M.Sc. Program (Semester I&II) in Geology

(Scheme Teaching and examination under semester pattern NEP 2020)

SEMESTER I

Major and Elective Paper, Code	Theory / Practical	Teaching Scheme			Credit	Examination Scheme					
		Hours/ week				Duration in hrs.	Max. Marks		Total	Minimum Marks	
		Theory	Practical	Total			External	Internal		Theory	Practical
Major I, (PSCGEOT01)	Paper I	4		4	3	4	80	20	100	40	
Major II, (PSCGEOT02)	Paper II	4		4	3	4	80	20	100	40	
Major III, (PSCGEOT03)	Paper III	4		4	3	4	80	20	100	40	
(Select any one) Elective, PSCGEOE- Papers 01to 05	Paper IV	4		4	3	4	80	20	100	40	
Practical I, PSCGEOP01	Practical 1		4	4	2	4	75	25	100		50
Practical II, PSCGEOP02	Practical 2		4	4	2	4	75	25	100		50
Research Methodology, RMGEOT05	Paper I	4		4	3	4	80	20	100	40	
Seminar	Theory	--	--	--	1	1	--	50	50	--	--
TOTAL		**20**	**8**	**28**	**20**	**29**	**550**	**200**	**750**	**200**	**100**

SEMESTER II

Major and elective Paper,Code	Theory / Practical	Teaching Scheme			Credit	Examination Scheme					
		Hours/ week				Duration in hrs.	Max. Marks		Total	Minimum Marks	
		Theory	Practical	Total			External	Internal		Theory	Practical
Major I, PSCGEOT04	Paper IV	4		4	3	4	80	20	100	40	
Major II, PSCGEOT05	Paper V	4		4	3	4	80	20	100	40	
Major III, PSCGEOT06	Paper VI	4		4	3	4	80	20	100	40	
(Select any one) Elective PSCGEOE- Papers 06 to 10	Paper V	4		4	3	4	80	20	100	40	
Practical III, PSGEOP03	Practical 3	--	4	4	2	4	75	25	100	--	50
Practical IV, PSGEOP04	Practical 4	--	4	4	2	4	75	25	100	--	50
OJT/FP (On Job Training, Internship/Apprenticeship/Field Project), OJT, GEO-01	Paper II	4	--	4	3	4	80	20	100	40	--
Seminar	Theory	--	--	--	1	1	--	50	50	--	--
TOTAL		**20**	**8**	**28**	**20**	**29**	**550**	**200**	**750**	**200**	**100**

Note- Internal assessment will be based on actual field work with or without collaborated in GSDA, GSI, other Geological organization and also work with NGO's for the rural development.

Eligibility to the course

Subject to their compliance with the provisions of this direction and of other ordinances in force from time to time, the following applicant candidates shall be eligible for the admission to Master of Science and examinations thereof.

Eligibility for Semester I

For M.Sc. Geology for admission to the M. Sc. Semester I in Geology, a candidate shall have offered Geology as one of the subject at the B.Sc. level.

General Instructions

- Theory examination for all Semesters will be at university level
- The examination of Semester I shall comprise of five theory papers of 3 hours duration of 80 marks each. Twenty marks will be allotted for internal assessment for each theory paper.
- The examination of Semester II shall comprise of four theory papers of 3 hours duration of80 marks each. Twenty marks will be allotted for internal assessment for each theory paper.
- Question paper will consist of five questions and each question will be of 16 marks.
- Five questions will be based on four units with internal choice.
- Fifth question will be compulsory with questions from each of the four units havingequal weightage and there will be no internal choice.
- Practical examination will be of 3 hours duration and separately for each semester having80 marks each and 20 marks for internal assessment.
- Practical Examinations for Odd Semester and for Even semester both will be at universitylevel with external examiners.
- The examinee shall be required to pass in theory and practicals separately.
- The marks will be given for all examinations and they will be converted into grade points.The final grade card will have marks, credits, grades, grade points, SGPA and CGPA.
- Practical examination: 75 marks + 05 mark Viva-voce+ 20 marks internal examination and Class Record

Gondwana University, Gadchiroli

FACULTY OF SCIENCE & TECHNOLOGY

As per National Education Policy – 2020

Syllabus

M.Sc. (Geology)

Semester I & II

(Two Years Degree Course)

Prepared by

Board of Studies in Geology
Gondwana University, Gadchiroli

(2023 – 24)

Distribution of Courses for M.Sc. Semester I Geology

M.Sc. Semester I		
Sr. No	**Course Title**	**Paper Title**
1	Major Paper I	Paper I. Mineralogy and Crystallography (4)
2	Major Paper II	Paper II: Igneous Petrology (4)
3	Major Paper III	Paper III Metamorphic Petrology and Geological Mapping (4)
4	Major-Elective (I)	Paper 1 Stratigraphy and Indian Geology (4)
5	Major Elective (II)	Paper 2 Mining Geology and Valuation of Mineral Property (4)
6	Major Elective (III)	Exploration Geochemistry (4)
7	Major Elective (IV)	Mineral Exploration (4)
8	Major Elective (V)	Quaternary Geology and Limnogeology (4)
9	Research Methodology	Research Methodology in Geology (RM-4)

Major Paper-1 (Mandatory)

Mineralogy and Crystallography

(PSCGEOT01)

Unit I:

Isotropic and anisotropic substances; Reflection, refraction and refractive index; Relief, birefringence and Becke line effect; Optically uniaxial and biaxial minerals; Determination of optic sign of uniaxial and biaxial minerals; interference figures; Pleochroism and determination of pleochroic scheme in minerals; X-ray crystallography and Bragg's equation; Application of X-ray diffraction spectrometry in mineral characterization; Application of following techniques in mineralogy: Differential Thermal Analysis (DTA), Thermogravimetric Analysis (TGA), Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Electron Probe Micro Analyser (EPMA); Application of thermal, magnetic and radioactive properties of minerals.

Unit II:

Principle of crystal structure; Bonding in minerals; Coordination and co-ordination numbers; Silicate structures and structural formula; Isomorphism and solid solution; Types of ionic substitution; Polymorphism and types of polymorphic transformations; Pseudomorphism; Conversions of oxide and element weight percentages; Calculation of mineral formulae.

A detailed study of following mineral groups with reference to their general formulae, classification, atomic structure, chemistry, experimental work and paragenesis:

Non-silicates: Carbonates- Calcite Group, Aragonite Group, Dolomite Group; Phosphates- Apatite, Monazite; Sulphates- Gypsum, Anhydrite, Barite, Alunite Group; Halides- Halite, Sylvite, Fluorite; Nitrates- Trona, Soda niter; Oxides and Hydroxides- Spinel Group, Hematite Group, Rutile Group, Bauxite Group, Periclase.

Unit III:

A detailed study of following mineral groups with reference to their general formulae, classification, atomic structure, chemistry, experimental work and paragenesis:

Silicates: Nesosilicates- Olivine Group, Garnet Group and Aluminosilicate Group; Sorosilicates- Epidote Group, Scapolite Group; Cyclosilicates- Beryl, Tourmaline; Inosilicates- Pyroxene Group, Amphibole Group; Phyllosilicate- Mica Group, Chlorite Group, Serpentine Group, Pyrophyllite, Talc; Tectosilicates- Quartz, Feldspars, Feldspathoides and zeolite Group.

Unit IV:

Crystals, crystalline solids and their formation; Ordered patterns, nets and lattices; Symmetry in crystals; Axial ratio, indices, lettering and order of the crystallographic axes; Crystallographic notation (Weiss and Miller indices and convention in notation); Classification of crystals-introduction to 32 classes of symmetry; The crystal systems and symmetry types; Stereographic representation of crystal symmetry and their uses; Imperfection of crystals and crystal defects; Twinning- causes, effects and genetic types.

Practicals:

Study of rock forming minerals in hand specimen and thin sections: Physical and optical properties of common rock forming minerals; Study of Becke line; Determination of refractive indices and birefringence; An-content of plagioclase; Pleochroism and Dichroism: pleochroic scheme of tourmaline, biotite, hornblende, actinolite, glaucophane, hypersthene, aegirine, andalusite and other silicate minerals; Use of Berek Compensator (and other Compensators), Quartz wedge and gypsum plate; Determination of length-fast and length-slow character of minerals; Study of Interference figures of uniaxial and biaxial minerals and determination of optic sign; Refractive Index determination by immersion method; Interpretation of X-ray diffractograms of common minerals and components of the bulk rocks; Stereographic projection of crystals.

Books Recommended:

Mineralogy and Mineral Optics:

Battey, M.H. (1981) Mineralogy for students 2nd Edn. Longmans.

