

M.Sc. GEOLOGY
Semester IV

Theory Paper/ Practical	Title	Teaching Scheme (Hrs/ week)			Credits	Examination Scheme					
		Th	Pr.	Total		Duration (Hrs)	Max. Marks		Total Marks	Min. Passing Marks	
							External	Internal		Th	Pr.
Paper-I	Ore Geology and Ore Microscopy (3+1)	4		4	4	3	80	20	100	40	
Paper-II	Indian Mineral Deposits and Mineral Economics (3+1)	4		4	4	3	80	20	100	40	
Paper-III	Mining Geology and Mineral Exploration (1+3)	4		4	4	3	80	20	100	40	
Paper-IV	Optional (Any one) 1. Petroleum Exploration (4) 2. Elements of Mining and Drilling Techniques (3+1) 3. Marine Geology and Oceanography (2+2)	4		4	4	3	80	20	100	40	
Practical I	Ore Geology, Ore Microscopy, Mineral Exploration, Optional and Geological Field Work (Marks: 55 Pract. + 05 Viva-voce + 20 Field Work + 20 Internal Assessment and Class Record)		8	8	4	3	80	20	100		40
Practical II	Project Work (Marks: 60 Project Evaluation + 20 Project Seminar / Presentation + 20 Viva-voce)		8	8	4	3	80	20	100		40
	Seminar	2		2	1	---		25	25	10	
	Total	18	16	34	25		480	145	625	170	80

FIELD WORK:

Candidate shall attend geological excursion organized by the Department for a period of two to four weeks. This will include field work, visit to geologically important places, mines, geological and scientific organisations. Candidates should submit the field report at the end of excursion alongwith the geological specimens collected during the programme. The field work is a part of Practical I of Semester IV.

PROJECT WORK:

Every student is required to carry out **Experimental / Field Based Project Work** (this is in lieu of practical II of semester IV) on a related research topic of the subject /course. On the basis of this work, student must submit the Project Report (typed and properly bound) in two copies at least one month prior to commencement of the final Practical Examination of Semester IV.

After Semester-II the candidates are required to carry out geological mapping independently in an area of about 50 Sq. Km. approved by the Head of the Department and Project Guide for about two to three weeks as a part of project work. The area/ topic of the project work shall be assigned to the students at the end of Semester - II depending upon the expertise available in the Department.

The Project report shall comprise introduction, aims and objectives, short literature review, methodology/ materials and methods, experiments and results, discussion, conclusion and references along with the declaration by the candidate that the work is original and not submitted to any University or Organization for award of the degree, and certificate by the supervisor and forwarded through Head of the Department. The project report will be essentially evaluated by two referees, which includes **Project Guide** as internal referee and one **external referee**.

The Project Work will carry total 100 marks and will be evaluated by both external and internal examiner in the Department.

For written Project work	: 80 Marks (20 marks for project presentation)
For Viva-Voce	: 20 Marks

Total	: 100 Marks

Paper-I

Ore Geology and Ore Microscopy

Unit I:

Modern concept of ore genesis; Spatial and temporal distribution of ore deposits -a global perspective; Comparison between Earth's evolutionary history and evolutionary trends in ore deposits; Ore deposits and Plate Tectonics; Mode of occurrence of ore bodies -morphology and relationship of host rocks; Study of principal ore mineral groups, their textures and structures; Paragenesis and zoning of ores and their significance; Geological thermometers; Fluid inclusion in ores: principles, assumptions, limitations and applications.

Unit II:

Concept of ore bearing fluids, their origin and migration; Wall-rock alteration; Structural, physico-chemical and stratigraphic control of ore localization.

Petrological ore associations with Indian examples wherever feasible: Orthomagmatic ores of mafic-ultramafic association - diamonds in kimberlites, REE in carbonatites, Ti-V ores, chromite and PGE, Ni ores, Cyprus type Cu-Zn deposit.

