RASHTRASANT TUKADOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR

MASTER OF SCIENCE

GEOLOGY

(Syllabus: I - IV Semesters)

Two Year (Four Semester Course)

2023-2024

RASHTRASANT TUKADOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR

Scheme of Teaching and Examination for M. Sc. GEOLOGY (CBCS) as per NEP 2020

Structure and Credit Distribution of PG Degree Program for Two years

Choice Based Credit System (Semester Pattern)

With Effect from 2023-2024

M. Sc. GEOLOGY Semester I												
Course Category	**Code**	**Theory / Practical**	**Teaching Scheme (Hours / Week)**			**Credits**	**Examination Scheme**					
							Duration in hrs.	**Max. Marks**		**Total Marks**	**Minimum Passing Marks**	
			Theory	**Practical**	**Total**			**SEE**	**CIE**		**Theory**	**Practical**
DSC	MGE1T01	**Paper 1:** Mineralogy, Crystallography, Stratigraphy and Indian Geology (1+1+1+1)	4	-	4	4	3	80	20	100	40	-
DSC	MGE1T02	**Paper 2:** Igneous Petrology and Metamorphic Petrology (2+2)	4	-	4	4	3	80	20	100	40	-
DSE	MGE1T03	**Paper 3**: **Elective** Magmatic and Metamorphic Ore Systems, Cosmochemistry and Medical Geology (2+1+1) **OR** Precambrian Geology, Planetary Geology and Forensic Geology (2+1+1)	4	-	4	4	3	80	20	100	40	-
RM	MGE1T04	**Paper 4**: General Principles, Mapping Techniques, Computer techniques, Software and Geostatistical Methods and Instrumentation Techniques (1+1+1+1)	4	-	4	4	3	80	20	100	40	-
DSC	MGE1P01	**Practical 1:** Based on Paper – 1	-	6	6	3	3	50	50	100	-	50
DSC	MGE1P02	**Practical 2:** Based on Paper - 2 (Including RM)	-	6	6	3	3	50	50	100	-	50
		TOTAL	**16**	**12**	**28**	**22**	**--**	**420**	**180**	**600**	**160**	**100**

CIE = Continuous Internal Evaluation and SEE = Semester End Examination

M. Sc. GEOLOGY Semester II												
Course Category	**Code**	**Theory / Practical**	**Teaching Scheme (Hours/ Week)**			**Credits**	**Examination Scheme**					
							Duration in hrs.	**Max. Marks**		**Total Marks**	**Minimum Passing Marks**	
			Theory	**Practical**	**Total**			**SEE**	**CIE**		**Theory**	**Practical**
DSC	MGE2T05	**Paper 5:** Sedimentology, Palaeontology and Palaeobiology (2+1+1)	4	-	4	4	3	80	20	100	40	-
DSC	MGE2T06	**Paper 6:** Geochemistry, Structural Geology and Tectonics (1+2+1)	4	-	4	4	3	80	20	100	40	-
DSE	MGE2T07	**Paper 7**: **Elective** Exploration Methods and Sequence Stratigraphy, Biostratigraphy and Hydrocarbon Exploration (2+2) **OR** Mineral Exploration and Applied and Industrial Micropaleontology (2+2)	4	-	4	4	3	80	20	100	40	-
OJT	MGE2P03	**Practical 3**: Field Excursion	-	8	8	4	3	50	50	100	-	50
DSC	MGE2P04	**Practical 4:** Based on Paper - 5	-	6	6	3	3	50	50	100	-	50
DSC	MGE2P05	**Practical 5:** Based on Paper – 6	-	6	6	3	3	50	50	100	-	50
		TOTAL	**12**	**20**	**32**	**22**	**-**	**390**	**210**	**600**	**120**	**150**

CIE = Continuous Internal Evaluation and SEE = Semester End Examination

M. Sc. GEOLOGY Semester III												
Course Category	**Code**	**Theory / Practical**	**Teaching Scheme (Hours / Week)**			**Credits**	**Examination Scheme**					
							Duration in hrs.	**Max. Marks**		**Total Marks**	**Minimum Passing Marks**	
			Theory	**Practical**	**Total**			**SEE**	**CIE**		**Theory**	**Practical**
DSC	MGE3T08	**Paper 8:** Hydrogeology, Geomorphology and Remote Sensing (2+1+1)	4	-	4	4	3	80	20	100	40	-
DSC	MGE3T09	**Paper 9:** Environmental Geology, Geohazards and Engineering Geology (1+1+2)	4	-	4	4	3	80	20	100	40	-
RP	MGE3P06	**Practical 6:** Field Based Research Project	-	4	4	4	3	50	50	100	-	50
DSE	MGE3T10	**Paper 10: Elective** Quaternary Geology and Limnogeology (2+2) **OR** Paleontology and Paleobiology (2+1+1)	4	-	4	4	3	80	20	100	40	-
DSC	MGE3P07	**Practical 7:** Based on Paper – 8	-	4	4	2	3	50	50	100	-	50
DSC	MGE3P08	**Practical 8:** Based on Paper - 9	-	8	8	4	3	50	50	100	-	50
		TOTAL	**12**	**16**	**28**	**22**	**-**	**390**	**210**	**600**	**120**	**150**

CIE = Continuous Internal Evaluation and SEE = Semester End Examination

M. Sc. GEOLOGY Semester IV												
Course Category	**Code**	**Theory / Practical**	**Teaching scheme (Hours / Week)**			**Credits**	**Examination Scheme**					
							Duration in hrs.	**Max. Marks**		**Total Marks**	**Minimum Passing Marks**	
			Theory	**Practical**	**Total**			**SEE**	**CIE**		**Theory**	**Practical**
DSC	MGE4T11	**Paper 11:** Ore Geology, Indian Mineral Deposits and Mineral Economics (1+2+1)	4	-	4	4	3	80	20	100	40	-
DSC	MGE4T12	**Paper 12:** Coal Geology, Petroleum Geology and Atomic Minerals (2+1+1)	4	-	4	4	3	80	20	100	40	-
DSC	MGE4T13	**Paper 13:** Watershed Management and Geographical Information Systems (2+2)	4	-	4	4	3	80	20	100	40	-
DSE	MGE4T14	**Paper 14: Elective** Mining Geology and Unconventional Energy Resources (2+2) **OR** Remote Sensing in Mineral Exploration, Geophysics and Geogenic Hazards (1+1+2)	4	-	4	4	3	80	20	100	40	-
RP	MGE4P09	Research Project (RP)	-	12	12	6	3	100	100	200	-	100
		TOTAL	**16**	**12**	**28**	**22**	**-**	**420**	**180**	**600**	**160**	**100**

