



St. Xavier's College – Autonomous Mumbai

Syllabus for Ist Semester Courses in **M.Sc. Geology** (June 2013 onwards)

Courses:

M.S.Geo.1.01 – Stratigraphy and Geology of India

M.S.Geo.1.02 - Geochemistry

M.S.Geo.1.03 – Structural Geology

M.S.Geo.1.04 – Mineralogy : Descriptive and Optical

Practical Course:

M.S.Geo.1.01. PR, M.S.Geo.1.02. PR, M.S.Geo.1.03. PR and
M.S.Geo.1.04. PR. (Pertinent to the above mentioned theory
courses)

M.Sc-I Geology Course: M.S.Geo.1.01
Title: Stratigraphy and geology of India

Learning Objective: To understand the tectonics and geological formations in different basins through geological ages from studying the rock strata which will in turn, help in building the geological history of Indian subcontinent.

Number of lectures: 60

Unit 1: (15 lectures)

Precambrian Stratigraphy

Precambrian geochronology, Precambrian Stratigraphy of:

Dharwar Supergroup

Aravalli and Delhi fold belts

Singhbhum shear zone

Sausar Belt

Vindhyan Supergroup

Cuddapah Supergroup

Precambrian-Cambrian boundary

Unit 2: (15 lectures)

Palaeozoic and Gondwana Stratigraphy

Palaeozoic of Kashmir

Palaeozoic of Spiti

Gondwana Supergroup

Permian-Triassic Boundary

Unit 3: (15 lectures)

Mesozoic Stratigraphy

Triassic of Spiti

Jurassic of Kutch

Cretaceous of Trichinopalli

Deccan Volcanics

Cretaceous- Tertiary Boundary

Unit 4: (15 lectures)

Cenozoic Stratigraphy

Palaeogene Systems of India

Neogene Systems of India

Evolution of Himalaya

-Pleistocene-Holocene Boundary

Practical Courses

Stratigraphy and geology of India

Study of Geological Maps to establish the geological sequence of the area in the Chronological order

List of Recommended Reference Books

- 1) K. S. Valdiya (2010), The Making of India-Geodynamic Evolution; Macmillan Publishers India Ltd.
- 2) M. Ramakrishnan and R. Vaidyanadhan (2008), Vol. I and II, Geology of India; Geological Society of India, Bangalore.
- 3) Roy, R. Lemon (1990), Principles of Stratigraphy; Merrill Publishing Company, Ohio
- 4) Harold L. Lewis (1987), Earth through Time; 3rd Edition. Saunders College Publishing, New York
- 5) D. N. Wadia (1984), Geology of India; 4th edition. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- 6) M. S. Krishnan (1982), Geology of India and Burma; 6th Ed. CBS Publishers and Distributors (India).

M.Sc-I Geology Course: M.S.Geo.1.02

Title: Geochemistry

Course Objectives: To learn basic concepts, applications, and scope of geochemistry. Studying Importance of geochemistry in Precambrian stratigraphy, and current status of numerous chemical analysis techniques. Studying importance in Climate Change, petrological and Paleoceanographic problems.

Number of lectures: 60

Unit 1: (15 lectures)

Introduction

Basic principles of geochemistry.

Elements: Atomic Structure, Formation, Abundance, Distribution in Earth and Solar System.

Periodic Table with special reference to transitional and trace elements.

Geochemical Classification of Elements.

Trace element – Definition and Types.

Thermodynamics

Basic Concepts and terms, Fugacity and Activity.

Oxidation and Reduction reactions

Kinematics.

Unit 2: (15 lectures)

Isotope Geochemistry

Introduction to Techniques used in geochemical analysis(ICPMS, AMS, EPMA)

Stable Isotopes of Carbon and Oxygen and its application in Geological Studies.

Radioactive Isotopes: Radioactivity, Decay scheme.

Introduction to Isotopic Systems of Carbon-14, Rb/Sr, Sm/Nd, Lu/Hf, U-Th-Pb, K/Ar, $^{40}\text{Ar}/^{39}\text{Ar}$.

Petrogenetic implications of Sm-Nd, Rb-Sr.

Trace Element Geochemistry

Unit 3: (15 lectures)

Application of Geochemistry

Sedimentary Rocks (weathering, Diagenesis)

Igneous Rocks (Partial Melting and Fractional Crystallization)

Metamorphic Rocks(P-T-t Path)

Unit 4: (15 lectures)

Ocean Geochemistry

Ocean CaCO_3 Cycles

Geochronometry of Marine Deposits

Geochemical evidence of quaternary sea-level changes.