Berry, L.G. and Mason, B. and Dietrich, R.V. (1983) Mineralogy, 2nd Edn,Freeman. Bunn, C.W. (1961) Chemical Crystallography, Clarendon.

Donald Bloss (1971) Crystallography and Crystal chemistry, Holt, Rinehart and Winston.

Deer, W.A., Howie, R.A., and Zussman, J. (1992) An Introduction to the rock forming minerals, Longman.

Hutchinson, C.S. (1974) Laboratory Handbook of Petrographic Techniques, JohnWiley. Klein, C. and Hurlbut, Jr., C.S. (1993) Manual of Mineralogy, John Wiley. Kerr, P.F. (1977) Optical Mineralogy 4th Edn., McGraw-Hill

Phillips, Wm, R. and Griffen, D.T. (1986) Optical Mineralogy, CBS Edition.

Putnis, Andrew (1992) Introduction to Mineral Sciences, Cambridge University Press. Santosh, M. (1988) Fluid Inclusions, Geological Society of India, Banglore.

Spear, F.S. (1993) Mineralogical Phase Equilibria and Pressure -Temperature-Time Paths, Mineralogical Society of America Publication.

Winchell, A.N. (1962) Elements of Optical Mineralogy, John Wiley.

Slemmons, D.B. (1962). Determination of Volcanic and Plutonic Plagioclases using a three- or Four-Axis Universal Stage, Geological Society of America.

Szymanski, A. (1988). Technical Mineralogy and Petrography, Elsevier.

Hota, R.N. (2011) Practical Approach to Crystallography and Mineralogy, CBS Publisher andDistributors Pvt Ltd., New Delhi.

Major Paper-2 (Mandatory)
Igneous Petrology

PSCGEOT02

Unit I:

Magma- its nature and composition. Factors controlling evolution of magma; Introduction to mantle petrology mantle metasomatism and mantle heterogeneities; Magmatism in relation to plate tectonics; Chemical characteristics of igneous rocks in the following tectonic setting: Mid Oceanic Ridge, Island Arcs, Oceanic plateaus, Continental Margins, Continental Rifts and Continental intraplates; Plume magmatism and hot spots; Large igneous provinces, mafic dyke swarms and layered complexes.

Unit II:

Mantle melting: Partial melting (batch and fractional melting); Crystal fractionation (equilibrium and fractional (Rayleigh) crystallization); Contamination (AFC process) and dynamic melting.
Crystallisation of magma, fractional crystallization and differentiation, liquid immiscibility and assimilation. Influence of volatiles and role of oxygen fugacity in magmatic crystallizations; Phase equilibrium studies - binary systems, ternary systems and their relations to magma genesis and crystallization in the light of modern experimental works.

Unit III:

Textures and structures of igneous rocks; Petrography and Interpretation of igneous textures in terms of rate of nucleation and crystal growth; Major, Trace and Rare Earth Element systematics in igneous rocks; Silica/alumina saturation, variation diagrams (Harker, AFM and TAS diagrams) their applications and limitations; Mg Number, Alteration Index, Saturation Index and other geochemical parameters; Fractional crystallization, liquid lines of descent and lever rule.

Unit IV:

IUGS classification of igneous rocks (QAPF diagram); weight norm, cation norm; Petrology and petrogenesis of major igneous rock types with Indian examples of ultramafic, komatiite, basalt, granite, pegmatite, alkaline rocks, anorthosite, spilite, boninite, carbonatite, kimberlite, lamproite, lamphrophyre and charnockite.

Practicals:

Megascopic and microscopic study of different igneous rocks; Calculation of CIPW norms; Modal analysis; Exercises on Crystal Fractionation of Igneous Rock Suites. Exercises on Partial Melting of Igneous Rock Suites. Preparation and description of variation diagrams. Exercises on theconstruction and interpretation of Spider diagrams of N-type MORBs, E-type MORBs, OIBs, etc.

Books Recommended:

Best, M. G. (2003) Igneous and Metamorphic Petrology, 2nd Edn.,
Blackwell. Bose, M.K. (1997) Igneous Petrology, World Press, Kolkata.

Cox, K. G., Bell, J. D. and Pankhurst, R. J. (1979) The Interpretation of Igneous Rocks,
UnwinHyman. Faure, G. (2001) Origin of Igneous Rocks, Springer.
Hall, A. (1996) Igneous Petrology, 2nd Edn., Longman.

LeMaitre R.W. (2002) Igneous Rocks: A Classification and Glossary of Terms, Cambridge Uni.Press. McBirney, A.R. (2006) Igneous Petrology, 3rd Edn., Jones & Bartlett.

Middlemost, E.A.K. (1985) Magmas and Magmatic Rocks, Longman.

Parfitt, E. and Wilson, L. (2008) Fundamentals of Physical Volcanology, Wiley-Blackwell. Phillpotts, A.R. (1994) Principles of Igneous and Metamorphic Petrology, Prentice Hall ofIndia. Sood, M.K. (1982) Modern Igneous Petrology, Wiley-Interscience Publ., New York.

Srivastava, R.K. and Chandra, R. (1995) Magmatism in Relation to Diverse Tectonic Settings, A.A. Balkema, Rotterdam.

Wilson, M. (1993) Igneous Petrogenesis, Chapman and Hall, London.

Winter, J.D. (2001) Introduction to Igneous and Metamorphic Petrology, Prentice-Hall. Bell, Keith (Ed.) (1989) Carbonatites: Genesis and Evolution, Unwin Hyman, London.

Bell, K., Kjarsgaard, B.A. and Simonetti, A. (1998) Carbonatites – Into the twenty-first Century,Journal of Petrology, Spl. Vol.39 (11 & 12).

Carmichael, J., Turner and Verhoogen (1974) Igneous Petrology, McGraw Hill.

Fitton, J.G. Upton, B.J.G. (Eds) (1987) Alkaline Igneous Rocks, Geological Society,London. LeBas, M.J. (1977) Carbonatite-nephelinite Volcanis, Wiley.

Rock, N.M.S., (1991) Lamprophyres, Blackie, lasgow.

Perchuk, L.L. and Kushiro, I. (Eds.) (1991) Physical Chemistry of Magmas, SpringerVerlag. Gupta, Alok (1998) Igneous Rocks, Allied Publishers Limited.

Allegre, C.J. and Hart, S.R. (1979) Trace elements in Igneous Petrology, Elsevier.Hughes, C.J. (1982) Igneous Petrology, Elsevier.

Hota, R.N. (2011) Practical Approach to Petrology, CBS Publisher & Distributors Pvt Ltd., New Delhi.

Major Paper-3 (Mandatory)

Metamorphic Petrology and Geological Mapping

PSCGEOT03

Unit I:

Metamorphism: Nature and scope; Factors controlling metamorphism (T, P and fluids); Types of metamorphism: Regional, contact, dynamic, hydrothermal, impact, retrograde and ocean floor metamorphism; Transient geotherm, and pressure-temperature regimes; Protolith types and characteristic metamorphic minerals; metamorphic textures.

Unit II:

Metamorphic facies and sub-facies series; metamorphic zones; regional metamorphism of pelitic, carbonate and mafic rocks; high grade metamorphism of granulite and eclogite; Metamorphic differentiation, metasomatism and granitization, anatexis and origin of migmatites, granites, charnokites, amphibolites in the light of experimental studies; Ultra high temperature and ultra high pressure (blue schist) metamorphism; Pressure – temperature – time paths and metamorphic terrains in relation to plate tectonics; Regional metamorphism and Paired metamorphic belts; Relationship of metamorphic rocks and associated mineral deposits; Tectonic controls of metamorphism.

Unit III:

Thermodynamic principles of metamorphic reactions, Mineralogical phase rule for closed and open systems; Gibb's free energy, entropy, enthalpy, activity and fugacity of metamorphic reactions (solid-solid and dehydration reactions); Clausius – Clapeyron equation; Isograds and reaction isograds; Role of fluids, Nucleation and growth in solids kinetics of metamorphic reactions, Arrhenius relations, diffusion and interface controlled reactions; Experimental studies on metamorphic reactions; Concepts of geothermometry and geobarometry; Metamorphic projections in positive and negative space; ACF, AKF and AFM diagrams; Schrienemakers rule and construction of petrogenetic grids.

Unit IV:

Objectives of Geological mapping, precision required in geological mapping; Topographic maps and base maps for geological mapping, topographic maps and their numbering by Survey of India; Types of geological maps and sections; Geological symbols in maps; General principles of geological mapping; Mapping methods in sedimentary, igneous and metamorphic terrains.

