lithounits involving folding and faulting on flat and undulating topography.
- Determination of the relation between major and minor structural elements of deformation through stereographic projection of orientation data.
- Analysis of stress orientation on the basis of fracture data.
- 2D and 3D strain analysis.

SUGGESTED READINGS:

1. *Structural Geology of Rocks and Regions* by George H. Davis, Stephen J. Reynolds, and Charles F. Kluth
2. *An Introduction to Metamorphic Tectonic Processes or Deformation Microstructures* by Paul Passchier and Rudolph Trouw.
3. Billings M.P. (1987). *Structural Geology*, 4th edition Prentice-Hall.
4. Davis, G.H., Reynolds, S.J., and Kluth, C.F. (2012). *Structural Geology of Rocks and Region*. 3rd edition. John Wiley and Sons, Inc.
5. Fossen, H. (2016). *Structural Geology*. Second Edition. Cambridge University Press.
6. Ghosh, S.K (1993). *Structural Geology Fundamentals and Modern Development*. Pergamon Press.
7. Twiss R. J. and Moores E.M. (2007). *Structural Geology*, Second Edition, W.H. Freeman and
8. Company.
9. Ramsay, J.G., 1967. *Folding and fracturing of rocks*. McGraw-Hill.
10. Ramsay, J.G. and Huber, M.I., 1984 & 1987. *The Techniques of Modern Structural Geology* Volume 1 & 2, respectively. Academic Press.
11. Ragan, D. M., 2009. *Structural Geology: an introduction to geometrical techniques*. 4th Edition, Cambridge University Press (For Practical)

Course Name: REMOTE SENSING AND GIS

Course Code: MSCAGLMCE906

COURSE OBJECTIVES

This course aims to provide a comprehensive understanding of the principles, techniques and applications of Remote Sensing (RS), Geographic Information Systems (GIS) and Global Positioning System (GPS) in Earth Sciences. It introduces the theoretical foundations of electromagnetic radiation, aerial photography, photogrammetry, satellite remote sensing, image interpretation and spatial database management. The course further emphasizes the acquisition, processing, analysis and integration of geospatial data for geological mapping, natural resource assessment, environmental monitoring and socio-economic decision-making using modern geospatial technologies.

COURSE LEARNING OUTCOMES

Upon successful completion of this course, students will be able to:

- Explain the fundamental principles, scope and applications of Remote Sensing, GIS and GPS in Earth Sciences.
- Describe the characteristics of the electromagnetic spectrum and its role in remote sensing data acquisition.
- Interpret the interaction of electromagnetic radiation with the atmosphere and Earth's surface across different wavelength regions.
- Explain the principles of aerial photography, photogrammetry, stereoscopic vision and aerial photo interpretation.
- Describe the characteristics of Earth observation platforms, sensors and satellite datasets used in geoscientific investigations.
- Explain the principles of thermal, microwave and Synthetic Aperture Radar (SAR) remote sensing and their applications.
- Develop, manage and analyse spatial databases using raster and vector GIS techniques.
- Perform spatial analysis, data integration, multilayer analysis and cartographic modelling using GIS.
- Explain the principles of GPS positioning, survey techniques and geodetic applications.
- Integrate Remote Sensing, GIS and GPS datasets for geological investigations, environmental monitoring, natural resource management and socio-economic applications.

THEORY

Unit 1: Fundamentals of Remote Sensing (Lectures – 08)

Definition, principles, scope and applications of Remote Sensing. Components of a remote sensing system. Types of Remote Sensing (passive and active). Digital imagery versus conventional photography. Applications of Remote Sensing in Earth Sciences.

Unit 2: Aerial Photography and Photogrammetry (Lectures – 02)

Principles of aerial photography. Types and geometry of aerial photographs. Scale, stereoscopy, stereo pairs and photomosaics. Fundamentals of photogrammetry. Principles of aerial photo interpretation. Image interpretation elements including tone, texture, pattern, shape, size, shadow, association and site.

Unit 3: Electromagnetic Radiation and Interaction with Matter (Lectures – 10)

Fundamentals of electromagnetic (EM) radiation and the electromagnetic spectrum. Basic laws governing electromagnetic radiation and their significance in Remote Sensing. Spectral signatures of Earth surface materials. Atmospheric interaction of electromagnetic radiation.

Atmospheric windows and their significance. Common wavelength regions and their applications in Earth observation.

