STRUCTURE AND SYLLABUS

OF

M. Sc. Geology

2019 - 20 ADMISSION ONWARDS

(UNDER MAHATMA GANDHI UNIVERSITY PGCSS REGULATIONS 2019)

EXPERT COMMITTEE IN GEOLOGY (PG)

MAHATMA GANDHI UNIVERSITY
PRIYADARSHINI HILLS P. O.
KOTTAYAM, KERALA 686 560, INDIA
www.mgu.ac.in
2019

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Acknowledgement

The support and guidance from various eminent personalities made this restructuring of M. Sc. Geology syllabus under PG- CSS 2019 is a success. I place on record my gratitude to the Hon. Vice Chancellor and Pro - Vice Chancellor of Mahatma Gandhi University, Kottayam for the initiative and guidance in restructuring the syllabus. I express profound gratitude to the members of the University Syndicate and Academic council for fruitful steering of the program.

I am thankful to members of Faculty of Science and Expert Committee in Geology for their support and guidance. Administrative support from the Registrar and his office is thankfully acknowledged. Thanks to Academic and the Finance Sections for prompt response to solve technical snags.

I also grateful to all teachers who participated in the workshop organized by the University for restructuring the syllabus. I extend my gratitude to all professionals, academicians and other stakeholders who gave valuable suggestions in this regard.

Mahatma Gandhi University Kottayam

M. Sc. Geology

2019 - 20 ADMISSIONS ONWARDS

(MAHATMA GANDHI UNIVERSITY REGULATIONS PGCSS 2019, 2019-20 Academic Year Onwards)

Aim of the Programme

The M. Sc. Geology programme is designed to:

Provide knowledge of advanced branches of Geology at post graduate level

Understand the Earth and its various processes, both external and internal that shape it

Develop skills in exploration and extraction of natural resources such as minerals, rocks, fossil fuel and water

Recognize the Earth as an environmental realm and chalk out plans for conserving its resources

Promote geological research which has immense potential in the future

Duration of the Programme:

Duration of program will be 4 semesters spread over 2 academic years.

Eligibility for Admission: B.Sc. Geology/B.Sc. Geology and Water Management with pass minimum of 50%

Medium of Instruction and Assessment: English

Faculty under which the degree is awarded: Science

MAHATMA GANDHI UNIVERSITY

Syllabus of M. Sc. GEOLOGY PROGRAMME (2019 admission onwards)

PROGRAMME OUTCOME

Geology is an interdisciplinary subject which explores the interior structure of the earth. It incorporates inputs from almost all science disciplines. Geologists are mainly involved in the exploration and extraction of natural resources such as minerals, rocks, fossil fuel and water. As it is a fast growing area geologists will have to play a vital role in our future. Those who complete post graduation in Geology can show their skills in this area. They can also engage in geological research which has immense potential in the current scenario.

GENERAL OUTLINE OF M. Sc. GEOLOGY PROGRAMME

M. Sc. Geology is a four semester programme, under choice based credit system (CBCS) spread over two academic years. The academic requirements of this programme include theory courses, practical courses, geological, field mapping training, study tour, dissertation projects and viva voce. Distribution of courses, instructional hours and credits is given in table 1.1

1. Theory Courses

There are two types of theory courses viz. Programme Core (PC) and Programme Elective (PE). Programme cores are spread over Semester I to III (four Courses in each semester). The respective college/department may opt for any three of the six programme electives included in the scheme depending on feasibility and infrastructural facility.

2. Practical Courses

Each semester has one practical course and examination.

3. Geological Field Mapping

Geological field mapping is included in the second semester and its participation is a mandatory requirement. The training is to be scheduled in a single batch, for duration of maximum 15 days. It may be guided by a member of faculty in any place of geological interest in India. Alternatively, the student may be attached to an organization engaged in geological field work (say, Geological Survey of India) for imparting training.

4. Dissertation Project

Each student should undertake an individual dissertation fieldwork during fourth semester under guidance and supervision of a staff member. A staff, member may supervise the work of more than one student in related fields of study in adjacent field areas, but should be separate on topics. He/she should choose a topic within the purview of the course curriculum. The work can be done in collaboration with scientific research institute/ establishment/ academic institutions on cooperating co- guide/s from that organization.

Eighteen working days equivalent to ninety hours may year marked to collect filed data and for experiment, survey, analysis and interpretations during fourth semester. If additional time required it should be availed outside instructional hours including vacation and holidays. Each student should submit a thesis (certified as authentic and bonafide by both supervising teacher and head of the department) prior to attending viva voce. The work done should be presented before examiners and part of viva voce. Submission of thesis prior viva voce and presentation during it are mandatory requirements, without which course will be incomplete.

5. Viva voce

A viva voce examination will be conducted board of examiners at the time of evaluation of the project.

6. Question paper pattern for theory courses

All theory examinations are of three (3) hour duration. Each question paper has a maximum weightage of 30 and has three parts.

Part A: Short answer type questions with a weightage of 1.

Part B: Short essay type questions with a weightage of 2.

Part C: Essay type questions with a weightage of 5.

Criteria of internal assessment, conduct of examination, evaluation are available in university website *mgu.ac.in*

M. Sc. PROGRAMME IN GEOLOGY

SEMESTER WISE DISTRIBUTION OF COURSES, CONTACT HOURS AND CREDITS

Sem	Course Code	Course Title		Contact hours/week	Credit	Total Credit 80
I	GL010101	Geomorphology and Geomatics		5	4	19
	GL010102	Applied Mineralogy		5	4	
	GL010103	Structural Geology and Tectonics		6	4	
	GL010104	Stratigraphy and Quaternary Geology		5	3	
	GL010105 Practical 1	Geomorphology, Geomatics, Mineralogy and Structural Geology		4	4	
II	GL010201	Igneous and Metamorphic Petrology		6	4	21
	GL010202	Sedimentology and Geostatistics		5	4	
	GL010203	Geochemistry and Isotope Geology		5	4	
	GL010204	Climatology and Marine Geology		5	3	
	GL010205 Practical 2	Petrology		4	4	
	GL010206 Training	Field Mapping Training		2*	2	
III	GL010301	Exploration Geology and Geophysics		6	4	19
	GL010302	Advanced Economic Geology		6	4	
	GL010303	Mining and Engineering Geology		4	4	
	GL010304	Hydrogeology		5	3	
	GL010305 Practical 3	Exploration Geology, Economic Geology and Hydrogeology		4	4	
IV	Elective 1	GL800401	Fuel Geology and Micropalaeontology	6 (7)**	4	21
		GL800402	Advanced Palaeontology	5 (7)**	3	
		GL800403	Environmental Geology and Disaster Management	5 (7)**	4	
		GL800404	Elective Practical	4	3	
	Elective 2	GL810401	Gemmology	6 (7)**	4	
		GL810402	Planetary Geology	5 (7)**	3	
		GL810403	Analytical Geochemistry	5 (7)**	4	
		GL810404	Elective Practical	4	3	
	GL010401 Project	Dissertation		5**	5	
	GL010402 Viva Voce	Viva Voce		Nil***	2	

Fourth Semester Elective Courses

Elective Group	Course Code	Course Title
Group 1 - Elective 1	GL800401	Fuel Geology and Micropalaeontology
	GL800402	Advanced Palaeontology
	GL800403	Environmental Geology and Disaster Management
	GL800404	Elective Practical
Group 2 - Elective 2	GL810401	Gemmology
	GL810402	Planetary Geology
	GL810403	Analytical Geochemistry
	GL810404	Elective Practical

* 2 hours per week allotted for Field mapping training (GL010206) in the II semester will be engaged as theory classes and the field mapping training program will be carried out (maximum up to 15 days) towards the end of the II semester.

** 5 hours per week allotted for Dissertation (GL010401) in the IV semester will be engaged as theory classes and the Dissertation program will be carried out continuously for 90 hours (18 days including fieldwork) towards the end of the IV semester.

*** Viva voce does not require any contact hours per week.

M. Sc. GEOLOGY
SYLLABUS OF PROGRAMME CORE (THEORY)

SEMESTER	COURSE CODE	CONTACT/ WEEK	CONTACT/ SEMESTER	CREDITS
I	GL010101	5 HOURS	90 HOURS	4

GEOMORPHOLOGY AND GEOMATICS

Unit I **(12 hours)**

Basic concepts of geomorphology – ancient and modern ideas – catastrophism – uniformitarianism. Geomorphological cycle – Davis and Penck, King, Hack and Gilbert models. Systems approach and ideas of process geomorphology. Analysis of the geomorphic processes – geomorphic agents and processes – endogenic, exogenic processes and controls- geological and structural controls. Landforms in arid and semi arid environments.

Unit II **(12 hours)**

Fluvial Geomorphology – river forms and processes, longitudinal profile, base level – control; relation between channel width, depth and current velocity; basics of stream discharge, velocity and turbulence; sediment transport, landforms of fluvial origin. Hypsometry. Tectonic geomorphology.

Unit III **(10 hours)**

Topographic maps – morphometric elements and parameters. Morphometric analysis of drainage basins – linear, aerial and relief aspects. Laws of drainage composition. Evolution of slopes.

Unit IV **(12 hours)**

Applications of geomorphology in mineral prospecting, civil engineering, hydrogeology and environmental studies. Geomorphology of Kerala- geomorphic divisions. Evolution of Kerala coast during the Quaternary period.

Unit V **(12 hours)**

Basic concepts of remote sensing. Types and platforms of remote sensing. Energy sources and radiation principles. Electromagnetic radiation- EMR spectrum. Energy interaction with atmosphere and earth surface. Satellite remote sensing- basic principles. LANDSAT, SPOT. Indian remote sensing satellites. Thermal, Multi-spectral and Hyper-spectral remote sensing. Microwave remote sensing- Radar, SLAR system, SRTM, LIDAR.

Unit VI **(12 hours)**

Aerial photography- basic principles, geometrical characteristics of aerial photographs. Types of aerial photographs- vertical/oblique/high oblique. Aerial mosaics. Flight plan of aerial photography. Photogrammetry – analogue and digital photogrammetry. Terminologies associated with photogrammetry- Scale, Relief displacement, Vertical exaggeration and Stereoscopic Image parallax – a brief description. Stereoscopic vision – Stereoscopes – types - pocket and mirror stereoscopes. Tilt, drift and crab in aerial photographs.

Unit VII **(10 hours)**

Fundamentals of GIS- basic concepts. Components of GIS- hardware and software. Projections, geographic and Cartesian co-ordinates; georeferencing. Datum transformation; GIS data structures- Raster and Vector, DEM; WebGIS- definition and concepts; GIS softwares- open source- QGIS, GRASS; commercial softwares- ArcGIS, ERDAS. Open source spatial data processing. Digital cartography.

Unit VIII **(10 hours)**

Navigation and positioning system- GPS, GLONAS, BAIDU, GALILEO, IRNSS.

Application of aerial photographs and satellite imageries in petroleum, mineral and groundwater exploration, geotechnical engineering projects, geological mapping, wet land and waste land mapping.

