

NATIONAL COLLEGE (AUTONOMOUS), TIRUCHIRAPALLI – 1

M.Sc., APPLIED GEOLOGY – Course Structure under CBCS

(Applicable to the candidates admitted from the academic year 2016-2017 onwards)

Semester	Paper No.	Title of the Paper	Instr Hrs/ Week	Credit	Exam Hrs.	Marks			Total
						Internal	External		
							W	O	
I	CC I	Geomorphology and Marine Geology	6	5	3	25	75		100
	CC II	Geotectonics and Structural geology	6	5	3	25	75		100
	CC III	Stratigraphy and Palaeontology	6	5	3	25	75		100
	CC IV P	PRACTICAL I - Palaeontology, Structural Geology, Survey(GPS & Total Station) & Remote Sensing	6	5	4	25	70	5	100
	EC I	Remote sensing	6	4	3	25	75		100
		Total	30	24					500
II	CC V	Advanced crystallography and Mineralogy	6	5	3	25	75		100
	CC VI	Engineering Geology, Mining Geology & Ore Dressing	6	5	3	25	75		100
	CC VII	Hydrogeology and Groundwater Management	6	5	3	25	75		100
	CC VIII P	PRACTICAL II - Crystallography, Mineralogy, Mining Geology, Hydrogeology and soil mechanics.	6	5	4	25	70	5	100
	EC II	Environmental Geology & Disaster Management	6	4	3	25	75		100
		Total	30	24					500
III	CC IX	Igneous and Metamorphic Petrology	6	5	3	25	75		100
	CC X	Sedimentology and Sedimentary Petrology	6	5	3	25	75		100
	CC XI P	PRACTICAL III – Petrology, Geoexploration, GIS and Geo statistics.	6	5	4	25	70	5	100
	EC III	Geoexploration	6	4	3	25	75		100
	EC IV	GIS and Geo statistics	6	4	3	25	75		100
		Total	30	23					500

IV	CC XII	Economic Geology, Mineral Economics and Ore Microscopy	6	5	3	25	75		100
	CC XIII P	PRACTICAL IV - Economic Geology, Ore Microscopy, Blow pipe and well logging.	6	4	4	25	70	5	100
	EC V	Fuel Geology	6	4	3	25	75		100
	EC VI	Industrial training, Geological mapping and Field instructional tour. Report submission& Viva voce	2	2	-	25	75		100
		Project (Dissertation 75 marks & Viva Voice - 25 Marks)	10	4	-	75	-	25	100
		Total	30	19					500
				90					2000

There will be oral test for all practical examinations. The oral test will carry 5 marks in the external component.

SEMESTER- I

PAPER – CC I

GEOMORPHOLOGY AND MARINE GEOLOGY

P16GY1N

UNIT 1: Geomorphology: Scope of Geomorphology – Fundamental concepts – Significance of structure, process and time – A brief account of concepts of Davis and Penck in the evolution of landforms – Characteristic features of landforms – Hill slope characters & development– Characteristics and types of fluvial landforms – Fluvial cycle – Concept of peneplains – Stream rejuvenation, causes and effects.

UNIT 2: Aeolian landforms – Characteristics and types; Arid Cycle of erosion – Glacial landforms, periodicity of glaciations and its causes – Geomorphology of coasts, classification of shorelines and their evolution. Eustatic changes and causes. Landforms produced by volcanoes.

UNIT 3: Influence of lithology on relief, Karst topography - Relationship of geologic structures to topography. Development of landforms of flat lying, tilted, folded, dome and faulted structures. Development of drainage systems and drainage patterns. geological interpretation from drainage analysis

Geomorphic features of India. Geomorphologic applications in exploration for groundwater, mineral and oil and in engineering projects.

UNIT 4: Marine Geology: Introduction to Marine Geology – Nomenclature and dimensions bathymetric features - Physical and chemical properties of ocean water. Factors affecting general oceanic circulation of water – A note on surface currents in Pacific, Atlantic, Indian and Polar Regions - Anatomy of waves, breaker and its types, wave refraction, Long shore rip and turbidity currents. Tides and other motions related to the sea–upwelling, estuaries, fjords, turbidity and its origin.

Oceanographic instruments pertaining to geological operations. Van veen grab, Peterson grab, Corers, Boomerang grab, Water sampler – Nansen water sampler – Reversing thermometer, Bathy thermograph - Probing the sea floor: Echo sounding, Seismic shooting, seismic refraction and reflection.

UNIT5: Distribution and classification of ocean sediments. Coral reefs and their characteristics Theories of atoll formation; Impact and evidences of Eustatic change in sea-level. Beaches and coastline formation.

Marine mineral resources – lithogenous, terrigenous, hydrogenous and biogenous deposits. A brief note on Ocean Thermal Energy Conversion (OTEC); Marine pollution and its control – Coastal zone management. Laws of the Sea and their implications.