Practicals:

Metamorphic Petrology:

Study of metamorphic rocks of different metamorphic facies in hand specimens; Detailed study of textures in thin sections with reference to time relations between the phases of deformation and recrystallization of minerals; Calculation of ACF, AKF and AFM values from chemical and structural formulation of minerals and their graphical representation; Construction of petrogenetic grid; Estimation of pressure and temperature from important models of geothermobarometry.

Geological Mapping:

Study of topographical survey sheets of Survey of India.

Books Recommended:

Metamorphic Petrology:

Harker, Alfred (1964) Metamorphism, Methuen, London.

Turner, F.J. (1980) Metamorphic Petrology, McGraw Hill, New York.

Yardlley, B.W.D. (1989) An introduction to Metamorphic Petrology, Longman Scientific and Technical, New York.

Philopotts, A.R. (1994) Principles of Igneous and Metamorphic Petrology, PrenticeHall. Bhaskar Rao, B. (1986) Metamorphic Petrology, IBH & Oxford.

Kretz, R. (1994) Metamorphic Crystallization, John Wiley.

Blatt, H. and Tracy, R.J. (1996) Petrology (Igneous, Sedimentary, Metamorphic), W.H. Freeman andCo., NewYork.

Bucher, K. and Frey, M. (2002) Petrogenesis of Metamorphic Rocks (7th Rev. Ed.), Springer–Verlag.

Powell, R. (1978) Equilibrium thermodynamics in Petrology: An Introduction, Harper and Row Publ.,London.

Spear, F.S. (1993) Mineralogical Phase Equilibria and pressure – temperature – time Paths, Mineralogical Society of America.

Wood, B.J. and Fraser, D.G. (1976) Elementary Thermodynamics for Geologists, Oxford UniversityPress, London.

Stuwe, K. (2007) Geodynamics of the Lithosphere. Springer-Verlag. Spry, A. (1976) Metamorphic Textures, Pergamon Press.

Winter, J.D. (2001) An introduction to Igneous and Metamorphic Petrology, Prentice Hall.

Yardley, B.W.D., Mackenzie, W.S. and Guilford, C. (1995) Atlas of Metamorphic Rocks and theirtextures, Longman Scientific and Technical, England.

Geological Mapping:

Mathur, S.M. (2001) Guide to Field Geology, Prentice-Hall, New Delhi Compton, R.R. (1962) Manual of Field Geology. John Wiley and Sons, Inc. Lahi, F.H. (1987) Field Geology, CBS Publishers.

Forrester, J.D. (1957) Principles of Field Geology and Mining Geology. John Wiley.

Electives Paper- 01 (Optional)
Stratigraphy and Indian Geology

PSCGEOE-01

Unit I:

Approaches to measurement of geological time; Stratigraphic Principles and concept of Litho, Bio and Chrono Stratigraphy, brief idea about sequence, magneto- seismic- chemo- and event stratigraphy; Stratigraphic correlations; Precambrian chronostratigraphy of Aravalli craton, Dharwar craton, Eastern Ghats mobile belt, Bastar Craton, Southern Granulite belt and Singhbhum craton.

Unit II:

Proterozoic stratigraphy of Cuddapah, Vindhyan, Godavari Supergroup and their equivalents; Precambrian/Cambrian boundary. Concept, classification, fauna, flora and age limits of Gondwana Supergroup and related paleogeography, paleoclimate, depositional characteristics and igneous activities.

Unit III:
Classification, depositional characteristics, fauna, and flora of Triassic, Jurassic and Cretaceous systems in major basins of India; Stratigraphy of Deccan Trap, Permian/Triassic boundary.

Unit IV:
Classification, depositional characteristics, fauna, and flora of the Palaeogene, Neogene and Quaternary systems and their equivalents in India; Epoch boundaries of the Cenozoic in India. Cretaceous/Tertiary boundary. Paleogene/ Neogene boundary.

Practicals:

Study of rocks in hand specimens from known Indian stratigraphic horizons; Exercises on stratigraphic classification and correlation, sequence, magneto and seismic stratigraphic interpretations; Study and understanding of plate-movements through important periods during Phanerozoic eon; Evolution of ocean systems during Phanerozoic.

Books Recommended:

Boggs, S. (2001) Principles of Sedimentology and Stratigraphy, Prentice Hall.
Danbar, C.O. and Rodgers, J. (1957) Principles of Stratigraphy, John Wiley andSons.

Doyle, P. and Bennett. M.R. (1996) Unlocking the Stratigraphic Record, John Wiley and Sons.Krishnan,M.S. (1982) Geology of India and Burma, C.B.S. Publ. and Distributors, Delhi.
Naqvi, S.M. and Rogers, J.J.W. (1987) Precambrian Geology of India, Oxford UniversityPress.

Pascoe, E.H. (1968) A Manual of the Geology of India and Burma (Vols.I-IV), Govt. of India Press,Delhi.

Pomerol, C. (1982) The Cenozoic Era: Tertiary and Quaternary, Ellis Harwood Ltd., Halsted Press. Schoch, Robert, M. (1989) Stratigraphy: Principles and Methods, Van Nostrand Reinhold, New York.Ramakrishnan, M. and Vaidyanadhan, R. (2008) Geology of India, Vol.1, Geological Society of India, Bangalore.

Vaidyanadhan, R. and Ramakrishnan, M. (2008) Geology of India, Vol.2, Geological Society of India,Bangalo

Electives Paper- 02 (Optional)
Mining Geology and Valuation of Mineral Property

PSCGEOE-02

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.

Unit II:

Underground exploration methods in mining; Location of 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 III:

Types of mineral properties for valuation; Objectives of valuation; Stages of mineral exploration and need for valuation; Basic features in valuation of a mineral property; Examination of mineral property and the past records.

Importance of sampling in valuation theory of sampling, bias in sampling; Methods of sampling mineral deposits- types of samples and their collection during trenching, pitting and drilling; logging and storage; Methods of combining the assays of core and sludge samples; methods of collection, recording and presentation of sample data; Salting of samples and safeguards; Reduction of sample for testing; Types of grades of ore, sample weightage and calculation of average grades; Statistical methods in the estimation and use of range of grades, variance, standard deviation, skewness, standard error of mean; Basic concepts about the use of variogram and krigging; Geostatistics for overall grade estimation.

Unit IV:

Use of cut-off grade in outlining ore; Classification of ore reserves and mineral resources; Methods inestimation of ore reserves and limitations; Use of computers in ore reserve estimation; Value of ore based on recoverable value and smelter schedule; Costs in the production of ore- direct costs and indirect costs, depreciation cost and depletion cost; Alternate methods of amortization, pay back period, future costs and future profits, present value of future profits; life of the mine, deferment period and discount for hazards in mining, Hoskold formula; Net value of prospects; Developed mines and working mines; Estimation of profitability of a mineral prospect; Discounted cash flow return on investments; Valuation report.

Practicals:

Preparation of mine plan; Sampling problems: Calculation of average assay value by using sampling data obtained by drilling and by sampling in underground mine workings; Calculation of ore reserves by various methods; Calculation of present value / net value of a prospect, developed mine (non producing) and a developed and producing mine.

Books Recommended:

Mining Geology and Valuation of Mineral Properties:

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.

Electives Paper- 03 (Optional)
Exploration Geochemistry
PSCGEOE-03

Unit I:

Geochemical concepts – terminology and their definitions in geochemical exploration; Back ground, threshold, anomaly; Primary and secondary environments and dispersion, additive, leakage and diffused halos; Zoning, mobility, migration, indicator and pathfinder elements; Mineral pathfinders.

Unit II:

Sampling techniques – pitting, trenching, augering, core sampling, bulk sampling, chip sampling, channel sampling, grid sampling, reconnaissance and detailed sampling, composite and selective sampling, logarithmic sampling (mine scale), ridge and spur sampling; Contamination, Pacing in the field.

Unit III:

Geochemical techniques in exploration – lithogeochemical, pedogeochemical, hydrogeochemical, biogeochemical, atmogeochemical and stream sediment surveys; Regional and detailed surveys.

Unit IV:

Area selection and sequential exploration model; General geochemical survey procedure; Geochemical conceptual models; Geochemical, metallogenic and biogeochemical provinces, geochemical associations, geochemical relief, productive plutons; Vegetation anomaly; Precision and accuracy.

Practicals:

Geochemical isoconcentration contour maps; Geochemical exploration problems with type areas; Identification of Fluoroscent minerals; Interpretation of Geochemical data using probability graphs; Geochemical modelling problems.