Application of remote sensing in geologic mapping, structural mapping, tectonic analysis, geomorphologic mapping.

Application of GIS in geology, disaster management and water resources management.

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37. http://www.webgis.com/
38. https://www.qgistutorials.com/

COURSE OUTCOME

The course offers a clear cut understanding on the various aspects and methods of information technology in daily life and also its applications in delineating the geomorphological characteristics of planetary bodies. These studies have a significant role in the planning and implementation of all development projects. This course is intended to make the students able to handle the software which has been used in this platform.

M. Sc. GEOLOGY
SYLLABUS OF PROGRAMME CORE (THEORY)

SEMESTER	COURSE CODE	CONTACT/ WEEK	CONTACT/ SEMESTER	CREDITS
I	GL010102	5 HOURS	90 HOURS	4

APPLIED MINERALOGY

Unit I **(8 hours)**

Crystalline state, symmetrical lattice, Bravais lattice, point groups and their symmetry.

Unit II **(14 hours)**

Principles of mineral optics- Birefringence. Optical accessories and their uses. Conoscopic study and interference figures. Dispersion in minerals. Procedure for determining 2V (Mallards method), optic sign, scheme of pleochroism and sign of elongation.

Unit III **(12 hours)**

Silicate structure – co-ordination number and silicon tetrahedra.
Nesosilicates: Olivine- Fo-Fa series, structure, properties, paragenesis and P-T stability; Garnet- structure, chemistry, properties and paragenesis; Al_2SiO_5 polymorphs.
Sorosilicates: Melilite- composition and structure

Unit IV **(12 hours)**

Inosilicates: Single chain- Pyroxenes- T-O-T beam structure and classification; orthopyroxene- Enstatite-Ferrosilite series- properties and paragenesis. Clinopyroxenes – Ca-, Ca-Na- and Na-, chemistry, properties and paragenesis.
Double chain- Amphiboles- orthoamphiboles and clinoampbiboles– chemistry, structure, properties and paragenesis.

Unit V **(12 hours)**

Cyclosilicates: Cordierite, Tourmaline and Beryl- chemistry, structure, properties and paragenesis.
Phyllosilicates: Sheet structure- Brucite and Gibbsite sheet, TO, TOT, TOT+c and TOT+O structures. Clay and mica- chemistry, structure, properties and paragenesis.

Unit VI **(12 hours)**

Tectosilicates – Silica group; structure, P-T stability of SiO_2 polymorphs; Feldspars– structure and classification, Plagioclase and Alkali feldspars- properties and paragenesis. Solid solution and exsolution, intergrowths – Huttenlocher, Peristerite and Boggled, perthite, myrmekite, graphic and rapakivi and its significance; twinning in feldspars- simple and polysynthetic.

Unit VII **(8 hours)**

Structure, properties and paragenesis of following non-silicates: Spinel, Perovskite, Calcite and Dolomite.

Unit VIII **(12 hours)**

Chemical analysis of minerals- Principles of X- ray diffraction, Bragg's law, Basic feature of X-ray diffractometer, single crystal and powder methods. Preparation of sample for XRD study and interpretation of data. Basic principles of EPMA analysis.

REFERENCES

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COURSE OUTCOME

The course offers a detailed understanding of minerals; their origin, structure, composition and properties. This course also focuses on the analytical methods used in the chemical analysis of minerals. This will act as foundation for understanding the concepts in geochemical and petrological studies, as mineralogy is considered as one of the pillar subject in Geosciences.

M. Sc. GEOLOGY
SYLLABUS OF PROGRAMME CORE (THEORY)

SEMESTER	COURSE CODE	CONTACT/ WEEK	CONTACT/ SEMESTER	CREDITS
I	GL010103	6 HOURS	108 HOURS	4

STRUCTURAL GEOLOGY & TECTONICS

UNIT I **(20 hours)**

Deformations- homogenous and heterogenous deformation- elastic and plastic deformation. Concept of stress and strain – types of stress – lithostatic, compressive and tensile stress. Normal and shear stress. Strain– dialation and distortion. Stress and strain ellipsoids, stress strain graphs - concepts of Flinn Diagram & Mohr's Circle. Nature of rocks and minerals under stress – brittle and ductile conditions.

UNIT II **(20 hours)**

Fold- Cylindrical and non-cylindrical folds. Classification of folds - Ramsay's classification, Donath and Parkers classification. Drag folds – minor folds and their use in determining major fold structure. Mechanics of folding. Poly-phase deformation – canoe and inverted canoe folds. Superimposed folds and interference patterns. Ramsay's classification of superimposed folds- dome, basin, mushroom, boomerang and hook folds.

UNIT III **(18 hours)**

Fault systems related to plate tectonic domains. Shear zone – types, geometry and mechanism of formation. Brittle and ductile shears and associated structures. Thrust – large scale thrust and their tectonic significance. Mapping of structural features.

UNIT IV **(18 hours)**

Tectonites - classification, tectonic fabrics. Foliation – definition and types. Fracture cleavage and transposed foliation. Origin of axial plane foliation. Use of axial plane foliation and fracture cleavage in structural interpretation. Lineation – classification and origin.

UNIT V **(18 hours)**

Spatial orientation of planar and linear fabrics. Fundamentals of geometric analysis. Petrofabric analysis – field and laboratory techniques involved in the construction of fabric diagrams and their interpretation. Graphical representation of structural data –stereographic and equal-area projections in structural geology – π and β diagrams, histogram and rose diagram. Strain analysis.

UNIT VI **(14 hours)**

Geodynamic settings of plate margins. Tectonic framework of Indian plate- Evolution of Himalaya, Central Indian Tectonic Zone (CITZ). Supercontinents- Indian plate journey through Rodinia, Gondwana and Pangaea. Tectonic framework of Southern Granulite Terrain (SGT). Shear zones in SGT- Moyar, Bhavani, Attur, Palghat-Cauvery and Achenkoil.

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COURSE OUTCOME

The course offers advanced study of the structures in rocks with respect to change in stress-strain scenario; and includes analyses of faults, folds, and other structures associated with shear zones & poly deformed rocks. The course covers structural mapping methods, and structural analysis using various graphical representations. It also aims the study of present tectonic scenario & evolution of the Indian Plate.

M. Sc. GEOLOGY
MODIFIED SYLLABUS OF PROGRAMME CORE (THEORY)

SEMESTER	COURSE CODE	CONTACT/ WEEK	CONTACT/ SEMESTER	CREDITS
I	GL010104	5 HOURS	90 HOURS	3

STRATIGRAPHY AND QUATERNARY GEOLOGY

Unit I **(12 hours)**

Stratigraphic principles and evolution. Chronostratigraphy, Biostratigraphy and Lithostratigraphy, stratigraphic correlation. Evolution of Geological Time Scale. Procedures in seismic stratigraphy, magneto-stratigraphy, cyclostratigraphy, pedostratigraphy, chemostratigraphy and sequence stratigraphy.

Unit II **(10 hours)**

Major geological events in Phanerozoic Eon. Major extinction events in Phenerozoic. K- T Boundary extinction and its causes. Volcanic eruption and Meteorite impact hypothesis.

Unit III **(12 hours)**

Precambrian stratigraphy: Precambrian Crust- Nature and evolution of primitive crust and characteristic features of Achaean crust. Detailed study of Precambrian stratigraphy in India with special references to SGT, Dharwar, Bastar, Singhbhum, Aravalli and Bundelkhand Cratons.

Unit IV **(10 hours)**

Mobile belts in India – Pandyan, Eastern Ghats, Satpura and Aravalli mobile belts. Evolution and stratigraphy of Proterozoic sedimentary basins of India – Cuddapah, Vindhyan, Kurnool.

Unit V **(12 hours)**

Phanerozoic stratigraphy of India- Palaeozoic Stratigraphy of Kashmir and Kumaon. Stratigraphy and evolution of Deccan Volcanic Province, Gondwana Super group. Cenozoic of Bengal basin. Boundary problems- Permian-Triassic and Cretaceous-Tertiary with special references to India.

Unit VI **(12 hours)**

Definition of Quaternary. Significance and subdivisions. Archives of Quaternary history; tree rings, corals, speleothems (cave deposits), peat deposits, dunes, lake sediments, marine sediments, glaciers, fluvial deposits. Climate and climate variability: various time scales of climate variability.

Unit VII **(12 hours)**

Quaternary dating methods– Radiocarbon, Uranium series, Luminescence– TL & OSL, Dendrochronology, Varve chronology, Lichenology and layers in Ice cores.

Relative dating methods – Using surface weathering, Amino acids and obsidian hydration. Techniques for establishing age equivalence - Oxygen isotope chronostratigraphy, Tephro chronology and using paleosols.

Unit VIII **(10 hours)**

Ice Ages during Quaternary- factors controlling glacial cycles. Various stages in Quaternary glaciations. Eustatic Sea Level changes and their global significance.

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COURSE OUTCOME

The course offers a detailed knowledge on different types of conventional and advanced stratigraphic approaches in studying the earth history. It aims to have a deeper knowledge in the Precambrian and Phanerozoic stratigraphy of Earth with special reference to India. The course of Quaternary Geology aims understanding different proxies, dating techniques and important processes in Quaternary period.

M. Sc. GEOLOGY
SYLLABUS OF PROGRAMME CORE (PRACTICAL)

SEMESTER	COURSE CODE	CONTACT/ WEEK	CONTACT/ SEMESTER	CREDITS
I	GL010105	4 HOURS	72 HOURS	4

PRACTICAL 1

GEOMORPHOLOGY, GEOMATICS, MINERALOGY AND STRUCTURAL GEOLOGY

GEOMORPHOLOGY AND GEOMATICS (28 hours)

Interpretation of satellite imageries. Identification and mapping of drainage patterns, lineaments, litho contacts and geological structures. Hypsometric analysis

Interpretation of aerial photos with special references to topography, drainage, structure and geology. Simple calculations based on aerial photos- determination of photo scale, total number of photos required to cover a given area, height of objects and relief displacement from aerial photographs.

Morphometric analysis using GIS software and toposheets.

Data inputs to GIS software. Georeferencing, digitization and digital cartography. Determination of slope and slope map preparation. Identification of lineaments and preparation of lineament maps.

MINERALOGY (18 hours)

Mathematical Crystallography: Axial ratios, Zone symbols, Law of Anharmonic ratio and Napier's rule.

Stereographic projection of Normal class of Isometric, Tetragonal, Hexagonal, Orthorhombic, Monoclinic, Triclinic System and Rhombohedral class.

Identification of typical mineral hand specimens based on physical properties. Determination of the following optical characters of minerals: Order of Interference colour, Sign of Elongation, Optic sign Scheme of Pleochroism, Optic orientation, Optic axial angle and Extinction Angle.

STRUCTURAL GEOLOGY (26 hours)

Interpretation of complex geological maps - 25 Nos. Trigonometric and stereographic solution to problems in structural geology (unconformities, fold and fault). Geometric analysis of planar and linear structures, Fabric diagrams, Rose diagrams, Histograms, β diagram and π diagram, strain analysis.

