

# Himalayan Garhwal University Uttarakhand (India)



## A STUDY AND EVALUTION SCHEME OF MASTER OF SCIENCE OF GEOLOGY

**M.Sc. (Geology)**

**Academic Session 2017-18 onwards**

### SUMMARY

Programme	M.Sc. (Geology)
Duration	Two year (Four Semester)
Medium	English

# **HIMALAYAN GARHWAL UNIVERSITY UTTARAKHAND**

## **SYLLABI**

### **DEPARTMENT OF GEOLOGY**

#### **M.Sc. Geology Course (4 – Semester)**

#### **Effective from session 2017-18**

Candidates who have passed the three years B.Sc. examination with Geology as one of the major subject, or earned prescribed number of credits for a undergraduate degree through the examinations conducted by a University / autonomous institution or possesses such qualifications recognized by the HGU as equivalent to an undergraduate degree, will be considered eligible for admission to the 4 – semesters M.Sc. course in Geology.

The M.Sc. course in geology shall be imparted to the students for two academic sessions consisting of four semesters. The odd semesters (1 & 3) will run from July to November and even semesters (2 & 4) December to April. Candidates will be examined and evaluated at the end of each semester in the different courses of theory and practical as per the marks given against each course. A semester shall normally extend over a period of 15 weeks i.e. 90 days and each week shall have 30 hours of instruction including lab / field work as applicable.

The core courses will be compulsory for all the students admitted to M.Sc. geology. There will be 13 core papers, 4 practical, 02 elective and 01 dissertation covering major branches of geology, and two sessions of field training of 2 – 3 weeks duration, which are compulsory for all the students. The field training and the viva voce examinations will be conducted by at least two internal examiners during 2 & 4 semesters, 70% marks are allotted for lab work / report / thesis evaluation and 30% marks for viva voce / sessional / seminar presentation. The semester break can also be utilized for the geological field training.

The area of dissertation will be assigned to the students at the end of second semester. The final report must be submitted by the end of fourth semester with a seminar presentation before the faculty members and one examiner for the purpose of evaluation. The dissertation shall be of 100 marks and shall be evaluated jointly by an internal and the external examiner for seminar presentation / viva voce. The sessional work is related to dissertation and to be awarded by the supervisor.

The details of courses, semester schedule, credits and maximum marks for each course are given below.

# HIMALAYAN GARHWAL UNIVERSITY UTTARAKHAND

## M.Sc. Geology Course (4-Semester)-2017-2019

### Marks Evaluation

#### **Semester-1**

<b>Course No.</b>	<b>Title of the Courses</b>	<b>Theory</b>	<b>Sessional</b>
MGY-001	General Geology and Geotectonics	70	30
MGY-002	Geomorphology	70	30
MGY-003	Structural Geology	70	30
MGY-004	Crystallography and Mineralogy	70	30
MGY-005	Practical	70	30
	Total		500

#### **Semester-2**

<b>Course No.</b>	<b>Title of the Courses</b>	<b>Theory</b>	<b>Sessional</b>
MGY-006	Palaeontology	70	30
MGY-007	Stratigraphy	70	30
MGY-008	Igneous Petrology and Geochemistry	70	30
MGY-009	Sedimentary and Metamorphic Petrology	70	30
MGY-010	Practical	70	30
	Total		500

#### **Semester-3**

<b>Course No.</b>	<b>Title of the Courses</b>	<b>Theory</b>	<b>Sessional</b>
MGY-011	Economic Geology-Processes and Distribution	70	30
MGY-012	Mineral Exploration and Mining Geology	70	30
MGY-013	Engineering Geology	70	30
MGY /E-001	Marine Geology; Himalayan Geology, Glaciology (any one)	70	30
MGY-014	Practical	70	30
	Total		500

#### **Semester-4**

<b>Course No.</b>	<b>Title of the Courses</b>	<b>Theory</b>	<b>Sessional</b>
MGY-015	Geohydrology	70	30
MGY-016	Remote Sensing and GIS	70	30
MGY /E-002	Quaternary Geology; Advance micropaleontology, Paleoseismology (any one)	70	30
MGY-017	Practical	70	30
MGY-018	Project oriented Dissertation	70	30
	Total		500
	Grand Total	(1400+600) =	2000

# **HIMALAYAN GARHWAL UNIVERSITY UTTARAKHAND**

## **Detailed syllabus of M.Sc. Geology**

### **SEMESTER-1**

#### **MGY-001: General Geology and Geotectonics**

**Unit-I:** Milky Way and the solar system, universe; Earth's orbital parameters, Size and shape of the earth; Modern theories on the origin of the Earth and other planetary bodies; Interior of the earth and age of earth; radioactive isotopes and their applications in earth sciences.; Geological Time Scale. Theories about the origin of life, atmosphere and hydrosphere; Meteorites;

**Unit-II:** Earth's gravity and magnetic fields; Isostasy. Palaeomagnetism; Continental drift; Seafloor spreading; Concept of plate tectonics (evidences and objections), types of plate boundaries and associated important geological features like oceanic trenches; volcanic arcs; mid-ocean ridges, magnetic anomaly stripes and transform faults; Island arcs.

**Unit-III:** Orogeny and epirogeny; Volcanoes- causes and products, volcanic belts; Earthquakes-causes, measurements and effects. Seismic belts of the earth. Seismic zones of India; Rift valley. Lineament; Craton, Shields, platform and mobile belt.