Unit 4: Earth Observation Systems and Data Acquisition (Lectures – 10)

Earth observation platforms and data acquisition systems. Spaceborne, airborne and UAV platforms. Passive and active Remote Sensing systems. Optical, thermal and microwave sensors. Remote sensing data products. Geometric, radiometric and atmospheric corrections. Data repositories and archives. Major Earth observation missions and datasets used in Earth Sciences including Landsat, Sentinel, MODIS, IRS, Resourcesat, Cartosat, LISS-III, LISS-IV and RISAT.

Unit 5: Thermal and Microwave Remote Sensing (Lectures – 10)

Principles of thermal and microwave Remote Sensing. Thermal radiation, emissivity and land surface temperature. Microwave interaction and radar backscatter from vegetation, soil, snow and water. Introduction to Synthetic Aperture Radar (SAR). Fundamentals of thermal, microwave and SAR data processing. Applications of thermal, microwave and SAR Remote Sensing in Earth Sciences.

Unit 6: Geographic Information System (GIS) (Lectures – 08)

Introduction to Geographic Information Systems (GIS). Components of GIS. Raster and vector data models. Spatial data acquisition through digitization and scanning. GIS hardware and software. Spatial database design and management. Spatial analysis, overlay analysis, buffering, map algebra and cartographic modelling. Data integration, updating, merging and multilayer geospatial analysis. Applications of GIS in Earth Sciences.

Unit 7: Global Positioning System (GPS) and Geospatial Integration (Lectures – 04)

Principles, scope and applications of the Global Positioning System (GPS). GPS segments and position determination. GPS receiver types and survey techniques. Geodetic applications of GPS. Integration of Remote Sensing, GIS and GPS. Applications of integrated geospatial technologies in geological mapping, lithological and structural mapping, mineral exploration, groundwater exploration, environmental monitoring and socio-economic studies.

PRACTICAL (Lectures – 52)

1. Georeferencing of topographic maps and satellite datasets.
2. Digitization of georeferenced maps using point, line and polygon vector layers, followed by spatial data editing.
3. Generation of True Colour Composite (TCC), False Colour Composite (FCC) and pan-sharpened satellite imagery.
4. Image enhancement, visual image interpretation and computation of spectral indices (NDVI, NDWI and NDSI).
5. Creation and management of raster and vector GIS databases, including spatial analysis and cartographic modelling.
6. GPS-based field survey, waypoint collection and geospatial mapping.

7. Integration of Remote Sensing, GIS and GPS datasets for geological, environmental and natural resource applications.

SUGGESTED READINGS

4. Jensen, J. R. "Remote sensing of the environment: an earth resource perspective, Pearson Education Limited." (2014).
5. Lillesand, Thomas, Ralph W. Kiefer, and Jonathan Chipman. *Remote sensing and image interpretation*. John Wiley & Sons, 2015.
6. Gupta, Ravi P. *Remote sensing geology*. Springer, 2017.

Group C

Course Name: PALAEOBIOLOGY

Course Code: MSCAGLMCE907

Course Objective

This course aims to provide students with a comprehensive understanding of the origin and evolution of life, patterns of morphological evolution, taphonomic processes, biodiversity trends, mass extinctions, palaeobiogeography, biostratigraphy, micropalaeontology, palynology, and trace fossils. It emphasizes the application of fossil evidence in reconstructing evolutionary history, palaeoenvironments, palaeoclimate, plate tectonic evolution, and stratigraphic correlation, while developing analytical and interpretative skills in palaeobiology.

Course Learning Outcome

Upon successful completion of the course, students will be able to interpret fossil evidence to understand the evolution and diversification of life, analyze evolutionary patterns and taphonomic processes, evaluate biodiversity changes and mass extinctions, apply palaeobiogeographic and biostratigraphic principles, identify and utilize microfossils, palynomorphs, and trace fossils in geological investigations, and integrate palaeobiological data for reconstructing ancient environments, climates, and Earth history.

THEORY

Unit 1: Early life (Lectures– 04)

Evidence of Precambrian life, Indian occurrences, Origin of hard part, Ediacaran fauna, Cambrian explosion, Burgess Shale fauna, SSF.

Unit 2: Morphodynamics (Lectures– 04)

Patterns of morphological changes in fossil lineages. Modes of evolution, tempo of evolution. Ontogeny: patterns and its role in organic evolution,

Unit 3: Taphonomy (Lectures-03)

Taphonomic processes and how these processes can influence fossilization of an organism

Unit 4: Biodiversity (Lectures-03)

Biodiversity trends in the Phanerozoic, biases for this trend.