UNIT 1: Geotectonics: Volcanism and Volcanic zones. Major tectonic features of the earth; shield areas, mobile, zones, rift valleys, mid oceanic ridges and submarine canyons–Seismic belts of India – Geodynamics of Indian plate

UNIT 2: Geosynclines, Isostasy, Island arcs, Deep sea trenches, Continental drift, Sea floor spreading and Plate tectonics. Orogeny and orogenic cycles – Epeirogeny and evolution of plateaus. Structural and tectonic features of India – Quaternary tectonics

UNIT 3: Structural geology: Mechanical principles – three stages of rock deformation – elastic, plastic and rupture. Concept of stress, strain and the resulting ellipsoids. Mechanics of deformations. Factors controlling behaviour of rock material. Folds – description and classification, recognition, mechanics and causes of folding – Recognition of top and bottom of beds–Geometry of folds – Symmetrical and non Symmetrical folds– Superposed folds – Types – I, II, III

UNIT 4: Faults – Description, classification, recognition criteria and mechanics of faulting. Fault rocks – Foliated – Non Foliated – Cohesive – Incohesive - Quantitative and qualitative classifications of joints. Modes of representation of joints – Histograms, Rose diagrams and preparation of stereogram. Unconformities – types, recognition, significance, distinction from faults and their use in dating structural events

UNIT 5: Cleavage, schistosity and lineation – their description origin and relation to major structures. Petrofabric analysis – Field and laboratory techniques – petrofabric diagrams and their interpretation. Classification and characteristics of Tectonites, Diapirs and related structural features. Method of writing the geological report.

REFERENCES

1. Belosov, V.V., 1962 - Basic problems in Geotectonics, McGraw Hill
2. Billing, M.P. (1974) - Structural Geology, prentice Hall
3. Compton, R.R. – 1962 - Manual of field geology, Wiley
4. Condie, K.C., 1976 - Plate Tectonics and Crustal evolution
5. De Sitter. :U. 1956 - Structural geology, McGraw Hill
6. Hobbs, R.F.et.al.1976 - An outline of structural geology, Woiley
7. Hills, E.L.1965 - Elements of Structural Geology, Asia Publication House.
8. Hudson, J. N., 1963 - Earthquakes and Earth Structure
9. Jeffrey's, H., 1969 - The Earth, Cambridge University Press
10. Jeffrey's, H., 1969 - The Earth, Cambridge University Press
11. Navin, C.M. 1953 - Principles of Structural Geology, wiley.
12. Philips, F.C.1954 - The use of Stereographic projection in Structural Geology, Arnold Publishers
13. Spencer, E.M., 1977 - Introduction to structure of the earth, McGraw Hill
14. Ragan, D.M. – 1973 - Structural Geology, Wiley
15. Ramsay, J.G. 1967 - Folding and fracturing of Rocks. McGraw Hill
16. Wilson, T.J., 1976 - Continent Adrift and Continents Aground Readings from Scientific American
17. Windley, B.F., 1977 - The evolving continents
18. Runcorn.S.K., 1962 - Continental Drift, Academic Press

UNIT 1 Stratigraphic Principles: Study of Standard Stratigraphic Scale – Methods of correlation – Homotaxis and Contemporaneity – Stratigraphic terminology, nomenclature and classification – Applications of Lithostratigraphy, Biostratigraphy, Chronostratigraphy and stratotypes; Causes of imperfections in geological records.

Types of Stratigraphy and their applications, Lithostratigraphy, Bio-Stratigraphy, Chronostratigraphy Magneto-stratigraphy, Seismic stratigraphy. Sequence stratigraphy and chemostratigraphy – Dharwan Craton – Eastern Ghat Mobile Belt (EGMB) – Southern Granulite Terrain (SGT).

UNIT 2 : Precambrian formations in India – Cuddapah and Vindhyan Super Groups – Cambrian of Salt Range – Permo–Carboniferous of Salt Range – Gondwana Super Group – Studies pertaining to Triassic of Spiti, Jurassic of Kutch and Cretaceous of Tiruchirappalli

UNIT 3 : Deccan traps – inter and infra traps – Siwalik Super Group. Age problems pertaining to Indian stratigraphy: a) Saline series b) Deccan trap. Study of the following boundary problems with reference to India: a) Precambrian – Cambrian b) Permian – Triassic c) Cretaceous – Tertiary.

UNIT 4: Organic evolution: History of the concept of evolution – Preformation theory; Baer's law; Biogenetic law; Lamarckism; Darwinian principles - Natural, Sexual and Artificial selections; Theory of pangenesis; Mutation theory (De Vries and Modern version); Orthogenesis; Isolation. Detailed morphology, evolution and stratigraphic importance of the following groups: Corals, Graptolites, Trilobites, Brachiopods and Ammonites. Evolution of plants through geological ages: Gondwana flora and their stratigraphic significance.

UNIT 5: Brief accounts on the principal groups of vertebrates through geologic time – Devonian fishes and Mesozoic reptiles; Evolutionary trends of Horse, Elephant and Man. Micropaleontological techniques: Sampling methods, separation of microfossils from matrix, slide preparation and thin sectioning. Types of microfossils; General morphology, stratigraphic importances: Ecological as well as palaeoecological significances of foraminifera, ostracoda and spores and pollens. Micropaleontologic applications related to environmental interpretation, petroleum exploration, and marine geological studies.

