Syllabus for

M.Sc. (Geology)

National Education Policy-2020

Effective from AY 2025-2026

Department of Geology

Dr. Nityanand Himalayan Research & Study Centre,
Doon University, Dehradun, Uttarakhand A State
Government University as per
Doon University Act 2005

Introduction

In alignment with the National Education Policy (NEP) 2020, this course integrates research projects to cultivate an innovative and independent mindset in students. Geology is fundamentally a field-oriented science where practical skills are paramount. Geologists must be adept at identifying geological structures, assessing rock and soil conditions, and evaluating groundwater resources. These skills are critical for diverse applications, including resource exploration, geotechnical engineering, land-use planning, and disaster mitigation.

This course begins with foundational fieldwork common to all students. Following this, each student will select and develop a research project based on their interests, guided by a faculty mentor. These projects are designed to enhance essential professional skills such as independence, teamwork, and decision-making, preparing students for successful careers in industry, government, and entrepreneurship.

Objectives

1. To enable the students to undertake research projects that are relevant, significant, and futuristic.
2. To apply pre-learned concepts to design a research problem with the help of a literature survey.
3. Enable students to do sufficient groundwork in preparing the outline of a research plan, including grants, infrastructural requirements, and resource procurement.
4. To encourage research culture, which includes exploring collaborative project ideas.

Outcomes

I. Students will do the groundwork for research by identifying a relevant research topic (relevance will be decided based on the subject), identifying the queries, and conducting a literature review.

II. Define well-formulated specific objectives that help develop the overall research methodology,

III. By the end of the semester, the student is expected to compile and communicate the research proposal in the proper format, along with funding components and their justification.

NEP (M.Sc. Geology) COURSE STRUCTURE

Table 1

List of Discipline Specific Core (DSC) Courses

Course Code	Title of the courses	Credit	Sub total	Remark
Semester-I				
GEC-501	Igneous & Metamorphic Petrology	4	16	Core course
GEC-502	Sedimentology	4		Core course
GEC-503	Structural Geology	4		Core course
GEC-504	Mineralogy and Geochemistry	4		Core course
GEC-505	Lab-GEC (501-504)	2	2	Lab work
DSE	Elective Subject	2	2	Core course
SEC	**Seminar/ Presentation**	2	2	Skill Training
	Total No. of credits		**22**	
Semester-II				
GEC-551	Palaeontology	4	16	Core course
GEC-552	Stratigraphy and Himalayan Geology	4		Core course
GEC-553	Remote Sensing and GIS	4		Core course
GEC-554	Geomorphology and Glaciology	4		Core course
GEC-555	Lab-GEC (551-554)	2	2	Lab work
DSE	Elective Subject	2	2	Core course
SEC	**Field Training**	2	2	Skill Training
	Total No. of credits		**22**	
Semester-III				
GEC-601	Engineering Geology and Environmental Geology	4	16	Core course
GEC-602	Economic Geology and Mineral Exploration	4		Core course
GEC-603	Marine Geology	4		Core course
GEC-604	Geohydrology	4		Core course
GEC-605	Lab-GEC (601-604)	2	2	Lab work
DSE	Elective Subject	2	2	Core course
SEC	**Internship**	2	2	Skill Training
	Total No. of credits		**22**	
Semester-IV				
GED-651	Project-oriented dissertation	22	**22**	Dissertation

Discipline Specific Core (DSC): It represents those courses of Geology (Table 1), which would be pursued by a student as a mandatory requirement of his/her programme. These courses will be appropriately graded and arranged across the semesters of study, being undertaken by the student.

Table 2 List of Discipline Specific Elective (DSE) Courses			
S.No.	**Course Code**	**Title of Theory Course**	**Credits**
1	GEE-109	Sequence Stratigraphy and Basin Analysis	2
2	GEE-110	Quaternary Geology	2
3	GEE-111	Gemology	2
4	GEE-112	Geoheritage, Geoparks and Geotourism	2
5	GEE-113	Disaster Management	2
6	GEE-114	Natural Energy Resources	2
7	GEE-115	UAV (Unmanned Aerial Vehicle) Science	2
8	GEE-116	Geomagnetism	2

The Discipline Specific Elective (DSEs): It represents those courses of Geology for which the students have the liberty to choose in different semesters.

SEMESTER -I

GEC-501: IGNEOUS AND METAMORPHIC PETROLOGY

Unit-I: Magma differentiation, fractional crystallization, assimilation, liquid immiscibility; Gibbs Phase rule, Study of phase equilibria in binary (Diopside-Anorthite, Forsterite- Silica, Leucite-Silica, Albite- Anorthite, Orthoclase-Anorthite) and ternary silicate systems (Orthoclase-Albite-Silica, Diopsite-Albite-Anorthite, Diopside-Foresterite-Silica, Fayalite-Leucite-Silica) in the light of modern experimental works.

Unit-II: Texture, Structure and IUGS classification schemes of igneous rocks; Petrogenesis and tectonic setting of major igneous rock types and suites: Ultramafic rocks- komatiite, lamprophyres, kimberlite; Ophiolites, flood basalt, anorthosite, Tonalite-Trondhjemite- Granodiorite (TTG), granitoids, alkaline rocks and carbonatites with special reference to Indian examples.

Unit-III: Mineralogical Phase rule, Types of metamorphism; Texture of regional & contact metamorphic rocks, deformation and metamorphism; Nature and types of metamorphic reactions; Concept and classification of metamorphic facies; Faces series; Graphical representation of minerals in ACF, AKF, AFM and A'F'M' diagrams; Time relation between phases of deformation and metamorphic crystallization.

Unit-IV: Description of metamorphic faces with special reference to their characteristics minerals, mineral assemblages, metamorphic reactions and pressure-temperature conditions of metamorphism. Metamorphism of shale, mafic and calcareous rocks; Isograds and Reaction Isograds; Metamorphic differentiation; Anatexis and origin of migmatites; Paired metamorphic belts.; Geothermobarometry; Pressure-Temperature-Time(P-T-t) paths.