Unit 5: Mass Extinctions (Lectures-03)

Mass extinction events, causes, intensities, selective patterns, and recovery from the crisis. Present-day biotic crisis.

Unit 6: Paleobiogeography and plate tectonics (Lectures– 04)

Concept of palaeobiogeography, migration pathway and plate tectonic evolution through time.

Unit 4: Biostratigraphy (Lectures– 08)

Application of fossils in age determination and correlation. Important invertebrate fossils, vertebrate, fossils, plant fossils and microfossils in Indian stratigraphy.

Unit 5: Microfossils (Lectures– 05)

Types of microfossils, environmental significance of microfossils. Use and application of Microfossils. Foraminifera: morphology and evolution;

.Unit 6: Palynology and trace fossils (Lectures– 06)

Application of palynology and trace fossils.

PRACTICAL (Lectures– 52)

1. **Fossil Identification & Taxonomy:** Extensive handling of invertebrate, vertebrate, and paleobotanical specimens to identify diagnostic morphological features.
2. **Micropaleontology & Palynology:** Processing, separating, and identifying microfossils (e.g., foraminifera, pollen) utilized in petroleum exploration and paleoclimatology.
3. Study of ontogenetic growth patterns through biometric analysis.
4. Numerical techniques to study populations.
5. Phenetic and cladistic analysis.
6. **Quantitative Paleobiology:** Using statistical software to model evolutionary rates, construct diversity curves, and analyze phylogenetic relationships.
7. **Biomechanical & CT Analysis:** Applying 3D digital modelling and geometric morphometrics to study fossil locomotion and functional morphology

SUGGESTED READINGS:

1. Clarkson, E. N. K. 2013. Invertebrate Palaeontology and Evolution, Blackwell Science
2. Armstrong, H. A., & Brasier, M. D. (2005) Microfossils. Blackwell Publishing.
3. Arnold, C. A. (2018) An Introduction to Paleobotany. Surjeet Publications

4. Benton, M. J. & Harper, D. A. T. (2016). Introduction to Paleobiology and the fossil record. Wiley
5. Canfield, D. E. & Konhauser, K.O. (2012). Fundamentals of Geobiology, Blackwell.
6. Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution. 4th Edition by Blackwell Publishing.
7. Cockell, C., Corfield, R., Edwards, N. & Harris, N. (2007). An Introduction to the Earth-Life System Cambridge University Press.
8. Cowen, R. (2000). History of Life. Wiley-Blackwell.
9. Doyle, P. 1996. Understanding Fossils: An Introduction to Invertebrate Palaeontology, John Wiley and Sons
10. Lieberman, B. S. & Kaesler, R. (2010). Prehistoric Life-Evolution and the Fossil Record, Wiley Blackwell.
11. Lumine, J. I. (1999). Earth-Evolution of a Habitable World, Cambridge University Press.
12. Ray, A. K. (2008) Fossils in Earth Sciences. PHI Learning
13. Saraswati, P. K. & Srinivasan, M. S. (2016). Micropaleontology: Principles and Applications, Springer International Publishing Switzerland.
14. Shukla, A. C. & Misra, S. P. (1975). Essentials of paleobotany. Vikas Publisher
15. Stanley, S. M. & Luczaj, J. A. (2014). Earth System History (4th Edition), W. H. Freeman (Macmillan)
16. Stewart, W. N. and Rothwell G.W. (2001). Paleobotany and the evolution of plants, Cambridge University Press.
17. Taylor, Edith L., Taylor, Thomas N. & Krings, M. (2009). Paleobotany: The Biology and Evolution of Fossil Plants (2nd Ed.). Academic Press

Course Name: ADVANCED STRATIGRAPHIC PRINCIPLES AND BASIN ANALYSIS

Course Code: MSCAGLMCE908

COURSE OBJECTIVES:

This course aims to provide an advanced understanding of stratigraphic principles and sedimentary basin evolution through the integration of sedimentology, stratigraphy, tectonics and geochronology. The course emphasizes modern concepts of facies analysis, sequence stratigraphy, basin architecture and depositional systems, enabling students to reconstruct basin evolution and interpret the spatial and temporal relationships preserved in the stratigraphic record. It also develops analytical, field-based and research skills required for basin analysis in academic and industrial geoscience.