**Unit-IV:** Principles of Geodesy; Global Positioning System (GPS) and its application in crustal motion monitoring including neotectonics; Palaeoposition of India and Geodynamics of the Indian plate; Continental shield areas and mountain chains.

#### **Books recommended**

1. Halis, J.R. (1983): Applied Geomorphology.
2. Sharma, H.S. (1990): Indian Geomorphology, Concept Publishing Co. New Delhi.
3. Agrawal, L. C. Introduction to Geomorphology.
4. Gass, I.G. et al. (1982): Understanding the Earth, Artemis Press (Pvt.) Ltd. U.K.
5. Windley, B. (1973): The Evolving continents, John Wiley & Sons publ.
6. Condie, Kent. C. (1982): Plate Tectonics & Crustal Evolution, Pergamon Press.

#### **MGY-002: Geomorphology**

**Unit-I:** Development, scope; Basic concepts of geomorphology; Denudational processes; Weathering and erosion; Evolution of slopes; Role of lithology, peneplanation, endogenous and exogenous forces responsible for landscape evolution; Concept of tectonic geomorphology; **Unit-II:** River forms and processes – stream flow, hydrographs; River and drainage basin: Drainage pattern, network characteristics, Valleys and their development, processes of river. Erosion, transportation and deposition of fluvial, coastal, glacial, karst, lacustrine and aeolian landforms.

**Unit-III:** Geomorphic cycles and their interpretation. Submarine relief. Geomorphic indicators of neotectonic movements: Stream channel morphology changes, drainage modifications, fault reactivation topography, Uplift – subsidence pattern in coastal areas; their characteristics and development, fluvial processes on hill slopes.

**Unit-IV:** Geomorphology and topographic environmental change– causes, effects on processes and landforms and rejuvenation of landforms. Ice ages; Applied Geomorphology and its application.

#### **Books recommended**

1. Thornbury, W.D. (1980): Principle of Geomorphology, Wiley Eastern Ltd. New York.
2. Holmes, A. (1992): Holmes Principles of Physical Geology, Chapman & Hall publ.

3. Gass, I.G. et al. (1982): Understanding the Earth, Artemis Press (Pvt.) Ltd. U.K.
4. Windley, B. (1973): The Evolving continents, John Wiley & Sons publ.
5. Condie, Kent. C. (1982): Plate Tectonics & Crustal Evolution, Pergamon Press.
6. Patwardhan, A.M., 1999. The Dynamic Earth System, Prentice Hall.
7. Bull, William B., 2007. Tectonic Geomorphology of mountains. Blackwell publication.
8. Bull, William B., 2009. Tectonically active landscapes. Wiley-Blackwell publication.
9. Burbank, D. W. and Anderson, Robert, S., 2001. Tectonic Geomorphology. Blackwell Publ.

### **MGY-003 Structural Geology**

**Unit-I:** Scope and importance of structural geology, Stratum contours and isopach maps. Geological mapping and map reading. Concept of stress, strain and their ellipsoid. Stress-strain relationships of elastic, plastic and viscous materials; Strain markers in deformed rocks. Measurement of strain; Mohr circle. Different types of failures and sliding criteria. Top and bottom criteria.

**Unit-II:** Geometry and classifications of folds, and faults; Mechanism of folding, faulting and progressive deformation. Geometry and mechanics of fracturing and conditions for reactivation.

**Unit-III:** Major tectonic features and associated structures in extensional -, compressional -, and strike-slip-terrenes. Shear Zones: Brittle and ductile shear zones, geometry and products of shear zones; Mylonites and cataclasites, their origin and significance.

**Unit-IV:** Foliations, lineation, L-, L-S-, and S-tectonic fabrics. Joints, Unconformities. Superposed deformation. Unconformities and basement-cover relations. Use of stereographic and equal area projections.

### **Books recommended**

1. Davies, A.Z.: Structural Geology.
2. Ghosh, S. K.: Structural Geology, Fundamental and Modern Concepts, Pergamon Press.
3. Ramsay J. G. (1967): Folding and fracturing of Rocks, McGraw Hill Pub.
4. Ramsay J.G. & Huber M. I. (1983): The Techniques of Modern Structural Geology-I, Strain Analysis, Academic Press.
5. Ramsay J.G. & Huber M. I., (1987): The Techniques of Modern Structural Geology-II, Strain Analysis, Academic Press.
6. Hobbs, B.E., Means, W.D. & Williams, P.F. (1976): An outlines of Structural Geology, John Wiley and Sons publ.
7. Turner, F.J. & Weiss, L.E. (1963): Structural analysis of Metamorphic Tectonites, McGraw Hill publ.

### **MGY-004 Crystallography and Mineralogy**

**Unit-I:** Scope and application of crystallography. Symmetry Elements, Hermaun Muguin notation Concept of point group, space lattice, space group, Derivation of 230 space groups. Bragg' law, X-ray crystallography, Lattice defects.

**Unit-II:** Classification of crystals into systems and their classes of symmetry. Derivation and description of 32 classes. Crystal projections, Twinning.

**Unit-III:** Physical, Electrical, magnetic and chemical characters of minerals; Classification of silicates; Behavior of isotropic and anisotropic minerals in polarized light, cross nicol and conosopic condition, refractive index, double refraction, extinction angle, birefringence, sign of elongation, interference figures, dispersion. Pleochroic scheme and determination of fast and slow vibration directions. Universal stage.