Elemental and isotopic proxies for past ocean temperature estimations

Tracers of past ocean circulation

Geochemical Indicators of Ice sheet dynamics during Glacial and Interglacial periods

Past Global Climate Change and tectonics indicated by marine microfossil Geochemical analysis.

Practical Course:

Geochemistry

Mineral Calculations

Normalization and End Member Calculations

Feldspar Group

Pyroxene Group

Olivine Group

Amphibole Group

NORM Calculations

Geochemical analysis of Marine Core data and interpreting past Ocean Circulation patterns, Past Global Climate change, Regional Climate Change.

List of Recommended Reference Books

1. Geochemistry, 2nd edition, 1996, by Arthur Brownlow, Prentice Hall.
2. Principles and Application of Geochemistry, 2nd edition, 1998, by Gunter Faure, Prentice Hall.
3. Principles of Geochemistry, 4th edition, 1985, by Brian Mason and Carleton B. Moore, Wiley Eastern Limited.
4. The Oceans and the Marine Geochemistry, First Edition, 2006, by Henry Elderfield, Elsevier.

M.Sc-I Geology Course: M.S.Geo.1.03

Title: Structural Geology

Learning Objectives: To understand the concept of stress and strain and how rock behaves under different stress regimes. To learn the methods of structural analysis in complicated terrains and relationship between tectonics and crustal deformation. Detailed study of tectonites, rock fabric and its relation with deformation.

Number of lectures: 60

Unit 1:

(15 lectures)

Tectonites and microfabric

Concept of scale and homogeneity of geological body

Types of tectonites

Tectonite fabric and fabric domains

Fabric symmetry

Penetrative and non-penetrative discontinuities

Basic concepts of geometrical analysis

Interpretation of structure and fabric

Microfabric

Introduction

Deformation mechanisms

Crystal defects

Principles and types of microstructure development

Recovery, meta-dynamic recrystallisation & static grain growth

Grain shape & crystallographic fabric development

Deformation by transfer of dissolved material and structures in veins

Crystallographic preferred orientations in deformed rocks

Unit 2:

(15 lectures)

Foliation and lineation

Foliation

Axial plane foliation- fracture cleavage, crenulation cleavage, slaty cleavage, schistosity and metamorphic layering

Origin of axial plane foliations

Transposed foliation

Cleavage bedding relationship

Structural association of gently dipping schistosity

Field study of high grade gneissic terrain

Recognition of shear zones

Kinematic classification of shear zones

Fabric distribution in shear zones

Mylonites

Lineation

Description- Slickensides, fold axes, intersection lineation, mineral lineation, deformed pebbles, rods, mullions and boudinage

Origin of lineation

Lineation and kinematics

Problem of lineations indicating extension parallel to fold axes

Determining shear sense with lineation and in absence of lineation

Unit 3:

(15 lectures)

Structural associations and analysis

Strain measurement, stress-strain relationship

Mathematical expression of deformation

Cross section and data projection

Structure contouring

Slate belts and flat lying sediments

Fold geometry and outcrop patterns

Complex folds, Dome and basins

Analysis of area with complex structure

Extensional deformation regime- Study of Indian examples

Fold and thrust belts- Study of Indian examples

Recognition of faults on geological maps, seismic profiles and structure contour maps

Tectonic melanges

Wrench faults and associated structures

Multiply deformed belts of low and medium metamorphic grade- Indian examples

Restoration and balancing of geological section

Unit 4:

(15 lectures)

Tectonics and crustal deformation

Plate tectonics- Ridges, trenches, transform faults, geometry of plate motion, stress and strain within plates

Extensional, compressional and strike slip tectonic regimes

Tectonic settings- Ophiolites, cratons, active and passive margins, arc systems, orogens

Evolution of the crust-mantle system

Seismic structure of the crust

Plate tectonics and mountain belts

Changes in tectonic settings with time

Crustal deformation

Practical Course:

Structural geology

Profiles and cross sections of geological maps with showing various structural features: folds, faults, dykes, two series of dipping beds.