COURSE LEARNING OUTCOMES:

- Explain advanced stratigraphic principles governing the spatial and temporal distribution of sedimentary successions.
- Describe the origin, evolution, and classification of sedimentary basins in different tectonic settings.
- Interpret lithofacies, facies associations, depositional environments and basin-fill architecture using field and subsurface data.
- Apply concepts of sequence stratigraphy, systems tracts, sea-level fluctuations and accommodation space to stratigraphic analysis.
- Integrate lithostratigraphic, biostratigraphic, chronostratigraphic, magnetostratigraphic and chemostratigraphic data for regional correlation.
- Evaluate the influence of tectonics, climate, sediment supply and eustatic sea-level changes on basin evolution.
- Construct and interpret stratigraphic columns, facies models, correlation panels and geological cross-sections.
- Develop scientific interpretation, field documentation, and research skills for solving advanced problems in stratigraphy and basin analysis.

THEORY

Unit 1: Advanced Stratigraphic Principles (Lectures– 04)

Principles of stratigraphy. Lithostratigraphy, biostratigraphy, chronostratigraphy, sequence stratigraphy, magnetostratigraphy and chemostratigraphy. Stratigraphic correlation.

Unit 2: Sedimentary Facies and Depositional Systems (Lectures– 10)

Facies concepts and facies models. Lithofacies, biofacies and ichnofacies. Facies associations. Continental, transitional and marine depositional systems. Recognition and interpretation of depositional environments.

Unit 3: Sequence Stratigraphy (Lectures– 08)

Sequence stratigraphic concepts. Accommodation space and sediment supply. Relative and eustatic sea-level changes. Systems tracts, sequence boundaries, flooding surfaces and stacking patterns. Applications of sequence stratigraphy in basin interpretation.

Unit 4: Basin Analysis (Lectures– 10)

Classification and evolution of sedimentary basins. Plate tectonic controls on basin formation. Basin subsidence and basin-fill architecture. Provenance analysis. Basin modelling. Basin evolution using sedimentological, stratigraphic and structural data.

Unit 5: Applied Stratigraphy and Basin Modelling (Lectures– 08)

Integration of field observations, well logs, seismic data and geochronological information in basin analysis. Stratigraphic cross-sections and correlation panels. Applications of basin analysis in hydrocarbon, groundwater, mineral and environmental investigations.

PRACTICAL(Lectures– 52)

1. Measurement and preparation of stratigraphic sections and lithologs.
2. Identification and interpretation of lithofacies, sedimentary structures and depositional environments.
3. Preparation of stratigraphic correlation panels and geological cross-sections.
4. Facies analysis and interpretation of depositional systems from outcrop and subsurface data.
5. Sequence stratigraphic interpretation using facies succession and systems tracts.
6. Provenance analysis using petrographic and sedimentological datasets.
7. Preparation and presentation of a basin analysis report based on field and laboratory investigations.

SUGGESTED READINGS

1. Andrew D. Miall – *Principles of Sedimentary Basin Analysis*. Publisher: Springer
2. Philip A. Allen & John R. Allen – *Basin Analysis: Principles and Application*. Publisher: Wiley-Blackwell.

Course Name: GEOHERITAGE AND GEOTOURISM

Course Code: MSCAGLMCE909

COURSE OBJECTIVES:

- Differentiate geotourism from general ecotourism and nature tourism.
- Identify and evaluate National Geological Monuments and potential Global Geoparks in India.
- Design sustainable geotourism itineraries that benefit local communities while preserving geoheritage.

COURSE LEARNING OUTCOME:

Sustainable development, conservation of geoheritage, and marketing India's spectacular geological marvels.

Unit 1: Foundations of Geotourism&Geoheritage (Lectures- 10)

- Definition of geotourism, geodiversity, geoheritage, and geoconservation. The "ABC" calculator (Abiotic, Biotic, Cultural components of landscapes).
- Global Frameworks: UNESCO Global Geoparks network—criteria, status, and international case studies.