M. Sc. GEOLOGY
SYLLABUS OF PROGRAMME CORE (THEORY)

SEMESTER	COURSE CODE	CONTACT/ WEEK	CONTACT/ SEMESTER	CREDITS
II	GL010201	6 HOURS	108 HOURS	4

IGNEOUS AND METAMORPHIC PETROLOGY

Unit I **(14 hours)**

Magma characteristics- physical properties. Petrogenesis- partial melting in the lithosphere- depleted and fertile mantle, mantle melting mechanisms- Thermal perturbation, adiabatic uplift and volatile influx. Generation of heterogenous magma from single mantle source, diversification of magma- AFC process. Magma generation in relation to tectonic setting- Mid ocean ridge volcanism, subduction related volcanism (Island arc and continental arc volcanism), Oceanic intraplate volcanism and continental flood basalts. Large Igneous Provinces with Deccan Basalt Province as example.

Unit II **(14 hours)**

Elementary thermodynamics, Phase rule in igneous petrology and three component systems: Ternary eutectic system- Di-An-Fo system, Ternary system with solid solution- Di-An-Ab system, Ternary peritectic system- Fo-Qtz-Di system, Ternary system with solvus- Ab-Or-Qtz system

Unit III **(12 hours)**

Mineralogy, texture mode of occurrence and genesis of basalts. Basalt tetrahedron (Yodder and Tilley). Ophiolite sequence and its significance. Continental alkaline magmatism: Mineralogy, texture, mode of occurrence, genesis and economic importance of Carbonatites, Lamprophyres, Kimberlites and Komatiites.

Unit IV **(14 hours)**

Mineralogy, texture, mode of occurrence and genesis of granites and granitoids. Brief description of granites in the South Indian shield. Layered igneous complex and their significance. Sittampundi layered complex, South India. Anorthosites: Massif and layered types, origin and tectonic significance. Intrusives of Kerala- distribution, petrography, geochemistry, tectonic setting, age and petrogenesis.

Unit V **(14 hours)**

Elementary thermodynamics and phase rule in metamorphic petrology. Metamorphic facies, Metamorphic reactions-Polymorphic transformations, exsolution reactions, solid-solid net transfer reactions, continuous reactions, devolatilization reactions, ion exchange reactions, oxidation/reduction reactions and reaction involving volatile species. Fabrics and their development – classification, nomenclature and petrographic descriptions of metabasic, metapelitic and metacarbonate rocks.

Unit VI **(10 hours)**

Mineral paragenesis and chemographic diagrams- ACF, AKF and AFM diagrams – merits and demerits. Schreinmaker's rule and petrogenetic grid.

Unit VII **(14 hours)**

Granulite facies rocks with special references to charnockites and khondalites of South India. Role of anhydrous fluids in granulite metamorphism – Carbonic metamorphism, Fluid inclusions, importance of fluid inclusion in metamorphic studies. Ultra High Temperature (UHT) and Ultra High Pressure (UHP) metamorphism.

Unit VIII **(16 hours)**

Geothermobarometry– basic concept. Metamorphic P-T-t paths – clockwise and anticlockwise paths and their tectonic implications. Isobaric cooling and isothermal decompression– disequilibrium textures. Metamorphism in relation to plate tectonics - paired metamorphic belts. Polymetamorphism, metasomatism, granitization and migmatites– anataxis and retrograde metamorphism.

REFERENCES

1. Winter, J.D. (2001) An introduction to igneous and metamorphic petrology, Printice Hall, New Jersey.
2. Wilson, M. (1989) Igneous Petrogenesis. Unwin Hyman Inc., USA
3. Philipots A. (1994) Principle of Igneous and metamorphic petrology, Prentice Hall of India Pvt Ltd, New Delhi.
4. Bowen, N. L. (1956) The Evolution of the Igneous Rocks. Dover publication, Inc, New York
5. Soman, K., (2004) Geology of Kerala, Geological society of India, Bangalore.
6. Ramakrishan and Vaidyanathan (2008) Geology of India, Geo. Soc. India, Bangalore.
7. Middlemost E.A.K. (1985) Magmas and Magmatic rocks, Longman, New York.
8. Subramanian K.S. & Selvan, T.A. (2001) Geology of Tamil Nadu, Geo Soc India, Bangalore.
9. Gupta, A. K., (1998), Igneous rock. Allied Publishers Ltd, Chennai
10. Ehler, G. E. and Blatt H., 1999, Petrology-Igneous, sedimentary and metamorphic, CBS Publishers and distributors, New Delhi.
11. Mihir K. Bose (1997), Igneous petrology, The World Press Private Ltd, Calcutta.
12. Philipots, A., and Ague, J. J., (2011) Principles of Igneous and metamorphic petrology, Cambridge publishers
13. Winkler, H.G.F., 1979, Petrogenesis of metamorphic rock, Springer-Verlag.
14. Mason, R., 1990, Petrology of the metamorphic rocks, Unwin Hyman, London.
15. Miyashiro, A., 1972, Metamorphism and Metamorphic Belts, Allen and Unwin.
16. Tyrrell, G.W., 1987, The principles of petrology, B. I. Publications PVT LTD.
17. Turner, F.J. and Verhoogen, J., 1999, Igneous and metamorphic petrology.
18. Barth, T.F.W., 1962, Theoretical Petrology, Wiley, Edition 1, Dover Publication.
19. Johanson, 1952, Manual of Petrographic Methods, Mc Graw Hill.

COURSE OUTCOME

Igneous Petrology offers the students a detailed idea about the magma, its characteristics, diversity and its generation with respect to different tectonic settings. It offers students the experimental models for the crystallization – melting process in the deep crust and in the mantle. It also intends to provide a detailed understanding of the important igneous rock types found on earth with special reference to its petrogenesis. Metamorphic petrology offers deep understanding in metamorphic processes and reactions. This course intends to impart the students a comprehensive knowledge in experimental petrology, geothermobarometry and relation between metamorphism and plate tectonics.

M. Sc. GEOLOGY
SYLLABUS OF PROGRAMME CORE (THEORY)

SEMESTER	COURSE CODE	CONTACT/ WEEK	CONTACT/ SEMESTER	CREDITS
II	GL010202	5 HOURS	90 HOURS	4

SEDIMENTOLOGY AND GEOSTATISTICS

Unit I **(14 hours)**

Sedimentary processes- weathering, sediment transported by fluids - fundamentals of fluid flow- open channel flow- laminar flow, turbulent flow- Reynolds number, Froude Number, particle entrainment. Particle settling velocity- Stoke's law. Sediment load, process of sediment transport- by fluids, gravity and flow velocity

Unit II **(14 hours)**

Depositional environments –Facies: Terrestrial-Fluvial, glacial, Aeolian and lacustrine systems. Transitional- deltaic, beach and barrier island, estuarine and tidal flat systems. Marine- Shallow and deep marine systems. Carbonate and evaporate environment. Heavy mineral assemblage in sedimentary rocks, methods of heavy mineral separation and analysis. ZTR index, provenance analysis.

Unit III **(14 hours)**

Textural study of sediments- Techniques of grain size measurement- Sieve analysis, Settling Analysis- sedimentation balance. Grain Size parameters -graphic parameters of Folk and Ward- application in palaeo-environment studies. Surface textures of sediments.

Unit IV **(10 hours)**

Sedimentary structures– origin, classification-primary, secondary and organic structures; palaeo-environmental significance of sedimentary structures. Application of textures and structures in basin studies. Origin, classification and petrography of sandstone, conglomerate and mudstone. Diagenesis of carbonate sediments and siliciclastic sediments.

Unit V **(8 hours)**

Types of sedimentary basins and their tectonic settings– divergent, intraplate, convergent, transform and hybrid settings- fore arc, fack arc and retro arc basins. Sedimentary basins of India and its tectonic framework.

Unit VI **(14 hours)**

Basic Statistics- population and sample, collection of data. Types of data – primary and secondary. Methods of collecting primary data. Classification and tabulation. Graphs and diagrams. Graphs – frequency polygon, frequency curve, histogram, ogives; Diagrams – bar diagram. Population characteristics – measures of central tendency, dispersion, skewness and kurtosis.

Unit VII **(8 hours)**

Elementary probability and distribution– classical definition of probability, axiomatic definition of probability, random variables, probability density functions, estimation of parameters. Hypothesis testing, Chi-square, t and F tests. Normal and lognormal distribution. Linear Krigging and Co-krigging.

Unit VIII **(8 hours)**

Correlation and Regression – Pearson's coefficient correlation, Rank correlation, Species association, Diversity indices, Interpolation and approximation. Concept of geostatistics. Statistical analysis and interpretation of geochemical data and drainage morphometric parameters.

REFERENCES

1. Gupta and Kapoor: Fundamentals of Mathematical Statistics. Sultan Chandra and Sons.
2. Freund: Mathematical Statistics. Prentice Hall of India.
3. Davis: Statistics and Data Analysis in Geology (3rd Edn.), John Wiley and Sons.
4. Pal: Statistics for Geoscientists. Concept Publishing Company.
5. Blatt, Middleton, and Murray: Origin of Sedimentary Rocks, Prentice Hall, 1972.
6. Carver (Ed.) Procedures in Sedimentary Petrology, John Wiley, New York 1971.
7. Folk: Petrology of Sedimentary Rocks, Hempill's, Texas, 1968.
8. Krumbein and Pettijohn: Manual of Sedimentary Petrography, Appleton Century Co., 1938.
9. Pettijohn: Sedimentary Rocks, Harper and Row ,1957
10. Pettijohn,Potter and Siever: Sand and Sandstone , Springer Verlag, 1972.
11. Pickering, Hiscott and Hedn: Deep Marine Environments – Clastic Sedimentation and Tectonics, Unwin and Hyman, 1989.
12. Selley: Ancient Sedimentary Environments, Corwell University Press, 1972.
13. Gary Nichols: Sedimentology and Stratigraphy (Second Edn.) ,Wiley Blackwell, 2009
14. Prothero and Schwab: Sedimentary Geology: An Introduction to Sedimentary Rocks and Stratigraphy, Freeman and Company, New York, 1996.
15. Boggs, S. Jr., 2010, Principles of Sedimentology and Stratigraphy, Pearson Education, Inc.

COURSE OUTCOME

This course offers a solid foundation in basic principles and concepts of sedimentology and a thorough understanding in different sedimentary processes, environments of deposition and tectonic settings of sedimentary basins. This course also enriches the ideas of texture and structure of sedimentary rocks by providing analytical tools and statistical methods, to make the students capable in interpreting the sedimentary history.

M. Sc. GEOLOGY
SYLLABUS OF PROGRAMME CORE (THEORY)

SEMESTER	COURSE CODE	CONTACT/ WEEK	CONTACT/ SEMESTER	CREDITS
II	GL010203	5 HOURS	90 HOURS	4

GEOCHEMISTRY AND ISOTOPE GEOLOGY

Unit I **(12 hours)**

Origin and cosmic abundance of elements. Geochemical classification of elements. Geochemical cycles. Chemical evolution of the earth. Primary geochemical differentiation. Classification of meteorites. Geochemical constitution of earth's crust, mantle, core and meteorites. Phase transitions in the mantle.

