SYLLABUS for M. Sc. (Tech) APPLIED GEOLOGY
Choice Based Credit System (Semester Pattern)
Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur
Effective from 2018-2019

Candidates opting for this course are advised to go through the direction relating to the course "DIRECTION RELATING TO THE EXAMINATION LEADING TO THE DEGREE OF MASTER OF SCIENCE, SEMESTER PATTERN (CHOICE BASED CREDIT SYSTEM) AND DEGREE OF MASTER OF SCIENCE AND TECHNOLOGY (APPLIED GEOLOGY). SEMESTER PATTERN, (CHOICE BASED CREDIT SYSTEM) (FACULTY OF SCIENCE & TECHNOLOGY)" which is available on R. T. M. Nagpur University website.
The direction will provide details on admission criteria, rules for ATKT, scheme of examination, absorption scheme for CBS students into CBCS pattern, elective papers, foundation course papers, subject centric papers, coding pattern, pattern of question papers, practicals, distribution of marks, seminars, project work, internal assessment, calculation of SGPA and CGPA, etc.

Scheme of teaching and examination under semester pattern Choice Based Credit System (CBCS) for M.Sc. (Tech) Program in APPLIED GEOLOGY

M.Sc. (Tech) APPLIED GEOLOGYSemester I

Code	Theory / Practical	Teaching Scheme (Hrs/ week)			Credits	Examination Scheme					
		Th	Pr.	Total		Duration (Hrs)	Max. Marks		Total Marks	Min. Passing Marks	
							External	Internal		Th	Pr.
1T1	Mineralogy and Crystallography (3+1)	4		4	4	3	80	20	100	40	
1T2	Igneous Petrology (4)	4		4	4	3	80	20	100	40	
1T3	Sedimentology (4)	4		4	4	3	80	20	100	40	
1T4	Paleontology and Applied Paleobiology (3+1)	4		4	4	3	80	20	100	40	
1P1	Mineralogy, Crystallography, and Igneous Petrology (Marks: 75 Pract. Exam. + 05 Viva-voce + 20 Internal Assessment and Class Records)		8	8	4	3	100	---	100		40
1P2	Sedimentology, Paleontology and Applied Paleobiology (Marks: 75 Pract. + 05 viva-voce + 20 Internal Assessment and Class Records)		8	8	4	3	100	---	100		40
1S1	Seminar 1	2		2	1	---		25	25	10	
	Total	18	16	34	25		520	105	625	170	80

Code	Theory / Practical	Teaching Scheme (Hrs/ week)			Credits	Examination Scheme					
		Th	Pr.	Total		Duration (Hrs)	Max. Marks		Total Marks	Min. Passing Marks	
							External	Internal		Th	Pr.
2T1	Metamorphic Petrology (4)	4		4	4	3	80	20	100	40	
2T2	Structural Geology, Geodynamics and Tectonics (3+1)	4		4	4	3	80	20	100	40	
2T3	Stratigraphy and Indian Geology (2+2)	4		4	4	3	80	20	100	40	
2T4	Geochemistry (4)	4		4	4	3	80	20	100	40	
2P1	Metamorphic Petrology and Structural Geology (Marks: 75 Pract. + 05 Viva-voce +20 Internal Assessment and Class Record)		8	8	4	3	100	----	100		40
2P2	Stratigraphy, Geochemistry, Geological Field Work and Mapping (Marks: 55 Pract. + 05 Viva-voce + 20 Field Work and Mapping + 20 Internal Assessment and Class Record)		8	8	4	3	100	----	100		40
2S1	Seminar 2	2		2	1	---		25	25	10	
	Total	18	16	34	25		520	105	625	170	80

M.Sc. (Tech) APPLIED GEOLOGYSemester III

Code	Theory / Practical	Teaching Scheme (Hrs/ week)			Credits	Examination Scheme					
		Th	Pr.	Total		Duration (Hrs)	Max. Marks		Total Marks	Min. Passing Marks	
							External	Internal		Th	Pr.
3T1	Instrumentation Techniques, Geostatistics and Computer Application in Geology (1+2+1)	4		4	4	3	80	20	100	40	
3T2	Indian Mineral Deposits and Mineral Economics (3+1)	4		4	4	3	80	20	100	40	
3T3	Ore Geology (4)	4		4	4	3	80	20	100	40	
3T4	Mining Geology & Valuation of Mineral Property (2+2)	4		4	4	3	80	20	100	40	
3P1	Instrumentation Techniques, Geostatistics, Computer Application in Geology (Marks: 75 Pract. + 05 Viva-voce + 20 Internal Assessment and Class Record)		8	8	4	3	100	----	100		40
3P2	Ore Geology, Mining Geology and Valuation of Mineral Property (Marks: 75 Pract. + 05 Viva-voce + 20 Internal Assessment and Class Records)		8	8	4	3	100	----	100		40
3S1	Seminar 3	2		2	1	---		25	25	10	
	Total	18	16	34	25		520	105	625	170	80

M.Sc. (Tech) APPLIED GEOLOGYSemester IV

Code	Theory / Practical	Teaching Scheme (Hrs/ week)			Credits	Examination Scheme					
		Th	Pr.	Total		Duration (Hrs)	Max. Marks		Total Marks	Min. Passing Marks	
							External	Internal		Th	Pr.
4T1	Mineral Exploration (4)	4		4	4	3	80	20	100	40	
4T2	Elements of Mining and Drilling Techniques (3+1)	4		4	4	3	80	20	100	40	
4T3	Geomorphology, Remote Sensing and GIS (1+2+1)	4		4	4	3	80	20	100	40	
4T4	Fuel Geology (Coal, Petroleum and Nuclear) (2+1+1)	4		4	4	3	80	20	100	40	
4P1	Mineral Exploration and Mine/ Industrial Training (Marks: 55 Pract. + 05 Viva-voce + 20 Mine/ Industrial Training + 20 Internal Assessment and Class Record)		8	8	4	3	100	----	100		40
4P2	Geomorphology, Remote Sensing and GIS and Fuel Geology (Marks: 75 Pract. + 05 Viva-voce + 20 Internal Assessment and Class Record)		8	8	4	3	100	----	100		40
4S1	Seminar 4	2		2	1	---		25	25	10	
	Total	18	16	34	25		520	105	625	170	80

M.Sc. (Tech) APPLIED GEOLOGYSemester V

Code	Theory / Practical	Teaching Scheme (Hrs/ week)			Credits	Examination Scheme					
		Th	Pr.	Total		Duration (Hrs)	Max. Marks		Total Marks	Min. Passing Marks	
							External	Internal		Th	Pr.
5T1	Ore Microscopy and Ore Dressing (1+3)	4		4	4	3	80	20	100	40	
5T2	Hydrogeology and Watershed Management (3+1)	4		4	4	3	80	20	100	40	
5T3	Core Elective 1 Optional (Any one) 1) Exploration Geochemistry (4) 2) Quaternary Geology & Limnogeology (3+1)	4		4	4	3	80	20	100	40	
5T4	(Core Subject Centric-1) 1) Environmental Geology & Geohazards	4		4	4	3	80	20	100	40	
5P1	Ore Microscopy, Ore Dressing,Hydrogeology&Watershed Management (Marks: 75 Pract. + 05 Viva-voce + 20 Internal Assessment and Class Record)		8	8	4	3	100	---	100		40
5P2	Based on paper 5T3 and Environmental Geology (Marks: 75 Pract. + 05 Viva-voce + 20 Internal Assessment and Class Records)		8	8	4	3	100	---	100		40
5S1	Seminar 5	2		2	1	---		25	25	10	
	Total	18	16	34	25		520	105	625	170	80

M.Sc. (Tech) APPLIED GEOLOGYSemester VI

Code	Theory / Practical	Teaching Scheme (Hrs/ week)			Credits	Examination Scheme					
		Th	Pr.	Total		Duration (Hrs)	Max. Marks		Total Marks	Min. Passing Marks	
							External	Internal		Th	Pr.
6T1	Engineering Geology and Geotechniques (3+1)	4		4	4	3	80	20	100	40	
6T2	Applied and Industrial Micropaleontology (4)	4		4	4	3	80	20	100	40	
6T3	Core Elective 2: Optional (Any one) 1)Petroleum Exploration (4) 2)Basin Analysis and Sequence Stratigraphy (2+2) 3)Marine Geology and Oceanography (3+1)	4		4	4	3	80	20	100	40	
6T4	(Core Subject Centric -2) 1) Geodesy and Mapping	4		4	4	3	80	20	100	40	
6P1	Engineering Geology and Applied & Industrial Micropaleontology (Marks: 75 Pract. + 05 Viva-voce + 20 Internal Assessment and Class Record)		8	8	4	3	100	----	100		40
6P2	Based on Paper 6T3,Geodesy and Geological Field Work (Marks: 55 Pract. + 05 Viva-voce +20 Field Work + 20 Internal Assessment and Class Record)		8	8	4	3	100	----	100		40
6S1	Seminar 6	2		2	1	---		25	25	10	
	Total	18	16	34	25		520	105	625	170	80

M.Sc.(Tech) APPLIED GEOLOGY

Semester I

Code	Theory / Practical	Teaching Scheme (Hrs/ week)			Credits	Examination Scheme					
		Th	Pr.	Total		Duration (Hrs)	Max. Marks		Total Marks	Min. Passing Marks	
							External	Internal		Th	Pr.
1T1	Mineralogy and Crystallography (3+1)	4		4	4	3	80	20	100	40	
1T2	Igneous Petrology (4)	4		4	4	3	80	20	100	40	
1T3	Sedimentology (4)	4		4	4	3	80	20	100	40	
1T4	Paleontology and Applied Paleobiology (3+1)	4		4	4	3	80	20	100	40	
1P1	Mineralogy, Crystallography, and Igneous Petrology (Marks: 75 Pract. Exam. + 05 Viva-voce + 20 Internal Assessment and Class Records)		8	8	4	3	100	---	100		40
1P2	Sedimentology, Paleontology and Applied Paleobiology (Marks: 75 Pract. + 05 viva-voce + 20 Internal Assessment and Class Records)		8	8	4	3	100	---	100		40
1S1	Seminar 1	2		2	1	---		25	25	10	
	Total	18	16	34	25		520	105	625	170	80

1T1

Mineralogy and Crystallography

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.