Unit 2: India's Geoheritage and National Geological Monuments (Lectures- 12)

- Precambrian & Stratigraphic Wonders: The Lonar Meteorite Crater (Maharashtra); Columnar Basaltic Lava at St. Mary's Island (Karnataka); Stromatolite parks in Rajasthan/Madhya Pradesh.
- Tectonic & Geomorphic Marvels: The Tethyan Himalayan Sequence (Spiti Valley), the Deccan Traps volcanic province, and the Grand Canyon of India (Gandikota, Andhra Pradesh).
- Speleology & Karst Topography: Borra Caves (Andhra Pradesh), KremLiatPrah/Mawsmi Caves (Meghalaya).

Unit 3: Field-Based Geotourism& Itinerary Design (Lectures- 08)

- Developing Geotrails: Designing interpretive panels, self-guided geotrails, and digital maps for tourists.
- Indian Case Studies: Creating a 3–5 day geo-itinerary (e.g., *The Volcanic Trail of the Western Ghats* or *The Stratigraphic Journey of the Spiti Valley*).
- Risk Assessment: Managing tourist safety in rugged terrains (landslide zones, flash flood risks in mountain terrains).

Unit 4: Geoconservation, Policy, and Sustainability (Lectures- 08)

- The Legislative Gap: Current status of geoheritage protection bills in India. The role of the Geological Survey of India (GSI) and INTACH.
- Threats to Geoheritage: Urbanization, unscientific mining, unregulated tourism, and weathering.
- Community-Based Geotourism (CBGT): Involving local indigenous communities (e.g., in Northeast India) as geo-guides to generate sustainable livelihoods.

Unit 5: Digital Geotourism& Marketing(Lectures- 06)

- Virtual Geotourism: Use of 3D virtual outcrops, drone videography, and AR/VR applications for accessible geoheritage.
- Marketing India's Geo-Assets: Rebranding traditional tourism circuits (like the Golden Triangle) to highlight underlying geological landscapes; leveraging social media for citizen science and geo-awareness.

PRACTICAL (Lectures - 52)

The practical component transitions from basic spatial inventory methods to digital public outreach and an essential field evaluation project.

1. **Inventorying Geodiversity:** Utilizing topographic sheets and the Geological Survey of India (GSI) *Bhukosh* portal to identify and document local geological formations, geomorphological features, and landforms.
2. **Applying the "ABC" Assessment Matrix:** Field or desktop evaluation of a chosen Indian site to calculate its Abiotic (geology/climate), Biotic (flora/fauna), and Cultural (history/archaeology/folklore) tourism value.

3. **Designing Interpretive Panels & Graphic Layouts:** Creating a professional, tourist-friendly interpretive signboard for a National Geological Monument (e.g., Lonar Crater or St. Mary's Island). Translating complex geological jargon into accessible, engaging public language.
4. **Geotrail GIS Mapping & Digital Storytelling:** Using Google Earth Pro or QGIS to map out a 4-stop "Geotrail." Embedding multimedia data (photos, descriptions of rock types, structural features) to build a downloadable interactive tourist map.
5. **Carrying Capacity & Risk Assessment Models:** Calculating the *Physical Carrying Capacity (PCC)* and *Effective Carrying Capacity (ECC)* of a vulnerable geosite (e.g., a popular karst cave system in Meghalaya or Andhra Pradesh) to prevent over-tourism. Mapping geo-hazards (landslide zones, flash flood paths) along popular tourist routes.
6. **Mandatory Field Project / Itinerary Pitch:** Designing a comprehensive 3-day geotourism brochure and business proposal for an under-promoted region in India, detailing logistics, community empowerment opportunities, and a strict geoconservation protocol.

SUGGESTED READINGS:

- Dowling, R. K., & Newsome, D. (Eds.). (2018). *Handbook of Geotourism*. Edward Elgar Publishing.
- Geological Survey of India (GSI). (2001). *National Geological Monuments*. GSI Special Publication. (*The primary inventory guide for Indian geoheritage*).
- Reynard, E., & Brilha, J. (Eds.). (2018). *Geoheritage: Assessment, Protection, and Management*. Elsevier.
- Newsome, D., & Dowling, R. (2010). *Geotourism: The Tourism of Geology and Landscape*. Goodfellow Publishers.
- Singh, S. (2021). *Geography of India*. McGraw Hill India. (*Useful for geomorphological and regional context across the subcontinent*).
- Reports and toolkits from the UNESCO Global Geoparks Council regarding framework establishment and local community engagement guidelines.

