Since 1919

NATIONAL COLLEGE (AUTONOMOUS)

(Nationally Re-accredited at "A" Level by NAAC)

(Recognized as a College with Potential for Excellence by UGC)

Tiruchirappalli - 620001

M. Sc. Applied Geology

Programme Structure & Syllabus

Outcome Based Education System (OBES)

(Applicable to the Candidates Admitted from the Academic Year 2025-2026 Onwards)

Since 1961

POST GRADUATE AND RESEARCH DEPARTMENT OF GEOLOGY

POST GRADUATE AND RESEARCH DEPARTMENT OF GEOLOGY
NATIONAL COLLEGE (AUTONOMOUS)

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Vision

- To transform the Department into one of the best learning centres for Geology in the State and the country

Mission

- To ignite the young minds with lofty ideals and inspire them to achieve excellence in the field of Geology
- To provide an understanding of the Earth System and apply these to the needs of society
- To prepare the next generation of Geologists to use latest technologies in the exploration of resources especially rocks and minerals, water and hydrocarbons

Programme Structure

Category	No of courses	Total Credits
Core Course (T+P)	15	70
Elective Course	05	20
Total	**20**	**90**

M. Sc. Applied Geology

(Programme Code - AGEPG1983)

Programme Structure

(Applicable for candidates admitted from the academic year 2025 – 2026)

Sl. No.	Semester	Course Code	Course	Course Title	Exam Hours	Instructional Hours / Week	Credits	Internal Exam	External Exam	Total Marks
1.	I	P25GY1	Core I	Indian Stratigraphy	3	5	5	25	75	100
2.		P25GY2	Core II	Palaeontology	3	5	5	25	75	100
3.		P25GY3	Core III	Advanced Crystallography and Mineralogy	3	5	5	25	75	100
4.		P25GY4P	Core IV	Practical I – Palaeontology, Advanced Crystallography and Mineralogy	4	10	4	25	75	100
5.		P25GY5E1	Elective I	A. Environmental Geology and Marine Geology	3	5	4	25	75	100
		P25GY5E2		B. Climate Change Studies						
		P25GY5E3		C. Micropalaeontology						
						30	23			
6.	II	P25GY6	Core V	Igneous and Metamorphic Petrology	3	5	5	25	75	100
7.		P25GY7	Core VI	Sedimentary Petrology and Sedimentology	3	5	5	25	75	100
8.		P25GY8P	Core VII	Practical II – Petrology, Engineering Geology and Mining Geology	4	5	4	25	75	100
9.		P25GY9E1	Elective II	A. Engineering Geology, Mining Geology and Ore Dressing	3	10	4	25	75	100
		P25GY9E2		B. Geotechnics						
		P25GY9E3		C. Geological Oceanography						
10.		P25GY10E1	Elective III	A. Geomorphology	3	5	4	25	75	100
		P25GY10E2		B. Isotope Geology						
		P25GY10E3		C. Quaternary Geology						
						30	22			
11.	III	P25GY11	Core VIII	Geotectonics and Structural Geology	3	5	5	25	75	100
12.		P25GY12	Core IX	Economic Geology and Mineral Economics	3	5	5	25	75	100
13.		P25GY13	Core X	Geoexploration	3	5	5	25	75	100
14.		P25GY14P	Core XI	Practical III – Structural Geology, Economic Geology, and Geoexploration	4	10	4	25	75	100
15.		P25GY15E1	Elective IV	A. Fuel Geology	3	5	4	25	75	100
		P25GY15E2		B. Instrumentation Techniques in Geology						
		P25GY15E3		C. Petroleum Exploration and Mud Logging						
						30	23			
16.	IV	P25GY16	Core XII	Hydrogeology	3	5	5	25	75	100
17.		P25GY17P	Core XIII	Practical IV – Hydrogeology and Geostatistics	4	6	4	25	75	100
18.		P25GY18P	Core XIV	Practical V – Remote Sensing and GIS	4	6	4	25	75	100
19.		P25GY19E1	Elective V	A. Remote Sensing and GIS	3	5	4	25	75	100
		P25GY19E2		B. Remote Sensing Applications in Geosciences						
		P25GY19E3		C. Medical Geology						
20.		P25GYP20	Dissertation			8	5	75	25	100
						30	22			
Grand Total						120	90			2000

Note:

- Participation in Geological field instructional tour and Geological Field Mapping tour is mandatory for all the students of M.Sc. Applied Geology programme.
- The tour reports submitted by the students will be considered for the internal marks of the practical examinations of the last semester.

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY1	Core	Core Course – I INDIAN STRATIGRAPHY	Theory	5	5

Course Description:

This course aims to provide comprehensive knowledge on the principles, methods, and applications of stratigraphic studies. It focuses primarily on Indian Stratigraphy encompassing geological evolution of the Indian subcontinent from the Precambrian to the Cenozoic Era, emphasizing the lithological and palaeontological aspects and economic importance of major stratigraphic units. For understanding regional stratigraphy a separate unit has been allotted for the stratigraphy of Tamil Nadu and Pondicherry.

Course Objectives: To impart knowledge on

1. Principles and methods of stratigraphy and their applications.
2. Stratigraphic framework and economic significance of the Indian Precambrian formations.
3. Stratigraphy, fossils wealth, and economic importance of Indian Palaeozoic and Mesozoic formations.
4. Stratigraphy, fossils wealth, and economic importance of Cenozoic stratigraphy and boundary problems relating to Indian stratigraphy.
5. Geological and stratigraphic setup of Tamil Nadu and Pondicherry.

Unit 1: Essentials of Stratigraphy: Principles of Stratigraphy – Major Stratigraphic Divisions of India – Stratigraphic nomenclature: global level and India – International chronostratigraphic chart: Stratotypes, Global Boundary Stratotype Sections and Points (GSSP) – Concept of lithostratigraphy, chronostratigraphy, biostratigraphy, chemostratigraphy, sequence stratigraphy and magneto-stratigraphy – Methods of stratigraphic correlation – Methods of palaeogeographic reconstruction – Homotaxis and contemporaneity – Facies concept in Stratigraphy: Walther's law – Applications of Stratigraphy.

Unit 2: **Precambrians:** Stratigraphy of Indian Archaean granites, Greenstone belts, Geological evolution of Archaean nuclei (Dharwar Craton, Bastar, Singhbhum, Aravalli and Bundelkhand) – Economic Importance of the Indian Archaeans – Proterozoic Mobile Belts: Eastern Ghats Mobile Belt, Southern Granulite Terrain, Central Indian Tectonic Zone, Aravalli-Delhi Belt, North Singhbhum Mobile Belt – Proterozoic sedimentary basins: Cuddapah and Vindhyan Super Groups and their equivalence – Economic importance of the Indian Proterozoic formations.

Unit 3: **Palaeozoic to Mesozoic:** Stratigraphy, fossils and economic importance of: Cambrian of Salt Range – Permo-Carboniferous of Salt Range, Jammu and Kashmir and Spiti – Gondwana Supergroup – Triassic of Spiti – Jurassic of Kutch–Cretaceous of Trichinopoly and Narmada Valley – Bagh beds and Lameta beds – Deccan traps.

Unit 4: Cenozoic, Boundary Problems in Indian Stratigraphy: Stratigraphy, fossils and economic importance of: Assam – Bengal basins – Garhwal-Shimla Himalayas – Siwalik Super Group – Karewas of Kashmir – Indo-Gangetic Alluvium – Overview of Himalayan Geology and Quaternary stratigraphy of India – Age problem pertaining to Saline series and Deccan traps – Boundary problem pertaining to Precambrian/Cambrian, Permian/Triassic, Cretaceous/Tertiary, Paleogene/Neogene and Neogene/Quaternary formations of India.

Unit 5: Geology of Tamil Nadu and Pondicherry: Outline of structure and tectonics – Stratigraphy and economic importance of: Sathyamangalam Group, Layered Mafic and Ultrabasic Complexes – Peninsular Gneissic Complex: Kolar Group, Khondalite and Charnockite Group – Migmatite Complex – Alkaline Complexes (Older) – Mafic dykes – Alkali-Syenite-Carbonatite Complexes (Younger) – Ultra basics / basics (Younger), Granite (Younger) – Salient features of Palaeozoic, Mesozoic and Cenozoic Era – Tectonic block-wise litho-assemblages of Tamil Nadu.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. Principles and methods of stratigraphy and their applications.
2. Stratigraphic framework and economic significance of the Indian Precambrian formations.
3. Stratigraphy, fossils wealth, and economic importance of Indian Palaeozoic and Mesozoic formations.
4. Stratigraphy, fossils wealth, and economic importance of Cenozoic stratigraphy and boundary problems relating to Indian stratigraphy.
5. Geological and stratigraphic setup of Tamil Nadu and Pondicherry.
6. Applying stratigraphic knowledge in palaeogeographic reconstruction, correlation, and resource exploration.

Text Books:

1. **Geological Society of India (2022).** Geology and Mineral Resources of the States of India: Tamil Nadu and Puducherry (Ed. N.P. Nathan and K. Gopalakrishnan), Published by the Geological Society of India, Bengaluru.
2. **Geological Survey of India (2006).** Geology and Mineral Resources of the States of India, Part VI - Tamil Nadu and Pondicherry, GSI Misc. Publ. No. 30, GSI Operation: Tamil Nadu, Kerala & Pondicherry (Government of India), Chennai.
3. **Geological Survey of India (2014).** Geology and Mineral Resources of Tamil Nadu and Puducherry. Miscellaneous Publication No. 30 (Part VI), III Revised Edition, Published by the GSI, Kolkata.
4. **Krishnan, M. S (1982).** Geology of India and Burma, CBS Publishers & Distributors, Delhi.
5. **Ramakrishnan, M and R. Vaidhyanadhan (2008).** Geology of India, Vols. I & II, Geological Society of India, Bangalore.
6. **Ravindrakumar (1998).** Fundamentals of Historical Geology and Stratigraphy of India, Wiley Eastern Ltd., New Delhi.
7. **Wadia, D. N (1998).** Geology of India, Tata McGraw Hill, India.

Reference Books:

1. **Brenner, R. E and T. R. McHargue (1988).** Integrative Stratigraphy: Concepts and Applications, Prentice Hall.
2. **Doyle, P and M. R. Bennett (1996).** Unlocking the Stratigraphic Record, John Wiley and Sons.
3. **Geological Society of India (1990).** Stratigraphic Boundary Problems in India, Memoir 16, ISSN No: 0016-7622, Geological Society of India, Bangalore.
4. **Hedberg, H. D (2008).** International Stratigraphic Guide – A Guide to Stratigraphic Classification, Terminology and Usage, John Wiley & Sons, New York.
5. **Miall, A. D (1997).** The Geology of Stratigraphic Sequence, Springer-Verlag.
6. **Brookfield, M.E (2004).** Principles of Stratigraphy, Wiley Blackwell Publishing.
7. **Naqvi, S. M and J. J. W. Rogers (1987).** Precambrian Geology of India, Oxford University Press.
8. **Robert, M. S (1989).** Stratigraphy: Principles and Methods, Van Nostrand Reinhold, New York.
9. **Valdiya, K.S (2016).** The Making of India – Geodynamic Evolution, Second Edition, Springer Publications, London.

Web Resources:

1. e-PGPathshala: https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=bsA+3rVcyoJ6GW6UkeQmhw==
2. eGyanKosh: BGYCT-137 Stratigraphy and Palaeontology: https://egyankosh.ac.in/handle/123456789/69594
3. International Commission on Stratigraphy: http://www.stratigraphy.org
4. Geological Survey of India: https://www.gsi.gov.in
5. List of Indian Stratigraphical Systems | Geology: https://www.geographynotes.com/geology-2/indian-stratigraphical-systems/list-of-indian-stratigraphical-systems-geology/5944

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs) – Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	3
CO4	9	9	9	9	3	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	3	3
Total	54	54	54	54	18	18
Weightage %	21.42	21.42	21.42	21.42	7.14	6.51

Course Outcomes Mapped with Knowledge Levels:

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	9	9	9	9
CO2	9	9	9	9	9	9
CO3	9	9	9	9	9	9
CO4	9	9	9	9	9	9
CO5	9	9	9	9	9	9
CO6	9	9	9	9	9	9

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation:

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	1	5	-	5	20%
K2	1	2	1	1	5	-	5	20%
K3	1	1	1	1	4	-	4	16%
K4	1	1	1	1	4	-	4	16%
K5	-	1	-	1	2	-	2	8%
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20%
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100%**

The Cos and Pos for the **INDIAN STRATIGRAPHY** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY2	Core	Core Course – III PALAEONTOLOGY	Theory	5	5

Course Description:

This course deals with the principles and applications of Palaeontology, including the study of fossil organisms and their significance in understanding Earth's history. Emphasis is placed on the evolution and extinction of life, vertebrate and invertebrate fossils, microfossils, plant fossils, and their role in stratigraphic correlation, paleoenvironmental reconstruction, and resource exploration.

Course Objectives: To impart knowledge on

1. To introduce the fundamental concepts of paleontology and the origin and preservation of fossils.
2. To study vertebrate and invertebrate evolution through geologic time.
3. To understand the morphology and significance of microfossils and plant fossils.
4. To explore the applications of paleontological data in geological and environmental studies.
5. To learn techniques for fossil analysis and their use in paleoclimate and paleoecological interpretations.

Unit 1: Concepts of Paleontology: Theories on origin of life – Fossils: types, nature and modes of preservation of fossils – Taphonomic processes: death, preburial and post burial changes of organisms – Evolution of life through geological time – Mass extinctions: causes and effects – Paleontology and evolution: macroevolution and microevolution, punctuated equilibrium and phyletic gradualism – Outline on Stromatolites, Ediacara fauna and Largerstatten.

Unit 2: Vertebrate Paleontology: Vertebrate life through ages – Devonian fishes –Mesozoic reptiles –Dinosaurs: their classification and extinction – Evolution of Proboscidea(Elephant), Equidae (Horse) and Hominidae (Man) – Important vertebrate fossils in Indian Stratigraphy.

Unit 3: Invertebrate Paleontology: Morphology, evolution and time range of Graptolites, Trilobites, Brachiopods, Lamellibranchs, Gastropods, Cephalopods, Echinoids and Corals–Important invertebrate fossils in Indian Stratigraphy.

Unit 4: Micropaleontology and Paleobotany: Microfossils and their types – Micropaleontological techniques: Separation of microfossils – General morphology of foraminifera and ostracoda – Evolution of plants through ages – Gondwana flora and their significance – Outline on dinoflagellates, diatoms, spores and pollens – Important plant fossils in Indian Stratigraphy – Outline on nanofossils.

Unit 5: Applications of Palaeontology: Uses of paleontological data in paleoecology, palaeoclimatology, paleogeography, paleogeophysics, evolutionary studies, correlation and biostratigraphy – Radiocarbon dating of fossils – Oxygen and carbon isotope studies of microfossils and their applications – Applications of microfossils in the interpretation of paleoenvironment, paleooceanography, seafloor tectonism, and hydrocarbon exploration.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. The origin and evolution of life, fossilization processes, and extinction events.
2. Evolution of vertebrate life, including fishes, dinosaurs, and mammals.
3. Invertebrate fossils and their role in evolutionary history.
4. The importance of microfossils and plant fossils in stratigraphic correlation.
5. Applying palaeontological data for paleoecological, paleoclimatic, and resource exploration studies.
6. Applying fossil records, isotope studies, and dating techniques for reconstructing paleoenvironmental and geohistorical interpretations.

Text Books:

1. **Amaldas Gupta (2016).** An Introduction to Palaeontology, World Press Pvt. Ltd.
2. **Bignot, G (1985).** Elements of Micropalaeontology, Graham Trotman.
3. **Clarkson, E and N.K. Clarkson (1998).** Invertebrate Palaeontology & Evolution, Wiley-Blackwell.
4. **Doyle, P (1996).** Understanding Fossils: An Introduction to Invertebrate Palaeontology, John Wiley & Sons Ltd.
5. **Jain P.C and M.S. Anatharaman (2018).** An Introduction to Paleontology, Vishal Publications.
6. **Raup, D.M and S.M Stanley (1985).** Principles of Paleontology, CBS Publications.
7. **Saraswati P. K and M.S. Srinivasan (2016).** Micropaleontology - Principles and Applications, Springer International Publishing.
8. **Sreepat Jain (2017).** Fundamentals of Invertebrate Palaeontology, Springer.
9. **Woods, H (1959).** Invertebrate Palaeontology, Cambridge.

Reference Books:

1. **Armstrong Howard, A and D. B. Martin (2005).** Microfossils, Blackwell Publishing.
2. **Benton, M. J (2015).** Vertebrate Palaeontology and Evolution (IV Edition), Wiley-Blackwell.
3. **Colbert, E.M (1960).** Evolution of the Vertebrates, Wiley Eastern.
4. **Easton, W. H (1960).** Invertebrate Paleontology, Harper's Geoscience Series,
5. **Hag, B.U and A. Boersma (1978).** Introduction to Marine Micropalaeontology. Elsevier.
6. **Moore, R.C., Lalieker, C.D and A.G. Fischer (1952).** Invertebrate Fossils, McGraw Hill.
7. **Prothero, D. R (2007).** Evolution - What the Fossils Say and Why it Matters? Columbia University Press.
8. **Reed Wicander and J. S. Monroe (2007).** Historical Geology: Evolution of Earth and Life through Time (VI Edition), Brooks / Cole, Cengage Learning.
9. **Romer, A.S (1960).** Vertebrate Palaeontology, Chicago Press.
10. **Shrock, R.R and W.H Twenhofel (1953).** Principles of Invertebrate Palaeontology, Arnold Publications.

Web Resources:

1. Paleontology Portal: https://www.paleoportal.org
2. eGyanKosh: BGYCT-137 Stratigraphy and Palaeontology: https://egyankosh.ac.in/handle/123456789/69594
3. Paleontology Lecture Notes: https://www.academia.edu/10084149/Paleontology_Lecture_Notes
4. GEOL 331 Lecture Notes: https://www.geol.umd.edu/~tholtz/G331/331Syl.html

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs) – Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	3	3	3	3
CO2	9	9	9	3	3	3
CO3	9	9	9	9	3	3
CO4	9	9	9	9	9	3
CO5	9	3	9	9	9	9
CO6	9	3	9	9	9	9
Total	54	42	48	42	36	30
Weightage %	21.42	16.66	19.04	16.66	14.28	11.90

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	3	3	1	0	0
CO2	9	9	3	3	1	0
CO3	1	3	9	3	3	1
CO4	0	1	3	9	3	3
CO5	0	0	1	3	9	3
CO6	0	0	0	1	3	9

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	1	5	-	5	20
K2	1	2	1	1	5	-	5	20
K3	1	1	1	1	4	-	4	16
K4	1	1	1	1	4	-	4	16
K5	-	1	-	1	2	-	2	8
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20
Total	**5**	**6**	**4**	**5**	**20**	**5**	**25**	**100**

The Cos and Pos for the **PALAEONTOLOGY** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY3	Core	Core Course – III ADVANCED CRYSTALLOGRAPHY AND MINERALOGY	Theory	5	5

Course Description:

This course provides an in-depth understanding of crystallography, mineral optics, and descriptive mineralogy. It focuses on crystallographic symmetry, X-ray techniques, optical properties of minerals, and mineral chemistry. The course also covers the physical, chemical, and optical properties of important rock-forming and accessory minerals, emphasizing their paragenesis and geological significance.

Course Objectives: To impart knowledge on

1. Advanced crystallographic concepts and X-ray crystallography techniques.
2. Optical mineralogy and its application in mineral identification.
3. Physical and optical properties of uniaxial and biaxial minerals.
4. Chemical and structural properties of minerals and their classification.
5. Paragenesis and geological significance of important mineral groups.

Unit 1: Advanced Crystallography: Derivation of 32 Crystal classes and their symmetry projections – Hermann mauguin notation – Stereographic and gnomonic projections of crystals belonging to normal classes – 14 Bravais space lattices – X-ray Crystallography: Derivation of Bragg's law and its applications, Powder diffraction method, Powder diffractometer – Monochromatic radiations – Space lattice- unit cell-motif-point, group-space group – Concepts of crystal field theory and mineralogical spectroscopy – Stoichiometry – Atomic substitution in minerals – Lattice defects (point, line and planar).

Unit 2: Optical mineralogy: Polarization – Double refraction in calcite – Nicol prism – Polarizing microscope and Its accessories (quartz wedge, mica plate, gypsum plate, berek compensator, micrometer ocular) and their uses – Orthoscopic and conoscopic study of minerals – Ray velocity surface of uniaxial and biaxial minerals – Optic axis: primary and secondary optic axes – Indicatrix: uniaxial and biaxial minerals – Interference figure, sign of elongation, optic sign – Methods of determination of refractive indices of minerals.

Unit 3: Optical properties of uniaxial and biaxial minerals – Mineral orientation, dispersion, pleochroic scheme, birefringence, twinning, extinction angle – Determination of optic sign using interference figures, sign of elongation and optic axial angle – Optical anomalies and irregularities in minerals – U stage techniques for determination of anorthite content and twin laws in plagioclase.

Unit 4: Descriptive mineralogy: Classification of minerals – Physical properties of minerals–Mineral properties: Isomorphism, polymorphism, pseudomorphism, exsolution, order and disorder relations, fluorescence in minerals – Thermoluminescence study and its significance – Metamict state, staining techniques and micro chemical tests – Structural classification of silicate minerals and their compositional variations – Optical properties, physical properties and paragenesis of the following mineral groups: olivine, pyroxene, amphibole, mica, chlorite, halide and clay.