Unit II **(8 hours)**

Goldschmidt's classification of elements. Nernst's partition coefficient (compatible and incompatible elements), LILE and HFSE. Major, minor and trace elements, REEs and PGEs.

Unit III **(12 hours)**

Application of geochemistry in petrogenesis- Harker variation diagrams, differentiation index, AFM diagram, TAS classification diagram, spider diagrams, REE diagram and tectonic discrimination diagram for granitic and basaltic rocks. Oxidation potential, Eh-pH diagrams and their applications in sedimentation process.

Unit IV **(10 hours)**

Introduction to isotope geology: Isotopes, isobars and isotones, stable and radioactive isotopes. Various decay mechanisms- alpha, beta (positron and negatron), gamma decay, electron capture and branched decay. Radioactive decay, half-life and basic equation for age calculation.

Unit V **(12 hours)**

Study of different radioactive systematics: Rb-Sr - model age and isochron age, mineral and whole rock isochrones, their merits and demerits. Importance of Sr initial concentration in understanding the source characteristics of igneous and metamorphic rocks.

Sm-Nd systematics - isochron ages, isotopic evolution of Nd, CHUR model, epsilon parameter and nature of mantle source, BABI, crustal residence of igneous and metamorphic rocks.

Unit VI **(14 hours)**

U-Th-Pb systematics - model age, ^{207}Pb-^{206}Pb method, U-Pb Concordia-discordia method, U-Pb, Th-Pb isochron methods, Zircon dating- analysis of single zircon and SHRIMP analysis.

K-Ar systematics - modal age and isochron age, the problem of Ar loss. Applications – metamorphic veil. Ar- Ar method.

Fission track method of dating. Cosmogenic radionuclides and their applications- ^{14}C method of dating.

Unit VII **(12 hours)**

Stable isotope studies- Isotope fractionation, Delta notation and its significance, significance of stable isotopes of Carbon, Oxygen and Sulphur in petrology.

Isotope hydrogeology – fractionation, H-O isotopes in water vapor and hydrologic cycle, $\delta^{18}O$ and $\delta^{2}H$, Global meteoric water line, altitude, attitude and latitudinal effects on rain water. Paleoclimatic records of sediments and polar ice from isotopes.

Unit VIII **(10 hours)**

Analytical techniques: Methods based on emission and absorption spectra- Basic concept of Flame photometer, Spectrophotometer, Atomic Absorption Spectrometer (AAS), Inductively coupled plasma - atomic emission and mass spectrometer (ICP-AES & MS), isotope mass spectrometer and x-ray fluorescence (XRF).

REFERENCES

1. Mason, B. and Moore, C.B. (1985) Principles of geochemistry, Wiley Eastern Ltd, Bangalore
2. Faure G. (1986) Principles of isotope geology1, John Wiley & Sons
3. Faure, G., Mensing, T. M., Tsotopes – Principles ans Applications, Wiley India Pvt. Ltd., New Delhi
4. Krauskopf, E.B. (1979) Introduction to geochemistry, McGraw Hill Book Company, New Delhi.
5. Gill, R. (1989) Chemical fundamentals of geology, Unwin Hyman, London
6. Albarede F. (2003) Geochemistry- An introduction, Cambridge university press.
7. Dickin, A.P. Radiogenic isotope geology. Cambridge University Press.

COURSE OUTCOME

Isotope geology offers detailed study of decay schemes of radiogenic and stable isotopes. The isotopic systems will be discussed with special reference to evolution of Earth and Earth processes. Geochemistry includes basic concepts which act as the basement for all advanced branches of geology. This course will make students able to analyze and conclude the geological history of Earth and rock systems through current isotopic and geochemical signatures.

M. Sc. GEOLOGY
SYLLABUS OF PROGRAMME CORE (THEORY)

SEMESTER	COURSE CODE	CONTACT/ WEEK	CONTACT/ SEMESTER	CREDITS
II	GL010204	5 HOURS	90 HOURS	3

CLIMATOLOGY AND MARINE GEOLOGY

Unit I **(12 hours)**

Atmosphere and atmospheric processes - structure and composition of the atmosphere; role of ozone, water vapour and carbon dioxide. Heat budget and radiation balance, factors affecting solar radiation. Milankovitch Cycle, Koppen system of climate classification.

Unit II **(16 hours)**

General concepts of atmospheric circulation and wind patterns - jet streams, formation and types of clouds and precipitation. Storms – tropical cyclones and anti-cyclones. Greenhouse effect and global warming, basics of El Niño and La Nina, Fundamentals of Monsoon systems in India.

Unit III **(16 hours)**

Paleo oceanographic expeditions & development of Marine Geology. Ocean floor drilling programmes – DSDP, ODP & JOIDES. Surface currents - origin, distribution, influencing factors, Coriolis Effect and Ekman Transport. Geostrophic currents.

Unit IV **(10 hours)**

General distribution of temperature, salinity and density in sea water. TS diagrams and water masses, deep ocean circulation and conveyor belt. Concepts of coastal and deep water upwelling and downwelling.

Unit V **(12 hours)**

Marine sedimentation & distribution – terrigenous, biogenous and chemogenous sediments with particular reference to oozes. Turbidity currents and turbidites. Ocean floor morphology, tectonic origin of ocean basins, classification of marine environments

Unit VI **(12 hours)**

Redox environments and diagenesis in marine sediments. Mineral resources of oceans and factors controlling their distribution – polymetallic nodules, phosphatic and hydrothermal sulfide deposits, beach placers. Coastal zone, Mud banks, Coral reefs - types and formation, Eustatic sealevel changes and their impacts, Law of the sea, EEZ and CRZ.

Unit VII **(12 hours)**

Instruments used for offshore geological sampling - grabs, dredgers and corers. Position fixing systems – GPS and DGPS. Ocean floor Survey – Single and Multi-beam echo sounding methods, sidescan sonar, ROVs & AUVs, and scuba diving.

REFERENCES

1. Pinet Paul, R. Oceanography – An Introduction to the Planet Oceanus, West Publishing Co, 1992.
2. King, C.A.M. Beaches and Coasts, Arnold, London, 1972.
3. Krumbein, W.C. and Pettijohn, F.J. Manual of Sedimentary Petrology, Appleton Century Co., 1938.
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5. Pettijohn, F.J., Potter, P.E and Siever, R Sand and sandstone, Springer Verlag, 1972.
6. Pickering, K. T. Hiscott, R.N. and F.J. Hedn. Deep Marine Environments – clastic sedimentation and Tectonics, Unwin and Hyman, 1989.
7. Pond, S. and Pickard, G.L. Introductory Dynamical Oceanography, 2nd Ed., Pergamon Press, 1983.
8. Roy Chester. Marine Geochemistry, Unwin Hyman, 1990.
9. Selley, R.C Ancient Sedimentary Environments, Corwell University Press, 1972.
10. Trask P.D Recent Marine Sediments, Dever Publications .1939.
11. William L. Donn – Meteorology, McGraw –Hill Books Co., New York, 1975
12. Narora B, Atmosphere, Weather and Climate: An introduction to Meteorology, Saunders Co., Philadelphia.
13. M. Grant Gross, Principles of Oceanography.
14. Emerson, E and Hedges, J – Chemical Oceanography and the Marine Carbon Cycle. Cambridge University Press, 2008

COURSE OUTCOME

The course is mainly focused on the aspects of Marine Geology, as it is also deals with the fundamentals of Climatology and Oceanography. The course covers various marine expeditions, marine environments, depositional & erosional processes, origin of oceanic basins and morphologic features, marine mineral resources, offshore geologic sampling & ocean floor survey methods, Eustatic sea level changes and Law of the Sea.

M. Sc. GEOLOGY
SYLLABUS OF PROGRAMME CORE (PRACTICAL)

SEMESTER	COURSE CODE	CONTACT/ WEEK	CONTACT/ SEMESTER	CREDITS
II	GL010205	4 HOURS	72 HOURS	4

PRACTICAL 2

PETROLOGY

IGNEOUS PETROLOGY **(24 hours)**

Megascopic and microscopic study of the following rocks with special stress to genetic significance: granite, syenite, diorite, pegmatite, aplite, lamprophyre, gabbro, dolerite, basalt, dunite, peridotite, pyroxenite, anorthosite and kimberlite.

Petrochemical Calculations: CIPW Norm and related calculations- 15 exercises.

Use of IUGS triangular diagrams for classification of' igneous rocks- 15 Nos.

Problem of application of Lever rule– 10 nos.

METAMORPHIC PETROLOGY **(24 hours)**

Megascopic and microscopic identification of the following rocks with special references to genetic significance of their mineralogy, textures/structures: slate, phyllite, schist, charnockite, khondalite, gneiss, pyroxene granulite, amphibolite, marble, quartzites and leptynite.

Graphical representation of metamorphic mineral paragenesis using ACF and AKF diagrams of the following facies -1 each. Greenschist, Amphibolite, Granulite, Eclogite, Albite-Epidote-Hornfels, hornblende-hornfels, Pyroxene- hornfels and Sanidinite facies. Simple thermobarometric calculations.

SEDIMENTOLOGY **(24 hours)**

Textural analysis of sediments: Sieve analysis, settling analysis, Size analysis. Size measurement and calculation of Shape parameters, plotting and interpretation of such data. Preparation of grain mounts -10 numbers. Study of grain mounts of magnetite, ilmenite, monazite, garnet, sillimanite, quartz, zircon, leucoxene and chromite. Heavy mineral separation. Megascopic and microscopic study of limestone, sandstone, shale, conglomerate, breccia, clay, laterite, grit and arkoses.

M. Sc. GEOLOGY
SYLLABUS OF PROGRAMME CORE (THEORY)

SEMESTER	COURSE CODE	CONTACT/ WEEK	CONTACT/ SEMESTER	CREDITS
III	GL010301	6 HOURS	108 HOURS	4

EXPLORATION GEOLOGY AND GEOPHYSICS

Unit I **(12 Hours)**

Principles of geological prospecting and mineral exploration. Resource and reserve – McKelvey and UNFC classification. Stages of exploration: Reconnaissance & Prospecting - General, Detailed, and Mine Exploration. Criteria for exploration - guides to ores.

Unit II **(12 hours)**

Collection of exploration data and sampling techniques – Pitting, trenching and underground workings. Rock sampling methods – channel sampling, chip sampling, bulk sampling and bore hole sampling. Drilling - Design of drilling programme, types of drilling – coring and non-coring, vertical and inclined drilling. Borehole logging, ore reserve estimation, geostatistical method - concept, and conventional method.

Unit III **(14 Hours)**

Principles of Geochemical exploration, Geochemical cycle, geochemical mobility of element, factors controlling mobility of elements in the surficial and deep seated environments, Indicators and Pathfinders, threshold values and geochemical anomalies, dispersion pattern.