Course Name: RESEARCH METHODOLOGY WITH AI

Course Code: MSCAGLRMAI901

COURSE OBJECTIVE:

COURSE LEARNING OUTCOME:

Unit1: Introduction to Research (Lectures- 06)

The concept of research, characteristics of good research, Application of Research, Meaning and sources of Research problem, characteristics of good Research problem, Research process,

outcomes, application of Research, Meaning and types of Research hypothesis, Importance of Review of Literature, Organizing the Review of Literature.

Unit2: Types of Research (Lectures- 08)

Types of research, pure (basic, fundamental) and applied research, qualitative and quantitative. Research Design: Meaning, need, types of research design – Exploratory, Descriptive, Casual research Design, Components of research design, and Features of good Research design. Experiments, surveys and case study Research design.

Unit3: Sampling, Data Collection and analysis (Lectures- 10)

Types and sources of data – Primary and secondary, Methods of collecting data, Concept of sampling and sampling methods – sampling frame, sample, characteristics of good sample, simple random sampling, purposive sampling, convenience sampling, snowball sampling, classification and tabulation of data, graphical representation of data, graphs and charts – Histograms, frequency polygon and frequency curves, bell shaped curve and its properties. Statistical Methods for Data Analysis: Applications of Statistics in Research, measures of central tendency and dispersion

Unit4: Research Report (Lectures- 06)

Research report and its structure, journal articles – Components of journal article. Explanation of various components. Structure of an abstract and keywords. Thesis and dissertation. components of thesis and dissertations. Referencing styles and bibliography.

Unit5: Ethics in Research (Lectures- 06)

Plagiarism - Definition, different forms, consequences, unintentional plagiarism, copyright infringement, collaborative work. Qualities of good Researcher.

Unit6: ICT Tools for Research(Lectures- 06)

Role of computers in research, maintenance of data using software such as Mendeley, Endnote, Tabulation and graphical presentation of research data and software tools. Web search: Introduction to Internet, use of Internet and WWW, using search engines and advanced search tools.

Unit 7: AI in research(Lectures- 04)

AI augmented quantitative and qualitative data analysis workflow while identifying data hallucination and bias; Authentic use of AI while writing research article.

PRACTICAL(Lectures- 52)

1. Statistical methods using Excel
2. Plotting of graphs using both excel and origin software
3. Application several softwares to learn the process of checking plagiarism.

Semester-IV(2yr PG)/ Semester-II (1yr PG)

Course Name: LITERATURE RIVEW

Course Code: MSCAGLRD1001

Course Name: DISSERTATION

Course Code: MSCAGLRD1002

MINOR COURSES

Course name: REMOTE SENSING

Course Code: MSCAGLMN701

COURSE OBJECTIVES

This course aims to introduce the fundamental concepts and applications of Remote Sensing (RS) and Geographic Information System (GIS). It provides students with a basic understanding of remote sensing principles, aerial photography, satellite data and GIS techniques for mapping and spatial analysis. The course also highlights the applications of geospatial technologies in geology, environmental studies, natural resource management and disaster management.

COURSE LEARNING OUTCOMES

Upon successful completion of this course, students will be able to:

- Explain the basic principles, scope, and applications of Remote Sensing, GIS, and GPS.
- Describe the electromagnetic spectrum and its role in remote sensing.
- Identify different remote sensing platforms, sensors, and commonly used satellite data.
- Understand the fundamentals of aerial photography, photogrammetry, and aerial photo interpretation.
- Explain the basic concepts of GIS, including raster and vector data models.
- Describe the principles and applications of GPS in surveying and mapping.
- Recognize the role of integrated geospatial technologies in geological, environmental, and natural resource studies.

THEORY

Unit1: Introduction to Remote Sensing (Lectures–08)

Definition, scope and principles of Remote Sensing. Types of Remote Sensing. Electromagnetic spectrum and basic interaction of electromagnetic radiation with atmosphere and Earth's surface. Applications of Remote Sensing.

Unit 2: Remote Sensing Platforms, Sensors and Data (Lectures–08)

Remote sensing platforms and sensors. Satellite and aerial remote sensing. Indian Remote Sensing (IRS) satellites. Introduction to thermal and microwave remote sensing.

Unit 3: Aerial Photography and Photogrammetry (Lectures–06)

Fundamentals of aerial photography. Types and scales of aerial photographs. Basic principles of photogrammetry. Elementary aerial photo interpretation.

Unit 4: Geographic Information System (GIS) (Lectures–10)

Introduction to GIS and its components. Raster and vector data models. Data input, digitization

and database concepts. Basic spatial analysis and map generation. Applications of GIS in geology and environmental studies.