Unit 5: Optical properties, physical properties and paragenesis of the following mineral groups: Quartz, feldspar, feldspathoid, zeolites, garnet, epidote, spinel, alumino-silicates – Optical properties, physical properties and paragenesis of the following minerals: zircon, sphene, topaz, staurolite, beryl, cordierite, tourmaline, wollastonite, apatite, fluorite, corundum and calcite.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. The Principles of crystallography, including crystal symmetry, space lattices, Bravais lattices, and Bragg's Law.
2. Optical properties of minerals using polarizing microscopes, interference figures, and conoscopic techniques.
3. Uniaxial and biaxial mineral properties, including birefringence, pleochroism, extinction angles, and optic sign determination.
4. Classification of minerals based on their physical, chemical, and optical characteristics, including polymorphism, pseudomorphism, and exsolution.
5. Paragenesis, structural classification, and compositional variations of different mineral groups.
6. Applying crystallographic and mineralogical concepts in geological research, industrial applications, and resource exploration.

Text Books:

1. **Berry, L.G and B. Mason (2019).** Elements of Mineralogy (II eBook Edition), CBS Publishers and Distributors, New Delhi.
2. **Dana, F.S (1955).** A Text Book of Mineralogy, Asia publishing House, Wiley.
3. **Dexter Perkins. (2017).** Minerology (III ed.). Pearson India Education Services Pvt. Ltd.
4. **Gribble, C.D. (2005).** Rutley's elements of mineralogy (XXVII ed.). CBS Publication, New Delhi.
5. **Mason, Band L.G. Berry (2004).** Elements of Mineralogy (II Edition), CBS Publishers.
6. **Phillips, P.C (1956).** An Introduction to Crystallography, Longmans Green & Co.
7. **Read, H.H (1974).** Rutley's Elements of Mineralogy, Thomas Murby & Co.
8. **Winchell, A.N (1968).** Elements of Optical Mineralogy, Wiley Eastern Pvt. Ltd.

Reference Books:

1. **Cornelis Klen and Cornelius S. Hurlbut (1985).** Manual of Minerology, John Wiley &Sons
2. **Deer, W.A., Howie, R.A and J. Zuessman (1966).** An Introduction of the Rock Forming Minerals, Longmans.
3. **Dyar, M and M.E. Gunter (2007).** Mineralogy and Optical Mineralogy, Mineralogical Society of America.
4. **Gribble, C.D and A.J. Hall (1985).** A Practical Introduction to Optical Mineralogy, Springer.
5. **Kerr, P.F (1959).** Optical Mineralogy, McGraw Hill, New York.
6. **Nesse, W.D (1991).** Introduction to Optical Mineralogy, Oxford University Press, Oxford.
7. **Wade, F.A and R.B. Mattox (1960).** Elements of Crystallography and Mineralogy, Harper & Bros.

Web Resources:

1. eGyanKosh: BGYCT-133 Crystallography, Mineralogy and Economic Geology: https://egyankosh.ac.in/handle/123456789/58908
2. e-PGPathshala: https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=8zYwEsyFCoiPyJlPmzHDxg==

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs) – Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	3	3	3	3
CO2	9	9	9	3	3	3
CO3	9	9	9	9	3	3
CO4	9	9	9	9	9	3
CO5	9	3	9	9	9	9
CO6	9	3	9	9	9	9
Total	54	42	48	42	36	30
Weightage %	21.42	16.66	19.04	16.66	14.28	11.90

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	3	3	1	0	0
CO2	9	9	3	3	1	0
CO3	3	3	9	3	3	1
CO4	9	3	3	9	3	3
CO5	9	3	1	3	9	3
CO6	9	9	0	1	3	9

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation:

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	-	4	-	4	16
K2	1	1	1	2	5	-	5	20
K3	1	1	1	1	4	-	4	16
K4	1	1	1	2	5	-	5	20
K5	-	1	-	1	2	-	2	8
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20
Total	**5**	**5**	**4**	**6**	**20**	**5**	**25**	**100**

The Cos and Pos for the **ADVANCED CRYSTALLOGRAPHY AND MINERALOGY** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY4P	Core	Core Course – IV PRACTICAL 1 PALAEONTOLOGY, ADVANCED CRYSTALLOGRAPHY AND MINERALOGY	Practical	10	4

Course Description:

This practical course provides hands-on experience in palaeontology, crystallography, and mineralogy. It focuses on fossil identification, crystallographic techniques, and optical mineralogy. The course trains students to apply theoretical knowledge in laboratory settings, enhancing skills in fossil morphology, crystal symmetry, and mineral analysis.

Course Objectives: To impart knowledge on

1. Morphological characters of fossils such as corals, Graptolites, Trilobites, Brachiopods, Cephalopods, Echinoderms and, their evolutionary trends,
2. Morphological characters of microfossils such as foraminifera and ostracoda and plant fossils
3. Stereographic projection of natural crystals of normal classes, anharmonic ratio, Napier's theorem and equation of the normal, measuring interfacial angle using contact goniometer
4. Identification of minerals by the study of their physical and optical properties and optical mineralogical experiments
5. Identification of minerals based on element / oxide values.

A. Palaeontology:

- Morphology of Corals, Graptolites, Trilobites, Brachiopods, Cephalopods and Echinoderms with special reference to their evolutionary characters
- Identification of plant fossils
- Identification of foraminifera and ostracoda

B. Crystallography:

- Stereographic projection of natural crystals of normal classes
- Symmetry projections of 32 classes
- Calculation of crystal elements to test the knowledge of application of tangent relation
- Anharmonic ratio, Napier's theorem and equation of the normal
- Use of contact goniometer in measuring interfacial angles.

C. Mineralogy:

- Identification of minerals from the study of physical and optical properties
- Determination of optical vibration directions, dichroic and pleochroic schemes, sign of elongation, optic sign of uniaxial and biaxial minerals
- Identification of minerals based on element / oxide values.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. Morphological characters of fossils such as corals, Graptolites, Trilobites, Brachiopods, Cephalopods, Echinoderms and, their evolutionary trends,
2. Morphological characters of microfossils such as foraminifera and ostracoda and plant fossils
3. Stereographic projection of natural crystals of normal classes, anharmonic ratio, Napier's theorem and equation of the normal, measuring interfacial angle using contact goniometer
4. Identification of minerals by the study of their physical and optical properties
5. Optical mineralogy experiments
6. Identification of minerals based on element / oxide values.

Course Outcomes Mapping with Program Outcomes (POs) – Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	3
CO4	9	9	9	9	3	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	3	9
Total	54	54	54	54	18	24
Weightage %	20.93	20.93	20.93	20.93	6.97	9.30

Course Outcomes Mapped with Knowledge Levels:

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	3	1	3	0
CO2	9	9	9	9	1	9
CO3	9	3	9	3	3	1
CO4	3	9	9	9	3	3
CO5	9	9	3	9	9	3
CO6	9	3	9	3	3	1

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

The Cos and Pos for the **PRACTICAL 1 PALAEONTOLOGY, ADVANCED CRYSTALLOGRAPHY AND MINERALOGY** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY5E1	Elective	Elective Course – I ENVIRONMENTAL GEOLOGY AND MARINE GEOLOGY	Theory	5	4

Course Description:

This course is a combination of Environmental Geology and Marine Geology. Environmental Geology part encompasses concepts of the subject, energy sources of disasters, natural disasters such as earthquakes, volcanic eruption, flood, mass movement, soil erosion, coastal hazards and the role of Geology in their mitigation, human impact on coral reef and mangrove ecosystem, water pollution, desertification and urbanization. The Marine Geology part includes physical and chemical properties of ocean water, oceanic circulation, sea-level changes, origin of ocean basins, marine mineral resources, marine pollution, Laws of the Sea.

Course Objectives: To impart knowledge on

1. Concepts of environmental geology and geological hazards.
2. Natural disasters, their impacts and the role of Geology in mitigating the impacts
3. Marine geological processes, ocean dynamics, and sedimentation.
4. Impacts of human activities on terrestrial and marine environments.
5. Marine mineral resources, marine pollution, Law of the Sea, EEZ and SEZ.

Unit 1: Basic concepts of Environmental Geology – Outline of Earth in space and time – Energy sources of disasters: internal and external sources – Earthquakes: hazards of earthquakes, strategies for their reduction and the role of geology – Volcanic activity: its hazards of volcanic activity, strategies for their reduction and the role of geology.

Unit 2: River flooding: factors governing its severity, its hazards, strategies for their reduction and the role of geology – Mass movement: factors influencing slope stability, types and hazards of mass movement, strategies for their reduction and the role of geology – Soil erosion: factors influencing it, its hazards, strategies for their reduction and role of geology – Environmental impacts of: mining activities, hydropower projects, disposal of nuclear wastes.

Unit 3: Coastal hazards (coastal erosion, coastal flooding, sea water intrusion): strategies for their reduction and the role of geology – Impacts of human activities on marginal marine environments: estuaries, mangroves and corals reef – Global climate change: causes and effects – Surface and groundwater pollution – Desertification: causes and effects – Impacts of urbanization – Coastal Regulation Zone, Submarine groundwater discharge.

Unit 4: Marine Geology: Physical properties of ocean water – General oceanic circulation of water and factors affecting it – Convergence, divergence and upwelling, El Nino – Indian Ocean Dipole – Thermohaline circulation and oceanic conveyor belt – Formation of bottom waters – Major water masses of the world's oceans – Chemistry of ocean water –– Sea level changes and eustatic changes.

Unit 5: Factors controlling deposition and distribution of oceanic sediments – Geochronology of oceanic sediments – Diagenetic changes in oxic and anoxic environments – Origin of ocean basins – Marine mineral resources – Tectonism and marine deposits – Marine pollution: pollutants in the marine environment, causes and remedial measures – Law of the Sea, EEZ and SEZ.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. Concepts of Environmental Geology, natural disasters such as earthquake and volcanic eruption and the role of Geology in mitigating their impacts

2. Natural disasters such as river flooding, mass movements, soil erosion, and the role of Geology in mitigating their impacts and about environmental impacts of human activities.
3. Impact of human activities on coastal and marine environments and assess strategies for environmental conservation.
4. Examine marine geological processes, including ocean circulation, water chemistry, seafloor tectonics, and hydrothermal systems.
5. The distribution and deposition of oceanic sediments and their significance in geochronology and resource exploration.
6. Marine pollution, the Law of the Sea, and sustainable management of oceanic resources.

Text Books:

1. **Duff, D (1993).** Holmes' Principles of Physical Geology (IV Edition), Chapman & Hall.
2. **Keller, E.A (2012).** Introduction to Environmental Geology (V Edition), Pearson Prentice Hall.
3. **Kennett, J.P (1982).** Marine Geology. Prentice Hall, London.
4. **Kind, A.H (1979).** Introduction to Marine Geology and Geomorphology, Edward Arnold.
5. **Montgomery, C.W (2019).** Environmental Geology (IX Edition), McGraw-Hill Pub.
6. **Trujillo, A.P and H.V. Thurman (2011).** Essentials of Oceanography, X Edition Prentice Hall.
7. **Valdiya, K.S (1987).** Environmental Geology – Indian Context, Tata McGraw Hill Publications.

Reference Books:

1. **Bhatt, J.J (1994).** Oceanography: Exploring the Planet Ocean. D. Van. Nostrand Company, New York.
2. **Ross, D.A (1977).** An Introduction to Oceanography, Prentice Hall.
3. **Gross, M.G (1977).** Oceanography: A View of the Earth, Prentice Hall.
4. **Jin Erickson (2002).** Environmental Geology, Facts on File, Inc.
5. **Kerth. S (1996).** Ocean Science, John Wiley & Sons Inc.
6. **Philip, K (1950).** Marine Geology, Wiley.
7. **LaMoreaux, J.W (2019).** Environmental Geology, Springer Science+Business Media.
8. **McConnell, R.L and D.C Abel (2015).** Environmental Geology Today, Jones and Bartlett Learning.
9. **Reichard, J.S (2011).** Environmental Geology, McGraw Hill.
10. **Seibold, E (1982).** The Sea Floor. Springer-Verlag.
11. **Shepard, F. P (1994).** Submarine Geology, Harper and Row Publ.
12. **Turekian, K.K (1968).** Oceans, Prentice Hall Publ.

Web Resources:

1. Geological Society of America: https://www.geosociety.org
2. National Centre for Earth Science Studies (NCESS): https://www.ncess.gov.in
3. Indian National Centre for Ocean Information Services (INCOIS): https://incois.gov.in

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs) – Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	3
CO4	9	9	9	9	3	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	3	9
Total	54	54	54	54	18	24
Weightage %	20.93	20.93	20.93	20.93	6.97	9.30

Course Outcomes Mapped with Knowledge Levels:

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	3	3	1	0	0
CO2	9	9	3	3	1	0
CO3	3	3	9	3	3	1
CO4	9	3	3	9	3	3
CO5	9	3	1	3	9	3
CO6	9	9	0	1	3	9

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation:

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	-	4	-	4	16
K2	1	1	1	2	5	-	5	20
K3	1	1	1	1	4	-	4	16
K4	1	1	1	2	5	-	5	20
K5	-	1	-	1	2	-	2	8
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20
Total	**5**	**5**	**4**	**6**	**20**	**5**	**25**	**100**

The Cos and Pos for the **ENVIRONMENTAL GEOLOGY AND MARINE GEOLOGY** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY5E2	Elective	Elective Course – I CLIMATE CHANGE STUDIES	Theory	5	4

Course Description:

This course encompasses the fundamentals of climate systems, climate processes, paleoclimatology, natural climate variability, and anthropogenic climate change. It also includes climate dynamics, past climate evidence, and future climate projections, integrating both natural and human-induced factors influencing climate change.

Course Objectives: To impart knowledge on

1. The fundamental principles of climate systems and their classification.
2. Climate processes, energy balance, and climate feedback mechanisms.
3. Methods and proxies used in paleoclimatology.
4. Natural causes of climate variability across different timescales.
5. The impacts of human activities on climate and future climate scenarios.

Unit 1: Fundamentals of Climate: Solar spectrum and Earth's radiation balance; latitudinal and seasonal variation of temperature, pressure, air density, humidity – Constitution and stratification of the Earth's atmosphere – Global ocean circulation – Water cycle – Classification of current climates: Koppen's and Thornthwaite's scheme of classification

Unit 2: Climate Processes: Earth's energy imbalance and energy flow – Radiative forcing – Rising Temperature – Solar irradiance – Greenhouse effect – Carbon-dioxide and carbon – Climate forcing, and climate feedbacks – Earth's atmosphere – Earth's land surface – The world ocean – Cryosphere and melting ice – Ocean-Atmosphere Interface – Land-Atmosphere interface.

Unit 3: Paleoclimatology: Principles of Paleoclimatology – Causes of climate change – Multidisciplinary approach in Paleoclimatology – Proxies of palaeoclimate, Paleo-atmospheres: Ice-core record – Paleo-sea level: Sediment core record – Biological concepts in Paleoclimatology.

Unit 4: Natural Climate Change: Orbital climate change and geologic evidence – Millennial-scale climate change, Holocene climate change, Centennial climate change and Decadal climate change – Inter annual climate change in the Tropics: ENSO – Ice core record of climate change: glacial, interglacial climate and climate proxies from ice cores - Sea-level change: historical sea-level and evidence for Sea-Level Change – Role of volcanoes in climate change.

Unit 5: Anthropogenic Climate Change: Human activities impacting the climate system – Fossil fuel, atmospheric change, land use – Ocean acidification – Rising sea level – Melting glaciers – More violent storms – Deforestation – Desertification – Species migration and extinctions – Changing seasons and disruption of life cycles – Projections of future climate – Intergovernmental Panel on Climate Change and Summary of the latest assessment report.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. The fundamental principles of climate systems and their classification.
2. Climate processes, energy balance, and climate feedback mechanisms.
3. Methods and proxies used in paleoclimatology.
4. Natural causes of climate variability across different timescales.
5. The impacts of human activities on climate and future climate scenarios.
6. Latest climate change assessment report of the IPCC

Text Books:

1. **Mcilveen, J.F.R (1992).** Fundamentals of Weather and Climate, Springer-Science Business Media.
2. **Ralph J. C (2001).** Climate Change Science, National Research Council.
3. **Thomas Farmer, G (2015).** Modern Climate Change Science: An Overview of Today's Climate Change Science, Springer.
4. **Trevor Letcher (2009).** Climate Change, Elsevier Science.

Reference Books:

1. **Asheem Srivastav (2019).** The Science and Impact of Climate Change, Springer.
2. **Fátima Alves, Walter Leal Filho and Ulisses Azeiteiro (2018).** Theory and Practice of Climate Adaptation, Springer International Publishing.
3. **James Rodger Fleming (1998).** Historical Perspectives on Climate Change, Oxford University Press.
4. **Lamb, H. H (2006).** Climate: Present, Past and Future: Volume 1 - Fundamentals and Climate Now, Routledge (Taylor &Francis Group).
5. **Michael D. Mastrandrea, Stephen H. Schneider (2010).** Preparing for Climate Change, The MIT Press.
6. **Thomas M. Cronin (1999).** Principles of Paleoclimatology, Columbia University Press.

Web Resources:

1. e-PGPathshala: https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=bsA+3rVcyoJ6GW6UkeQmhw==
2. Intergovernmental Panel on Climate Change (IPCC): https://www.ipcc.ch
3. NASA Climate Change and Global Warming: https://climate.nasa.gov

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs) – Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	3
CO4	9	9	9	9	3	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	3	9
Total	54	54	54	54	18	24
Weightage %	20.93	20.93	20.93	20.93	6.97	9.30

Course Outcomes Mapped with Knowledge Levels:

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	3	1	3	0
CO2	9	9	9	9	1	9
CO3	9	3	9	3	3	1
CO4	3	9	9	9	3	3
CO5	9	9	3	9	9	3
CO6	9	3	9	3	3	1

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation:

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	-	4	-	4	16
K2	1	1	1	2	5	-	5	20
K3	1	1	1	1	4	-	4	16
K4	1	1	1	2	5	-	5	20
K5	-	1	-	1	2	-	2	8
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20
Total	**5**	**5**	**4**	**6**	**20**	**5**	**25**	**100**

The Cos and Pos for the **CLIMATE CHANGE STUDIES** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY5E3	Elective	Elective Course – I MICROPALAEONTOLOGY	Theory	5	4

Course Description:

This course provides an in-depth understanding of micropaleontology, focusing on microfossils and their significance in stratigraphy, paleoecology, and petroleum exploration. It covers the morphology, classification, ecology, and geological applications of various microfossil groups such as Foraminifera, Ostracoda, Radiolaria, Conodonts, Diatoms, and Palynomorphs. The course integrates sampling, processing techniques, and applications of microfossils in environmental and resource studies.

Course Objectives: To impart knowledge on

1. The fundamentals and historical development of micropaleontology.
2. The morphology, classification, and paleoecological significance of different microfossil groups.
3. Sampling techniques, processing, and preparation of microfossil samples.
4. Role of microfossils in stratigraphy, paleoenvironmental reconstruction, and resource exploration.
5. Industrial applications of micropaleontology, particularly in hydrocarbon and coal exploration.

Unit 1: Introduction to micropaleontology – Historical development of micropaleontological studies: world-wide in general and India in particular – Surface and sub-surface sampling methods, processing of samples, preparation of thin sections of larger foraminifera – Sampling techniques for ecological studies living microforms – Scanning Electron Microscope (SEM) photographic techniques.

Unit 2: Test morphology, wall structure, dimorphism, classification, evolution and ecology/paleoecology of foraminifera – Biometrics of important larger foraminifera – Stratigraphy of foraminifera with emphasis on Indian stratigraphic horizons.

Unit 3: Carapace morphology, ecdysis, scatter diagrams (Ontogenic studies), classification, evolution and ecology/paleoecology of Ostracoda – Applications of functional morphological characteristics in environmental studies, Carapace/valve ratio, adult/juvenile ratio, predation and pyritisation of carapace to interpret paleoecology and hydrocarbon potential – Morphology, mineralogy and geological distribution of nannofossils.

Unit 4: Skeletal morphology, wall structure, classification, palaeoecology and palaeoceanography of Radiolaria – Morphology and classification of Conodonts, Bryozoa – Outline of Silicoflagellates and dinoflagellates.

Unit 5: Diatoms and Pteropods – Palynological techniques, morphology, distinguishing characteristics of spores and pollen and their uses in oil industry – Applications of microfossils: biostratigraphical, paleoecological, paleobiogeographical and economical (hydrocarbon and coal) uses – Divisions of the marine environment and their characteristic fauna and flora.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. The fundamentals and historical development of micropaleontology.
2. The morphology, classification, and paleoecological significance of different microfossil groups.
3. Sampling techniques, processing, and preparation of microfossil samples.
4. Role of microfossils in stratigraphy, paleoenvironmental reconstruction, and resource exploration.
5. Industrial applications of micropaleontology, particularly in hydrocarbon and coal exploration.

Text Books:

1. **Armstrong, H.A and Brasier, M.D. (2005).** Microfossils. Blackwell Publishing.

2. **Bandhatia, S.B. (1987).** Micropaleontology: Principles and Applications. Himalaya Publishing House.
3. **Haq, B.U and A. Boersma (1998).** Introduction to Marine Micropaleontology. Elsevier.
4. **Saraswati P.K and M.S. Srinivasan (2016).** Micropaleontology Principles and Applications. Springer.