Unit IV **(12 Hours)**

Geochemical survey and sampling – lithological & pedological. Atmospheric and hydrogeochemical surveys, Geobotanical survey techniques, Biogeochemical survey.

Unit V **(14 hours)**

Concept of geophysical exploration. Electrical prospecting, Resistivity survey, concept of resistivity and current flow within ground, Vertical Electrical Sounding (VES) and Constant Separation Traversing (CST). Fundamental types of electrode spreading – Wenner, Schlumberger and Dipole-Dipole configurations, apparent resistivity curves, limitations of resistivity survey. Induced Polarization and Self Potential methods.

Unit VI **(14 hours)**

Concept of magnetic prospecting, Magnetometers, Magnetic anomalies and Magnetic time scale. Magnetotelluric survey. Concept of Gravity survey, principles of gravity measurements, stable and unstable gravimeters. Gravity anomalies - regional and local, factors that affect gravity measurements, gravity corrections.

Unit VII **(18 hours)**

Seismic waves - types, concepts of seismic refraction, reflection and geometry of their spreading, instruments used for seismic survey, geometry and significance of travel time curves. Seismic refraction survey - field survey arrangement, geometry of refracted ray paths, interpretation of refraction surveys, applications and limitations of seismic refraction survey. Seismic reflection survey - single and multi-channel survey, seismic reflection data - seismic trace, shot gather and CMP gather, applications and limitations of seismic reflection survey.

Unit VIII **(12 hours)**

Radiometric methods - basic concepts of radioactivity and radioactive particles, radioactive rocks and minerals, instruments used in detection and measurements of radiation.

REFERENCES

1. Bagchi, T.C. Elements of Prospecting and Exploration, Kalyan Publishers.
2. Crompton, R.R. Mannual of Field Geology, John Wiley.
3. Dobrin, M.B. Introduction to Geophysical Prospecting, Pergamon Press.
4. Davis and Dewiest. Hydrogeology, 1966.
5. Ginzburg, I.I. Principles of geochemical Prospecting, Pergamon Press.
6. Griffths, D.H. and Kind, R.F Applied Geophysics for Geologists and engineers, Pergamon Press.
7. Kearey, P Brooks (1991) An introduction to geophysical exploration, Blackwell.
8. Kovalarkim. Biochemical Hill.
9. Lahee, F.H. Field Geology, McGraw Hill.
10. Low, J.W Geologic Field Methods, Harper and Brothers.
11. Malyuga, D.P. Biochemical Methods of Prospecting, Consultants Bureau, New York.
12. Milson J (1989) Field geophysics, John Wiley & sons
13. Moon, Charles, Michel Whateley and Antony Evans (2005), Introduction to Mineral Exploration, Wiley – Blackwell.
14. Rose, K.W., Hawkes, H.E. and Webb, J.S., Geochemistry in Mineral Exploration, Academic Press.
15. Sinha, R.K. and Sharma, N.L. Mineral economies, Oxford and IBH Publishers.
16. Todd, D.K. Groundwater Hydrology, John Wiley and Sons, 1980.
17. William Lowrie, Fundamentals of Geophysics, Cambridge University Press, 1997.

COURSE OUTCOME

The course is focused on various geological prospecting and mineral exploration methods. It covers stages of exploration, grading of ores, drilling programme designing and ore reserve estimation. Various geochemical survey methods and atmospheric & geobotanical survey techniques are included. The course also deals with various geophysical prospecting methods that can be used to find out the occurrence and extent of ore deposits, including method of application and limitations.

M. Sc. GEOLOGY
SYLLABUS OF PROGRAMME CORE (THEORY)

SEMESTER	COURSE CODE	CONTACT/ WEEK	CONTACT/ SEMESTER	CREDITS
III	GL010302	6 HOURS	108 HOURS	4

ADVANCED ECONOMIC GEOLOGY

Unit I **(14 hours)**

Introduction to Mineral deposits. Morphology of ore bodies. Genetic classification of ore deposits. Physico- chemical environment of ore formation- source, migration and traps in ore formation.

Unit II **(16 hours)**

Magmatic deposits in ultramafic rocks- chromite - podiform and stratiform, diamonds in Kimberlites, PGE deposits; Deposits associated with mafic rocks- Cu-Ni-Fe sulphide deposits; Deposits associated with felsic rocks - REE deposits. Pegmatitic deposits.

Unit III **(16 hours)**

Hydrothermal deposits- types, formation and properties of hydrothermal fluids, conditions favouring hydrothermal deposit formation- P-T-X condition and tectonic environment.
Magmatic hydrothermal deposits- Prophyry, Greisen, Skarn deposits. Seawater hydrothermal deposits- VHMS, Sedex, MVT. Other types- Unconformity-type U, Epithermal Ag-Au, lode Au deposits

Unit IV **(14 hours)**

Sedimentary deposits- Syn sedimentary- QPC type U, phosphatic nodules, nodular Fe-Mn. BIF. Deposits formed by mechanical concentration- Placer deposits and types. Deposits formed by residual concentration- Bauxite and laterite; Infiltration- sandstone-type U; Supergene enrichment- Gossan.

Unit V **(12 hours)**

Metamorphic deposits- Graphite and Aluminium refractory minerals. Metamorphosed deposits- Gondite. Non-metallic deposits – Asbestos, Talc, Clay and Tourmaline,

Unit VI **(12 hours)**

Introduction to Geothermometric studies using indicator mineral, trace element and stable isotope of ore. Fluid inclusion studies in relation to ore genesis. Application of Laser Raman techniques in fluid inclusion studies.

Unit VII **(14 hours)**

Global metallogenic epochs and provinces with special references to Witwatersrand and Bushweld. Major metallogenic episodes in India. Mineralisation at plate boundaries.

Unit VII **(10 hours)**

Texture of ores and ore paragenesis. Ore microscope- parts and principles, use of reflected light in ore microscopy. Optical properties of following ore minerals; galena, pyrrhotite, pyrite, chalcopyrite, sphalerite, hematite, magnetite, psilomelane, bauxite.

REFERENCES

1. Evans, A. M., 1980, An introduction to Ore Geology, Blackwell Scientific Publication.
2. Asoke Mukherjee, 1970, Metamorphic and Metamorphosed Sulphide Deposits, Econ. Geol., Vol. 656, No. 70.
3. Asoke Mukherjee, 1988, Ore Genesis – A Holistic Approach, Prentice Hall, Calcutta.
4. Jensen M. L. and Bateman, A. M., 1962, Economic Mineral Deposits, Wiley.
5. Kraukoff K. B., Introduction to Geochemistry, Mc Grew Hill.
6. Kula C Misra, Understanding mineral deposits, Kluver Academic Publishers.
7. Robb, L., 2005, Introduction to Ore forming process, Blackwell Science Ltd, UK.
8. Brian Mason, 1966, Principles of Geochemistry, Wiley.
9. Brown, J. C. and Dey, A. K., 1936, India's Mineral Wealth, Oxford.
10. Cameron, E. N., 1961, Ore Microscopy, Wiley.
11. Edwards, A. B., 1960, Textures of the Ore Minerals, Aust. Inst. of Minerals and Metals.
12. Gaudin, A. M, 1938, Principles of Mineral Dressing, Mc Graw Hill.
13. Stanton R. L., Ore Petrology, Mc Grew & Hill
14. Park, C. G. and Mac Diarmid, R. A., 1964, Ore deposits, Freeman.
15. Roger Taylor, 2009, Ore textures, Recognition and Interpretation, Springer Dordrecht Heidelberg, London.
16. Prasad, U., 1996, Economic Mineral Deposits, CBS Publishers.
17. Wadia D. N., 1994, Minerals of India, National Book Trust, India, 5th edition.

COURSE OUTCOME

This is the subject which connects geology directly to industry. This course offers a detailed study of origin of economic minerals deposits, its identification, properties, and distribution in India. The student will be familiar with how, where, and when Earth's most important ore deposits have formed, and basic concepts of mineral deposit modeling. This course also aims at providing a comprehensive knowledge in reflective light optics and ore textures.

M. Sc. GEOLOGY
SYLLABUS OF PROGRAMME CORE (THEORY)

SEMESTER	COURSE CODE	CONTACT/ WEEK	CONTACT/ SEMESTER	CREDITS
III	GL010303	4 HOURS	72 HOURS	4

MINING AND ENGINEERING GEOLOGY

Unit I **(10 hours)**

Mining terminologies: Methods of mining – Open cast-Manual and Mechanised, Glory hole, Underground – Gophering, Breast stoping, Open Underhand stoping, Open Overhand stoping, Pillar and Chamber and Alluvial mining - Sluicing, Hydraulicking, Drift mining, Dredging, Derrick and Cableway. Shaft sinking – Mine support and ventilation.

Unit II **(8 hours)**

Coal mining methods: Surface Mining Methods – Strip mining, Open-pit mining, Auger mining, Mountaintop removal mining. Underground Mining Methods– Room-and-pillar mining, Longwall mining, Retreat mining, Blast mining and Horizon mining.
Sea Bed mining – Marine mining equipments and methods – General ideas.

Unit III **(10 hours)**

Principles of mineral dressing. Types and uses of Crushers, Grinding mills, Screens and Classifiers. Physical methods of separation by grain size, gravity and magnetism. Chemical methods – reagents and their functions. Floatation. Flowsheets and its importance.

Unit IV **(8 hours)**

Plans to be prepared and maintained in a mine – EMP, Mining plan, Mine closure plan, Surface plan etc. Mining legislation in India – National Mineral Policy.Mining hazards. Mining and environment.

Unit V **(8 hours)**

Role of Geology in Civil engineering. Engineering properties of rocks. Rock as construction and foundation material, road aggregate. Rock mass classification – general ideas of RMR, RQD and SMR. Soils – Geological and Engineering classification.

Unit V I **(10 hours)**

Geological considerations in the following engineering projects: Dams, reservoirs and tunnels, bridges and highway roads.

Unit VII **(10 hours)**

Reservoir sedimentation: Causes and effects, desilting methods. Coastal erosion – Near shore dynamics, erosion mechanisms and long shore drift. Measures for controlling coastal erosion – sea walls, groins and harbours.

Unit VIII **(8 hours)**

Seismicity in stable continental regions of India and Seismic Zonation maps, Earthquake resistant structures.

REFERENCES

1. Arogyaswamy, R.N.P. Courses in mining geology, Oxford and IBH pub. Co.
2. Howard L Hartman,Jan M.Mutmansky,Introductory Mining Engineering, John Wiley and Sons Inc 2002.
3. Barry A. Wills, Tim Napier-Munn.Mineral Processing Technology, An Introduction to the Practical Aspects of Ore Treatment and Mineral Recovery,Elsevier Science & Technology Books
4. R.M Umathy, Text book of Mining geology, Dattsons 2002.
5. Gaudin, A.M. Principles of Mineral Dressing, McGraw Hill, 1938.
6. Taggart, A.P. Handbook of Mineral Dressing, Willey.
7. Kenneth J.P. Marine Geology, Prentice Hall Inc. 1982.
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9. Krynine, D.P. and Judd, W.R. Principles of Engineering geology and Geotechnics, CBS Publishers and Distributors, New Delhi, 2001.
10. Petters, W.C. Exploration and Mining Geology. John Wiley.
11. Reedman, JH Techniques in Mineral Exploration, Allied Scientific Publishers.
12. Robert B. Johnson and Jerome V. Degraff Principles of Engineering Geology, John Willey and Sons 1976.
13. Chenna Kesavulu, Text book of Engineering Geology, Macmillan India Ltd,Madras, 1993.
14. Donald P. Coduto, Geotechincal engineering principles and practices, Prentice Hallof India, Pvt. Ltd, New Delhi, 2001.

