SYLLABUS

I SEMESTER

Sem	Course Code	Course Title	Credit	Marks		
				I	E	T
I	P19GY1	GEOTECTONICS AND STRUCTURAL GEOLOGY	5	25	75	100

The course aims to

- Understand the dynamic processes of the earth.
- Provide knowledge on plate tectonics and plate tectonic features.
- Understand the deformation concepts and explain the deformation in rocks such as fold, fault, joint and unconformity.
- Gain knowledge on petro fabrics and petrofabric analysis.

UNIT 1: Concepts of seismology and Earth's internal structure – Interplate and intraplate seismicity – Earth's gravitational field, principles of geodesy, concept of geoid and spheroid, Isostasy – Geomagnetism, polarity reversals, polar wandering, and paleomagnetism – Thermal structure of the Earth, heat flow and thermodynamics of lithosphere, mantle and core, volcanism and volcanic zones – Radioactivity, radioactive isotopes and their applications – Overview on geosynclines.

UNIT 2: Theory of plate tectonics, tectonic features along plate boundaries: shield areas, mobile zones, rift valleys, mid-oceanic ridges, triple junctions, submarine canyons and Island arcs, relationship of plate tectonics with seismicity, volcanism and mountain building – Continental drift theory and supportive evidences – Concept of supercontinent, their assembly and breakup – 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 – Deformation mechanism – 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 circles – Stereographic projections of structural elements.

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

UNIT 5: Fold: Nomenclature, classification, recognition, and mechanics of folding – 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: their description, geometry and relation to major structures – Petro fabric analysis: petro fabric diagrams and their interpretation – Classification and characteristics of Tectonites, L- L-S-, and S- tectonic fabrics.

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., New Jersey, USA.
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. Theory of Structural Geology, CBS Publishers.
7. Hobbs, Bruce E., Winthrop D. Means, and Paul F. Williams 1976 An outline of Structural Geology, John Wiley & Sons, Inc., New York, Wiley.
8. Patwardhan, A.M (2010). The Dynamic Earth System, II Edition, PHI Learning Private Ltd., New Delhi
9. Valdiya, K. S. 1984 Aspects of Tectonics – Focus on south central Asia. Tata McGraw-Hill.

References:

1. Condie, K. C. 1989 Plate Tectonics and Crustal Evolution, 3rd Ed., Pergamon, Oxford Press.
2. Davis, G .H. 1984 Structural Geology of Rocks and Regions, John Wiley & Sons.
3. De Sitter, U. 1956 Structural Geology, McGraw Hill.
4. Donald L. Turcotte and Gerald Schubert 2014, Geodynamics, Cambridge University Press
5. Fossen, H. 2010: Structural Geology, Cambridge University Press:
6. Kearey, P., Klepeis, K. A. and Vine, F. J. 2009 Global Tectonics, 3rd Edition. Wiley-Blackwell.
7. Keller, E. A. and Pinter, N. 2001 Active Tectonics, 2nd Edition, Pearson Publications.
8. Pollard, D. D. and Fletcher, R. C. 2005 Fundamentals of Structural Geology, Cambridge University Press.
9. Ragan, D. M. 2009 Structural Geology - An Introduction to Geometrical Techniques (Fourth Edition), Cambridge University Press.
10. Ramsay, J. G., 1967 Folding and fracturing of Rocks. McGraw Hill.
11. Robert J. Twiss and Eldridge M. Moores 2006 Structural Geology, 2nd Edition, W. H. Freeman Publishers..
12. Rowland, S. M., Duebendorfer, E. M. and Schiefelbein, I. M. 2007 Structural Analysis and Synthesis: Laboratory Course in Structural Geology, 3rd Edition, Wiley-Blackwell.

Web Resources:

i) United States Geological Survey https://www.usgs.gov/science/science-explorer/Geology
ii) https://www.aapg.org/about/petroleum-geology/geology-and-petroleum/plate-tectonics

Outcomes

After the completion of this course the students would be able to

- Realize the geodynamic process that take place in the earth.
- Gather knowledge in plate tectonics and plate tectonic features.
- Comprehend the deformation concepts and be familiar with the rock's structural deformities (folds, faults, shear zones, joints and unconformities).
- Ascertain the petrofabrics (lineation, foliation, cleavages) and Interpret petrofabric diagrams.

Sem	Course Code	Course Title	Credit	Marks		
				I	E	T
I	P19GY2	STRATIGRAPHY	5	25	75	100

This course aims to

- Understand the Stratigraphic Scale, Principles of Stratigraphy and Correlations
- Comprehend the Precambrian (Archaean and Proterozoic) Stratigraphy of India
- Familiar with the Phanerozoic (Paleozoic, Mesozoic and Cenozoic) Stratigraphy of India
- Recognize the economic and paleontological importance of the stratigraphic formations of India.
- Provide knowledge on the regional Stratigraphy.

UNIT 1: Principles of Stratigraphy – Concept of lithostratigraphy, Chronostratigraphy, Biostratigraphy, Chemostratigraphy – Stratigraphic nomenclature: global level and India – International Chronostratigraphic Chart: Stratotypes, Global Boundary Stratotype Sections and Points (GSSP) – Methods of stratigraphic correlation – Homotaxis and contemporaneity – Facies concept in Stratigraphy: Walther's law – Outline of Earth's climatic history – Imperfections in geological records – Major Stratigraphic Divisions of India – Applications of stratigraphy.

UNIT 2: 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 (Purana) sedimentary basins: Cuddapah and Vindhyan Super Groups – Economic Importance of the Indian Proterozoic formations

UNIT 3: Stratigraphy, fossils and economic importance of: Cambrian of Salt Range – Permo-Carboniferous of Salt Range – Gondwana Supergroup - Triassic of Spiti, Jurassic of Kutch, Narmada Valley and Cretaceous of Trichinopoly and Deccan traps

UNIT 4: Stratigraphy, fossils and economic importance of: Assam – Bengal basins – Garhwal-Shimla Himalayas – Siwalik Super Group and 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 and, Neogene/Quaternary formations of India.

UNIT 5: Geology of Tamilnadu 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 Sediments.

Text Books:

1. Krishnan, M. S. 1982 Geology of India and Burma, C.B.S. Publ. and Distributors, Delhi.
2. Krumbein and Sloss 1956 Stratigraphy and Sedimentation, McGraw Hill.
3. Ramkrishnan, M. and Vaidhyanadhan, R. 2008. Geology of India, Volume I and II, Geological Society of India, Bangalore.
4. Ravindrakumar 1988 Fundamentals of Historical Geology and Stratigraphy of India, Wiley Eastern

Ltd., New Delhi.
5. Subramanian. K. S. and Selvan, T. A. 2001 Geology of Tamilnadu and Pondicherry, Geological Society of India, Bangalore, 192p.
6. Wadia, D. N. 1998 Geology of India, Tata McGraw Hill, India.

References:

1. Andrew, D. M. 1997 Geology of stratigraphic sequences, Springer Publications, New York.
2. Boggs, S. 2001 Principles of Sedimentology and Stratigraphy, Prentice Hall.
3. Brenner, R. E. and Mc Hargue, T. R. 1988 Integrative Stratigraphy: Concepts and Applications, Prentice Hall.
4. Doyle, P. and Bennett, M. R. 1996 Unlocking the Stratigraphic Record, John Wiley and Sons.
5. GSI 1990 Stratigraphic Boundary Problems in India, Memoir 16, ISSN No: 0016-7622, Geological Society of India, Bangalore, 116p.
6. GSI 2006 Geology and Mineral Resources of the States of India, Part VI - Tamil Nadu and Pondicherry, GSI Misc. Publn. No. 30, GSI Operation: Tamil Nadu, Kerala & Pondicherry (Government of India), Chennai.
7. Hedberg, H. D. International Stratigraphic Guide – A Guide to Stratigraphic Classification, Terminology and Procedure, John Wiley & Sons, New York.
8. Miall, A. D. 1997 The Geology of Stratigraphic Sequence, Springer-Verlag.
9. Michael E. Brookfield 2004 Principles of Stratigraphy, Wiley Blackwell Publishing.
10. Naqvi, S. M. and Rogers, J. J. W. 1987 Precambrian Geology of India, Oxford University Press.
11. Pascoe, E. H. 1968 A Manual of the Geology of India and Burma (Vols. I-IV), Govt. of India Press, Delhi.
12. Rayner, D. H. 1976 Stratigraphy of the British Isles, Cambridge Univ. Press.
13. Riser, J. A. M. 2001 Quaternary Geology and the Environment, Springer, Praxis Publishing, Chichister, UK.
14. Robert, M. S. 1989 Stratigraphy: Principles and Methods, Van Nostrand Reinhold, New York.
15. Vail, P. R. 1988 An overview of the fundamentals of sequence stratigraphy and key definitions. Sea level changes - an integrated approach. SEPM Publ. No. 42.
16. Weller, A. K. 1958 Principles of Stratigraphy, Asia Publishing House.