**Unit-IV:** Crystal chemistry and chemical bonds, ionic radii, coordination number (CN) and polyhedron. Physical and optical characters of mineral groups: Olivine, pyroxene, amphibole, garnet, mica, spinel, feldspar, quartz, feldspathoid, zeolite, aluminum silicate, epidote, apatite, tourmaline, talc, fluorite, corundum, scapolite, sphene, zircon, beryl and gem stones.

#### **Books recommended**

1. Sands, D.E. (1975): An Introduction to Crystallography, W.A. Benjamin Inc., N. Y.
2. Phillips, F.C.: Introduction to Crystallography.
3. Evans, R.C. (1964): Introduction to Crystal Chemistry, Cambridge Uni. Press.
4. Dana, E.S. & Ford, W.E.: A Text book of Mineralogy, Wiley Eastern Ltd.
5. Berry, L.G., Mason, B. & Dietrich, R.V.: Mineralogy, CBS Publishers.
6. Kerr, P.F.: Optical mineralogy, McGraw Hill publ.
7. Moorhouse, W.W.: Optical Mineralogy.
8. Pearson: Mineralogy
9. Dear, Howie and Zussman:- Mineralogy

#### **MGY-005 Practical**

**General geology and Geotectonics:** Study of various models related to- Origin, age and interior of earth, volcano, earthquake, active tectonics. (15 marks)

**Geomorphology:** Analysis of geomorphological features from various morphogenetic regions of India; preparation of geomorphological maps on different scales (1:1,00,000 & 1: 50,000); Preparation of longitudinal and cross valley profiles; Altimetric analysis, hypsometric analysis, Morphometry of drainage basins; (15 marks)

**Structural Geology:** Preparation and interpretation of geological maps and sections; Structural problems concerning economic mineral deposits. (15 marks)

**Crystallography and Mineralogy:** Crystal model and projection; Study of minerals in hand specimen and microscopic study of rock forming minerals using optical accessories. (15 marks)

**Laboratory records:** (10 marks)

**Viva-voice:** (10 marks)

### **SEMESTER 2**

#### **MGY-006 Palaeontology**

**Unit-I:** Modes of preservation of fossils and taphonomic considerations, condition for fossilization, Relationship of paleontology with different branches of geology. Dating of fossils. Use of paleontological data in a) Stratigraphy, b) Palaeoecology and evolution. Trace fossils.

**Unit-II:** Major evolutionary theories of organic evolution; Mass extinctions events and their causes. Environmental significance of fossils and Palaeoecology. Paleobiogeography. Early Precambrian life and Edicaran fossil assemblages. Evolution of the fossil record through geological time scale. Gondwana flora.

**Unit-III:** A brief study of morphology, classification, evolutionary trends and distribution of trilobite, graptolite, coral, bivalves, cephalopodan, gastropods, echinoids, Mollusca and brachiopods.

**Unit-IV:** Study of microfossils- foraminifera, ostracoda, conodonts, nannofossils, ichnofossils, radiolarian and diatoms and their significance. Evolution of vertebrate with special reference to horse, elephant, man, dinosaurs.

### **Books Recommended**

1. Clarkson, E. N.K. (1998): Invertebrate Paleontology and Evolution.
2. Smith, A.B. (1994): Systematic and fossil record- Documenting Evolutionary patterns.
3. Protheno, D.R. (1998): Bringing fossils to life- An introduction to Paleontology, McGraw Hill publ.
4. Boardman, R.S., Cheetham, A.M. & Rowell, A.J. (1988): Fossil Invertebrate, Black well.
5. Stearn, C.W. & Carroll, R.L. (1989): Paleontology-the record of life, John Willey publ.
6. Shrock, R.R. & Twenhoffel, W.H., 1952. Principles of Invertebrate Paleontology. CBS Publ.
7. Swinerton, HH., 1961. Outlines of Paleontology. Edward Arnold Publishers
8. Jain, P.C. & Anantharaman, M.S., 1983. Paleontology: Evolution & Animal Distribution. Vishal Publ.
9. Lehmann, U., 1983. Fossil Invertebrate. Cambridge Univ. Press.
10. Rastogi, 1988. Organic evolution. Kedrnath and Ramnath Publ.
11. Michael Benton 2004. Vertebrate Palaeontology, 3rd Edition. Wiley-Blackwell.

### **MGY-007: Stratigraphy**

**Unit-I:** Scope, development and interrelation of stratigraphy; Principles of Stratigraphy; Types of Stratigraphy- litho, bio, chrono, event, sequence, seismic and magneto and their interrelationships. Concept of lithofacies and biofacies; Lithostratigraphic, chronostratigraphic and biostratigraphic subdivisions. Methods for paleogeographic reconstruction.

**Unit-II:** Geological Time Scale. Major boundary problems- Cambrian/Precambrian, Permian/Triassic, Cretaceous/Tertiary and Pliocene-Pleistocene; Paleogeography and igneous activity in the Indian subcontinent in the geological past. Stratigraphy and geochronology of the Archaean cratonic nuclei, mobile belts and tectonic framework.

**Unit-III:** Proterozoic/ Precambrian stratigraphy of India: -tectonic framework, geological history and evolution of sedimentary basins. Precambrian mobile belts.