References

1. Krishnan, M.S. 1956 – Geology of India and Burma, Higgin bothams.
 2. Wadia, D.N. 1953 – Geology of India , Mc Millan
 3. Rayner, D. H., 1976 - Stratigraphy of the British Isles, Cambridge Univ. Press
 4. Wells, A.K., 1956 - Outlines of Historical Geology, McGraw Hill, London
 5. Krumbein and Sloss 1956 - Stratigraphy and Sedimentation, McGraw V Hill
 6. Ravindharakumar, 1988 - Historical Geology and Stratigraphy of India, Wiley Eastn
 7. International Stratigraphic Guide – A guide to stratigraphic classification, Terminology and procedure-H.D Hedberg-John wiley and sons, New York
 8. Colbert, E.M., 1960 - Evolution of the vertebrates, Wiley Eastern
 9. Easton - Invertebrate Paleontology
 10. Jain, P.C.and Anatharaman, M.S.-An introduction to Paleontology, Vishal Publications.
 11. Woods, H. 1959 –Invertebrate Palaeontology, Cambridge.
 12. Romer, A.S. 1960 – Vertebrate Palaeontology, Chicago press.
 13. Amold, C.A. – 1947 – An introduction to palaeobotany.
 14. Shrock. R.R. and Twenhofel , W.H – 1953 – Principles of invertebrate Palaeontology, Amold publication
 15. Moore, R.C. Lalieker, C.D. and Fischer, A.G, 1952 – Invertebrate Fossils Mc Graw Hill.
 16. Jones. D.J – 1958 – An introduction to Microfossils, Harper brothers
 17. B.U. Hag and A. Boersma (1978) Introduction to Marine Micropalaeontology. Elsevier, Netherlands, 376 P.
 18. Gignoux, M., 1960 - Stratigraphical Geology, McGraw Hill
 19. Kummel, B., 1961 - History of the Earth, S.Chand and Company
 20. Pascoe, E.S. – 1968 – A manual of the geology of India and Burma, Government of India, Pub.
 21. Gregory, J.N and Barrot, B.H – General stratigraphy, Methuen.
 22. Boggs, S.Jr., 1987 - Principles of Sedimentology and Stratigraphy, Merill Publishing Co.
 23. Weller, A.K., 1958 - Principles of Stratigraphy, Asia Publishing House
 24. Black, R.M., 1972 - The Elements of Paleontology, Cambridge
 25. Carroll and Stearns 1988 - Paleontology, Wiley
 26. Raup & Stanley, 1985 - Principles of Paleontology, CBS Publications
 27. G.Bignot (1985) - Elements of Micro palaeontology Graham Trotman,
 28. ClarksOn, 1985 - Invertebrate Paleontology and Evolution, ELBS
 29. Dunbar, C.O., and Rodgers 1960 - Principles of Stratigraphy-McGraw Hill
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PALAEOLOGY: Megascopic study of Corals, Graptolites, Triobites, Brachiopods, Lamellebranches, Gastropods, Ammonites and Echinoderms with special reference to their evolutionary characters. Study of plant fossils. Microscopic study of some forams and ostracods.

STRUCTURAL GEOLOGY: Interpretation of complex geological maps, study of actual field geological maps; problems relating to depth, thickness and three point problem; use of 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, aerial 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, landforms, drainage network and land use / land cover from aerial photographs and satellite images.

UNIT 1: Fundamentals of Remote Sensing: Definition, types - Energy sources and radiation principles – Electromagnetic spectrum – Divisions - Stefan Boltzman's law – Blackbody – Wien's displacement law - Active and passive remote sensing system – various platforms of remote sensing

Energy interaction in the atmosphere: Scattering, absorption, transmission, atmospheric window; Energy interaction with the earth's surface features – spectral reflectance curve; Data Acquisition, Receiving and recording – PIXEL –Path and Row – Swath; Ideal and real remote sensing system; Thermal and Microwave remote sensing

UNIT 2: Aerial Remote Sensing: Types of aerial photographs; Photographic scale – causes for variation; Flight planning; Parallax, Vertical Exaggeration; Stereoscopy - Stereovision – stereoscopes: Lens and mirror stereoscopes – precision study of aerial photos using stereoscope, stereo-plotting instruments; Mosaics – Types and construction of mosaics; Annotation - Factors affecting results: outline of digital photogrammetry.

UNIT 3: Satellite Remote Sensing: Types of satellites: Polar orbiting, geostationary and spy satellites; Scanning systems and Detectors: Across-track and along-track scanning systems, FOV & IFOV, charge couple devices; Sensors and their resolutions: spatial, spectral, radiometric and temporal; Data products: photographic and digital; Sensor characteristics of LANDSAT, SPOT, IRS series of satellites and other high resolution satellites; Indian space programme: past, present and future; Outline hyperspectral remote sensing and LIDAR.

UNIT 4: Remote Sensing Data Interpretation : Visual interpretation: Elements of photo and image interpretation, interpretation strategies and keys – Digital interpretation – Elements of digital data – Digital image processing and outline of various DIP techniques – Description of image restoration and rectification: Geometric and radiometric corrections, and noise removal –Image enhancement: contrast, spatial feature and multi-image manipulation – Description of image classification: supervised, unsupervised and hybrid classification – Description of data merging and GIS integration, hyper spectral image analysis and biophysical modelling.