Web Resources:

i) International Commission on Stratigraphy http://www.stratigraphy.org/index.php/ics-chart-timescale
ii) https://www.aapg.org/about/petroleum-geology/geology-and-petroleum/sedimentology-and-stratigraphy
iii) GSI Portal https://www.gsi.gov.in/webcenter/portal/OCBIS
iv) GSSP https://timescalefoundation.org/gssp/index.php?parentid=all (GSSP Table for All Periods). [*GSSP*-Global Boundary Stratotype Section and Point Ages from "The Geologic Time Scale 2012" by F.M. Gradstein, J. G. Ogg, M. D. Schmitz and G. M. Ogg, (2012, Elsevier) with updates from "A Concise Geologic Time Scale 2016" by J. G. Ogg, G. M. Ogg, and F. M. Gradstein (2016, Elsevier)]
v) United States Geological Survey (USGS) https://www.usgs.gov/science/science-explorer/Geology

Outcomes

On completion of the course the students will

- Demonstrate the principles of Stratigraphy and correlation.
- Gather knowledge on the Precambrian Stratigraphy of India and their importance.
- Acquire knowledge of Phanerozoic (Paleozoic, Mesozoic and Cenozoic) Stratigraphy of India and their importance
- Demonstrate the boundary Problems in Stratigraphy scale.

Sem	Course Code	Course Title	Credit	Marks		
				I	E	T
I	P19GY3	PALAEONTOLOGY	5	25	75	100

This course aims

- To know the basic concepts of palaeontology and theories of evolution
- To understand the basic morphology, evolution and significance of the major groups of organisms.
- To illustrate how palaeontology can be applied to both the geological and biological sciences (evolution, paleoecology, biostratigraphy, and biogeography)

Unit 1: Concepts of Palaeontology : Fossils - types of fossils – Nature and modes of preservation of fossils - Taphonomic processes: Death, pre burial and post burial changes of organisms – Largerstatten - collection and preparation of fossils - Imperfection in geological records – Evolution of life through geological time scale – Mass extinctions and their causes - Precambraian fossils: Stromatolites, Ediacaran fauna.

UNIT 2: Organic evolution: Theories on the origin of life – Organic evolution and evidences of evolution - Mechanism of evolution: mutation, adaptation, variations, isolation, speciation - Theories of evolution; Lamarckism, Darwinism, Neodarwinism, Orthogenesis, pangenesis, Recapitualation, Mutation theory – Paleontology and evolution: Macroevolution and Microevolution, Punctuated Equilibrium and Phyletic Gradualism - Classification of organisms: concept of species and binomial Nomenclature - Habits and habitats.

UNIT 3: Paleobotany: Evolution of plants through ages - dinoflagellates, spores and pollens - Gondwana flora and their stratigraphic significance - Important plant fossils in Indian Stratigraphy.
Invertebrate paleontology: Evolution of invertebrates through ages - Morphology, evolution and stratigraphic importance of Corals, Graptolites, Trilobites, Brachiopods and Ammonites - Important invertebrate fossils in Indian Stratigraphy.

UNIT 4: Vertebrate paleontology: Evolution of Vertebrates through geologic time – Devonian fishes and Mesozoic reptiles - Evolutionary trends of Horse, Elephant and Man. Important vertebrate fossils in Indian Stratigraphy.
Applications of palaeontology: Uses of paleontological data in paleoecology, palaeoclimate, paleogeography, paleogeophysics, evolutionary studies correlation and biostratigraphy – Radiocarbon dating of fossils and its application

UNIT 5: Micropaleontology: Microfossils and types of microfossils - Micropaleontological techniques - Methods of preparation of microfossils - General morphology of foraminifera and ostracoda - Oxygen and Carbon isotope studies of microfossils and their utility - Applications of microfossils in environmental interpretation, petroleum exploration and marine geological studies.

Textbooks

1. Bignot G., 1985, Elements of Micro palaeontology, Graham Trotman,
2. Clarkson, Euan, N.K. Clarkson, 1998, Invertebrate Palaeontology & Evolution, Wiley-Blackwell.
3. Doyle, Peter, 1996, Understanding fossils : an introduction to invertebrate palaeontology, John Wiley & Sons Ltd
4. Jain P.C., and Anatharaman M.S., 2018, An introduction to Paleontology, Vishal Publications.
5. Raup & Stanley, 1985, Principles of Paleontology, CBS Publications

6. Saraswati P. K., Srinivasan, M.S., 2016, Micropaleontology - Principles and Applications, Springer International Publishing.
7. Sreepat Jain, 2017, Fundamentals of Invertebrate Palaeontology, Springer
8. Woods H., 1959, Invertebrate Palaeontology, Cambridge.

References

1. Amold C.A., 1947, An Introduction to palaeobotany, Mcgraw-Hill Book Company, Inc.
2. Armstrong Howard A., and Brasier Martin D., 2005, Microfossils, Blackwell Publishing
3. Benton, M. J., 2015, Vertebrate Palaeontology and Evolution, 4th Edition, Wiley-Blackwell.
4. Colbert E.M., 1960, Evolution of the vertebrates, Wiley Eastern.
5. Easton W. H., 1960, Invertebrate Paleontology, Harper's geoscience series.
6. Hag B.U., and Boersma A., 1978, Introduction to Marine Micropalaeontology. Elsevier, Netherlands, 376 P.
7. Jones D.J, 1958, An introduction to Microfossils, Harper brothers
8. Moore R.C., Lalieker C.D., and Fischer A.G., 1952, Invertebrate Fossils, Mc Graw Hill.
9. Prothero, D. R., 2007, Evolution - What the Fossils Say and Why It Matters? Columbia University Press
10. Reed Wicander and James S. Monroe 2007, Historical Geology: Evolution of Earth and Life Through Time, Sixth Edition
11. Romer A.S., 1960, Vertebrate Palaeontology, Chicago press.
12. Shrock R.R., and Twenhofel W.H., 1953, Principles of invertebrate Palaeontology, Amold publication

Outcomes

On completion of the course the students will demonstrate their

- Understanding of how life has evolved through geologic time.
- Ability to describe and identify fossils and analyze the geologic information through them.
- Apply the knowledge gained in the exploration of earth resources.
- Apply the knowledge and reveal earth's past climate, geography, ecology and biology.
- Ability to communicate scientific and technical information effectively through appropriate oral, visual, and written presentation.

Sem	Course Code	Course Title	Credit	Marks			
				I	E	O	T
I	P19GY4P	PALAEONOTOLOGY, STRUCTURAL GEOLOGY, SURVEY, REMOTE SENSING AND GIS	4	25	70	5	100

This course aims

- To impart knowledge on the morphological characters and evolutionary characters of marine invertebrates, identification of Foraminifera and Osctracods and, plant fossil
- To learn - to interpret complex geological maps, stereographic projection techniques in problems of structural geology, depth and thickness of geological formations, determine the attitude of tabular bodies and interpretation of lithological data from inclined boreholes, study the distance and attitude of geological formations using trigonometric functions in three point problems.
- To train in the mapping and surveying part using advanced electronic instruments.
- To impart knowledge on photogrammetry, annotation of aerial photographs and satellite images, interpretation of Remote Sensing data for geological applications.
- To impart practical knowledge right from data input, georeferencing, digital data analysis, to lay out of map.

PALAEONTOLOGY: Megascopic study of corals, Graptolites, Triobites, Brachiopods, Lamellebranchs, Gastropods, Cephalopods and Echinoderms with special reference to their evolutionary characters - Study of plant fossils - Microscopic study of some foraminifera and ostracoda.

STRUCTURAL GEOLOGY: Interpretation or complex geological maps, study of actual field geological maps; problems relating to depth, thickness and three point problem; use for stereographic projection for solution of problems in structural geology. Borehole problems involving determination of attitude of tabular bodies and interpretation of lithological data from inclined boreholes, preparation of Latitudinal vertical sections.

SURVEY: Problems related to GPS and Total Station.

REMOTE SENSING: Elementary exercises' relating to photogrammetry: Determination of scale, flying height, areal extent, flight planning measures, overlap and sidelap. Annotation of aerial photographs; Stereriovision test. Orientation of aerial photographs for interpretation using mirror stereoscope. Annotaion of IRS satellite image. Visual interpretation of lithology, geological structures (Including lineaments), landforms, drainage network and land use / land cover from aerial photographs and satellite images.

GIS: Fundamentals of GIS: Data Structure, Data Management, Creating a Project/View - Geo coding / Geo referencing - Concept of GIS - Thematic layer creation, point, line, polygon, shape file, digitization, editing,contouring and analysis -Layout fixing the area, North arrow position, legend, scale and title - Presentation of the data.