Suggested Readings:

- Phillpotts, A.R. (1994) Principles of Igneous and Metamorphic Petrology, Prentice Hall.
- Best, R. G. (2003) Igneous and Metamorphic Petrology, 2nd Edn., Blackwell.
- Bose, M. K. (1997) Igneous Petrology, World Press, Kolkata.
- Turner, F.J. (1980) Metamorphic Petrology, McGraw Hill, New York.
- Winter, J.D. (2001) An introduction to Igneous and Metamorphic Petrology, Prentice Hall.

GEC-502: SEDIMENTOLOGY

Unit- I: Shape, size, fabric and surface texture of sedimentary rocks; Fluid flow mechanics and formation of sedimentary bed forms. Concept of faces and implication of facies in environmental interpretation and basin analysis. Diagenesis -Physical and chemical processes.

Unit- II: Conglomerates, Petrogenesis of sandstone, problem of greywacke, plate tectonics and sandstone composition, Argillaceous rocks-composition and classification. Dolomites, limestones - their petrographic characteristics.

Unit-III: Walther's law and sedimentary environments. Sedimentary cycles, rhythms and cyclothems. Modern and ancient sedimentary environments. Continental clastic depositional sedimentary models- alluvial, fluvial, lacustrine, aeolian and glacial deposits.

Unit-IV: Transitional and marine sedimentary facies models; deltaic, tidal flats, barrier islands, terrigenous shelves and shallow seas. Carbonate platforms and reefs and sabakhas, Continental rise and ocean basins: Tectonic classification of sedimentary basins.

Suggested Readings:

- Reading H. G. 1996 : Sedimentary Environments and Facies, Blackwell
- Boggs Sam Jr, 1995 . Principles of Sedimentary and Stratigraphy, Prentice Hall
- Collins, J.D., and Thompson. D.B. (1982): Sedimentary Structures, George Allen and Unwin. London.
- Lindholm. R.C. (1987) A Practical approach to Sedimentary, Allen and Unwin, London
- Selley, .C. (2000) Applied Sedimentology, Academic Press.
- Tucker, M.E. (1981) : Sedimentary Petrology: An Introduction, Wiley & Sons, New York.

GEC-503: STRUCTURAL GEOLOGY

Unit-1: Concept of stress and strain. Stress-strain relationships of elastic, plastic and viscous materials. Types of strain ellipses and ellipsoids; their properties and significance. Measurement of strain in deformed rocks; Mechanical principles and properties of rocks and their controlling factors. Theory of rock failure; brittle and ductile deformation.

Unit-II: Mechanics of folding and buckling. Folds geometry, and classification. Superimposed folds and their interference patterns. Analytical methods of determining fold style. Causes and dynamics of faulting. Normal faults and strike - slip faults. Overthrust and nappe within implications to thrust tectonics. Thin skinned deformation and decollement. Salt domes and diapers. Concept of balanced cross sections.

Unit-Ill: Joints, rock cleavage and foliations; their origin, domain character, relationship with major structures and geological significance. Transposed foliations. Linear structures and boudinage; their origin, relationship with major structures and significance. Deformation of linear structures.

Unit-IV: Brittle and ductile shear zones; their geometry, strain pattern, kinematics and significance. Rotation of structural elements. Concept of Petro fabric analysis. Use of stereographic and equal area projections for representing different types of fabric.

Suggested Readings:

- Ramsay J. G, 1967. Folding and Fracturing of Rocks. McGraw Hill.
- Turner F.J and Weiss, L.E., 1963. Structural Analysis of Metamorphic Tectonites McGraw Hill.
- Davis G. R., 1984. Structural Geology of Rocks and Region. John Wiley.
- Ghosh, S. K., 1995. Structural Geology: Fundamentals of Modern Development. Pergamon.
- Valdiya K.S, 1998. Dynamic Himalaya. University Press.

GEC-504: MINERALOGY AND GEOCHEMISTRY

Unit-I: Introduction to space group, space lattice and x-ray crystallography; Structural classification of silicates; Study of following group of minerals with reference to chemical and structural formula, classification, atomic structure, chemistry, physical and optical properties, occurrences: Olivine, Garnet, Epidote, Calcite, Beryl, Pyroxene, Amphibole, Mica, Feldspars, Feldspathoids, Silica and Al silicates.

Unit-II: Pleochroism and determination of pleochroic scheme, Interference figures and determination of optic sign; Extinction; Uniaxial and Biaxial indicatrix and dispersion in minerals. Formation of Uniaxial and Bi-axial interference figures, Mica, Gypsum and Quartz plates; Universal stage and their uses in the determination of optical properties of minerals.

Unit-Ill: Composition of Earth and its constituents (Crust, mantle and core); Ionic and co-ordination number; Rules of ionic substitution, coupled substitution; Distribution coefficient: Capture admission and camouflage, Geochemical classification of elements; Behaviour of major and trace including rare earth elements during magmatic crystallization.

Unit-IV: Near-surface geochemical environment: Eh-pHI diagram; Principle of chemical mass balance and rock- cycle; Chemical weathering of minerals and rocks. Radiogenic isotopes in geochronology and petrogenesis: Rb-Sr, Sm-Nd, -Pb isotopic system.

Suggested Readings:

- Balley, M.. (1981) Mineralogy for students 2nd Edn. Longmans.
- Faure, G. (1986) Principles of Isotope Geology, 2nd Edn., John Wiley.
- Krausko pf, K.B. (1967) Introduction to Geochemistry, McGraw Hill.
- Mason, B. and Moore, C.B. (1991) Introduction to Geochemistry, Wiley Eastern.
- Rollinson. H.R. (1993) Using geochemical data: Evaluation, Presentation, Interpretation, Longman. U.K.