**Unit-IV:** Study of stratigraphic distribution and lithology of Phanerozoic rocks of India; Paleozoic and Mesozoic formations of India with special reference to type localities, history of sedimentation, fossil content. Gondwana Supergroup. Cenozoic stratigraphy: Deccan Volcanics, Siwalik basin and Indogangetic plains.

### **Books recommended**

1. Krumbein, W. C. & Sloss, L.L. (1963): Stratigraphy and sedimentation.
2. Freeman, W. H. & Kummel, Co. (1961): History of the earth.
3. Hollis D. Hedbug (Ed.) International stratigraphic guide. John Wiley and Sons Pub.
4. Schoch, Robert, M. (1989): Stratigraphy-Principles & Methods, Van Nostrand Reinhold, New York.
5. Krishnan, M.S. (1982): Geology of India & Burma, C.B.S. Publishers & Distributors, Delhi.
6. Valdiya, K.S. (2009): The Making of India: Geodynamic Evolution. Macmillan Publishers.
7. Biyani A.K. 2006. Dimensions of Himalayan. SSPH, Delhi
8. Danbar, C.O. & Rodgers, J. (1957): Principles of Stratigraphy, John Wiley & Sons.
9. Naqvi, S.M. & Rogers, J.J.W. (1987): Precambrian Geology of India, Oxford Univ. Press.
10. Wadia, D., 1973. Geology of India. Mc Graw Hill Book co.
11. Ravindra Kumar, 1985. Fundamentals of Historical Geology & Stratigraphy of India. Wiley Eastern.

### **MGY-008: Igneous Petrology & Geochemistry**

**Unit-I:** Generation and crystallization of magmas, Crystallization of albite- anorthite, diopside-anorthite systems; Magmatic evolution and differentiation: Petrogenetic significance of the textures and structures of igneous rocks. Magma-mixing, -mingling and immiscibility.

**Unit-II:** Classification of igneous rocks: Mode, CIPW norm, IUGS and other standard classifications; Magmatism and tectonics. Origin of magmas: Inter-relationship between tectonic settings and igneous rock suites.

**Unit-III:** Igneous rocks- mineralogy, petrogenesis and distribution of Ultramafic rocks: Dunite-peridotite-pyroxinite suite; kimberlitic, lamprophyres, lamproites, komatiites; Basic rocks: Gabbro, Dolerites; Basalts and related rocks; Intermediate rocks: Diorite-monzonite-syenite suite; Andesites and related rocks; Acidic rocks: Granite-syenite Rhyolites and related rocks; Alkaline rocks: Carbonatites; Ophiolite suite. Deccan volcanic province.

**Unit-IV:** Geochemistry – definition and scope, cosmic abundance of the elements, geochemical classification of the elements, geochemical structure of the Earth, meteorite and their classification; Geochemical cycles. Isotope Geochemistry.

#### **Books recommended**

1. Gupta, A.K. (1998): Igneous Rocks Allied Publishers Ltd., New Delhi.
2. Jackson: Textbook of lithology.
3. Winter, J.D. (2001): An Introduction to Igneous and Metamorphic Petrology
4. McBirney, A.R. (1984): Igneous Petrology, Freeman Cooper & Co. California.
5. Phillips A.: Introduction to igneous and metamorphic petrology, Prentice Hall Pub.
6. Turner, F.J. & Verhoogen, J.: Igneous & Metamorphic petrology CBS Publications.
7. Bose, M.K. (1997): Igneous Petrology, World Press, Kolkatta.
8. Best, Myron G. (2002): Igneous and Metamorphic Petrology, Blackwell Science.
9. Blatt, Harvey; Tracy, Robert J.; Owens, Brent (2005), Petrology: igneous, sedimentary, and metamorphic (New York: W. H. Freeman).
10. Gunter Faure (1987). Principles of isotope geology. 2nd edition.

### **MGY-009 Sedimentary and Metamorphic Petrology**

**Unit-I:** Sediments and Sedimentary rocks: Processes of formation; diagenesis and lithification. Sedimentary textures. Definition, measurement and interpretation of grain size. Primary structures, Biogenic and chemical sedimentary structures.

**Unit-II:** Clastic and non-clastic rocks their classification, Clastic sediments- gravel, sand and mud; Classification of conglomerates, sandstones and mudstones, and carbonate rocks. Sedimentary structures and their significance; Provenance, Heavy minerals and their significance; Tectonics and sedimentation. Cyclic sediments.

**Unit-III:** Types and agents of metamorphism. Metamorphic grades and zones; Phase rule; Textures and structures of metamorphic rocks, Poly-metamorphism. Metamorphic reactions, Metamorphism of arenaceous, argillaceous and basic rocks; Metamorphism in space and time: Metamorphic Facies Regional and thermal metamorphism of impure, siliceous carbonate rocks; Pelitic and basic rocks.

**Unit-IV:** ACF, AKF and AFM diagrams/projection, common minerals of metamorphic rocks; Minerals assemblages., migmatites. Petrographic classification of common metamorphic rocks; Metasomatism. Isograds and retrograde metamorphism.