Outcomes

- The student would gain knowledge on the morphological characters and evolutionary characters of marine invertebrates, identify Foraminifera, Osctracods and plant fossils
- After the completion of the course the student will be able to - interpret complex geological maps, understand and solve problems relating to depth, thickness, three point problem using trigonometric principles, stereographic projection techniques for solving problems in Structural Geology, solve borehole problems involving determination of attitude of tabular bodies and interpret the lithological data from inclined boreholes, and to perform mapping and surveying part using advanced electronic instruments like Total station and GPS.
- The hands-on exercises in the course would make the students well trained in the basics of photogrammetry apart from the application of Remote Sensing data for various important applications relevant to Geology. This would brighten their employment opportunities, especially in private industry.
- To impart practical knowledge right from data input, georeferencing, digital data analysis, to lay out of map.

Sem	Course Code	Course Title	Credit	Marks		
				I	E	T
I	P19GY5E	REMOTE SENSING AND GIS	4	25	75	100

This course aims

- To impart knowledge on the fundamentals of Remote Sensing
- To impart knowledge on the essentials and latest developments in Aerial Remote Sensing
- To impart knowledge on essentials and latest developments in Satellite Remote Sensing
- To impart knowledge on the applications of Remote Sensing in Geosciences
- To impart knowledge on the essentials and latest developments in GIS

Unit 1: **Fundamentals of Remote Sensing**: Processes and Elements of Electromagnetic Remote Sensing – Electromagnetic spectrum and its components – Energy sources and radiation principles – Platforms of Remote Sensing – 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 and LIDAR Remote Sensing

Unit2: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 – Mosaics: types their construction; Annotation of aerial photographs – Principles of photointerpretation – Outline of digital photogrammetry

Unit 3:Satellite Remote Sensing: Types of satellites – Scanning systems and Detectors: Across-track and along-track scanning systems – FOV, IFOV and CCD – Types of sensor resolution – Satellite data products – 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 – Image interpretation: visual and digital interpretation techniques – 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 Positioning System (GPS)

GIS: Components – Data Structure in GIS – 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 – (GPS): basic concept, structure, applications.

Text Books

1. Allum, J.A.E (1978). Photogeology and regional mapping, Pergamon Press Ltd., Oxford
2. Anji Reddy, M (2001). Textbook of Remote Sensing and GIS, BSP PS Publications, New Delhi
3. Gupta, R.P (2008). Remote Sensing Geology, II Edition, Springer Pub., New Delhi

4. Lillesand, T.M., Kiefer, R.W and Chhipman, J.W (2017). Remote Sensing and Image Interpretation, VI Edition, John Wiley& Sons Inc., New Delhi
5. Miller, V.C (1961). Photogeology. McGraw-Hill Publishers, New York
6. Narayan, L.R.A (1999). Remote sensing and its application. Universities Press Ltd., Hyderabad
7. Pandey, S.N (1987). Principles and applications of photogeology. Wiley Eastern Ltd., New Delhi
8. Rampal, K.K (1999). Handbook of Aerial Photography and Interpretation. Concept Publishers Company, New Delhi
9. Sabins, F.F (1997). Remote Sensing principles and interpretation, III Edition, W.H. Freeman & Company, Publishers, New York
10. Prithvish Nag and S. Sengupta (2008). Introduction to Geographical Information System. Concept Publishing Company, New Delhi
11. Chang, K (2006). Introduction to Geographic Information Systems. Tata McGraw Hill Pub. Co. Ltd., New Delhi
12. Tor Bernhardsen (2009). Geographic Information Systems: An Introduction, John Wiley & Sons Inc., Student Edition, New Delhi
13. Gupta, R.K (2011). Geographic Information System: Fundamentals and Applications. Arise Publishers, New Delhi

Reference Books

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

Outcomes

On completion of the course Students would have sufficient knowledge on the

- fundamentals of Remote Sensing
- essentials of Aerial Remote Sensing
- essentials of Satellite Remote Sensing
- applications of Remote Sensing in various fields of Geosciences
- essentials and latest developments in GIS

Sem	Course Code	Course Title	Credit	Marks		
				I	E	T
II	P19GY6	ADVANCED CRYSTALLOGRAPHY & MINERALOGY	5	25	75	100

Course Objectives:

The course aims to

- Educate the fundamentals and advanced procedures of crystallography.
- Acquaint the students with polarizing microscope and optical properties of minerals
- Impart knowledge on the optical accessories and their applications.
- Impart knowledge on the optical properties, physical properties and paragenesis of important rock forming minerals

UNIT 1: Advanced crystallography: Derivation of 32 Crystal classes and their symmetry projections – Hermann mauguin notation – Spherical, 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 – Debye-scherrer method - 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. 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: Polarizing Microscope and Its Accessories - Quartz wedge, mica plate, gypsum plate, berek compensator, micrometer ocular and their uses. 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: 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 Group, pyroxene group, amphibole group, mica group, chlorite group, halide groups and clay minerals.

UNIT 5: Optical properties, physical properties and paragenesis of the following mineral groups: Quartz, Feldspar, Feldspathoid and Zeolites groups - Garnet Group, Epidote group, Spinel group, 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.

References

1. Dana, E.S. – 1955 – Text Book of mineralogy, wile
2. Philips, P.C. – 1956 – An introduction to Crystallography, Longmans Green & co.
3. Winchell, A.N. – 1968 – Elements of optical Minerology, parts, I & II Eiley Eastern
4. Wahiatrom, E.E, - 1960 – Optical Crystallography, Wiley.
5. Deer, W.A. Howie, R.A. &Zussman, J-1962 – Rock forming Mineralogy Vols. 1 to 5, Longmans.

6. Naidu, P.R.J. – 1958 – 4-Axes universal stage, commercial printing and publishing house.
7. Heinrich, E.W. – 1965 – Microscopic identification of Minerals McGraw Hill.
8. Grim,R.N. – 1953 – Clay Mineralogy , McGraw Hill.
9. Kerr, P.F. – optical Mineralogy, McGraw Hill.

OUTCOMES:

On completion of the course the student will able to

- Understand various x-ray techniques and their applications in mineralogy.
- Recognize the usage of accessories of polarizing microscope
- Identify minerals through their optical properties.
- Distinguish and classify rock forming silicates
- Characterize the mineral groups and minerals through their properties.

Sem	Course Code	Course Title	Credit	Marks		
				I	E	T
II	P19GY7	GEOMORPHOLOGY	5	25	75	100

Course Objectives:

The course aims

- To impart knowledge on fundamental concepts, changing concepts and paradigms, present research frontiers and future thrust areas.
- Students would gain knowledge on the driving forces of landform formation, energy balance of the Earth's surface processes, physiography of the Earth
- To impart a comprehensive knowledge on weathering, soil and drainage
- To impart a comprehensive knowledge on fluvial, glacial, groundwater andaeolian Geomorphology
- To impart a comprehensive knowledge on tectonic and volcanic geomorphology, landforms related to rock type and structure
- To impart knowledge on coastal, marine, climatic geomorphology and on geomorphology of India

Unit-1: Geomorphology – Introduction

Concepts of geomorphology - Changing concepts and paradigms, present geomorphic research frontiers, geomorphology for future studies – Fundamental driving forces of landform formation: internal and external forces – Energy balance of the Earth's surface processes – Physiography of the Earth – Applications of Geomorphology

Unit-2: Weathering, Soil and Drainage

Weathering: Types and products, factors affecting rates of weathering, applications – Soils: Soil development process, factors affecting soil production, soil profiles, soil classification, soils and landscapes, impact of human activities on soil – Erosion, transportation and deposition of Earth materials – Hill slopes: processes, climatic influence on slope processes, slope morphology, and slope evolution, applications – Drainage: patterns, quantitative analysis, evolution

Unit-3: Fluvial, Glacial, Groundwater, Aeolian Geomorphology

Fluvial Geomorphology: fluvial processes and landforms, stream flow, stage discharge relationship, hydrographs and flood frequency analysis and, applications of fluvial geomorphology – Glacial Geomorphology: glacial processes and landforms, applications – Groundwater Geomorphology: processes, landforms, and applications – Aeolian Geomorphology: Aeolian processes, Aeolian features and landforms, applications -

Unit-4: Tectonic and Volcanic Geomorphology, Landforms related to rock type and structure

Tectonic Geomorphology: Tectonic processes, tectonic settings, landforms and landscape response to tectonics, markers of tectonic geomorphology, applications – Volcanic Geomorphology: Distribution and styles of volcanism, eruptive mechanism and products, eruption sizes and types, 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 settings and drivers, coastal processes and landforms, applications – Shoreline Studies: Classification of shorelines and their evolution - Marine Geomorphology: Marine settings and drivers, 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– Geomorphology of India: Major geomorphic features of India: coastal, peninsula and extra peninsula, river basins of India