GEC-505: LAB WORK: Lab-GEC-501,502,503,504

Igneous petrology: Megascopic and microscopic studies of major igneous rock types: CIPW non calculation.

Metamorphic Petrology: Study of metamorphic rocks in thin sections with reference to texture/structure, time relation between phases of deformation and metamorphic crystallization, mineralparent rock, metamorphic facies/sub-facies/zones to which rock can be assigned and representation of assemblage in ACF, AKF, AFM and A'F'M' diagrams; estimation of pressure and temperature from important models of Geothermobarometry

Sedimentology: Detailed study of clastic and non-clastic rocks in hand specimens. Study of assemblages of sedimentary structures in context to their palaeo-environment significance. Microscopic examination of important rock types. Heavy mineral separation, their petrographic characters, graphical representation and representation and interpretation. Grain size analysis by sieving method, plotting of size distribution data as frequency and cumulative curves. Computation of statistical parameters and interpretation.

Structural Geology: Study of naturally deformed rocks in hand specimens. Geometrical analysis of folds and faults. Preparation and interpretation of geological maps. Applications of stereographic and equal arcs projections. Strain analysis using software and manually.

Elective Subject (DSE):

SEC: Seminar/Presentation

Students will deliver a presentation related to the problem and research methodology of the dissertation before the faculty members, research scholars and M.Sc. students. The head of the department will constitute a board to evaluate the presentation of the candidate.

SEMESTER-II

GEC-551: PALAEONTOLOGY

Unit I: Theories of origin of life. Organic evolution-Punctuated equilibrium and phyletic gradualism models. Mass extinctions and their causes. Early Precambrian life and Ediacaran fossil assemblage; Ichnology, classification and use.

Unit II: Palaeobiology (palaeoecology, communities, functional morphology and taphonomy); Gondwana flora.

Unit III: Brief morphology, evolution and Classification of Brachiopoda, Mollusca, Cephalopoda, Gastropoda, Bivalvia, Trilobita, Echinoids, Foraminifera, Radiolaria, Ostrocoda and diatoms.; Significance of microfossils in oil exploration.

Unit IV: Evolution of vertebrates with special reference to horse, elephants, man. Dinosaurs and the cause of their extinction.

Suggested Readings:

- Raup and Stanley, Principles of Palaeontology,
- Bilal U. Haq and A. Boersome, Introduction to Marine Micropalaeontology, G.Bignot, Elements of Micropalaeontology,
- David Raup and Stanley (1985). Principles of Palaeontology., CBS Pub., Delhi
- Glaessner, M.F. (1945). Principles of Micropaleontology. Melbourne Univ. Press.
- Schrock, Twenhofel and Williams (1953). Principles of Invertebrate Paleontology. CBS, Delhi

GEC-552: STRATIGRAPHY AND HIMALAYAN GEOLOGY

Unit I: Code of stratigraphic nomenclature. Concept of sequence stratigraphy. Modern methods of stratigraphic correlation. Brief ideas of quantitative, magneto, seismic, chemo, and event stratigraphy. Proterozoic formations of Peninsular - Extra peninsular India.

Unit-II: Collision of India with Asia and the emergence and evolution of the Himalaya and the Himalayan Foreland basin. Introduction and subdivision of the Himalayas; Precambrian-Proterozoic rocks of the Himalaya, their sedimentation, metamorphism and igneous activities; Paleotectonics, palaeogeography and closure of the Tethys Sea.

Unit III: Precambrian life, stratigraphic records of India. Boundary problems: Archean-Proterozoic, Precambrian- Cambrian, Permo-Triassic, Cretaceous -Tertiary, Neogene-Quaternary. In Brief: Paleozoic-Mesozoic and Cenozoic stratigraphy, fossils, Paleogeography, Paleoclimate, Tectonism and economic deposits. Outline of Phanerozoic-type sections of the world.

Unit IV: Cretaceous volcanism and the Himalayan stratigraphy of different tectono-geomorphic units. Quaternary development and Holocene-recent tectonic movements and earthquakes in the Himalaya. Himalayan geochronology and tectonics

Suggested Readings:

- Stratigraphic Principles & Practice, J. Marvin Weller
- Principles of stratigraphy V-2, Amadeus W. Grabau
- Stratigraphy by D.N. Wadia
- Geology of India & Burma by M.S. Krishnan
- Gansser, A., 1959. Geology of the Himalayas.
- Wadia, D., 1973. Geology of India. McGraw Hill Book co.
- Krishnan, M.S., 1982. Geology of India and Burma, 6th Edition. CBS Publ.
- Valdiya, K.S, 1980. Geology of the Kumaon Himalayas. WIHG Publ.
- Valdiya, K.S., 1998. Dynamic Himalya

GEC-553: REMOTE SENSING AND GIS

Unit-1: Definition of' remote. Remote sensing platforms: Air- and space-based.

Unit-Il: Types and characteristics of sensors. Concepts of mono-band, multispectral and hyperspectral remote sensing. Basics of optical, thermal and microwave remote sensing. Concept of LiDAR. Characteristics of IRS sensors.

Unit-Ill: The structure of Digital Image. Conceptual aspects of Digital Image Processing. Basic processes of image rectification, enhancement and classification. Definition and components of Geographic Information System (GIS). Raster and vector data formats. Basic knowledge about data acquisition, manipulation, analyses and representation in GIS.

Unit-IV: Application of remote sensing and GIS in geomorphological investigations, tectonic investigations, lithological mapping, groundwater exploration, mineral exploration, Oil & Gas exploration and geohazard management.