### **Books recommended**

1. Best, Myron G., Igneous and Metamorphic Petrology (C B S Publishers, New Delhi).
2. Blatt, Harvey; Tracy, Robert J.; Owens, Brent (2005), Petrology: igneous, sedimentary, and metamorphic (New York: W. H. Freeman).
3. Pettijohn, F. J. Sedimentary rocks ( McGraw-Hill, New Delhi)
4. Verma, V. K. And Prasad, C., Sedimentology (Harman Publishing House, New Delhi)
5. Folk, R. L. Petrology of sedimentary rocks, Hemphills, Austin, Texas.
6. Blatt, H., Middleton, G and Murray, R., Origin of Sedimentary Rocks, Prentice Hall
7. Reineck, H.E., and Singh, I. B.:Depositional Sedimentary Environments, Springer, verlag, N.Y.

### **MGY-010 Practical**

**Palaeontology:** Study of important invertebrate fossil belonging to brachiopoda, bivalve, gastropoda, cephalopoda, trilobita and echinods. (10 marks)

**Stratigraphy:** Exercise on stratigraphic classification and correlation of stratigraphically important rocks, Preparation of Paleogeographic maps and Stratigraphic columns; Chronological study of important rocks. (10 marks)

**Igneous Petrology & Geo Chemistry:** Megascopic study of different types of igneous rocks; Microscopic study of important igneous rocks. (10 marks)

**Sedimentary and metamorphic Petrology:** Study of sedimentary and metamorphic rocks in hand specimen and thin sections with emphasis on texture, structure and mineral composition; Size and shape analysis; Heavy mineral identification and Palaeocurrent analysis. Graphic construction of ACF, AKF and AFM diagrams. (10 marks)

**Geological field training:** Students will be required to visit geologically important areas, laboratories/institutes of repute and submit a report thereon, under the supervision of a faculty member. The field work should be at least 15 days. (20 marks)

**Laboratory records:** (10 marks)

**Viva-voice:** (10 marks)

## **SEMESTER 3**

### **MGY-011 Economic Geology**

**Unit-I:** Ore, ore minerals and gangue, tenor of ore, classification of ore deposits; fluid inclusions.

Metallogenic deposits and provenances of India. Process of formation of minerals deposits-

Magmatic, hydrothermal and surface processes of ore formation. Mineralization and tectonics.

Controls of ore localization

**Unit-II:** Indian mineral deposits- occurrence, geology, origin and distribution in India of metalliferous deposits- base metals, iron, manganese, aluminum, chromium, nickel, gold, silver, molybdenum. Indian deposits of non-metals – mica, asbestos, barites, gypsum, graphite, apatite and beryl.

**Unit-III:** Coal- classifications and origin. Coal resources of India. Coal bed Methane (CBM), and nuclear mineral resources. Origin migration and entrapment of petroleum, properties of source of reservoir rocks, structural and stratigraphic and combination traps, petroliferous basins of India.

**Unit-IV:** Mineral economics- National Mineral Policy; Conservation and utilization of mineral resources; Marine mineral resources and Law of Sea. Strategic, critical and essential minerals. international trade of minerals and petroleum and gas. Occurrence of mineral resources in Himalaya.

### **Books recommended**

1. Chatterjee, K.K. (1993): An Introduction to Mineral Economics, Wiley Eastern Ltd.
2. Karanth, R.V. (2000): Gems and gem Industry in India, Geol. Soc. India, Bangalore.
3. Krishnaswamy, S. (1979): India's Mineral Resources, Oxford and IBH Co.
4. Tiwari, S. K.: Ore Geology, economic mineral and mineral economics Vol.-2.
5. Evans, A.M. (1993): Ore Geology and Industrial Minerals, Blackwell.
6. Stanton, R.L. (1972): Ore Petrology, McGraw Hill.
7. Barnes, H.L. (1979): Geochemistry of Hydrothermal Ore Deposits, John Wiley.
8. Guilbert, J.M. and Park, Jr.C.F. (1986): The Geology of Ore Deposits, Freeman.
9. Mookherjee, A. (2000): Ore Genesis-A Holistic Approach, Allied Publisher.
10. Jensen and Bateman Economic minerals
11. U.Prasad -Economic Mineral Deposits

### **MGY-012 Mineral Exploration and Mining Geology**

**Unit-I:** Principles of mineral prospecting and exploration- Resource, reserve definitions; mineral resource in industries - historical perspective and present.

**Unit-II:** Estimation of grade and reserve of ore, factors affecting reliability of ore reserve estimation, Sampling, assaying and evaluation of mineral deposits. sampling, subsurface sampling including pitting, trenching and drilling, techniques of well logging.

**Unit-III:** Geological, geophysical, geochemical, radioactive and geobotanical methods of surface and sub-surface exploration on different scales. Core logging, Exploitation and conservation of mineral and other natural resources. Environmental issues in exploration.

**Unit-IV:** Mining Geology- Methods of surface and subsurface mining; coal mining. Role of geologists in mining. Environmental issues in mining and beneficiation.

### **Books recommended**

1. P.K. Banerjee and S. Ghosh (1997): Elements of prospecting for non-fuel mineral deposits.
2. Bagchi, T.C., Sengupta, D.K. & Rao, S.L.V.N. (1979): Elements of Prospecting and Exploration.
3. Sinha, R.K. & Sharma, N.L. (1976): Mineral Economics.
4. Arogyaswami, R.N.P. (1996): Courses in Mining Geology

### **MGY-013 Engineering Geology**

**Unit-I:** Engineering properties of rocks and physical characteristics of building stones, concretes and other aggregates. idea of rock and soil mechanics. Rock as construction material.