Books Recommended:

Govett, G.J.S. (1983). Rock Geochemistry in mineral exploration, Vol.3. Elsevier Scientific Publishing Company.
Govett, W.K., Hoffman, S.J., Merthens, M.B., Sinclair, A.J. and Thomson, I. (1987). Exploration Geochemistry, Design and Interpretation of Soil Survey. Reviews in Economic Geology, Vol.4.
Hale, M. and Plant, J.A. (1994) Handbook of Exploration Geochemistry – Drainage Geochemistry, vol6, Elsevier Scientific Publishing Company.
Levinson, A.A. (1974) Introduction to Exploration Geochemistry, Applied Publishing Ltd.
USA.Reedman, J. H. (1979) Techniques in mineral exploration. Applied Science Publishers.
Rose, Arthur W., Herbert, E. Hawkes and Webb, John S. (1979) Geochemistry in Mineral Exploration. 2nd edition, Academic Press.
Solov, A.P. (1987) Geochemical Prospecting. Mir Publishers, Moscow.

Electives Paper- 04 (Optional)
Mineral Exploration

PSCGEOE-04

Unit I:

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; Brief idea about 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 II:

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: lithogeochemical, pedogeochemical, 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 III:

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

Gravity method: Variation of gravity over the surface of the earth; Principle of gravimeters; Gravity field surveys; Various types of corrections applied to gravity data; Preparation of gravity anomaly maps and their interpretation in terms of shape size and depth of the causative body.

Magnetic method: Geomagnetic field of the earth; Magnetic properties of rocks; Working principle of magnetometers; Field surveys and data reductions; Preparation of magnetic anomaly maps and their quantitative interpretation; Magnetic anomalies due to single pole and dipole; Introduction to Aeromagnetic survey; Three dimensional current flow, potential due to a point current source.

Electrical methods: S.P. and I.P. method; Resistivity method: Basic principles, various types of electrode configurations; Field procedure: profiling and sounding; Application of electrical methods in ground water prospecting and civil engineering problems.

Unit IV:

Seismic methods: fundamental principles of wave propagation, refraction and reflection surveys for single interface, horizontal and dipping cases; Concept of seismic channel and multi-channel recording of seismic data; End-on and split spread shooting techniques CDP method of data acquisition, sorting, gather, stacking and record section seismic velocity and interpretation of seismic data application in mineral and petroleum exploration.

Radioactivity methods: Alpha, beta, gamma radiation sources; Field equipment and procedures.
Description of borehole environment; Brief outline of various well-logging techniques: Principles of electrical logging and its application in petroleum, groundwater and mineral exploration.

Practicals:

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

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:

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,Banglore.

Electives Paper- 05 (Optional)
Quaternary Geology and Limnogeology

PSCGEOE-05

Unit I:

Aim, objectives and utility of Quaternary studies. Quaternary Stratigraphy. Evolution of man and cultural stages. Morphostratigraphy. Oxygen isotope stages in geological thermometers and marine sedimentary records and glacial and interglacials. Quaternary deposits in India.

Unit II:

Introduction to climatic geology. Significance of paleoclimatic changes, sources of paleoclimate reconstruction. Quaternary Paleoclimate. Causes of ice ages and other climatic changes; Soils and paleosoils and their significance in interpreting Quaternary climates. Quaternary sea level changes. Linkage of the modern climate to past climatic variation (with special emphasis on the Holocene). Evolution of man and cultural stages.

Unit III:

Geochronological methods used in dating Quaternary events (K/Ar and 39Ar/ 40Ar dating, Radiocarbon dating, Thermoluminescence (TL), Cosmogenic radionuclides, U-series, 210Pb, 137Cs, Paleomagnetic dating, Dendrochronology).

Unit IV:

Definition and scope of Limnogeology. Lakes as archives of earth history. Major divisions of lakes. The Geological evolution of lake basins. Chemistry, Ecology and Groundwater Hydrology of Lakes. Advances and Applications of the freshwater fossil Diatoms in limnogeological study. The physical environment of lakes, The chemical environment of lakes; The biological environment of lakes, Age determination in lake deposits, Sedimentological archives in lake deposits. Geochemical archives in lake deposits.

Methods of investigations of lakes: Lead and Cesium Chronology, Radiocarbon Chronology, Oxygen Stable isotopes, Drought Signatures, Tsunami Signatures, Storm Signatures, Anthropogenic Metal Signatures Modelling, Land Use Changes, Earthquake Signatures. Lake sediment records of carbonaceous particles from fossil-fuel combustion. Soot Particle counting: indirect method of lake sediment dating.

Practicals:

Study of palaeogeographic maps of Quaternary period. Standardization of stratigraphic sequences on the basis of facies analysis.

Study of sediment core of lake: cutting, labelling, and sample preparation for geochemical investigations. Preparation of Smear Slide: complete layout for preparation of smear slides and examination with a wild petrographic scope. Process of Maceration of lake/ river sediments to prepare diatom slides. Identification of water quality using sedimentary diatoms. Geochemical archives in lake deposits. Soot Particle counting for lake sediment dating.

Books Recommended:

Quaternary Geology:

Arnold (2002) Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett), Oxford Univ. Press, New York.

Bowen, D.Q. (1978) Quaternary Geology.

Pomerol, (1982) The Cenozoic Era: Tertiary and Quaternary. Ellis Harwood Ltd.

Soil Survey Staff (1992) Keys to soil taxonomy. Vth Edition SMSS Monograph No. 19.

Tiwari, M.P. and Mohabey, D.M. (Eds.) (1999) Quaternary of India. Gondwana Geological Magazine, Spl. Vol. 4.

Oerlemans, J. (2001) Glaciers and climate change. A.A Balkema .

Limnogeology:

Wetzel, R.G. Limnology of Lakes and River Ecosystem. Third Edition.

Benson, L., Kashgarian, M., Rye, R., Lund, S., Paillet, F., Smoot, J., Kester, C., Mensing, S., Meko, D., and Lindström, S. (2002) Holocene multidecadal and multicentennial droughts affecting Northern California and Nevada: Quaternary Science Reviews, v. 21

Kharaka, Y.K., Robinson, S.W., Law, L.M., and Carothers, W.W. (1984) Hydrogeochemistry of Big SodaLake, Nevada; an alkaline meromictic desert lake: Geochimica et Cosmochimica Acta, v. 48

Lebo, M.E., Reuter, J.E., and Meyers, P.A. (1994) Historical changes in sediments of Pyramid Lake, Nevada, USA: consequences of change in the water balance of a terminal desert lake: Journal of Paleolimnology, v.12.

Meyers, P.A., Tenzer, G.E., Lebo, M.E., and Reuter, J.E. (1998) Sedimentary record of sources and accumulation of organic matter in Pyramid Lake, Nevada, over the past 1,000 years: Limnology and Oceanography, v. 43.

Rosen, M.R., Arehart, G.B., and Lico, M.S. (2004) Exceptionally fast growth rate of <100-yr-old tufa, Big Soda Lake, Nevada: Implications for using tufa as a paleoclimate proxy: Geology, v. 32.

Russell, I.C. (1885) Geological History of Lake Lahontan, a Quaternary lake of northwestern Nevada: Washington, United States Geological Survey, 288p.

Taylor, K., Alley, R.B., Fiacco, J., Grootes, P.M., Lamorey, G.W., Mayewski, P.A., and Spencer, M.J. (1992) Ice core dating and chemistry by direct-current electrical conductivity: Journal of Glaciology, v. 38.

Yang, Z.R., Graham, E.Y. and Lyons, W.B. (2003) Geochemistry of Pyramid Lake sediments: influence of anthropogenic activities and climatic variations within the basin: Environmental Geology, v.43.

RESEARCH METHODOLOGY

RM: GENERAL PRINCIPLES, MAPPING TECHNIQUES, COMPUTER TECHNIQUES, SOFTWARE, GEOSTATISTICAL METHODS AND INSTRUMENTATION TECHNIQUES (4)

Unit I:

Objectives of Geological mapping, precision required in geological mapping; topographic maps and their numbering by Survey of India; Topographic maps and base maps for geological mapping, Types of geological maps and sections; Geological symbols in maps; General principles of geological mapping; Mapping methods in sedimentary, igneous and metamorphic terrains.