CIE = Continuous Internal Evaluation and SEE = Semester End Examination

M. Sc. GEOLOGY Semester I												
Course Category	**Code**	**Theory / Practical**	**Teaching Scheme (Hours / Week)**			**Credits**	**Examination Scheme**					
							Duration in hrs.	**Max. Marks**		**Total Marks**	**Minimum Passing Marks**	
			Theory	**Practical**	**Total**			**SEE**	**CIE**		**Theory**	**Practical**
DSC	MGE1T01	**Paper 1:** Mineralogy, Crystallography, Stratigraphy and Indian Geology (1+1+1+1)	4	-	4	4	3	80	20	100	40	-
DSC	MGE1T02	**Paper 2:** Igneous Petrology and Metamorphic Petrology (2+2)	4	-	4	4	3	80	20	100	40	-
DSE	MGE1T03	**Paper 3**: **Elective** Magmatic and Metamorphic Ore Systems, Cosmochemistry and Medical Geology (2+1+1) **OR** Precambrian Geology, Planetary Geology and Forensic Geology (2+1+1)	4	-	4	4	3	80	20	100	40	-
RM	MGE1T04	**Paper 4**: General Principles, Mapping Techniques, Computer techniques, Software and Geostatistical Methods and Instrumentation Techniques (1+1+1+1)	4	-	4	4	3	80	20	100	40	-
DSC	MGE1P01	**Practical 1:** Based on Paper – 1	-	6	6	3	3	50	50	100	-	50
DSC	MGE1P02	**Practical 2:** Based on Paper - 2 (Including RM)	-	6	6	3	3	50	50	100	-	50
		TOTAL	**16**	**12**	**28**	**22**	**--**	**420**	**180**	**600**	**160**	**100**

CIE = Continuous Internal Evaluation and SEE = Semester End Examination

SEMESTER - I

PAPER 1: MINERALOGY, CRYSTALLOGRAPHY, STRATIGRAPHY AND INDIAN GEOLOGY (1+1+1+1)

Unit I:

Silicate structures and structural formula; Isomorphism and solid solution; Types of ionic substitution; Polymorphism and types of polymorphic transformations; Pseudomorphism and types of pseudomorphism; Zoning in minerals; Physical properties of minerals. Reflection, Refraction, Diffraction & Interference; Optical Properties under polarising mode: Refractive index, Becke-line effect, Relief, Pleochroism; Birefringence, Interference and it's order; mineral groups with reference to their general formulae, classification, atomic structure, chemistry, experimental work and paragenesis: Nesosilicates, Aluminosilicate; Sorosilicates, Phyllosilicate, Tectosilicates.

Unit II:

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.

Unit III:

Concept of stratigraphy; Approaches to measurement of geological time; Concept of Litho, magneto, seismic, chemo, and bio stratigraphy; Definition and cratons in India, Proterozoic successions in India. Paleozoic rock formations of India (Spiti, Kashmir); Mesozoic rock formations of India (Spiti, Kashmir, Jaisalmer, Kachchh, Kaveri-Palar, Krishna-Godavari, Narmada Valley); Classification, depositional characteristics, fauna, and flora of Gondwana Supergroup; Rajamhal Traps, Lameta, Deccan Volcanic Province and Intertrappeans.

Unit IV:

Classification, depositional characteristics, fauna, and flora of tertiary basins of India (Rajasthan, Kachchha, Saurashtra, Cambay, Bombay offshore, Kerala, Kaveri, Krishna-Godavari, Bengal); Evolution of life during Paleogene; Andaman Island arc and back-arc sea; Quaternary developments in India and Himalaya; Siwalik Group; Holocene Stratigraphy of India; Ocean around Indian Peninsula. Docking of India with Eurasia and Evolution of Himalaya;

Practical:

Mineral identification (megascopic and microscopic); study of Becke line, pleochroism, birefringence, uniaxial and biaxial mineral identification. Study of crystals and crystal systems. Exercise on stratigraphic classification and rock layers; study and understanding of plate-movements through important periods from India.

Books Recommended: MINERALOGY, CRYSTALLOGRAPHY

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, Bangalore.
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.

Books Recommended: STRATIGRAPHY AND INDIAN GEOLOGY

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.
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.

PAPER 2: IGNEOUS PETROLOGY AND METAMORPHIC PETROLOGY (2+2)

Unit I:

Chemical characteristics of igneous rocks in the following tectonic setting: Mid Oceanic Ridge, Island Arcs, Oceanic plateaus, Continental Margins, Continental Rifts and Continental intraplates; Plume magmatism and hot spots; Large igneous provinces, mafic dyke swarms and layered complexes. Mantle melting: Partial melting (batch and fractional melting); Crystal fractionation (equilibrium and fractional (Rayleigh) crystallization); Contamination (AFC process) and dynamic melting. Phase equilibrium studies - binary systems, ternary systems and their relations to magma genesis.

Unit II:

Textures and structures of igneous rocks; Major, Trace and Rare Earth Element systematics in igneous rocks; Silica/alumina saturation, variation diagrams (Harker, AFM and TAS diagrams) their applications and limitations; IUGS classification of igneous rocks: Plutonic, volcanic, mafic and ultramafic (QAPF diagram);Weight norm, cation norm; Petrology and petrogenesis of major igneous rock types with Indian examples of ultramafic, komatiite, basalt, granite, pegmatite, alkaline rocks, anorthosite, spilite, boninite, carbonatite, kimberlite, lamproite, lamphrophyre and charnockite

Unit III:

Physico-Chemical controls of 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; Facies and sub-facies series (Classifications of Escola, Miyashiro and Yardley); Metamorphic zones; Metamorphic differentiation; Metasomatism; Granitization and crustal anatexis; Paired metamorphic belts.

Unit IV:

Enthalpy, Entropy, Gibb's free energy, chemical potential, fugacity and activity; tracing the chemical reactions in P-T space; Claussius-Clapeyron equation and slopes of metamorphic reactions; Fourier's law of heat conduction; mass and energy change during fluid-rock interaction; ACF, AKF and AFM diagrams; Schrienemakers rule and construction of petrogenetic grids. Progressive and Retrogressive metamorphism of Calcareous, Mafic, Ultramafic, Granitic, and Peltic rocks

Practical:

Megascopic and microscopic study of different igneous rocks; Calculation of CIPW norms; Modal analysis; variation diagrams. Megascopic and microscopic study of different metamorphic rocks. Calculation of ACF, AKF and AFM values and their presentation.

Books Recommended: IGNEOUS PETROLOGY

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. 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 & 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.

Books Recommended: METAMORPHIC PETROLOGY

Bhaskar Rao, B. (1986) Metamorphic Petrology, IBH & Oxford.
Blatt, H. and Tracy, R.J. (1996) Petrology (Igneous, Sedimentary, Metamorphic), W.H. Freeman and Co., New York.