**Unit-II:** Geological investigations site geological and geotechnical investigations for construction of dams, bridges, Methods of mapping of above sites.

**Unit-III:** Mass movements with special emphasis on landslides and causes of hill slope instability. Earthquake-resistant structures Landslides-causes, origin, classification, prevention and monitoring

**Unit-IV:** Problems of groundwater in engineering projects. Coastal geotechnics. Environmental considerations related to civil engineering projects. Geotechnical case studies of major projects in India

### **Books recommended**

1. Attewell, P. B. & Farmer, J. W. (1976): Principles of engineering Geology, Chapman & Hall. Publ.
2. Bell, F. G. (1983): Fundamentals of engineering geology, Butterworths, London.
3. Barish, N. N. (1962): Economic analysis for engineering and managerial decisions.

4. Clarke: Reservoir engineering.
5. Coates, R. E. (1970): Rock Mechanics, Canadian deptt. Of Energy, Mines & Resources Ottawa.
6. Farmer, I. W. (1968): Engineering properties of rocks, E & F. N. Spon-Ltd.
7. Gupta, H. K. & Rastogi, B. K. (1976): Dams and Earthquakes, Elsevier and Scientific Pub. Co.
8. Hock, E. & Bray, J. (1978): Rock slope engineering, Instt. of mining and metallurgy, London.
9. Krynine D. P. & Judd W. R. (1998): Principles of engineering geology & geo-techniques.
10. Legget, R. F. & Karrow P. F. (1983): Hand Book of Geology in civil engineering.
11. Neil Duneon, (1969): Engineering geology and rock mechanics, London hill.
12. Zaruba, Q. and Mencl, V. (1976): Engineering geology, Scientific publishing Amsterdam.

**MGY/E-001 (Select any one from the given three papers)**

**A. Marine Geology**

**Unit-I:** Hypsography of the continents and ocean floor –continental shelf, slope, rise and abyssal plains. Morphologic and tectonic domains of the ocean floor. Structure, composition and mechanism of the formation of oceanic crust., hydrothermal vents- Ocean margins and their significance.

**Unit-II:** Estuaries: classification; tides in estuaries; sedimentation in estuaries; salinity intrusion in estuaries; coastal pollution, coastal zone management.

**Unit-III:** Ocean Circulation, Coriolis effect El Nino. Thermohaline circulation major water masses of the world’s oceans. Oceanic sediments: Factors controlling the deposition and distribution of oceanic sediments; geochronology of oceanic sediments, Tectonic evolution of the ocean basins. Mineral resources.

**Unit-IV:** Paleoceanography – Approaches to paleoceanographic reconstructions; various proxy indicators for paleoceanographic interpretation. Ocean Drilling Programme and its major accomplishments in paleoceanography Sea level processes and Sea level changes. Physical and chemical properties of sea water and their spatial variations. Residence times of elements in sea water. Biological productivity in the oceans.

**Books recommended**

1. Eugen Seibold 1999. The sea floor Amazon.com
2. John, A. 1996. Marine geology

**B. Himalayan Geology**

**Unit-I:** Introduction and classification of Himalayas; Geomorphology of Himalaya- glaciers, mountains, rivers, lakes, cold deserts, thermal springs. ; Elementary idea about glaciation in Himalaya.

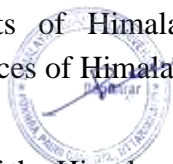
**Unit-II:** Tectonics and stratigraphy of Outer, Lesser, Higher Himalayas, Tethys succession and the Indus Suture Zone. Petrological composition of Himalaya. Himalayan geochronology. Active and neotectonics in Himalaya. Himalayan paleontology.

**Unit-III:** Geophysical studies in Himalaya. Origin and evolution of the Himalayas; The metallogeny and mineral deposits of the Himalayas. Paleotectonics, palaeogeography and closure of the Tethys Sea.

**Unit-IV:** Geo-environmental aspects of Himalaya; Mineral resources of Conservation and management of land and water resources of Himalaya.

**Books Recommended**

1. Gansser, A., 1959. Geology of the Himalayas.



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2. Wadia, D., 1973. Geology of India. McGraw Hill Book co.
3. Krishnan, M.S., 1982. Geology of India and Burma, 6th Edition. CBS Publ.
4. Valdiya, K.S., 1980. Geology of the Kumaon Himalayas. WIHG Publ.
5. Saklani, P.S., 1992. Geology of the Lesser Himalayas. Today & Tomorrow Publ.
6. Sinha, A.K. Global tectonics and metallogeny of the Himalayas.
7. Rupke, and Sharma, A.K. Geology and sedimentation of the Kumaon Lesser Himalayas.
8. Biyani, AK 2006. Dimensions of Himalayan Geology, SSPH Delhi

### **C. Glaciology**

**Unit-I:** Introduction, importance and implication of glaciological studies, Inventory of Himalayan glaciers, Identification system of glaciers. Preservation and future of glaciers.

**Unit-II:** Glacial morphology, glacial deposits and paleoglaciation, Paleoclimatic reconstruction, Hydrometry of glaciated basins, suspended sediment transport.

**Unit-III:** Mass balance studies; Net balance, Ablation, accumulation and snow density measurements, Relationship of mass balance to climate, Snow melt processes. Ice surface velocity, Methods of Ice depth estimation.