Suggested Readings:

- Lillesand, T.M., Kiefer, R. W. and Chapman, J. (2007): Remote Sensing and Image Interpretation, 6' Edition. Wiley
- Gupta, R. P. (2003). Remote Sensing Geology. 2' Edition. Springer
- Drury, S.A. (1993). Image Interpretation in Geology. 2nd Edition. Chapman & Hall

GEC-554: GEOMORPHOLOGY AND GLACIOLOGY

Unit-1: Definition and scope of geomorphology. Concept of landform – Process relationship in the evolution of landscape. Geomorphic Markers of active tectonics: Planar and Linear. River response to active tectonics. Tectonic modifications of alluvial and bedrock-channeled rivers

Unit-II: Introduction, importance, and implication of glaciological studies, geological action of glaciers; erosional and depositional landforms. Reconstruction of paleoclimatic history. Inventory of Himalayan glaciers, Identification system of glaciers. Glacial Hazards and Their Impact.

Unit-lll: Geomorphic Indices of active tectonics - Morphometric analysis: mountain-front sinuosity, hypsometric curve and hypsometric integral, drainage basin asymmetry, stream length gradient index, and valley-floor width to valley height ratio. overview of GPS system and Radar Interferometry.

Unit-IV: Glacial hydrochemistry. Application of remote sensing techniques in glaciology; Global positioning system, geodetic techniques and Ground penetrating radar. Mass balance studies; Net balance, Ablation, accumulation and snow density measurements, Relationship of mass balance to climate, Snow melt processes.

Suggested Readings:

- Burbank, D.W. and Anderson, R.S. (2011). Tectonic Geomorphology 2nd Edition. Blackwell Science.
- Burbank, D.W. and Anderson, R.S. (2001). Tectonic Geomorphology 1st Edition. Blackwell Science.
- Keller, E.A, and Pinter, N. (1996). Active tectonics: Earthquakes, Uplift, and Landscape. Prentice Hall
- V.F. Petrenko and Robert, W., 1999. Physics of Ice 1st Edition, Kindle Edition
- MM Bennett and N F Glasser, 2009, Glacial Geology: Ice Sheets and Landforms, Wiley
- Jon Erickson, 1996: Glacial Geology, Facts on File
- Peter Martin, Michael E. Brookfield, Steven Sadura, 2001: Principles of Glacial

GEC-555: Lab-GEC-551,552,553,554

Palaeontology: Systematic description of Brachiopoda, Mollusca, Cephalopoda, Gastropoda, Bivalvia, Trilobita, Echinoids. Foraminifera, Radiolaria, Ostrocoda, diatoms and vertebrates. Study of important Gondwana plant fossils.

Stratigraphy & Himalayan Geology: Study of characteristics of stratigraphic rocks of India and their distribution. Study of Paleogeographic maps of Phanerozoic.

Remote Sensing and GIS: Determination of the scale of aerial photographs and imageries. Visual interpretation of aerial photographs and imageries for geomorphological, lithological, tectonic and mapping,

Geomorphology & Glaciology: Calculation of heat balance equation; Exercise on flow movement/discharge; Meteorological and microclimatic parameters; Suspended sediment transport; Interpretation of glacial morphological maps; Exercise on mass balance.

Elective Subject: (DSE)

SEC: Field Training

Students will be required to do the mapping in structurally/lithologically varied terrain under the supervision of minimum 02 faculty members. The field work should be at least of 1 week duration and the students will submit a report of the field training to the department for the evaluation purpose.

SEMESTER - III

GEC-601: ENGINEERING GEOLOGY AND ENVIRONMENTAL GEOLOGY

Unit-I:. Engineering properties of rocks and physical characteristics of building stones and road aggregates. Elementary idea about rock mechanics and soil mechanics. Geological consideration for evaluation of dams and reservoir sites. Reservoir induced seismicity. Dam foundation rock problems. Grouting and Rock bolting. Problem of piping in reservoir areas.

Unit-Il: Fundamental concepts of environmental geology. Environmental protection-legislative measures in India. Greenhouse Gases and Their Environmental Impact; Control Measures and Sustainable Solutions

Unit-Ill: Geotechnical evaluation of tunnels- types, methods and problems. Stress conditions in tunnels. Bridges, their types and causes of their failure. Influence of geological conditions on Building foundation. Mass movement with emphasis on landslide. Causes of hill slope instability and preventive measure

Unit-IV: Geological Hazards and Risk Assessment; Earthquakes, Floods, Landslides, tsunamis. Environmental Impacts of Mining and Industrial Activities. Water Resource Degradation and Contamination. Soil Quality and Degradation.

Suggested Readings:

- Sharma P.V, Environmental and Engineering Geophysics
- Krynine D.P and Judd W.R., Principles of Engineering Geology and Geotechniques
- Bell F.G., Fundamental of Engineering Geology
- Jeger C., Rock Mechanics and Engineering
- Valdiya KS., Environmental Geology
- Keller, E.A.:- Environmental Geology
- Buyant, E.: -Natural Hazards
- Patwarrdhan, A.M.: -The Dynamic Earth System
- Bell, F.G.: -Geological Hazards
- Smith, K.: -Environmental Hazards

GEC-602: ECONOMIC GEOLOGY AND MINERAL EXPLORATION

Unit-1: Mineralization and tectonism; Geological setting, characteristics and genesis of ferrous, base and noble metals. Important process of ore formation. Methods of mineral deposit studies including ore microscopy, fluid inclusions and isotopic systematic. Metallogenic epochs and provinces of India.

Unit-Il: Concept of exploration. Geological, geophysical, geochemical and geobotanical criteria and surface and sub-surface exploration methods. Application of Remote Sensing in mineral exploration. Pitting, trenching, drilling and sampling methods. Methods of petroleum and ground water exploration. Estimation of grade and reserve of ores. Techniques of well logging.

Unit-Ill: Origin, migration and entrapment of petroleum. Properties of source and reservoir rocks. Structural, stratigraphic and combination traps. Petroliferous basins of India. Origin of coal deposits. Classification, rank and grading of coal. Coal resources of India. Gas hydrates, coal bed methane and nuclear mineral resources. Occurrence of mineral resources in the Himalaya.