UNIT 5: Remote Sensing Applications in Earth Sciences: Remote sensing interpretation for lithological and structural mapping, geomorphological studies, mineral exploration, groundwater exploration, land use / land cover mapping, hazard zonation mapping: earthquakes, volcanoes, landslides, floods, soil erosion and for pollution studies

References

1. Lillesand, T.M and R.W. Kiefer (2000). Remote sensing and image interpretation. John Wiley & Sons, New York
 2. Sabins, F.F (1987). Remote sensing principles and interpretation. Freeman Publishers, New York
 3. Miller, V.C (1961). Photogeology. McGraw-Hill Publishers, New York
 4. Siegal, B.S and R. Gillespie (1980). Remote sensing in Geology, John Wiley & Sons, New York
 5. Curran, P (1988). Principles of remote sensing. Corgman Publishers, London
 6. Pandey, S.N (1987). Principles and applications of photogeology. Wiley Eastern Ltd., New Delhi
 7. Allum, J.A.E (1978). Photogeology and regional mapping, Pergamon Press Ltd., Oxford
 8. Barrett, E.C and C.F. Curtis (1982). Introduction to environmental remote sensing. Chapman & Hall Publishers, New York.
 9. Anji Reddy, M (2001). Textbook of remote sensing and GIS, BSP PS Publications, New Delhi
 10. Bruno Marcolongo and Franco Mantovam (1997). Photogeology – Remote sensing applications in earth sciences, Oxford & IBH Publishers Co. Pvt. Ltd., New Delhi
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 12. Jean Yves Scanvic (1997). Aerospatial remote sensing in geology. Oxford & IBH Publishers Co. Pvt. Ltd.
 13. Agarwal, C.S and Garg, P.K (2000). Textbook on remote sensing in natural resources monitoring and management, Wheeler Publishing Company Ltd., New Delhi
 14. Narayan, L.R.A (1999). Remote sensing and its application. Universities Press Ltd., Hyderabad.
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SEMESTER II

PAPER CC V ADVANCED CRYSTALLOGRAPHY AND MINERALOGY

P16GY6N

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 application; Powder diffraction method.Space lattice-UNIT cell-motif-point group-space group

UNIT 2 : Optical mineralogy: Polarization – double refraction in calcite – Nicol prism. 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.

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, metamict state, staining techniques and micro chemical tests. Structural classification of silicate minerals and their compositional variations, optical and physical properties, and paragenesis of the following mineral groups and minerals: – Olivine Group - pyroxene group – amphibole group-mica, chlorite groups and clay minerals

UNIT 5 :Framework silicates (tekto silicates) – Quartz, Feldspar Feldspathoid and Zeolites groups; Miscellaneous silicates - Ortho and ring silicates - Garnet Group, Epidote group, Spinel group, Alumino-silicates, 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.

PAPER- CC VI ENGINEERING GEOLOGY, MINING GEOLOGY AND ORE DRESSING
P16GY7N

UNIT 1 : ENGINEERING GEOLOGY: Applications of Engineering Geology. Role of Geologists in Civil Engineering, Engineering properties and characteristics of soils. Engineering performance of rocks – Strength and elastic properties. Properties of building stones, concrete aggregates and rail road ballast.

Elementary concepts of Rock mechanics and rock engineering. Soil Mechanics.

Geological reconnaissance, site investigation, characterization and problems related to civil engineering projects. Ground investigation (Bore holes and trial bits SPT; drilling, RQD sampling and logging etc.) Geotechnical report.

Geological and geotechnical investigations for the control/preventive/ remedial measures of Land slides. Slope stability - Geosynthetics. Geological investigations pertaining to the foundation of bridges, buildings, highways and airfields.

UNIT 2 : Types of Dams – Geological investigations of Dam sites. Dam construction - problems – remedial measures. Spill ways and reservoir problems. Tunnels: problems relating to tunneling in hard and soft grounds. Geological investigations preceding tunneling. Geological investigations pertaining to control/preventive measures of coastal erosion. Geotechnical investigations pertaining to the construction of harbour and docks. A note on earthquake resistant structures.

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. Types of mining- Non entry mining-Lake harvesting

UNIT 4 : Subsurface mining / Underground mining;- Stoping: Open stopes – supported stopes, shrinkage stopes. Caving;- Top slicing-sub level caving –block caving. Ground water control – Mine ventilation

Coal Mining: Prospecting and planning – underground mining –Room and pillar method – long wall (advancing & retreating) method –Pillar robbing- Hydraulicking – Power source roofing – transportation; 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; - Flotation – Definition, principle and application, –Frothing agents – collecting agents – Dispersing agents –floatation Machines – Flotation practice and Filtration.

References

1. Krynine, D. P. and Judd, W. R. 1957 principles of Engineering Geology and Geotechniques, McGraw Hill.
2. Legget, R. F. 1962 Geology and Engineering, McGraw Hill.
3. Gokhale, K.V.G.K & Rao, D.M.1981 Experiments in Engineering Geology, McGraw Hill.
4. Arogyaswamy, R. N. P. 1973 Courses in Mining Geology, Oxford & IBH, New Delhi.
5. Higham, S 1951 An introduction to Metalliferous mining, Lord
6. Gokhale, K.V.G.K and Rao, T.C. 1978 Ore deposits of India distribution and processing, Thomson.
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8. Fox, C. S. 1949 Engineering Geology, New York.
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10. Venkat Reddy, D. 2010 Engineering Geology, Vikas publ. House Pvt. Ltd., New Delhi.
11. Gauding, A.M. 1939 Principles of Mineral Dressing , McGraw Hill.
12. Thamus, P.J. 19790 An introduction to mining, Methun.
13. Taggart, A.E. Elements of ore dressing.
14. Stanton, R.L. 1972 Ore Petrology, Mcraw Hill.

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PAPER - CC VII HYDROGEOLOGY AND GROUNDWATER MANAGEMENT P16GY8N

UNIT I: HYDROGEOLOGY: - Introduction - Hydrogeological Cycle: Groundwater occurrence in igneous, sedimentary and metamorphic rocks – Vertical distribution of groundwater in hard rock regions – Water bearing properties of rocks. Geologic formations as aquifers; Types of aquifers; Movement of Groundwater – Laminar and turbulent flow – Darcy's law and its applications; Determination of Permeability in the laboratory and in the field.