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- 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 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; Conversions of oxide and element weight percentages; Calculation of mineral formulae.

Books Recommended:

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.
Deer, W.A., Howie, R.A. and Zussman, J. (1992) An Introduction to the rock forming minerals, Longman.
Donald Bloss (1971) Crystallography and Crystal chemistry, Holt, Rinehart and Winston.
Hota, R.N. (2011) Practical Approach to Crystallography and Mineralogy, CBS Publisher and Distributors Pvt Ltd., New Delhi.
Hutchinson, C.S. (1974) Laboratory Handbook of Petrographic Techniques, John Wiley.
Kerr, P.F. (1977) Optical Mineralogy 4th Edn., McGraw-Hill
Klein, C. and Hurlbut, Jr., C.S. (1993) Manual of Mineralogy, John Wiley.
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.
Slemmons, D.B. (1962)Determination of Volcanic and Plutonic Plagioclases using a three- or Four-Axis Universal Stage, Geological Society of America.
Spear, F.S. (1993) Mineralogical Phase Equilibria and Pressure -Temperature-Time Paths, Mineralogical Society of America Publication.
Szymanski, A. (1988). Technical Mineralogy and Petrography, Elsevier.
Winchell, A.N. (1962) Elements of Optical Mineralogy, John Wiley.

1T2

Igneous Petrology

Unit I:

Introduction to rocks and magmas; Internal structure and thermal properties of the earth; The nature of magmas (temperature, viscosity and volatile component); Melting (partial melting, batch melting, dynamic melting) and generation of magmas; Movement and storage of magma (magma chambers and modes of emplacement); A window to the mantle of the earth and its heterogeneity (Study of mantle and crustal xenoliths, xenocrysts and glimmerites). Mantle metasomatism; The superdeep magmas.

Unit II:

Introduction to phase petrology; Phase relations of silicates and silicate melts; Binary systems (Ab-An, Ge-Ac, Co-Es, An-Si, Ne-Ab, Ne-Si, Lu-Si and Fo-Si); Ternary systems (Ab-An-Si, Ab-Fy-Si, Fy-Ne-Si, An-Lc-Si); Diversity and evolution of magma; Generation of magmas vis-a-vis plate tectonics.

Unit III:

IUGS classification of igneous rocks: Plutonic rocks, volcanic rocks, ultramafic rocks, gabbros, charnockites, carbonatites, lamprophyres, TAS classification for ultramafic and alkaline rocks; Weight norms and cation norms; Forms, textures and structures of igneous rocks; Petrography and interpretation of igneous textures in terms of rate of nucleation and crystal growth.

Unit IV:

Petrography and petrogenesis of major igneous rock clans with Indian examples and world famous localities: The basalt clan (MORB, OIB, CFB, spillites, komatiites); The andesites, boninites and related rocks.The trachyte-syenite clan; Granites and granitic rocks; The anorthosites and ultramafic rocks; Nephelinites and carbonatites; Lamprophyres, lamproites and kimberlites; The alkaline rocks. LIP's; Lunar basalts; Magmatism on other planets in solar system.

Practicals:

Megascopic and microscopic study of different igneous rocks; Calculation of CIPW and molecular norms; Modal analysis; Preparation and description of variation diagrams. Exercises related to various igneous processes such as crystal fractionation, partial melting and magma mixing.

Books Recommended:

Allegre, C.J. and Hart, S.R. (1979) Trace elements in Igneous Petrology, Elsevier
Bell, K., Kjarsgaard, B.A. and Simonetti, A. (1998) Carbonatites – Into the twenty-first Century, Journal of Petrology, Spl. Vol.39 (11 & 12)
Bell, Keith (Ed.) (1989) Carbonatites: Genesis and Evolution. Unwin Hyman, London.
Best, M. G. (2003) Igneous and Metamorphic Petrology, 2nd Edn., Blackwell.
Bose, M.K. (1997) Igneous Petrology, World Press, Kolkata.
Carmichael, J., Turner and Verhoogen (1974) Igneous Petrology, McGraw Hill.
Cox, K. G., Bell, J. D. and Pankhurst, R. J. (1979) The Interpretation of Igneous Rocks. Unwin Hyman.
Faure, G. (2001) Origin of Igneous Rocks, Springer.
Fitton, J.G. and Upton, B.J.G. (Eds) (1987) Alkaline Igneous Rocks, Geological Society, London.
Gupta, Alok (1998) Igneous Rocks, Allied Publishers Limited.
Hall, A. (1996) Igneous Petrology, 2nd Edn., Longman.
LeMaitre R.W. (2002) Igneous Rocks: A Classification and Glossary of Terms, Cambridge Uni. Press.
Hota, R.N. (2011) Practical Approach to Petrology, CBS Publisher and Distributors Pvt Ltd., New Delhi
Hughes, C.J. (1982) Igneous Petrology, Elsevier
LeBas, M.J. (1977) Carbonatite-nephelinite Volcanics, Wiley.
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 of India.
Perchuk, L.L. and Kushiro, I. (Eds.) (1991) Physical Chemistry of Magmas. Springer Verlag.
Rock, N.M.S., (1991) Lamprophyres, Blackie, Glasgow
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.

1T3

Sedimentology

Unit I:

Liberation and flux of sediments;Rock Cycle; Texture of sedimentary rocks and their significance; grain size parameters; Analysis of shape and roundness; Paleocurrent, heavy mineral and provenance studies; Processes of sediment transport; Fluid flow mechanics and formation of sedimentary bedforms;Sedimentary structures.

Unit II:

Classification and composition of conglomerate, sandstones, shale and carbonate rocks; Diagenesis - physical and chemical, processes and evidences of diagenesis in sandstones, mud rocks and carbonate rocks; Detailed study of siliceous, phosphatic and ferruginous rocks; Study of evaporites such as gypsum, anhydrite and halite; Dolomites, their petrographic characteristics and models of dolomitization.

Unit III:

Paleo-climate and paleoenvironment analysis; Implication of facies in environmental interpretation and basin analysis; Tectonics and sandstones composition; Study of economic mineral deposits in sedimentary rocks from India; Study of sedimentary basins of India: Precambrian- Proterozoic, Gondwana, Post Gondwana, Paleogene, Neogene and Quaternary sedimentation. Sedimentary environments.

Unit IV:

Field and laboratory techniques in sedimentology: Recording of sedimentary textures and structures, preparation of lithologs and thin section staining, cathodoluminescence, SEM studies, Determination of grain size of sediments; Application of trace element, rare earth element and stable isotope geochemistry to sedimentological problems with examples from India.

Practicals:

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 separation and their microscopic characters, graphic representation and interpretation; Grain-size analysis by sieving method; Plotting of size-distribution data as frequency and cumulative curves, computation of statistical parameters and interpretation.

Books Recommended:

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

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.

1T4

Paleontology and Applied Paleobiology

Unit I:

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

Unit II:

Vertebrate life through ages; Evolution and extinction of dinosaurs with special emphasis on Indian dinosaurs; Mammalia characters, Origin and evolution of the mammals; 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 angiosperm plants; Pre-Gondwana flora; A brief idea about Indian Gondwana and Paleogene flora; Application of paleobotany in assessing paleoclimate and paleoenvironment; Fossil record applied to sequence stratigraphy and depositional environment.

Unit IV:

Concept of evolution and extinction; Micro and macro-evolution; Phylogenetic analysis; Distribution, migration and dispersal of organisms applied to paleobiogeography; Stable isotope studies of shells in paleoclimatology; Applications of important mega and micro fossils in the exploration of coal and petroleum. Dendrochronology and its application. Introduction to important microfossils.

Practicals:

Study of modes of preservation of fossils; Study of morphological characters of important invertebrate fossils belonging to Brachiopoda, Bivalvia, Gastropoda, Nautiloidea, Ammonoidea, Belemnoidea, Trilobita, Echinoidea, Graptoloidea and Corals; Study of important trace fossils and microfossils; Study of important Indian Gondwana and Paleogene flora; Paleogeographic maps.

Books Recommended:
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.