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.

PAPER 3: **ELECTIVE 1**: MAGAMATIC AND METAMORPHIC ORE SYSTEMS, COSMOCHEMISTRY AND MEDICAL GEOLOGY (2+1+1)

Unit I:

Magmatism in relation to plate tectonics; chemical characteristics of igneous rocks in the following tectonic setting: Mid Oceanic Ridge, Island Arcs, Oceanic plateaus, Continental Margins, Continental Rifts and Continental intraplates; Liquid immiscibility and assimilation; Influence of volatiles and role of oxygen fugacity in magmatic crystallizations; Mg Number, Alteration Index, Saturation Index and other geochemical parameters; Fractional crystallization, liquid lines of descent and lever rule;

Unit II:

Large igneous provinces, mafic dyke swarms and layered complexes; Plume magmatism and hot spots; Petrology and petrogenesis of major igneous rock types with Indian examples of ultramafic, komatiite, basalt, granite, pegmatite, alkaline rocks, anorthosite, spilite, boninite, carbonatite, kimberlite, lamproite, lamprophyre and charnockite.

Unit III:

Granitization and crustal anatexis; Pressure – temperature – time paths and metamorphic terrains; Paired metamorphic belts; Ultra high temperature (granulite, Pyroxene Hornfels and Sanidine) and ultra-high pressure (blue schist, eclogite) metamorphism; Petrography and origin of following rock types: hornfelses, amphibolites, and Migmatites; Problem of charnockites. Progressive and Retrogressive metamorphism of Calcareous, Mafic, Ultramafic, Granitic, and Peltic rocks

Unit IV:

Medical geology: perspective and prospects, natural distribution and abundance of elements, geogenic sources, anthropogenic sources, biological functions of elements, geological impacts on nutrition, volcanic emission and health, fluoride in natural water, speciation of trace elements.

Books Recommended: MAGAMATIC ORE SYSTEMS

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. 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 & Distributors Pvt Ltd., New Delhi.
Hughes, C.J. (1982) Igneous Petrology, Elsevier.
LeBas, M.J. (1977) Carbonatite-nephelinite Volcanis, 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.

Books Recommended: METAMORPHIC ORE SYSTEMS

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 (7^{th} 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.

Books Recommended: COSMOCHEMISTRY AND MEDICAL GEOLOGY

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.
Alloway, 2005, Bioavailability of Elements in Soil, in Selinus (26 p.)
Bunnell et al., 2013, GIS and Health (11 p.)
Bunnell, J. E., Finkelman, R. B., Centeno, J. A., and Selinus, 2007, Medical Geology: A globally emerging discipline (9 p.)
Centeno et al., 2016, Medical Geology and Health - Status Overview (3 p.)
Cook, 2013, Public Health and Geological Processes (18 p.)
Edmunds and Smedley, 1996, Groundwater geochemistry and health: an overview (15 p.)
Eggers et al., 2015, Health Risk Associated with Uranium Mining on Tribal Lands (28 p.)
Finkelman et al., 2003, Case Study: Coal Combustion and Human Health in China, in Skinner and Berger
Fordyce, 2007, Selenium Geochemistry and Health (4 p.)
Komatina, 2004, Chapter 1 - Introduction and Overview (37 p.)
Komatina, 2004, Chapter 4 - Anthropogenic (man-made) Factors (35 p.)
National Research Council, 2007, Chapter 6 - Earth Perturbations & Public Health Impacts (12 p.)

PAPER 3: **ELECTIVE 2**: PRECAMBRIAN GEOLOGY, PLANETARY GEOLOGY AND FORENSIC GEOLOGY (2+1+1)

Unit I:

Stratigraphy and geochronology of Dharwar Craton, Bastar Craton, Singhbhum Craton, Aravalli-Bundelkhand Craton; Stratigraphy and geochronology of Southern Granulite Terrain, Eastern Ghat Mobile Belt, Aravalli-Delhi fold belt, Central Indian Tectonic Zone;

Unit II:

Stratigraphy and geochronology of Proterozoic sedimentary basins of India (Cuddapah, Kaladgi, Bhima, Bijawar, Pranhita-Godavari, Indravati, Chhattisgarh, Vindhyan, and Himalaya).

Unit III:

Kepler's Laws of Planetary Motion; Bode's Law; Introduction to Planetary Science in Solar System and Extra-Solar System – Planets, Moons, Dwarf planets and protoplanets, Asteroids, Comets, Kuiper Belt objects and other small bodies; Formation and evolution of planetary system; Planetary composition and mineralogy – rocky, icy, gaseous composition; Planetary morphology

and processes – impact cratering, volcanism, tectonism; Planetary atmosphere and space weather; Planetary exploration and future prospects (Indian and International contexts)- remote sensing, ground-based, space- based, robotic and in-situ experiments and instrumentations.

Unit IV:

Use of geological information in criminal investigation; emphasize on geochemistry, geochronology, geophysics, and soil characteristics in tracing the origins and history of criminal evidences; new techniques for authentication of artefacts and arts.

Books Recommended: PRECAMBRIAN GEOLOGY

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.

Books Recommended: PLANETARY GEOLOGY

1. Planetary Sciences by lmke de Pater and Jack J. Lissauer, 2015
2. Exoplanets by Sara Seager, 2011
3. Exoplanetary Atmospheres: Theoretical Concepts and Foundations by Kevin Heng, 2017
4. Introduction to Astrochemistry: Chemical Evolution from Interstellar Clouds to Star and Planet Formation by Satoshi Yamamoto, 2017
5. The Physics and Chemistry of the Interstellar Medium by A. G. G. M. Tielens, 2010

Books Recommended: FORENSIC GEOLOGY

Fordyce, 2007, Selenium Geochemistry and Health (4 p.)
Komatina, 2004, Chapter 1 - Introduction and Overview (37 p.)
Komatina, 2004, Chapter 4 - Anthropogenic (man-made) Factors (35 p.)
National Research Council, 2007, Chapter 6 - Earth Perturbations and Public Health Impacts (12 p.)
Ruffell, A. and McKinley, J. (2004) Forensic Geoscience: applications of geology, geomorphology and geophysics to criminal investigations. Earth Science Reviews volume 69, Pages 235-247.