COURSE OUTCOME

Mining Geology provides a proper understanding on various mining terminologies and different methods practiced in alluvial, opencast and underground mining according the type of deposits. These studies also provide basic information on mineral dressing, mining plans and mineral policies. Engineering Geology offers the basic concepts and its application in engineering practices. This course intends to make the students able to identify the suitable sites for different engineering constructions, identify potential geological hazards and manage various structures to prevent and control them.

M. Sc. GEOLOGY
SYLLABUS OF PROGRAMME CORE (THEORY)

SEMESTER	COURSE CODE	CONTACT/ WEEK	CONTACT/ SEMESTER	CREDITS
III	GL010304	5 HOURS	90 HOURS	3

HYDROGEOLOGY

Unit I **(10 hours)**

Hydrology and hydrogeology – Hydrological cycle- precipitation, evaporation, runoff. Geologic formations as aquifers. Geologic structures favoring groundwater occurrence and movement. Vertical distribution of groundwater. Groundwater reservoirs – aquifer, aquiclude, aquifuge and aquitard. Types of aquifers– unconfined, confined, leaky and bounded aquifers – artesian aquifers; springs and their types.

Unit II **(10 hours)**

Aquifer properties: Porosity, Permeability, Void Ratio, Specific Yield and Specific Retention – Aquifer parameters– Hydraulic conductivity, Transmissivity and Storativity. Hydraulic Conductivity determination – Lab tests – Permeameter methods and Field tests – Auger Hole test, Tracer test and Pump test. Aquifer properties in relation to rock types and rock structures.

Unit III **(10 hours)**

Groundwater exploration- Remote sensing and GIS applications- brief idea. Surface investigations of groundwater- Geophysical methods: electrical resistivity- Wenner and Schlumberger methods. Brief description of seismic refraction, gravity and magnetic methods. Subsurface investigations- test drilling, resistivity logging, SP logging, radiation logging- brief description.

Unit IV **(12 hours)**

Groundwater movement – Water table and Piezometric level (surface) – Theory of groundwater flow – Darcy's law and its experimental verification – differential equation governing groundwater flow. Hydrogeologic boundaries, flow nets, hydraulic conductivity and its determination in lab and field. Groundwater level fluctuations, global climatic change in relation to groundwater.

Unit V **(12 hours)**

Well hydraulics: Aquifer tests, Organization and conduct of pumping tests, Pumping test data analysis and Recovery test, Drawdown and cone of depression– Steady radial flow to a well in confined and unconfined aquifers – Thiem's equation and Dupuit-Forchheimer equation. Unsteady radial flow into wells in confined and unconfined aquifers – Theis equation – Theis, Chow and Cooper-Jacob methods – Isotropic non-leaky artesian aquifer.

Unit VI **(12 hours)**

Well design criteria. Water wells– types of wells. Methods for drilling deep wells – Cable Tool method, Rotary method, Air Rotary method, Rotary Percussion method, Reverse Circulation Rotary method, DTH method– Construction, design, development and maintenance of wells. Well production, specific capacity of pumps and specification of pumps.

Unit VII **(12 hours)**

Quality of groundwater: Chemical characteristics of groundwater – Graphical representation of water quality data:– Interpretation of hydrochemical analysis data: Hill-Piper Trilinear diagram, Durov's diagram and U. S. Salinity diagram – Sodium Adsorption Ratio (SAR) – Water quality standard: Domestic Water Criteria, Irrigation Water Criteria and Industrial Water Criteria– a brief idea.

Unit VIII **(12 hours)**

Saline water intrusion in coastal and other aquifers and its prevention. Ghyben-Herzberg relationship– methods and need for artificial recharge to aquifers. Groundwater management: consumptive use, conjunctive use. Groundwater development– safe yield and optimal mining policy. Groundwater provinces of India. Groundwater conditions in Kerala.

REFERENCES

1. Bouwer, H. Groundwater Hydrology, 1978.
2. Davis, S.N. and Dewiest, R.J.N. Hydrogeology, John Wiley and Sons Inc. New York, 1966.
3. Hiscock K (2005) Hydrogeology, Principle & Practice, Blackwell publishing.
4. Krisch R (2006) Groundwater geophysics, Springer - Verlag
5. Linsley, R. K., Kohler, M. A. and Taulhus, J. L. H. Applied Hydrology, Tata Mc Graw Hill, 1975.
6. Todd, D. K. Groundwater Hydrology, John Wiley and Sons, 1980.
7. Walton, W. C. Groundwater Resource Evaluation, Mc Graw Hill Inc., 1970.
8. Reghunath, H.M. Groundwater. 2nd Edn. Wiley Eastern Limited. 1992.
9. Sharma H.S. Well Hydraulics and Tube Wells.

COURSE OUTCOME

The course offers proper understanding on various aspects of surface water and groundwater, and covers various aquifer and water quality analyses. The course also deals with well hydraulics, investigation & exploration methods of groundwater, and the causes & remedies for saline water intrusion. The course has significant role in the planning and implementation of projects related to hydrogeology.

M. Sc. GEOLOGY
SYLLABUS OF PROGRAMME CORE (PRACTICAL)

SEMESTER	COURSE CODE	CONTACT/ WEEK	CONTACT/ SEMESTER	CREDITS
III	GL010305	4 HOURS	72 HOURS	4

PRACTICAL 3

EXPLORATION GEOLOGY, ECONOMIC GEOLOGY AND HYDROGEOLOGY

EXPLORATION GEOLOGY **(20 Hours)**

Ore reserve estimation –grade and tonnage calculation, geological section preparation. Interpretation of borehole data. Geological section preparation.

ECONOMIC GEOLOGY **(22 Hours)**

Megascopic identification of ore minerals. Characterization, paragenesis. Occurrence and uses of important economic mineral deposits in India.
Identification of ore minerals under ore microscope - 5 Nos.

HYDROGEOLOGY **(30 Hours)**

Solution of problems based on Darcy's Law. Preparation and interpretation of water table contour maps. Computation of aquifer parameters from pumping data Graphical representation of hydrochemical data:-Piper Trilinear diagram. Vector diagram. Circular diagrams, Stiff's polygon. Determination of pH and TDS of ground water samples - 10 nos. Determination of Ca, Na and K using Flame photometer

M. Sc. GEOLOGY
SYLLABUS OF PROGRAMME ELECTIVE GROUP 1 (THEORY)

SEMESTER	COURSE CODE	CONTACT/ WEEK	CONTACT/ SEMESTER	CREDITS
IV	GL800401	6 (7)** HOURS	126 HOURS	4

FUEL GEOLOGY AND MICROPALAEONTOLOGY

Unit I **(16 hours)**

Coal Geology – Origin of Coal, Coalification process, insitu and transported theory of coal formation. Microscopic and Megascopic constituents of Coal. Macerals and its types. Microlithotype and Lithotype. Impurities in Coal.

Unit II **(18 hours)**

Different varieties of Coal. Humic and sapropelic coal. Concept of coal maturity and ranks of coal. Thermal maturity indicator – Vitrinite reflectance. Classification of coal - Peat, lignite, bituminous and anthracite coal. Analysis for the assessment of coal quality - Proximate and ultimate analysis.

Spatial and temporal distribution of coal in India – Gondwana and Tertiary coal.

Unit III **(14 hours)**

Petroleum geology: Introduction – Chemical and physical properties of petroleum. Origin of petroleum- Organic and Inorganic concepts. Kerogen and its types. Migration, accumulation and entrapment of petroleum.

Unit IV **(20 hours)**

Source and Reservoir rocks. Characteristics of reservoirs. Types of reservoir traps – Classification of traps- Structural, Diapiric, Stratigraphic, Hydromorohic traps and Combination traps. Geological age of reservoir rocks.

Reservoir mechanics – Methods of petroleum exploration – surface, sub surface and geophysical methods. Petroliferous basins with special reference to India.

Unit V **(18 hours)**

Mud logging and well logging. Profile of a petroleum drilling well. Duties of a petroleum geologist. Shale factor and Shale density analysis. Master log. Reservoir engineering – Analysis of Resistivity, Gamma, SP, Neutron and Density log.

Non conventional Petroleum resources – Introduction to Coal Bed Methane (CBM), Shale gas, Gas hydrates, Tar sands, Oil shales. Plastic and solid hydrocarbons.

Unit VI **(12 hours)**

Radioactive mineral deposits. Geological characteristics and genesis of major types of Uranium and Thorium deposits and their distribution in India. Black sand deposits of Kerala and Tamil Nadu.

Unit VII **(14 hours)**

Micropaleontology- scope and classification of Microfossils. Application of microfossils in petroleum exploration and paleoenvironment reconstruction. Collection and preparation of Microfossils

Unit VIII **(14 hours)**

Classification, morphology, ecology and stratigraphic importance of foraminifera, radiolaria, diatoms, ostracoda. Introduction to Palynology- applications in petroleum exploration.

REFERENCES

1. John M Hunt Petroleum Geochemistry and Geology, W H Freeman and Company, 1996.
2. Leverson, A.I, Geology of Petroleum, 2nd Edn, CBS Publishers and distributors, New Delhi.
3. North, F.K., Petroleum geology, Unwin Hyman Inc, USA, 1990.
4. Chapman R.E, Petroleum Geology, Elseiver Science Publishing company Inc. Newyork, 1983
5. Jon Gluyas & Richard Swarbrick, Petroleum Geoscience, Blackwell Science publishing Ltd UK 2004.
6. Knut Bjorlykke, Petroleum Geoscience- From Sedimentary to Rock Physics, Springer Heidelberg Dordrecht, London, New York 2010.
7. Stach, E., (eds.), 1975, Stach's Textbook of Coal Petrology, Gebruder Borntraeger, Berlin
8. Thomas, L., 2012, Coal Geology, Wiley India Pvt Ltd, Delhi.
9. Brasier, M.D. Microfossils, George Allen & Unwin, 1980.
10. Bignot, G. Elements of micropaleontology, IHRDC-Boston, 1985.
11. Cushman, A. Joseph. Foraminifera, Harward University Press, 1959.
12. Howard A. Amstrong, Martin D.Brasier, Microfossils, Second edition, Blackwell Publishing, USA 2005.
13. Haq, B.U. & Boersma, A. Introduction to Marine micropalaeontology, Elsevier, 1998.