Applied Paleobiology

Allison, P.A. and Briggs, D.E.G. (1991) Taphonomy. Releasing the data locked in the fossils record, Plenum Press.
Bergland, B.E. (1986) Handbook of Holocene paleoecology & paleohydrology, John Wiley, New York.
Dodd, J. Robert and Stanton, Robert. J. Jr. (2012) Paleoecology: Concepts and Applications. Second Edition (Reprint), Wiley India Pvt. Ltd., New Delhi.
Dord, J.R. and Stanta, R.J. (1981) Palaeoecology concepts and applications, John Wiley and Sons.
Jones, T.P. and Rowe, T.P. (1999) Fossil Plants and Spores Modern Techniques, Geological Society of London.
Patnaik, R. (2003) Reconstruction of Upper Siwalik palaeoecology and palaeoclimatology using microfossil palaeocommunities, Palaeogeography, Palaeoclimatology, Palaeoecology, Vol. 197.
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.
Shipad N. Agashe (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.

M.Sc. (Tech) Applied Geology
Semester II

Code	Theory / Practical	Teaching Scheme (Hrs/ week)			Credits	Examination Scheme					
		Th	Pr.	Total		Duration (Hrs)	Max. Marks		Total Marks	Min. Passing Marks	
							External	Internal		Th	Pr.
2T1	Metamorphic Petrology (4)	4		4	4	3	80	20	100	40	
2T2	Structural Geology, Geodynamics and Tectonics (3+1)	4		4	4	3	80	20	100	40	
2T3	Stratigraphy and Indian Geology (2+2)	4		4	4	3	80	20	100	40	
2T4	Geochemistry (4)	4		4	4	3	80	20	100	40	
2P1	Metamorphic Petrology and Structural Geology (Marks: 75 Pract. + 05 Viva-voce +20 Internal Assessment and Class Record)		8	8	4	3	100	----	100		40
2P2	Stratigraphy, Geochemistry, Geological Field Work and Mapping (Marks: 55 Pract. + 05 Viva-voce + 20 Field Work and Mapping + 20 Internal Assessment and Class Record)		8	8	4	3	100	----	100		40
2S1	Seminar 2	2		2	1	---		25	25	10	
	Total	18	16	34	25		520	105	625	170	80

FIELD WORK:

Each candidate must carry out field work of 10 to 20 days duration in igneous / sedimentary / metamorphic (including structurally deformed) terrain. The field report should be based on the mapping as well as laboratory work on the rock samples collected during the field work. The field work should be treated as a part of practical 4examination of semester II and the field report shall be assessed by field excursion In-charge.

2T1

Metamorphic Petrology

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 and steady state geotherms; Protolith types and characteristic metamorphic minerals; metamorphic textures.

Unit II:

Facies and sub-facies series (Classifications of Escola, Miyashiro and Yardley); Metamorphic zones; Metamorphic differentiation; Metasomatism; Granitization and crustal anatexis; Pressure – temperature – time paths and metamorphic terrains; Paired metamorphic belts; Ultra high temperature (granulite) and ultra-high pressure (blue schist, eclogite) metamorphism; Petrography and origin of following rock types: hornfelses, amphibolites, charnockites, and Migmatites

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; Metamorphic projections in positive and negative space; ACF, AKF and AFM diagrams; Schrienemakers rule and construction of petrogenetic grids.

Unit IV:

Regional Metamorphism of mafic and ultramafic rocks, pelitic sediments and impure calcareous rocks; Experimental studies on metamorphic reactions; Concepts of geothermometry and geobarometry; Relationship of metamorphic rocks and associated mineral deposits; Tectonic controls of metamorphism.

Practicals:

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; Estimation of pressure and temperature from important models of geothermobarometry.

Books Recommended:

Bhaskar Rao, B. (1986) Metamorphic Petrology, IBH & Oxford.
Blatt, H. and Tracy, R.J. (1996) Petrology (Igneous, Sedimentary, Metamorphic), W.H. Freeman and Co., NewYork.
Bucher, K. and Frey, M. (2002) Petrogenesis of Metamorphic Rocks (7th Rev. Ed.), Springer–Verlag.

Harker, Alfred (1964) Metamorphism, Methuen, London.
Kretz, R. (1994) Metamorphic Crystallization, John Wiley.
Philopotts, A.R. (1994) Principles of Igneous and Metamorphic Petrology, Prentice Hall.
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.
Stuwe, K. (2007) Geodynamics of the Lithosphere. Springer-Verlag.
Spry, A. (1976) Metamorphic Textures, Pergamon Press.
Turner, F.J. (1980) Metamorphic Petrology, McGraw Hill, New York.
Winter, J.D. (2001) An introduction to Igneous and Metamorphic Petrology, Prentice Hall.
Wood, B.J. and Fraser, D.G. (1976) Elementary Thermodynamics for Geologists, Oxford University Press, London.
Yardley, B.W.D., Mackenzie, W.S. and Guilford, C. (1995) Atlas of Metamorphic Rocks and their textures, Longman Scientific and Technical, England.
Yardlley, B.W.D. (1989) An introduction to Metamorphic Petrology, Longman Scientific and Technical, New York.

2T2
Structural Geology, Geodynamics and Tectonics

Unit I:

Theories of rock failure; Mechanical principles, properties of rocks and their controlling factors; Concept of stress and strain: Stress ellipsoid; Mohr circle construction; Stress-strain relationship; Strain parameters, Types of strain ellipses and ellipsoids and their properties; Strain Analysis: Graphical representations of strain (Flinn, Ramsay, and Nadai-Hossack plots), progressive deformation.

Unit II:

Description of folds; Causes of folding; similar fold and shear fold, kink bands, chevron folds and conjugate fold; decollement; 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; field and laboratory techniques, graphical treatment.

Unit III:

Stereographic projections;π and β diagrams; 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; Continental drift, supercontinents, sea-floor spreading, hot-spots and plumes, diapers and salt-domes; Cratons and mobile belts; Theory of Plate Tectonics: concept, plate motions and driving forces, pros and cons; Geology of plate boundaries, Wilson cycle; Precambrian tectonics; Phanerozoic plate tectonics; Evolution of Indian subcontinent: from supercontinent assembly to break-up of Gondwanaland; Evolution of the Himalayas and Indian Ocean; Seismotectonics and the 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.

Books Recommended:
Structural Geology

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.
Marshak, S. and Mitra, G. (1988) Basic methods of Structural Geology, Prentice-Hall, New Jersey.
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.

Geodynamics and Tectonics:

Condie, K.C. (1989) Plate Tectonics and Crustal Evolution, 3rd Ed., Pergamon, Oxford Press.
Gass, I.G. (1982) Understanding the Earth, Artemis Press (Pvt) Ltd. U.K.
Kearey Phillips and Vine, F.J. (1996) Global Tectonics, Blackwell Science, Oxford.
Keary, P., Klepeis, K.A. and Vine, F.J. (2012) Global Tectonics, Third Edition (Reprint), Wiley-Blackwell, Wiley India Pvt. Ltd.
Moores, E and Twiss, R.J. (1995) Tectonics, Freeman.
Moores, Eldridge M. and Twiss, Robert J. (1995) Tectonics, Freeman and Company.
Patwardhan, A.M. (1999) The Dynamic Earth System, Prentice-Hall, New Delhi
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.
Valdiya, K.S. (1984) Aspects of Tectonics -Focus on south central Asia, Tata McGraw- Hill.
Valdiya, K.S. (2010) The Making of India: Geodynamic Evolution,Macmillan Publishers India Limited.
Windley, B.F. (1977) The Evolving Continents, John Wiley and Sons, New York.

2T3

Stratigraphyand Indian Geology

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 stratigraphicclassification 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 and Sons.
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 University Press.
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.
Ramakrishnan, M. and Vaidyanadhan, R. (2008) Geology of India, Vol.1, Geological Society of India, Bangalore.
Schoch, Robert, M. (1989) Stratigraphy: Principles and Methods, Van Nostrand Reinhold, New York.

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

2T4

Geochemistry

Unit I:

Introduction to geochemistry; Basic principles of chemistry; Major, minor and trace elements and their representation on variation diagrams for presentation of geochemical data (bivariate, multivariate, element ratio variation, enrichment-depletion and vector diagrams); Use of major elements for classification and characterisation of igneous, metamorphic and sedimentary rocks.

Unit II:

Trace and REE, their normalisation and role in petrogenesis of major rock groups; Stable isotopes, their normalisation, fractionation and role in understanding various geological processes; Radiogenic isotopes and their use in geochronology and identification of crustal and mantle reservoirs.

Unit III:

Formation of universe and origin of elements; Cosmic abundance of elements; Primary differentiation and geochemical classification of elements; Geochemical composition of the Solar System, the Sun, Planets, Moon, Comets, Asteroids and meteorites; Geochemical composition of the earth and its constituent parts such as crust, mantle, core; Geochemistry of igneous, metamorphic and sedimentary rocks.

Unit IV:

The composition of atmosphere, biosphere and hydrosphere; The geochemical cycle; Primary and secondary dispersion of elements and their use in geochemical exploration for mineral deposits; Anomalies and various methods of geochemical surveys; Eh-pH diagrams, colloids and colloidal processes and methods of biogeochemical surveys; Primary concepts of Medical Geology; Trace elements and human health; Geological health hazards; Geopharmacy.

Practicals:
Demonstration of sampling methods for geochemical analysis; Preparation of anomaly maps using chemical data; Calculation of important indices related to petrogenesis and weathering; Discriminant diagrams and interpretation of geochemical data; REE and trace elements plotting and interpretation; End member calculations from given EPMA data.