Reference Books:

1. **Banner, F.T and R. Williams (1994).** Foraminiferal Ecology and Paleoecology. Chapman & Hall.
2. **Bolli, H.M., Saunders, J.B and K. Perch-Nielsen (1985).** Plankton Stratigraphy. Cambridge University Press.
3. **Kennett, J.P., (1982).** Marine Geology. Prentice Hall.

Web Resources:

1. Geological Society of America: https://www.geosociety.org
2. Micropaleontology Principles and Applications: https://doi.org/10.1007/978-3-319-14574-7
3. Palaeontology Portal: https://www.paleoportal.org

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	3	3	3	3
CO2	9	9	9	3	3	3
CO3	9	9	9	9	3	3
CO4	9	9	9	9	9	3
CO5	9	3	9	9	9	9
CO6	9	3	9	9	9	9
Total	54	42	48	42	36	30
Weightage %	21.42	16.66	19.04	16.66	14.28	11.90

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	3	3	1	0	0
CO2	9	9	3	3	1	0
CO3	1	3	9	3	3	1
CO4	0	1	3	9	3	3
CO5	0	0	1	3	9	3
CO6	0	0	0	1	3	9

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation:

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	-	4	-	4	16
K2	1	1	1	2	5	-	5	20
K3	1	1	1	1	4	-	4	16
K4	1	1	1	2	5	-	5	20
K5	-	1	-	1	2	-	2	8
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20
Total	**5**	**5**	**4**	**6**	**20**	**5**	**25**	**100**

The Cos and Pos for the **MICROPALAEONTOLOGY** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY6	Core	Core Course – V IGNEOUS AND METAMORPHIC PETROLOGY	Theory	5	5

Course Description:

The course deals with the origin, classification, and evolution of igneous and metamorphic rocks. It emphasizes the role of physical and chemical processes in petrogenesis, thermodynamic principles, tectonic settings, and metamorphic transformations of rocks.

Course Objectives: To impart knowledge on

1. Forms, structures, textures, and genesis of igneous rocks and their evolution through magmatic processes.
2. Thermodynamic principles and crystallization behaviour of magmas in various systems.
3. Relationship between igneous rocks and tectonic settings and study important Indian rock suites.
4. Metamorphic processes, structures, mineralogical changes, and their tectonic significance.
5. Thermodynamic principles to study metamorphic equilibria, geothermobarometry, and common metamorphic rock types.

Unit 1: Forms of igneous rocks – Structures and textures of igneous rocks – Classification of igneous rocks – Outline on the generation of magma – Types of magma and their chemical composition – Physical properties of magma – Viscosity, temperature and pressure relationships in magmas – Magma ascent and magma diversity: magmatic differentiation, assimilation, magma –mixing, –mingling and –immiscibility – Types of mantle melting (batch, fractional and dynamic).

Unit 2: Elementary thermodynamics: Laws of thermodynamics, Gibb's Phase rule and Lever rule and their application to igneous petrogenesis – Bowen's reaction series – Crystallization of unary magma: SiO_2 system – Crystallization of binary magma: simple eutectic (Diopside-Anorthite), solid solution (Albite-Anorthite, Forsterite-Fayalite) and incongruent melting (Forsterite-Silica) – Crystallization of ternary magma: Diopside-Forsterite-Silica melt systems, Diopside-Albite-Anorthite melt systems and Anorthite-Forsterite-Silica melt systems – Role of volatiles in crystallization – Trace elements and their application in fractional crystallization – REE distribution in rocks and their application to igneous systems.

Unit 3: Igneous rocks and plate tectonic settings: igneous rocks at divergent boundary (mid-oceanic ridges, rift valleys), igneous rocks at convergent boundary (subduction zones), igneous rocks in intraplate (above hotspots, continental flood basalt and large igneous provinces) – Outline on the petrogenetic aspects of important rock suites of India: Deccan basalts, dolerites, ultramafics, komatiites, layered intrusive complexes, anorthosites, alkaline rocks, carbonatites, syenites, granites (granitoids), kimberlites, lamprophyres, and ophiolites.

Unit 4: Metamorphism: controls, limits and agents – Types of metamorphism – Outline on metamorphism of partial melting, metasomatism, anataxis and palingensis – Metamorphic structures and textures – Mineralogical changes due to metamorphism: zones, grades and facies – Chemographic diagrams: ACF, AKF, AFM – Plate tectonic significance of metamorphism: Pressure Temperature Time (P-T-t) paths and metamorphic facies series.

Unit 5: Equilibrium concepts in thermodynamics: enthalpy, entropy, Gibb's free energy, chemical potential and equilibrium – Gibb's phase rule and Claussius-Clapeyron equation –Geothermobarometer – Metamorphism of pelitic, mafic and impure carbonate rocks – Study on common metamorphic rocks: slate, phyllite, schist, gneiss, amphibolite, eclogite, granulite, khondalite, migmatite, marble, quartzite.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. The physical, chemical properties of magmas, classification, structures, and textures of igneous rocks.
2. Application of thermodynamic principles in the crystallization processes of magmas and interpret phase diagrams.
3. Relation between the distribution of igneous rocks to plate tectonic settings and study the petrogenesis of Indian rock suites.
4. Metamorphic processes, types, structures, mineralogical changes, and the significance of metamorphic facies.
5. Application of thermodynamic concepts to metamorphic equilibria and study geothermobarometric methods.
6. The identification, classification and description of common igneous and metamorphic rocks based on mineralogy, texture, and origin.

Text Books:

1. **Best, M.G (1993).** Igneous and MetamorphicPetrology, CBS Publishers and Distributors.
2. **Ehlers E.G (1999).** Petrology: Igneous Sedimentary & Metamorphic, CBS Publishers and Distributors.
3. **Hatch R. H and A.K. Wells (2003).** Petrology of the Igneous Rocks, CBS Publishers and Distributors.
4. **Haldar S. K and Tisljar Josip (2014).** Introduction to Mineralogy and Petrology, Elsevier.
5. **Turner, F.J and J. Verhoogen (1960).** Igneous and Metamorphic Petrology, McGraw Hill.
6. **Tyrrell, G.W (1963).** Principles of Petrology, Asia Publishing House.
7. **Winter J.D (2014).** Igneous and Metamorphic Petrology, Prentice Hall.

Reference Books:

1. **Antony Hall (1992).** Igneous Petrology, ELBS.
2. **Frost, B. R and D.C Frost (2014).** Essentials of Igneous and Metamorphic Petrology, Cambridge University Press.
3. **Gautham Sen (2014).** Petrology, Springer Publications.
4. **McKenzie, W.S., Donaldson, C.H and C. Guilford (1982).** Atlas of Igneous Rocks and their Textures, Longman.
5. **McBirney, A.R (1994).** Igneous Petrology, CBS Publishers and Distributors.
6. **Morse, S.A (1980).** Basalts and Phase Diagrams, Springer Verlag.
7. **Phillipots R. Anthony and Cornelis Klein (2017).** Earth Materials: Introduction to Mineralogy and Petrology, Cambridge University Press.
8. **Raymond, L. A (2001).** Petrology: The Study of Igneous, Sedimentary and Metamorphic Rocks, McGraw Hill.
9. **Winkler, H.G.F (1967).** Petrogenesis of Metamorphic Rocks, Springer and Verlag.

Web Resources:

1. eGyanKosh: Block-1 Igneous Petrology- I: https://egyankosh.ac.in/handle/123456789/66682
2. eGyanKosh: Block-2 Igneous Petrology- II: https://egyankosh.ac.in/handle/123456789/66686
3. eGyanKosh: Block-4 Metamorphic Petrology: https://egyankosh.ac.in/handle/123456789/66699
4. e-PGPathshala: https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=8zYwEsyFCoiPyJlPmzHDxg==

Course Articulation Matrix (Mapping COs with POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	3
CO4	9	9	9	9	3	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	3	3
Total	54	54	54	54	18	18
Weightage %	21.42	21.42	21.24	21.24	7.14	7.14

Course Outcomes Mapped with Knowledge Levels:

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	1	9	3	9
CO2	9	3	9	9	9	9
CO3	9	9	9	3	9	9
CO4	1	9	3	9	9	9
CO5	9	9	9	3	3	9
CO6	3	9	9	9	9	9

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation:

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	-	4	-	4	16
K2	1	1	1	1	5	-	5	20
K3	1	1	1	1	4	-	4	16
K4	1	1	1	2	5	-	5	20
K5	-	1	-	1	2	-	2	8
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20
Total	**5**	**5**	**4**	**5**	**20**	**5**	**25**	**100**

The Cos and Pos for the **IGNEOUS AND METAMORPHIC PETROLOGY** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY7	Core	Core Course – VI SEDIMENTARY PETROLOGY AND SEDIMENTOLOGY	Theory	5	5

Course Description:

This course provides a comprehensive account on the processes involved in sedimentation, lithification, and diagenesis. It focuses on the classification, composition, and characteristics of sedimentary rocks. The course also encompasses techniques in sedimentology, sedimentary facies analysis, basin analysis, provenance studies, and sequence stratigraphy, essential for reconstructing depositional environments and sedimentary basin evolution.

Course Objectives: To impart knowledge on

- The processes of sedimentation, lithification, diagenesis, and classification of sedimentary rocks.
- Analytical techniques used in sedimentology for sediment characterization and provenance studies.
- Sedimentary environments and facies distribution in different depositional settings.
- The relationships between plate tectonics and sedimentation, along with the classification of sedimentary basins.
- Sedimentary provenance, basin evolution, sequence stratigraphy, and depositional systems.

Unit 1: Sedimentation Process: Sedimentation, lithification and diagenesis – Textures and structures of sedimentary rocks – Classification and composition of sedimentary rocks – Study of residual deposits: terra rosa, clay with flint, laterite, bauxite, residual clays – Study of clastic rocks: rudaceous (Conglomerate and Breccia), arenaceous (Sandstone and its classification), volcano-clastic deposits, siltstones, mudstones – Study of non-clastic rocks (limestones and dolomites, siliceous deposits, ferruginous deposits, carbonaceous deposits, phosphatic deposits, evaporites).

Unit 2: Techniques in Sedimentology – Collection and analysis of field data – Quantitative grain size analysis of sediments – Interpretation of data for understanding the geological significance – Microscopical techniques – Cathodoluminesence – X–ray diffraction – Scanning electron microscope – Application of trace elements, rare earth elements and stable isotope geochemistry in Sedimentology – Heavy minerals and their significance.

Unit 3: Sedimentary facies and products: continental, continental margin, oceanic facies – Non marine environments: desert, fluvial, lake and glacial-environments, climatic significance of red beds – Transitional environments: coast, estuary, deltas, shore fans, barrier complexes and peritidal complexes – Marine environments – Continental shelf, slope and rise – Sedimentary basins of India and their importance.

Unit 4: Concept of plate tectonics and sedimentation – Classification and description of basins: down-warp basins, rift basins, interior basins, foreland basins, subduction basins, pull apart basins, delta type basins, composite basins – Basin formation: basins in compressional zones, strike slip zones, transform fault zones – Geosynclines: stratigraphy and sedimentation.

Unit 5: Provenance and Basin analysis: Basin and its lithic fill, palaeoslope, palaeocurrent, palaeo-fluvial channels and depositional environment – Diagnostic and maturation, sediment chemistry, basin evolution and tectonics – Sequence stratigraphy: para-sequence sets and stacking patterns: progradational stacking, aggradational stacking, retrogradational stacking – Depositional sequence: Low-stand System Tract (LST), Transgressive System Tract (TST), High-stand system Tract (HST) – Sequence boundary, transgressive surface, maximum flooding surface.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. The processes involved in sedimentation, lithification, diagenesis, and classify sedimentary rocks.
2. Sedimentological techniques and analytical tools for the study of sediments and sedimentary rocks.
3. Sedimentary facies and depositional environments.
4. Sedimentary basins in relation to plate tectonics and basin-forming processes.
5. Provenance studies and interpret basin evolution based on sediment chemistry and structural controls.
6. Sequence stratigraphy and its application in sedimentary basin analysis.

Text Books:

1. **Gary Nichols (2019).** Sedimentology and Stratigraphy, Wiley India.
2. **Petijohn, F.J (2002).** Sedimentary Rocks (III Edition), CBS Publishers & Distributors.
3. **Prothero, D. R and Schwab, F (2003).** Sedimentary Geology: An Introduction to Sedimentary Rocks and Stratigraphy, W. H. Freeman.
4. **Reading, H.G. (1996).** Sedimentary Environments: Processes, Facies and Stratigraphy. Blackwell Publishing.
5. **Sengupta (2018).** Introduction to Sedimentology, CBS Publishers
6. **Tucker, M.E (2001).** Sedimentary Petrology, Blackwell Science.
7. **Williams, H., Turner, F.J and C.M Billbert (1954).** Petrography, Freeman

Reference Books:

1. **Bayly, B (1968).** Introduction to Petrology, Prentice Hall.
2. **Bhattacharyya, C. Chakraborty (2000).** Analysis of Sedimentary Successions, Oxford and IBH Publishing Co.
3. **Blum, M.D., Marriot, S.B and F. Leclair (2005).** Fluvial Sedimentology, Blackwell Publishing, London
4. **Hsu, K.J (2004).** Physics of Sedimentology (II Edition), Springer Verlag, London
5. **Krumbein, W.C. and L.L. Sloss (1951).** Stratigraphy and Sedimentation, Freeman.
6. **Michael McLane (1995).** Sedimentology, Oxford University Press, London
7. **Sam Boggs (2000).** Principles of Sedimentology and Stratigraphy, Pearson USA

Web Resources:

1. eGyanKosh: Block-3 Sedimentary Petrology: https://egyankosh.ac.in/handle/123456789/66693
2. e-PGPathshala: https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=8zYwEsyFCoiPyJlPmzHDxg==

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs) – Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	3
CO4	9	3	3	9	9	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	9	3
Total	48	42	48	54	30	18
Weightage %	20	17.5	20	22.5	12.5	7.5

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	9	9	9	9
CO2	9	9	9	9	3	3
CO3	9	9	9	9	9	3
CO4	9	9	3	9	9	3
CO5	9	9	9	9	3	9
CO6	3	9	9	9	9	9

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	-	4	-	4	16
K2	1	1	1	1	5	-	5	20
K3	1	1	1	1	4	-	4	16
K4	1	1	1	2	5	-	5	20
K5	-	1	-	1	2	-	2	8
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20
Total	**5**	**5**	**4**	**5**	**20**	**5**	**25**	**100**

The Cos and Pos for the **SEDIMENTARY PETROLOGY AND SEDIMENTOLOGY** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY8P	Core	Core Course – VIII PRACTICAL II PETROLOGY, MINING GEOLOGY AND ENGINEERING GEOLOGY	Practical	10	4

Course Description:

This practical course provides comprehensive hands-on training in the identification and interpretation of igneous, sedimentary, and metamorphic rocks using megascopic and microscopic techniques. It also imparts practical knowledge on mining geology, particularly ore reserve estimation, and engineering geology, focusing on engineering properties of rocks and rock mass classification systems used in construction and mining industries.

Course Objectives: To impart knowledge on

1. Identification of igneous and metamorphic rocks by the study of their physical and optical properties and interpretation of petrogenetic processes using variation diagrams.
2. Identification of sedimentary rocks by the study of their physical and rocks and analyzing sediment grain size for deciphering depositional environment interpretations.
3. Identification of metamorphic rocks and interpreting metamorphic assemblages using graphical methods.
4. Engineering properties of rocks and application of Engineering Geology principles in field-based situations.
5. Ore reserve estimation techniques.

A. Petrology

i) Igneous Petrology

- Identification of igneous rocks using their megascopic and microscopic characters
- Problems relating to C.I.P.W. Norm
- Harker's diagram and Niggli variation diagram
- Problems relating to Niggli values and Niggli basis
- Variation diagrams

ii) Sedimentary Petrology

- Identification of sedimentary rocks from their megascopic and optical characteristics
- Grain size analysis of sediments

iii) Metamorphic Petrology

- Identification of metamorphic rocks from their megascopic and optical characteristics
- ACF, AKF and AFM diagrams for representation of metamorphic rock assemblages

B. Engineering Geology

- Field description of rocks in engineering practices –
- Engineering properties of rocks:
  a) Compressibility and consolidation of rocks
  b) Terzagi's theory of one dimensional theory of one dimensional consolidation
  c) Shearing strength
- Rock Mass Rating (RMR)
  – a. Rock Quality Designation (RQD)
  b. Q System and
  c. Geological Strength Index.

C. Mining Geology

- Problems relating to evaluation of ore reserves.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. Identification of igneous and metamorphic rocks by the study of their physical and optical properties and interpretation of petrogenetic processes using variation diagrams.
2. Identification of sedimentary rocks by the study of their physical and rocks and analyzing sediment grain size for deciphering depositional environment interpretations.
3. Identification of metamorphic rocks and interpreting metamorphic assemblages using graphical methods.
4. Engineering properties of rocks and application of Engineering Geology principles in field-based situations.
5. Assess and classify rock masses using Rock Mass Rating (RMR), RQD, Q-System, and Geological Strength Index (GSI).
6. Ore reserve estimation techniques.

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs) – Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	3
CO4	9	9	9	9	3	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	3	3
Total	54	54	54	54	18	18
Weightage %	21.42	21.42	21.42	21.42	7.14	7.14

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	9	9	9	3
CO2	9	9	9	9	9	3
CO3	9	9	9	9	9	3
CO4	9	9	9	9	9	3
CO5	9	9	9	9	9	3
CO6	9	9	9	9	9	3

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

The Cos and Pos for the **PRACTICAL II PETROLOGY, MINING GEOLOGY AND ENGINEERING GEOLOGY** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY9E1	Elective	Elective Course – II ENGINEERING GEOLOGY, MINING GEOLOGY AND ORE DRESSING	Theory	5	4

Course Description:

This course includes the fundamental aspects of Engineering Geology, Mining Geology, and Ore Dressing. It emphasizes the geological considerations in civil engineering projects, the techniques involved in mineral exploration and mining operations, and the principles of mineral processing and ore dressing. The course integrates theoretical concepts with practical applications relevant to the mining and construction industries.

Course Objectives: To impart knowledge on

1. Engineering properties of soil, rock, building stones, concretes and aggregates, role of geology in engineering projects such as dams, tunnels, and buildings.
2. Mineral exploration techniques, and mine development.
3. Methods and techniques of ore dressing and mineral beneficiation.
4. Assessment of the environmental impact and sustainable practices in mining and engineering geology.
5. Ore dressing techniques

Unit 1: **Engineering Geology:** Role of Geologist in Engineering Geology – Areas covered by Engineering Geology – Basic studies required by Engineering Geologist – Elementary concepts of Rock Mechanics and Soil Mechanics – Engineering Properties of Soil and Rock – Methods for measuring engineering properties of soil and rock – Engineering properties of building stones, concretes and aggregates – Rock Mass Rating (RMR): parameters for estimating Rock Quality Designation (RQD) in the rock mass – Geological Strength Index(GSI) – Rock Index Tests – Outlines on Standard Penetration Test (SPT), Seismic Cone Penetration Test (SCPT) and Core Recovery (CR) – Rock Failure Criteria (Mohr-Coulomb, Griffith and Hoek-Brown Criteria) and Shear strength of rock discontinuities – Rock Mass Classification – Geological reconnaissance, site investigation, characterization and problems related to civil engineering projects – Geotechnical Report (GTR).

Unit 2: Geological investigations pertaining to tunnelling / excavation, underground caverns, reservoirs, dams and barrage, highways, ghat roads and bridges – Geological investigations pertaining to coastal protection structures – Resource evaluation of construction materials – Environmental considerations related to Civil Engineering projects – Role of Engineering Geology in geohazards and mitigation measures: Landslides and geosynthetics, earthquakes and climate change – Important Engineering Geological case studies in India.

Unit 3: **Mining Geology:** Role of Geologist in Mining Geology – Sampling: principles and types of sampling – Drilling: types of drills and methods of drilling – Geological logging – Explosives and blasting methods – Rock excavations: haulage, shafts and shaft sinking – Ore reserve estimation: assaying and evaluation of ore bodies and their extensions – Factors controlling the choice of various mining methods – Outline of Mines and Minerals Act of India.

Unit 4: Mining Methods: Alluvial mining: panning, sluicing, hydraulicking, drift mining and dredging – Opencast mining and mine machinery pertaining to it (power shovel, bucket wheel excavator, conveyor and spreader) – Underground mining: Stopping (open stopes, supported stopes, shrinkage stopes) and caving (top slicing, sub level caving and block caving) – Underground coal mining methods: Room and pillar method, long wall (advancing and retreating) method, pillar robbing, hydraulicking, power source roofing – Strip mining of coal.