**Unit-IV:** Physics of ice and snow, Mechanics of snow/ice creep, Ice crystals, engineering properties of glacial material, glacial hydrochemistry. Application of remote sensing techniques in glaciology, Application of advanced surveying techniques, Global positioning system, geodetic techniques; Ground penetrating radar.

### **Books Recommended**

1. V.F. Petrenko and Robert, W., 1999. Physics of Ice 1st Edition, Kindle Edition
2. MM Bennett and N F Glasser, 2009, Glacial Geology: Ice Sheets and Landforms, Wiley
3. Jon Erickson, 1996: Glacial Geology, Facts on File
4. Peter Martin, Michael E. Brookfield, Steven Sadura, 2001: Principles of Glacial Geomorphology and Geology 1st Edition, Prentice Hall
5. Paterson, 1968: Physics of Ice

### **SOES/MGY-014 Practical**

**Ore genesis and Indian mineral deposits:** Study of economic minerals in hand specimen; Megascopic and microscopic characterization of coals bands. Completion of outcrops in the given maps and calculation of coal reserves; Study of geological maps and sections of important oilfields of India and world; Preparation of mineral maps of India; Calculation of grade and ore/oil reserves. Interpretation of remote sensing data for mineral exploration.

**Engineering Geology:** Study of properties of common rocks with reference to their utility in engineering projects. Study of maps and models of important engineering structures, dam sites and tunnels. Interpretation of geological maps for landslides problems. Survey of a plot using Chain, Prismatic compass, Plane table, Dumpy level, Theodolite, Total station and Ground Penetrating Radar (Depending upon the availability of the instruments); their uses and precautions in handling.

**Marine Geology:** Preparation of marine topographic profiles from the contour map of the India; Plotting of major marine tectonic features on outline map of the world; Grain size analysis of beach sands; Preparation of marine resource map of India.

**Himalayan Geology:** Construction of physiographic and structural profiles, Interpretation of geological, structural and geomorphological features from the toposheets, Identification of deformation patterns in the rock specimens.

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

## Semester 4

### MGY- 015 Geohydrology

**Unit-I:** Hydrological Cycle and its components. Groundwater origin types and occurrences, hydrological properties of rocks- porosity, permeability, specific yield and specific retention; hydraulic conductivity, transmissibility, storage coefficient. Classification of aquifers; Springs; Hot water and mineral water springs.

**Unit-II:** Sub-surface movement and vertical distribution of groundwater. Darcy's law- its range and validity; Determination of permeability in laboratory and in field; Evaluation of aquifer parameters of confined, semi-confined and unconfined aquifers.

**Unit-III:** Groundwater Exploration- geological, geophysical, geo-botanical and remote sensing methods. Hydro-stratigraphic units, Groundwater provinces of India. Hydrogeology of Uttarakhand.

**Unit-IV:** Groundwater Quality- Physical, chemical, biological, radiological properties of water; Quality criteria for different uses; Graphical presentation of groundwater quality data; Groundwater contamination; natural and anthropogenic contaminants; water pollution; Problems and management of groundwater; Rainwater harvesting.

#### **Books recommended:**

1. Bouver, H. (1978): Groundwater Hydrology, McGraw Hill.
2. Fetter, C.W. (1990): Applied Hydrogeology, CBS Pub. New Delhi.
3. Todd, D.K. (1988): Ground Water Hydrology, John Wiley & Sons, New York.
4. Davies, S.N. and De-West, R.J.N. (1966): Hydrology, John Wiley & Sons, New York.
5. Raghunath, H.M. (1983): Ground Water, Wiley Eastern Ltd. Calcutta.

### MGY- 016 Remote Sensing and GIS

**Unit-I:** Elementary idea about photogeology: electro-magnetic spectrum, types & geometry of aerial photographs; factors affecting aerial photography; types of camera, film and filters; factors affecting scale; mosaics and annotation; vertical exaggeration; Concept of Stereoscopy.

**Unit-II:** Fundamentals of remote sensing; remote sensing systems; space platforms and orbit patterns; remote sensing sensors; thermal, radar and hyperspectral images; signatures of rocks, minerals and soils. Application of remote sensing in geoscience and geomorphological studies.

**Unit-III:** Types of Indian and Foreign Remote Sensing Satellites, Digital image processing; fundamental steps in image processing; elements of pattern recognition and image classification.

**Unit-IV:** Introduction to Geographic Information System (GIS); components of GIS; product generation in GIS; tools for map analysis; integration of GIS with remote sensing. Operational principles and uses GPS and VPS.

#### **Books Recommended:**

1. Bhatta, B., 2008. Remote Sensing and GIS. Oxford, New Delhi.
2. Druy, S.A., 1987. Image Interpretation in Geology. Allen and Unwin.
3. Gupta, R.P., 1990. Remote Sensing Geology. Springer Verlag.
4. Lilleasand, T.M. & Kiffer, R.W., 1987. Remote Sensing & Image Interpretation. John Wiley.