Books Recommended:

Allegre, C.J. and Michard, G. (1974) Introduction to Geochemistry, Reidel, Holland.
Anderson, G.M. and Crerar, D.A. (1993) Thermodynamics in Geochemistry- the Equilibrium Model, Oxford University Press, New York.
Faure, G. (1986) Principles of Isotope Geology, John Wiley.
Faure, G. (1991) Inorganic Geochemistry, Prentice Hall.
Fletcher, P. (1993) Chemical Thermodynamics for Earth Scientists, Longman Scientific and Technical, London.
Glasstone, S. (1947) Thermodynamics for Chemists, East and West Publishers.
Govett, G.J.S. (Ed) (1983) Handbook of Exploration Geochemistry, Elsevier.

Henderson, P. (1987) Inorganic Geochemistry, Pergamon Press.
Hoefs, J. (1980) Stable Isotope Geochemistry, Springer Verlag.
Krauskopf, K.B. (1994) Introduction to Geochemistry, Mc Graw Hill.
Krauskopf, K.B. and Bird, D.K. (1995) Introduction to Geochemistry, McGraw-Hill International Edn.
Marshal, C.P. and Fairbridge, R.W. (1999) Encyclopaedia of Geochemistry. Kluwer Academic.
Mason, B. (1982) Principles of Geochemistry, Wiley Eastern.
Mason, B. and Moore, C.B. (1991) Introduction to Geochemistry, Wiley Eastern.
Nordstrom, D.K. and Munoz, J.L. (1985) Geochemical Thermodynamics, The Benjamin Cummings Publishing Co. Inc.
Powell, R. (1978) Equilibrium Thermodynamics in Petrology, Harper and Row.
Wood, B.J. and Fraser, D.G. (1977) Elementary thermodynamics for geologists, Oxford.
Yoder, H.S. (Ed.) (1979) The Evolution of the Igneous Rocks, Princeton University Press.

M.Sc. (Tech) APPLIED GEOLOGY

Semester III

Code	Theory / Practical	Teaching Scheme (Hrs/ week)			Credits	Examination Scheme					
		Th	Pr.	Total		Duration (Hrs)	Max. Marks		Total Marks	Min. Passing Marks	
							External	Internal		Th	Pr.
3T1	Instrumentation Techniques, Geostatistics and Computer Application in Geology (1+2+1)	4		4	4	3	80	20	100	40	
3T2	Indian Mineral Deposits and Mineral Economics (3+1)	4		4	4	3	80	20	100	40	
3T3	Ore Geology (4)	4		4	4	3	80	20	100	40	
3T4	Mining Geology & Valuation of Mineral Property (2+2)	4		4	4	3	80	20	100	40	
3P1	Instrumentation Techniques, Geostatistics, Computer Application in Geology (Marks: 75 Pract. + 05 Viva-voce + 20 Internal Assessment and Class Record)		8	8	4	3	100	----	100		40
3P2	Ore Geology, Mining Geology and Valuation of Mineral Property (Marks: 75 Pract. + 05 Viva-voce + 20 Internal Assessment and Class Records)		8	8	4	3	100	----	100		40
3S1	Seminar 3	2		2	1	---		25	25	10	
	Total	18	16	34	25		520	105	625	170	80

3T1

Instrumentation Techniques, Geostatistics and Computer Application in Geology

Unit I:

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 fluorescenece spectrometry; Scanning and transmission electron microscopy; Instrumental Neutron Activation Analysis (INAA); Isotope dilution technique; Electron Probe Micro Analysis (EPMA), X ray defractometry; Thermal Ionisation and gas source mass spectrometry.

Unit II:

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.

Unit III:

Events, sample space; Random variables, discrete and continuous probability distributions, joint probability distributions, conditional probability distributions; Binomial, Poisson, Normal, Chi-square, t and F test. Application of geostatistical techniques to Geochemistry, Hydrogeology, Environmental Geochemistry, Paleobiology and Mineral Exploration.

Unit IV:

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, spreadsheets; 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.

Practical:

Instrumentation Techniques:

Introduction to common analytical instrumental techniques as taught in theory; 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; Wet assay of Cu, Pb, Zn, Al, Cr, Fe, Mn, Ti, Na, K etc.

Geostatistics and Computer Applications in Geology:

Problems in calculating various statistical parameter for a given data; student test, chi-square test; least square method; Statistical models; Practical training in data analysis using different computer software available in the department.

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.

Geostatistics/ Statistical Methods in Geology:

Chiles, J.P. and Delfiner, P. (1999) Geostatistics: Modeling Spatial Uncertainity, John Wiley & Sons,NY
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.
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 & 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 Publishing Co.

Computer Applications in Geology:

No Textbook - only handouts and web pages

3T2
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 mineral deposits with reference to their mineralogy, mode of occurrence, origin, geological association and geographical distribution in India: 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:

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

Mineral Economics:

Chaterjee, K.K. (1993) An Introduction to Mineral Economics, Wiley Eastern.
Sinha, R.K. and Sharma, N.L. (1993) An Introduction to Mineral Economics, Wiley Eastern

3T3
Ore Geology

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; Detailed study of all principal ore mineral groups- their textures and structures; Paragenesis and zoning of ores and their significance.

Unit II:

Concept of ore bearing fluids, their origin and migration; Wall-rock alteration; Structural, physico-chemical and stratigraphic controls of ore localization; Geochemical modelling of ore deposits; Chemical composition of ores and host rocks -bulk chemistry, trace elements, REE and isotopes (stable and radiogenic); Organic matter in ores and their significance; Geothermometry and geobarometry of ore assemblages; Fluid inclusion in ores: principles, assumptions, limitations and applications.

Unit III:

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; Ores of silicic igneous rocks -Kiruna type Fe-P, pegmatoids, greisens, skarns, porphyry associations, Kuroko-type Zn-Pb-Cu.

Unit IV:

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 - metamorphism of ores, metamorphogenic ores; Ores related to weathering and weathered surfaces - laterite, bauxite, Ni/Au laterite; Contemporary ore-forming systems: Black smokers, mineralized crusts, Mn nodules.

Practical:

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

Books Recommended:

Barnes, H.L (1979) Geochemistry of Hydrothermal Ore Deposits, John Wiley.
Craig, J.M. and Vaughan, D.J. (1981) Ore Petrography and Mineralogy, John Wiley.
Edwards, R. and Atkinson, K. (1986) Ore Deposit Geology, Chapman and Hall, London.
Evans, A.M. (2012) Ore Geology and Industrial Minerals, Third Edition (Reprint), Blackwell Publishing and Wiley India Pvt. Ltd.
Guilbert, J.M. and Park, Jr. C.F. (1986) The Geology of Ore Deposits, Freeman.
Jensen, M.L. and Bateman, A.M. (1981) Economic Mineral Deposits, John Wiley and Sons, New York.
Klemm, D.D. and Schneider, H.J. (1977) Time and Strata Bound Ore Deposits, Springer Verlag.
Mookherjee, A. (2000) Ore genesis -a Holistic Approach, Allied Publishers.
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.
Wolf, K.H. (1981) Hand book of Strata Bound and Stratiform Ore Deposits, Elsevier.

3T4
Mining Geology and Valuation of Mineral Property

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;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 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.

Unit IV:

Use of cut-off grade in outlining ore; Classification of ore reserves and mineral resources; Methods in estimation of ore reserves and limitations; Costs in the production of ore- direct costs and indirect costs, depreciation cost and depletion cost; Alternate methods of amortization, payback 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.

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:

Arogyaswamy, R.N.P. (1995) Courses in Mining Geology, Oxford and IBH Publishing Co., New Delhi.
Bagchi, T.C., Sen Gupta, D.K. and Rao, S.V.L.N. (1979) Elements of Prospecting and Exploration, Kalyani Publishers, New Delhi.
Clark, G.B. (1967) Elements of Mining, Asia Publishing House.
McKinstry, H.E. (1972) Mining Geology, Prentice-Hall Inc.
Thomas, L.J. (1978) An Introduction to Mining, Methuen, Brisbane.

M.Sc. (Tech) APPLIED GEOLOGY

Semester IV

Code	Theory / Practical	Teaching Scheme (Hrs/ week)			Credits	Examination Scheme					
		Th	Pr.	Total		Duration (Hrs)	Max. Marks		Total Marks	Min. Passing Marks	
							External	Internal		Th	Pr.
4T1	Mineral Exploration (4)	4		4	4	3	80	20	100	40	
4T2	Elements of Mining and Drilling Techniques (3+1)	4		4	4	3	80	20	100	40	
4T3	Geomorphology, Remote Sensing and GIS (1+2+1)	4		4	4	3	80	20	100	40	
4T4	Fuel Geology (Coal, Petroleum and Nuclear) (2+1+1)	4		4	4	3	80	20	100	40	
4P1	Mineral Exploration and Mine/ Industrial Training (Marks: 55 Pract. + 05 Viva-voce + 20 Mine/ Industrial Training + 20 Internal Assessment and Class Record)		8	8	4	3	100	----	100		40
4P2	Geomorphology, Remote Sensing and GIS and Fuel Geology (Marks: 75 Pract. + 05 Viva-voce + 20 Internal Assessment and Class Record)		8	8	4	3	100	----	100		40
4S1	Seminar 4	2		2	1	---		25	25	10	
	Total	18	16	34	25		520	105	625	170	80

Mine/ Industrial Training:

Each candidate shall undergo Mine / Industrial Training of 10 days to 20 days duration in any working mine or industry or organization related to earth science and submit Mine / Industrial Training report to the Head of the Department. This training shall be treated as a part of practical

7examination of semester IV and the field report shall be assessed by the Head of the Department and training and placement in-charge.