Unit 5: Ore Dressing: Physical and chemical properties of minerals as applied to mineral – Comminution: crushing and crushers (Jaw crushers, gyratory crushers and stamping) – Grinding and grinding mill (ball mill, rod mill and pebble mill) – Size separation: screening and screen separators (grizzly, trammel, vibratory, gyratory), sieve scale,

grizzlie, vibrating screens – Settling, free settling hindered settling, gravity concentration – Classification and classifiers (hydraulic, spiral, hydrocyclone) – Concentration: leaching, ore sorting, gravity concentration (panning, jig, spiral concentrator, shaking table, multigravity separator), magnetic separation, electrostatic separation, dense medium separation (flotation), dewatering (sedimentation, filtration, thermal dying) – Floatation: principle and application, frothing, collecting, and dispersing agents, floatation machines, practice and filtration.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. Engineering properties of soil, rock, building stones, concretes and aggregates, role of geology in engineering projects such as dams, tunnels, and buildings.
2. Mineral exploration techniques, and mine development.
3. Methods and techniques of ore dressing and mineral beneficiation.
4. Assessment of the environmental impact and sustainable practices in mining and engineering geology.
5. Interpret geological maps, cross-sections, and borehole data relevant to engineering and mining applications.
6. Ore dressing techniques

Text Books:

1. **Arogyaswamy, R.N.P (1986).** Courses in Mining Geology, Oxford & IBH Publishing Co., New Delhi.
2. **Bell, F. G (1983).** Fundamentals of Engineering Geology, Butterworths.
3. **Blyth, F. G H. and M. H. De Freitas (1984).** Geology for Engineers (VII Edition), Elsevier.
4. **Haldar, S.K (2018).** Mineral Exploration Principles and Applications, Elsevier.
5. **Krynine, D. P and W.R. Judd (2018).** Principles of Engineering Geology and Geotechnics, CBS Publ.
6. **McKinstry, H. E (2000).** Mining Geology, Asia Publishing House.
7. **Pandey, V. K and A. Mishra (2017).** Handbook of Engineering Geology, CBS Publishers and Distributors
8. **Parbin Singh (2013).** Engineering Geology, S. K. Kataria& Sons.
9. **Taggart, A.E (1964).** Elements of Ore Dressing, Wiley.
10. **Venkat Reddy, D (2010).** Engineering Geology, Vikas Publ. House Pvt. Ltd., New Delhi.

Reference Books:

1. **Abzalov, M (2016).** Applied Mining Geology, Springer International Publishing.
2. **Das, B. M and K. Shoban (2017).** Principles Geotechnical Engineering(IX Edition), Cengage Learning.
3. **Donald, P. C (2017).** Geotechnical Engineering: Principles and Practices (II Edition), Pearson Education.
4. **Gokhale, K.V.G.K and D.M. Rao (1981).** Experiments in Engineering Geology, Tata McGraw Hill.
5. **Joseph, E. B (1984).** Physical and Geotechnical Properties of Soils (II Edition), McGraw-Hill Inc.
6. **Maslov, N. N (1987).** Basic Engineering Geology and Soil Mechanics, Mir Publishers.
7. **Murthy, V.N.S (2018).** Soil Mechanics and Foundation Engineering, CBS Publishers and Distributors.
8. **Ries, H and T.L. Watson (2011).** Elements of Engineering Geology. John Wiley & Sons.
9. **Singh, A and P. Rastogi (2006).** Modern Geotechnical Engineering (III Edition), CBS Publ.
10. **Stanton, R.L (1972).** Ore Petrology, McGraw Hill.
11. **Thamus, P.J (1979).** An Introduction to Mining, Methun.

Web Resources:

1. https://www.sciencedirect.com/journal/engineering-geology
2. https://www.britannica.com/science/mining
3. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=8zYwEsyFCoiPyJlPmzHDxg==

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs) – Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	3
CO4	9	3	3	9	9	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	9	3
Total	48	42	48	54	30	18
Weightage %	20	17.5	20	22.5	12.5	7.5

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	9	9	9	9
CO2	9	9	9	9	3	3
CO3	9	9	9	9	9	3
CO4	9	9	9	9	9	3
CO5	9	9	9	9	9	9
CO6	9	9	9	9	9	9

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	-	4	-	4	16
K2	1	1	1	2	5	-	5	20
K3	1	1	1	1	4	-	4	16
K4	1	1	1	2	5	-	5	20
K5	-	1	-	1	2	-	2	8
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20
Total	**5**	**5**	**4**	**6**	**20**	**5**	**25**	**100**

The Cos and Pos for the **ENGINEERING GEOLOGY, MINING GEOLOGY AND ORE DRESSING** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY9E2	Elective	Elective Course – II GEOTECHNICS	Theory	5	4

Course Description:

This course provides an in-depth understanding of Geotechnics, emphasizing the study of soil and rock mechanics, site investigations, geotechnical testing, construction materials, and geological aspects of civil engineering projects. It highlights the significance of geotechnical investigations in the design and execution of infrastructure projects and addresses the geological causes of structural failures and their mitigation.

Course Objectives: To impart knowledge on

1. The fundamentals of soil and rock mechanics.
2. Site investigations and geotechnical testing.
3. Geological considerations in construction materials and foundation types.
4. Geological investigations for infrastructure projects like dams, tunnels, and coastal structures.
5. Natural hazards affecting engineering structures and adoption of suitable mitigation strategies.

Unit 1: Introduction to Geotechnics – Formation of the Quaternary soil layers – Soils of Geological past – Review on Indian bedrocks – Soil properties: soil components and classification – Structure of soils – Mechanics of materials: stress and strain under conditions of tension, compression and shear – Elastic, plastic and time-dependent material – Multi-axis stress state – Conditions of failure – Soil Mechanics: soil stress and deformation – Tension in the soil-water system: total pressure, pore pressure and effective pressure – Soil compression – Soil shear and failure – Soil composition – The consolidation process – Soil's carrying capacity – Soil pressure – Soil slope stability – Rock mechanics*:* Rock strength and deformation properties – Rock mechanics calculations – Rock classification.

Unit 2: Geological reconnaissance, site investigation, characterization and problems related to Civil Engineering projects – Geotechnical Report (GTR) – Laboratory and field geotechnical tests: Applications of Geophysical (electrical) methods in Geotechnical investigations or Civil Engineering problems – Ground investigations – Penetration tests: Standard Penetration Test (SPT) and Seismic Cone Penetration Test (SCPT) – Drilling, Sampling (Bore Holes and Trial Bits) - Core Recovery (CR) – Logging, Bore-Log Report and Data Interpretation – Rock Quality Designation (RQD) – Bienawiski's Rock Mass Rating (RMR).

Unit 3: Construction materials: Geologic considerations and physical characteristics of building stones, concrete aggregates and rail road ballasts – Outline on Geosynthetics – Types of foundations and safe bearing capacity – Environmental considerations related to Civil Engineering Projects – Geological investigations pertaining to the development of roads/highways, airfields, bridges and buildings.

Unit 4: Dams and Reservoirs: Types of dams, geological investigations for dams and reservoirs – Dam foundation, construction, problems and remedial measures – Spill way problems and reservoir problems – Tunnels/Excavation sites: Geological investigations preceding tunneling or excavation – Problems relating to tunneling or excavation in hard and soft grounds – Coastal Structures: Geotechnical investigations pertaining to the construction of harbour and docks.

Unit 5: Natural hazards / geological causes for the failures of engineering structures and mitigation strategies – Geological and geotechnical investigations for the areas prone to mass movements with special emphasis on landslides – Causes of hill-slope Instability – Slope stability – Geological investigations pertaining to coastal protection, structures for control or preventive measures of coastal erosion and other impacts – A note on

earthquake-resistant structures – Impacts of climate change on Engineering Geology and mitigation measures – Important Engineering Geological case studies.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. The fundamental principles of Geotechnics including soil and rock mechanics.
2. Site investigations for engineering projects and, interpretation of geotechnical data.
3. The evaluation of geological characteristics of construction materials and design foundations.
4. Geotechnical considerations in construction of dams, tunnels, coastal, other civil structures.
5. Identifying sites areas prone for geological hazards and their mitigation measures.
6. Applying geotechnical knowledge in the planning and execution of slope stability analysis, earthworks, and ground improvement techniques.

Text Books:

1. **Das, B. M and K. Shoban (2017).** Principles Geotechnical Engineering (XI Edition), Cengage Learning.
2. **Gokhale, K.V.G.K and D. M. Rao (1981).** Experiments in Engineering Geology, Tata McGraw-Hill.
3. **Pandey, V. K and A. Mishra (2017).** Handbook of Engineering Geology, CBS Publishers and Distributors.
4. **Parbin Singh (2013).** Engineering Geology, S. K. Kataria& Sons
5. **Sivakugan N and Das, B. M (2014).** Geotechnical Engineering: A Practical Problem Solving Approach, Cengage Publishers.

Reference Books:

1. **Bell, F. G (1983).** Fundamentals of Engineering Geology, Butterworths.
2. **Blyth, F. G. H and M. H. De Freitas (1984).** Geology for Engineers (VII Edition), Elsevier.
3. **Coduto, D. P., Yeung, M. R and W. A. Kitch (2010).** Geotechnical Engineering: Principles and Practices, Prentice Hall.
4. **Harrison, J. P and J. A. Hudson (2001).** Engineering Rock Mechanics: Part 2: Illustrative Worked Examples, Pergamon Publishers.
5. **Hudson, J. A and J. P. Harrison (2000).** Engineering Rock Mechanics: An Introduction to the Principles, Pergamon Publishers.
6. **Krynine, D. P and W. R. Judd (2018).** Principles of Engineering Geology and Geotechnics, CBS Publishers and Distributors.
7. **Maslov, N. N (1987).** Basic Engineering Geology and Soil Mechanics, Mir Publishers.
8. **Murthy, V. N. S (2018).** Soil Mechanics and Foundation Engineering, CBS Publishers and Distributors.
9. **Richard Bassett (2011).** A Guide to Field Instrumentation in Geotechnics: Principles, Installation and Reading, CRC Press.
10. **Ries, H. and T. L. Watson (2011).** Elements of Engineering Geology. John Wiley & Sons.
11. **Robert W. Day (2012).** Geotechnical Engineers Portable Handbook (II Edition), McGraw-Hill Education.
12. **Ruwan Abey Rajapakse (2015).** Geotechnical Engineering Calculations and Rules of Thumb (II Edition), Butterworth-Heinemann.
13. **Steve Hencher (2012).** Practical Engineering Geology (Applied Geotechnics), CRC Press.
14. **Venkat Reddy, D (2010).** Engineering Geology, VikasPubl. House Pvt. Ltd.
15. **Vutukuri, V. S., Lama, R. D and S. S. Saluja (1974).** Handbook of Mechanical Properties of Rocks (Vol. 1, 2, 3 & 4), Trans./Tech. S. A.

Web Resources:

1. Geological Society of London – https://www.geolsoc.org.uk/
2. International Society for Soil Mechanics and Geotechnical Engineering – https://www.issmge.org/
3. NPTEL Online Course: Geotechnical Engineering – https://nptel.ac.in/

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs) – Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	3
CO4	9	3	3	9	9	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	9	3
Total	48	42	48	54	30	18
Weightage %	20	17.5	20	22.5	12.5	7.5

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	9	9	9	9
CO2	9	9	9	9	3	3
CO3	9	9	9	9	9	3
CO4	9	9	9	9	9	3
CO5	9	9	9	9	9	9
CO6	9	9	9	9	9	9

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	-	4	-	4	16
K2	1	1	1	2	5	-	5	20
K3	1	1	1	1	4	-	4	16
K4	1	1	1	2	5	-	5	20
K5	-	1	-	1	2	-	2	8
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20
Total	**5**	**5**	**4**	**6**	**20**	**5**	**25**	**100**

The Cos and Pos for the **GEOTECHNICS** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY9E3	Elective	Elective Course – II GEOLOGICAL OCEANOGRAPHY	Theory	5	4

Course Description:

This course deals with aspects that provide in-depth understanding of the geological aspects of oceans, including their origin, evolution, structure, and processes. It covers oceanic circulation, sedimentation, tectonics, and resources of the ocean floor. The course also emphasizes the chemical and isotopic characteristics of marine environments, palaeo-oceanographic reconstructions, sea level changes, marine pollution, and ocean management practices.

Course Objectives: To impart knowledge on

1. The fundamental concepts and history of oceanography.
2. Morphology and tectonic evolution of ocean basins.
3. Physical and chemical processes in the ocean.
4. Marine mineral resources and their geological significance.
5. Paleoceanographic methods and sea-level changes.
6. Marine pollution, ocean laws, and management strategies.

Unit 1: History of development of Oceanography – Origin of seas and oceans –. Ocean morphology, deep ocean floor and various topographic features, ridges, seamounts, coral reefs, continental shelf, slope, benches and canyons – Hydrothermal vents and seawater-basalt interaction.

Unit 2: Oceanic circulation, waves, currents and tides- T-S diagrams: mixing processes in the oceans – Characteristics of important water masses – Wind generated waves in the oceans: their characteristics; shallow and deep-water waves – Propagation, refraction, and reflection of waves – Wave spectrum, principles of wave forecasting– Nearshore geological processes, sea level changes with special emphasis on Quaternary-Oceanic sediments and distribution of marine microfossils – Stratigraphy and geochemistry of deep-sea deposits.

Unit 3: Tectonic history of the oceans – Tectonics of continental margins, continental shelves, divergent margins, active margins and marginal basins – Global tectonics and seafloor spreading – Chemical properties of sea water – Chemistry of oceanic rocks – marine instrumentation on navigation with special mention on geological studies such as dredges, grabs, water samplers, underwater cameras, etc.

Unit 4: Mineral resources of the oceans – Diagenetic changes in oxic and anoxic environments – Mobility of redox metals – Isotope geochemistry and paleoceanography – Sedimentary markers (biological and chemical) of palaeoenivronmental conditions – Paleoceanography – Approaches to paleoceanographic reconstructions: various proxy indicators for paleoceanographic interpretation – Reconstruction of monsoon variability by using marine proxy records – Opening and closing of ocean gateways and their effect on circulation and climate during the Cenozoic – Sea level processes and sea level changes.

Unit 5: Hydrocarbons beneath the sea floor – Marine gas hydrates and their economic potential – Ocean laws and management – Marine pollution-Deep-sea drilling projects and modern research in marine geology – Marine geology of Antarctic sea and other cold seas/oceans.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. The origin, evolution, and morphology of oceans and associated topographic features.
2. Oceanic circulation, wave dynamics, sedimentation processes, and sea-level changes.
3. Tectonic history and chemical properties of sea water and oceanic rocks.

4. Marine resources, paleoceanographic reconstructions, and geochemical proxies for environmental interpretation.
5. Hydrocarbon resources, marine gas hydrates, marine pollution, and ocean management
6. Interpretation of marine geological data using tools such as seismic profiles, bathymetric maps, and core samples to assess oceanographic and environmental processes.

Text Books:

1. **Grant Gross, M. (1977).** Oceanography; A view of the Earth, Prentice Hall.
2. **Kennet, J.P., (1982).** Marine Geology, Prentice Hall.
3. **Pinet, P.R. (2019).** Invitation to Oceanography. Jones & Bartlett Learning.
4. **Ross, D.A. (1982).** Introduction to Oceanography, 3rd Edition, Prentice Hall.
5. **Seibold, E. and Berger, W.H., (1982).** The Sea floor, Springer-Verlag.

Reference Books:

1. **King, C.A.M (1975).** Introduction to marine Geology and Geomorphology. Edward Arnold.
2. **Shepard, F.P (1978).** Geological Oceanography, Heinmann.
3. **Savindra Singh, (2020).** Oceanography, Pravalika Publications.
4. **Svedrup, J.F (1969).** The Ocean, A Scientific American book, W.H. Freeman and company.
5. **Weisberg, C.P (1979).** Oceanography. McGraw Hill.
6. **Komar, P.D. (1976).** Beach processes and sedimentation, Prentice Hall.

Web Resources:

1. e-PGPathshala: https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=bsA+3rVcyoJ6GW6UkeQmhw==
2. https://www.nodc.noaa.gov/ (National Oceanographic Data Center)
3. https://www.unesco.org/en/ocean-science
4. https://marine.geo.soton.ac.uk/
5. https://www.sciencedirect.com/journal/marine-geology

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs) – Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	3
CO4	9	3	3	9	9	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	9	3
Total	48	42	48	54	30	18
Weightage %	20	17.5	20	22.5	12.5	7.5

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	9	9	9	9
CO2	9	9	9	9	3	3
CO3	9	9	9	9	9	3
CO4	9	9	9	9	9	3
CO5	9	9	9	9	9	9
CO6	9	9	9	9	9	9

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	-	4	-	4	16
K2	1	1	1	2	5	-	5	20
K3	1	1	1	1	4	-	4	16
K4	1	1	1	2	5	-	5	20
K5	-	1	-	1	2	-	2	8
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20
Total	**5**	**5**	**4**	**6**	**20**	**5**	**25**	**100**

The Cos and Pos for the **GEOLOGICAL OCEANOGRAPHY** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY10E1	Elective	Elective Course – III GEOMORPHOLOGY	Theory	5	4

Course Description:

This course includes the fundamental concepts of Geomorphology, driving forces of landform formation, physiography of the Earth, exogenous and endogenous geomorphic processes, Processes and landforms formed due to weathering, soil formation, erosion, transportation and deposition processes, hill slope processes, drainage development, action of river, glaciers, wind, tectonism, volcanism, coastal, marine, climate and anthropogenic activities. It also includes a comprehensive account on landforms related to rock type and structure and, major geomorphic features of India.

Course Objectives: To impart knowledge on

1. Fundamental concepts of Geomorphology, landform formation, physiography of the Earth, exogenous and endogenous geomorphic processes.
2. Processes and landforms formed due to weathering, soil formation, erosion, transportation and deposition processes, hill slope processes, drainage development
3. Processes and landforms formed due to the action of river, glaciers, wind, tectonism and volcanism
4. Processes and landforms formed due to the action of coastal, marine, climate and anthropogenic activities.
5. Processes and landforms related to rock type and structure, major geomorphic features of India and, river basins of India

Unit 1: Geomorphology – Introduction: Fundamental concepts of Geomorphology – Fundamental driving forces of landform formation: internal and external forces – Energy balance of the Earth's surface processes – Physiography of the Earth – Outline of geomorphic processes: exogenous and endogenous processes – Applications of Geomorphology.

Unit 2: Weathering, Soil and Drainage: Weathering: types and products, factors affecting rates of weathering, landforms formed by weathering, applications – Soils: soil development process, factors affecting soil production, soil profiles, soil classification, soils and landscapes,– Erosion, transportation and deposition of Earth materials – Hill slopes: processes, climatic influence on slope processes, slope morphology, and slope evolution, applications – Drainage: patterns, evolution, quantitative analysis.

Unit 3: Fluvial, Glacial, Groundwater, Aeolian Geomorphology: Fluvial Geomorphology: fluvial processes and landforms, applications of fluvial geomorphology – Glacial Geomorphology: glacial processes and landforms, applications – Groundwater Geomorphology: processes, landforms, and applications – Aeolian Geomorphology: aeolian processes, landforms, applications.

Unit 4: Tectonic and Volcanic Geomorphology, Landforms related to Rock Type and Structure: Tectonic Geomorphology: tectonic processes, landforms and landscape response to tectonics, markers of tectonic geomorphology, applications – Volcanic Geomorphology: volcanic landscapes, processes of volcanic landform evolution, applications – Landforms related to rock type and structure - Outline on impact craters – Anthropogenic activities and landforms

Unit 5: Coastal, Marine, Climatic Geomorphology and Geomorphology of India: Coastal Geomorphology: coastal processes and landforms, applications – Shorelines: classification of shorelines and their evolution – Marine Geomorphology: marine processes and landforms, applications – Climatic Geomorphology: records of changing climate cycles, Koppen climate classification, climate related landform and processes, landscape response to climate, landscape controls on climate, applications – Major geomorphic features of India: coastal, peninsula and extra peninsula – River basins of India.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. Fundamental concepts of Geomorphology, landform formation, physiography of the Earth, exogenous and endogenous geomorphic processes.
2. Processes and landforms formed due to weathering, soil formation, erosion, transportation and deposition processes, hill slope processes, drainage development
3. Processes and landforms formed due to the action of river, glaciers, wind, tectonism and volcanism
4. Processes and landforms formed due to the action of coastal, marine, climate and anthropogenic activities.
5. Processes and landforms related to rock type and structure
6. Major geomorphic features of India and river basins of India

Text Books:

1. **Dayal, P (2010).** A Text Book of Geomorphology, Rajesh Publications.
2. **Kale, V and Gupta, A. (2018).** Introduction to Geomorphology, Universities Press, Orient Black Swan Pub.
3. **Kale, V. (2014).** Landscapes and Landforms of India, Springer.
4. **Plummer, C.C., Carlson, D.H and Hammersley, L. (2016).** Physical Geology (XV Edition), McGraw-Hill Education.
5. **Savindra Singh (2018).** Geomorphology, Prayag Pustak Bhawan.
6. **Sharma, H.S. (2010).** Geomorphology in India, Prayag Pustak Bhawan.
7. **Siddhartha, K. (2018).** The Earth's Dynamic Surface: A Book of Geomorphology (Paperback), Books Wagon Pub.
8. **Thornbury, W.D. (2018).** Principles of Geomorphology (III Edition), New Age International Publishers.
9. **Vaidyanathan, R. (2002).** Geomorphology of the Indian Subcontinent, Published by the Indian Society of Remote Sensing.