UNIT 2: Groundwater Detection: **Surface Methods:** Geomorphological, Structural and Biological evidences – **Subsurface Methods:** Applications and limitations of Geophysical methods in groundwater targeting - Detailed account of principles, field procedure, electrode arrangements, instruments and interpretation of resistivity data. Brief study of Electrical Well-logging method of groundwater detection - Application of Remote Sensing methods in groundwater exploration.

UNIT 3: Well Design and Well development: Brief introduction about Dug wells, Tube wells, Jetted wells, Infiltration Galleries and Collector wells. Design of Tube well, Well Screening and Artificial Packing – Well development through pumping, Bridging, Surging with air, Back washing, Acidizing – Method of sealing of poor quality wells, Sealing of top, intermediate and bottom zones in tube wells. Fluctuations of groundwater levels; causes and control, Features of Recharge and discharge areas; Recharge methods and practices.

UNIT 4 : Pump Tests: Methodology and need for pump test – Testing of flowing wells: Theim's Method, Theis's method, Jacob's method, Chow's method - Evaluation of aquifer parameters through Pump Tests - Estimation of water flow from vertical and horizontal Well-pipes – Hydraulic conductivity and field methods for determining the Hydraulic conductivity below the water table. Groundwater basins; data collection for basin investigations – Water balance studies – Safe yield and overdraft. Conjunctive use of surface and groundwater reservoirs in India; Sea water intrusion in Coastal areas and its prevention – Groundwater province of India.

UNIT 5: Geochemical method of groundwater exploration: Water Quality - Quality of water in various rock types – Water quality parameters and their standards for domestic, industrial and irrigation purposes. Physical tests for determining water quality – Chemical tests for estimation of water quality – graphical representation of water quality – Diseases and Virological aspects of underground water and remedial measures. Groundwater problems in mining, a case study from Neyveli. Rainwater harvesting and management.

References

1. Todd, D.K. 1959: Ground water Hydrology. John Wiley & Sons.
2. Davis, S.N. & Dewiest 1966 Hydrogeology, John Wiley & Sons. Wiest R.J.M.
3. Raghunath, H.M. 1983 Ground water, Wiley Eastern.
4. Gautam Mahajan- 1989: Evaluation and Development of Groundwater, Ashish Publishing House.
5. Ramakrishnan. S: 1998 – Ground water –By Author.
6. Tolman., G.F. 1937 Ground water McGraw Hill. New York.
7. Walton, W.C. 1970 ground water Resources evaluation McGraw Hill.
8. Karanath, K.R. 1987 ground water Assessment Development & management Tata McGraw Hill

CRYSTALLOGRAPHY, MINERALOGY, MINING GEOLOGY AND HYDROGEOLOGY

P16GY9PN

CRYSTALLOGRAPHY: Sterographic 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: Mineral Calculation - 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 and anorthite content of oriented sections of plagioclase.

MINING GEOLOGY: Problems relating to evaluation of Ore reserves.

HYDROGEOLOGY

Study of hydrological data and their interpretations - Interpretation of pumping test data - Representation of water analysis data on different types of diagrams – Water quality analysis.

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UNIT 1: Definition, scope, basic concepts - Earth in space and time - Energy sources of disasters: internal and external sources - Mass extinctions through geologic time - Major climatic changes through geologic time - Human fatalities from natural disasters.

UNIT 2 : Factors governing flood severity, flood characteristics, hazards of flooding, strategies for their reduction and the role of geology - **Mass movements:** factors influencing slope stability, types of mass movement, hazards of mass movement, strategies for their reduction and the role of geology - **Soil erosion:** Soil formation, soil classification, factors influencing soil erosion, hazards of soil erosion, strategies for their reduction and role of geology.

UNIT 3: Earthquake distribution, its relation to plate tectonics, hazards of earthquakes, strategies for their reduction and the role of geology: Tsunami - **Volcanic activity:** Distribution of volcanoes and its relation to plate tectonics, hazards of volcanic activity, strategies for their reduction and the role of geology - **Coastal hazards:** Coastal erosion, coastal flooding, sea water intrusion and their hazards, strategies for their reduction and the role of geology. Global warming and Climate changes.

UNIT 4: Environmental impacts of mining activities: surface, underground and coal mining, impacts of mineral processing - **Urbanisation:** causes, impacts, urban planning and role of geology - **Land use planning - Desertification,** causes, impacts, strategies for their control - **Human population:** nature and rate of growth, causes and impacts - Outline of environmental laws.-waste disposal:Solid and liquid waste, and their sources,radioactive wastes,their disposal strategies,role of geology in waste disposal planning

UNIT 5: Climatology: Atmosphere: Nature, Composition, layering, importance of ozone layer, greenhouse effect. Insolation: Factors affecting heat budget of earth. Horizontal and vertical distribution of temperature; Inversion of temperature, Global pressure belts, Condensation, precipitation, Tropical and mid latitude Cyclones-Genesis and Characteristics-Monsoon, Thunderstorm-Climate Classification

References

1. Abott, P.L (2000). Natural Disasters, McGraw Hill Publications, New York.
2. Coates, D.R (1985). Geology and Society, Chapman and Hall Publishers, New York
- 3 .Keller, E.A (1976). Environmental Geology, Charles E. Merrill Pub. London.
4. Howard, A.D and Irwin Remson (1978). Geology in Environmental Planning, McGraw Hill Publications, New York.
5. Lundgren, L (1986). Environmental Geology, Prentice Hall Publishers, New Jersey.
6. Montgomery, C.W (2000). Environmental Geology, McGraw Hill Pub. New Delhi.
7. Valdiya, K.S (1987). Environmental Geology - Indian Context, Tata McGraw Hill Publications, New Delhi.