4T1
Mineral Exploration

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; Geological modelling 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.

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 and applications.

Magnetic method: Introduction, 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; Introduction to Aeromagnetic survey.

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 groundwater prospecting and civil engineering problems.

Unit IV:

Seismic methods: Introduction; Theoretical background; Elastic parameters; Seismic Waves; Propagation of the seismic waves; Seismic velocity; Geometry of reflected wave path; Geometry of refracted wave path; Instruments; Data Corrections; Data Processing; Interpretation.

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:

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 borehole data; Preparation of grade maps of mineral deposits based on sampling data.

Books Recommended:

Arogyaswamy, R.N.P. (1995) Courses in Mining Geology, Oxford and IBH Publishing Co., New Delhi.
Bagchi, T.C., Sen Gupta, D.K. and Rao, S.V.L.N. (1979) Elements of Prospecting and Exploration. Kalyani Publishers, New Delhi.
Brooks, A.R. (1972) Geobotany and Biogeochemistry in Mineral Exploration, Harper and Row.
Clark, G.B. (1967) Elements of Mining, Asia Publishing House.
Compton, R.R. (1985) Geology in the Field, John Wiley and Sons Inc.
Dobrin, M.B. (1976) Introduction to Geophysical Prospecting, McGraw Hill.
Hawkes, H.E. and Webb, J.S. (1980) Geochemistry in Mineral Exploration, Harper and Row.
Howel, B.F. (1959) Introduction to Geophysical Prospecting, McGraw Hill.
Lowrie, W. (1997) Fundamentals of Geophysics, Cambridge University Press.
McKinstry, H.E. (1972) Mining Geology, Pretice-Hall Inc.
Mussett, A.E. & Khan, M.A. (2000) Looking into the Earth: An Introduction to Geological Geophysics. Cambridge University Press.
Pacal, Z. (Ed.) (1977) Geochemical Prospecting Methods, Ustrendi.
Parasnis, D.S. (1975) Principles of Applied Geophysics, Chapman and Hall.
Peters, W. C. (1978). Exploration and Mining Geology, John Wiley and Sons Inc.
Ramam, P.K. (1989) Principles and Practices of Mineral Exploration, Geological Society of India, Banglore.
Rose, A.W., Hawkes, H.E. & Webb, J.A. (1979) Geochemistry in Mineral Exploration, Academic Press.
Sharma, P.V. (1986) Geophysical Methods in Geology, Elsevier.
Sharma, P.V. (1997) Environmental and Engineering Geophysics, Cambridge University Press.
Sharma,V.P. (1999) Applied and environmental geophysics.
Stenislave, M. (1984) Introduction to Applied Geophysics, Reidel Publ.
Thomas, L.J. (1978) An Introduction to Mining. Methuen, Brisbane.
Vogelsang, D. (1995) Environmental Geophysics -A Practical Guide, Springer Verlag.

4T2
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 openings; 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, Mine organization; Rescue work, welfare measures.

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; Safety measures in open cast and underground mines;

Unit IV:

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; Deviation in drill holes: their measurements and correction; Directional drilling.

Books Recommended:

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

4T3
Geomorphology, Remote Sensing and GIS

Unit I:

Geomorphic concepts; Landforms: Role of Lithology, peneplaination, endogenous and exogenous forces responsible, climatic and tectonic factors and rejuvenation of landforms;Denudational processes: Weathering, erosion, transportation, weathering products and soil formation, slope processes; Drainage basin morphometry; Major processes and associated landforms: Tectonic, fluvial, aeolian, coastal, karst and glacial; Geomorphic features and zones of India.

Unit II:

Fundamentals of EMR, radiation laws, black and grey body radiation, atmospheric effect in remote sensing; Interaction of EMR with atmosphere and Earth surface; Interaction of TIR wavelength with terrain feature and vegetation; Interaction of Microwave with Earth surface.
Aerial photography: Sequence involved in the aerial photography: Types, stereoscopy, geometrical characteristic, film and filter; Instrumentation and vertical exaggeration;Calculations of heights and slopes from aerial photographs; Principles of photogrammetry; Aerial photo interpretation – photo recognition elements and Interpretation of different geological features on B/W aerial photographs.

Unit III:

Orbit and Sun-synchronous aspect of satellite; Remote Sensing Sensor: Platforms and sensor resolution and calibration aspects of remotely sensed data, microwave sensor and False Colour Composite (FCC); Fundamentals of digital image processing: Image rectification, Image enhancement and Image classification; TIR remote sensing and its applications; Principle of microwave remote sensing and its applications; Geological applications of remote sensing; LANDSAT, SKYLAB, SPOT, SEASAT, ICONOS and other foreign systems of satellites and their interpretation for geological studies; Space research in India: Bhaskara, IRS series and their applications.

Unit IV:

Principles and components of GIS; Geospatial data, data for GIS application, spatial data models and data structures; Vector and raster based GIS; Spatial data acquisition, Vector overlay analysis; Neighbourhood Operation; Raster spatial analysis; Buffer analysis; Visualization and query of spatial data; Overlay analyses; Terrain analysis (DEM); Line generation; Introduction to GIS and remote sensing software; Geological applications of GIS; Principle and application of GPS.

Practical:

Topographical map interpretation for different landforms; Analysis of weathering trends; Drainage basin morphometry; Relief and slope analyses; Determination of photo scale, aerial photo interpretation for geological and geomorphological applications, parallax measurements for height determination, dip and thickness of beds; Study of landforms and interpretation of lithology and structure from aerialphotograph and satellite images; Tracing of lineament and rosettes; Identification of landform on toposheets, aerial photographs and satellite images; Generation of DEM and DTM; FCC interpretation of satellite images; Image processing and GIS software.

Books Recommended:
Geomorphology:

Kale and Gupta, Introduction to Geomorphology.
Rice, Fundamentals of Geomorphology.
Sharma, H.S. (1990) Indian Geomorphology, Concept Publishing Company, New Delhi.
Thornbury, W.D. (1980) Principles of Geomorphology, Wiley Easton Ltd., New York.

Remote Sensing and GIS:

Anji Reddy, M. (2001) Textbook of Remote Sensing and Geographical Information Systems, BS Publication, Hyderabad.
Berhardsen, T. (1999) Geographic Information System: an introduction, Wiley, New York.
Bonham-Carter, G.F. (1994) Geographic Information System for Geoscientists: Modelling with GIS, Pergamon.
Burrough, P.A. (1986) Principles of Geographical Information Systems for land resources assessment, Clarendon Press, Oxford.
Burrough, P.P. and MacDonnel, R.A. (1998) Principles of GIS, Oxford University Press.
Curran, P.J. (1985) Principles of Remote Sensing, Longman Scientific & Tech. Group, Essex, England.
Drury, S.A. (2001) Image Interpretation in Geology, Chapman and Hall, London.
Gupta, R.P. (1991) Remote Sensing Geology, Springer-Verlag.
Jain, A.K. (1989) Fundamentals of digital image processing, Prentice Hall India.
Jensen, J.R. (1986) Introductory Digital Image Processing: A Remote Perspective, Prentice Hall, New Jersy.
Lattman, L.H. and Ray, R.G. (1965) Aerial photographs in field geology, McGraw Hill.
Pande, S.N. (1987) Principles and Applications of Photogeology, Wiley Eastern Limited.
Lillesand, T.M. and Kiefer, R.W. (2000) Remote Sensing and Image Interpretation, John Wiley and Sons Inc., New York.
Maguire, D.J., Goodchild, M.F. and Rhind, D.W. (1991) GIS - Principles and Applications, Longman Scientific and Technical.
Mikhail, E.M. (1980) Photogrammatry, Harper and Row.
Miller, V.C. (1961) Phologeology, McGraw Hill.
Paine, D.P. (1981) Aerial photography and Image Interpretation for Resource Management, John Wiley.
Ray, R.G. (1969) Aeriat Photographs in Geologic Interpretations, USGS Proc Paper 373.
Richards, J.A. (1986) Remote Sensing Digital Analysis: an introduction, Springer-Verlag, Berlin.
Sabins, F.F. Jr. (2000) Remote Sensing Principles and Interpretations, W.H. Freeman & Company, USA
Siegal, B.S. and Gillespie, A.R. (1980) Remote Sensing in Geology, John Wiley.

4T4
Fuel Geology (Coal, Petroleum and Nuclear)

Unit I:

Origin of coal; Sedimentology of coal bearing strata; Structures associated with coal seams; Proximate and Ultimate analysis of coal; Rank, grades and types of coal; Indian and International classification for coking and non-coking coals; Coal preparation: coal carbonization, coal gasification, underground coal gasification (UCG), coal hydrogenation and coal combustion.

Unit II:

Coal Petrology – concept of 'lithotype', 'maceral' and 'microlithotype; Classification and optical properties of macerals and microlithotypes; Techniques and methods of coal microscopy; Reflectance and fluorescence microscopy; Application of coal petrology for different industrial purposes; Geological and geographical distribution of coal and lignite deposits in India; Coal exploration and estimation of coal reserves; Indian coal reserves and production of coal in India;
Coal Bed Methane (CBM); Generation, retention and exploration of methane from coal beds.