Unit-IV: Principles of mineral beneficiation. Comminution classification, liberation, concentration. floatation methods, jigging, electromagnetic and magnetic separation, amalgamation, syndication. Strategic, critical and essential minerals. India's status in mineral production. National: Mineral Policy. Substitution and conservation. Mineral concession rules. Marine minerals resources and Law of Sea.

Suggested Readings:

- Craig, J.M. & Vaughan, D.J, 1981: Ore Petrography and Mineralogy-John wiley
- Evans, A.M., 1993: Ore Geology and Industrial Minerals-Blackwell
- Torling, D.H, 1981: Economic Geology and Geotectonies-blackwell Sci publ.
- Mckinstry, H.E., 1962: Mining Geology. I Ed.-Asia Publishing House
- Clark, G.B., 1967: Elements of Mining.III Ed.-John Wiley
- Arogyaswami, R.P.N., 1996: Courses in Mining Geology. IV Ed.-Oxford IBH
- Mason, B.C. (1982). Principles of Geochemistry, Johi. Wilay & Sons.
- Jeffery, G.H, Basett, J., Mendhan, J. and Denney, R.C. (1989). Vogel's text book of
- quantitative Chemical analysis. 5th ed. ELBS.

GEC-603: MARINE GEOLOGY

Unit-I: Definition and Scope of the subject. History of development of Oceanography, Ocean Drilling Programme (OP),and its major accomplishments.

Unit-Il: Ocean Circulation, Surface Circulation, Concept of mixed layers, Thermocline and pycnocline, Concept of upwelling, El Nino, Deep Ocean circulation, Formations of Bottom waters, Water masses of the world oceans and sea sediments (oozes etc.).

Unit-IlI: Palaeoceanography: Approaches to palaeoceanographic reconstructions. Reconstruction of monsoon variability by using marine proxy records. Eustatic Changes.

Unit-IV: Global climate pattern and energy budget, Climate controlling factors. Plate tectonics and climate change Milankovitch cycles, Atmosphere and Ocean interaction and its effect on climate. An overview of Paleoclimatic reconstruction; Pleistocene Glacial-Interglacial cycles; Future climate: Anthropogenic activity and its effect on Global climate.

Suggested Readings:

- Palaeoceanography by J.J. Bhatt
- Ocenography by Savander Singh
- Paleoclimatology: climate through ages by C.. Brooks
- Climate Change in Pre history by W.J. Burrough
- Introduction to Physical Oceanography by R.h. Stewart
- Gross, M.G, 1977. Oceanography: A view of the Earth, Prentice Hall. Hag and Boersma, 1978. Intro duction to Marine Micropalcontology, Elsevier.
- Hasllett, S.K, 2002. Quaternary Environmental Micropalacontology, Oxford University Press, New York.

GEC-604: GEOHYDROLOGY

Unit-I: Hydrological Cycle, Ground Water- origin, type and occurrence. Hydrological properties of rocks- porosity, permeability, specific yield, specific retention, hydraulic conductivity, transmissibility and storage coefficient. Subsurface movement and vertical distribution of Ground Water.

Unit- II: Aquifer and their types. Significance of perched aquifers, Confined and unconfined aquifers. Darcy Law, its range and validity. Springs hydrology.

Unit-Ill: Quality of Ground water: Chemical characteristics of ground water in relation to various uses- domestic, irrigation and industrial purposes. Ground water artificial recharge- methods and factors controlling recharge.

Unit-IV: Geological and geophysical methods of ground water exploration. Ground water management, artificial recharge, ground water legislation and ground water provinces of India.

Suggested Readings:

- Todd, D.K., 1980: Groundwater Hydrology- John Wiley
- Davis, S.N and De Wiest, R.J.M., 1966: Hydrogeology- John Wiley
- Freeze, R.A and Cherry, J.A., 1979: Ground Water- Prentice Hall

GEC-605: Lab-GEC-601, 602,603,604

Engineering & Env Geology: Study of engineering geological maps, preparation of cross sections and description of the terrain. Exercise in calculation of engineering properties of rocks. Problems related to hill slope instability and interpretation of geological maps for landslide problems

Economic Geology & Min Exploration: Study of ores in hand specimen. Geographical distribution of classic ore deposits of India and world. Study of metallic minerals under the reflecting microscope. Tectonic Geomorphology: Exercises on mapping of tectonic geomorphological features and computation of geomorphic indices, using map and remote sensing data. Ore reserve estimation and vetting of easy values. Interpretation of bore hole logs. Interpretation of seismic and resistivity data. Study of gravity data maps and their interpretation.

Marine Geology: Study of modern surface water mass assemblages of various microfossils from different oceans. Depth biotopes and estimation of paleodepth of the ocean using microfossils group. Thermocline and deep surface waters of the modern oceans

Geohydrology: Hydrological properties of rock and soil characteristics- Specific gravity, degree of saturation, moisture content, void ratio, porosity and permeability. Delineation and description of hydro chemical and Ground water provinces of India. Chemistry of ground water.

Elective Subject: (DSE)

SEC: Internship

Students will be required to submit an Internship (of Min. 03 weeks duration) report.

SEMESTER-IV

GEC-651: DISSERTATION

The project-oriented dissertation must be submitted by the end of fourth semester. It's not just a long essay; it's a hands-on research project where you will apply geological principles to investigate a specific problem. This typically involves practical work like:

- Fieldwork: Mapping a geological area, collecting rock/soil/water samples.
- Laboratory Analysis: Studying samples using laboratory techniques.
- Data Modeling: Using softwares to simulate geological processes.

This entire project must be compiled into a formal written thesis and submitted by the end of your fourth semester, making it the final, major academic task of your degree.