Unit 5: Global Positioning System (GPS) and Geospatial Applications (Lectures–06)

Principles and components of GPS. GPS receivers and basic surveying methods. Integration of Remote Sensing, GIS and GPS. Applications of geospatial technologies in natural resource management, environmental monitoring and disaster management.

PRACTICAL(Lectures - 52)

1. Georeferencing of published maps using suitable Ground Control Points (GCPs).
2. Digitization of georeferenced maps using point, line, and polygon vector layers.
3. Preparation of True Colour Composite (TCC) and False Colour Composite (FCC) from multispectral satellite imagery.
4. Computation and interpretation of basic spectral indices (NDVI, NDWI, and NDSI).

SUGGESTED READINGS

1. Jensen, J. R. "Remote sensing of the environment: an earth resource perspective, Pearson Education Limited." (2014).

Course Name: NATURAL HAZARDS AND THEIR MITIGATION

Course Code: MSCAGLMN702

COURSE OBJECTIVE:

- To provide students an understanding the need for studying the natural hazards management
- Develop an understanding about the various types disasters
- To create awareness about disaster prevention and risk reduction
- To gain knowledge on Climate Change Adaptation

COURSE LEARNING OUTCOME:

- Understand the need and significance of studying disaster management
- Understand the different types of disasters and causes for disasters
- Gain knowledge on the impacts of disasters on environment and society

Unit 1: Natural Hazards: (Lectures-05)

Concepts, Definitions and Types

Unit 2: Mitigation: (Lectures-05)

Concepts and Definitions

Unit 3: Natural hazards and mitigation types.

(Lectures- 05)

Unit 4: Geophysical hazards

(Lectures- 10)

Earthquake, volcanic eruption, landslides, tsunamis.

Unit 5: Hydrological hazards: (Lectures- 05)

Avalanches, floods

Unit 6: Climatological hazards: (Lectures-05)

Extreme temperatures, draughts, wildfires

Unit 7: Meteorological hazards

(Lectures- 05)

Severe storms, cyclones, hurricanes, typhoons and tornadoes.

Unit 8: Biological hazards: Disease outbreaks and epidemics

(Lectures- 04)

Course Name: PALAEONTOLOGY (Minor)

Course Code: MSCAGLMN801

COURSE OBJECTIVE

This course aims to introduce students to the fundamental principles of palaeontology, including fossilization, taxonomy, major fossil groups, vertebrate and plant evolution, and the history of life through geological time. It emphasizes the significance of fossils in understanding biological evolution, stratigraphic correlation, palaeoenvironmental reconstruction, and the influence of geological and climatic processes on the evolution of life.

COURSE LEARNING OUTCOME

Upon successful completion of the course, students will be able to explain the principles of fossilization and taxonomy, identify major fossil groups, describe the evolutionary history of plants and animals through geological time, apply basic concepts of biostratigraphy and micropalaeontology, and interpret fossil evidence for reconstructing past environments and Earth's evolutionary history.

THEORY

Unit 1: Fossils and Fossilization (Lectures – 05)

Nature and significance of fossils; fossilization processes; modes of fossil preservation; exceptional preservation; fossil record and its importance in geological studies.

Unit 2: Taxonomy and Major Fossil Groups (Lectures – 08)

Species concept, taxonomic hierarchy, principles of binomial nomenclature; introduction to major invertebrate fossil groups (Trilobita, Brachiopoda and Mollusca) and their evolutionary and biostratigraphic significance.

Unit 3: Micropalaeontology and Palaeobotany (Lectures – 08)

Introduction to microfossils with emphasis on Foraminifera; significance of microfossils in stratigraphy and palaeoenvironmental studies; introduction to palynology; origin and evolution of land plants; Gondwana flora and its geological significance.

Unit 4: Vertebrate Evolution (Lectures – 10)

Origin and classification of vertebrates; major evolutionary innovations including the evolution of jaws, terrestrial adaptation, amniotes, mammals, dinosaurs, birds, and whales; introduction to human evolution.

Unit 5: Evolution of Life Through Geological Time (Lectures – 11)

Geological Time Scale; Precambrian life; Cambrian Explosion; diversification of marine life during the Palaeozoic; Mesozoic marine and terrestrial faunas; Cenozoic radiation of mammals; major mass extinction events and their impact on biodiversity; relationship between climate, plate tectonics, and the evolution of life.