Unit III:

Petroleum:Different states, natural occurrences, chemical composition and physical properties of different fractions; Origin of Petroleum: Transformation of organic matter into kerogen, organic maturation, thermal cracking of kerogen; Migration of oil and gas;Reservoir rocks: General attributes and petrophysical properties; Classification of reservoir rocks- fragmental reservoir rocks and chemical reservoir rocks; Reservoir fluids- water, oil and gas; Hydrocarbon traps: Structural, stratigraphic and combination traps;Cap rock:Definition and general properties; Petroliferous basins ofIndia; Elements of petroleum exploration; Hydrocarbons: Present status and future prospects.

Unit IV:

Mineralogy and geochemistry of radioactive minerals; Mode of occurrence, origin, association and distribution of atomic minerals in nature (U, Th, Be, rare metals and REE etc); Atomic minerals as source of energy; Metallogenic epochs and provinces of uranium mineralisation; Principles and methods of exploration for radioactive mineral deposits; Radiometric surveys: Methods of detection and measurement of radioactivity; Geiger Muller Counters and Scintillation Counters; Gamma ray logging of bore holes; Application of radioactivity in geochronometry; Uranium and thorium exploration in India; Productive geological horizons in India; Atomic fuels and environment; Nuclear power stations of India and future prospects.

Practical:

Macroscopic characterization of banded coals; Completion of outcrop in the given maps and calculation of coal reserve; Preparation of polished particulate mounts of coal; Microscopic examination of polished particulate mounts (identification of macerals); Proximate analysis of coal; Laboratory analysis related to coal bed methane studies.

Study of geological maps and sections of important oil fields of India; Calculation of petroleum reserves; Problems on classification of oil field water based on chemical composition.

Megascopic identification of common minerals used in atomic industry.

Books Recommended:
Coal Geology

Acharyya, S.K. (2000) Coal and Lignite Resources of India: An overview, Geological Society of India, Banglore.
Chandra, D., Singh, R.M. and Singh, M.P. (2000) Textbook of Coal (Indian Context), Tara Book Agency, Varanasi.
Francis, W. (1961) Coal, Edward Arnold Ltd.
Scott, A.C. (1987) Coal and Coal-bearing strata: Recent Advances, Blackwell Scientific Publications.
Singh, M.P. (Ed.) (1998) Coal and Organic Petrology, Hindustan Publ. Corp., New Delhi.
Stach, E. et al. (1975) Stach's textbook of coal petrology, Berlin: Gebruder Borntraeger.
Stach, E., Mackowsky, M.T.H., Taylor G.H., Ghandra, D., Telchmuller, M. and Telchmuller, R. (1982) Stach's Text Book of Coal Petrology, Gebruder Borntraeger, Stuttgart.
Taylor, G.H., Teichmüller, M. and Davis, C. (1998) Organic Petrology: A new handbook incorporating some revised parts of Stach's Textbook of Coal Petrology.
Taylor, G.H., Teichmuller, M., Davis, A., Diessel, G.F.K., Littke, R. and Robert, P. (1998) Organic Petrology, Gebruder Borntraeger, Stuttgart.
Thomas, Larry (2002) Coal Geology, John Wiley and Sons Ltd., England.

Van Krevelen, D.W. (1993) Coal: Typology-Physics-Chemistry-Constitution, Elsevier Science, Netherlands.

Petroleum Geology:

Holson, G.D. and Tiratsoo, E.N. (1985) Introduction to Petroleum Geology, Gulf Publ. Houston, Texas.
Leverson, A.L. (1970) Geology of Petroleum, Freeman and Company.
North, F.K. (1985) Petroleum Geology, Allen and Unwin.
Selley, R.G. (1998) Elements of Petroleum Geology, Academic Press.
Tissot, B.P. and Welte, D.H. (1984) Petroleum Formation and Occurrence, Springer- Verlag.

Nuclear Geology:

Aswathanarayana, U. (1985) Principles of Nuclear Geology, Oxford Press.
Boyle, R.W. (1982) Geochemical Prospecting for Thorium and Uranium Deposits, Elsevier.
Dahlkamp, F.J. (1993) Uranium Ore Deposits, Springer Verlag.
Durrance, E.M. (1986) Radioactivity in Geology, Principles and Application, Ellis Hoorwool.

M.Sc. (Tech) APPLIED GEOLOGY
Semester V

Code	Theory / Practical	Teaching Scheme (Hrs/ week)			Credits	Examination Scheme					
		Th	Pr.	Total		Duration (Hrs)	Max. Marks		Total Marks	Min. Passing Marks	
							External	Internal		Th	Pr.
5T1	Ore Microscopy and Ore Dressing (1+3)	4		4	4	3	80	20	100	40	
5T2	Hydrogeology and Watershed Management (3+1)	4		4	4	3	80	20	100	40	
5T3	Core Elective 1 Optional (Any one) 1) Exploration Geochemistry (4) 2) Quaternary Geology & Limnogeology (3+1)	4		4	4	3	80	20	100	40	
5T4	(Core Subject Centric-1) 1) Environmental Geology & Geohazards	4		4	4	3	80	20	100	40	
5P1	Ore Microscopy, Ore Dressing, Hydrogeology&Watershed Management (Marks: 75 Pract. + 05 Viva-voce + 20 Internal Assessment and Class Record)		8	8	4	3	100	---	100		40
5P2	Based on paper 5T3 and Environmental Geology (Marks: 75 Pract. + 05 Viva-voce + 20 Internal Assessment and Class Records)		8	8	4	3	100	---	100		40
5S1	Seminar 5	2		2	1	---		25	25	10	
	Total	18	16	34	25		520	105	625	170	80

5T1

Ore Microscopy and Ore Dressing

Unit I:

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; Structures and textures of ores, their interpretation and paragenesis; Application of ore microscopy in mineral dressing.

Unit II:

Nature and Scope of mineral dressing; Relation of ore dressing to smelting and utility; Properties of minerals in relation to their dressing; Liberation: Practice of crushing and grading and grinding; Working principles of Jaw, Gyratory, Cone and roll crusher; Stamp, Rod and Ball Mills.

Unit III:

Concentration, screening and sizing: Concentration processes such as preliminary washing and sorting; Heavy fluid separation; Use of Classifiers (Hydraulic and Pneumatic); Jigging; Tabling, Floatation and Agglomeration; Electrostatic, Centrifugal and Maganetic separation; Amalgamation and heat treatment methods; Concentration of ores by chemical leaching; Process of dewatering, filteration, drying and thickening methods, dressing systems and plants.

Unit IV:

Flow sheets of common types of ores; Methods of dressing of coal, clays, flurospar, graphite, micas, gypsum, talc, diamond, barite and common ores of copper, manganese, chromium, gold, lead, zinc, titanium, tin, zirconium, thorium and uranium; Flow sheets of important concentration plants of India.

Practical:
Ore Microscopy:

Preparation of polished sections of ores and mounting. 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. Microchemical tests for ore minerals.

Ore Dressing:

Mechanical analysis by sieving, size analysis under microscope. Separation of minerals by panning and tabling. Preparation of flow sheets of the important concentration plants of India and flow sheets of common types of ores.

Books Recommended:
Ore Microscopy:
Craig, J.R. and Vaughan, D.J. (1981) Ore Petrography and Mineralogy, John Wiley.

Craig, J.R. and Vaughan, D.J. (1994) Ore Microscopy and Ore Petrology, John Wiley.
Galopin, R. And Henry, N.F.M. (1972) Microscopic study of opaque minerals, McCrone Research Associates Ltd., London.
Ineson, P.R. (1989) Introduction to Practical Ore Microscopy, Longman Publishers.
Picot, P. and Johan, Z. (1982) Atlas of Ore Minerals, Elsevier Publishers.
Ramdohr, P. (1969) The Ore Minerals and their Intergrowths, Pergamon Press.
Sahoo, R.K. (2011) Atlas of oxide ores of India and their textures, SSDN Publishers and Distributors, New Delhi.
Stanton, R.L. (1972) Ore Petrology, McGraw Hill.

Ore Dressing:

Gaudin, A.M. (1974) Principles of mineral dressing, Tata McGraw Hill.
Kelly, E.G. and Spottiswood, D.J. (1982) Introduction to mineral processing, John Wiley.
Taggart, A.F. ( ) Hand book of mineral dressing.
Wills, B.A. (1992) Mineral processing technology, Pergmon Press.

5T2
Hydrogeology and Watershed Management

Unit I:

Hydrological cycle; Controls of geology on groundwater occurrence, movement and distribution; Classification of aquifers and aquifer systems; Mode of occurrence of groundwater in different geological formations and groundwater provinces of India; Darcy's law and Reynolds number; Aquifer parameters; Water table contour maps and flow net analysis; Seepages and springs.

Unit II:

Groundwater quality and environmental aspects; Chemical characteristics of groundwater in relation to various uses – domestic, industrial and irrigation; Saline water intrusion in coastal and other aquifers and its preventive measures; Environmental effects of over-exploitation of groundwater; Water logging problems; Causative factors of groundwater level fluctuations and environmental influences; Radioisotopes in hydrogeological studies.