Departmental Guide: Each student undertaking dissertation work at an external institution will be assigned a faculty member from the Department of Geology, Doon University. This Departmental Guide will be responsible for the overall academic guidance and assessment of the dissertation.

ELECTIVE COURSES (DSE)

GEE 109: SEQUENCE STRATIGRAPHY AND BASIN ANALYSIS

Unit I: Concept of sequence Stratigraphy. Evolution, order and duration of sequences. Applications and significance of sequence Stratigraphy

Unit II: Concept of facies and basin analysis. Walther's law and sedimentary environments. Sedimentary cycles, rhythms and cyclothems. Modern and ancient sedimentary environments. Continental clastic depositional sedimentary models-alluvial, fluvial, lacustrine, aeolian and glacial deposits.

Unit III: Transitional and marine sedimentary faces models - deltaic, tidal flats, barrier islands, terrigenous shelves and shallow seas. Carbonate platforms and reefs and sabakhas, Continental rise and ocean basins.

Unit IV: Sedimentation pattern and depositional environments of selected undeformed sedimentary basins of India. Himalayan sedimentary basins, Tectonic classification of sedimentary basins.

Course Outcomes: This course enables students to understand the principles of sequence stratigraphy and basin analysis, including the interpretation of depositional sequences, sedimentary facies, and sedimentary environments. Students will develop skills to analyze sedimentary basins, especially those in India, and integrate stratigraphic and tectonic data for reconstructing basin evolution and assessing resource potential.

Suggested Readings:

- Reading H. G. 1996 : Sedimentary Environments and Facies, Balckwell
- Reading H.E and Singh, I.B. 1980 : Depositional Sedimentary Environments, Springer Verlag
- Boggs Sam Jr, 1995 . Principles of Sedimentary and Stratigraphy , Prentice Hall
- Selley .C., 1998. Applied Sedimentology, Academic Press
- Mill, A.D. 2000 : Principles of Sedimentary Basin Analysis, Springer Verlag
- Eirsele, G. 1992 : Sedimentary Basins, Springers Verlag.
- Bhattacharya A and Chakraborti , C .2000 . Analysis of Sedimentary Successions, Oxford and IBH

GEE 110: QUATERNARY GEOLOGY

Unit-I: Importance of Quaternary period and location of Quaternary basin. Oxygen Isotope stratigraphy, biostratigraphy and magneto stratigraphy. Quaternary climates glacialinterglacial cycles, eustatic changes.

Unit-Il: Proxy indicators of paleoenvironmental/' paleoclimatic changes, - land, ocean and cryosphere (ice core studies). Responses of geomorphic systems to climate, sea level and tectonics on variable time scales in the Quaternary.

Unit-Ill: Quaternary dating methods, -radiocarbon, Uranium series, luminescence, aminoacid, relative dating methods. Quaternary stratigraphy of India- continental records (fluvial, glacial, acolian, palaeosols, speleothems and durierust); marine records; continental-marine correlation of Quaternary record.

Unit-IV: Evolution of man and Stone Age cultures. Plant and animal life in relation to glacial and interglacial cycles during Quaternary. Indo-Gangetic Plain, Himalayan glaciations. Climate change and global warming; neotectonics.

Course Outcomes: This course provides students with an understanding of Quaternary climate cycles, stratigraphic methods, and dating techniques. It equips them to interpret paleoenvironmental changes using proxy records and analyze the impact of climate, tectonics, and sea-level changes on geomorphic systems, with special reference to Indian Quaternary records and human evolution.

Suggested Readings:

• D. Q. Bowen, 1978: Quaternary Geology, Pergamon
• R. F. Flint, 1971: Glacial and Quaternary geology
• A.G. Dawson, 1992, Ice age earth. Late quaternary geology and climate. Routledge, London
• Griffith Taylo, 2008: History of Geomorphology and Quaternary Geology

GEE 111: GEMOLOGY

UNIT I: Gemmology – Fundamental concepts, History of gemmology – India as a leader, Minerals – Basic idea about Minerals and Crystals; their Origin, Chemical composition and crystallographic divisions of minerals.

UNIT II: Gemstones – Basic qualities of gemstones, the 4 'C's – Colour, Clarity, Carat and Cut, Differences and similarities between Minerals and Gemstones. Weights and measures, Treatments and Enhancements, Valuation of gemstones.

UNIT III: Gemstone classification – Precious gemstones and Semi-precious gemstones, Gemstone Varieties – Natural, Cultured and imitation, Synthetic and stimulant Gemstones.

UNIT IV: Utility of gemstones, Gemstone and Astrology, Crystal healing, Birthstones – Garnet, Amethyst, Aquamarine, Diamond, Emerald, Pearl, Ruby, Peridot, Sapphire, Opal, aTourmaline, Topaz, Citrine, Turquoise, Zircon, Tanzanite.

Course outcome: This course has been formulated in such a manner that students from all the streams get the basic idea about gemstones, their formation, identification and valuation Presently, minerals, rocks and gemstones are also used for crystal therapy as a branch of medicinal gemmology, hence, this course would offer significant diversity in learning.

Suggested Readings:

- Fritsch, E., & Rondeau, B. (2009). Gemology: The developing science of gems. Elements, 5(3), 147-152.
- Manutchehr-Danai, M. (2005). Dictionary of gems and gemology. Berlin, Heidelberg: Springer Berlin Heidelberg.
- Rossman, G. R. (2009). The geochemistry of gems and its relevance to gemology: Different traces, different prices. Elements, 5(3), 159-162
- Anderson, Basil W.,1990. Gem Testing. Rev. by E. A. Jobbins. 10th ed., Butterworth, London. Anderson.
- Basil W., and James Payne, 1998. The Spectroscope and Gemmology. GemStone Press, Woodstock, VT.
- Campbell Pedersen, Maggie., 2010. Gem and Ornamental Materials of Organic Origin. NAG Press, London.
- Sunagawa, Ichiro., 2005. Crystals: Growth, Morphology and Perfection. Cambridge Universtiy Press, Cambridge.
- Winter, Colin H. 2003. A Students Guide to Spectroscopy. OPL Press, Leatherhead, Surrey.