Unit III:

Petrological ore associations with Indian examples wherever feasible: Ores of silicic igneous rocks - Kiruna type Fe-P, pegmatoids, greisens, skarns, porphyry associations, Kuroko-type Zn-Pb-Cu; Ores of sedimentary affiliation - chemical and clastic sedimentation; Stratiform and stratabound ore deposits (Sedimentary BIF, manganese, non-ferrous ores); Placers and palaeoplacers; Ores of metamorphic affiliations; Ores related to weathering and weathered surfaces - laterite, bauxite, Ni/Au laterite; Contemporary ore-forming systems (black smokers, mineralized crusts, Mn nodules).

Unit IV:

The ore microscope; preparation of polished section of ores; Physical and optical properties of ore minerals under reflected light; quantitative measurement of reflectivity and microhardness; Microchemical techniques- etch test and microchemical elemental test, contact chromatography of polished section of ores and its uses; Structures and textures of ores, their interpretation and paragenesis; Application of ore microscopy in mineral dressing.

Practicals:

Ore Geology:

Study of physical properties and identification of ores, non-metallic minerals, industrial rocks and minerals, gemstones and semi-precious minerals in hand specimens.

Ore Microscopy:

Description of optical properties and identification of ore minerals in polished sections under incident light and determination of paragenetic sequence; Exercises in the determination of reflectivity and microhardness of common ore minerals.

Books Recommended:

Ore Geology:

Edwards, R. and Atkinson, K. (1986) Ore Deposit Geology, Chapman and Hall, London.

Craig, J.M. and Vaughan, D.J. (1981) Ore Petrography and Mineralogy, John Wiley

Evans, A.M. (2012) Ore Geology and Industrial Minerals. Third Edition (Reprint), Blackwell Publishing and Wiley India Pvt. Ltd.

Sawkins, F.J. (1984) Metal Deposits in relation to Plate Tectonics, Springer Verlag.

Stanton, R.L. (1972) Ore Petrology, McGraw Hill.

Torling, D.H. (1981) Economic Geology and Geotectonics, Blackwell Sci. Publ.

Barnes, H.L (1979) Geochemistry of Hydrothermal Ore Deposits, John Wiley.

Klemm, D.D. and Schneider, H.J. (1977) Time and Strata Bound Ore Deposits, Springer Verlag.

Guilbert, J.M. and Park, Jr. C.F. (1986) The Geology of Ore Deposits, Freeman.

Mookherjee, A. (2000) Ore genesis -a Holistic Approach, Allied Publishers.

Wolf, K.H. (1981) Hand book of Strata Bound and Stratiform Ore Deposits, Elsevier.

Jensen, M.L. and Bateman, A.M. (1981) Economic Mineral Deposits. John Wiley and Sons, New York.

Ore Microscopy:

Ramdohr, P. (1969) The Ore Minerals and their Intergrowths, Pergamon Press.

Ineson, P.R. (1989) Introduction to Practical Ore Microscopy, Longman Publishers.

Picot, P. and Johan, Z. (1982) Atlas of Ore Minerals, Elsevier Publishers.

Craig, J.R. and Vaughan, D.J. (1994) Ore Microscopy and Ore Petrology, John Wiley.

Sahoo, R.K. (2011) Atlas of oxide ores of India and their textures, SSDN Publishers and Distributors, New Delhi.

Paper-II
Indian Mineral Deposits and Mineral Economics

Unit I:

Study of the following Indian ore deposits with reference to their mineralogy, mode of occurrence, origin, geological association and geographical distribution: Iron, manganese, gold, aluminium, chromium, copper, lead and zinc.

Unit II:

Study of the following Indian ore deposits with reference to their mineralogy, mode of occurrence, origin, geological association and geographical distribution: Tin, tungsten, titanium, nickel and molybdenum; Minerals used in metallurgical, refractory and abrasive industries.