Unit III:

Surface and subsurface methods of groundwater exploration; Application of remote sensing in groundwater exploration; Collection of hydrogeological data and preparation of hydrographs; Selection of suitable site for well construction; Type and design of wells, methods of well construction, well completion and well development; Pump tests and evaluation of hydrologic properties through various methods for steady and unsteady flow.

Unit IV:

Artificial recharge to groundwater and rainwater harvesting; Management of groundwater resources; Conjunctive use of groundwater and surface water; Concept of watershed: Watershed characters, importance of water resources; Technical aspects of artificial recharge structures; Groundwater legislation; Role of NGOs and government policies in watershed development.

Practical:

Delineation of hydrological boundaries on water-table contour maps and estimation of permeability; Determination of groundwater flow direction; Problems in calculating transmisivity, specific retention and specific yield; Interpretation of well inventory data; Analysis of hydrographs and estimation of infiltration capacity; Pumping test: time-drawdown and time-recovery tests and evaluation of aquifer parameters; Step drawdown tests, Electric resistivity sounding for delineation of fresh aquifers; Study of geophysical well logs; Estimation of TDS using resistivity and SP logs; Exercises on groundwater exploration using remote sensing techniques; Water budgeting problems.

Books Recommended:

Davies, S.N. and De Wiest, R.J.N. (1966) Hydrogeology, John Wiley and Sons, New York.
Driscoll, F.G. (1988) Groundwater and Wells, UOP, Johnson Div. St. Paul. Min. USA.
Karanth, K. R. (1989) Hydrogeology, Tata McGraw Hill Publishers.
Nagabhushaniah, H.S. (2001) Groundwater in Hydrosphere (Groundwater hydrology), CBS Publ.
Raghunath, H.M. (1990) Groundwater, Wiley Eastern Ltd.,
Todd, D.K. (1995) Groundwater Hydrology, John Wiley and Sons.
Tolman, C.F. (1937) Groundwater, McGraw Hill, New York and London.

5T3
Core Elective 1
1)Exploration Geochemistry

Unit I:

Geochemistry in mineral exploration: Brief history and present status; Geochemical cycle; Geochemical environments, mobility and distribution of major, minor and trace elements and secondary environment; Anomalies and background values; Indicator elements; Primary dispersion: related patterns, haloes.

Unit II:

Secondary dispersion and accumulation of elements, weathering, formation of soil, secondary dispersion patterns, haloes and geochemical anomalies in soils, residual overburden, bed rocks, over blind ore bodies, over transported overburden and in waters and plants; Geochemical, metallogenic and biogeochemical provinces; Vegetation anomaly; Precision and accuracy.

Unit III:

Interpretation of geochemical anomalies including pathfinders and preparation of different geochemical maps and treatment of geochemical data; Geochemical techniques in exploration: lithogeochemical, pedogeochemical, hydrogeochemical, biogeochemical, atmogeochemical and stream sediment surveys; Regional and detailed surveys.

Unit IV:

Biochemical, geobotanical and geozoological prospecting; Application of remote sensing in geobotanical exploration; Selected case histories of geochemical exploration of Copper, Lead, Zinc, Nickel and Chromium; Geochemical aspects of geothermal resources; Area selection and sequential exploration model; Geochemical conceptual models.

Practical:

Preparation and interpretation of geochemical anomaly maps using probability graphs; Problems based on analysis of data obtained in geochemical exploration; 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, vol 6, 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.

2)Quaternary Geology and Limnogeology

Unit I:

Significance of Quaternary studies; Quaternary Stratigraphy;Quaternary deposits in India;Evolution of man and cultural stages; Morphostratigraphy;Criteria used for defining Pliocene- Pleistocene boundary; Pleistocene-Holocene boundary.

Unit II:

Scope of paleoclimatic studies;Sources of paleoclimate reconstruction; QuaternaryPaleoclimate; 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).

Unit III:

Geochronologicalmethods used in dating Quaternary events: K-Ar and ^{39}Ar-^{40}Ar dating, Radiocarbon dating (^{14}C),^{12}C- ^{13}C dating,Thermoluminescence (TL), ^{210}Pb and ^{137}Cs Chronology;Paleomagnetic dating; MagneticSusceptibility study and paleorainfall; Dendrochronology;Stable Oxygen isotopes and paleoclimates.

Unit IV:

Scope of Limnogeology; Majordivisions of lakes;Physical, Chemical and Biological environments of lakes;Geological evolution of lake basins; Applications of the freshwater fossil Diatoms and polynomorphs in limnogeological study;Methods of investigations oflake signatures: Drought, tsunami, storm, anthropogenic metal, land use changes, earthquake;Sedimentological and geochemical archive in lake deposits;Lake sediment records of carbonaceous particles from fossil-fuel combustion and Soot Particle counting.

Practical:

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

Limnogeology:

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 Soda Lake, 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.
Smol, J.P., Birks, H.J.B. and Last, W.M. (2003) Tracking Environmental change using lake sediments: Terrestrial, Algal and Siliceous Indicators, Paleoenvironmental Research Book Series, 371p.
Taylor, K., Alley, R.B., Fiacco, J., Grootes, P.M., Lamorey, G.W., Mayewski, P.A. & Spencer, M.J. (1992) Ice core dating and chemistry by direct-current electrical conductivity: Journal of Glaciology, v. 38.
Wetzel, R.G. Limnology of Lakes and River Ecosystem, Third Edition.
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.

Practical 5P2:
Practical for Environmental Geology:

Preparation of seismic zonation maps of India and world; Demarcation of landslide prone areas in the Himalaya; Demarcation of flood prone areas in the outline map of India; Preparation of volcanic hazard zonation map; Presentation of chemical analysis data and plotting chemical classification diagrams; Preparation of oceanic and atmospheric circulation maps.

5T4
Core (Subject Centric) 1
1)Environmental Geology and Geohazards
(Candidate can opt for this paper in their main subject of post-graduation only)

Unit I:

Components of environmental geology; Time scales of global changes in the ecosystem and climate; Major icehouse and greenhouse periods; Impact of oceanic and atmospheric circulation on climate and rain fall; Atmospheric carbon-dioxides increase and global warming; Paleo-temperature estimation from ice cores.

Unit II:

Physical, chemical and biological domains of environment; Air, water and noise pollution, their causes and remedial measures; Surface weathering, development of soil and soil pollution; Impact of mining on environment.

Unit III:

Problems of urbanization, human population and their impact on environment; Alternative sources of energy: Solar, wind, tidal, geothermal, hydal, nuclear; Waste disposal and related problems; Environmental legislations.

Unit IV:

Earthquake and tsunami – causes of occurrence and their impact as natural hazard; Seismic hazard zones; Neotectonics in seismic hazard assessment; Landslide and volcanic hazards- their causes and control; Coastal erosion, its causes and control; Major river belts of India, flood hazards and their mitigation.

Books Recommended:
Bell, F.G. (1999) Geological Hazards, Routledge, London.
Bryant, E. (1985) Natural Hazards, Cambridge Univ. Press.
Keller, E.A. (1978) Environmental Geology, Bell and Howell, USA.
Lal, D.S. (2007) Climatology, Sharda Pustak Bhawan, Allahabad.
Patwardhan, A.M. (1999) The Dynamic Earth System, Prentice Hall.
Perry, C.T. and Taylor, K.G. (2006) Environmental Sedimentology, Blackwell Publ.
Smith, K. (1992) Environmental Hazards, Routledge, London.
Subramaniam, V. (2001) Textbook in Environmental Science, Narosa International.
Valdiya, K.S. (1987) Environmental Geology – Indian Context, Tata McGraw Hill.

M.Sc. (Tech) APPLIED GEOLOGY

Semester VI

Code	Theory / Practical	Teaching Scheme (Hrs/ week)			Credits	Examination Scheme					
		Th	Pr.	Total		Duration (Hrs)	Max. Marks		Total Marks	Min. Passing Marks	
							External	Internal		Th	Pr.
6T1	Engineering Geology and Geotechniques (3+1)	4		4	4	3	80	20	100	40	
6T2	Applied and Industrial Micropaleontology (4)	4		4	4	3	80	20	100	40	
6T3	Core Elective 2: Optional (Any one) 1) Petroleum Exploration (4) 2) Basin Analysis and Sequence Stratigraphy (2+2) 3) Marine Geology and Oceanography (3+1)	4		4	4	3	80	20	100	40	
6T4	(Core Subject Centric -2) 2) Geodesy and Mapping	4		4	4	3	80	20	100	40	
6P1	Engineering Geology and Applied & Industrial Micropaleontology (Marks: 75 Pract. + 05 Viva-voce + 20 Internal Assessment and Class Record)		8	8	4	3	100	----	100		40
6P2	Based on Paper 6T3, Geodesy and Geological Field Work (Marks: 55 Pract. + 05 Viva-voce +20 Field Work + 20 Internal Assessment and Class Record)		8	8	4	3	100	----	100		40
6S1	Seminar 6	2		2	1	---		25	25	10	
	Total	18	16	34	25		520	105	625	170	80

FIELD WORK:

Candidate shall attend geological excursion organized by the Department for a period of 10 to 20days. 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 12 of Semester VI and field report will be evaluated by the field excursion in-charge.