5. Miller, V.C., 1961. Photogeology. McGraw Hill.
6. Moffitt, F.H. and Mikhail, E.M., 1980. Photogrammetry. Harper and Row.
7. Pandey, S.N., 1987. Principles and Application of Photogeology. Wiley Eastern, New Delhi.
8. Sabbins, F.F., 1985. Remote Sensing – Principles and Applications. Freeman.
9. Siegal, B.S. and Gillespie, A.R., 1980. Remote Sensing in Geology. John Wiley.
10. Rampal K.K. 1999. Hand book of aerial photography & interpretation. Concept publication.
11. Barrett, E.C. & Curtis, L. F.: Introduction to Environmental Remote Sensing.
12. Curran, P.J. (1988): Principles of Remote Sensing.

**MGY/E-002 (Select any one from the given three papers)**

**A. Quaternary Geology**

**Unit-I:** Importance of Quaternary period and location of Quaternary area. Oxygen Isotope stratigraphy, biostratigraphy and magnetostratigraphy. Quaternary climates – glacial-interglacial cycles, eustatic changes,

**Unit-II:** 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-III:** Quaternary dating methods, –radiocarbon, Uranium series, luminescence, amino-acid, relative dating methods. Quaternary stratigraphy of India– continental records (fluvial, glacial, aeolian, palaeosols and duricrust); 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. Magnetostratigraphy- basic concepts and magnetostratigraphy of Siwaliks. Indo-Gangetic Plain, Himalayan glaciations. Climate change and global warming.

**Books recommended**

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

**B. Advanced Micropaleontology, vertebrate paleontology, paleobotany**

**Unit-I:** Different kinds of microfossils. Application of microfossils in correlation, petroleum exploration, paleoclimatic and paleoceanographic studies. Techniques in micropalaeontology. Oxygen and Carbon isotope studies of microfossils and their use in paleoceanographic and paleoclimatic interpretation.

**Unit-II:** Morphology, classification and geological evolutions of Microfossils such as foraminifera, ostracoda, conodonts, nannofossils, ichnofossils, SSF, stromatolites and collection,

**Unit-III:** Vertebrate Paleontology – Brief study of vertebrate life through ages. Evolution of reptiles and mammals; Evolutionary trend in Hominidae, Equidae and Proboscides; Siwalik vertebrate fauna.

**Unit-IV:** Plant fossils: types of plant fossils. Gondwana flora and their significance. Spores and pollens and application of palynology.

### **Books Recommended**

1. Saraswati, PK and Srinivasan MS. Micropaleontology. Springer
2. Jenkins, JM, Applied Micropaleontology. Springer
3. Benton, MJ ,2012. Vertebrate Paleontology
4. Braiser 2013, Micropaleontology

### **C. Paleoseismology**

**Unit-I:** Broad tectonic regimes of the earth. Elementary idea about natural hazards of internal origin. Earthquakes- classifications, causes, impact, methods of study, global distribution and earthquake belts. Paleoseismology- definition and scope. Seismic zonation of India. Reservoir induced seismicity.

**Unit-II:** Measurement of earthquakes- different types of intensity, magnitude and moment scale. Interrelationship between them. Geological evidences of paleoearthquakes, fault fragmentation. Present day stress field in India; Liquefaction and its impact.

**Unit-III:** Field and lab studies of paleoearthquakes- evidences, geomorphic and tectonic features associated with different kind of seismic faults. Geochronological studies of earthquake and their interpretation with local geology. Quantitative calculation of displacement

**Unit-IV:** Relationship between active tectonics and paleoseismology. Methods of study of active tectonics Paleoseismological studies of peninsular India with special reference to Himalaya.

### **Books Recommended**

1. James Mc Calpin – Paleoseismology
2. Yeats – Geology of Earthquakes
3. Burbank- Tectonic Geomorphology
4. Kelpin- Active Tectonics
5. Bull, WB. Tectonic Geomorphology of Mountain

### **MGY-017 Practical**

**Geohydrology:** Delineation of hydrological boundaries on water table, contour maps and estimation of permeability; Analysis of hydrographs and estimation of infiltration capacity; Chemical analysis of water in evaluation of aquifer parameters; Exercise on ground water exploration using remote sensing techniques. (10 marks)

**Remote Sensing and GIS:** Aerial Photo interpretation, identification of rocks and various landforms; Introduction to GIS software's. Exercise on Digital Image Processing; Creating a FCC from raw data, Registration of satellite data with a toposheet of the area; Enhancing the satellite images; Classification of images; DEM analysis and its applications (10 marks)

**Quaternary Geology/Micropaleontology/Seismology:** Exercises related to topographic maps (2D representation, contouring, land use gradients; Study of possible tectonic plates (lineaments) from topographic maps; Hazard Zonation Mapping; Identification of various landscapes and drainage using satellite images and topographic maps. (10 marks)

**Geological field training:** Students will be required to visit geologically important areas including mines, dams, oil fields, fossiliferous sequences and laboratories/institutes of repute and submit a report thereon, under the supervision of a faculty member. The field work should be at least 15 days either in peninsular India or extra-peninsular India. (30 marks)

**Laboratory records:** (10 marks)

**Viva-voce:** (10 marks)

### **MGY-018 Project oriented Dissertation**

The area of dissertation shall be assigned to the students at the end of second semester based on the expertise available in the Department. The project oriented dissertation must be submitted by the end of fourth semester. During the course of completion of dissertation work the students will be required to complete various assignments given to them by their respective supervisors or the Head of Department for the purpose of their evaluation.

Beside classroom seminars, the students will have to present their dissertation work in the form of seminar before the board of examiners including the supervisors which will be followed by viva voce examination.