Unit III:

Study of the following Indian mineral deposits with reference to their mineralogy, mode of occurrence, origin, geological association and geographical distribution: Minerals used in ceramics, cosmetic, glass, fertilizers, cement, chemical, paints and pigments, electrical and gemstone industries.

Unit IV:

Concept of mineral economics; Significance of minerals in National economy; Use of various minerals in industries; Production and its effect on prices of minerals; Demand and supply, their effect on prices; International aspects of mineral industries; Cartels and their influence on mineral industry; Mineral resources in India and their present status and future development; Strategic, critical and essential minerals; Conservation and substitution of minerals; Mines and mineral legislation in India, Mineral development fund; Law of sea bed for marine mineral resources; United Nations Framework Classification (UNFC); National Mineral Policy; Statistical modelling for the future requirements and production levels of minerals in India.

Books Recommended:

Indian Mineral Deposits:

- Banerjee, D.K. (1992) Mineral Resources of India, The World Press Pvt. Ltd., Kolkata
Sharma, N.L. and Ram, K.S.V. (1964) Introduction to India's Economic Minerals, Dhanbad Publishers.
Deb, S. (1980) Industrial Minerals and Rocks of India, Allied Publishers, New Delhi.
Krishnaswamy, S. (1979) India's Mineral Resources, Oxford and IBH, New Delhi.
Babu, T.M. (1994) Tin in India, Geological Society of India, Bangalore.
Babu, T.M. (1998) Diamonds in India, Geological Society of India, Bangalore.
Radhakrishnan, B.P. and Curtis, L.C. (1999) Gold in India, Geological Society of India, Bangalore.
Karanth, R.V. (2000) Gems and Gem Industry in India, Geological Society of India, Bangalore.

Mineral Economics:

- Sinha, R.K. & Sharma, N.L. (1993) An Introduction to Mineral Economics, Wiley Eastern
Chatterjee, K.K. (1993) An Introduction to Mineral Economics, Wiley Eastern.

Paper-III

Mining Geology and Mineral Exploration

Unit I:

Application of Geology in mining; Geological work at an operating mine; Guides in the location of ore deposits- physiographic, lithologic, stratigraphic, mineralogic and structural guides; Intersecting loci and ringed targets; Location and extension of ore deposits and dislocated ore bodies; Persistence of ore in

depth; Duties of mining geologist; Preparation of Mine plans; Geotechnical investigations for mine planning; Geological report writing.

Unit II:

Mineral Exploration – its significance, necessity and objectives; Methods in mineral exploration- objectives and limitations of different methods; Stages of mineral exploration; Geological methods of surface and subsurface exploration- evaluation of outcrop, panning, trenching, pitting, drilling etc; Drilling methods used in mineral exploration; choice of drilling; Types of drill patterns and density of exploratory drilling; Exploratory mining methods; Methods in outlining the ore body; Geological modeling for mineral exploration with specific examples of Indian mineral deposits.

Unit III:

Fundamentals of geochemical prospecting; Geochemical environments, mobility and distribution in dispersion of elements in primary and secondary environments; Geochemical exploration practices in different environments glacial, desertic and tropical; Methods of geochemical exploration: lithochemical, pedochemical, biogeochemical, hydrogeochemical, atomogeochemical, geobotanical methods; Statistical analysis and interpretation of geochemical prospecting data; Designing exploration models for search of different type of mineral deposits.

Unit IV:

Geophysical methods of prospecting of metallic and non-metallic mineral deposits.

Gravity method: Principle, instrumentation, field procedure and application; Gravity field surveys; Various types of corrections applied to gravity data; Preparation of gravity anomaly maps and their interpretation.

Magnetic method: Principle, instrumentation, field procedure and application; Introduction to Aeromagnetic survey.

Electrical methods: S.P. and I.P. method; Resistivity method: Principle, instrumentation, field procedure and application.

Seismic methods: Principle, instrumentation, types, field procedure and application.

Radioactivity methods: Principle, instrumentation, field procedure and application.