6T1
Engineering Geology and Geotechniques

Unit I:

Scope of geology in civil engineering and mining industry; Various stages of engineering geological investigations for civil engineering projects; Engineering properties of rocks and soils: soil classification, rock discontinuities; Physical characters of building stones, metal and concrete aggregates; Use of remote sensing in engineering geology.

Unit II:

Preliminary geological investigations for the various engineering projects: dams, reservoirs, tunnels, highways, bridges, hydroelectric power projects, shoreline and airfield engineering; Case history of engineering projects and geological causes for mishaps and failure of engineering structures.

Unit III:

Mass movements with special emphasis on landslides and cause of hill slope instability; Earthquake and seismicity, seismic zones of India, aseismic design of building; Influence of geological conditions on foundation and design of buildings.

Unit IV:

Geophysical methods for the selection of engineering sites; exploratory drilling, study and construction of subsurface sections based upon drilling data; Core logging: core recovery, preservation of cores, R.Q.D. analyses; Preparation and presentation of geotechnical reports.

Practical:

Study of engineering properties of rocks/ soil with reference to their use in engineering projects; Study of models and maps of important engineering structures such as tunnels and dams; Interpretation of geological maps for various engineering geology projects; Preparation of subsurface sections based on drilling data; RQD analysis.

Books Recommended:

Bell, F.G. (1981) Engineering properties of Soils and Rocks, Butterworths Publication, London.
Bell, F.G. (1993) Fundamentals of Engineering geology, Butterworths Publication, London.
Garg, S.K. (2009) Physical and Engineering Geology, (6th Ed.), Khanna Publishers, New Delhi.
GSI (1975) Engineering Geology Case Histories, Geological Survey of India, Misc. Publ., No. 29.
Gupte, R.B. (2002) Text Book of Engineering Geology, Vidyarthi Griha Prakashan, Pune.
Keary, P., Brooks, M. and Hill, I. (2002) An introduction to geophysical exploration, 3rd Ed., Blackwell.

Kesavulu, N.C. (2009) Textbook of engineering geology, 2nd Ed., Macmillan Publishers India ltd.
Krynine, D.P. and Judd, W.R. (1998) Principles of Engineering Geology and Geotechnics, CBS Publishers & Distributors, New Delhi.
Reddy, D.V. (1998) Engineering Geology for Civil Engineering, Oxford & IBH Pub.Co. Pvt. Ltd., Delhi.
Rider, M.H. (1986) The Geological Interpretation of Well Logs. (Rev. Ed.) Whittles Publishing, Caithness.
Ries, H. and Watson, T.L. (1947) Elements of Engineering Geology, 2nd Ed., John Wiley & Sons, New York.
Schultz, J.R. and Cleaves, A.B. (1951) Geology in Engineering, John Willey and Sons, New York.
Singh, P. (1994) Engineering and General Geology, S.K. Kataria and Sons, Delhi.
Telford, W.M., Geldart, L.P., Sherrif, R.E. and Keys, D.A. (1976) Applied Geophysics, Cambridge Univ. Press.
Verma, B.P. (1997) Rock Mechanics for Engineers, 3rd Ed., Khanna Publishers, New Delhi.
Wittke, Walter (1990). Rock Mechanics: Theory and Applications with case Histories, Springer – Verlag Publication.

6T2
Applied and Industrial Micropalaeontology

Unit I:

Scope of Applied Micropaleontology; Modern field and laboratory techniques in the study of microfossils (collection, sampling and processing techniques); Diatoms: Outline of morphology, classification and their significance in environmental study, paleolimnology, paleoceanography and economic geology; Brief introduction of Cyanobacteria, Calcareous nannofossils, Ostracoda, Radiolaria, Conodonts and their significance in geosciences.

Unit II:

Foraminifera: Outline morphology of foraminifera and their significance in paleoceanographic, paleoclimatic, paleobathymetric, biostratigraphy reconstructions; Calcareous algae (Rhodophyta and Chlorophyta): morphology and internal structure, broad classification and their significance; Spores/pollen: Morphology, classification, production, dispersal and sedimentation of palynomorphs and their applications in paleoclimate and paleoenvironment interpretation; Types of organic matters; Brief introduction of dinoflagellate, phytoliths and acritarchs and their significance in geosciences.

Unit III:

Advances in environmental micropaleontology;oxygen and carbon isotopes study of microfossil tests and their applications;Microfossils and Earth's orbital cycles (Milankovitch Cycles);Forecasting of monsoon using microfossils;Delineation of Oxygen Minimum Zones (OMZ) using microfossils;Interpreting freshwater and marine pollution using microfossils;Reconstruction of diatom inferred past water quality and paleosalinity from sediment cores;Problems of global warming and role of micropaleontologists.

Unit IV:

Implications of micropalaeontology to petroleum exploration, Biosteering and reservoir characterisation with examples;Significance of palynology in source rock evaluation and organic

matter maturation;Significance of microfossils in coal exploration;Increasing biostratigraphic resolution with Molecular Biology;Microfossils in the study of sedimentary ore deposits.

Practical:

Microscopic study of the selected taxa of Foraminifera, Ostracodes, Calcareous Algae, Diatoms, Pollens and Spores (Cretaceous and Cenozoic), dinoflagellates, Conodonts;SEM applications in micropaleontology;Study of the polluted and unpolluted environments using diatoms;Processing techniques used in separation of diatoms and palynomorphs,biofacies map using microfossils.
Real time well site micropalaeontology and techniques used in industrial micropaleontology for petroleum explorationdiscovery: Bio-Sequence stratigraphy;Building a reservoir zonation using microfossils.

Books Recommended:

Agashe, Shipad N. (1995) Paleobotany, Oxford and IBH Publ., New Delhi.
Arnold (2002) Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett), Oxford University Press, New York.
Bergland, B.E. (1986) Handbook of Holocene paleoecology and paleohydrology, John Wiley, New York.
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.
Smol, J.P., Birks, H.J.B. And Last, W.M. (2003) Tracking Environmental change using lake sediments: Terrestrial, Algal and Siliceous Indicators. Paleoenvironmental Research Book Series, 371p.
Stewart, Wilson N. and Rothwell, Gar W. (1993) Paleobotany and the Evolution of Plants, Cambridge Univ. Press.
Stoermer, E.F. and Smol, J.P. (1999)(Eds.) The Diatoms: Applications for the Environmental and Earth Sciences,Cambridge University Press, 469p.
Traverse Alfred (1988) Paleopalynology, Unwin Hyman, USA.
Wray, J.L. (1977) Calcareous Algae, Elsevier.

6T3
Core Elective 2
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.

Practical:

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 ExtensionService, 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.
Duruble, 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.
Leverson, A.L. (1970) Geology of Petroleum. Freeman and Company.
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.
Peters, K.E., Walters, C.C. andMoldowan, 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,
Rider, M.H. (1985) The Geological Interpretation of Well Logs, Blackie, London.
Schlumberger Education Services, New York, 1989.
Selley, R.C. (1998) Elements of Petroleum Geology, II Edition,Academic Press.
Serra, O. (1984) Fundamentals of Well Log Interpretation, Vol.1 and 2,Elsevier.
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.

2)Basin analysis and Sequence Stratigraphy

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.

Practical:

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

Books Recommended:
Basin Analysis:
Allen P. A. and Allen, J.R.L. (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.

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.

Practical:

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.

Practical 6P2:
Practicals for Geodesy

Conducting the following surveys and plotting –
Compass traverse survey using Brunton Compass and Prismatic compass; Theodolite traverse survey and plane table traverse survey with telescopic alidade; Trignometric surveys; Triangulation;Geological mapping by plane table and telescopic alidade; Profile leveling by Abney level and Dumpy
level; Contouring by direct method and indirect method; Stadia survey using theodolite.
Study of topographical survey sheets of Survey of India.

6T4
Core (Subject Centric) 2
1) Geodesy and Mapping
(Candidate can opt for this paper in their main subject of post-graduation only)

Unit I:

Principles of surveying methods; Instrumental methods used in geological mapping and mineralsurveys and their usefulness in different conditions; Types of mineral deposit surveys, instruments used- prismatic compass, Brunton compass, theodolite, and plane table with alidade; Method of survey, recording the readings and plotting the traverse, triangulation and establishment of horizontal control points.

Unit II:

Leveling and contouring : Instruments for leveling - hand level, Abney level, Dumpy level, automatic level; Methods of leveling- spot leveling, differential leveling, profile leveling and trigonometric leveling; Plane table survey with telescopic alidade and its use in detailed geological mapping; Astronomical observation of true N-S and latitude.

Unit III:

Fundamentals of mine surveys, surveys in open cast mines and underground mines; Geologicalmapping in open cast and underground mines.

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.

Books Recommended:
Bomford, B.G. (1971) Geodesy, Oxford.
Clark, D. (1962) Plane and Geodetic Surveying (Volume I and II) Asia Publishing House.
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.
Hosmer, G.L. (1946) Geodesy, Wiley.
Kanetkar, T.P. and Kulkarni, S.V. (1990) Surveying and Leveling (Vol. I and II), Pune Vidyarthi Griha Prakashan, Pune.
Kissam, P. (1956) Surveying Instruments and Methods for Survey of Limited Extent. McGraw Hill.
Lahi, F.H. (1987) Field Geology, CBS Publishers.
Mathur, S.M. (2001) Guide to Field Geology, Prentice-Hall, New Delhi