Reference Books:

1. **Adrian Harvey. (2012).** Introducing Geomorphology: A Guide to Landforms and Processes, Dunedin Academic Press Ltd.
2. **Ahnert, F. (1998).** Introduction to Geomorphology, Routledge Publishers, New Delhi, 360p.
3. **Bierman, P.R and Montgomery, D.R. (2014).** Key Concepts in Geomorphology, W. H. Freeman & Co.
4. **Burbank, D.W and Anderson, R.S. (2008).** Tectonic Geomorphology, Blackwell Science Ltd.
5. **Gutierrez, M. (2005).** Developments in Earth Surface Processes: Climatic Geomorphology, Elsevier Pub.
6. **Rugget, R.J. (2017).** Fundamentals of Geomorphology (Fourth Edition), Routledge Pub.
7. **Summerfield, M A. (1991).** Global Geomorphology, Pearson Educational, for Prentice Hall.
8. **Tarbuck, E.J and Lutgens, F.K. (2014).** Earth – An Introduction to Physical Geology, Pearson Education.
9. **Thompson, G.R and Turk, J (1997).** Introduction to Physical Geology (II Edition), Brooks/Cole Publishers.

Web Resources:

1. https://earthobservatory.nasa.gov/
2. https://www.unep.org/
3. https://www.usgs.gov/

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs) – Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	3
CO4	9	3	3	9	9	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	9	3
Total	48	42	48	54	30	18
Weightage %	20	17.5	20	22.5	12.5	7.5

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	9	9	9	9
CO2	9	9	9	9	3	3
CO3	9	9	9	9	9	3
CO4	9	9	9	9	9	3
CO5	9	9	9	9	9	9
CO6	9	9	9	9	9	9

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	-	4	-	4	16
K2	1	1	1	2	5	-	5	20
K3	1	1	1	1	4	-	4	16
K4	1	1	1	2	5	-	5	20
K5	-	1	-	1	2	-	2	8
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20
Total	**5**	**5**	**4**	**6**	**20**	**5**	**25**	**100**

The Cos and Pos for the **GEOMORPHOLOGY** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY10E2	Elective	Elective Course – III ISOTOPE GEOLOGY	Theory	5	4

Course Description:

This course introduces the principles and applications of isotopes in geological processes. It encompasses both stable and radiogenic isotopes, radioactive decay mechanisms, isotope geochemistry, and geochronology. Emphasis is placed on understanding isotopic behavior in Earth systems and their significance in dating rocks, tracing geological processes, and exploring natural resources. Analytical methods such as mass spectrometry and techniques for interpreting isotopic data are also covered.

Course Objectives: To impart knowledge on

1. Basic principles of radioactivity, the structure of atomic nuclei, and the mechanisms of radioactive decay.
2. Fundamentals of stable isotope geochemistry and their role in environmental and geological systems.
3. Effect of crystal structure and geochemical behaviour on the retention and distribution of daughter isotopes in Earth's reservoirs.
4. Applying isotope systems (Sr, Nd, Pb, Ar) in geochronology, mineral exploration, paleoclimate reconstruction, and geothermometry.
5. Isotope analysis using mass spectrometry, and evaluate dating techniques and their geological implications.

Unit 1: Introduction to isotopes and nuclear systematic: Discovery of radioactivity, stable and radiogenic isotopes – Introduction to isotope geology – Nuclear structure, atomic weights, nuclear stability and abundance – Theory and mechanism of decay, particles emitted, positron, negatron and alpha decay – Equations of radioactive decay and radiogenic growth.

Unit 2: Fundamentals of stable isotope geochemistry – Oxygen and hydrogen isotopes in the hydrosphere, atmosphere and lithosphere – Stable isotopes of carbon, nitrogen and sulphur – Fractionation of stable isotopes – Carbon isotopes in the Earth's reservoirs – Sulphur isotopes and their applications in ore geology.

Unit 3: Effect of mineral/crystal structures, growth and retention of daughter isotopes in earth systems – Abundances of unstable nuclides in earth, core, mantle, crust, oceans and different rock types; their decay schemes – Radioactive elements as major elements, minor elements and trace elements and their geochemical behaviour.

Unit 4: Geochronology – Isotope Geology of Sr, Nd, Pb and Ar, and their applications – Applications of stable isotopes in geothermometry and geobarometry – Isotopes in mineral exploration, petroleum exploration, paleo-climate evaluation, health and environmental aspects – Cosmogenic nuclides and their applications.

Unit 5: Introduction to analytical techniques and mass spectrometry – Mass spectrometer: instrumentation, chemical separation, isotope dilution and ratio analysis – Methods of dating: Isochron method, model/mineral ages, fission track, ^{40}Ar-^{39}Ar, U and Th disequilibrium, choncordia method, ^{14}C, Be and Al – Interpretation and geological significance of ages – Isotope systematics of K-Ar, Rb-Sr, Sm-Nd, U-Th-Pb in igneous, metamorphic and sedimentary rocks and in evolution of ocean, crust and mantle.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. The concepts of nuclear structure, radioactivity, and types of radioactive decay.
2. The role of stable isotopes (O, H, C, N, S) in Earth systems and geological processes.
3. The influence of mineral structures and geochemical behavior on isotope distribution and retention.
4. Applying isotopic systems for dating geological events and reconstructing temperature-pressure conditions.
5. The analytical methods such as isotope dilution and mass spectrometry used in isotope geology.
6. Interpreting age data and isotope signatures to infer geological history and processes across different rock types.

Text Books:

1. **Faure, G (1986).** Principles of Isotope Geology (II Edition), John Wiley & Sons.
2. **Faure, G and T. M. Mensing (2005).** Isotopes: Principles and Applications (III Edition), John Wiley & Sons.
3. **Sharp Zachary (2006).** Principles of Stable Isotope Geochemistry, Prentice Hall.

Reference Books:

1. **Dickin, A. P (1995).** Radiogenic Isotope Geology, Cambridge University Press.
2. **Faure, G and J.L. Powell (1972).** Strontium Isotope Geology. Springer Verlag.
3. **Hoefs, J (1987).** Stable Isotope Geochemistry (III Edition). Springer-Verlag.
4. **Rollinson, H. R (1993).** Using Geochemical Data: Evaluation, Presentation, Interpretation, Longman, Harlow.
5. **William, W.M (2014).** Isotope Geochemistry, Wiley.

Web Resources:

1. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000014ER/P000274/M025989/ET/1557721551Paper4_Module33_etext.pdf
2. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/http://sites.iiserpune.ac.in/~p.subramanian/Isotope-Allegre.pdf
3. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://ocw.mit.edu/courses/12-570-seminar-in-geophysics-mantle-convection-spring-1998/7f02e4cc6ac42e0395ff2f26ad931c9e_030398_notes.pdf

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs) – Course Articulation Matrix

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	9	9
CO4	9	3	3	9	9	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	9	3
Total	48	42	48	54	36	24
% Weightage	19.04	16.66	19.04	21.42	14.28	9.52

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	9	9	9	3
CO2	9	9	9	9	3	3
CO3	9	9	9	3	9	3
CO4	9	9	9	9	9	3
CO5	9	9	9	9	9	1
CO6	9	9	9	9	9	9

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	-	4	-	4	16
K2	1	1	1	2	5	-	5	20
K3	1	1	1	1	4	-	4	16
K4	1	1	1	2	5	-	5	20
K5	-	1	-	1	2	-	2	8
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20
Total	**5**	**5**	**4**	**6**	**20**	**5**	**25**	**100**

The Cos and Pos for the **ISOTOPE GEOLOGY** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY10E3	Elective	Elective Course – III QUATERNARY GEOLOGY	Theory	5	4

Course Description:

This course on Quaternary Geology explores the most recent geological time period, focusing on climatic fluctuations, glaciations, environmental changes, and the interaction between humans and their environment. It introduces stratigraphic records, dating methods, glacial and periglacial processes, and the application of Quaternary studies in climate change, natural hazards, and human history.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. The fundamentals of Quaternary Geology, including its stratigraphy, key events, and dating methods.
2. Exploring climatic and glacial events of the Quaternary, with emphasis on glaciation dynamics and Milankovitch cycles.
3. Glacial and periglacial processes, associated landforms, and their feedback mechanisms in climate systems.
4. Methods for Quaternary reconstruction using paleoenvironmental proxies like sediments, fossils, and isotopes.
5. Relevance of Quaternary geology to modern-day issues, such as climate change, geohazards, and land management.

Unit 1: Introduction to Quaternary Geology: Overview of the Quaternary period: timing, stratigraphy, and significance – Methods of dating Quaternary deposits: Radiocarbon dating, dendrochronology, luminescence dating – The role of Quaternary geology in understanding long-term Earth processes – Key events of the Quaternary: glaciations, interglacials, and transitions.

Unit 2: Climate Change and Glaciations: Climate during the Quaternary: evidence of climatic shifts – Ice ages: conditions, causes, and consequences – The Pleistocene Glaciations: distribution of ice sheets and their impact – Late Pleistocene climatic fluctuations and Holocene warming – Global climatic cycles: Milankovitch cycles and their influence on Earth's climate.

Unit 3: Glacial and Periglacial Processes: Formation and dynamics of glaciers and ice sheets – Glacial erosion, deposition, and landforms – Periglacial environments and features: frost action, solifluction, and permafrost – Ice-sheet dynamics and climate feedbacks – The Last Glacial Maximum and its global impact.

Unit 4: Quaternary Reconstruction: Methods of Quaternary reconstruction: sediment analysis, pollen analysis, and isotopic studies – Marine and terrestrial records of Quaternary climates – Vegetation and fauna during the Quaternary: evidence from fossils and pollen – The role of human activities in shaping Quaternary environments – Human impact and extinction events during the late Quaternary.

Unit 5: Quaternary Geology and Its Modern Applications: Applications of Quaternary geology in understanding climate change – Quaternary geology in environmental studies and land management – Case studies: impacts of past climate events on present–day ecosystems – Quaternary Geohazards: earthquakes, volcanic eruptions, and sea–level changes – Human history and Quaternary geology: from the Ice Age to modern times.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. The geological significance and stratigraphic framework of the Quaternary Period.
2. Climatic fluctuations and glacial-interglacial cycles during the Quaternary.
3. Glacial and periglacial processes and interpret related geomorphic features.
4. Application of reconstruction techniques to interpret past environmental and climatic conditions.

5. Applications of Quaternary studies in understanding climate change and geohazards.
6. Interplay between human evolution, migration, and Quaternary environmental changes.

Text Books:

1. **Bowen, D. Q (2008).** Quaternary Geochronology: Methods and Applications. Wiley-Blackwell.
2. **Clark, P. U and R.W. Houghton (2009).** Glacial and Periglacial Geomorphology. Springer.
3. **Ehlers, J and Gibbard, P. L (2007).** Quaternary Glaciations – Extent and Chronology. Elsevier.
4. **Gibbard, P. L and T. van Kolfschoten (2004).** The Quaternary Period in the World. Elsevier.
5. **Hughes, T and R. Gagliardi (2011).** Glacial Systems and Processes. Cambridge University Press.
6. **John Lowe and Mike Walker (2015).** Reconstructing quaternary environments, III Ed.. Routledge, Taylor & Francis Group.
7. **Markgraf, V (2017).** Paleoenvironmental Reconstruction: Methods and Results. Springer.

Reference Books:

1. **Bradley, Raymond, S (1948).** Paleoclimatology: reconstructing climates of the Quaternary, III edition, Academic Press, Elsevier.
2. **Faegri, K and J. Iversen (1989).** Textbook of Pollen Analysis. Wiley.
3. **Last, W. M and J. P. Smol (2001).** Tracking Environmental Change Using Lake Sediments: Volume 2: Physical and Geochemical Methods. Springer.
4. **Ruddiman, W. F (2008).** Earth's Climate: Past and Future. W.H. Freeman.

Web Resources:

1. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://core.ac.uk/download/pdf/10199494.pdf
2. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.utoledo.edu/nsm/envsciences/pdfs/4200-5200%20Quat_Syll15.pdf
3. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://cteco.uconn.edu/guides/resource/CT_ECO_Resource_Guide_Quaternary_Geology.pdf

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs) – Course Articulation Matrix

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	9	9
CO4	9	3	3	9	9	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	9	3
Total	48	42	48	54	36	24
% Weightage	19.04	16.66	19.04	21.42	14.2	9.52

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	9	9	9	3
CO2	9	9	9	9	3	3
CO3	9	9	9	3	9	3
CO4	9	9	9	9	3	3
CO5	9	9	9	9	9	1
CO6	9	9	9	9	9	9

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	-	4	-	4	16
K2	1	1	1	2	5	-	5	20
K3	1	1	1	1	4	-	4	16
K4	1	1	1	2	5	-	5	20
K5	-	1	-	1	2	-	2	8
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20
Total	**5**	**5**	**4**	**6**	**20**	**5**	**25**	**100**

The Cos and Pos for the **QUATERNARY GEOLOGY** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY11	Core	Core Course – VIII GEOTECTONICS AND STRUCTURAL GEOLOGY	Theory	5	5

Course Description:

This course includes the structure and dynamics of the Earth's interior, tectonic movements, and deformation of rocks. It covers theories such as continental drift, seafloor spreading and, plate tectonics, structural and tectonic features of India. It also includes concepts of stress, strain, rock deformation, rheology, and kinematic-dynamic analysis, geological structures such as fault, joints, unconformity and fold. It also concerns with petrofabric analysis and their interpretation.

Course Objectives: To impart knowledge on

1. The basic concepts of seismology, isostasy, geomagnetism, thermal structure of the Earth, and volcanic activities including mantle plumes.
2. Continental drift, seafloor spreading, plate tectonics, and tectonic features of the Indian plate.
3. The concept of stress, strain, rock deformation, rheology, and kinematic-dynamic analysis.
4. Classification and mechanics of faults, joints, unconformities, shear zones, and gravity-induced structures.
5. Folding mechanisms, superimposed folds, fabrics, and tectonites, and gain practical insights through petro-fabric analysis.

Unit 1: Concepts of seismology and Earth's internal structure – Earth's gravitational field – Isostasy – Geomagnetism, polarity reversals, polar wandering and palaeomagnetism – Thermal structure of the Earth, heat flow and thermodynamics of lithosphere, mantle and core, volcanism and volcanic zones – Mantle plumes and their origin.

Unit 2: Theory of plate tectonics, tectonic features along plate boundaries, relationship of plate tectonics with seismicity, volcanism and mountain building – Continental drift theory and supportive evidences – Concept of seafloor spreading and supportive evidences – Structural and tectonic features of India – Geodynamics of Indian plate – Outline of Himalayan orogeny – Overview on Quaternary tectonics and neotectonics.

Unit 3: Concept of stress and strain, stress-strain relationships for elastic, plastic and viscous materials – Behaviour of rocks and minerals under stress – Measurement of strain in deformed rocks – Rheological properties of rocks – Forces and mechanism of rock deformation – Role of fluids in deformation processes – Deformation at microscale, superposed deformation – Kinematic and dynamic analysis of deformation – Various states of stress and their representation by Mohr's circles – Stereographic projections of structural elements.

Unit 4: Fault: Nomenclature and classification, mechanics and causes of faulting, recognition of faults in the field – Structural analysis of faults – Fault-related folding – Geometry and mechanics of shear zones – Joints: classifications, modes of representation– Unconformities: types, recognition, significance, their use in dating structural events and, their recognition in the field – Gravity induced structures.

Unit 5: Fold: Nomenclature, classification, mechanics of folding, and recognition of folds in the field – Structural analysis of folds – Deformation of linear structures by flexural slip folding and shear folding; superimposed folding, type 1, 2 and 3 interference patterns – Fabrics: foliations, lineations, cleavage, schistosity, gneissose structure, mullions and boudinage – Petro fabric analysis: petro fabric diagrams and their interpretation – Classification and characteristics of Tectonites, L- L-S-, and S- tectonic fabrics.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. Earth's interior structure, gravity, heat flow, magnetism, and mantle plume processes.
2. Continental drift, seafloor spreading, plate tectonics, and tectonic features of the Indian plate
3. The concept of stress, strain, rock deformation, rheology, and kinematic-dynamic analysis.
4. Interpret fault and joint structures, their classifications, and identify them in the field.

5. Classification and mechanics of faults, joints, unconformities, shear zones, and gravity-induced structures.
6. Folding mechanisms, superimposed folds, fabrics, and tectonites, and petro-fabric analysis.

Text Books:

1. **Allan Cox (1973).** Plate Tectonics, Freeman & Co.
2. **Belosov, V. V (1962).** Basic Problems in Geotectonics, McGraw Hill.
3. **Billings, M. P (1974).** Structural Geology, Prentice-Hall, Inc.
4. **Bloom, A. L (2004).** General Geology, V.V.P. Press.
5. **Ghosh, S. K (1993).** Structural Geology: Fundamental and Modern Developments, Pergamon Press.
6. **Gokhale, N.W (2019).** Theory of Structural Geology, CBS Publishers.
7. **Hobbs, B. E., Means, W. D. and P.F. Williams (1976).** An Outline of Structural Geology, John Wiley & Sons.
8. **Jain, A.K. (2019).** An Introduction to Structural Geology, Geological Society of India Book Series.
9. **Valdiya, K. S (1984).** Aspects of Tectonics – Focus on South Central Asia, Tata McGraw-Hill.

Reference Books:

1. **Condie, K. C. (1989).** Plate Tectonics and Crustal Evolution (III Edition), Pergamon Press.
2. **Davis, G.H (1984).** Structural Geology of Rocks and Regions, John Wiley & Sons.
3. **Turcotte, D. L and Schubert, G (2014).** Geodynamics, Cambridge University Press.
4. **Fossen, H (2010).** Structural Geology, Cambridge University Press.
5. **Kearey, P., Klepeis, K. A and Vine, F. J (2009).** Global Tectonics (III Edition), Wiley-Blackwell.
6. **Keller, E. A and Pinter, N (2001).** Active Tectonics (II Edition), Pearson Publications.
7. **Pollard, D. D and Fletcher, R. C (2005).** Fundamentals of Structural Geology, Cambridge University Press.
8. **Ragan, D. M (2009).** Structural Geology - An Introduction to Geometrical Techniques (IV Edition), Cambridge University Press.
9. **Ramsay, J. G (1967).** Folding and Fracturing of Rocks, McGraw Hill.
10. **Robert J. T and E. M. Moores (2006).** Structural Geology (II Edition), W. H. Freeman Publishers.
11. **Rowland, S. M., Duebendorfer, E. M and I. M. Schiefelbein (2007).** Structural Analysis and Synthesis: Laboratory Course in Structural Geology (III Edition), Wiley-Blackwell.

Web Resources:

1. http://geologylearn.blogspot.com/2015/08/deformation-mechanisms-and.html3.
2. http://www.yourarticlelibrary.com/geology/rocks/rock-cleavage-meaning-types-andimportance-geology/915064.
3. https://flexiblelearning.auckland.ac.nz/rocks_minerals/rocks/schist.html5.
4. https://www.britannica.com/science/foliation-geology

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs) – Course Articulation Matrix

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	9	9
CO4	9	3	3	9	9	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	9	3
Total	48	42	48	54	36	24
% Weightage	19.04	16.66	19.04	21.42	14.28	9.52

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	9	9	9	3
CO2	9	9	9	9	3	3
CO3	9	9	9	3	9	3
CO4	9	9	9	9	3	3
CO5	9	9	9	9	9	1
CO6	9	9	9	9	9	9

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	-	4	-	4	16
K2	1	1	1	2	5	-	5	20
K3	1	1	1	1	4	-	4	16
K4	1	1	1	2	5	-	5	20
K5	-	1	-	1	2	-	2	8
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20
Total	**5**	**5**	**4**	**6**	**20**	**5**	**25**	**100**

The Cos and Pos for the **GEOTECTONICS AND STRUCTURAL GEOLOGY** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY12	Core	Core Course – IX ECONOMIC GEOLOGY AND MINERAL ECONOMICS	Theory	5	5

Course Description:

This course encompasses the important processes of formation and classification of economic minerals, metallogenetic epochs and provinces, relation between plate tectonics and ore genesis. It also includes origin, mode of occurrence, Indian distribution and uses of metallic minerals and several important industrial minerals. Also the course includes Mines and Mineral Legislation of India, India's National Mineral Policy and strategies for mineral conservation and substitution.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. Important processes of formation of economic minerals.
2. Classification and controls of ore ocalization, genetic linkages to tectonics and geothermometry tools.
3. Origin, occurrence, and distribution of economically important metallic minerals in India.
4. Origin, occurrence, and distribution of economically important non-metallic industrial minerals in India.
5. Mines and Mineral Legislation of India, India's National Mineral Policy and strategies for mineral conservation and substitution.

Unit 1: Economic Geology: Processes of formation of mineral deposits: Magmatic concentration – Sublimation – Contact metasomatism – Hydrothermal (Cavity, filling and replacement) – Sedimentation – Evaporation – Residual and Mechanical Concentration – Oxidation and Supergene Enrichment – Metamorphism.

Unit 2: Classification of mineral deposits – Controls of ore localization: structural, stratigraphic, physical and chemical controls – Metallogenetic epochs and provinces – Plate tectonics and ore genesis – Geologic thermometry – Geobarometry – Stable and radiogenic isotopes of ores and the host rocks –Fluid inclusion in ore mineral assemblages: Physical and chemical properties, microthermometry.

Unit 3: Origin, mode of occurrence, Indian distribution and uses of the following metallic minerals: Iron, Manganese, Copper, Lead and Zinc, Chromium, Gold, Aluminium and Graphite.

Unit 4: Origin, mode of occurrence, Indian distribution and uses of the following ores: Asbestos, Barite, Graphite and Magnesite – Mineralogy, origin, mode of occurrence, Indian distribution of minerals used in refractory, fertiliser, ceramic, cement, glass, paint, abrasive industries.