THIRD SEMESTER

PAPER – CC IX

IGNEOUS AND METAMORPHIC PETROLOGY

P16GY11N

UNIT 1: IGNEOUS PETROLOGY

Igneous activity – magmatic generation and magma types in Ocean Floor, Island Arcs, Orogenic Continental Margins and Intra-continental Orogenic Belts. Nature and Physical properties of Magmas. Igneous Textures and their petrogenetic significances. Classification of Igneous Rocks: Mode and Norm, CIPW Norm, IUGS Classification of plutonic and volcanic rocks. Irvine and Baragar's Classification.

Introduction to principles and laws of thermodynamics. Gibb's Phase rule and its application to igneous petrogenesis. Derivation and application of Lever Rule.

Crystallization of binary magma - Simple Eutectic (Albite-Silica), Solid Solution (Forsterite-Fayalite) and incongruent melting (Forsterite-Silica). Ternary melt-systems of Diopside – Forsterite – Silica, Diopside - Albite – Anorthite and Anorthite – Forsterite – Silica. Effects of vapours (H₂O, CO₂ and O₂) on melting and crystallization – with reference to basaltic magma.

UNIT 2: Magmatic Differentiation and fractional crystallization. Bowen's reaction series.

Liquid immiscibility, Soret effect, Assimilation, Application of trace elements in fractional crystallization. Distribution and behavior of major-oxide elements in rocks. Application of Bivariate (Harker Diagram) and Triangular (AFM Diagram) variation diagrams. REE distribution in rocks and their application to igneous systems.

UNIT 3: Petrography and Petrogenesis of oceanic regions, convergent plate boundaries, continental flood basalts, continental alkaline rocks, ultra alkaline and silica poor rocks-granites and anorthosites. Petrography of Lamprophyres, Kimberlites, Komatiites and Carbonatites.

Chemistry of rocks: Brief outline of Analytical wet chemical methods using AAS, XRF, ICP.

UNIT 4: METAMORPHIC PETROLOGY

Agents of metamorphism, Types of metamorphism, Paired metamorphic belts, Metamorphic reactions (dehydration, decarbonation, exchange, solid-solid and oxidation-reduction reactions), Metamorphic textures and structures. Classification of metamorphic rocks based on chemical composition and mineralogy.

Metamorphism in relation to orogeny. Grades, Zones and facies of metamorphism – A critical review of facies concept – Facies of Contact Metamorphism, Facies of Regional (dynamothermal) metamorphism and Facies and Burial metamorphism.

UNIT 5: Compositional (Chemographic) diagrams - ACF, AKF and AFM diagrams. Mineralogical phase rule and its application to geothermometry and geobarometry. Metamorphic diffusion. Migmatites and granitisation. Metasomatism, Mineral Paragenesis during progressive metamorphic facies/grades of pelitic, basic and impure calcareous rocks.

References

1. Tyrrell. G.W.(1963)- Principles of Petrology – Asia Publishing House.
2. Turner.F.J and Verhoogen.J –1960.- Igneous & Metamorphic petrology – McGraw Hill.
3. MacKenzie.W.S. et.al.,-(1982); Atlas of Igneous rocks and their textures – Longman.
4. McBirney.A.R.(1994) – Igneous Petrology – CBS Publishers and Distributors.
5. Raymond.L.A.-2002- Petrology – McGraw Hill.
6. Hall- A (1992) – Igneous Petrology – ELBS.
7. Morse.S.A – (1980)- Basalts and Phase diagrams –Springer – Verlag.
8. Winter. J.D.- (2001) – Igneous and Metamorphic Petrology –Prentice Hall.
9. Winkler, H.G.F. – 1967 – Petrogenesis of Metamorphic Rocks, Springer and Verlog
10. Phillipots. R. Anthony (1994) – Principles of igneous and metamorphic petrology, Prentice-Hall of India, New Delhi.
11. Best. 12. Yardley

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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 – Breccia – Arenaceous – Sandstones – Classification - Volcaniclastic deposits – Siltstones – Mudstones. Study of Nonclastic 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 – Cathodoluminescence – 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 current, estuarine, deltas, shore fans, barrier complexes and peritidal 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 – Basins in Strike slip zones – Basins in 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.

References

1. Williams, H. Turner, F.J. & Billbert, C.M. – 1954 – Petrography, Freeman.
2. Pettijohn, F.J.- 1967 – Sedimentary Rocks, Harpers and Bros
3. Bayly, B. – 1968 – Introduction to Petrology, Prentice Hall.
4. Krumbein, W.C. & Pettijohn, F.J. – 1938 – Manual of Sedimentary Petrography, Appleton century co.
5. Krumbein, W.C. & Sloss, L.L. – 1951 – Stratigraphy and Sedimentation, Freeman.

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**PAPER – CC XI P PRACTICAL – III : PETROLOGY, GEOEXPLORATION, GIS
AND GEO STATISTICS P16GY13PN**

Petrology:

Megascopic and Microscopic study of igneous, sedimentary and metamorphic rocks.