Unit II:

Introduction to common operating systems; Use of computers and software as tools in the areas of geological problem-solving, report-writing, and presentations; Windows-based software applications including word-processing, spread sheets; Graphing, image manipulation and drawing; Brief idea about computer software used in earth sciences such as Archinfo, ArcGIS, Elvis, QGIS, Mapinfo, Autocad, GCD-kit, Rockware, Rockworks, Igpet, Petrograf, Surfer, Aquachem, Statpack, SPSS, Tilia, Past etc

Unit III:

Universe, Population, Frequency distribution, Skewness and Kurtosis, Arithmatic Mean, Geometric Mean, Variance, Median, Mode, Standard Deviation, Coefficient of Variability, Confidence Interval, Regression, Correlation, Random Data, Krigging and its use in grade estimation. Events, sample space; Random variables, discrete and continuous probability distributions.

Unit IV:

12 Thin section and polished section making; Sample etching, staining and model count techniques; Principle and geological application of Spectrophotometry, Atomic absorption spectrophotometry; Inductively coupled plasma – atomic emission spectrometry, optical emission spectrometry and mass spectrometry; X ray fluorescenece spectrometry; Scanning and transmission electron microscopy; Instrumental Neutron Activation Analysis (INAA); Isotope dilution technique; Electron Probe Micro Analysis (EPMA), X ray defractometry

Books Recommended: GENERAL PRINCIPLES, MAPPING TECHNIQUES

Compton, R.R. (1962) Manual of Field Geology, John Wiley and Sons, Inc.
Forrester, J.D. (1957) Principles of Field Geology and Mining Geology, John Wiley.
Lahi, F.H. (1987) Field Geology, CBS Publishers.
Mathur, S.M. (2001) Guide to Field Geology, Prentice-Hall, New Delhi

Books Recommended: COMPUTER TECHNIQUES, SOFTWARE
No Textbook - only handouts and web pages

Books Recommended: STATISTICAL METHODS

Cooley, W.W. and Lohnes, P.R. (1971) Multivariate data analysis, John Wiley and Sons.
Creighton, J.H.G. (1994) First course in probability models and statistical inference, Springer Verlag.
Davis, J.G. (1986) Statistics and data analysis in geology, John Wiley.
Isaaks, E.A. and Srivastava, R.M. (1990) An Introduction to Geostatistics, Oxford University Press.
Journel, A.G. and Huijbregts, C. (1978) Mining Geostatistics, Academic Press, London.
Chiles, J.P. and Delfiner, P. (1999) Geostatistics: Modeling Spatial Uncertainty, John Wiley & Sons, New York.
Johnson, R.A. and Wichern, D.W. (1982) Applied multivariate statistical analysis, Prentice Hall Inc., New Jersey.
Journel, A.G. and Huijbregts, Ch. (1978) Mining Geostatistics, Academic Press.
Armstrong, M. (1998) Basic linear geostatistics, Springer Verlag, Berlin.
Kubackova, L., Kubacek, L. and Kukuca, J. (1987) Probability and Statistics in Geodesy and Geophysics, Elsevier.
Morrison, D.F. (1967) Multivariate statistical methods, McGraw-Hill.
Pandalai, H.S. and Saraswati, P.K. (Eds.) (2000) Geological data analysis: Statistical Methods, Hindusthan Publishing Corporation (India), New Delhi.
Pitman, J. (1993)Probability, Springer Verlag, (also Narosa Publishers).
Spiegel, M.R. (1982) Probability and Statistics, Schaums Outline Series, McGraw-Hill Int., Singapore, Asian Student Edn.
Walpole, R.E. and Myers, R.H. (1989) Probability and statistics for engineers and scientists, Macmillan Publ. Co.

Books Recommended: INSTRUMENTATION TECHNIQUES

Hota, R.N. (2011) Geochemical Analysis, CBS Publisher and Distributors Pvt Ltd., New Delhi.
Jeffrey, P.G. (1970) Chemical methods of rock analysis, Pergamon Press.
Perry, D.L. (1990) Instrumental Surface Analysis of Geologic Materials, VCH Pub. Inc., New York.
Shapiro, L. and Brannock, W.W. (1975) Rapid analysis and silicates, Carbonate and phosphate rocks, USGS Bulletine, 1144 A

Distribution of Courses for M.Sc. Semester II Geology

M.Sc. Semester II		
Sr.No.	**Course Title**	**Paper Title**
1	Major Paper V	Paper V: Sedimentology, Geo-statistics and Computer Application in Geology (4)
2	Major Paper VI	Paper VI: Paleontology and Applied Paleo-biology (4)
3	Major Paper VII	Paper VII: Geochemistry and Instrumentation Techniques (4)
4	Major-Elective (VI)	Paper 1 Structural Geology, Geodynamics and Tectonics (4)
5	Major Elective (VII)	Paper 2 Marine Geology and Oceanography (4)
6	Major Elective (VIII)	Paper 3: .Basin analysis and Sequence Stratigraphy (4)
7	Major Elective (IX)	Paper 4: Applied and Industrial Micropaleontology (4)
8	Major Elective (X)	Paper 5: Elements of Mining and Drilling Techniques (4)
9	OJT/FP (On Job Training,Internship/ Apprenticeship/Field Project)	1. Field Project In Geology OR 2. On Job Training with various Geological Organization. Credits (4)

Major Paper-4 (Mandatory)
Sedimentology, Geo-statistics and Computer Application in Geology

PSCGEOT04

Unit I:

Liberation and flux of sediments, rock cycle; Texture of sedimentary rocks and their significance; Processes of sediment transport; Classification and composition of conglomerate, sandstones, shale and carbonate rocks; Sedimentary structures.

Unit II:

Paleocurrent, heavy mineral study and provenance; Diagenesis - physical and chemical, processes and evidences of diagenesis in sandstones, mud rocks and carbonate rocks; Study of evaporites such as gypsum, anhydrite and halite; Detailed study of siliceous, phosphatic and ferruginous rocks.

Unit III:

Facies analysis; Sedimentary environments and facies: Continental – Alluvial, lacustrine, desert-aeolian and glacial; Transitional and Marine; Sedimentary basins of India- Precambrian-Proterozoic, Gondwana, post-Gondwana and Quaternary sedimentation.

Unit IV:

Arithmatic mean, Mode, Median, Range, Variance, Frequency, Skewness, Kurtosis, Standard deviation, Probability. Distributions: Binomial, Poisson, Normal, Gamma, Exponential, Hypergeometric, Multinomial, Chi-square. Application of geostatistical techniques to earth sciences. Use of computers and software as tools in the areas of geological problem-solving, report-writing, and presentations; Brief idea about computer software used in earth sciences such as Archinfo, ArcGIS, Elvis, Mapinfo, Autocad, GCD-kit, Rockware, Rockworks, Igpet, Petrograf, Surfer, Aquachem, Statpack, Tilia, Past etc.

Practicals:

Sedimentology:

Detailed study of clastic and non-clastic rocks in hand specimens; Study of assemblages of sedimentary structures in context of their paleoenvironmental significance; Microscopic examination of important rock-types; Heavy mineral analyses; Grain-size analyses; Plotting of size- distribution data as frequency and cumulative curves, computation of statistical parameters and interpretation; Staining test.

Geostatisitics and Computer Application in Geology:

Computation of various statistical parameters for a given data; student test, chi-square test; least square method; Statistical models; Practical training in data analysis using different computer softwares available in the department.

Books Recommended:

Sedimentary petrology:

Blatt, H., Middleton, G.V. and Murray, R.C. (1980) Origin of Sedimentary Rocks, Prentice-Hall Inc. Collins, J.D. and Thompson, D.B. (1982) Sedimentary Structures, George Allen and Unwin, London.Lindholm, R.C. (1987) A Practical Approach to Sedimentology, Allen and Unwin, London.

Miall, A.D. (2000) Principles of Basin Analysis, Springer-Verlag.

Pettijohn, F.J. (1975) Sedimentary Rocks (3rd Ed.), Harper and Row Publ., New Delhi.

Reading, H.G. (1997) Sedimentary Environments and facies, Blackwell Scientific Publication. Reineck, H.E. and Singh, I.B. (1973) Depositional Sedimentary Environments, Springer-Verlag.Selley, R.C. (2000) Applied Sedimentology, Academic Press.

Tucker, M.E. (1981) Sedimentary Petrology: An Introduction, Wiley and Sons, New York.Tucker, M.E. (1990) Carbonate Sedimentolgy, Blackwell Scientific Publication.

Hota, R.N. (2011) Practical Approach to Petrology, CBS Publisher and Distributors Pvt Ltd., New Delhi

Geostatistics/ Statistical Methods in Geology:

Pitman, J. (1993) Probability, Springer Verlag, (also Narosa Publishers).

Creighton, J.H.G. (1994) First course in probability models and statistical inference, Springer Verlag.Davis, J.G. (1986) Statistics and data analysis in geology, John Wiley.