PRACTICAL (Lectures – 52)

1. Study of fossils showing different modes of preservation.
2. Identification and description of common invertebrate fossils (Brachiopoda, Bivalvia, Gastropoda and Cephalopoda).
3. Identification of selected microfossils (Foraminifera) and their basic morphology.
4. Study of representative plant fossils and their morphology.
5. Study of vertebrate teeth and bones for identification of major vertebrate groups.
6. Preparation of simple taxonomic descriptions and identification keys.
7. Geological Time Scale exercise and stratigraphic distribution of major fossil groups.

SUGGESTED READINGS

1. Armstrong, H. A. & Brasier, M. D. (2005). *Microfossils*. Blackwell Publishing.
2. Clarkson, E. N. K. (2012). *Invertebrate Palaeontology and Evolution* (4th ed.). Wiley-Blackwell.
3. Cowen, R. (2013). *History of Life* (5th ed.). Wiley-Blackwell.
4. Doyle, P. (1996). *Understanding Fossils: An Introduction to Invertebrate Palaeontology*. John Wiley & Sons.
5. Lieberman, B. S. & Kaesler, R. L. (2010). *Prehistoric Life: Evolution and the Fossil Record*. Wiley-Blackwell.
6. Ray, A. K. (2008). *Fossils in Earth Sciences*. PHI Learning.
7. Benton, M. J. (2015). *Vertebrate Palaeontology* (4th ed.). Wiley-Blackwell.
8. Taylor, T. N., Taylor, E. L. & Krings, M. (2009). *Paleobotany: The Biology and Evolution of Fossil Plants* (2nd ed.). Academic Press.

Course Code: GROUNDWATER GEOLOGY(Minor)**Course Code: MSCAGLMN802****Course Objectives:**

Water is a basic life supporting system. The rise in global population and the quest for better living standard has greatly stressed the water resources. The course content primarily focuses on groundwater, which being easily available is amenable to greater exploitation. Thus, this course aims to enable students to acquire knowledge about the physical and chemical attributes, occurrence, movement, and exploration of the groundwater resources.

Course Learning Outcomes:

- The students can access the occurrence of groundwater, water bearing properties of formations, aquifer types and aquifer parameters.
- They can develop an idea about construction, design and development of water wells,

- aquifer parameter estimation and the science of groundwater flow under different conditions.
- The students will use the concepts of groundwater exploration.

THEORY

Unit 1: Introduction and basic concepts

(Lectures – 10)

Scope of hydrogeology and its societal relevance, Hydrologic cycle: precipitation, evapo-transpiration, run-off, infiltration, and subsurface movement of water. Rock properties affecting groundwater, Vertical distribution of groundwater, Types of aquifer, aquifer parameters, anisotropy, and heterogeneity of aquifers

Unit 2: Groundwater flow

(Lectures – 08)

Darcy's law and its validity, Intrinsic permeability and hydraulic conductivity, Groundwater flow rates and flow direction Laminar and turbulent groundwater flow.

Unit 3: Well hydraulics and Groundwater exploration

(Lectures – 10)

Basic Concepts (drawdown; specific capacity etc.), Elementary concepts related to equilibrium and non-equilibrium conditions for water flow to a well in confined and unconfined aquifers.

Unit 4: Groundwater level fluctuations and artificial recharge of groundwater (Lectures – 05)

Unit 5: Groundwater chemistry

(Lectures – 08)

Physical and chemical properties of water and water quality, Introduction to methods of interpreting groundwater quality data using standard graphical plots. Sea water intrusion in coastal aquifers.

PRACTICAL(Lectures – 52)

1. Preparation and interpretation of water level contour maps and depth to water level maps.
2. Study, preparation and analysis of hydrographs for differing groundwater conditions
3. Water potential zones of India (map study)
4. Determination of hydraulic gradient/slope from water table depth data.

SUGGESTED READINGS:

- Todd, D. K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.
- Davis, S. N. and De Weist, R.J.M. 1966. Hydrogeology, John Wiley & Sons Inc., N.Y.
- Karanth K.R., 1987, Groundwater: Assessment, Development and management, Tata McGraw-Hill Pub. Co. Ltd.
- Raghunath, H. M. 1998. Groundwater, New Age International Publishers, New Delhi, 563.
- Fetter, C. W. Applied Hydrology, CBS publisher and distributor.