PAPER 4: RM: GENERAL PRINCIPLES, MAPPING TECHNIQUES, COMPUTER TECHNIQUES, SOFTWARE, GEOSTATISTICAL METHODS AND INSTRUMENTATION TECHNIQUES (1+1+1+1)

Unit I:

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

Unit II:

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

Unit III:

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

Unit IV:

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

Books Recommended: GENERAL PRINCIPLES, MAPPING TECHNIQUES

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

Books Recommended: COMPUTER TECHNIQUES, SOFTWARE

No Textbook - only handouts and web pages

Books Recommended: STATISTICAL METHODS

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

Books Recommended: INSTRUMENTATION TECHNIQUES

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

M. Sc. GEOLOGY Semester II												
Course Category	**Code**	**Theory / Practical**	**Teaching Scheme (Hours/ Week)**			**Credits**	**Examination Scheme**					
							Duration in hrs.	**Max. Marks**		**Total Marks**	**Minimum Passing Marks**	
			Theory	**Practical**	**Total**			**SEE**	**CIE**		**Theory**	**Practical**
DSC	MGE2T05	**Paper 5:** Sedimentology, Palaeontology and Palaeobiology (2+1+1)	4	-	4	4	3	80	20	100	40	-
DSC	MGE2T06	**Paper 6:** Geochemistry, Structural Geology and Tectonics (1+2+1)	4	-	4	4	3	80	20	100	40	-
DSE	MGE2T07	**Paper 7**: **Elective** Exploration Methods and Sequence Stratigraphy, Biostratigraphy and Hydrocarbon Exploration (2+2) **OR** Mineral Exploration and Applied and Industrial Micropaleontology (2+2)	4	-	4	4	3	80	20	100	40	-
OJT	MGE2P03	**Practical 3**: Field Excursion	-	8	8	4	3	50	50	100	-	50
DSC	MGE2P04	**Practical 4:** Based on Paper - 5	-	6	6	3	3	50	50	100	-	50
DSC	MGE2P05	**Practical 5:** Based on Paper – 6	-	6	6	3	3	50	50	100	-	50
		TOTAL	**12**	**20**	**32**	**22**	**-**	**390**	**210**	**600**	**120**	**150**

CIE = Continuous Internal Evaluation and SEE = Semester End Examination

SEMESTER – II

PAPER 5: SEDIMENTOLOGY, PALAEONTOLOGY AND PALAEOBIOLOGY (2+1+1)

Unit I:

Rock cycle, Liberation and flux of sediments, Processes of sediment transport and deposition, Texture of sedimentary rocks and their significance; Grain size parameters; Sediment shape and roundness; Paleocurrent, heavy mineral and provenance; Primary sedimentary structures; Pene-Contemporaneous Deformation Structures (PCDS); Biogenic structures. Classification and composition of conglomerate, sandstones, shale and carbonate rocks.

Unit II:

Diagenesis-physical and chemical, processes and evidences of diagenesis in sandstones, mud rocks and carbonate rocks; Study of siliceous, phosphatic, ferruginous rocks, evaporates, dolomites. Sedimentary environments and facies – facies model for fluvial, glacial, lacustrine, fluvioglacial, fluviolacustrine, delataic, siliciclastic, shallow and deep marine environments.

Unit III:

Types of fossils, modes of preservation of fossils and concepts of taphonomy; Origin of life; Types of growth; Species concept and speciation; Ediacara fauna; Brief morphology and evolutionary trends in Bivalves, Gastropods, Cephalopods, Brachiopods, Echinoids, Graptoloides, Trilobites and corals; Vertebrate life through ages; Evolution and extinction of dinosaurs with special emphasis on Indian dinosaurs, Evolution of Homo; Evolution of mammals; Major extinction and origination through ages.

Unit IV:

Approach to palaeobotany; Classification of fossil plants; Evolutionary trend in angiosperm plants; Pre-Gondwana flora; A brief idea about Indian Gondwana and Paleogene flora; Micro and macro-evolution; Phylogenetic analysis; Application of paleobotany in assessing paleoclimate and paleoenvironment; Fossil record applied to sequence stratigraphy and depositional environment; Dendrochronology and its application; Ichnofossils and their significance; Brief idea about types of microfossils and their significance; Application of palynology in stratigraphy and climate studies. Types of organic matter and their significance in hydrocarbon exploration; Thermal Maturation and its significance.

Practical: SEDIMENTOLOGY

Detailed study of clastic and non-clastic rocks in hand specimens; Microscopic examination of important rock-types; Heavy mineral analyses; Grain-size analyses; Plotting of size-distribution data as frequency and cumulative curves, plotting and analysis of sedimentological data.

Practical: PALAEONTOLOGY AND PALAEOBIOLOGY

Study of the morphological characters of Bivalvia, Gastropoda, Cephalopods, Brachiopoda, Trilobita, Echinoidea and Corals; Study of vertebrate fossils; Study of trace fossils and important microfossils; Study of important Indian Gondwana and Paleogene flora.

Books Recommended: SEDIMENTOLOGY

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.

Books Recommended: PALAEONTOLOGY AND PALAEOBIOLOGY

Agashe, Shripad N. (1995) Paleobotany, Oxford and IBH Publ., New Delhi.
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.
Ray AK (2008) Fossils in Earth Sciences. Prentice Hall of India.
Jain P.C. and Amanthraman M.S (2016) Palaeontology (paleobiology) Evolution and animal distribution, Vishal publishing company.
P. K. Saraswati and M.S Srinivasan (2015) principles and Applications, Springer publication

PAPER 6: GEOCHEMISTRY, STRUCTURAL GEOLOGY AND TECTONICS (1+2+1)

Unit I:

Introduction to geochemistry; Atomic Structure and properties of elements, the Periodic Table; Rules of atomic substitution (Goldschmidt and Ringwood); Goldschmidt's classification of elements; Geochemical classification of elements (Major, Minor, and Trace); Laws of thermodynamics and basic concepts; Thermodynamics of solution (Chemical potential, Gibbs-Duhem equation, Roult's law, Henry's law, Lewis fugacity rules); Chemical kinetics (Rates of chemical reaction and influence of temperature, pressure and catalyst on them).

Unit II:

Concept of stress and strain: Stress ellipsoid; Mohr circle construction; Stress-strain relationship; Strain ellipsoids, Graphical representations of strain (Flinn, Ramsay, and Nadai-Hossack plots). Geometric and genetic classification of folds; Ramasay's Classification 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.

Unit III:

Stereographic projections; pi and beta 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), seismic waves and relation between Vp, Vs and density; rock magnetism and its origin; polarity reversals, polar wandering and supercontinent cycles; continental drift, sea floor spreading; mantle plumes and their origin; plate tectonics: types of plate boundaries and their inter-relationship; Evolution of Indian subcontinent: from supercontinent assembly to break-up of Gondwanaland; Evolution of the Himalayas and Indian Ocean.

Practical: GEOCHEMISTRY
Practical related to major oxides, REE and trace elements, variation diagrams.

Practical: STRUCTURAL GEOLOGY AND TECTONICS
Preparation and interpretation of geological maps and cross sections; stereographic projections; Recording and plotting of the field data; Study of deformed structures in hand specimens.