Walpole, R.E. and Myers, R.H. (1989) Probability and statistics for engineers and scientists,Macmillan Publ. Co.

Johnson, R.A. and Wichern, D.W. (1982) Applied multivariate statistical analysis, Prentice Hall Inc.,New Jersey.

Cooley, W.W. and Lohnes, P.R. (1971) Multivariate data analysis, John Wiley and Sons.Morrison, D.F. (1967) Multivariate statistical methods, McGraw-Hill.

Pandalai, H.S. and Saraswati, P.K. (Eds.) (2000) Geological data analysis: Statistical Methods.Hindusthan Publishing Corporation (India), New Delhi.

Spiegel, M.R. (1982) Probability and Statistics, Schaums Outline Series, McGraw-Hill Int., Singapore,Asian Student Edn.

Kubackova, L., Kubacek, L. and Kukuca, J. (1987) Probability and Statistics in Geodesy andGeophysics, Elsevier.

Journel, A.G. and Huijbregts, Ch. (1978) Mining Geostatistics, Academic Press.Armstrong, M. (1998) Basic linear geostatistics, Springer Verlag, Berlin.

Isaaks, E.A. and Srivastava, R.M. (1990) An Introduction to Geostatistics, Oxford University Press. Journel, A.G. and Huijbregts, C. (1978) Mining Geostatistics, Academic Press, London.

Chiles, J.P. and Delfiner, P. (1999) Geostatistics: Modeling Spatial Uncertainity, John Wiley &Sons, New York.

Computer Application in Geology:

No Textbook - only handouts and web pages

Major Paper-5 (Mandatory)
Paleontology and Applied Paleobiology

PSCGEOT05

Unit I:

Types of fossils and taphonomy; Origin of life; Modern Concept of systematic of fossils; Biostratigraphy; Concept of species and type specimens; speciation and radiation; Types of growth; Brief morphology and evolutionary trends in Bivalves, Gastropods, Cephalopods, Brachiopods, Echinoids, Crinoids, Graptolites, Corals and Trilobites; Ichnofossils, their modes of preservation and significance.

Unit II:

Vertebrate life through ages; Evolution and Extinction of dinosaurs, Indian dinosaurs; Mammalia-Origin and evolution of the mammals, mammalian characters; Siwalik mammals; Evolutionary changes in Equidae; Evolution of Homo; Major extinction and origination through ages.

Unit III:

Approach to paleobotany; Classification of fossil plants; Evolutionary trend in angiosperms plants; A brief idea about Indian pre-Gondwana; Gondwana and Paleogene flora; Application of paleobotany in assessing paleoclimate and paleoenvironment; Dendrochronology and its application; Introduction to important animal and plant microfossils.

Unit IV:

Concept of evolution and extinction; Micro and macro-evolution, evolutionary lineages and their application to biochronology; Phylogenetic analysis; Molecular biology and its application Distribution, migration and dispersal of organisms applied to paleobiogeography and plate-tectonics; Fossil record applied to sequence stratigraphy and depositional environment; Paleoecological and paleoclimatological significance of fossils. Stable isotope studies in paleoclimatology; Applications of important mega and micro fossils in the exploration of coal and petroleum.

Practicals:

Study of modes of preservation of fossils; Study of the morphological characters of some important invertebrate fossils belonging to Brachiopoda, Bivalvia, Gastropoda, Nautiloidea, Ammonoidea, Trilobita, Echinoidea and Corals; Study of important vertebrate fossils; Study of important trace fossils and microfossils; Study of important Indian Gondwana and Paleogene flora; Shell petrography of bivalves and brachiopods; Measurements of dimensional parameters and preparation of elementary bivariate growth curves and scatter plots. Paleogeographic maps.

Books Recommended:

General Paleontology

Boardman, R.S., Cheethan, A.M. and Rowell, A.J. (1988) Fossil Invertebrates, Blackwell.
Clarksons, E.N.K. (1998) Invertebrate Paleontology and Evolution, Allen and Unwin, London.Dobzhansky, Ayala, Stebbins and Valentine (1977) Evolution, Freeman.
Horowitz, A.S. and Potter, E.D. (1971) Introductory Petrography of Fossils, Springer Verlag.
Mayr, E. (1971) Population, Species and Evolution, Harvard.
Prothero, D.R. (2004) Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.), McGraw Hill. Raup, D.M. and Stanley, S.M. (1985) Principles of Paleontology , CBS Publishers, New Delhi.
Smith, A.B. (1994) Systematics and Fossil Record – Documenting Evolutionary Patterns, Blackwell.Strean, C.W. and Carroll, R.L. (1989) Paleontology – the record of life, John Wiley.

Applicative Paleobiology

Allison, P.A. and Briggs, D.E.G. (1991) Taphonomy. Releasing the data locked in the fossils record,Plenum Press.
Dord, J.R. and Stanta, R.J. (1981) Palaeoecology concepts and applications, John Wiley and Sons.
Patnaik, R. (2003) Reconstruction of Upper Siwalik palaeoecology and palaeoclimatology using microfossil palaeocommunities, Palaeogeography, Palaeoclimatology, Palaeoecology, Vol. 197.
Bergland, B.E. (1986) Handbook of Holocene paleoecology & paleohydrology, John Wiley, New York.Jones, T.P. and Rowe, T.P. (1999) Fossil Plants and Spores Modern Techniques, Geological Society ofLondon.
Prothero, D.R. (2004) Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.), McGraw Hill.Seaward, A.C. (1991) Plant fossils, Today's and Tomorrow, New Delhi.
Agashe, Shipad N. (1995) Paleobotany, Oxford and IBH Publ., New Delhi.
Stewart, Wilson N. and Rothwell, Gar W. (1993) Paleobotany and the Evolution of Plants, Cambridge University Press.
Dodd, J. Robert and Stanton, Robert. J. Jr. (2012) Paleoecology: Concepts and Applications. Second Edition (Reprint), Wiley India Pvt. Ltd., New Delhi

Major Paper-6 (Mandatory)
Geochemistry and Instrumentation Techniques

PSCGEOT06

Unit I:

Principles of geochemistry; Origin and abundance of elements in the solar system and Earth; Chemical composition and properties of atmosphere, hydrosphere and lithosphere; Geochemical cycles; Atomic structures and properties of elements in the periodic table with special reference to major, minor and trace elements (transition, LILE, HFSE) including rare earth elements; Geochemical classification of elements.

Unit II:

Radiogenic isotopes: Basic principles, decay scheme and radiometric dating methods of K-Ar, Ar – Ar, U-Pb, Rb–Sr and Sm-Nd in rocks; Petrogenetic implications of isotope study eg. Sm-Nd and Rb-Sr; Radiometric dating of single minerals and whole rocks; Stable isotope geochemistry of carbon, oxygen, hydrogen and sulphur and their applications to geology; Geochemistry of U and Th in rocks, minerals and sediments.

Unit III:

Laws of thermodynamics; concept of internal energy, heat capacity, enthalpy and entropy; Gibbs free energy and chemical potential; fugacity and activity; Raoult's law and Henry's law; Principles of geothermobarometry; Principles of ionic substitution in minerals; Element partitioning between minerals and melts, in mineral assemblages /rock formation and their use in pressure-temperature estimation; Geochemistry of natural waters and sedimentary rocks; Mineral stability in Eh-pH diagram; Elemental mobility in surface environment; Geochemical processes involved in rock weathering and soil formation; Metamorphism as a geochemical phenomenon.

Unit IV:

Thin section and polished section making. Sample etching, staining and model count techniques. Principle and geological application of Cathodoluminiscence, Thermoluminiscence, Spectro-photometry, Flame photometry, Atomic absorption spectrophotometry; Inductively coupled plasma

– Atomic emission spectrometry, Optical emission spectrometry and Mass spectrometry; X ray Fluorescence spectrometry; Scanning and Transmission electron microscopy; Instrumental Neutron Activation Analysis (INAA); Isotope dilution technique; Electron Probe Microanalysis (EPMA), X ray defractometry; Thermal Ionisation and gas source mass spectrometry.

Practicals:

Rock analyses (rapid method of silicate analysis) and FeO determination by titration method; Determination of loss on ignition (LOI) of rock samples; Presentation of analytical data; Preparation of classificatory and variation diagrams and their interpretation; Plotting of REE data and their interpretation; Calculation of weathering indices in soil and sediments; Wet assay of Cu, Pb, Zn, Al, Cr, Fe, Mn, Ti, Na, K etc.