Geometrical construction of folds

Completion of outcrop and construction of geological map

Structure contour maps

Interpretation and cross sections of geological maps of complex structural areas

Equal-area net

a. Locating fold axis- β and π diagram

b. Point diagrams and contouring for various fabric elements

List of Recommended Reference Books

1. Hobbs D.W., Means W.D. And Williams P.F. (1976), An Outline of Structural Geology, John Wiley.
2. Groshong, R.H (2006), 3-D Structural Geology, Springer-Berlin-Hydelberg-New York
3. Fossen, H. (2010), Structural Geology, Cambridge University Press
4. Passicher C.W, Myers J.S and Kroner A. (1990), Field geology of high grade gneiss terraines; Narosa Publishing house, Springer Verlag and IUGS
5. Hatcher Jr. R.D. (1990), Structural Geology, Merrill Publishing Company.
6. Leyshon, P. R. And Lisle, R.J (2004), Stereographic projection techniques for geologists and civil engineers, Cambridge University Press
7. Condie, K (1976), Plate tectonics and crustal evolution, Butterworth Heinemann Publication
8. Ragan D.M. (1968), Structural Geology- An Introduction to Geometrical Techniques, 2nd ed., John Wiley and Sons.
9. Badgley P.C. (1959), Structural Methods for the Exploration Geologist, Oxford Book Company.
10. Ramsay J.G. and Huber M.I. (2002), The Techniques of modern structural geology, 2nd ed., Vol. 2, Elsevier Science Ltd.
11. Ghosh S.K. (1993), Structural Geology, Pergamon Press.

M.Sc. Geology Course: M.S.Geo.1.04

Title: Optical and Descriptive Mineralogy

Learning Objectives:

1. To bring about an understanding of the principals of optical mineralogy.
2. To understand the structure, chemistry and occurrence of important mineral groups.

Number of lectures: 60

Unit 1: (15 lectures)

Optics principals

Introduction to Petrological Microscope

Optics of Petrological Microscope.

Accessories: quartz, mica, gypsum plates - construction and usage.

Adjustments and maintenance of petrological microscope.

Unit 2: (15 lectures)

Properties of Minerals under polarised light:

Twinkling, Pleochroism, Interference / polarisation colours

Determination of:

Birefringence, RI, 2V, optical sign of minerals

Unit 3: (15 lectures)

Study of the following groups of rock forming minerals with particular reference to their: structure, chemistry and occurrence.

Ortho and Ring Silicates: Olivine group, Garnet Group.

Chain Silicates: Pyroxene group, Amphibole group.

Unit 4: (15 lectures)

Study of the following groups of rock forming minerals with particular reference to their: structure, chemistry and occurrence.

Sheet Silicates: Mica Group.

Framework Silicates: Feldspar group, Silica minerals

Practical Course:

Practicals in : determination of magnification of petrological microscope, calibration of eyepiece, calculating Birefringence, thickness of mineral grain, optical orientation, optic sign, 2V, R.I measurement, determination of Anorthite content in Plagioclase, Measurement of extinction angle.

List of recommended Reference Books:

1. Read H.H. (Rev. ed. C.D. Gribble) (1988), Rutley's Elements of Mineralogy" (27TH Edition), CBS Publications.
2. Cornelius K. and Hurlbut Jr. S. (1994), Manual of Mineralogy, Twenty first Edition and Minerals and Rocks Exercises in Crystallography, J. Wiley & Sons.

3. Dana J.D. and Ford W.E. (rev. ed.) (2010), Dana's Manual of Mineralogy, J. Wiley & Sons.
4. Rogers A.F. and Kerr P.F. (1942), Optical Mineralogy (2nd Edition), McGraw- Hill Co. Inc., New York.
5. Berry L.G., Mason B.H. and Dietrich R.V. (1983), Mineralogy, concepts, descriptions, determinations, W.F. Freeman and Co.
6. Deer W.A., Howie A.H. and Zussman J. (1992), An introduction to rock forming minerals, Longman Scientific and Technical.
7. Shelly David (1985), Optical Mineralogy (2nd Edition), Elsevier.
8. Nesse W.D. and Schulze D.J. (2004), Introduction to Optical Mineralogy" (Third Edition) and An Atlas of Minerals in Thin Section, Oxford University Press.
9. Perkins Dexter (2011), Mineralogy (International Edition), Pearson Education.
10. Wenk H.R. and Bulakh A. (2004), Minerals: their constitution and origin, Cambridge University Press.



St. Xavier's College – Autonomous Mumbai

Syllabus for IInd Semester Courses in **M.Sc. Geology** (November 2013 onwards)

Courses:

M.S.Geo.2.01 – Remote Sensing and Image Interpretation

M.S.Geo.2.02 - Igneous Petrology

M.S.Geo.2.03 – Metamorphic Petrology

M.S.Geo.2.04 – Sedimentary Petrology

Practical Course:

M.S.Geo.2.01. PR, M.S.Geo.2.02. PR, M.S.Geo.2.03. PR
and M.S.Geo.2.04. PR. (Pertinent to the above mentioned
theory courses)

M.Sc-I Geology Course: M.S.Geo.2.01

Title: Remote Sensing and Image Interpretation

Learning Objectives:

Understand the analytical aspects of image processing with special emphasis on processing remotely sensed imagery for geological data interpretation, field mapping.