Books Recommended: GEOCHEMISTRY

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.

Books Recommended: STRUCTURAL GEOLOGY AND TECTONICS

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.

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. (1989) Dynamic Himalaya, Universities Press, Hyderabad.
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.

PAPER 7: ELECTIVE 1: EXPLORATION METHODS AND SEQUENCE STRATIGRAPHY, BIOSTRATIGRAPHY AND HYDROCARBON EXPLORATION (2+2)

Unit I:

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.

Unit II:

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.

Unit III:

Fundamentals of sequence stratigraphy; 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. Application and significance of sequence Stratigraphy; Subsidence analysis; depositional sequence. Sequence stratigraphic approach in basin analysis with Indian examples.

Unit IV:

Biostratigraphic events concept. The units of biostratigraphy. High resolution biostratigraphy. Biosteering. Echostratigraphic techniques. Quantitative Stratigraphy. Biostratigraphic Workstation. Calibration of seismic sections. Thermal history and hydrocarbon maturity. Significance of Micropalaeontology in Petroleum Exploration and Reservoir Characterization. Introduction to different biomarkers used in oil exploration; Significance of major microfossil groups such as foraminifers, Diatoms, ostracods, dinoflagellates, pollen and spores in hydrocarbon exploration. Preparation of lithologs and composite logs; coring and core analysis; examination of well cuttings.

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

Practical: SEQUENCE STRATIGRAPHY AND HYDROCARBON EXPLORATION
Preparation of facies maps and facies diagrams; Study of vertical profile sections; Map projections of different oil horizons in Indian sedimentary basins, their stratigraphic order; 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); Laboratory analysis related to coal bed methane studies. Map projections of different oil horizons in Indian sedimentary basins, their stratigraphic order. Laboratory analysis related to coal bed methane studies.

Books Recommended: EXPLORATION METHODS

Arogyaswamy, R.N.P. (1995) Courses in Mining Geology, Oxford and IBH Publishing Co., New Delhi. 25 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.
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. 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.

Books Recommended: SEQUENCE STRATIGRAPHY AND HYDROCARBON EXPLORATION

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.

Hydrocarbon Exploration:

Baker, R.A (2001) Primer of Oil well Drilling: A basic text of oil and gas drilling, Petroleum Extension Service, University of Texas at Austin.
Barwis, J.H. (1990) Sandstone Petroleum Reservoir, Springer-Verlag, Berlin.
Berg, R.R. (1986) Reservoir Sandstones, Prentice Hall, New Jersey.
Bhandari, L.L., Venkatachala, B.S., Kumar, R., Swamy, S.N., Garga, P. and Srivastava, D.C. (Eds.) (1983) Petroliferous Basins of India, Petroleum Asia Journal, Himachal Times Group.
Biswas, S.K., Dave, A., Garg, P., Pandey, J., Maithani, A. and Thomas, N.J. (Eds.) (1993) Proceedings of 2nd Seminar on Petroliferous Basins of India, Dehra Dun, Dec.18-20, 1991, Vol. 1, 2 and 3, Indian Petroleum Publishers, Dehra Dun.
Bordenave, M.L. (Ed.) (1993) Applied Petroleum Geochemistry, Editions Technip, Paris.
Chilinger, G.V. and Vorabutr, P. (1981) Drilling and Drilling Fluids, Elsevier Science, Amsterdam.
Deutsch, C.V. (2002) Geostatistical Reservoir Modelling, Oxford University Press, Oxford.
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. and Moldowan, J.M. (2005) The Biomarker Guide (Vol. 1 & 2), Cambridge University Press, Cambridge.
Bateman, R.M. (1985) Open Hole Log Analysis and Formation Evaluation, Reidel, Dordrecht.
Ransom, R.C. (1995) Practical Formation Evaluation, John Wiley & Sons, New York.
Sahay, B., Rai, A. and Ghosh, M. (1984) Wellsite Geological Techniques for Petroleum Exploration, Oxford & IBH, New Delhi.
Saraswati, P.K. and Srinivasan, M.S. (2016). Micropaleontology: Principles and Applications. Springer, 219p.

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.

PAPER 7: ELECTIVE 2: MINERAL EXPLORATION AND APPLIED AND INDUSTRIAL MICROPALEONTOLOGY (2+2)

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;

Unit II:

Fundamentals of geochemical prospecting; Geochemical environments, mobility and distribution in dispersion of elements in primary and secondary environments; Methods of geochemical exploration: Lithogeochemical, pedogeochemical, biogeochemical, hydrogeochemical, atomogeochemical, geobotanical methods

Unit III:

Modern field and laboratory techniques in the study of microfossils; Diatoms: Outline of morphology, classification and their significance in environmental study, paleolimnology, paleoceanography and economic geology; Brief introduction of Cyanobacteria, Calcareous nannofossils, Calcareous Algae, Phytoliths, acritarchs, Ostracoda, Spores/pollen and their significance in geosciences. Foraminifera: Outline morphology and their significance in paleoceanographic, paleoclimatic, paleobathymetric, biostratigraphy reconstructions; Types of organic matters.

Unit IV:

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; Pollution study using microfossils; Problems of global warming and role of

micropaleontologists. Utility of Microfossils in petroleum exploration, Biosteering and reservoir characterisation; Significance of palynology in source rock evaluation and organic matter maturation; Thermal history and hydrocarbon maturity.

Practical: MINERAL EXPLORATION

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

Practical: APPLIED AND INDUSTRIAL MICROPALEONTOLOGY

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 exploration discovery: Bio-Sequence stratigraphy; Building a reservoir zonation using microfossils.

Books Recommended: MINERAL EXPLORATION

Arogyaswamy, R.N.P. (1995) Courses in Mining Geology, Oxford and IBH Publishing Co., New Delhi. 25 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.
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. 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.

Books Recommended: APPLIED AND INDUSTRIAL MICROPALEONTOLOGY

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.
Saraswati, P.K. and Srinivasan, M.S. (2016). Micropaleontology: Principles and Applications. Springer, 219p.
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.

OJT: FIELD EXCURSION

Candidate shall attend geological excursion organized by the Department for a period of 7 days. This will include field work, visit to geologically important places, mines, geological and scientific organisations. Candidates should submit the field report at the end of excursion along with the geological specimens collected during the programme.