References

1. Adrian Harvey. 2012. Introducing Geomorphology: A Guide to Landforms and Processes, Dunedin Academic Press Ltd., Edinburgh, 124p.
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 and Company Publishers, New York, 494p.
4. Burbank, D.W and Anderson, R.S. 2008.*Tectonic Geomorphology*, Blackwell Science Ltd., Oxford, U.K, 274p.
5. Dayal, P (2010). A Text Book of Geomorphology, Rajesh Publications, New Delhi, 730p.
6. Gutierrez, M. 2005. Developments in Earth Surface Processes: Climatic Geomorphology, Elsevier Pub., Amsterdam, 760p.
7. Kale, V and Gupta, A. (2018). Introduction to Geomorphology, Universities Press, Orient BlackSwan Pub., Chennai, 278p.
8. Kale, V. 2014.*Landscapes and Landforms of India*, Springer Netherlands, 271p.
9. Plummer, C.C., Carlson, D.H and Hammersley, L. 2016.*Physical Geology* (15th Edition), McGraw-Hill Education, New York, 595p.
10. Rugget, R.J. 2017.*Fundamentals of Geomorphology (Fourth Edition)*, Routledge Pub., Oxon, 543p.
11. Savindra Singh (2018).*Geomorphology*, PrayagPustakBhawan, Allahabad,
12. Sharma, H.S. 2010.*Geomorphology in India*, PrayagPustakBhawan, Allahabad, 563p.
13. Siddhartha, K. (2018).*The Earth's Dynamic Surface*: *A Book of Geomorphology* (Paperback), Books Wagon Pub., 588p.
14. Summerfield, M A. 1991.*Global Geomorphology*, Pearson Educational, for Prentice Hall, London, 537p.
15. Tarbuck, E.J and Lutgens, F.K. 2014. Earth – An Introduction to Physical Geology, Pearson Education, Inc. New York, 904p.
16. Thompson, G.R and Turk, J 1997. Introduction to Physical Geology (2nd Edition), Brooks/Cole Publishers, California, 300p.
17. Thornbury, W.D. 2018.*Principles of Geomorphology (3rd Edition)*, New Age International Publishers, New Delhi, 614p.
18. Vaidyanathan, R. 2002.*Geomorphology of the Indian Subcontinent*, Published by the Indian Society of Remote Sensing, 29p.

Encyclopaedic works

1. Goudie, A.S. (ed.). 2004.*The Encyclopaedia of Geomorphology (Volumes 1&2)*, Routledge, London

Course Outcomes

On completion of the course the student will able to

- Students would have a comprehensive knowledge on the fundamental concepts, changing concepts and paradigms, present research frontiers and future thrust areas.
- Students would have gained knowledge on the driving forces of landform formation, energy balance of the Earth's surface processes, physiography of the Earth
- Students would have a comprehensive knowledge on weathering, soil and drainage
- Students would have a comprehensive knowledge on fluvial, glacial, groundwater and aeolian Geomorphology
- Students would have a comprehensive knowledge on tectonic and volcanic geomorphology, landforms related to rock type and structure
- Students would have a comprehensive knowledge on coastal, marine, climatic geomorphology and on geomorphology of India

Sem	Course Code	Course Title	Credit	Marks		
				I	E	T
II	P19GY8	HYDROGEOLOGY	5	25	75	100

Course Objectives:

The course aims to

- Make the student understand the occurrence and distribution of groundwater.
- Impart knowledge on groundwater movement.
- Acquaint the students with water wells and well hydraulics.
- Impart knowledge on groundwater exploration and management.
- Provide a comprehensive knowledge on groundwater quality and pollution.

UNIT I: 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 ground water: springs, hot springs, geysers, water wells, and artesian wells.

UNIT II: 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 - Ground water flow: rates, direction, dispersion and diffusion - Flow line and flow nets - Ground water table mapping and Ground water zonation – Groundwater fluctuations; causes and effects - Impact of global climate change on groundwater.

UNIT III: 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 – Well hydraulics: Unidirectional and radial flow to a well (steady and unsteady) – Pumping test: Theis's method, Theim's Method, Copper-Jacob's method, Chow's method - Well flow near aquifer boundaries.

UNIT IV: 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 ground water; test drilling, resistivity logging – 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.

UNIT V: 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 – Drinking water quality standards: WHO (2011), BIS (2012) – Outline of irrigation water quality standards – Groundwater quality contamination: microorganisms in groundwater, groundwater hardness, sea-water intrusion – Groundwater issues due to urbanization; solid and liquid waste disposal and plume migration models – Application of isotopes (H, C, O) in groundwater – Groundwater scenario in Tamilnadu.

Text books

1. Arul. P., (2000) Text Book of Ground Water, Dhanam agency, Tamilnadu
2. David Keith Todd., (2005) Groundwater Hydrology, Wiley India Pvt. Limited, New Delhi.
3. Hamid Rizvi S.M., (2015) Geomorphology and Hydrogeology, Kalyani Publishers New Delhi.
4. Gokhale N.W., (2009) All about water, CBS Publishers, New Delhi.
5. SaxenaR. N., GuptaD.C. (2017) Elements of Hydrology and Groundwater, PHI Learning Private limited, New Delhi

Reference books

1. Fetter C.W., (2007) Applied Hydrogeology, CBS Publishers, New Delhi.
2. Raghunath H.M., (2007) Groundwater, Wiley Eastern Limited, New Delhi.
3. Ramakrishnan S. (1998) Groundwater, KJ Graphs arts, Chennai.
4. Sankar Kumar Nath., (2000) Geophysical Prospecting for Ground Water, Oxford and IBH, New Delhi.
5. Sathya Prakash Garg., (1993) Groundwater and Tube Wells, Oxford University Press, Newyork.

Course Outcomes

On completion of the course the studentswould have

- Gained knowledge on the occurrence and distribution of groundwater.
- Acquired knowledge on groundwater movement
- Understood well hydraulics and construction of water wells.
- Gained sufficient knowledge to evaluate and apply appropriate techniques to explore groundwater and manage groundwater resources.
- Gained knowledge on the analysis and evaluation of groundwater quality.

Sem	Course Code	Course Title	Credit	Marks		
				I	E	T
II	P19GY9P	CRYSTALLOGRAPHY, MINERALOGY, MINING GEOLOGY, HYDROGEOLOGY AND ENGINEERING GEOLOGY	5	25	75	100

Course Objectives:

The course aims to

- impart knowledge on crystallographic projections.
- Familiarise students with the identification procedures of minerals
- develop skills in ore reserve estimation.
- develop expertise in hydrogeology and groundwater management.
- impartskills in engineering geological works and problems.

CRYSTALLOGRAPHY: Stereographic and Gnomonic projections 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.

MINERALOGY: Megascopic and microscopic study of important rock forming silicates - Determination of dichroic and pleochroic schemes, optic sign of uniaxial and biaxial minerals, sign of elongation, optic axial angle by Mallard's method

MINING GEOLOGY: Problems relating to evaluation of Ore reserves.

HYDROGEOLOGY: Analysis of rainfall data – Hydrological data and their interpretations - Pumping test data and their Interpretation – Water quality analysis - Plotting and analysis of hydro-geochemical data.

ENGINEERING GEOLOGY

Demonstration of engineering properties of geological materials: rocks, soils, clays and construction aggregates – Numerical exercises for the determination of engineering properties of various geological materials.

References

1. Dana, E.S. 1955 Text Book of mineralogy, wile
2. Dyar, M and Gunter, M.E. 2007. *Mineralogy and Optical Mineralogy*, Mineralogical Society of America, 705p.
3. David Keith Todd., (2005) Groundwater Hydrology, Wiley India Pvt. Limited, New Delhi.
4. Gribble, C.D and Hall, A.J. 1985. *A Practical Introduction to Optical Mineralogy*, Springer, 252p.
5. Fetter C.W., (2007) Applied Hydrogeology, CBS Publishers, New Delhi.
6. Gokhale, K. V. G. K. and Rao, D. M., 1981 Experiments in Engineering Geology, Tata McGraw Hill.
7. Vutukuri, V. S., Lama, R. D. and Saluja, S. S., 1974 Handbook of Mechanical Properties of Rocks, Vol 1,2,3 & 4, Trans Tech. S.A., Switzerland.

Course Outcomes:

On completion of the course the student will able to

- Identify minerals through microscopic and megascopic studies.
- Determine the interfacial angle of natural crystals through projections and trigonometry.
- Evaluate the ore reserves.
- Interpret the field hydrogeological data.
- Apply the geotechnical skills for engineering geological problems.