COURSE OUTCOME

The course offers detailed study about natural fuels like coal and petroleum, their formation and distribution especially in Indian sedimentary basins. This course also intended to make the students aware about unconventional energy resources like shale gas, CBM and gas hydrates. It will also discuss different exploration and extraction techniques used in petroleum industry. A part of this course includes detailed study of microfossils such as foraminifera, radiolarian, diatoms and ostracods. Aim of this course is to make students familiar with the processes, terms and works happening in petroleum industry.

M. Sc. GEOLOGY
SYLLABUS OF PROGRAMME ELECTIVE GROUP 1 (THEORY)

SEMESTER	COURSE CODE	CONTACT/ WEEK	CONTACT/ SEMESTER	CREDITS
IV	GL800402	5 (7)** HOURS	126 HOURS	3

ADVANCED PALEONTOLOGY

Unit I **(20 hours)**

Applications of paleontology, Phylogenic tree, Trends and mechanism of evolution, Origin of life, Theories of organic evolution. Application of stable isotope studies of oxygen, carbon and sulphur in paleontology.

Unit II **(16 hours)**

Stromatolites – types, classification and stratigraphic importance. Evolutional history of Ammonites, Trilobites and Graptolites. Major mass extinction events in earth's history.

Unit III **(14 hours)**

Early fishes – morphology, jawless, armored & lung fishes. Evolution, classification and chronological distribution of Pisces. Amphibians – early & modern forms.

Unit IV **(30 hours)**

Primitive reptiles, Mesozoic reptiles - dinosaurs, aquatic & marine reptiles, flying reptiles. Mesozoic birds – Anchiornis, Archaeopteryx, Confuciusornis, Hesperornis & Ichthyornis. Cenozoic & modern birds – Paleognaths & Neognaths

Unit V **(32 hours)**

Mammals, Family Elephantidae – Stegotetrabelodon, Mammuthus, Loxodonta & Elephas. Evolution of horses from Hyracotherium to Equus. Human evolution from apes to Homo Sapience, Siwalik vertebrates.

Unit VI **(14 hours)**

Palynology - Spores & Pollens - morphology, classification, and applications. Preparation of palynofossils.

REFERENCES

1. Benton, M. J., Vertebrate Palaeontology, Chapman & Hall, London, 1990.
2. Anis Kumar Ray, Fossil in Earth science, Prentice Hall of India pvt. Ltd, 2008.
3. Colbert, H. Edwin. Evolution of the Vertebrates, John Wiley and Sons, 1961.
4. Stanley, S.M., Earth and life through time, W.H. Freeman and company, 1986.
5. Valdiya, K.S. Geodynamic evolution of India, MacMillon, 2008.
6. Tiwari, S.K., Atext book of stratigraphy, micropalaeontology and palaeobotany, Kalyani publishers, New Delhi, 2004.
7. Berry, E.W. An introduction to Palaeontology, Sonali publications, 2004.
8. Nield, E W and Tucker, V C T, Paleontology –An Introduction, Pergamon Press.
9. Michael J Benton and David A. T Harper, Paleobiology and the fossil record, Wiley – Blackwell (2009)
10. Michael J Benton, Vertebrate paleontology, Blackwell science (2008)
11. Jones J. Daniel. Introduction to Microfossils, Harper and Brothers, 1956.
12. Romer, A.S. Vertebrate Palaeontology, Chicago University Press, 1966.

COURSE OUTCOME

The course intends systematic study of Paleontology since the origin of life. It is mainly focused on concepts and theories of evolution and vertebrate paleontology. It deals with the early life forms and evolutional history of Trilobites, Graptolites and Ammonites. The vertebrate evolution includes the evolution of Pisces, Amphibians, Reptiles, Birds, Elephants and Homo Sapience. The course also covers stable isotope studies in Palaeontology, important forms of Siwalik Vertebrates and Palynology.

M. Sc. GEOLOGY
SYLLABUS OF PROGRAMME ELECTIVE GROUP 1 (THEORY)

SEMESTER	COURSE CODE	CONTACT/ WEEK	CONTACT/ SEMESTER	CREDITS
IV	GL800403	5 (7)** HOURS	126 HOURS	4

ENVIRONMENTAL GEOLOGY AND DISASTER MANAGEMENT

Unit I **(12 hours)**

The geosphere as a natural environment of the Earth – evolution of biosphere as a consequence of interaction of primary geospheres, viz., atmosphere, hydrosphere and lithosphere. Concepts of global warming and its impacts.

Unit II **(18 hours)**

Water pollution– sources- natural and anthropogenic, problems due to disposal of wastes, dumps, sewage and agricultural drainage. Solutions to water pollution. Soil pollution: soil quality parameters, industrial waste effluents and their interaction with soil. Soil erosion and conservation.

Unit III **(16 hours)**

Controls of groundwater pollution– natural, induced– source, control, surface barriers, runoff controls– hydrodynamic controls, collection and treatment, detoxification and biodegradation, health hazards due to groundwater pollution. Marine pollution– causative factors– land based sources, marine based sources. Types of pollution – oil spills – effects on ecosystems.

Unit IV **(14 hours)**

Coastal environments: Distribution, variation and interaction of physicochemical and geological parameters on near shore and fore shore ecosystems. Impacts of coastal erosion. Wetlands – environmental significance, Ramsar sites of Kerala, Mangroves.

Unit V **(18 hours)**

Environmental impact analysis – basic concepts and models. Environmental problems of mining activities. Environmental impacts of river sand mining and hydroelectric projects. Biogeochemical factors in environmental health. Human use, trace elements and health.

Unit VI **(14 hours)**

Introduction to key concepts, terminologies and their complexities (Hazard, vulnerability, Exposure, Risk, Crisis, emergencies, Vulnerability, Disasters, Resilience). Types and classifications of disasters. Comprehensive disaster management plan. The Disaster Management Cycle: Mitigation, preparedness, Response and Recovery phases. Relevance of disaster management plan in Kerala. Land use planning.

Unit VII **(20 hours)**

Risk management for natural hazards: Earthquake-risk and impact- prediction and preparedness, post earthquake recovery. Tsunami- Indicator of tsunamis- propagation in deep and shallow water- prediction of tsunamis. Community based mitigation.

Landslide risk- Causes, Effects, Preparedness and Mitigation measures with special reference to Kerala, Landslide zonation mapping.

Flood risk- Types of flood, major causes, flood risk analysis and management.

Cyclone risk- framework for preparedness and mitigation- risk mapping, early warning and communication.

Draught risk- Drought and development-drought monitoring- issues in drought management- use of information technology in drought monitoring

Unit VIII **(14 hours)**

Disaster management Act, 2005– Institutional arrangements for Disaster Management, Role of the Union and the States in Disaster Management, Role of Local self- Government. National Disaster Management Policy. Kerala State Disaster Management Policy.

REFERENCES

1. Arthur N. Strahler and Alan H Strahler Environmental Science, Wiley, 1973.
2. Donald R. Coates (Ed). Environmental Geomorphology and Environmental Geoscience, Wiley International, 1973.
3. Estes, J.E. and Senger, L.W., Remote Sensing – Techniques for Environmental Analysis, Hamilton Publishing Co., 1974.
4. Peter, T. Flawn. Environmental Geology, John Wiley and Sons, 1970.
5. Simmons, I. G., The Ecology of Natural Resources, Edward Arnold Ltd. 1981.
6. Abbott P L Natural Disasters 8thEdn McGraw-Hill New York 2009
7. Donald Hyndman, David Hyndman Natural Hazards and Disasters 3rdEdn Brooks Cole 2011
8. National Disaster Management Guidelines—Management of Disasters, 2008. A publication of National Disaster Management Authority, Government of India., July 2008, New Delhi.
9. www.ndma.gov.in
10. www.sdma.ker.in

COURSE OUTCOME

The course offers an understanding on the fundamental concept of environmental geology. This course is intended to create awareness on environmental laws and environmental protection acts. This course will also provide awareness about the disaster management system.

M. Sc. GEOLOGY
SYLLABUS OF PROGRAMME ELECTIVE GROUP 1 (PRACTICAL)

SEMESTER	COURSE CODE	CONTACT/ WEEK	CONTACT/ SEMESTER	CREDITS
IV	GL800404	4 HOURS	72 HOURS	3

PRACTICAL 4
ELECTIVE PRACTICAL

FUEL GEOLOGY & MICROPALAEONTOLOGY **(72 hours)**

Coal analysis- Proximate analysis. Analysis and interpretation of log data.
Identification of micro fossils- Foraminifera

M. Sc. GEOLOGY
SYLLABUS OF PROGRAMME ELECTIVE GROUP 2 (THEORY)

SEMESTER	COURSE CODE	CONTACT/ WEEK	CONTACT/ SEMESTER	CREDITS
IV	GL810401	6 (7)** HOURS	126 HOURS	4

GEMMOLOGY

Unit I **(12 hours)**

Gems – introduction, natural gems, mineral gems, organic gems. Gem rarity, durability and prices. Classification – precious and semi-precious, faceted and carbochon, natural and synthetic, enhanced and unenhanced, simulant and fake.

Unit II **(12 hours)**

Geological sources of gems, Processes of gem formation – solution, precipitation, petrifaction, hydrothermal processes, crystallization, condensation. Gem Deposits – primary, secondary – alluvial and eluvial.

Unit III **(14 hours)**

Chemical composition of gemstones. Nature of gem crystals- crystallography, form, habit and twinning. Physical properties – hardness, specific gravity and cleavage.

Unit IV **(20 hours)**

Optical properties – colour, transparency, light reflection, double refraction, total internal reflection, dispersion, polarization, absorption, luster, sheen, play of colours, opalescence, adularescence, iridescence, chatoyancy, asterism. Isotropism and anisotropism in gemstones. Pleochroism, interference.

Unit V **(20 hours)**

Fashioning of gemstones - cutting styles, critical angle, composite stones, gemstone polishing, lapidary techniques and gemstone carving. Diamonds: Diamond cutting and polishing methods, diamond grading including cut, colour, clarity and carat weight. Gemstone simulants: Glass, plastics, diamond simulants, assembled or composite stones.

Unit VI **(16 hours)**

Differentiating natural gemstones from its synthetics and simulants. Different Types of synthetics & its identification

Unit VII **(14 hours)**

Gemstone synthesis and treatments - methods of staining, heat treatment, diffusion treatment, fracture filling, cavity filling, coatings, dyeing, laser drilling, atomic irradiation and their detection. Synthesis of gemstones: Diamond synthesis, thin diamond films, chemical vapour deposition (CVD). Methods of manufacture: flame-fusion (Vernueil), flux-melt, hydrothermal, Crystal-pulling (Czochralski), skull-crucible method, zone melting.