M. Sc. GEOLOGY Semester III												
Course Category	**Code**	**Theory / Practical**	**Teaching Scheme (Hours / Week)**			**Credits**	**Examination Scheme**					
							Duration in hrs.	**Max. Marks**		**Total Marks**	**Minimum Passing Marks**	
			Theory	**Practical**	**Total**			**SEE**	**CIE**		**Theory**	**Practical**
DSC	MGE3T08	**Paper 8:** Hydrogeology, Geomorphology and Remote Sensing (2+1+1)	4	-	4	4	3	80	20	100	40	-
DSC	MGE3T09	**Paper 9:** Environmental Geology, Geohazards and Engineering Geology (1+1+2)	4	-	4	4	3	80	20	100	40	-
RP	MGE3P06	**Practical 6:** Field Based Research Project	-	4	4	4	3	50	50	100	-	50
DSE	MGE3T10	**Paper 10: Elective** Quaternary Geology and Limnogeology (2+2) **OR** Paleontology and Paleobiology (2+1+1)	4	-	4	4	3	80	20	100	40	-
DSC	MGE3P07	**Practical 7:** Based on Paper – 8	-	4	4	2	3	50	50	100	-	50
DSC	MGE3P08	**Practical 8:** Based on Paper - 9	-	8	8	4	3	50	50	100	-	50
		TOTAL	**12**	**16**	**28**	**22**	**-**	**390**	**210**	**600**	**120**	**150**

CIE = Continuous Internal Evaluation and SEE = Semester End Examination

SEMESTER - III

PAPER 8: HYDROGEOLOGY, GEOMORPHOLOGY AND REMOTE SENSING (2+1+1)

Unit I:

Hydrological cycle; Controls of geology on groundwater occurrence, movement and distribution; hydrogeological parameters of aquifers; Classification of aquifers and aquifer systems; groundwater provinces of India and Maharashtra (and region-wise also); Darcy's law and Reynolds number; Aquifer parameters; Groundwater quality parameters; chemical characteristics of groundwater for drinking, domestic and irrigation use; saline water intrusion in coastal aquifers and its preventive measures.

Unit II:

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 wells; 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 III:

Concepts in process geomorphology, Davis cycle of erosion, Endogenous and exogenous forces, Role of climate and lithology in landform formation, peneplaination, rejuvenation of landforms slope processes, Weathering, erosion, transportation, weathering products and soil formation, soil profile, drainage basin morphometry, major processes and associated landforms: tectonic, fluvial, aeolian, coastal, karst and glacial, Geomorphic features and zones of India

Unit IV:

Electromagnetic radiation, radiation laws, interaction of EMR with atmosphere and terrain features, platforms and sensors, resolution and calibration aspects of remotely sensed data, fundamentals of digital image fundamentals of digital image processing and classification Principle, Interaction of TIR wavelength with terrain feature and vegetation and application of TIRS; Photogrammetry, Aerial photo/Image interpretation keys, Interpretation of different geological, geomorphological and structural features on B/W aerial photographs and False Colour Composite (FCC). Applications of remote sensing in mineral, oil explorations and ground water studies.

Practical:

Hydrographs, water-table contour maps, estimation of aquifer properties; pumping test; water budgeting problems; well inventory of open dug well, interpretation of well inventory data. Topographical map interpretation for different landforms; analysis of weathering trends, Drainage basin morphometry; Relief and slope analyses

Determination of photo scale, Study of landforms and interpretation of lithology and structure, lineaments and geomorphology from aerial photograph and satellite images (FCC)

Books Recommended: HYDROGEOLOGY

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., 22
Todd, D.K. (1995) Groundwater Hydrology, John Wiley and Sons.
Tolman, C.F. (1937) Groundwater, McGraw Hill, New York and London.

Books Recommended: GEOMORPHOLOGY AND REMOTE SENSING

Kale and Gupta, Introduction to Geomorphology.
Rice, Fundamentals of Geomorphology.
Sharma, H.S. (1990) Indian Geomorphology, Concept Publishing Company, New Delhi.
Thornbury, W.D. (1960) Principles of Geomorphology, Wiley Easton Ltd., New York.
Drury, S.A. (4001) Image Interpretation in Geology, Chapman and Hall, London.
Gupta, R.P. (1991) Remote Sensing Geology, Springer-Verlag.
Pande, S.N. (1987) Principles and Applications of Photogeology, Wiley Eastern Limited.
Lillesand, T.M. and Kiefer, R.W. (4000) Remote Sensing and Image Interpretation, John Wiley and Sons Inc., New York.
Lattman, L.H. and Ray, R.G. (1965). Aerial photographs in field geology, McGraw Hill.
Way, D.S. (1973). Terrain Analysis. N3/4-ITC Delft, The Netherlands, Mc Graw Hill.

PAPER 9: ENVIRONMENTAL GEOLOGY, GEOHAZARDS AND ENGINEERING GEOLOGY (1+1+2)

Unit I:

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. Stefan-Boltzmann equation and planetary temperature; cause and effects of global climate change; Earth's radiation budget; greenhouse gases and effect; biogeochemical cycle of carbon, ocean acidification, coral bleaching, Milankovitch cycle, sea level rise, marginal marine environments- estuaries, mangroves and lagoons; ozone hole depletion, eutrophication and acid rain.

Unit II:

Geohazards: meaning and types of geohazards, and consequences of geohazards, Earthquake: recent and historical earthquakes, causes of occurrence, earthquake prediction and their impact as natural hazard; Seismic hazard zones; Neotectonics in seismic hazard assessment in central India; Tsunami – causes, occurrence and prediction, Landslide their causes and prediction and prevention landslide mapping, Volcanic hazards their causes, prediction and prevention; geological hazards vulnerability and risk assessment using remote sensing and GIS, Important case studies of natural hazards. Impact of mining on environment, mine fire and blow out, mining waste and disposal, suitable site selection and related problems; soil erosion, land degradation and soil pollution; Surface and groundwater pollution, their causes and remedial measures, groundwater issues due to urbanization and irrigation, water logging problems; flood hazards and their mitigation, Nuclear waste, their causes and remedial measures, Coastal erosion, its causes and control; Glaciers, their melting effects and mitigation; major river belts of India.

Unit III:

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; Rock discontinuities; Physical characters of building stones, metal and concrete aggregates; Use of remote sensing in engineering geology.

Unit IV:

Geological investigations for the various engineering projects: dams, reservoirs, landslides, tunnels, highways, bridges, hydroelectric power projects, shoreline and airfield engineering; Earthquake and seismicity, seismic zones of India, aseismic design of building; 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:

Preparation of seismic zonation maps of India; Recent Tsunami zonation map of India, Demarcation of landslide prone areas in India; Demarcation of flood prone areas in the outline map of India; Preparation of volcanic hazard zonation map Environmental and geological hazards assessment using remote sensing and GIS.

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

Books Recommended: ENVIRONMENTAL GEOLOGY, GEOHAZARDS

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.