Practicals:

Preparation of Mine plan; Diagrammatic representation of open cast and underground mining; Preparation and interpretation of geochemical anomalies maps; Problems based on statistical analysis of data obtained in geochemical exploration.

Calculation of average assay value of ore based on sampling data from bore holes and underground mine workings; Calculation of ore reserves; Preparation of vertical sections and level plans of ore deposit from bore hole data; Preparation of grade maps of mineral deposits based on sampling data;

Study of gravimeter, magnetometer and seismographs; Resistivity survey; Interpretation of underground structure on the basis of seismic data.

Books Recommended:

Mining Geology and Mineral Exploration:

- McKinstry, H.E. (1972) Mining Geology, Pretice-Hall Inc.
- Arogyaswamy, R.N.P. (1995) Courses in Mining Geology, Oxford and IBH Publishing Co., New Delhi.
- Thomas, L.J. (1978) An Introduction to Mining, Methuen, Brisbane.
- Clark, G.B. (1967) Elements of Mining, Asia Publishing House.
- Bagchi, T.C., Sen Gupta, D.K. and Rao, S.V.L.N. (1979) Elements of Prospecting and Exploration, Kalyani Publishers, New Delhi.
- Pacal, Z. (Ed.) (1977) Geochemical Prospecting Methods, Ustrendi.
- Brooks, A.R. (1972) Geobotany and Biogeochemistry in Mineral Exploration- Harper and Row.
- Rose, A.W., Hawkes, H.E. & Webb, J.A. (1979) Geochemistry in Mineral Exploration, Academic Press.
- Hawkes, H.E. and Webb, J.S. (1980) Geochemistry in Mineral Exploration, Harper and Row.
- Dobrin, M.B. (1976) Introduction to Geophysical Prospecting, McGraw Hill.
- Howel, B.F. (1959) Introduction to Geophysical Prospecting, McGraw Hill.
- Lowrie, W. (1997) Fundamentals of Geophysics, Cambridge University Press.
- Mussett, A.E. & Khan, M.A. (2000) Looking into the Earth: An Introduction to Geological Geophysics, Cambridge University Press.
- Sharma, P.V. (1986) Geophysical Methods in Geology, Elsevier.
- Sharma, P.V. (1997) Environmental and Engineering Geophysics, Cambridge University Press.
- Vogelsang, D. (1995) Environmental Geophysics -A Practical Guide, Springer Verlag.
- Parasnis, D.S. (1975) Principles of Applied Geophysics, Chapman and Hall.
- Stenislave, M. (1984) Introduction to Applied Geophysics, Reidel Publ.
- Ramam, P.K. (1989) Principles and Practices of Mineral Exploration, Geological Society of India, Bangalore.
- Nguyen, J.P. (1996) Drilling, Editions Technip, Paris.

Paper-IV (Optional)

1. Petroleum Exploration

Unit I:

Introduction to Petroleum geology, types of petroliferous basins and their relation to hydrocarbon potential; Global geographic and stratigraphic distributions of oil and gas; Classification and stratigraphy of petroliferous basins of India. Estimation of oil and gas reserves and resources; Basin mapping – structure and isopach contouring, lithofacies and biofacies maps; Petrophysics- rock fluid system and interaction, reservoir characteristics, reservoir heterogeneity and drive mechanisms of carbonate and clastic reservoirs.

Unit II:

Methods and techniques for petroleum exploration, surface indications and direct detection of hydrocarbons; Geochemical methods of Petroleum exploration; Sniffer surveys; Introduction to different biomarkers used in oil exploration; Significance of major microfossil groups such as foraminifers, calcareous algae, ostracods, dinoflagellates, pollen and spores in hydrocarbon exploration; Case studies of Indian sedimentary basins; Sub-surface exploration techniques: concept of potential, magnetic, gravity and seismic methods of geophysical exploration; Seismic data acquisition, processing and interpretation; Synthetic seismograms; Gas hydrates and CBM exploration.