GEE 112: GEOHERITAGE, GEOPARKS AND GEOTOURISM

UNIT I: Introduction and importance of Geodiversity, Geoheritage, Geoconservation, Geoparks and Geotourism; History of the concept. UNESCO geoparks, Geopark networks across the globe; Geotourism and National geological Monuments.

UNIT II: Geological outcrops and society; Threats to geodiversity; Conservation, protection, maintenance of geological sites and related features of National importance; Conservation of geosites as a tool to protect geoheritage.

UNIT III: Potential geoparks and geosites in India; Rajasthan, Odisha, Karnataka, Andhra Padesh, Madhya Pradesh, Telangana, Tamil Nadu, Kerala, Gujarat, Himachal Pradesh

UNIT IV: Guidelines for selection of Geosites; Geoheritage laws, Role of local, state and national governments; Current status of Geoheritage protection in the country; Global geoheritage and protection laws.

Course Outcomes: India, like any other country, has unique geological and geomorphologic features distributed throughout the country that constitute its geoheritage. Over time, the development process obliterates many of these features, and this loss necessitates the preservation of representative and/or spectacular features that explain the geological process over geological time. Geoheritage has been a neglected feature in India's conservation landscape. Due to the lack of awareness and stringent laws, little effort is being made to preserve these national treasures. Unfortunately, beyond declaration as geological monuments, little else has been done to protect these marvels of nature. There is an immediate need to make the public aware of the country's national treasures.

Suggested Readings

- A Monograph on National geoheritage monuments of India, Indian National Trust for Art and Cultural Heritage, Natural Heritage Division, New Delhi
- Ranawat, P. S., George, S., 2016 Potential Geoheritage & Geotourism Sites in India International Journal of Scientific and Research Publications, Volume 9, Issue 6, June 2019
- Ezzoura Errami, Margaret Brocx (Ed.) 2009. Geoheritage, Geoparks and Geotourism- Conservation and Management Series Springer. P 268.

GEE 113: DISASTER MANAGEMENT

UNIT I: Introduction on Disaster; Different Types of Disaster: A) Natural Disaster such as: flood, drought, cyclone, earthquakes, landslides, GLOF, avalanche, extreme weather events; B) Man-made Disaster such as: Fire, Dam failure, Industrial Pollution, Nuclear Disaster, Biological Disasters.

UNIT II: Disaster Management Act 2005; Prime Minister's 10-point agenda on Disaster Risk Reduction; Sendai Framework on Disaster Risk Reduction; Geo-meteorological hazard risk assessment; Climate change and Geo-meteorological hazard risk; Risk and Vulnerability Analysis: concept and analysis of risk; Risk Reduction; Vulnerability: Its concept and analysis, Strategic Development for Vulnerability Reduction.

UNIT III: Disaster Preparedness: Concept and Nature, Disaster Preparedness Plan, Prediction, Early Warnings and Safety Measures of Disaster; Role of Information, Education, Communication, and Training; Buildings for Seismic Hazards. National Disaster Management involves planning, rehabilitation, damage assessment, community participation, and psychological care.

UNIT IV: Disaster Response: Introduction, Disaster Response Plan Communication, Participation, and Activation of Emergency Preparedness Plan, Search, Rescue, Evacuation and Logistic Management, Role of Government, International and NGO Bodies; Relief and Recovery, Medical Health Response to Different Disasters.

Course outcome: The course outcome of this course is to make aware of both the Natural and Artificial disaster, their management techniques and familiarize the students with the foundations and recent trends in disaster management.

Suggested Readings

- Ahmad, A. (2010): Disaster Management: Through the New Millennium, Anmol Publications, New Delhi.29
- Bryant Edwards (2005). Natural Hazards, Cambridge University Press, U.K.
- Bureau of Indian Standards (2002). Indian Standards: Criteria for Earthquake Resistant Design of Structures, Part I, Fifth Revision.
- Burton, I., Kates, R.W. and White, G.F. (1993). Environment as Hazard, 2nd edition, Guilford Press, New York.
- Goel, S.L., (2006): Encyclopedia of Disaster Management, Deep and Deep Publications, New Delhi.
- Government of India, (2004): Disaster Management in India -A Status Report.
- NDMA (2009): National policy on Disaster Management, http://nidm.gov.in/PDF/policies/ndm_policy2009.pdf.

GEE 114: NATURAL ENERGY RESOURCES

UNIT I: Introduction to Energy Resources; Classification: Renewable and Non-Renewable Energy; Global and Indian energy scenario; Geological controls on energy resources; Energy resource exploration methods

UNIT II: Fossil Fuels: Origin, occurrence, and classification of coal, petroleum, and natural gas; Stratigraphy of Indian coalfields and petroleum basins; Methods of exploration, extraction, and production; Environmental impacts of fossil fuel extraction

UNIT III: Renewable Energy Resources: Solar, wind, hydro, geothermal, tidal, and bioenergy; Geological considerations for renewable energy (e.g., geothermal, hydro); Prospects of renewable energy in India; Integration with sustainable development goals

UNIT IV: Energy Resource Management and Policy: Energy resource conservation and sustainable use; Environmental and socio-economic impacts; National energy policy and legislation; Future energy trends and the role of geoscientists

Course Outcomes: This course enables students to comprehensively understand natural energy resources, including conventional (fossil fuels) and non-conventional (renewable) sources. By the end of the course, students will gain detailed knowledge of the geological formation, exploration techniques, and spatial distribution of coal, petroleum, natural gas, and renewable energy resources such as solar, wind, hydro, and geothermal. The course will also equip students to critically analyze energy extraction and consumption's environmental, economic, and social impacts. Through the study of national policies and sustainability frameworks, students will be able to appreciate the role of geoscientists in responsible energy resource management and policy-making. Furthermore, the course fosters skills in applying geological principles for sustainable energy planning and encourages informed participation in addressing global energy challenges.