Books Recommended: ENGINEERING GEOLOGY

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, 2 nd 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, 3 rd Ed., Khanna Publishers, New Delhi. Wittke, Walter (1990). Rock Mechanics: Theory and Applications with case Histories, Springer – Verlag Publication.

RP (Field Based Research Project): Candidate shall attend geological excursion organized by the Department for a period up to 7 days. This will include field work, visit to geologically important places, mines, geological and scientific organisations. Candidates should submit the field report at the end of excursion along with the geological specimens collected during the programme.

PAPER 10: ELECTIVE 1: QUATERNARY GEOLOGY AND LIMNOGEOLOGY (2+2)

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; Quaternary Paleoclimate; Causes of ice ages and other climatic changes; Soils and paleosoils and their significance in

interpreting Quaternary climates; Quaternary Sea level changes; Linkage of the modern climate to past climatic variation (with special emphasis on the Holocene).

Unit III:

Geochronological methods 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; Magnetic Susceptibility study and paleorainfall; Dendrochronology; Stable Oxygen isotopes and paleoclimates.

Unit IV:

Scope of Limnogeology; Major divisions 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 of lake 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.

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.

Books Recommended: 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.

PAPER 10: ELECTIVE 2: PALEONTOLOGY AND APPLIED PALEOBIOLOGY

Unit I:

Fossil record and geological time scales; Types of fossils, modes of preservation of fossils and concepts of taphonomy; Origin of life-– Punctuated Equilibrium and Phyletic Gradualism models.; Modern concept of systematic of fossils; Concept of species and type specimens; Types of growth; Ediacara fauna; Brief morphology and evolutionary trends in Bivalves, Gastropods, Cephalopods, Brachiopods, Echinoids, Graptoloides, Trilobites and corals; 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; Evolutionary changes in Proboscidea; 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 paleobotanyin 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.

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.

Books Recommended: PALEOBIOLOGY

Agashe, Shipad N. (1995) Paleobotany, Oxford and IBH Publ., New Delhi.

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.

Stewart, Wilson N. and Rothwell, Gar W. (1993) Paleobotany and the Evolution of Plants, Cambridge University Press.

M. Sc. GEOLOGY Semester IV												
Course Category	**Code**	**Theory / Practical**	**Teaching scheme (Hours / Week)**			**Credits**	**Examination Scheme**					
							Duration in hrs.	**Max. Marks**		**Total Marks**	**Minimum Passing Marks**	
			Theory	**Practical**	**Total**			**SEE**	**CIE**		**Theory**	**Practical**
DSC	MGE4T11	**Paper 11:** Ore Geology, Indian Mineral Deposits and Mineral Economics (1+2+1)	4	-	4	4	3	80	20	100	40	-
DSC	MGE4T12	**Paper 12:** Coal Geology, Petroleum Geology and Atomic Minerals (2+1+1)	4	-	4	4	3	80	20	100	40	-
DSC	MGE4T13	**Paper 13:** Watershed Management and Geographical Information Systems (2+2)	4	-	4	4	3	80	20	100	40	-
DSE	MGE4T14	**Paper 14: Elective** Mining Geology and Unconventional Energy Resources (2+2) **OR** Remote Sensing in Mineral Exploration, Geophysics and Geogenic Hazards (1+1+2)	4	-	4	4	3	80	20	100	40	-
RP	MGE4P09	Research Project (RP)	-	12	12	6	3	100	100	200	-	100
		TOTAL	**16**	**12**	**28**	**22**	**-**	**420**	**180**	**600**	**160**	**100**

CIE = Continuous Internal Evaluation and SEE = Semester End Examination

SEMESTER - IV

PAPER 11: ORE GEOLOGY, INDIAN MINERAL DEPOSITS AND MINERAL ECONOMICS (1+2+1)

Unit I: Mode of occurrence of ore bodies -morphology and relationship of host rocks; principal ore mineral groups; Paragenesis and zoning of ores and their significance; Concept of ore bearing fluids, their origin and migration; Wall-rock alteration; Structural, physicochemical and stratigraphic controls of ore localization. Ores of sedimentary affiliation - chemical and clastic sedimentation; Stratiform and stratabound ore deposits (Sedimentary BIF, manganese, non-ferrous ores); Placers and palaeoplacers; Ores of metamorphic affiliations; Ores related to weathering and weathered surfaces - laterite, bauxite, Ni/Au laterite; Contemporary ore-forming systems (black smokers, mineralized crusts, Mn nodules). Ore deposits and Plate Tectonics;

Unit II: 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, tin, tungsten, titanium, nickel and molybdenum

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; minerals used in metallurgical, refractory and abrasive 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: ORE GEOLOGY

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.

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.

Books Recommended: 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

PAPER 12: COAL GEOLOGY, PETROLEUM GEOLOGY AND ATOMIC MINERALS (2+1+1)

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:

Different states, natural occurrences, chemical composition and physical properties of different fractions of 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; Caprock; Definition and general properties; Petroliferous basins of India; 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.

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.
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: GebruderBorntraeger.
Stach, E., Mackowsky, M.T.H., Taylor G.H., Ghandra, D., Telchmuller, M. and Telchmuller, R. (1982) Stach's Text Book of Coal Petrology, GebruderBorntraeger, 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.
Thomas, Larry (2002) Coal Geology, John Wiley and Sons Ltd., England.
Van Krevelen, D.W. (1993) Coal: Typology-Physics-Chemistry-Constitution, Elsevier Science, Netherlands.

Books Recommended: 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

Books Recommended: ATOMIC MINERALS

Aswathanarayana, U. (1985) Principles of Nuclear Geology, Oxford Press.

Boyle, R.W. (1982) Geochemical Prospecting for Thorium and Uranium Deposits, EIsevier.

Dahlkamp, F.J. (1993) Uranium Ore Deposits, Springer Verlag.

Durrance, E.M. (1986) Radioactivity in Geology, Principles and Application, Ellis Hoorwool.

PAPER 13: WATERSHED MANAGEMENT AND GEOGRAPHICAL INFORMATION SYSTEMS (2+2)

Unit I: Concept of watershed: Watershed characteristics; Runoff, recharge and storage zones; Importance of watershed; Watershed management; Role of NGOs in watershed management; Case studies of watershed management; Selection of suitable site for wells; Groundwater legislation; Conjunctive use of groundwater and surface water; Groundwater level and rainfall data for hydrograph; Type and design of wells; Application of remote sensing in groundwater exploration.

Unit II: Artificial recharge of groundwater; Different methods for groundwater recharge: Contour trenches, Stream channel modification, Cement nalah bund, Percolation tank, Farm pond, Gabion structure, Underground bandhara or Sub-surface dyke, Injection wells or recharge wells, Recharge pits and shafts, Induce recharge, Roof top rainwater harvesting, Aquifer modification techniques: Borewell blasting technique, Hydro-fracturing; Surface and subsurface methods of groundwater exploration. Water management through Water User's Associations.