Unit 5: Mineral Economics: Significance of minerals in National economy – Tenor, grade and specifications for minerals – UNFC for resources – Mines and Mineral Legislation of India India's National Mineral Policy – Strategic, critical and essential minerals with reference to India – Mineral conservation and substitution.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. Important processes of formation of economic minerals.
2. Classification and controls of ore ocalization, genetic linkages to tectonics and geothermometry tools.
3. Origin, occurrence, and distribution of economically important metallic minerals in India.
4. Origin, occurrence, and distribution of economically important non-metallic industrial minerals in India.
5. Mines and Mineral Legislation of India and India's National Mineral Policy strategies
6. Mineral conservation and substitution.

Text Books:

1. **Bateman, A.M (1995).** Economic Mineral Deposits, Willey.
2. **Deb, S (1980).** Industrial Minerals and Rocks of India, Allied.
3. **Gokhale, K.V.G.K. and T.C. Rao (1978).** Ore Deposits of India, their Distribution and Processing, Thomson Press.

4. **Sinha, R.K (2019).** Mineral Economics, CBS Publishers.
5. **Tiwari, S.K (2019).** Ore Geology, Economic Minerals and Mineral Economics, Atlantic Pub.
6. **Umathay, R.M (2006).** Mineral Deposits of India. Dattsons.

Reference Books:

1. **Cameron, E.N (1961).** Ore Microscopy, Wiley.
2. **Coggin, B.J and A.K Dey (1995).** India's Mineral Wealth, Isha Books.
3. **Craig, J.R and D.J. Vaughan (1995).** Ore Microscopy and Ore Petrography (II Edition), John Willey & Sons
4. **Lindgren, W (1993).** Mineral Deposits, McGraw Hill.
5. **Park, C.F and R.A Macdiarmid (1970).** Ore Deposits, Freeman.
6. **Stanton, R.L (1972).** Ore Petrology, McGraw Hill.

Web Resources:

1. https://www.britannica.com/science/mineral-deposit/Formation-of-mineral-deposits3.
2. http://www.preservearticles.com/2012010519974/the-processes-of-formation-ofmineral-deposits-are-grouped-into-three-main-types.html4.
3. https://www.geologyforinvestors.com/classification-of-mineral-deposits/5.
4. https://iasmania.com/mineral-resources-india-iron-coal-aluminium-copper-lead-zinc/

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs) – Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	0
CO4	9	3	3	9	9	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	9	3
Total	48	42	48	54	30	15
Weightage %	20.25	17.72	20.25	22.78	12.65	6.32

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	9	9	9	0
CO2	9	9	9	9	3	3
CO3	9	9	9	3	3	3
CO4	9	9	9	9	3	1
CO5	9	9	9	9	9	9
CO6	9	9	9	9	9	9

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	-	4	-	4	16
K2	1	1	1	2	5	-	5	20
K3	1	1	1	1	4	-	4	16
K4	1	1	1	2	5	-	5	20
K5	-	1	-	1	2	-	2	8
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20
Total	**5**	**5**	**4**	**6**	**20**	**5**	**25**	**100**

The Cos and Pos for the **ECONOMIC GEOLOGY AND MINERAL ECONOMICS** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY13	Core	Core Course – X GEOEXPLORATION	Theory	5	5

Course Description:

This course encompasses principles and methods involved in geoexploration, including geological, geophysical, geochemical, and geobotanical approaches. It emphasizes exploration stages, sampling techniques, ore reserve estimation, and the application of modern field and laboratory techniques in mineral prospecting. Through theoretical knowledge and practical insights, the course equips students with skills essential for mineral resource evaluation and exploration.

Course Objectives: To impart knowledge on

1. The stages of geological exploration, prospecting methods, field documentation, sampling techniques, and ore reserve estimation.
2. The principles and applications of electrical, magnetic, electromagnetic, and well-logging techniques in geophysical exploration.
3. Principle, instrumentation, data collection and interpretation involved in gravitational, seismic, and radioactive methods used in geophysical surveys.
4. Geochemical principles, elemental classifications, geochemical cycles, and survey methodologies.
5. Methods of various geochemical and biogeochemical survey methods, geobotanical indicators, and their role in mineral exploration.

Unit 1: Geological Exploration: Stages of exploration – Scope, objectives and methods of prospecting, regional exploration and detailed exploration – Criteria controlling the choice of sites for geological prospecting – Marginal information of toposheets and study of field equipments – Field documentation and basic field procedures – Sampling (pitting, trenching, drilling), assaying and ore reserve estimation techniques – Categorization of ore reserves – Outline on exploratory mining – Ore controls as guides: mineralogical, structural, stratigraphical and geomorphological guides to ore search – Geological methods of surface and sub-surface exploration on different scales.

Unit 2: Geophysical Exploration: Outline on geophysical methods of exploration – Electrical methods: resistivity, self-potential and induced polarization methods, their principles, field procedures, instruments used, applications and limitations – Magnetic method: magnetic properties of rocks and minerals, Earth's magnetic field, regional and local anomalies, instruments used in exploration, procedures in field survey, interpretation of data, applications – Electromagnetic method: principles, instruments used, field procedures, interpretation of data, and applications, outline on magneto-telluric technique – Well logging techniques and their applications.

Unit 3: Gravitational method: Earth's gravitational field, geoid, principles, instruments used in exploration, field procedures, corrections, interpretation of data, applications and limitations – Seismic method: seismic refraction and reflection methods – principles, field procedures (data acquisition), data processing, data interpretation, and applications – Radioactive method: Radioactive decay, radioactivity in rocks and minerals, instruments used in exploration, procedures in field survey, interpretation of data, applications.

Unit 4: Geochemical Exploration: Origin of elements and abundance of elements in the earth's crust – Classification of elements: major, minor, trace and rare earth elements – Principles of geochemical prospecting: Geochemical cycle, geochemical environments, geochemical dispersion, geochemical mobility, geochemical anomalies and path finder elements – Geochemical survey: reconnaissance surveys and detailed surveys – Stages of a geochemical survey: planning, sampling, analysis, geochemical map, anomaly and interpretation.

Unit 5: Methods of Geochemical survey: lithogeochemical surveys, hydrogeochemical surveys, pedogeochemical surveys (stream sediments, lake sediments, glacial sediments, heavy minerals) – Biogeochemical exploration: principles, sampling, chemical analysis and interpretation of anomalies – Geobotanical indicators for mineral prospecting – Applications of Geochemistry in mineral exploration.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. The stages, scope, and field procedures involved in geological exploration.
2. Electrical, magnetic, electromagnetic, and well-logging methods in geophysical exploration.
3. Gravitational, seismic, and radioactive techniques for data acquisition and interpretation.
4. Geochemical principles, geochemical anomalies, and plan geochemical surveys effectively.
5. Interpretation of lithogeochemical, hydrogeochemical, pedogeochemical, and biogeochemical data in mineral exploration.
6. Integration of geological, geophysical, and geochemical exploration methods for effective mineral resource assessment.

Text Books:

1. **Bateman, A. M (1995).** Economic Mineral Deposits, Willey.
2. **Dhana Raju, R (2009).** Handbook of Mineral Exploration and Ore Petrology: Techniques and Applications, Geological Society of India.
3. **Mason, B and C. B. Moore (1982).** Principles of Geochemistry (IV Edition), John Wiley & Sons.
4. **Misra, K. C (2012).** Introduction to Geochemistry: Principles and Applications, Wiley-Blackwell.
5. **Misra, K. C (2012).** Understanding Mineral Deposits, Kluwer Academic Publishers.
6. **Ramachandra Rao, M. B (1975).** Outlines of Geophysical Prospecting: A Manual for Geologists, Prasaranga, University of Mysore, Mysore.
7. **Sharma, P.V (2004).** Geophysical Methods in Geology, Elsevier Inc.

Reference Books:

1. **Burger, H. R (1992).** Exploration Geophysics of the Shallow Subsurface, Prentice Hall.
2. **Dobrin, M. B (2001).** Introduction to Geophysical Prospecting, McGraw Hill Inc.
3. **Edwards, R and K. Atkinson (2013).** Ore Deposits Geology and its Influence on Mineral Exploration, Springer.
4. **Ginzburg, I. I (2013).** Principles of Geochemical Prospecting: Techniques of Prospecting for Non-Ferrous Ores and Rare Metals, International Series of Monographs on Earth Sciences, Volume 3, Pergamon.
5. **Govett, G. J. S (2013).** Hand Book of Exploration Geochemistry, Elsevier Science.
6. **Kearey, P. and M Brooks (1989).** An Introduction to Geophysical Exploration, English Language Book Society / Blackwell Scientific Publications.
7. **Kovalevsky, A. L (1987).** Biogeochemical Exploration for Mineral Deposits, VNU Science Press.
8. **Levinson, A.A (1976).** Introduction to Exploration Geochemistry, Applied Publication Co.
9. **Lowrie, W (1997).** Fundamentals of Geophysics, Cambridge.
10. **Marjoribanks, R (2010).** Geological Methods in Mineral Exploration and Mining (II Edition), Springer.
11. **Moon, C. J., Whateley, M. K. G. and A. M. Evans (2006).** Introduction to Mineral Exploration (II Edition).
12. **Raman, P. K (1989).** Principles and Practices of Mineral Exploration: A Professional Manual, Geological Society of India,
13. **William, W. M (2014).** Isotope Geochemistry, Wiley.

Web Resources

1. https://www.school-for-champions.com/astronomy/earth.htm#.WxddcO6FO703.
2. https://geoinfo.nmt.edu/geoscience/projects/astronauts/gravity_method.html4.
3. http://www.geol-amu.org/notes/b8-4-4.htm5. https://www.michigan.gov/documents/deq/GIMDL-USGSINF672R6_302983_7.pdf6.
4. http://www.geol-amu.org/notes/b8-3-6.html

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs) – Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	0
CO4	9	3	3	9	9	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	9	3
Total	48	42	48	54	30	15
Weightage %	20.25	17.72	20.25	22.78	12.65	6.32

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	9	9	9	0
CO2	9	9	9	9	3	3
CO3	9	9	9	3	3	1
CO4	9	9	9	9	3	0
CO5	9	9	9	9	9	9
CO6	9	9	9	9	9	9

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	-	4	-	4	16
K2	1	1	1	2	5	-	5	20
K3	1	1	1	1	4	-	4	16
K4	1	1	1	2	5	-	5	20
K5	-	1	-	1	2	-	2	8
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20
Total	**5**	**5**	**4**	**6**	**20**	**5**	**25**	**100**

The Cos and Pos for the **GEOEXPLORATION** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY14P	Core	Core Course – XI PRACTICAL III STRUCTURAL GEOLOGY, ECONOMIC GEOLOGY AND GEOEXPLORATION	Practical	10	4

Course Description:

This course is designed to equip students with practical skills in interpreting geological structures, economic minerals, and geoexploration data. It includes hands-on exercises in structural geology map interpretation, ore microscopy, and analysis of geophysical, geochemical, and well-logging datasets, essential for real-world geological applications in resource exploration and extraction.

Course Objectives: To impart knowledge on

1. Developing practical skills in solving structural geology problems and interpreting geological maps.
2. Identifying economically important ore minerals through megascopic and microscopic techniques.
3. The interpretation of geological, geophysical, and geochemical data.
4. Borehole data interpretation for evaluating subsurface geological structures.
5. Imparting analytical skills for integrating different types of exploration data in geological interpretations.

1. Structural Geology Problems and Structural Geology Map interpretation

- Interpretation of simple and complex geological maps and, study of field geological maps
- Determination of depth, thickness and three point problem
- Stereographic projections for studying geological structures
- Interpretation of borehole data – for determining attitude of tabular bodies and interpretation of lithological data from inclined boreholes, preparation of latitudinal vertical sections

2. Economic Geology and Ore Microscopy

- Identification of important ore minerals by the study of their megascopic characters
- Identification of important ore minerals by the study of their optical characters

3. Geoexploration

- Interpretation of geological maps
- Interpretation of geophysical data
- Interpretation of geochemical data
- Interpretation of well logging data

Course Outcomes: On completion of the course the student would have gained knowledge on

1. Interpreting simple and complex geological maps and solve structural geology problems such as depth, thickness, and three-point problems using field maps.
2. Analysing structural data using stereographic projection techniques and interpret borehole data for subsurface mapping.
3. Identifying economically important ore minerals based on megascopic properties.
4. Determining optical properties of ore minerals using ore microscope.
5. Interpreting geological, geophysical, geochemical, and well-logging data for exploration purposes.
6. Integrating field data with analytical tools for effective exploration and structural interpretations.

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs) – Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	0
CO4	9	3	3	9	9	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	9	3
Total	48	42	48	54	30	15
Weightage %	20.25	17.72	20.25	22.78	12.65	6.32

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	9	9	9	0
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	0
CO4	9	9	9	9	3	0
CO5	9	9	9	9	9	9
CO6	9	9	9	9	9	9

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

The Cos and Pos for the **PRACTICAL III STRUCTURAL GEOLOGY, ECONOMIC GEOLOGY AND GEOEXPLORATION** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY15E1	Elective	Elective Course – IV FUEL GEOLOGY	Theory	5	4

Course Description:

This course offers a comprehensive overview of the geological aspects of fossil and non-conventional fuels, with an emphasis on coal, petroleum, and nuclear energy resources. It also includes the origin, occurrence, exploration, and utilization of these fuels in both Indian and global contexts. The course provides a blend of theoretical knowledge on fuel-related geological processes and modern energy exploration techniques.

Course Objectives: To impart knowledge on

1. Understanding the geological processes involved in the formation and alteration of coal, including its petrographic constituents and geological settings.
2. Coal properties, classification systems, and its potential as a fuel and energy source including CBM.
3. Petroleum origin theories, reservoir and trap characteristics, and the geological distribution of oilfields.
4. Exploration techniques for hydrocarbons including drilling, logging, reserve estimation, and economic considerations.
5. Geology, occurrence, and utilization of nuclear fuels and non-conventional energy resources

Unit 1: Coal Geology: Origin of coal: peat formation and its environments, biochemical peatification, geochemical coalification, causes of coalification, coal maturity and diagenesis – Post depositional changes of coal seams – Coal Geology: sedimentology of coal bearing strata, types of seam discontinuities and structures associated with coal seams – Coal formation in geological space and time – Petrography of coal: lithotypes, micro-lithotypes and macerals and their applications.

Unit 2: Physical properties of coal – Chemical composition of coal – Chemical analysis of coal: proximate and ultimate analysis – Classification of coal: Indian classification and International classifications (I.S.O. classification) – Classification of coal in terms of rank, grade and type – Outline of underground coal gasification, coal as an oil prone rock, coal as a liquid fuel – Geological and geographical distribution of coal and lignite deposits of India – Outline of Coal Bed Methane (CBM).

Unit 3: Petroleum Geology: Petroleum: constituents and composition – Origin of petroleum: organic and inorganic, evidences in their favour and against – Formation and migration of petroleum – Reservoir rocks: porosity and permeability – Reservoir traps: structural, stratigraphic and combination traps – Oilfield fluids: water, oil and gas – Applied stratigraphy – facies, sequence and depositional environment – An outline of oil belts of the world and India – Sedimentary basins of India – Petroliferous basins of India – Geology of productive oilfields of India.

Unit 4: Prospecting methods for oil and gas: geological, geophysical (seismic) and geochemical methods – Micropaleontology in petroleum exploration – Oil and gas reserve estimation – Proved, probable and possible reserves – Deterministic methods – Drilling and logging procedures – Drilling RIG: components, concepts and operational procedures – Electrologs: principles, procedures and interpretation – Mudlogging units: basic concepts and utilities – Reservoir studies: principles – Oil recovery: enhanced oil recovery techniques (chemical methods, miscible methods, thermal method – Petroleum management and economics – Oil shale – Gas hydrates - Oil policy of India.

Unit 5: Nuclear and Non-conventional Energy Resources: Radioactive minerals: mineralogy, chemistry, geological characteristics, mode of occurrence, genesis of major types of atomic minerals – Metallogenic epochs and provinces of uranium mineralisation – Distribution of nuclear fuel deposits in India – Lithium: uses and, occurrences in India – Geothermal energy: principles of utilization of Earth's heat, types of geothermal source, geothermal energy sources in India, future scenario of geothermal energy in India.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. Origin, peatification, and coalification processes and interpret coal petrography.

2. Classification of coal based on rank, grade, and type; perform and interpret coal analyses.
3. The formation and migration of petroleum and characteristics of reservoir rocks and traps.
4. The methods for petroleum exploration and oil recovery, electrologs, and oilfield management.
5. Geological and geographical distribution of energy resources in India and abroad.
6. Genesis and occurrence of nuclear fuels and analyze the potential of non-conventional resources.

Text Books:

1. **Aswathanarayana, U (1985).** Principles of Nuclear Geology, Oxford Press.
2. **Chandra, D., Singh, R.M and M. P. Singh (2000).** Textbook of Coal (Indian Context), Tara Book Agency.
3. **Chandrasekharam, D (2005).** Geothermal Energy Resources of India: Past and the Present, World Geothermal Congress.
4. **Dhana Raju, R (2005).** Radioactive Minerals, Economic Geology series, Geological Society of India.
5. **Holson, G. D and E. N. Tiratso (1985).** Introduction to Petroleum Geology, Gulf Publishing.
6. **Larry Thomas (2013).** Coal Geology, John Wiley & Sons.
7. **Levorsen, T (1999).** Geology of Petroleum (II Edition), CBS Publishers and Distributors.
8. **Saxena, V. K (2004).** Geothermal Resources of India, Allied Publishers Pvt. Ltd.
9. **Selley, R.C (1998).** Elements of Petroleum Geology, Academic press.

Reference Books:

1. **Boyle, R.W (1982).** Geochemical Prospecting for Thorium and Uranium Deposits, Elsevier.
2. **Cataldi, R and M. C. S. Arrriaga (2020).** History of Geothermal Energy in the World to the 20th Century, ThinkGeoEnergy.
3. **Dahlkamp, F.J (1993).** Uranium Ore Deposits, Springer Verlag.
4. **Doveton, J.H (1994).** Geological Log Interpretation, SEPM, Tulsa.
5. **Henry, G (1994).** Geophysics of Sedimentary Basins, Technip, Rue Ginoux.
6. **Isabel Suárez-Ruiz and John C. Crelling (2008).** Applied Coal Petrology: The Role of Petrology in Coal Utilization, Academic Press.
7. **Lewis, D. W and D. McConchie (1994).** Analytical Sedimentology, Chapman & Hall.
8. **North, F.K (1985).** Petroleum Geology, Allen Unwin.
9. **Pohl Walter (2011).** Economic Geology: Principles and Practice: Metals, Minerals, Coal and Hydrocarbons - Introduction to Formation and Sustainable Exploitation of Mineral Deposits, John Wiley & Sons.
10. **Ravi Shankar Guha, S. K., Seth, N. N., Muthuraman, K., Pitale, U. L., Jangi, B. L., Prakash, G., Bandopadhyay, A. K and R. K. Sinha (1991).** Geothermal Atlas of India, Special Publication No.19, GSI.
11. **Singh, M.P (1998).** Coal and Organic Petrology, Hindustan Publishing Corporation.
12. **Sircar, A. and K. Yadav (2019).** Harnessing Geothermal Energy Applications in India, Technology Publications.
13. **Stach, E., Mackowsky, M-Th., Taylor, G.H., Chandra, D., Teichumullelr, M. and R. Teichmuller (1982).** Stach's Textbook of Coal Petrology, GebruderBorntraeger, Stuttgart.
14. **Yates, M (1980).** Earth Power: The Story of Geothermal Energy, Abingdon Publishers.

Web Resources:

1. https://raregeologybooks.files.wordpress.com/2014/10/elements-of-petroleum-geology.pdf.
2. https://www.geokniga.org/bookfiles/geokniga-basicpetroleumgeologybypeterlinkz- liborg.pdf.
3. https://www.researchgate.net/publication/266321762_Petroleum_geology

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs) – Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	0
CO4	9	3	3	9	9	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	9	3
Total	48	42	48	54	30	15
Weightage %	20.25	17.72	20.25	22.78	12.65	6.32

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	9	9	9	0
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	0
CO4	9	9	9	9	3	0
CO5	9	9	9	9	9	9
CO6	9	9	9	9	9	9

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	-	4	-	4	16
K2	1	1	1	2	5	-	5	20
K3	1	1	1	1	4	-	4	16
K4	1	1	1	2	5	-	5	20
K5	-	1	-	1	2	-	2	8
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20
Total	**5**	**5**	**4**	**6**	**20**	**5**	**25**	**100**

The Cos and Pos for the **FUEL GEOLOGY** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY15E2	Elective	Elective Course – IV PETROLEUM EXPLORATION AND MUD LOGGING	Theory	5	4

Course Description:

This course provides comprehensive knowledge into petroleum exploration techniques and mudlogging operations. It covers the principles of petroleum geology, drilling technologies, surface and subsurface logging, and interpretation techniques. The course emphasizes both theoretical understanding and field applications, ensuring students are industry-ready through exposure to practical instrumentation, data analysis, and safety protocols.

Course Objectives: To impart knowledge on

1. The principles of petroleum geology, drilling methods, borehole calculations, and well operations including testing and completion.
2. The basics of mudlogging, geological surveillance, cutting examination, hydrocarbon shows, and safety standards in worksite environments.
3. Mudlogging sensors, maintenance, operations, reporting, and practical lab training in rig activities.
4. Advanced down-hole measurements using MWD tools including resistivity, gamma ray, porosity, density, and geosteering technologies.
5. Logging while drilling (LWD) techniques, interpretation of logs, and sequence stratigraphy for reconstructing depositional environments.