Number of lectures: 60

UNIT 1

(15 lectures)

Concepts of Remote Sensing

Satellite imaging technology - Definitions of: Resolution, Classification of sensors, Accuracy and precision, Geolocation, georeferencing and geocoding, Orthoimages, Image products. Principles: Satellite Orbits, Geometry of a single image, Acquisition of stereoscopic data, Height from stereoscopic data, Ground control, Accuracy. History of optical sensors in space

UNIT 2

(15 lectures)

Principles of High Resolution Optical Sensors

Across track stereo, Along track stereo, Spatial and radiometric aspects, Sensor optics, Data recording and transmission, Sensors with GSD 1m to 16m and 1m or less.

UNIT 3

(15 lectures)

Introduction to Digital Image Processing

Introduction.
Image Rectification and Restoration.
Image Enhancement.
Contrast Manipulation.
Spatial Feature Manipulation.
Multi-Image Manipulation.

UNIT 4

(15 lectures)

Digital Imaging classification

Image Classification: Supervised Classification.
The Classification Stage: Minimum-Distance to Means Classifier, Parallelepiped Classifier, Gaussian Maximum Likelihood Classifier.
The Training Stage.
Unsupervised Classification.
Subpixel classification,

Hyperspectral Image Analysis
Classification Accuracy Assessment.

List Of Recommended Reference Books

1. Dowman Ian., Karsten Jacobsen., Gottfried Konecny and Rainer Sandau (2012), High Resolution Optical Satellite Imagery., Whittles Publishing.
 2. Schowengerdt Robert A., (2007), Remote Sensing – Models and Methods for Image Processing, 3rd ed., Elsevier (Academic Press).
 3. Lillisand T. M., Ralph W. Kiefer and Jonathan W. Chipman (2007), Remote Sensing and Image Interpretation, 6th ed, Wiley.
 4. Jensen John R. (2000), Remote Sensing of the Environment – An Earth Resource perspective, Pearson Education Series, Low Price Edition.
 5. Drury S.A., (1993), Image Interpretation in Geology, 2nd ed., Chapman and Hall, London.
 6. Ramasamy S.M., (2005), Remote Sensing in Geomorphology, New India Publishing Agency.
 7. Mather Paul M., (2004), Computer Processing of Remotely Sensed Images- An Introduction, 3rd ed., John Wiley.
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Practical Course:

Remote Sensing and Image Processing

- Interpretation of Satellite imagery for : Landuse/Landcover, Geomorphology, Geology.
 - Digital Image Processing (using number matrix): enhancement, manipulation and classification.
 - Digital image processing on Computer
 - Display of various types of image formats
 - Pallets and Display elements
 - Georeferencing
 - Image enhancement
 - Image classification
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M.Sc-I Geology Course: M.S.Geo.2.02

Title: Igneous Petrology

Course Objectives: To understand the principles and processes involved in the evolution and formation of Igneous rocks and provinces, and their significance in deciphering the Earth's evolution.

Number of lectures: 60

Unit 1: (15 lectures)

Role of Magma In Geological Processes

Magma definition, its physical property- Geothermal gradient and heat source.

Magmatism and plate tectonics.

Igneous texture and structure and their genetic significance.

Classification of Igneous rocks - historic perspective and the IUGS systematic

Igneous activity at the present day

Unit 2: (15 lectures)

Geochemical Tracers of Mantle Process

Introduction

Continental and Oceanic mantle Lithosphere.

MORB and depleted mantle.

OIB and enriched mantle.

Island arc basalt.

Concept of Hot Spots

Mantle Plumes- theory and structure

Trace Elements in Igneous processes- Melting and crystallization models- Application of trace elements to petrogenesis

Unit 3: (15 lectures)

Magma Evolution and Crystallisation

Igneous processes and diversity in igneous rocks.

Compositional variation in magmas

Magmatic differentiation

Mixing of magma

Assimilation of magma

Phase relations of silicates and silicate melt.

Binary and ternary system.

Partial melting

Unit 4: (15 lectures)

Petrogenetic Provinces

Large Igneous Provinces: Basaltic associations of continental areas, Basaltic rocks of the Ocean Basins.

Ophiolites.

Layered Gabbroic Intrusions.

Alkaline rocks, Nephelinites and Ijolites, Lamprophyres.

Carbonatites, Anorthosites, Kimberlites, Lamproites : Geology and Distribution in India.