Unit VIII **(18 hours)**

Description of following gem stones:
Beryl: emerald, aquamarine, heliodor, morganite, goshenite;
Calcite; Coral; Diamond; Epidote; Smithsonite; Sphene;
Chrysoberyl: alexandrite, cat's eye;
Corundum: ruby, sapphire, star ruby/sapphire;
Feldspar Group: moonstone, albite, amazomte, orthoclase, plagioclase, labradorite, sunstone;
Garnet Group: almandme, pyrope, grossular, andradite, spessartite, uvarovite;
Tourmaline: achroite, rubellite, indicolite;
Chalcedony Group: chalcedony carnelian, chrysoprase, moss agate, onyx, sardonyx; jasper; bloodstone;
Opal: fire opal, white opal; black opal, water opal;
Pearl: natural marine, freshwater;
Quartz: rock crystal, amethyst, citrine, smoky quartz, rose quartz, aventurine, quartz cat's eye, tiger's eye, rutilated quartz.

REFERENCES

1. Read, P. G., 2005, Gemmology, Robert Hale Pub., ed. 3.
2. Webster, R., 1976, Practical Gemmology, Robert Hale Pub., ed. 3.
3. Anderson, B. W., 1990, Gem Testing, Butterworths Pub., ed. 10.
4. Schumann, W., 2009, Gemstones of the world, Sterling.
5. O'Donoghue, M., and Joyner, L., 2003, Identification of gemstones (2003) Robert Hale Pub.
6. Liddicoat, R. T., 1993, Handbook of gem identification, Gemological institute of America.
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8. Robbins, M., 1994, Fluorescence: Gems and Minerals under Ultraviolet Light, Geoscience Pr.
9. Arem, J. E., 1977, Color Encyclopedia of Gemstones, Van Nostrand Reinhold.
10. Newman, R., 2003, Gemstone Buying Guide- How to evaluate, identify, select and care for colored gems, International Jewelry Pubs.
11. Korbel, P and Novak, M, 20012, The complete encyclopedia of minerals, Chartwell Books.

COURSE OUTCOME

The course is focused on a comprehensive learning in gemmology from formation, classification to final grading and evaluation. Basic gemmological techniques will be learned in order to identify gemstones and simulants.

M. Sc. GEOLOGY
SYLLABUS OF PROGRAMME ELECTIVE GROUP 2 (THEORY)

SEMESTER	COURSE CODE	CONTACT/ WEEK	CONTACT/ SEMESTER	CREDITS
IV	GL810402	5 (7)** HOURS	126 HOURS	3

PLANETARY GEOLOGY

Unit I **(16 hours)**

Earth in space - Universe, Big Bang theory, Milky Way, solar system, sun. Astronomical units. Inner planets, Outer planets, planetoids, moons.

Unit II **(14 hours)**

Origin of planets - Nebular hypothesis, Planetesimal hypothesis, double star hypothesis, condensation hypothesis, Urey's hypothesis. Origin of Earth's atmosphere.

Unit III **(16 hours)**

Portraits of planets - Earth's moon, general features, surface aspects. Origin of lunar surface. Geology of surface cover, sediment, volcanic flows, lunar craters. Structure of moon - crust and interior. Absence of atmosphere, origin and evolution of moon.

Unit IV **(18 hours)**

Terrestrial planets - Mercury, Venus, and Mars - physical attributes. General survey of atmosphere, atmospheric temperature, planetary surfaces and their morphology. Structure of planet-lithological make up of crust and interior and origin of the crust.

UNIT V **(16 hours)**

Outer planets - Jupiter, Uranus, Saturn, and Neptune- physical attributes. General survey of atmosphere, atmospheric temperature, planetary surfaces and their morphology. Structure of planet-lithological make up of crust and interior and origin of the crust.

UNIT VI **(16 hours)**

Other planetary objects- meteors, meteorites- classification of meteorites, asteroids, comets, origin, evidence of giant impacts spinifex texture, tektites, petrology of meteorites.

UNIT VII **(12 hours)**

Closer look on Saturn, observation methods, Saturn's rings, Saturn’s moons, Kuiper Belt.

UNIT VIII **(18 hours)**

Planetary exploration - Indian initiatives. Space crafts- Gemini series, Apollo missions, lunar rovers, first lunar landing. International Space station, Seismic method of exploration, Remote Sensing of physical and chemical attributes of planets.

REFERENCES

1. Cook, AH, 1973, Physics of Earth and planets. London: Macmillian
2. Kaula, WM, 1996, Theory of satellite geodesy. Blaisedell
3. Beatty, J., Petersen C. and Chaikin, A., 1999, The New Solar System, Cambridge University Press, Cambridge, England.
4. Lodders K. and Fegley, B., 1998, The Planetary Scientist's Companion, Oxford University Press, New York, 1998
5. Morrison, D., 1993, Exploring Planetary Worlds, Scientific American Library, New York.
6. Ahrens, T. (ed.), 1995, Global Earth Physics - A Handbook of Physical Constants, American Geophysical Union, Washington, D.C.
7. Pamela Clark, 2007, Dynamic Planet: Mercury in the Context of its Environment, Springer, New York.
8. Cattermole, P., 1994, Venus, The Geological Story, Johns Hopkins University Press, Baltimore.
9. Wilhelms, D., 1993, To a Rocky Moon - A Geologist's History of Lunar Exploration, University of Arizona Press, Tucson.
10. Cattermole, P., 1993, Mars - The Story of the Red Planet, Chapman and Hall, London.
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12. Rogers, J., 1995, The Giant Planet Jupiter, Cambridge University Press, Cambridge, England.
13. Hunt G., and Moore, P., 1982, Saturn, Rand McNally, New York.
14. Miner, E., 1998, Uranus - The Planet, Rings, and Satellites, Wiley, New York.
15. Miner, E. and Wessen, R., 2002, Neptune - The Planet, Rings, and Satellites, Praxis, Chichester, England.
16. White, A., 1980, The Planet Pluto, Pergamon, New York.
17. Davies, J., 2001, Beyond Pluto - Exploring the Outer Limits of the Solar System, Cambridge University Press, Cambridge, England.
18. www.pdsa.jpl.nasa.gov//planets

COURSE OUTCOME

The course provides students an opportunity to apply a wide range of subject matter pertaining to the Earth to the study of other planets of the solar system and their principal satellites. Students will benefit from such a course because it will expand their intellectual horizons and will prepare them to contribute to the on-going exploration of the solar system.

M. Sc. GEOLOGY
SYLLABUS OF PROGRAMME ELECTIVE GROUP 2 (THEORY)

SEMESTER	COURSE CODE	CONTACT/ WEEK	CONTACT/ SEMESTER	CREDITS
IV	GL810403	5 (7)** HOURS	126 HOURS	4

ANALYTICAL GEOCHEMISTRY

Unit I **(18 hours)**

Sampling- Different techniques in soil, rock and water sampling. National Geochemical sampling and mapping program of GSI. Geological controls on geochemical data.
Sample Preparation methods- Cleaning, drying, crushing, grinding, and powdering- mortar and pestle, pulveriser - planetary mill, Wilfley table, isodynamic separator, Isomagnetic separator. Sample solution preparation of rocks/sediments/soils/minerals – Open digestion, High Pressure-temperature digestion- Microwave digestion. Applications of Platinum crucible and Tefflon crucible. Preparation of thin section slides for microprobe and EDX analysis. Epoxy mounting and polishing.

Unit II **(14 hours)**

Wet chemical methods- Gravimetry, volumetric methods, calorimetric method UV-Spectrophotometer. Hydrochemistry– EC, TDS, pH, bicarbonates, cation analysis. Multi-elemental analysis for water quality studies – coliform analysis.

Unit III **(20 hours)**

Analytical methods on emission techniques- Flame Photometer, X-ray fluorescence (XRF), Inductively Coupled Plasma Atomic Emission Spectrometer (ICP-AES), Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES), Instrument Neutron Activation Analysis (INAA).

Unit IV **(20 hours)**

Analytical methods on absorption techniques- Atomic Absorption Spectrometer (AAS), Inductively Coupled Plasma Mass Spectrometer (ICP-MS), Laser Ablation ICP-MS, Multicollector and Magnetic Sector ICP-MS, Thermal Ionization Mass Spectrometer (TIMS), Secondary Ion Mass Spectrometry (SIMS), Sensitive high-resolution ion microprobe (SHRIMP), Isotope Ratio Mass Spectrometer (IRMS), Electron Probe Micro Analyzer (EPMA).

Unit V **(20 hours)**

Analytical methods on electron microscopic techniques- Scanning Electron Microscope (SEM-EDX), Transmission Electron Microscope (TEM)- HR-TEM, Atomic Force Microscope.

Unit VI **(18 hours)**

Application of geochemical data: major, minor, trace elements. Trace element geochemistry- Rare Earth Elements (REE), Platinum Group of Elements (PGE) and Transition metals. Compatible and incompatible elements, High Field Strength Elements (HFSE) and Large Ion Lithophile Elements (LILE). REE- HREE and LREE, Eu anomaly. REE chemistry, normalization, REE patterns for igneous rocks, sediments, sea water and river water. PGE-Chemistry, chondrite and primitive mantle normalization, interpreting PGE patterns. Spider diagram-normalization using chondrite, MORB, Primitive mantle, interpretation of spider diagrams.

Unit VII **(8 hours)**

Geochemical data for mineral exploration, and mineral genesis, environmental water quality monitoring. Geochemical anomalies and Bull's eye. Pollution of soil and water from Point and non-point sources.

Unit VIII **(8 hours)**

Geochemical data for understanding petrogenesis – Discrimination diagrams and tectonic environments. Tectonic discrimination diagrams for basaltic-andesitic, granitic rocks, clastic sediments- their merits and limitations.

REFERENCES

1. Rollinson, H.R. (1993) Using geochemical data: Evaluation, presentation, interpretation, Longman scientific and Technical, New York.
2. Mason, B. and Moore, C.B. (1985) Principles of geochemistry, Wiley Eastern Ltd, Bangalore.
3. Faure G. (1986) Principles of isotope geology1, John Wiley & Sons.
4. Krauskopf, E.B. (1979) Introduction to geochemistry, McGraw Hill Book Company, New Delhi.
5. Gill, R. (1989) Chemical fundamentals of geology, Unwin Hyman, London.
6. Albarede F. (2003) Geochemistry- An introduction, Cambridge university press.
7. Dhana Raju, R (2009) Hand book of geochemistry: Techniques and application in mineral exploration, Geological society of India, Bangalore.

COURSE OUTCOME

The course offers a detailed study of all analytical methods used in geochemistry. This will make students familiar with different instruments and geochemical calculations which will be needed in advanced research and exploration fields.

M. Sc. GEOLOGY
SYLLABUS OF PROGRAMME ELECTIVE GROUP 2 (PRACTICAL)

SEMESTER	COURSE CODE	CONTACT/ WEEK	CONTACT/ SEMESTER	CREDITS
IV	GL810404	4 HOURS	72 HOURS	3

PRACTICAL 4
ELECTIVE PRACTICAL

GEMMOLOGY **(72 hours)**

Megascopic identification of following gem minerals and its varieties:

Beryl, Calcite, Coral, Diamond, Epidote, Smithsonite, Sphene, Chrysoberyl, Corundum, Feldspar group, Garnet group, Tourmaline, Chalcedony group, Jasper, Bloodstone, Opal and Quartz