Unit III: Introduction to Geographic Information System, Principles and elements of GIS; GIS Data bases (DBMS), Geospatial data, Data for GIS applications, digital and analogue data, Vector and raster data models; advantages/disadvantages of raster and vector data models, Spatial data acquisition, Vector and raster overlay analysis; raster to vector conversion. Data integration

Unit IV: Neighbourhood Operation; Raster spatial analysis: Spatial resampling**,** Buffer analysis: point, line, polygon analysis; Visualization and query of spatial data; Digital elevation model (DEM) for slope and relief analysis, ASTER DEM, SRTM DEM and CARTO SAT DEM; Map projections, GIS and remote sensing software: ARC GIS, ERDAS, ENVI, Q-GIS and other open sources S/W; GIS in Watershed management and geology

Books Recommended: WATERSHED MANAGEMENT

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., 22
Todd, D.K. (1995) Groundwater Hydrology, John Wiley and Sons.
Tolman, C.F. (1937) Groundwater, McGraw Hill, New York and London.

Books Recommended: GEOGRAPHICAL INFORMATION SYSTEMS

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.

PAPER 14: ELECTIVE 1: MINING GEOLOGY AND UNCONVENTIONAL ENERGY RESOURCES (2+2)

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: Concept of conventional energy resources; impacts on conventional energy resources (water, coal and petroleum) through urbanization, growth of human population, industrialization, and their mitigations; Concept of nonconventional energy resources, energy generation through solar, wind and tidal power; shale gas.

Unit IV: Environmental aspects of energy utilization, renewable energy resources and their importance, energy conservation and management; energy generation through geothermal, hydal, nuclear sources, bio-mass, hydrogen and fuel cells.

Books Recommended: MINING GEOLOGY

Arogyaswamy, R.N.P. (1995) Courses in Mining Geology, Oxford and IBH Publishing Co., New Delhi. 25 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.

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 Clark, G.B. (1967) Elements. (1995) Drilling Technology Handbook, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Compton, R.R. (1985) Geology in the Field, John Wiley and Sons Inc.

Books Recommended: UNCONVENTIONAL ENERGY RESOURCES

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.

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.

PAPER 14: ELECTIVE 2: REMOTE SENSING IN MINERAL EXPLORATION, GEOPHYSICS AND GEOGENIC HAZARDS (1+1+2)

Unit I: Introduction to Remote Sensing in Mineral Exploration, Main Types of Mineral Deposits Spectra Rock and minerals, Spectral Characteristics of Rock Alterations Spectral Signature of Rocks, Criteria for Lithological, Structural and Geomorphological Mapping using Remote Sensing data, Image interpretation keys, Interpretation of different geological, geomorphological and structural features on B/W aerial photographs and False Colour Composite (FCC), Use of high-resolution data in Mineral Exploration studies some case studies of use of Remote Sensing in Mineral Exploration

Unit II: Introduction to Geophysics and its branches. Earth: shape and rotation. geophysical techniques and equipment in brief; ground penetrating radar, electromagnetic-ground conductivity imaging; electrical resistivity imaging; induced polarization imaging; self-potential imaging; magnetic and microgravity; seismic refraction, seismic surface waves, seismic reflection; geophysical applications in geology, archaeology, contaminated lands; borehole geophysics.

Unit III: Geohazards: meaning and types of geohazards, and consequences of geohazards, Earthquake: recent and historical earthquakes, causes of occurrence, earthquake prediction and their impact as natural hazard; Seismic hazard zones; Neotectonics in seismic hazard assessment in central India; Tsunami – causes, occurrence and prediction, Landslide their causes and prediction and prevention landslide mapping, Volcanic hazards their causes, prediction and prevention; geological hazards vulnerability and risk assessment using remote sensing and GIS, Important case studies of natural hazards.

Unit IV: Impact of mining on environment, mine fire and blow out, mining waste and disposal, suitable site selection and related problems; soil erosion, land degradation and soil pollution; Surface and groundwater pollution, their causes and remedial measures, groundwater issues due to urbanization and irrigation, water logging problems; flood hazards and their mitigation, Nuclear waste, their causes and remedial measures, Coastal erosion, its causes and control; Glaciers, their melting effects and mitigation; major river belts of India.

Books Recommended: REMOTE SENSING IN MINERAL EXPLORATION

Drury, S.A. (4001) Image Interpretation in Geology, Chapman and Hall, London.

Gupta, R.P. (1991) Remote Sensing Geology, Springer-Verlag.

Pande, S.N. (1987) Principles and Applications of Photogeology, Wiley Eastern Limited.

Lillesand, T.M. and Kiefer, R.W. (4000) Remote Sensing and Image Interpretation, John Wiley and Sons Inc., New York.

Books Recommended: GEOPHYSICS

Dobrin, M.B. (1976) Introduction to Geophysical Prospecting, McGraw Hill.

Howel, B.F. (1959) Introduction to Geophysical Prospecting, McGraw Hill.

Lowrie, W. (1997) Fundamentals of Geophysics, Cambridge University Press.

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.

Parasnis, D.S. (1975) Principles of Applied Geophysics, Chapman and Hall.

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.

Books Recommended: GEOGENIC HAZARDS

E. Byrant, Natural Hazards, Cambridge, 2005

A. Patrick, Natural disasters, McGraw Hill, 2003

Valdiya, K.S., Coping with natural hazards: Indian context, Orient Longman, Hyderabad, 2004

Erika Jahn, Landslides and their stabilization, Springer-Verlag, 1981.

Bell, F.G. (1999) Geological Hazards, Routledge, London.

Bryant, E. (1985) Natural Hazards, Cambridge Univ. Press.

Smith, K. (1992) Environmental Hazards, Routledge, London.

RP: RESEARCH PROJECT:

Every student is required to carry out Experimental / Field Based Research Project on a related research topic of the subject /course. On the basis of this work, student must submit the Project Report (typed and properly bound) in two copies prior to commencement of the final Practical Examination of Semester IV, as per the instructions by the Head of the Department.

After Semester-II, the candidates are required to carry out geological investigation approved by the Project Guide. The area/ topic of the project work shall be assigned to the students at the end of Semester – II, depending upon the expertise available in the Department.

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

The Project Work will carry total 100 marks and will be evaluated by both external and internal examiner in the Department as shown below:

For written Project Work	: 70 Marks (Evaluated by External examiner)
Project presentation	: 20 marks (Evaluated by External examiner)
For Viva-Voce	: 10 Marks (Evaluated by External examiner)
Internal Assessment	: 100 Marks (Evaluated by Internal examiner)
Total	: 200 Marks