Suggested Readings:

- Kumar, D. (2004) – Energy Resources: Conventional and Non-Conventional
- Boyle, G. (Ed.) (2012) – Renewable Energy: Power for a Sustainable Future
- Tissot, B.P. & Welte, D.H. (1984) – Petroleum Formation and Occurrence
- Government of India (Planning Commission, MNRE, etc.) – National Energy Policy and State of Renewable Energy Reports
- Singh, R.M. (2002) – Coal and Industrial Fuels
- Chandra, D. (1992) – Textbook of Coal (Indian Context)

GEE 115: UAV (UNMANNED AERIAL VEHICLE) SCIENCE

UNIT I: Fundamentals of UAV Technology: Introduction to UAVs: classifications, components, and specifications; Types of sensors: RGB, multispectral, thermal, LiDAR; Flight planning and mission design; UAV regulations, safety, and licensing in India (DGCA guidelines)

UNIT II: UAV Data Acquisition and Processing: Survey techniques using UAVs; Georeferencing and GPS integration; Structure-from-Motion (SfM) photogrammetry; 2D and 3D model generation: orthomosaics, DEMs, point clouds

UNIT III: Applications of UAVs in Geology: Geological and geomorphological mapping; Landslide and fault zone monitoring; Mineral exploration and quarry mapping; Coastal, fluvial, and glacial terrain studies using UAV data

UNIT IV: Data Analysis, Integration, and Interpretation: Integration of UAV data with GIS and remote sensing; Time-series analysis and change detection; Case studies in terrain analysis, erosion monitoring, and hazard assessment; Limitations, ethical issues, and future trends in UAV use in geosciences

Course Outcomes: Upon completing this course, students will gain practical and theoretical knowledge of UAV technology and its wide-ranging applications in the geosciences. They will understand the components, flight operations, and regulations governing drone use in India. The course will train students in UAV-based data acquisition, photogrammetry, and 3D model generation, equipping them to conduct high-resolution geological and geomorphological mapping. Through real-world examples and software practice, students will learn to integrate UAV-derived datasets with GIS and remote sensing tools for comprehensive geological analysis. The course will also promote awareness of current limitations, data ethics, and emerging trends in UAV use for geoscientific research and fieldwork.

Suggested Readings / Reference Books

- Colomina, I., & Molina, P. (2014) – Unmanned Aerial Systems for Photogrammetry and Remote Sensing – ISPRS Journal
- Sankey, T.T. & James, M.R. (2021) – Drones in Geosciences: From Research to Practice – Springer
- Perrone, A., et al. (2020) – UAVs for Geomorphological and Geological Mapping – Elsevier Chapters
- DGCA India Guidelines (Latest Edition) – Civil Aviation Requirements for RPAS (Drone Rules 2021)
- Gomez, C. & Purdie, H. (2016) – UAV-Based Remote Sensing in Geomorphology: A Review – Earth-Science Reviews

GEE 116: GEOMAGNETISM

Unit I: Fundamentals of Geomagnetism**:** Nature and origin of Earth's magnetic field; Geomagnetic elements and their global distribution**;** Geomagnetic poles and magnetic equator**;** Temporal variations: secular, diurnal, and magnetic storms**;** Geodynamo theory

Unit II: Paleomagnetism and Magnetic Stratigraphy: Remanent magnetization in rocks: TRM, CRM, VRM; Apparent polar wander paths (APWP) and plate reconstructions; Magnetic reversals and the magnetic time scale; Use of paleomagnetism in stratigraphy, tectonics, and dating; Marine magnetic anomalies and seafloor spreading

Unit III: Rock Magnetism and Magnetic Properties: Magnetic minerals and their properties; Magnetic susceptibility, coercivity, and saturation magnetization; Magnetic domains and hysteresis; Laboratory techniques in magnetic studies; Environmental magnetism

Unit IV: Applied Geomagnetism**:** Magnetic methods in geophysical exploration**;** Instruments: magnetometers (proton precession, fluxgate, etc.)**;** Field procedures and data reduction**;** Case studies: ore bodies, tectonic structures, archaeological sites**;** Magnetic anomalies in India and their geological significance

Course Outcomes: This course equips students with a comprehensive understanding of the Earth's magnetic field and its geological applications. Students will learn about geomagnetic principles, the behavior of magnetic minerals in rocks, and the role of paleomagnetism in reconstructing Earth's tectonic and stratigraphic history. They will gain hands-on knowledge of magnetic properties and techniques used in laboratory and field investigations. The course also covers the use of magnetic methods in geophysical exploration and the interpretation of magnetic anomalies. By the end of the course, students will be prepared to apply geomagnetic concepts in research, exploration, and environmental studies.

Suggested Readings

- **Merrill, R.T., McElhinny, M.W., & McFadden, P.L. (1998)** – *The Magnetic Field of the Earth: Paleomagnetism, the Core, and the Deep Mantle* – Academic Press
- **Butler, R.F. (1992) –** *Paleomagnetism: Magnetic Domains to Geologic Terranes* – Blackwell Scientific
- **Tarling, D.H. (1983)** – *Paleomagnetism: Principles and Applications in Geology, Geophysics and Archaeology* – Chapman and Hall
- **Telford, W.M., Geldart, L.P., & Sheriff, R.E. (1990)** – *Applied Geophysics* – Cambridge University Press
- **Subrahmanyam, A.S. & Verma, R.K. (1982)** – *A Textbook of Geophysics* – Tata McGraw-Hill