Unit III:

Oil well Drilling methods, drilling equipments, drilling rig - its components and functions, rig sizing and selection, drilling fluids, wellheads, casing and cementing operations, principles of kick control, fishing jobs, drill stem test (DST); Types of offshore and onshore drilling operations; Well completion; Well logging: Formation evaluation, Archie's formulae, principles, methods and application of logging tools including Spontaneous polarization, resistivity, microresistivity, induction, sonic, density, neutron techniques, hingle, pickett, MID, M-N cross plots, saturation estimation, natural gamma ray, gamma ray spectrometry, cement bond, variable density, caliper, dipmeter, formation microscanner and imager; Well log interpretation - quick lithology, porosity and permeability determination; Log interpretation case studies.

Unit IV:

Duties of a well-site geologist; Geotechnical order (GTO), coring and core analysis; Examination of well cuttings; Preparation of lithologs and composite logs; Principles of formation testing; Development geology, production and enhanced oil recovery (EOR) methods; Principles of petroleum economics.

Practicals:

Map projections of different oil horizons in Indian sedimentary basins, their stratigraphic order, and study of microfossils like foraminifers, calcareous algae, ostracods, dinoflagellates, pollen and spores in hydrocarbon exploration; Granulometric analysis, seismic facies analysis, seismic profile interpretation, preparation of different lithologs; Interpretation of different well log data from different sedimentary environment with the use of Electro-logging (SP, GR, resistivity, Neutron, Density, Dipmeter etc); Core sample studies (identifications of sedimentary structures, lithology, facies and paleoenvironment from core data); Time corrections applied to seismic data; Preparation of synthetic seismograms and calibration of well data; Laboratory analysis related to coal bed methane studies.

Books Recommended:

- Amadei, B. (1997) Rock Stress and its Measurement, Chapman & Hall, London.
- Baker, R.A (2001) Primer of Oil well Drilling: A basic text of oil and gas drilling, Petroleum Extension Service, University of Texas at Austin.
- Barwis, J.H. (1990) Sandstone Petroleum Reservoir, Springer-Verlag, Berlin.
- Berg, R.R. (1986) Reservoir Sandstones, Prentice Hall, New Jersey.
- Bhandari, L.L., Venkatachala, B.S., Kumar, R., Swamy, S.N., Garga, P. and Srivastava, D.C. (Eds.) (1983) Petroliferous Basins of India, Petroleum Asia Journal, Himachal Times Group.
- Biswas, S.K., Dave, A., Garg, P., Pandey, J., Maithani, A. and Thomas, N.J. (Eds.) (1993) Proceedings of 2nd Seminar on Petroliferous Basins of India, Dehra Dun, Dec.18-20, 1991, Vol. 1, 2 and 3, Indian Petroleum Publishers, Dehra Dun.
- Bordenave, M.L. (Ed.) (1993) Applied Petroleum Geochemistry, Editions Technip, Paris.
- Chilinger, G.V. and Vorabutr, P. (1981) Drilling and Drilling Fluids, Elsevier Science, Amsterdam.
- Deutsch, C.V. (2002) Geostatistical Reservoir Modelling, Oxford University Press, Oxford.
- Durable, O. (1998) Geostatistics in Petroleum Geology, AAPG Cont. Education Course Note Series 38.
- Asquith, G. and Gibson, C. (1982) Basic Well Log Analysis for Geologists, Academic Press, London.
- Goovaerts, P. (1997) Geostatistics for Natural Resources Modelling, Oxford University Press, Oxford.
- Guegen, Y. and Palciauskas, V. (1994) Introduction to Physics of Rocks, Princeton University Press.
- Gupta, P.K. and Nandi, P.K. (1995) Well Site Geological Techniques and Formation Evaluation: A User's Manual, Vol. I, Oil and Natural Gas Corporation, Dehra Dun.
- Hyne, N.J. (2001) Nontechnical Guide to Petroleum Geology, Exploration, Drilling and Production, 2nd edition, Pennwell Corporation, Tulsa, Oklahoma.
- Jaeger, J.C. and Cook, N.G.W. (1979) Fundamentals of Rock Mechanics, Chapman & Hall, London.
- Levenson, A.L. (1970) Geology of Petroleum. Freeman and Company.
- Rider, M.H. (1985) The Geological Interpretation of Well Logs, Blackie, London.
- Mallet, J.L. (2002) Geomodelling, Oxford Univ. Press, Oxford.
- Moore, C.H. (2001) Carbonate Reservoirs, Elsevier, Amsterdam.
- Serra, O. (2003) Well Logging and Geology, Editions Technip, Paris.
- Serra, O. (1984) Fundamentals of Well Log Interpretation, Vol.1 and 2. Elsevier.