Books Recommended:
Geochemistry:

Allegre, C.J. and Michard, G. (1974) Introduction to Geochemistry, Reidel, Holland.
Anderson, G.M. (2005) Thermodynamics of Natural Systems, Cambridge University Press.Winter, J.D. (2001) Introduction to Igneous and Metamorphic Petrology. Prentice-Hall.

Bloss, F.D. (1971) Crystallography and Crystal Chemistry, Holt, Rinehart, and Winston, NewYork. Drever, J.I. (1997) The Geochemistry of Natural Waters, 3rd Edn., Prentice Hall.

Evans, R.C. (1964) Introduction to Crystal Chemistry, Cambridge Univ. Press.

Faure, G. (1998) Principles and applications of geochemistry, 2nd Edn., Prentice Hall, New Jersy,593p. Faure, G. (1986) Principles of Isotope Geology, 2nd Edn., John Wiley.

Hoefs, J. (1980) Stable Isotope Geochemistry, Springer-Verlag.

Klein, C. and Hurlbut, C.S. (1993) Manual of Mineralogy, John Wiley and Sons, NewYork. Krauskopf, K.B. (1967) Introduction to Geochemistry, McGraw Hill.

Mason, B. and Moore, C.B. (1991) Introduction to Geochemistry, Wiley Eastern.

Rollinson, H.R. (1993) Using geochemical data: Evaluation, Presentation, Interpretation, Longman U.K. Wood, B.J. and Fraser, D.G. (1977) Elementary Thermodynamics for Geologists, Oxford University Press, London.

Rastogy, R.P. and Mishra, R.R. (1993) An Introduction to Chemical Thermodynamics, VikashPub. House.

Anderson, G.M. and Crerar, D.A. (1993) Thermodynamics in Geochemistry- the equilibrium model,Oxford University Press, New York.

Fletcher, P. (1993) Chemical thermodynamics for earth sciences. Longman Scientific and Technical,London.

Glasstone, S. (1947) Thermodynamics for Chemists, East and West Pub.

Instrumentation Techniques:

Shapiro, L. and Brannock, W.W. (1975) Rapid analysis and silicates, Carbonate and phosphate rocks, USGS Bulletine, 1144 A.

Jeffrey, P.G. (1970) Chemical methods of rock analysis. Pergamon Press.

Perry, D.L. (1990) Instrumental Surface Analysis of Geologic Materials, VCH Pub. Inc., New York.Hota, R.N. (2011) Geochemical Analysis, CBS Publisher and Distributors Pvt Ltd., New Delhi.

Electives Paper- 06 (Optional)
Structural Geology, Geodynamics and Tectonics

PSCGEOE-06

Unit I:

Theories of rock failure; Mechanical principles, properties of rocks and their controlling factors; Concept of stress and strain: Classes of stress; stress ellipsoid; Mohr circle construction; Stress trajectory; Two-dimensional stress analyses; Stress-strain relationship; Strain parameters, Types of strain ellipses and ellipsoids and their properties; Theory of deformation in two and three dimensions; Strain Analysis: Graphical representations of strain (Flinn, Ramsay, and Nadai-Hossack plots), progressive deformation, significance of geological structures in relation to strain, methods of strain measurements in naturally deformed rocks.

Unit II:

Description of folds; Mechanisms of folding (buckling, bending and flow), fold development and distribution of strains in folds; Biot's law - strain within buckled layer, similar fold and shear fold, kink bands, chevron folds and conjugate fold; Decollement; Cleavage, lineation, boudinage; Deformation of linear structures and planar structures by flexural slip folding and shear folding; Superimposed folding, Type 1, 2, 3 fold interference patterns; Geometric and genetic classification of folds,
Ramasay's classification of folds.

Concept of petrofabrics and symmetry; Types of fabric (planar and linear fabrics in deformed rocks), fabric element, and interpretation of fabric data on microscopic and megascopic scale; Field and laboratory techniques, graphical treatment.

Unit III:

Stereographic projections of linear and planar structures, □ and □ diagrams; Geometrical analysis of simple and complex structures on macroscopic scale; Thin-skinned deformation; Fractures and joints: their classification, nomenclature, relationships and significance; Mechanism of rock fracturing; Development of cleavage, lineation, foliation and schistosity in rocks and their mechanism; Faults: Causes, mechanism and dynamics of faulting, strike-slip faults, normal faults, thrust faults and nappe; Unconformities and their significance; Shear Zones: Brittle and ductile shear zones, geometry and products of shear zones; Mylonites and cataclasites: their origin and significance.

Unit IV:

Structure of the earth (crust, mantle and core), thermal structure of the earth; Concept of continental drift, supercontinents, sea-floor spreading, hot-spots and plumes, diapers and salt- domes; Cratons and mobile belts; Plate tectonics- recent advances, pros and cons; Geology of plate boundaries, Wilson cycle, plate motions and driving forces; Precambrian tectonics; Phanerozoic plate tectonics; Evolution of Indian subcontinent, Ur to Rodinia to Gondwanaland; Evolution of the Himalayas & Indian Ocean; Seismotectonics and earthquakes in India; Tectonics of the Indian plate.

Practicals:

Structural Geology

Preparation and interpretation of geological maps and cross sections; Structure contour maps, isopach maps and other facies maps, balanced cross-section, their importance in unraveling the geological history; Structural problems concerning economic deposit based on orthographic and stereographic projections; Recording and plotting of the field data; Study of deformed structures in hand specimens; Strain estimation from the data collected from the field; Study of dip-isogons from the fold profiles; Analysis of stress using Mohr Circle construction.

Books Recommended:

Ghosh, S.K. (1993) Structural Geology: Fundamental and Modern Developments, Pergamon Press.
Hobbs, B.E., Means, W.D. and Williams, P.F. (1976) An outline of Structural Geology, John Wiley and Sons, New York.
Ramsay, J.G. (1967) Folding and fracturing of rocks, McGraw Hill.

Ramsay, J.G. and Huber, M.I. (1983) Techniques of Modern Structural Geology, Vol. I, Strain Analysis, Academic Press.

Ramsay, J.G. and Huber, M.I. (1987) Techniques of Modern Structural Geology, Vol. II, Folds and Fractures, Academic Press.

Ramsay, J.G. and Huber, M.I. (2000) Techniques of Modern Structural Geology, Vol. III (Application of continuum mechanics), Academic Press.

Turner, F.J. and Weiss, L.E. (1963) Structural analysis of Metamorphic Tectonites, McGraw Hill.
Marshak, S. and Mitra, G. (1988) Basic methods of Structural Geology, Prentice-Hall, New Jersey.

Geodynamics and Tectonics:

Condie, K.C. (1989) Plate Tectonics and Crustal Evolution, 3rd Ed., Pergamon, Oxford Press. Kearey Phillips and Vine, F.J. (1996) Global Tectonics, Blackwell Science, Oxford.

Windley, B.F. (1977) The Evolving Continents, John Wiley and Sons, New York. Moores, E and Twiss, R.J. (1995) Tectonics. Freeman.

Keary, P., Klepeis, K.A. and Vine, F.J. (2012) Global Tectonics. Third Edition (Reprint), Wiley-Blackwell, Wiley India Pvt. Ltd.

Storetvedt, K.N. (1997) Our Evolving Planet: Earths History in New Perspective. Bergen (Norway), Alma Mater Fortag.

Summerfield, M.A. (2000) Geomorphology and Global Tectonics, Wiley. Patwardhan, A.M. (1999) The Dynamic Earth System, Prentice-Hall, New Delhi Gass, I.G. (1982) Understanding the Earth, Artemis Press (Pvt) Ltd. U.K.

Moores, Eldridge M. and Twiss, Robert J. (1995) Tectonics, Freeman and Company. Valdiya, K.S. (1984) Aspects of Tectonics -Focus on south central Asia, Tata McGraw-Hill. Valdiya, K.S. (1998) Dynamic Himalaya. Universities Press, Hyderabad.
Valdiya, K.S. (2010) The making of India Geodynamic Evolution, Macmillan Publishers India Ltd.

Electives Paper- 07 (Optional)
Marine Geology and Oceanography

PSCGEOE-07

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:

Marine Geology and Oceanography

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 Excercises in Oceanography Marine Geology, Prentice Hall,. Seibold, E. and Berger, W.H. (1982) The Sea Floor, Springer-Verlag.

Electives Paper- 08 (Optional)
Basin analysis and Sequence Stratigraphy

PSCGEOE-08

Unit I:

Concept of basin analysis; Tectonic classification and geothermal evolution of sedimentary basins; Allogenic and autogenic controls on sedimentation, modes of sediments transport sedimentary facies and facies models with Indian analogues; Paleocurrent analysis and sediment dispersal patterns; Quaternary sedimentology.