Sem	Course Code	Course Title	Credit	Marks		
				I	E	T
II	P19GY10E	ENGINEERING GEOLOGY, MINING GEOLOGY AND ORE DRESSING	5	25	75	100

Objectives:

The course aims

- To make the students to understand the principles and role of geology in engineering projects.
- To initiate expertise on the site selection andgeotechnical investigations for various civil engineering structures.
- To impart knowledge on site suitability analysis and mitigation strategies.
- To impart knowledge on mining methods and techniques.
- To familiarise students with ore dressing techniques.

UNIT 1: **ENGINEERING GEOLOGY:** Elementary concepts of Rock Mechanics and Soil Mechanics – Engineering properties of rocks and soils – Geological reconnaissance, site investigation, characterization and problems related to civil engineering projects – Outlines on Standard Penetration Test (SPT), Seismic Cone Penetration Test (SCPT) and Core Recovery (CR) – Overview on Rock Quality Designation (RQD) and Rock Mass Rating (RMR) – Geotechnical Report (GTR) – Geologic Considerations of Construction Materials – Geological investigations pertaining to the construction of Roads/Highways, Railways(rail tracks), Airfields/Runways, Bridges and Buildings – A note on seismic design of buildings – Geological and geotechnical investigations for the mitigation strategies of mass-movements with special emphasis on landslides – Causes of Hill-Slope Instability – Slope Stability – Outline on Geosynthetics.

UNIT 2: *Dams and Reservoirs:*Geological investigations for Dams and Reservoirs – Spill WayProblems and Reservoir Problems.*Tunnels/Excavation Sites:* Geological investigations preceding tunneling or excavation – problems relating to tunneling or excavation in hard and soft grounds.*CoastalStructures:* Geological investigations pertaining to coastal protection structures for control or preventive measures of coastal erosion and other impacts – Geotechnical investigations pertaining to the construction of harbour and docks. Important Engineering Geological Case Studies.

UNIT 3: **MINING GEOLOGY:** Mining terms and their descriptions. Sampling - Principles – Types of sampling – Collection & preparation of samples - Drilling: Types of drills and methods of drilling. Geological logging - Explosives and Blasting Methods - Rock excavations: Methods of stoping; Ventilation, Haulage, Shafts and shaft sinking. Assaying and evaluation of ore-bodies and their extensions-ore reserve estimation. Alluvial mining: panning, sluicing, hydraulicking, drift mining and dredging. Opencast mining: Mine machinery-power shovel, bucket wheel excavator, conveyor and spreader.

UNIT 4: Subsurface mining / Underground mining- Stoping: Open stopes, supported stopes, shrinkage stopes - Caving;- Top slicing, sub level caving, block caving - Ground water control and Mine ventilation - Coal Mining: Prospecting and planning – underground mining methods: Room and pillar method, long wall (advancing & retreating) method, Pillar robbing,- Hydraulicking, Power source roofing, strip mining of coal – Augering-cleaning –Grading – Shipping – Future trends in India - Mitigation of mining hazards - Factors controlling the choice of various mining methods.

UNIT 5: ORE DRESSING: Principles and scope of mineral dressing; Physical and chemical properties of minerals as applied to mineral dressing. Size reduction Fundamentals – Preliminary breaking – Jaw crushers – Gyratory crushers and Stamping; - Fine grinding – Wet and dry – Ball Mills;- Size separation –Screening –Sieve scale, Grizzlies , Vibrating screens;- Settling- Principles of settling, free settling hindered settling, gravity concentration;- Jigs;- Rakes Classifiers; - shaking tables – Wilfley tables – principles of magnetic separation and Electrostatic separation; - Floatation – Definition, principle and application, – Frothing agents – collecting agents – Dispersing agents –floatation Machines – Floatation practice and Filtration.

Course Outcomes:

After the completion of the course students will be able to:

- Understand the concepts of Engineering Geology, Rock Mechanics and Soil Mechanics for ascertaining the engineering properties of rocks and soils.
- Apply the knowledge in petrology, structural analyses andfield geology for the construction of civil engineering structures.
- Recognize geological causes for the failures of engineering structures and mitigation strategies.
- Select the appropriate mining methods.
- Get comprehensive knowledge on ore dressing techniques

References

1. Bell, F. G. 1983 Fundamentals of Engineering Geology, Butterworths.
2. Blyth, F. C., 1979 A Geology for Engineers, ELBS.
3. Blyth, F. G. H. and De Freitas, M. H., Geology for Engineers, Elsevier, 7th Edition.
4. Fox, C. S., 1949 Engineering Geology, New York.
5. Gokhale, K.V.G.K.and Rao, D.M., 1981 Experiments in Engineering Geology, McGraw Hill.
6. Krynine, D. P. and Judd, W. P., 1957 Principles of Engineering Geology, McGraw Hill.
7. Krynine, D. P. and Judd, W. R., 1957 principles of Engineering Geology and Geotechniques, McGraw Hill.
8. Legget, R. F., 1962 Geology and Engineering, McGraw Hill.
9. Maslov, N. N., 1987 Basic Engineering Geology and Soil Mechanics, Mir Publishers, Moscow.
10. Murthy, V. N. S., Soil Mechanics and Foundation Engineering, CBS Publishers Distribution Ltd., New Delhi.
11. Pandey, V. K. And Mishra, A., 2017 Handbook of Engineering Geology, CBS Publishers & Distributors Pvt. Ltd., New Delhi.
12. Parbin Singh, Engineering Geology, S. K. Kataria& Sons
13. Rise and Wateson: Elements of Engineering Geology.
14. Venkat Reddy, D., 2010 Engineering Geology, Vikas Publ. House Pvt. Ltd., New Delhi.
15. Gauding, A.M. 1939 Principles of Mineral Dressing, McGraw Hill.
16. Thamus, P.J. 19790 An introduction to mining, Methun.
17. Taggart, A.E. Elements of ore dressing.
18. Stanton, R.L. 1972 Ore Petrology, McGraw Hill.

Sem	Course Code	Course Title	Credit	Marks		
				I	E	T
III	P19GY11	IGNEOUS AND METAMORPHIC PETROLOGY	5	25	75	100

Course Objectives:

To impart knowledge on

- Forms, structures and textures, classification of igneous rocks, types of magma, their generation, physical properties
- Bowen's reaction series, crystallisation of unary, binary and ternary magma, trace elements and REE and their applications in igneous petrology
- Igneous rocks and plate tectonic settings, petrogenetic aspects of important rock suites of India
- Types of metamorphism, metamorphic structures and textures, metamorphic zones, grades and facies, chemographic diagrams and, plate tectonic significance of metamorphism
- Equilibrium concepts in thermodynamics, metamorphism of pelitic, mafic and impure carbonate rocks, study of common metamorphic rocks

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 – Magma ascent and magma diversity: magmatic differentiation, assimilation, fractional crystallization and liquid immiscibility.

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 (Albite-Silica), solid solution (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, granites (granitoids), layered intrusive complexes, anorthosites, carbonatites, komatiites, syenites, kimberlites, lamprophyres, and ophiolites.

Unit 4: Metamorphism: controls, limits and agents – Types of metamorphism – Short notes 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 – Brief study on common metamorphic rocks: slate, phyllite, schist, gneiss, amphibolite, eclogite, granulite, khondalite, migmatite, marble, quartzite.

Text books:

1. Best, M.G (1993). *Igneous and Sedimentary Petrology,* 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, New York.
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.

Course Outcomes

On the completion of the course the student would have acquired knowledge on

- Forms, structures and textures, classification of igneous rocks, types of magma, their generation, physical properties
- Bowen's reaction series, crystallisation of unary, binary and ternary magma, trace elements and REE and their applications in igneous petrology
- Igneous rocks and plate tectonic settings, petrogenetic aspects of important rock suites of India
- Types of metamorphism, metamorphic structures and textures, metamorphic zones, grades and facies, chemographic diagrams and, plate tectonic significance of metamorphism
- Equilibrium concepts in thermodynamics, metamorphism of pelitic, mafic and impure carbonate rocks, study of common metamorphic rocks

Sem	Course Code	Course Title	Credit	Marks		
				I	E	T
III	P19GY12	SEDIMENTOLOGY AND SEDIMENTARY PETROLOGY	5	25	75	100

Course Objectives

To impart knowledge on

- Textures and structures, and classification of sedimentary rocks,
- Techniques in Sedimentology, graphical representation of sediment size analysis data and their interpretation, applications of trace elements, REE and stable isotopes towards solving sedimentological problems
- Sedimentary facies and products
- Plate tectonics and sedimentation, classification and description of sedimentary basins, and formation of basins
- Sedimentary basin analysis

Unit 1: Sedimentation – 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 – Mechanical analysis of sediments – Graphical representation of size analysis data – Statistical parameters and their geological significance – Microscopical techniques – Cathodoluminesence – X–ray diffraction – Scanning electron microscope – Application of trace element, rare earth element and stable isotope geochemistry to sedimentological problems – Heavy minerals and their significance – Provenance of sediments – Sedimentary differentiation – Lithification and diagenesis.