Peters, K.E., Walters, C.C., Moldowan, J.M. (2005) *The Biomarker Guide (Vol. 1 & 2)*, Cambridge University Press, Cambridge.

Bateman, R.M. (1985) *Open Hole Log Analysis and Formation Evaluation*, Reidel, Dordrecht.

Ransom, R.C. (1995) *Practical Formation Evaluation*, John Wiley & Sons, New York.

Sahay, B., Rai, A. and Ghosh, M. (1984) *Wellsite Geological Techniques for Petroleum Exploration*, Oxford & IBH, New Delhi.

Schlumberger Manual Log Interpretation Principles/Applications, Vol. 1 & 2, Schlumberger Education Services, New York, 1989.

Selley, R.C. (1998) *Elements of Petroleum Geology*, II Edition. Academic Press.

Singh, L. (2000) *Oil and Gas Field of India*, Indian Petroleum Publishers, Dehra Dun.

Tiab, D. and Donaldson, E.C. (1996) *Petrophysics: Theory and Practice of Measuring Reservoir Rock and Fluid Transport Properties*, Gulf Publishing Company, Houston, Texas.

Tissot, B.P., Welte, D.H. (1984) *Petroleum Formation and Occurrence*, Springer-Verlag, Berlin.

Welte, D.H., Horsfield, B., Baker, R. (Eds.) (1997) *Petroleum and Basin Evolution: Insights from Petroleum Geochemistry, Geology and Basin Modeling*, Springer-Verlag, Berlin.

Whittaker, A. (1991) *Mud Logging Handbook*, Prentice-Hall, Englewood Cliffs.

Yarus, J.M. and Chambers, R.L. (Ed) (1994) *Stochastic Modelling and Geostatistics, Principles, Methods and Case Studies*, AAPG Computer Applications in Geology, No 3.

Zimmerle, W. (1995) *Petroleum Sedimentology*, Kluwer Academic Publishers, Dordrecht.

Paper-IV (Optional)

2. Elements of Mining and Drilling Techniques

Unit I:

Types of mines and the various mine workings; Method of breaking the rocks; Blast holes and their patterns; Blasting practices; Explosives used in mining; Subsidence and supporting of mine opening's; Transportation-haulage and hoisting; Mining machinery; Mine drainage; Ventilation and illumination.

Unit II:

Mine development; Methods of shaft sinking; Underground mining methods for metallic and non-metallic minerals; Underground coal mining methods.

Unit III:

Surface mining methods; Choice of mining method; Alluvial mining methods; Miscellaneous methods including solution methods and leaching methods, Sea bed mining for manganese nodules and coal bed methane; Mine organization; Safety measures in open cast and underground mines; Rescue work, welfare measures.

Unit IV:

Fundamentals of drilling; Purpose and applications of drilling; Brief idea about various common drilling techniques such as rotary, percussive and diamond drilling and their use; Factors influencing drilling; Drilling equipments and their use; Drilling bits: Coring and non-coring, blade bits, roller-cutter bits and diamond bits; Drilling fluids (flushing media); Casing and casing-string design; Coring: rotary and wire line, diamond core drilling, reverse circulation drilling, cable tool drilling, chip coring; Preservation of cores; Problems encountered in drilling (surface and underground) and remedies; Fishing and fishing tools; Deviation in drill holes: their measurements and correction; Directional drilling; Cementing of holes.