Unit 1: Petroleum Exploration – Petroleum Geology – Applied Mathematics in Petroleum Engineering – Oil Field Drilling:onshore and offshore drilling – Drilling rigs – Well types – The drill string – Drill bits – Well Profile – Bore-hole volume calculation and displacement – Lag time – Basic hydraulics – Drilling fluids – Formation pressure – Bore hole problems – Coring: objective of coring and core Analysis– Casing and Cementing – Fishing – Well completion – Well testing.

Unit 2: Basics of Mudlogging – Surface Logging – Tasks and Responsibilities – Geological Surveillance – Cutting Sampling – Collection, Examination – Lithological and mineralogical description – Calcimetry – Oil Shows – Fluorescence and cut fluorescence – Thin sections – Chemical tests – Gas sampling – Hydrocarbon gas analysis – Pore pressure calculation – Cutting evaluation – Sample examination procedure – Well site Geochemistry – Gases other than hydrocarbons – Communication skill – QHSE – Worksite environmental hazards – Offshore Safety – Quality control.

Unit 3: Mudlogging services, Mudlogging sensors – Operations – Maintenance – Inspection and calibrations – Trouble shooting – Technical specification – Reporting – Final well reports – Mud logging unit Installation and maintenance –Practical mudlogging, lab training on Rig up and Rig Down of sensors, equipment and monitoring realtime drilling followed by a Rig site visit.

Unit 4: Down-hole Measurement – Measuring While Drilling (MWD): MWD Principle – Telemetry types – Formation evaluation MWD-Sensor information – Natural gamma ray – Formation resistivity – Focused Current Resistivity (FCR) – Toroidal Resistivity – Electromagnetic wave Propagation resistivity – Multiple Propagation Resistivity (MPR) – Geo-Steering – Neutron Porosity MWD Tools – Formation Density MWD Tools – Drilling Performance MWD.

Unit 5: Down-hole Logging – Logging While Drilling (LWD) – Temperature logs – Caliperlogs – Self Potential Logs (SP) – Resistivity and Conductivity Logs – Gamma ray and Spectral Gamma ray logs – Sonic Logs – Density and Photo Electric factor Logs – The Neutron Log – The dip meter – Imaging Logs – MDT Sampling – Lithology

reconstruction from Logs – Facies Sequences and depositional environments from Logs – Sequence Stratigraphy and Stratigraphy..

Course Outcomes: On completion of the course the student would have gained knowledge on

1. Fundamentals of petroleum geology and drilling operations including well completion and testing.
2. Mudlogging techniques, geological sampling, and safety protocols at drilling sites.
3. Mudlogging unit operations, equipment calibration, and sensor monitoring in practical scenarios.
4. Down-hole measurements using MWD tools and interpret sensor data for formation evaluation.
5. Types of LWD logs and reconstruct lithology, facies, and depositional environments.
6. Integrating theoretical knowledge with field applications to evaluate well performance and stratigraphy using real-time data.

Text Books:

1. **Stamp L.D, (1964).** An Introduction in Stratigraphy, Thomas Murby, Museum St, WCI.
2. **Bhagwan Sahay. (1997).** Petroleum Exploration and Exploitation Practices, Allied Publishers, II Ed.
3. **Geological Survey of India (2005).** Geology & Mineral Resources of the States of India. Misc. Pub. No. 30.
4. **Levorsen, A.J. (2004).** Geology of Petroleum, CBS Publishers and Distributors Pvt Ltd., II Ed.
5. **Wadia, D.N (1953).** Geology of India, McMillan India.

Reference Books:

1. **Brian Frehner (2011).** Finding Oil: The Nature of Petroleum Geology, 1859–1920, University of Nebraska Press.
2. **Mudlogging Training Manuals (2020)** – GEOLOG International B.V
3. **Weller, J.M (1962).** Stratigraphic Principles and Practices, Harper & Bros.

Web Resources:

1. https://raregeologybooks.files.wordpress.com/2014/10/elements-of-petroleum-geology.pdf.
2. https://www.geokniga.org/bookfiles/geokniga-basicpetroleumgeologybypeterlinkz- liborg.pdf.
3. https://www.researchgate.net/publication/266321762_Petroleum_geology

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs) – Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	0
CO4	9	3	3	9	9	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	9	3
Total	48	42	48	54	30	15
Weightage %	20.25	17.72	20.25	22.78	12.65	6.32

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	9	9	9	0
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	0
CO4	9	9	9	9	3	0
CO5	9	9	9	9	9	9
CO6	9	9	9	9	9	9

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	-	4	-	4	16
K2	1	1	1	2	5	-	5	20
K3	1	1	1	1	4	-	4	16
K4	1	1	1	2	5	-	5	20
K5	-	1	-	1	2	-	2	8
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20
Total	**5**	**5**	**4**	**6**	**20**	**5**	**25**	**100**

The Cos and Pos for the **PETROLEUM EXPLORATION AND MUD LOGGING** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY15E3	Elective	Elective Course – IV INSTRUMENTATION TECHNIQUES IN GEOLOGY	Theory	5	4

Course Description:

This course introduces students to the fundamental principles, working mechanisms, applications, and limitations of advanced analytical and geophysical instruments used in geology. Covering a wide range of spectrometry, microscopy, crystallography, chromatography, and geophysical techniques, it emphasizes their role in mineral, rock, and groundwater studies for both academic and applied research.

Course Objectives: To impart knowledge on

1. Geochemical analysis methods and instrumental techniques like AAS, ICP-AES, and XRF.
2. Mass spectrometry techniques such as GSMS, ICP-MS, SSMS, AMS, TIMS, and SIMS, along with their applications in isotope and trace element analysis.
3. The principles and uses of instruments like SEM, EPMA, NAA, and chromatographic techniques in geological studies.
4. Instruments used in crystallographic and mineralogical studies, including XRD, emission spectroscopy, and Raman spectroscopy.
5. Geophysical instruments and field techniques used in gravity, magnetic, seismic, resistivity, and radiometric surveys.

Unit 1: Geochemical analysis: Qualitative analysis and quantitative analysis – Sampling and sample preparation – Dissolution procedures for geologic samples – Principles, applications and limitations of the following instruments: Atomic Absorption Spectrometry (AAS), Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES), X-Ray Fluorescence Spectrometry (XRF).

Unit 2: Principles, applications and limitations of the following instruments: Gas Source Mass Spectrometry (GSMS), Inductively Coupled Plasma-Mass Spectrometry (ICP-MS), Spark Source Mass Spectrometry (SSMS), Accelerator Mass Spectrometry (AMS), Thermal Ionisation Mass Spectrometry (TIMS), Secondary Ion Mass Spectrometry (SIMS).

Unit 3: Principles, applications and limitations of the following instruments: Scanning Electron Microscope (SEM), Electron Probe Microanalysis (EPMA), Neutron Activation Analysis (NAA), Liquid Chromatography (LC), Thin Layer Chromatography (TLC), High Performance Liquid Chromatography (HPLC).

Unit 4: Principles and applications of the following instruments used for crystallography and mineralogy: X-Ray Diffraction, Reflectance and Emission Spectroscopy, Thermal Emission Spectroscopy, Mossbauer Spectroscopy, Laser Raman Spectroscopy.

Unit 5: Principles, types, field procedure and application of the instruments used for the following geophysical surveying techniques: Gravity methods, Magnetic methods, Seismic methods, Resistivity methods and Radioactivity methods

Course Outcomes: On completion of the course the student would have gained knowledge on

1. The principles and working mechanisms of geochemical analysis instruments (AAS, ICP-AES, XRF).
2. The functionalities and limitations of advanced mass spectrometry instruments (GSMS, ICP-MS, SSMS, AMS, TIMS, SIMS).
3. Describe and Applications of the concepts of SEM, EPMA, NAA, and chromatography techniques in geosciences.

4. Applications of crystallography and mineralogical instruments like XRD, Raman, and Mossbauer spectroscopy.
5. Interpretation of data obtained through geophysical surveys using instruments for gravity, magnetism, resistivity, seismic, and radiometric methods.
6. Integrating the knowledge of analytical and geophysical techniques for applied geological research and environmental problem-solving.

Text Books:

1. **Douglas A. Skoog, James Holler, F., Stanley and R. Crouch (2016).** Principles of Instrumental Analysis (VII Ed.), Cengage Learning.
2. **Francis Rouessac, and Annick Rouessac (2007).** Chemical Analysis - Modern Instrumentation Methods and Techniques, Wiley.
3. **Robinson, E.S. and C. Coruh (2002).** Basic Exploration Geophysics, John Wiley.
4. **The Lord Energlyn and L. Brealey (1971).** Analytical Geochemistry, Academic Press, Elsevier.
5. **Ramachandra Rao, M. B (1975).** Outlines of Geophysical Prospecting - A Manual for Geologist, Prasaranga, University of Mysore.

Reference Books:

1. **Baedecker, P. A (1987).** Methods for Geochemical Analysis. U.S. Geological Survey Bulletin.
2. **Dobrin, M. B (2001).** Introduction to Geophysical Prospecting, McGraw Hill Inc.
3. **Keare, P and M. Brooks (1999).** An Introduction to Geophysical Exploration, Blackwell Scientific Publications.
4. **Potts, P.J (1995).** Microprobe Techniques in the Earth Sciences, Mineralogical Society (Great Britain) Chapman & Hall.
5. **Robin Gill (2014).** Modern Analytical Geochemistry - An Introduction to Quantitative Chemical Analysis Techniques for Earth, Environmental and Materials Scientists, Routledge.

Web Resources:

1. Thermo Fisher Scientific – Instrumentation Solutions
2. ScienceDirect – Analytical Techniques in Geoscience

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs) – Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	0
CO4	9	3	3	9	9	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	9	3
Total	48	42	48	54	30	15
Weightage %	20.25	17.72	20.25	22.78	12.65	6.32

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	9	9	9	0
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	0
CO4	9	9	9	9	3	0
CO5	9	9	9	9	9	9
CO6	9	9	9	9	9	9

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	-	4	-	4	16
K2	1	1	1	2	5	-	5	20
K3	1	1	1	1	4	-	4	16
K4	1	1	1	2	5	-	5	20
K5	-	1	-	1	2	-	2	8
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20
Total	**5**	**5**	**4**	**6**	**20**	**5**	**25**	**100**

The Cos and Pos for the **INSTRUMENTATION TECHNIQUES IN GEOLOGY** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY16	Core	Core Course –XII HYDROGEOLOGY	Theory	5	5

Course Description:

This course has been designed with the aim of providing a comprehensive understanding of groundwater systems, including their origin, occurrence, movement, distribution, quality, exploration methods, and management. It integrates geological, physical, chemical, and engineering perspectives to help students analyze, protect, and sustainably manage groundwater resources with emphasis on real-world applications, well hydraulics, modeling, and Indian scenarios.

Course Objectives: To impart knowledge on

1. Hydrological cycle, origin and occurrence of groundwater, hydrological properties of aquifers, aquifer types, and factors influencing groundwater distribution in different rock types.
2. Groundwater movement, apply Darcy's law in various media, determine hydraulic conductivity, and examine groundwater fluctuations and their causes.
3. Types of wells, their construction, development, and analysis of well performance using various methods.
4. Groundwater exploration techniques using geomorphic, geophysical, and isotopic methods and to understand groundwater resource management and recharge.
5. Evaluate groundwater quality, contamination sources, seawater intrusion, urbanization impact, and use of modeling and isotope techniques in hydrogeological studies.

Unit 1: Occurrence and Distribution of Groundwater: Origin of water on Earth – Hydrological cycle – Genesis of groundwater – Vertical distribution of groundwater – Hydrologic properties of aquifers – Geologic formations as aquifers: porosity, permeability and hydraulic conductivity and their ranges in representative rocks – Groundwater occurrence in igneous rocks, sedimentary rocks, metamorphic rocks, consolidated and unconsolidated sediments – Natural and artificial discharge of groundwater: springs, hot springs, geysers, water wells, and artesian wells.

Unit 2: Groundwater Movement and Groundwater Levels: Darcy's Law: experimental verification and validity; Darcy's Law in homogenous, heterogenous, isotropic and anisotropic media – Reynold's number and Bernoulli equation – Field and laboratory determination of hydraulic conductivity – Groundwater flow: rates, direction, dispersion and diffusion – Flow line and flow nets – Groundwater table mapping and Groundwater potential zonation – Groundwater fluctuations: causes and effects – Impacts of global climatic change on groundwater.

Unit 3: Water Wells and Well Hydraulics: Water wells: shallow wells and deep wells – Construction of a well: well drilling and well completion – Well development through pumping, bridging, surging with air, back washing, acidizing – Protection of well through sealing – Pumping test: Theis's method, Theim's method, Copper-Jacob's method, Chow's method – Well flow near aquifer boundaries.

Unit 4: Groundwater Exploration and Management: Geomorphological, structural and biological indicators of groundwater – Surface investigation methods of groundwater: remote sensing, electrical resistivity – Sub surface investigation methods of groundwater; test drilling, resistivity logging – Tracer-Isotope techniques–Managing groundwater resources: estimation of groundwater recharge and discharge, groundwater budget, residence time concept – Artificial recharge methods – Groundwater basin investigations and management practices – Groundwater regime in India. Rainwater harvesting techniques.

Unit5: Groundwater Quality: Groundwater composition and units of expression, mass-balance calculations – Rock water interaction: chemical equilibrium, free energy, redox reactions and cation / anion exchanges – Graphic representation of chemical data – Latest drinking water quality standards of WHO and BIS – Outline of irrigation water quality standards – Groundwater quality contamination – Sea-water intrusion: causes, effects, methods of their study and their control – Groundwater issues due to urbanization–Groundwater Modelling: solid and liquid waste disposal and plume migration models – Application of tracer (Tritium, Radon), isotope (H, C, O) techniques in groundwater – Major basins and drainage systems of Tamil Nadu–Groundwater scenario in India with special reference to Tamil Nadu.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. The origin, hydrological cycle, and occurrence of groundwater in various geological formations.
2. Application of Darcy's law and analysis of groundwater flow characteristics and fluctuations under natural and climatic influences.
3. The construction and development of wells and apply well hydraulics for determining aquifer characteristics.
4. Geomorphological, geophysical, and isotope techniques in groundwater exploration and application of principles of groundwater management.
5. Assessment of groundwater quality, contamination processes, and interpret water quality standards and seawater intrusion control measures.
6. Hydrogeological models and isotopic tools to understand contamination patterns, recharge processes and, groundwater status in India with special reference to Tamil Nadu.

Text Books:

1. **Gokhale, N.W (2009).** All about Water, CBS Publishers.
2. **Raghunath, H.M (2007).** Groundwater, Wiley Eastern Limited.
3. **Ramakrishnan, S (1998).** Groundwater, KJ Graphs Arts.
4. **Saxena,R. N. and Gupta, D. C (2017).** Elements of Hydrology and Groundwater, PHI Learning Private Ltd.
5. **Todd, D.K (2005).** Groundwater Hydrology, Wiley India Pvt. Ltd.

Reference Books:

1. **Fetter, C.W (2007).** Applied Hydrogeology, CBS Publishers.
2. **Hamid Rizvi, S.M (2015).** Geomorphology and Hydrogeology, Kalyani Publishers.
3. **Sankar Kumar Nath (2000).** Geophysical Prospecting for Groundwater, Oxford and IBH.
4. **Sathya Prakash Garg (1993).** Groundwater and Tube Wells, Oxford University Press.

Web Resources:

1. https://iah.org/education/general-public/groundwater-links-videos
2. https://ocw.mit.edu/courses/1-72-groundwater-hydrology-fall-2005/pages/lecture-notes/
3. chromeextension://efaidnbmnnnibpcajpcglclefindmkaj/https://nihroorkee.gov.in/sites/default/files/uploadfiles/Practicing-Hydrology.pdf
4. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://cluin.org/download/issues/mining/hydrogeology-and-mineral-resource-development.pdf

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	9	9	3	1
CO2	9	9	9	9	3	1
CO3	9	9	9	9	3	1
CO4	9	3	3	9	9	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	9	3
Total weightage	48	42	48	54	30	12
% Weightage	20.51	17.94	20.51	23.07	12.82	5.12

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	9	9	9	0
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	1
CO4	9	9	9	9	3	0
CO5	9	9	9	9	9	3
CO6	9	9	9	9	9	9

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	-	4	-	4	16
K2	1	1	1	2	5	-	5	20
K3	1	1	1	1	4	-	4	16
K4	1	1	1	2	5	-	5	20
K5	-	1	-	1	2	-	2	8
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20
Total	**5**	**5**	**4**	**6**	**20**	**5**	**25**	**100**

The Cos and Pos for the **HYDROGEOLOGY** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY17P	Core	Core Course – XIII PRACTICAL IV HYDROGEOLOGY, GEOSTATISTICS AND SURVEYING	Practical	6	4

Course Description:

This practical course introduces students to the applied aspects of hydrogeology, geostatistics, and survey methods. Through field-based and analytical exercises, students gain hands-on experience in groundwater investigations, statistical analysis of geological datasets, and modern survey techniques using instruments like Total Station, GPS/GNSS, and Auto Level. Emphasis is placed on integrating field observations with software-based data interpretation for research and professional applications.

Course Objectives: To impart knowledge on

1. Rainfall analysis, aquifer characterization, and groundwater quality assessment using hydrogeological techniques.
2. Interpreting resistivity data, conducting aquifer tests, and using statistical tools to evaluate groundwater datasets.
3. Applying statistical methods like PCA, factor analysis, regression, and clustering to geological data.
4. Using modern surveying instruments including Total Station, Auto Level, GPS/GNSS, and Plane Table.
5. Open-source software for hydrogeochemical and statistical data interpretation in geosciences.

1. Hydrogeology

- Rainfall analysis: Arithmetic, Isohyet, Thiessen polygon methods.
- Estimation of hydraulic properties of aquifers and related materials:
  - ✓ Porosity
  - ✓ Hydraulic conductivity
  - ✓ Transmissivity
  - ✓ Storativity
  - ✓ Specific yield
  - ✓ Hydraulic resistance and
  - ✓ Specific capacity.
- Interpretation of resistivity data for detection of water-bearing formations, fresh and saline groundwater
- Aquifer pumping test analysis
- Groundwater quality data evaluation for its suitability for drinking purpose (using WHO and BIS Standards) and irrigation purpose
- Graphical representation of water quality data,
- Concepts of statistical techniques for data analysis, analysis for correlations, factor and cluster analysis.
- Interpretation of hydrogeochemical data using opensource software.

2. Geostatistics

- Estimation of mean, mode, variance, standard deviation, variance, skewness, and kurtosis for the given geological dataset and, graphical representation of the results
- Correlation and regression analysis for the given geological dataset and interpretation of the relationships between the variables in the dataset
- Analysis of geological dataset using Principal Component Analysis (PCA) and interpretation of the results
- Analysis of geological dataset using hierarchical clustering technique and interpretation of the results
- Analysis of geological dataset using factor analysis technique and interpretation of the results

3. Surveying

- Determination of heights and distance using Total station
- Determination of area using Total station

- Traversing using Total station
- Determination of height(s) using Auto levelling
- Traversing using Plane table surveying
- GPS / GNSS survey

Course Outcomes: On completion of the course the student would have gained knowledge on

- Rainfall data analysis and estimate aquifer properties like porosity, transmissivity, and storativity using standard hydrogeological methods.
- Interpreting resistivity data, analyze pumping tests, and assess groundwater quality for drinking and irrigation purposes using BIS/WHO standards.
- Representing water quality data graphically and apply appropriate statistical methods for data correlation and clustering.
- Principal component analysis (PCA), factor analysis, and hierarchical clustering on geological datasets and interpret the results effectively.
- Operating modern survey equipment such as Total Station, Auto Level, Plane Table, and GPS for terrain analysis and mapping tasks.
- Integrating hydrogeological and geostatistical techniques using open-source tools for comprehensive groundwater investigations and environmental studies.

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs) – Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	3
CO4	9	9	9	9	3	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	3	3
Total	54	54	54	54	18	18
Weightage %	21.42	21.42	21.42	21.42	7.14	7.14

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	9	9	9	3
CO2	9	9	9	9	9	3
CO3	9	9	9	9	9	3
CO4	9	9	9	9	9	3
CO5	9	9	9	9	9	3
CO6	9	9	9	9	9	3

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

The Cos and Pos for the **PRACTICAL IV HYDROGEOLOGY, GEOSTATISTICS AND SURVEYING** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY18P	Core	Core Course – XIV PRACTICAL V REMOTE SENSING AND GIS	Practical	6	4

Course Description:

This course encompasses exercises to impart skills in Remote Sensing and GIS. It includes exercises pertaining to Aerial Remote Sensing involving photogrammetry and interpretation of aerial photographs for various applications and Satellite Remote Sensing involving visual and digital interpretation of satellite images for applications in Geosciences.

Course Objectives: To impart knowledge on

1. Aerial photogrammetry, stereo-viewing, orientation of aerial photographs.
2. Interpretation of aerial photographs for various geological applications.
3. Visual and digital interpretation of satellite imagery for landform and land use classification.
4. Working knowledge on GIS software (ArcGIS), attribute data handling, and spatial analysis.
5. Map layout generation for real-world applications.