- Mode to Chemistry of rocks.
- Mechanical analysis of sediments and statistical studies of data.
- Petrochemical calculations – C.I.P.W. Norm.
- Niggli values and Niggli Basis.
- Von wolff plots and variation diagrams,
- Harker’s diagram and Niggli variation diagram, ACF diagram.

Geoexploration:

Interpretation of geological maps.

Interpretation of geophysical data in solving geological problems.

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.

Geo Statistics: Problems in Geostatistics.

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UNIT 1: Geological 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. Pitting, trenching, drilling and exploratory mining. Mineralogical, structural, stratigraphical and geomorphological guides to ore search. Ore reserve estimation techniques.

UNIT 2: Geophysical Exploration: A concise account of limitations and applications of various geophysical exploration methods; Problem of ambiguity in geophysical interpretations; Principle, types, origin, instruments used, field procedure and interpretations of Self Potential method. Principles involved, instruments used, field procedures adopted and interpretations applied in Electrical Resistivity methods. Principle, types, origin, field procedure and interpretation of Induced Polarization method. A brief study of electrical well logging techniques.

UNIT 3: Geodesy of the earth. Newton's law and its application. The earth's gravitational field. Gravity corrections. Gravity survey measuring instruments. Gravitational effects over subsurface bodies of different shapes. Interpretation of gravity data and depth problems. Elastic properties of the earth materials. Types of seismic waves, their propagation and characteristics. Geophones, types of shooting methods, seismic energy source. Principle of refraction – interpretation of - horizontal two layer and three layers. Principle of reflection Seismic Survey.

UNIT 4: Basic concepts and principles of Magnetic Prospecting. Magnetism of the earth. Magnetic susceptibility of rocks. Magnetic effects from buried magnetic bodies. Instruments employed in magnetic prospecting. Magnetic survey on land and sea. Air-borne Magnetic Survey. Corrections and interpretation of magnetic data. Principles of Radioactive Prospecting. Radioactive decay, radioactivity of rocks and minerals. Instruments, field procedure and interpretations employed in radioactive survey.

UNIT 5: Geochemical Exploration: Origin and abundance of elements in the earth's crust. Mobility of elements; factors controlling mobility; Primary and Secondary dispersion pattern geochemical anomaly; background and threshold values; Geochemical explorations for gold and copper. Application of geochemistry in Mineral exploration and Oil prospecting. Brief outline of geobotanical exploration.

References:

1. McKinstry H.E. (1960) - Mining Geology: Asia Publishing House
2. Mathur S.M. (2001) – Guide to Field Geology: Prentice Hall of India.
3. Ramachandra Rao M.B.(1975) – Outlines of Geophysical Prospecting - A manual for Geologist: University of Mysore.
4. Dohr.G. (1984): Applied Geophysics- English Book Depot.
5. Lowire. W. (1997) - Fundamentals of Geophysics. Cambridge Low price
6. Dobrin M.B.(1981) - Introduction to Geophysical prospecting. McGraw – Hill International Book Company.
7. Kearey.P and Brooks.M (1984) An Introduction to Geophysical Exploration- ELBS.
8. Hawkes H.E. and Webb. U.S - (1962)- Geochemistry in mineral Explo. Harer & Row.
9. Mason.B (1966); -Principles of Geochemistry – Willey Toppan.
10. Burger. H.R. (1992)- Exploration Geophysics of the Shallow Subsurface: Prentice Hall
11. Robinson. E.S. and Coruh.C. (2002)- Basic Exploration Geophysics– John Wiley.
12. Gunter Faure. (1998) – Principles and applications of Geochemistry–prentice Hall.
13. Krauskope.B.K.- (1988) ;Introduction to Geochemistry.

GIS

UNIT 1 : Definition – Historical Development - Components of GIS – Computer Hardware and Software Modules of GIS. Data Structure in GIS - Types of Data - Raster and Vector. (Points, Lines and Polygons) - Data Conversion (Vector to Raster and Raster to Vector).

UNIT 2: Spatial Data Input Processes and Devices - Global Positioning System (GPS) – concept – history – types - applications. Entry of non-spatial data – Linking of Spatial & Non-spatial data – Data Verification – Data correction – Data Interpolation - Data analysis - Surface modeling – DEM and DTM - Data output. Data Quality and Errors - Sources of Errors – Errors due to Natural Variation – Errors during measurement – Errors during entry – Errors during Process & Analysis. Application of GIS in Geological studies and natural resource management. Integration of GPS data in GIS.

UNIT 3: Quality index mapping-Landslide-Groundwater Potential and Hazard Zonation Mapping – Flood – Earthquake (Microzonation) – Tsunami - Mineral Resource Mapping-Coastal erosion.

GEOSTATISTICS:

UNIT 4: Concepts and Definitions: - Merits and limitation – Geostatistical tools – collection of data, sampling techniques, precautions in the use of secondary data. Organization of data – continuous and discrete, frequency, tabulation. Presentation of data: Tabular & diagrammatic illustration: Bar diagram & pie diagram – histogram & frequency polygon; Measures of tendency – Arithmetic mean, Median and Mode.

UNIT 5: Dispersion: Standard deviation – skewness, kurtosis – Karl Pearson’s coefficient of Skewness; Correlation and Regression-Concepts, Karl Pearson’s coefficient of correlation – Rank correlation Regression, lines of regression; Probability – Meaning and Uses. Addition and Multiplication theorems. Factor analysis. A brief note on statistical software- SPSS, GSTAT, GRADISTAT.