Unit 3: Sedimentary facies and products: Non-marine continental, continental margin, oceanic facies – Non marine environments: Desert, fluvial, lake and glacial-environments, climatic significance of red beds – Transitional environments :coastal currents, estuarine, deltas, shore fans, barrier complexes and pertidal complexes – Marine environments – Continental shelf, slope and rise – Climatic significance of carbonates.

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 – Lateral relationships and correlation of sedimentary strata.

Unit 5: 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 – A note on applications of Chemo-stratigraphy.

Text Books

1. Petijohn, F.J (2002). *Sedimentary Rocks (III Edition),* CBS Publishers & Distributors.
2. Prothero, D. R and Schwab, F (2003). *Sedimentary Geology; An Introduction to Sedimentary Rocks and Stratigraphy,* W. H. Freeman.
3. Tucker, M.E (2001). *Sedimentary Petrology,* Blackwell Science.
4. 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. Pvt. Ltd., New Delhi
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

Course Outcomes

On completion of the course students would have acquired knowledge about the

- Textures and structures, and classification of sedimentary rocks,
- Techniques in Sedimentology, graphical representation of sediment size analysis data and their interpretation, applications of trace elements, REE and stable isotopes towards solving sedimentological problems
- Sedimentary facies and products
- Plate tectonics and sedimentation, classification and description of sedimentary basins, and formation of basins
- Sedimentary basin analysis

Sem	Course Code	Course Title	Credit	Marks			
				I	E	O	T
III	P19GY13P	PETROLOGY &WELL LOGGING (PRACTICAL)	4	25	70	5	100

Course Objectives:

To impart knowledge on

- The identification of igneous rocks from their megascopic and optical characteristics, CIPW Norm calculation, problems relating to Niggli values and Niggli basis, variation diagrams
- The identification of sedimentary rocks from their megascopic and optical characteristics, Mechanical analysis of sediments and statistical studies of grain size data
- The identification of metamorphic rocks from their megascopic and optical characteristics, interpretation of ACF, AKF and AFM diagrams
- Interpretation of well logging data.

Igneous Petrology

- Megascopic and microscopic study of igneous rocks
- Problems relating to C.I.P.W. Norm
- Harker's diagram and Niggli variation diagram
- Problems relating to Niggli values and Niggli basis
- Von Wulff plots and variation diagrams

Sedimentary Petrology

- Megascopic and microscopic study of sedimentary rocks
- Mechanical analysis of sediments and statistical studies of grain size data

Metamorphic Petrology

- Megascopic and microscopic study of metamorphic rocks.
- ACF, AKF and AFM diagrams

Well logging

- Interpretation of well logging data.

Course Outcomes

On completion of the course students would be well acquainted with

- The identification of igneous rocks from their megascopic and optical characteristics, CIPW Norm calculation, problems relating to Niggli values and Niggli basis, variation diagrams
- The identification of sedimentary rocks from their megascopic and optical characteristics, Mechanical analysis of sediments and statistical studies of grain size data
- The identification of metamorphic rocks from their megascopic and optical characteristics, interpretation of ACF, AKF and AFM diagrams
- Interpretation of well logging data.

Sem	Course Code	Course Title	Credit	Marks		
				I	E	T
III	P19GY14E	FUEL GEOLOGY	4	25	75	100

Course Objectives

To impart knowledge on

- The origin of coal, sedimentology of coal bearing strata, coal formation in space and time and petrography pf coal
- Physical properties and chemical composition, classification of coal, underground coal gasification, distribution of coal deposits in India
- Origin of petroleum, reservoir rocks, reservoir traps, global oil belts, petroliferous basins of India
- Prospecting for oil and gas, micropaleontology in petroleum exploration, oil and gas reserve estimation, RIG drilling procedures, mudlogging concepts and utilities, oil recovery techniques, oil policy of India
- Exploration of radioactive minerals, productive horizons of atomic minerals in India, geothermal energy and its sources in India

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: Atomic Energy: Concept of atomic energy – Nuclear fuel cycle – Radioactive minerals: mineralogy, chemistry, geological characteristics, mode of occurrence, genesis and association of major types of atomic minerals in nature – Classification and applications of uranium deposits –

metallogenic epochs and provinces of uranium mineralisation – Methods of exploration for atomic minerals – Productive geological horizons of atomic minerals in India – Geothermal energy: Principles of utilization of Earth's heat – Types of geothermal source – Applications of geothermal sources – Exploration of geothermal sources – Geothermal sources in India- Future scenario of geothermal energy in India - Prospects of non-conventional fuel in India

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, Varanasi.
3. Chandrasekharam, D (2005). *Geothermal Energy Resources of India: Past and the Present,* World Geothermal Congress - 2005, pp.1-9.
4. Dhana Raju, R (2005). *Radioactive Minerals*, Economic Geology series, Geological Society of India, 65p.
5. Holson, G. D and E. N. Tiratso (1985). *Introduction to Petroleum Geology,* Gulf Publishing, Houston, Texas.
6. Larry Thomas (2013). *Coal Geology,* John Wiley & Sons.
7. Levorsen, T (1999). *Geology of Petroleum (II Edition),* CBS Publishers and Distributors, Delhi
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. Brown, J. C and A. K. Dey (1975). Mineral and Nuclear Fuels of the Indian Subcontinent and Burma, A guide to the Study of the Coal, Oil, Natural Gas, Uranium, and Thorium Resources of the area. India, 533p.
3. Cataldi, R and M. C. S. Arrriaga (2020). *History of Geothermal Energy in the World to the 20th Century*, ThinkGeoEnergy, Iceland.
4. Dahlkamp, F.J (1993). *Uranium Ore Deposits*, Springer Verlag.
5. Doveton, J.H (1994). *Geological Log Interpretation, SEPM*, Tulsa.
6. Isabel Suárez-Ruiz and John C. Crelling (2008). *Applied Coal Petrology: The Role of Petrology in Coal Utilization*, Academic Press.
7. Henry, G (1994). *Geophysics of Sedimentary Basins,* Technip, Rue Ginoux, Paris.
8. Lewis, D. W and D. McConchie (1994). *Analytical Sedimentology,* Chapman & Hall, New York.
9. North,F.K (1985). *Petroleum Geology*, Allen Unwin.
10. 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.
11. Singh, M.P (1998). *Coal and Organic Petrology,* Hindustan Publishing Corporation, New Delhi.
12. Sircar, A. and K. Yadav (2019). *Harnessing Geothermal Energy Applications in India*, Technology Publications, 200p.
13. 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, 144p.
14. Stach, E., Mackowsky, M-Th., Taylor, G.H., Chandra, D., Teichumullelr, M. and R. Teichmuller (1982). *Stach's Textbook of CoalPetrology*, Gebruder Borntraeger, Stuttgart.
15. Yates, M (1980). *Earth Power: The Story of Geothermal Energy*, Abingdon Publishers.

Course Outcomes

On completion of the course students would have acquired knowledge about

- Origin of coal, sedimentology of coal bearing strata, coal formation in space and time and petrography of coal.
- Physical properties and chemical composition, classification of coal, underground coal gasification, distribution of coal deposits in India
- Origin of petroleum, reservoir rocks, reservoir traps, global oil belts, petroliferous basins of India.
- Prospecting for oil and gas, micropaleontology in petroleum exploration, oil and gas reserve estimation, RIG drilling procedures, mudlogging concepts and utilities, oil recovery techniques, oil policy of India.
- The principles, geological characteristics, types, applications, exploration techniques and Indian occurrences of atomic minerals and geothermal energy resources.

Sem	Course Code	Course Title	Credit	Marks		
				I	E	T
IV	P19GY14E2	ISOTOPE GEOLOGY	4	25	75	100

Course Objectives:

To impart knowledge on

- The basic concepts of Isotope Geology, radioactivity and radioactive decay
- Stable isotopes in different spheres of the Earth
- Effect of mineral/crystal structures, growth and retention of daughter isotopes in earth systems, unstable nuclides in Earth
- Isotope Geology of Sr, Nd, Pb and Ar, and their applications
- Analytical techniques in Isotope Geology

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 Hhydrogen 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, Ffission 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.