1. Remote Sensing

1.1 Aerial Remote Sensing

- Elementary exercises relating to photogrammetry: determination of scale, flying height, areal extent, flight planning measures
- Annotation of aerial photographs
- Stereovision test
- Orientation of aerial photographs for interpretation using mirror stereoscope
- Interpretation of aerial photographs for identification of rock types, geological structures (Including lineaments), landforms and land use / land cover

1.2 Satellite Remote Sensing

- Annotation of satellite image
- Visual interpretation of satellite image for identification of rock types, geological structures (Including lineaments), landforms and land use / land cover
- Digital image processing for land use / land cover classification

1.3 GIS

- Introduction to ArcGIS and Arc Catalog
- Attribute data and basic querries
- Georeferencing and Digitization
- Data entry and editing
- Data conversion and analysis
- Surface analysis, density analysis
- Watershed analysis
- Spatial data visualization and Map lay out

Course Outcomes: On completion of the course the student would have gained knowledge on

1. Aerial photogrammetry, stereo-viewing, orientation of aerial photographs.
2. Interpretation of aerial photographs for various geological applications.
3. Visual and digital interpretation of satellite imagery for landform and land use classification.
4. Operate ArcGIS tools for georeferencing, digitization, and attribute data management.
5. Working knowledge on GIS software (ArcGIS), attribute data handling, and spatial analysis.
6. Map layout generation for real-world applications.

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs) – Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	3
CO4	9	9	9	9	3	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	3	3
Total	54	54	54	54	18	18
Weightage %	21.42	21.42	21.42	21.42	7.14	7.14

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	9	9	9	3
CO2	9	9	9	9	9	3
CO3	9	9	9	9	9	3
CO4	9	9	9	9	9	3
CO5	9	9	9	9	9	3
CO6	9	9	9	9	9	3

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

The Cos and Pos for the **PRACTICAL V REMOTE SENSING AND GIS** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY19E1	Elective	Elective Course – V REMOTE SENSING AND GIS	Theory	5	4

Course Description:

This course provides a comprehensive account of the principles and applications of Remote Sensing and Geographic Information Systems (GIS). It deals with the basic principles of electromagnetic remote sensing, energy interaction with Earth's atmosphere and surface features, aerial and satellite-based image interpretation, geospatial data analysis, and the integration of GIS and GNSS in geological investigations. Practical emphasis is laid on modern techniques such as UAV, LiDAR, and hyperspectral imaging to equip learners for environmental and geological problem-solving.

Course Objectives: To impart knowledge on

1. Basic principles of electromagnetic remote sensing, spectral reflectance of Earth's atmosphere and Earth's surface features, and data acquisition receiving and recording process.
2. Aerial Remote Sensing which includes types of aerial photographs, photographic scale and causes for its variations, flight planning missions, stereoscopes and stereo-viewing and photointerpretation elements.
3. Satellite remote sensing systems, Indian space missions, and digital image interpretation techniques.
4. Applications of satellite Remote Sensing in various fields of Geosciences
5. GIS concepts, data structures, processing, analysis, and applications in geology, along with GNSS technology.

Unit 1: Fundamentals of Remote Sensing: Processes and elements of electromagnetic Remote Sensing – Electromagnetic spectrum and its components – Energy sources and radiation principles – Energy interaction with Earth's atmosphere – Energy interaction with the earth's surface features – Spectral reflectance curve of vegetation, soil and water – Data acquisition, receiving and recording – Outline of thermal, microwave, LIDAR Remote Sensing, and GPR.

Unit 2: Aerial Remote Sensing: Types of aerial photographs – Photographic scale and causes for its variation – Flight planning procedures – Outline of parallax, relief displacement and vertical exaggeration – Stereoscopes: lens and mirror stereoscopes – Annotation of aerial photographs – Elements of photointerpretation – Outline of digital photogrammetry, UAV drone and terrestrial laser scanner.

Unit 3: Satellite Remote Sensing: Types of satellites – Scanning systems and detectors: across-track and along-track scanning systems –Sensor resolution and their types – Sensor characteristics of LANDSAT, SPOT, IRS series of satellites – Outline of high resolution satellites and Hyperspectral Remote Sensing – Indian space programme: past, present and future – Visual image interpretation: elements of image interpretation, image interpretation strategies and keys – Outline of Digital Image Processing techniques.

Unit 4: Remote Sensing Applications in Geology: Lithological mapping – Structural mapping – Mineral exploration – Groundwater exploration – Geomorphic mapping – Land use / land cover mapping – seismic zonation – Landslide zonation – Flood zonation – Soil erosion zonation – Pollution studies.

Unit 5: Geographic Information System (GIS) and Global Navigation Satellite System (GNSS):

GIS: Components – Data structure – Types of Data: raster and vector – Data conversion (Vector to Raster and Raster to Vector) – Spatial data input processes and devices – Entry of non-spatial data – Linking of spatial and non-spatial data – Data verification – Data correction – Data interpolation – Data analysis – Surface modelling – DEM and DTM – Data output – Data quality, errors and their sources – Application of GIS in Geological studies – GNSSS: basic concept, structure, applications.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. Basic principles of electromagnetic remote sensing, spectral reflectance of Earth's atmosphere and Earth's surface features, and data acquisition receiving and recording process.
2. Aerial Remote Sensing which includes types of aerial photographs, photographic scale and causes for its variations, flight planning missions, stereoscopes and stereo-viewing and photointerpretation elements.
3. Satellite remote sensing systems, Indian space missions, and digital image interpretation techniques.
4. Applications of satellite Remote Sensing in various fields of Geosciences
5. GIS concepts, data structures, processing, analysis, and its applications in geology.
6. Integration of GNSS and GIS applications for spatial data analysis

Text Books:

1. **Allum, J.A.E (1978).** Photogeology and Regional Mapping, Pergamon Press Ltd.
2. **Anji Reddy, M (2001).** Textbook of Remote Sensing and GIS, BSP PS Publications.
3. **Chang, K (2006).** Introduction to Geographic Information Systems. Tata McGraw Hill Pub. Co. Ltd.
4. **Gupta, R.K (2011).** Geographic Information System: Fundamentals and Applications. Arise Publishers.
5. **Gupta, R.P (2008).** Remote Sensing Geology, II Edition, Springer.
6. **Lillesand, T.M., Kiefer, R.W and Chhipman, J.W (2017).** Remote Sensing and Image Interpretation, John Wiley & Sons.
7. **Miller, V.C (1961).** Photogeology. McGraw-Hill Publishers.
8. **Narayan, L.R.A (1999).** Remote sensing and its application. Universities Press Ltd.
9. **Pandey, S.N (1987).** Principles and applications of photogeology. Wiley Eastern Ltd.
10. **Prithvish Nag and S. Sengupta (2008).** Introduction to Geographical Information System. Concept Publishing Company.
11. **Rampal, K.K (1999).** Handbook of Aerial Photography and Interpretation. Concept Publishers Company.
12. **Sabins, F.F (1997).** Remote Sensing Principles and Interpretation, III Edition, W.H. Freeman & Company.
13. **Tor Bernhardsen (2009).** Geographic Information Systems: An Introduction, John Wiley & Sons Inc.

Reference Books:

1. **Barrett, E.C and C.F. Curtis (1982).** Introduction to Environmental Remote Sensing. Chapman & Hall.
2. **Bruno Marcolongo and Franco Mantovam (1997).** Photogeology – Remote Sensing Applications in Earth Sciences, Oxford & IBH Publishers Co. Pvt. Ltd.
3. **Burran, P (1988).** Principles of Remote Sensing. Corgman Publishers.
4. **Heywood, I., Cornelius, S and S. Carver (2010).** An Introduction to Geographic Information Systems, III Edition, Dorling Kindersley (India) Pvt. Ltd.
5. **Jean Yves Scanvic (1997).** Aerospatial Remote Sensing in Geology. Oxford & IBH Publishers Co. .
6. **Lo, C.P and A.K.W. Yeung (2007).** Concepts and Techniques of Geographic Information Systems. Prentice-Hall India Pvt. Ltd.
7. **Siegal, B.S and R. Gillespie (1980).** Remote Sensing in Geology, John Wiley & Sons.

Web Resources:

1. https://gis-lab.info/docs/books/aerial-mapping/cr1557_15.pdf
2. https://www.earthdata.nasa.gov/learn/backgrounders/remote-sensing
3. https://geol260.academic.wlu.edu/course-notes/

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	9	9	3	3
CO2	9	9	9	9	3	0
CO3	9	9	9	9	3	0
CO4	9	3	3	9	9	3
CO5	9	9	9	9	3	0
CO6	9	9	9	9	9	3
Total weightage	48	42	48	54	30	9
% Weightage	20.77	18.18	20.77	23.37	12.98	3.89

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	9	9	9	0
CO2	9	9	9	9	9	3
CO3	9	9	9	9	3	3
CO4	9	9	9	9	3	0
CO5	9	9	9	9	3	1
CO6	9	9	9	9	9	9

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	-	4	-	4	16
K2	1	1	1	2	5	-	5	20
K3	1	1	1	1	4	-	4	16
K4	1	1	1	2	5	-	5	20
K5	-	1	-	1	2	-	2	8
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20
Total	**5**	**5**	**4**	**6**	**20**	**5**	**25**	**100**

The Cos and Pos for the **REMOTE SENSING AND GIS** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY19E2	Elective	Elective Course – V REMOTE SENSING APPLICATIONS IN GEOSCIENCES	Theory	5	4

Course Description:

This course offers an in-depth understanding of the applications of remote sensing in geosciences, with a focus on geological, geomorphological, hydrological, disaster, and coastal studies. Through the interpretation of spectral, physical, and structural properties, students will learn to apply remote sensing techniques to analyze earth features, map resources, and assess environmental changes.

Course Objectives: To impart knowledge on

1. Spectral and physical properties of rocks and minerals and their interpretation for geological mapping and mineral exploration.
2. Mapping various geomorphic features using Remote Sensing data
3. Monitoring surface and groundwater and, land use/land cover analysis using Remote Sensing data
4. Role of Remote Sensing for assessing natural hazards such as floods, landslides, earthquakes, etc.
5. Role of Remote Sensing for shoreline change, oil spill mapping, and habitat mapping.

Unit 1: Remote Sensing Applications in Geology: Spectral properties of rocks and minerals, elemental composition and spectra of rocks and minerals, physical properties and spectra, optimal spectral windows – Mapping of rock types – Mapping of geological structures: folds, faults, fractures / lineaments – Mineral exploration – Land and water degradation due to mining activity.

Unit 2: Remote Sensing Applications for Geomorphic Mapping: Mapping of Structural landforms – Denudational landforms – Fluvial landforms – Aeolian landforms – Coastal landforms – Drainage networks and patterns.

Unit 3: Remote Sensing Applications for Water Resource Studies and Land Use/ Land cover Analysis: Mapping and monitoring of surface water bodies – Monitoring of quality of surface water bodies – Groundwater potential zonation mapping in unconsolidated and hard rock areas - Land Use/ Land cover Analyses: Remote Sensing Applications in: Land use/Land cover classification system of USGS and NRSC – Mapping of land use/ land cover classes.

Unit 4: Remote Sensing Applications for Natural Disaster Studies: Mapping of flood prone and, flood affected areas – Mapping of earthquake prone and, earthquake affected areas – Mapping of volcanic eruption prone areas – Mapping of landslide prone areas, and landslide affected areas – Mapping of soil erosion prone areas.

Unit 5: Remote Sensing Applications for Coastal Applications: Mapping of erosion prone areas – Shoreline change analysis – Coastal wetland mapping – Oil spill mapping – Mapping of coral reef habitat – Mapping of mangrove habitats.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. Spectral and physical properties of rocks and minerals and their interpretation for geological mapping and mineral exploration.
2. Mapping various geomorphic features using Remote Sensing data
3. Monitoring surface and groundwater and, land use/land cover analysis using Remote Sensing data
4. Role of Remote Sensing for assessing natural hazards such as floods, landslides, earthquakes, etc.
5. Role of Remote Sensing for shoreline change, oil spill mapping, and habitat mapping.
6. Integrate knowledge from multiple remote sensing applications in geosciences for research and professional development.

Text Books:

1. **Lillesand, T.M., Kiefer, R.W and Chapman, J.W (2015).** Remote Sensing and Image Interpretation (VII Edition), John Wiley & Sons Inc.
2. **Gupta, R.P (2008).** Remote Sensing Geology (II Edition), Springer.
3. **Boris Escalante-Ramirez (2012).** Remote Sensing – Applications, InTech Pub.

Reference Books:

1. **Bruno Marcolongo and Franco Mantovam (1997).** Photogeology – Remote Sensing Applications in Earth Sciences, Oxford & IBH Publishers Co. Pvt. Ltd.
2. **Sabins, F.F (2007).** Remote Sensing Principles and Interpretation (III Edition), Waveland Pr. Inc.
3. **Wang, Y (2010).** Remote Sensing of Coastal Environments. CRC Press, Taylor & Francis Group.

Web Resources:

1. http://www.gdmc.nl/oosterom/PoRSHyperlinked.pdf2.
2. http://www.geoservis.ftn.uns.ac.rs/downloads/ISP/1999-fundamentals-of-remotesensing.pdf3.
3. https://webapps.itc.utwente.nl/librarywww/papers_2009/general/PrinciplesRemoteSensing.pdf

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	1
CO4	9	3	3	9	9	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	9	3
Total weightage	48	42	48	54	30	16
% Weightage	20.16	17.64	20.16	22.68	12.60	6.72

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	9	9	9	0
CO2	9	9	9	9	9	0
CO3	9	9	9	9	1	3
CO4	9	9	9	9	3	0
CO5	9	9	9	9	3	1
CO6	9	9	9	9	9	3

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	-	4	-	4	16
K2	1	1	1	2	5	-	5	20
K3	1	1	1	1	4	-	4	16
K4	1	1	1	2	5	-	5	20
K5	-	1	-	1	2	-	2	8
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20
Total	**5**	**5**	**4**	**6**	**20**	**5**	**25**	**100**

The Cos and Pos for the **REMOTE SENSING APPLICATIONS IN GEOSCIENCES** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GY19E3	Elective	Elective Course – V MEDICAL GEOLOGY	Theory	5	4

Course Description:

Medical Geology is an interdisciplinary science that explores the relationship between geological materials/processes and human and ecosystem health. This course provides insights into naturally occurring and anthropogenic sources of elements, exposure pathways, geochemical influences on health, and global environmental health issues. It integrates geological and biomedical knowledge to address public health challenges arising from the Earth's processes.

Course Objectives: To impart knowledge on

1. The fundamental relationship between public health and geological processes, including natural and anthropogenic sources of elements and their biological roles.
2. Exposure pathways of toxic elements like arsenic, fluoride, and radon, and understand related health effects and standards.
3. Geochemical causes of diseases such as tropical endomyocardial fibrosis and urolithiasis, and their relation to water chemistry.
4. Environmental cycles of iodine and nitrogen, and their effects on human health, including deficiencies and toxicities.
5. Health impacts of selenium and iodine deficiency, natural aerosolic mineral dusts, and micronutrient deficiencies in soils.

Unit 1: Medical Geology: perspectives and prospects – Public health and Geological processes: An overview of a fundamental relationship – Natural distribution and abundance of elements, anthropogenic sources – Uptake of elements on chemical and biological perspective and its functions – Geological impacts on nutrition.

Unit 2: Pathways and Exposure – Volcanic emissions and health – Radon in air and water – Arsenic in groundwater and the Environment – WHO and BIS standards for drinking water – Fluoride in natural waters, soils, sediments, plants – Fluorides and health: Bioavailability of fluoride, dental fluorosis, skeletal fluorosis, dental fluorosis in India, source, nature, cause and extent.

Unit 3: Water hardness and health effects – Geochemical basis for tropical endomyocardial fibrosis (EMF) – Effect of water hardness on urinary stone formation (urolithiasis) – Types of stones: Calcium oxalate, calcium phosphate, uric acid, magnesium ammonium phosphate stones, cysteine.

Unit 4: Iodine and health: The iodine cycle in the environment, iodine in drinking water, iodine in food, Iodine Deficiency Disorders (IDD), endemic cretinism, goitrogens – The nitrogen cycle, nitrate as fertilizers and environment, nitrogen loading in rice fields, nitrates from human and animal wastes, nitrates and health, nitrates and Methemoglobinemia, nitrates and cancer – Bioavailability of elements in soil.

Unit 5: Selenium deficiency and toxicity in the environment – Soils and iodine deficiency – Natural aerosolic mineral dusts and human health – Animals and Medical Geology – The impact of micronutrient deficiencies in agricultural soils and crops on the nutritional health of humans.

Course Outcomes: On completion of the course the student would have gained knowledge on

1. The fundamental relationship between public health and geological processes, including natural and anthropogenic sources of elements and their biological roles.
2. Exposure pathways of toxic elements like arsenic, fluoride, and radon, and understand related health effects and standards.

3. Geochemical causes of diseases such as tropical endomyocardial fibrosis and urolithiasis, and their relation to water chemistry.
4. Environmental cycles of iodine and nitrogen, and their effects on human health, including deficiencies and toxicities.
5. Health impacts of selenium and iodine deficiency, natural aerosolic mineral dusts, and micronutrient deficiencies in soils
6. The implications of micronutrient deficiencies and mineral dusts on animal and human health.

Text Books:

1. **Dissanayake, C.B and R.Chandrajith (2009).** Introduction to Medical Geology, Springer.
2. **Antony R. Berger (2003).** Geology and Health: Closing gap, Oxford Univ. Press.
3. **Valdiya, K.S (2004).** Geology, Environment and Society, University Press.
4. **Dissanayake, C.B and R. Chandrajith (2009).** Introduction to Medical Geology, Springer, London.

Reference Books:

1. **Komatica, M.M (2004).** Medical Geology, Vol. 2, Effects of Geological Environment on Human Health, Elsevier.
2. **Volfson (2010).** Medical Geology: Current Status and Perspectives, Russian Geological Society Pub.
3. **Lawrence K. Wang, Jiaping Paul Chen, Yung-Tse Hung, Nazih K. Shammas (2009).** Heavy Metals in the Environment, CRS Press, Taylor & Francis Group.

Web Resources:

1. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.redalyc.org/pdf/505/50550305.pdf
2. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://ijacskros.com/artcles/IJACS-M10.pdf
3. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://download.e-bookshelf.de/download/0000/0136/38/L-G-0000013638-0002346784.pdf

Mapping Course Outcomes (COs) Consistency with Program Outcomes (POs)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	9	9	3	3
CO2	9	9	9	9	3	3
CO3	9	9	9	9	3	1
CO4	9	3	3	9	9	3
CO5	9	9	9	9	3	3
CO6	9	9	9	9	9	3
Total weightage	48	42	48	54	30	16
% Weightage	20.16	17.64	20.16	22.68	12.60	6.72

Course Outcomes Mapped with Knowledge Levels

CO / K-Level	K1	K2	K3	K4	K5	K6
CO1	9	9	9	9	9	0
CO2	9	9	9	9	9	0
CO3	9	9	9	9	1	3
CO4	9	9	9	9	3	0
CO5	9	9	9	9	3	1
CO6	9	9	9	9	9	3

Legend: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation

Course Outcome (CO) Attainment Assessment Tools & Evaluation

K Levels	T1	T2	Assignment	Seminar	Total Scholastic Marks	Non Scholastic Marks	CIA Total	% of Assessment
K1	2	1	1	-	4	-	4	16
K2	1	1	1	2	5	-	5	20
K3	1	1	1	1	4	-	4	16
K4	1	1	1	2	5	-	5	20
K5	-	1	-	1	2	-	2	8
K6	-	-	-	-	-	-	-	-
Non Scholastic	-	-	-	-	-	5	5	20
Total	**5**	**5**	**4**	**6**	**20**	**5**	**25**	**100**

The Cos and Pos for the **MEDICAL GEOLOGY** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**

Programme Code	Course Code	Course Type	Course Title	Category	Hrs / Week	Credits
AGEPG1983	P25GYP20		DISSERTATION		8	5

Course Description:

This course enables students to undertake an independent research work in selected field of Geology under the supervision of a faculty member. It aims to cultivate critical research skills such as data collection, analysis, interpretation, and scholarly writing. This would lay the groundwork for potential doctoral studies or advanced research projects. The course culminates in a viva-voce examination, promoting students' analytical, research, and communication skills.

Course Objectives: To impart knowledge on

1. To enable students to formulate and plan a dissertation topic relevant to the field of geology
2. To encourage individual initiative and problem-solving in executing the research plan.
3. To develop the ability to collect, process, and interpret scientific data through field and/or laboratory work.
4. To enhance the student's ability to write a scientifically valid and structured dissertation.
5. To assess the student's understanding and presentation skills through an oral viva-voce examination.

- **The total marks for the course would be 100 of which evaluation for 75 marks (internal) would be done by the candidate's dissertation supervisor. It would be based on the**

  i) Plan of the dissertation work
  ii) Candidate's individual initiative for the completion of the dissertation
  iii) Execution of the plan by the candidate

- **Evaluation for the 25 marks (Oral) would be done by the external examiner. It would be based on candidate's performance in the Viva-voce**

Course Outcomes:

1. Formulate a research plan and identify appropriate methods to carry out research
2. Demonstrate initiative and accountability in independently executing a research project.
3. Collect, analyze, and interpret field/laboratory data relevant to the research topic.
4. Organize and present research results in a coherent, scientific format.
5. Defend their research outcomes during viva-voce with scientific reasoning.
6. Exhibit awareness of the societal, industrial, and academic relevance of their research.

The Cos for the **DISSERTATION** course in the M.Sc. Applied Geology Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge **Signature of the HoD**