Unit II:

Processes and characteristics of depositional environments such as fluvial, estuarine, deltaic, lagoonal, barrier beach, tidal flats and deep-sea environments; Flysch and molasse; Sedimentation and plate tectonics.

Unit III:

Sequence stratigraphy, its concept and evolution; Order and duration of sequences; Application and significance of sequence Stratigraphy; Fundamentals of sequence stratigraphy, depositional sequence, sequence architecture, types and boundaries, condensation and starvation; Conformity and types of sequence unconformities; Flooding surface, maximum flooding surface, marine flooding surface; Bed, bedset, parasequence, parasequence boundary, para-sequence set, regional unconformities.

Unit IV:

Lowstand system tract, transgressive system tract, transgressive surface and highstand system tract, overlap, offlap, toplap and onlap, aggradation, progradation, retrogradation, transgression and regression; Eustatic sea level changes, sediment supply, basin subsidence rate, and accommodation. Outcrop, subsurface and offshore sequence stratigraphy and their integration; Seismic stratigraphy; Sequence stratigraphy in well sections and application of well logs; Sequence stratigraphic approach in basin analysis with Indian examples.

Practicals:

Paleocurrent analysis; Preparation of facies maps and facies diagrams; Study of vertical profilesections of some selected sedimentary environments; Study of significant system tracts.

Books Recommended:

Basin Analysis:

Allen P. A. and J.R.L. Allen (2005) Basin Analysis: Principles and Application, Blackwell Publishers.
Miall, A.D. (2000) Principles of Basin Analysis, Springer-Verlag.
Perry, C.T. and Taylor, K.G. (2006) Envoronmental Sedimentology, Blackwell Publishers, U.K. Reading, H.G. (1996) Sedimentary Environments and facies, Blackwell Scientific Publishers. Reineck, H.E. and Singh, I.B. (1978) Depositional Sedimentary Environments, Springer-Verlag.

Sequence Stratigraphy:

Boggs, S. (2001) Principles of Sedimentology and Stratigraphy, Prentice Hall.

Coe, Angela, Dan Bosence, Kevin Church, Steve Flint, John Howell and Chris Wilson (2002): The Sedimentary Record of Sea Level Change , Cambridge Univ. Press.

Emery, D, (1996) Sequence Stratigraphy, Blachwell Scientific Publ.

Miall, A.D. (1997) The Geology of Stratigraphic Sequence, Springer-Verlag.

Reineck, H.E., and Singh, I.B. (1980) Depositional Sedimentary Environments, Springer-Verlag.

Vail, P.R., Mitchum, R.M., Todd, R.G., Widmier, J.M., Thompson, S., Sangree, J.B., Bubb, J.N.and Hatlelid, W.G. (1977) Seismic stratigraphy and global changes of sea level: American Association of petroleum Geologists, Vol.26.

Electives Paper- 09 (Optional)
Applied and Industrial Micropalaeontology

PSCGEOE-09

Unit I*:*

Definition and scope of the Applied and environmental Micropaleontology; Modern field and laboratory techniques in the study of microfossils (collection, sampling and processing techniques); Diatoms: Outline of morphology and classification, significance in paleolimnology/limnology, paleoceanographic and biostratigraphic interpretations; Applications of diatoms in environmental, climate and forensic science studies; Brief introduction of Cyanobacteria and Calcareous nannofossils and their geological significance; Brief introduction of Ostracoda, Radiolaria and Conodonts and their geological significance.

Unit II:

Foraminifera: planktic foraminifera, outline of morphology, significance in Cenozoic oceanic biostratigraphy and paleoceanographic, paleoclimatic interpretations; Benthic foraminifera - their brief morphology and application in bottom water paleoceanography and paleobathymetric reconstructions.
Calcareous algae (Rhodophyta and Chlorophyta): Broad classification, morphology and internal structure; Paleoenvironmental, paleogeographical, paleobathymetric, biostratigraphic significance of calcareous algae; Petroleum exploration using calcareous algae.
Spores/pollen: Morphology and classification; Production, dispersal and sedimentation of palynomorphs; Applications of pollens in environmental, climate and forensic science studies; Types of organic matters, concept of palynofacies and their application in paleoenvironment interpretation; Brief introduction of phytoliths and acritarchs and their significance.

Unit III:

Geochemical study of microfossil tests (stable isotopes, radiocarbon isotopes and elemental composition) and its application in Paleolimnology, Paleoceanography, Paleoclimatology and tracing history of marine and lake pollution; Microfossils and Earth's orbital cycles (Milankovitch Cycles).
Paleoclimatic importance of microfossils; Forecasting of monsoon using microfossils; Delineation of Oxygen Minimum Zones (OMZ) using microfossils; Freshwater and Marine pollution and interpreting pollution with the help of microfossils; Utility of microfossils in Paleoceanography and interpretation of sea floor tectonism from microfossils.

Unit IV:

Adaptation of academic micropalaeontology to industry and its future prospects; Samples derived from drilling wells and their reliability for micropaleontological analysis; Traditional uses of micropalaeontology in hydrocarbon exploration; High resolution applications and new approaches to applied micropalaeontology including biosteering and reservoir characterisation by detailed morphological analysis of microfauna / microflora with examples; Unconventional uses of micropalaeontology; Carbonate production in present-day oceans; Larger foraminifera and calcareous algae as carbonate reservoirs; Recognizing foraminiferal and calcareous algal reservoirs: Practical case study in India; Significance of palynology in source rock evaluation and organic matter maturation; Application of palynology in identifying ancient coast lines for petroleum exploration; Increasing Biostratigraphic resolution with Molecular Biology; Role of Micropaleontology in Economic Geology.

Practicals:

Applied Micropaleontology

Techniques of separation of microfossils from matrix; Microscopic study of the selected taxa of Foraminifera, Ostracodes, Calcareous Algae, Diatoms, Pollens and Spores, dinoflagellates; SEM applications in micropaleontology: Study of surface ultra structures of foraminifera, Calcareous Algae, Diatoms and Pollens and Spores; Preparation of diatom slides from the sediments of the polluted freshwater environments and identification of indicator Diatoms to assess urban stream health and water quality; Techniques in Diatom studies and palynology.

Industrial Micropaleontology

Checking the characteristics of sample; Processing and analyzing ditch cutting samples; Real time well site micropalaeontology: analysis simulation.
From exploration to production - from theory to practice
Exploration: Seismic stratigraphy (including pitfalls), Seismic stratigraphy exercise.
Exploration/Discovery: Bio-Sequence stratigraphy, exercise: well to seismic, identification ofsurfaces.
Appraisal exercise: second well, tie to first well seismic and exercise: third well, logcorrelation, compare result with biostratigraphy.
Graphic correlation as a tool: exercise; Building a reservoir zonation- exercise: horizontal drilling.

Books Recommended:

Traverse Alfred (1988) Paleopalynology, Unwin Hyman, USA.
Arnold (2002) Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett), OxfordUniversity Press, New York.
Bergland, B.E. (1986) Handbook of Holocene paleoecology and paleohydrology, John Wiley, NewYork.
Bignot, G., Grahm and Trottman (1985) Elements of Micropaleontology, London.
Jones, T.P. and Rowe, T.P. (1999) Fossil Plants and Spores Modern Techniques, Geological Society of London.
Kathal, P.K. (2011). Applied Geological Micropaleontology, Scientific Publishers, Jodhpur.
Kundal, P. (2003). Recent Developments in Indian Micropaleontology, Gondwana Geological Society, Sp. Vol. 6.
Kundal, P. and Humane, S.K. (Eds.) (2010) Applied Micropaleontology, Gondwana Geological Society, V. 24 (1).
Pipero, Dologes, R. (1988) Phytolith analysis: An Archaeobiological and Geological perspective, Academic Press.
Prothero, D.R. (2004) Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.), McGraw Hill.
Seaward, A.C. (1991) Plant fossils, Today's and Tomorrow, New Delhi.
Agashe, Shipad N. (1995) Paleobotany, Oxford and IBH Publ., New Delhi.
Stewart, Wilson N. and Rothwell, Gar W. (1993) Paleobotany and the Evolution of Plants, Cambridge Univ. Press.
Wray, J.L. (1977) Calcareous Algae, Elsevier.

Electives Paper- 10 (Optional)
Elements of Mining and Drilling Techniques

PSCGEOE-10

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 Pubishing 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.

PR/OJT: FIELD EXCURSION

Candidate shall attend geological excursion organized by the Department for a period of 7 days. 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 along with the geological specimens collected during the programme.