Text Books

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

Reference Books

1. Dickin, A. P (1995). *Radiogenic Isotope Geology,*Cambridge University Press, Cambridge.
2. Faure, G and J.L. Powell (1972). *Strontium Isotope Geology*. Springer Verlag, 188p.
3. Hoefs, J (1987). *Stable Isotope Geochemistry (III Edition)*. Springer-Verlag, Berlin.
4. Rollinson, H. R (1993). *Using Geochemical Data: Evaluation, Presentation, Interpretation*, Longman, Harlow.
5. William, W.M (2014). *Isotope Geochemistry,* Wiley

Course Outcomes

On completion of the course the students would have acquired a comprehensive knowledge about

- The basic concepts of Isotope Geology, radioactivity and radioactive decay
- Stable isotopes in different spheres of the Earth
- Effect of mineral/crystal structures, growth and retention of daughter isotopes in earth systems, unstable nuclides in Earth
- Isotope Geology of Sr, Nd, Pb and Ar, and their applications
- Analytical techniques in Isotope Geology

Sem	Course Code	Course Title	Credit	Marks		
				I	E	T
III	P19GY15E	ENVIRONMENTAL GEOLOGY AND MARINE GEOLOGY	4	25	75	100

Course Objectives

To impart knowledge on

- Basic concepts of Environmental Geology, Earth in space and time, mass extinction events, energy sources of disasters, strategies for reducing hazards of earthquake and volcanic activity
- River flooding, mass movements, soil erosion, their hazards, mitigation measures and the role of Geology in it, environmental impacts of mining activities, hydropower projects, disposal of nuclear waste.
- Hazards of coastal areas, mitigation measures and, the role of geology in it, impacts of human activities in coral reef, marine and estuarine environments, water pollution, global climatic changes, desertification and urbanisation
- Physical properties and chemistry of ocean water, ocean circulation and influencing factors, tectonic domains of ocean floor, formation of oceanic crust and, sea level changes
- Oceanic sediments – their deposition, distribution and geochronology, origin of ocean basins, marine mineral resources, marine pollution, laws of sea, EEZ and SEZ

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

Unit 2: River flooding: factors governing flood severity, flood characteristics, hazards of flooding, 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: soil formation, factors influencing soil erosion, hazards of soil erosion, 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 in coral reef, marine, estuarine environments – Global climate change: causes and effects – Surface and groundwater pollution – Desertification: causes and effects – Impacts of urbanization.

Unit 4: Marine Geology: Concepts and principles – Physical properties of ocean water – General oceanic circulation of water and factors affecting it – Formation of bottom waters – Major water masses of the world's oceans – Chemistry of ocean water – Morphologic and tectonic domains of the ocean floor – Structure, composition and mechanism of the formation of oceanic crust – Hydrothermal vents – Ocean margins and their significance – Sea level processes 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.

Text Books

1. Keller, E.A (2012). *Introduction to Environmental Geology (V Edition)*, Pearson Prentice Hall, New York, 705p.
2. Montgomery, C.W (2011). *Environmental Geology (IX Edition)*, McGraw-Hill Pub., New York, 511p.
3. Valdiya, K.S (1987). *Environmental Geology – Indian Context*, Tata McGraw Hill Publications, New Delhi, 583p.
4. Duff, D (1993). *Holmes' Principles of Physical Geology (IV Edition)*, Chapman & Hall, London.
5. Kind, A.H (1979). *Introduction to Marine Geology and Geomorphology*, Edward Arnold.
6. Kennett, J.P (1982). *Marine Geology*. Prentice Hall, London.

Reference Books

1. Bhatt, J.J (1994). *Oceanography: Exploring the Planet Ocean.* D. Van. Nostrand Company, New York.
2. DeWet, A., Menking, K and D. Merritts (2014). *Environmental Geology: An Earth Systems Approach,* Macmillan Learning, 500p.
3. Foley, D., McKenzie, G.D and R.O. Utgard (2009). *Investigations in Environmental Geology (III Edition)*, Pearson Prentice-Hall, 288p.
4. Gross, M.G (1977). *Oceanography: A View of the Earth,* Prentice Hall.
5. Kerth. S (1996). *Ocean Science,* John Wiley & Sons Inc. New York.
6. Kuenen, Philip (1950). *Marine Geology,* Wiley.
7. McConnell, R.L and D.C Abel (2015). *Environmental Geology Today*, Jones and Bartlett Learning, Burlington, 844p.
8. Reichard, J.S (2011). *Environmental Geology*, McGraw Hill, New York, 545p.
9. Seibold, E and W. H. (1982). *The Sea Floor*. Springer-Verlag, Berlin.
10. Shepard, F. P (1994). *Submarine Geology*, Harper and Row Publ. New York.
11. Turekian, K.K (1968). *Oceans,* Prentice Hall.

Course Outcomes

On completion of the course the students would have acquired a comprehensive knowledge about

- Basic concepts of Environmental Geology, Earth in space and time, mass extinction events, energy sources of disasters, strategies for reducing hazards of earthquake and volcanic activity
- River flooding, mass movements, soil erosion, their hazards, mitigation measures and the role of Geology in it, environmental impacts of mining activities, hydropower projects, disposal of nuclear waste.
- Hazards of coastal areas, mitigation measures and, the role of geology in it, impacts of human activities in coral reef, marine and estuarine environments, water pollution, global climatic changes, desertification and urbanisation
- Physical properties and chemistry of ocean water, ocean circulation and influencing factors, tectonic domains of ocean floor, formation of oceanic crust and, sea level changes
- Oceanic sediments – their deposition, distribution and geochronology, origin of ocean basins, marine mineral resources, marine pollution, laws of sea, EEZ and SEZ

Sem	Course Code	Course Title	Credit	Marks		
				I	E	T
III	P19GY15E2	CLIMATE CHANGE STUDIES	4	25	75	100

Course Objectives:

To impart knowledge on

- Earth's radiation balance, latitudinal and seasonal variation of climatic parameters, Earth's atmosphere, global ocean circulation, classification of current climates
- Earth's energy imbalance and energy flow and climatic processes
- Paleoclimatology and multidisciplinary approach in deducing Paleoclimate
- Important aspects of natural climatic changes and anthropogenic changes

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 iterface.

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.

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, Washington, D.C.
3. Thomas Farmer, G (2015). *Modern Climate Change Science: An Overview of Today's Climate Change Science,* Springer, New York.
4. Trevor Letcher (2009). *Climate Change*, Elsevier Science.

Reference books:

1. Asheem Srivastav (2019). *The Science and Impact of Climate Change*, Springer Singapore.
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, New York.

Course Outcomes

On completion of the course the student would have acquired a comprehensive knowledge on

- Earth's radiation balance, latitudinal and seasonal variation of climatic parameters, Earth's atmosphere, global ocean circulation, classification of current climates
- Earth's energy imbalance and energy flow and climatic processes
- Paleoclimatology and multidisciplinary approach in deducing Paleoclimate
- Important aspects of natural climatic changes and anthropogenic changes

Sem	Course Code	Course Title	Credit	Marks		
				I	E	T
IV	P19GY16	ECONOMIC GEOLOGY, MINERAL ECONOMICS AND ORE MICROSCOPY	5	25	75	100

Course Objectives:

To impart knowledge on

- The important processes of formation of mineral deposits
- Classification of mineral deposits, controls of ore localisation, metallogenetic epochs and provinces, plate tectonics and ore genesis, geologic thermometry and geobarometry, geological and geochemical modeling of ore deposits.
- The mode of occurrence, distribution in India, origin and uses of ore deposits such as asbestos, barite, bauxite, chromite, copper, gold, iron, lead and zinc, manganese. Magnesite andplacers
- Mines and Mineral legislation of India, India's National Mineral Policy, Mineral conservation and substitution.
- Ore microscope and study of ore minerals, microchemical techniques, ore textures and paragenesis

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 and 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 – Geological and Geochemical modeling of ore deposits.

Unit 3: Study of the following ore deposits with regard to their mode of occurrence, distribution in India, origin and uses; Asbestos, Barite, Bauxite, Chromite, Copper, Gold, Iron, Lead and Zinc, Manganese. Magnesite, Placer minerals.

Unit 4: Mineral Economics: definition and scope – Significance of minerals in National economy, peculiarities inherent in mineral industry – Tenor, grade and specifications for minerals – Mines and Mineral Legislation of India – India's National Mineral Policy – Strategic, critical and essential minerals with reference to India – Mineral conservation and substitution.

Unit 5: Ore Microscopy: Construction of ore microscope – Polishing and mounting of ores – Micro hardness: procedure for its determination and factors affecting it – Study of optical properties of ore minerals: colour, reflectivity, bi-reflectance, isotropism, anisotropism, polarization colours, rotation properties, internal reflections and relation sense – Instrumentation and methods of determination of reflectivity – Polarization figures of isotropic and anisotropic ore minerals – Microchemical techniques
– Ore textures and paragenesis – Applications of ore microscopy.