References

1. John C.Davis - 1973 - Statistics and Data Analysis in Geology, John Wiley & Sons.
2. Krumbein and Graybill 1965 - An introduction to Statistical methods in Geology, Mc Graw Hill.
3. Burrough, P.A.-1986- Principles of Geographical information system for land resource assessment.
4. Rajaraman, V. Fundamentals of Computers, Fourth edition, PHI.
5. Rober L. Miller and James Stevenkahn -1962, Statistical analysis in the Geological Sciences, John Wiley & sons, Inc.

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SEMESTER - IV

PAPER-CC XII - ECONOMIC GEOLOGY, MINERAL ECONOMICS AND ORE MICROSCOPY P16GY16N

UNIT 1 Economic geology: Processes of formation of mineral deposits – Magmatic, sublimation, contact metasomatic, 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 localisation – structural stratigraphic, physical and chemical; Metallogenic 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, Physical properties of Ore minerals, Determination of micro hardness; Factors affecting micro-hardness.

Study of optical properties – 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, Micro – chemical techniques, ore textures and paragenesis, application of Ore Microscopy.

References

1. Bateman, A.M. – 1995 – Economic Mineral Deposits, Willey.
2. Lindgren, W – 1993 – Mineral Deposits, McGraw Hill.
3. Cameron, E.N. – 1961 – Ore Microscopy, Wiley.
4. Sinha, R.K. & Sharma, N.L. – 1976 – Mineral Economics Oxford and IBH.
5. Graig, J.R. – Ore Microscopy and Ore Petrography.
6. Coggin, B & Dey, A.K. – 1995 – India's Mineral Wealth, OUP.
7. Park, C.F. & Macdiarmid, R.A. 1970 – Ore deposits, Freeman.
8. Deb, S, 1980 – Industrial Minerals and rocks of India, Allied.
9. Gokhale; K.V.G.K. & Rao, T.C. – 1978 – Ore deposits of India, their distribution and Processing, Thomson Press.
10. Stanton, R.L. 1972 – Ore Petrology, McGraw Hill.

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**PAPER CC XIII P - PRACTICAL – IV ECONOMIC GEOLOGY, ORE MICROSCOPY,
BLOW PIPE AND WELL LOGGING P16GY17PN**

ECONOMIC GEOLOGY

Megascopic identification of important ore mineral.

ORE MICROSCOPY

Identification of ore minerals using ore microcope

BLOW PIPE

Analysis of mixture of ore mineral

WELL LOGGING

Interpretation of well logging data.

Blow-pipe tests for selected ores. Volumetric analysis.

Separation and Identification of Heavy Minerals

UNIT 1: Natural sources of energy: Energy and their sources, fuels.

Coal Geology: Origin of coal. Sedimentology of coal bearing strata, types of seam discontinuities and structures associated with coal seams. Chemical analysis of coal (proximate and ultimate analysis).

Coal Petrology :- Classification and optical properties of macerals and micro-lithotypes. Techniques and methods of coal microscopy. Application of coal petrology. Classification of coal in terms of Rank, Grade and Type. Indian classification for coking and non-coking coals. International classifications (I.S.O. and Alpern's classification).

UNIT 2: Study of coal preparation, coal carbonization, coal gasification, coal hydrogenation, coal combustion and fertilizer from coal. Coal as a source rock in petroleum generation. Exploration and estimation of coal reserves. Distribution, reserves and production of coal and lignite in India. Coal bed methane – a new energy resource.

UNIT 3: Petroleum Geology: Petroleum – its composition. Origin (Formation of source rocks-kerogen, organic maturation and thermal cracking of kerogen) and migration of petroleum. Reservoir rocks-porosity and permeability. Reservoir traps – structural, stratigraphic and combination traps. field Oil fluids – water, oil and gas.

UNIT 4: Methods of prospecting for oil and gas (geological modeling). Elementary knowledge of drilling and logging procedures. Oil shale. An outline of oil belts of the world. Onshore and offshore petroliferous basins of India. Geology of productive oilfields of India. Oil policy of India. **Gas Hydrates:** Exposure to gas hydrates and future prospective.

UNIT 5: Atomic and Geothermal energy

Atomic Fuel: Concept of atomic energy. Radioactive minerals. Mode of occurrence and association of atomic minerals in nature. 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, exploration, distribution of geothermal energy. Application of geothermal sources. Geothermal sources in India. Future scenario.

A debate on eco-friendly fuel or energy.

References

1. Chandra, D., Singh, R.M. Singh, M.P., 2000: Textbook of Coal (Indian context). Tara Book Agency, Varanasi.
2. Singh, M.P. (Ed.) 1998: Coal and organic Petrology. Hindustan Publishing Corporation, New Delhi.
3. Scott, A.C., 1987: Coal and Coal-bearing strata: Recent Advances. The geological Society of London, Publication no. 32, Blackwell scientific Publications.
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7. North, F.K., 1985: Petroleum Geology. Allen Unwin.
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9. Durrance, E.M. 1986: Radioactivity in Geology-principles and application. Ellis Horwood.
10. Dahlkamp, F.J., 1993: Uranium Ore Deposits. Springer Verlag.
11. Boyle, R.W., 1982: Geochemical prospecting for Thorium and Uranium deposits, Elsevier.

EC VI INDUSTRIAL TRAINING, GEOLOGICAL MAPPING AND FIELD INSTRUCTIONAL
TOUR- REPORT

Project (Dissertation 75 marks & Viva Voice – 25 Marks)