Books Recommended :

Elements of Mining and Drilling Techniques:

- McKinstry, H.E. (1972) Mining Geology. Prentice-Hall Inc.
- Arogyaswamy, R.N.P. (1995) Courses in Mining Geology. Oxford and IBH Publishing Co., New Delhi.
- Thomas, L.J. (1978) An Introduction to Mining. Methuen, Brisbane.
- Clark, G.B. (1967) Elements of Mining. Asia Publishing House.
- Young, G.J. (1946) Elements of mining
- Peele, R. and Church, J.A. (1967) Handbook of mining (Vol. I and II) Wiley Eastern Ltd. New Delhi.
- Shevyakov, L.S. (1957) Mining of Mineral Deposits. Foreign Languages Publishing House, Moscow
- Lewis, R.S. (1964) Elements of Mining. John Wiley.
- Scott, J. (1967) Mining. Mir Publishers, Moscow.
- Chugh, C.P. (1983) Manual of Drilling Technology. Oxonian Press Pvt. Ltd.
- Chugh, C.P. (1984) Diamond Drilling. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
- Chugh, C.P. (1992) High Technology in Drilling and Exploration. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
- Chugh, C.P. (1995) Drilling Technology Handbook. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Paper-IV (Optional)

3. Marine Geology and Oceanography

Unit I:

History of development of marine geology; Origin of ocean basins; A brief account of tectonic history of the oceans; Oceanic crust; Deep ocean-floor topography; Morphology of ocean margins; Marine sediments, sources and composition, sediment types and distribution; Oceanic sediments and microfossils; Deep sea sediments and their relation to oceanic processes such as productivity, solution and dilution.

Unit II:

Oceanic circulation - Surface, intermediate and deep ocean circulation; Forces that produce and effect circulation patterns in world oceans; Important phenomena associated with surface circulation; Formation and movement of deep and bottom waters; Sedimentation rates; Calcite and aragonite compensation depth.

Unit III

Methods and instruments for exploring the ocean floor; Deep Sea Drilling Project (DSDP), Ocean Drilling Programme (ODP) and Joint Global Flux Studies (JGOFS) and their major accomplishments. Integrated Ocean Drilling Programme (IODP) and its aims and objectives; Sediment distribution in time and space as related to tectonic models; Marine stratigraphy, correlation and chronology; Deep sea hiatuses and their causes; Approaches to paleoceanographic and paleoclimatic reconstructions; Paleoceanographic changes in relation to earth system history including impact of the oceans on climate change.

Unit IV:

Evolution of oceans through the Cenozoic; Ocean gateways and their role in controlling global climates; Sea level changes during Quaternary with special reference to India; Reconstructing Quaternary climatic and oceanographic history on shorter time scales using marine records; Mineral resources of the ocean including polymetallic nodules; Hydrocarbons beneath the sea floor; Marine gas hydrates and their economic potential; Marine pollution and interpreting marine pollution with the help of microfossils.

Practicals:

Sedimentary facies; Bio facies; Depth biotopes and estimation of paleodepth of the ocean using benthic foraminiferal assemblages; Identification of modern and ancient surface water mass with the help of planktic foraminiferal assemblages; Identification of benthic foraminifera characteristic of Low oxygen environment; Identification of planktic foraminifera characteristic of warm and mixed layer, thermocline and deep surface water of the modern oceans; Study of modern surface water, mass assemblages of planktic foraminifera from Indian ocean, Atlantic ocean and Pacific ocean.

Books Recommended:

Kennett, J.P. (1982) Laboratory Exercises in Oceanography Marine Geology, Prentice Hall.
Seibold, E. and Berger, W.H. (1982) The Sea Floor, Springer-Verl