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, New Delhi
5. Tiwari, S.K (2019). Ore Geology, Economic Minerals and Mineral Economics, Atlantic Pub.

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
   Lindgren, W (1993). *Mineral Deposits,* McGraw Hill.
4. Park, C.F and R.A Macdiarmid (1970). *Ore Deposits,* Freeman.
5. Stanton, R.L (1972). *Ore Petrology,* McGraw Hill.

Course Outcomes

On completion of the course students would have acquired a comprehensive knowledge about

- The important processes of formation of mineral deposits
- Classification of mineral deposits, controls of ore localisation, metallogenetic epochs and provinces, plate tectonics and ore genesis, geologic thermometry and geobarometry, geological and geochemical modeling of ore deposits.
- The mode of occurrence, distribution in India, origin and uses of ore deposits such as asbestos, barite, bauxite, chromite, copper, gold, iron, lead and zinc, manganese. Magnesite and placers
- Mines and Mineral legislation of India, India's National Mineral Policy, Mineral conservation and substitution.
- Ore microscope and study of ore minerals, microchemical techniques, ore textures and paragenesis

Sem	Course Code	Course Title	Credit	Marks		
				I	E	T
IV	P19GY17P	ECONOMIC GEOLOGY, ORE MICROSCOPY AND GEOEXPLORATION	4	25	75	100

Course Objectives:

To impart knowledge on

- The identification of ore minerals based on physical and optical properties.
- Interpretation of geologic maps.
- Interpretation of geophysical data
- Geochemical analysis and Interpretation of geochemical data.

1) ***Economic Geology***

- Megascopic identification of important ore minerals.

2) ***Ore Microscopy***

- Identification of ore minerals using ore microscope.

3) ***Geoexploration***

- Interpretation of geological maps.
- Interpretation of geophysical data.
- Geochemical Exploration:
  - ✓Information on geochemical analysis and exploration.
  - ✓Demonstration for digestion techniques.
  - ✓Chemical analysis of rocks and minerals: Rapid method of silicate, carbonate, and phosphate analysis – Determination of calcium carbonate in limestones.
  - ✓Interpretation of geochemical data: Plotting of major elements, trace elements and REE data and their interpretation.

Course Outcomes

On completion of the course, students would have acquired practical knowledge on

- The identification of ore minerals based on physical and optical properties
- Interpretation of geologic maps.
- Interpretation of geophysical data.
- The analytical, calculation and interpretation techniques for geochemical methods of exploration.

Sem	Course Code	Course Title	Credit	Marks		
				I	E	T
IV	P19GY18E1	GEOEXPLORATION	4	25	75	100

Course Objectives:

To impart knowledge on

- The principles of geological exploration, guides to ore search and field geology.
- Geophysical exploration methods such as electrical, seismic, e;ectromagnetic and well-logging techniques
- Geophysical exploration methods such as magnetic, radioactive and gravity methods
- The principles of geochemistry, geochemical dispersion and mobility.
- Sampling and analytical techniques for geo- and biogeo-chemical methods of 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: Principles of Geochemistry – Geochemical environment – major, minor and trace elements including rare earth elements – Origin and abundance of elements in the earth's crust – Geochemical cycle – Element partitioning between minerals and melts; oxide-element conversions; chemical and isotopic fractionation – Principles of geochemical thermodynamics – Geochemical Prospecting: Principles and methods of geochemical prospecting – Geochemical dispersion: Primary and secondary dispersion – Pattern of dispersions: Primary halos and leakage halos – secondary halos and dispersion trains. Geochemical mobility: factors controlling mobility of elements: hypogene mobility and supergene mobility – Background values, threshold values and geochemical anomalies – Interpretation of geochemical anomalies – Key and path finder elements – Geothermometry and geothermobarometry.

Unit 5: Geochemical methods of surface and sub-surface exploration on different scales - Reconnaissance surveys and detailed surveys – Lithogeochemical surveys (sampling, analysis, contours of equal elemental values, interpretation) – Pedogeochemical surveys (soil zones, collection of soil sample, heavy mineral separation and interpretation) – Hydrogeochemical analysis (anomalies in natural water, anomalies in drainage sediments, collection of water samples and sediments, on spot and lab analysis, interpretation) – Spectral signature based geochemical mapping: Chemical properties of minerals and rocks and spectral reflection – spectral signature based geochemical mapping and rock discrimination – Applications of Geochemistry in mineral exploration and oil/hydrocarbon exploration - Geochemical exploration methods for gold and copper – Biogeochemical exploration: Principles, collection of plant material samples – Geobotanical methods of surface and sub-surface exploration for water, mineral or ore resources on different scales, chemical analysis, interpretation of anomalies, geobotanical indicators.

Text Books

1. Bateman, A. M (1995). *Economic Mineral Deposits,* Willey.
2. DhanaRaju, R (2009). *Handbook of Mineral Exploration and Ore Petrology: Techniques and Applications,* Geological Society of India, 494p.
3. Mason, B and C. B. Moore (1982). *Principles of Geochemistry (IV Edition),* John Wiley & Sons, 344p.
4. Misra, K. C (2012). *Introduction to Geochemistry: Principles and Applications,* Wiley-Blackwell.
5. Misra, K. C (2012). *Understanding Mineral Deposits*, Kluwer Academic Publishers, 860p.
6. Ramachandra Rao, M. B (1975). Outlines of Geophysical Prospecting: A Manual for Geologists, Prasaranga, University of Mysore, Mysore, 403p.
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, 461p.
6. Kearey, P. and M Brooks (1989). An Introduction to Geophysical Exploration, English Language Book Society / Blackwell Scientific Publications, 296p.
7. Kovalevsky, A. L (1987). Biogeochemical Exploration for Mineral Deposits, VNU Science Press, Utrecht, The Netherlands.
8. Kuzvart, M. and MBohmer (1986). *Prospecting and Exploration of Mineral Deposits*, Elsevier Science Ltd., 508p.
9. Levinson, A.A (1976). *Introduction to Exploration Geochemistry*, Applied Publication Co., Calgary.
10. Lowrie, W (1997). *Fundamentals of Geophysics*, Cambridge Low Price.
11. Marjoribanks, R (2010). *Geological Methods in Mineral Exploration and Mining*(2nd Edition), Springer,253p.
12. Moon, C. J., Whateley, M. K. G. and A. M. Evans (2006). *Introduction to Mineral Exploration (II Edition),* 481p.
13. Raman, P. K (1989). *Principles and Practices of Mineral Exploration: A Professional Manual,* Geological Society of India, 120p.
14. William, W. M (2014). *Isotope Geochemistry,* Wiley.

Course Outcomes:

After the completion of the course students would have acquired a comprehensive knowledge about

- The principles of geological exploration, guides to ore search and field geology.
- Geophysical exploration methods such as electrical, seismic, electromagnetic and well-logging techniques
- Geophysical exploration methods such as magnetic, radioactive and gravity methods
- The principles of geochemistry, biogeochemistry, geochemical dispersion and mobility.
- The sampling, analytical and interpretation techniques for geo- and biogeo- chemical methods of exploration.

Sem	Course Code	Course Title	Credit	Marks		
				I	E	T
IV	P19GY18E2	INSTRUMENTATION TECHNIQUES IN GEOLOGY	4	25	75	100

Course Objectives:

To impart knowledge on

- Sample preparation for geochemical analysis, instruments used for geochemical analysis such as AAS, ICP-AES, XRF, GSMS, ICP-MS, SSMS, AMS, TIMS and SIMS
- Principles, applications and limitations of SEM, EPMA, NAA, LC, TLC and HPLC
- Principles and applications of instruments used for Crystallography and Mineralogy
- Principles, types, field procedures and applications of the instruments used for geophysical survey

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

Text Books

1. Douglas A. Skoog, James Holler, F., Stanley and R. Crouch (2016). *Principles of Instrumental Analysis (VII Edition),* 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, 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.

Course Outcomes

On completion of the course students would have acquired a comprehensive knowledge about

- Sample preparation for geochemical analysis, instruments used for geochemical analysis such as AAS, ICP-AES, XRF, GSMS, ICP-MS, SSMS, AMS, TIMS and SIMS
- Principles, applications and limitations of SEM, EPMA, NAA, LC, TLC and HPLC
- Principles and applications of instruments used for Crystallography and Mineralogy
- Principles, types, field procedures and applications of the instruments used for geophysical survey

Sem	Course Code	Course Title	Credit	Marks		
				I	O	T
IV	P19GY19F	Field study and Internship (Report submission 75 marks & Viva Voce – 25 Marks)	4	75	25	100

Sem	Course Code	Course Title	Credit	Marks		
				I	O	T
IV	P19GY20P	Dissertation Work (Report submission 75 marks & Viva Voce – 25 Marks)	4	75	25	100