Granites and Granitic rocks

Practical Course:

1. Megascopic and Microscopic identification of igneous rocks.
2. CIPW normative calculation of igneous rocks.
3. Application of trace elements in igneous petrology.

List of Recommended Reference Books :

1. Bose M.K. (1997), Igneous Petrology. The World Press Pvt. Ltd. 568 p.
2. Bowen N.L. (1928), The evolution of Igneous Rocks. Princeton Univ. Press. N.J 332 p.
3. Hall A. (1987), Igneous Petrology. Longman. 573p.
4. Hatch F.H., Wells A.K and Wells M.K. (1984), Petrology of the igneous rocks. CBS Publishers, 551 p.
5. Philpotts A.R. (1994), Principles of igneous and metamorphic Petrology, Prentice Hall of India. 498p.
6. Turner F.J & Verhoogen J. (1951), Igneous and Metamorphic Rocks, McGraw Hill.
7. Williams H, Turner F.J & Gilbert C.M. (1955), Petrography. San Francisco: W.H. Freeman and company. 406p
8. Winter J. D. (2001), an Introduction to Igneous and Metamorphic Petrology, Prentice Hall, 697p.
9. Ehlers, E.G. and H. Blatt (1982), Petrology, Igneous, Sedimentary and Metamorphic, W.H Freeman, San Francisco.

M.Sc-I Geology Course: M.S.Geo.2.03

Title: Metamorphic Petrology

Learning Objectives: To understand the metamorphism and its controlling factors, to understand concept of metamorphic facies and significance of metamorphic mineral assemblages. To relate metamorphic textures with deformation conditions and to understand role of global tectonics in metamorphism.

Number of lectures: 60

Unit 1: (15 lectures)

Metamorphism and its controlling factors

Metamorphism and its limits

Metamorphic agents and changes: Role of temperature, pressure, stress and fluids

Types of metamorphism

Types of protolith

Classification of metamorphic rocks

Structures and textures of metamorphic rocks

Analysis of polydeformed and polymetamorphosed rocks

Analytical techniques

Unit 2: (15 lectures)

Thermodynamics and metamorphism

Phase rule and phase diagram

Chemographic diagrams: Basic concepts and common diagrams in metamorphic petrology

Projections in chemographic diagrams

Metamorphic facies and facies series

Types of metamorphic reactions

Petrogenetic grids

P-T-t paths

Calculation of equilibrium curve for metamorphic reactions

Examples of thermometry and barometry

Unit 3: (15 lectures)

Types and products of metamorphism-1

Metamorphism of pelitic rocks

Migmatites: Types and formation processes

Metamorphism of carbonate rocks

Metamorphism of mafic rocks

Unit 4: (15 lectures)

Types and products of metamorphism-2

Metamorphism of granitoids.

Charnockites

Metamorphic fluids, mass transport and metasomatism.

Impact metamorphism and Retrograde metamorphism.

Tectonics and metamorphism, Paired metamorphic belts

Practical Course:

Metamorphic petrology

☐ Plotting rock compositions on chemographic diagrams: ACF, AKF and AFM.

☐ Study of hand specimen of metamorphic rocks

Slate, Phyllites, Quartzite, Schists, Gneisses, Granulites, Khondalite, Leptynite, Charnockite, Eclogite, Amphibolite, Migmatite, Blueschist, Breccia, Mylonite,

☐ Study of thin sections of

a) Metapelitic rocks

b) Metabasic rocks

c) Granulites and eclogite

d) Marbles

List of Recommended Reference Books

1. Winter, John D. (2010): Principles of igneous and metamorphic petrology, PHI learning Pvt. Ltd.
2. Philpotts, A and Ague, J (2009): Principles of igneous and metamorphic petrology, Cambridge University Press
3. Williams H, Turner F.J & Gilbert C.M. (1955), Petrography, W.H. Freeman and company. San Francisco, 406p.
4. Blatt H., Tracy R.J. and Owens B.E. (2006), Petrology – Igneous, sedimentary and Metamorphic (3rd Edition), W.H. Freeman and Company, New York.
5. Passicher C.W, Myers J.S and Kroner A. (1990), Field geology of high grade gneiss terranes; Narosa Publishing house, Springer Verlag and IUGS
6. Yardley Bruce W.D. (1989), An Introduction to Metamorphic Petrology, Longman Singapore Publishers (Pvt.) Ltd.
7. Miyashiro A. (1998), Metamorphism and Metamorphic Belts, George Allen & Unwin, New York.
8. Mason Roger (1984), Petrology of the Metamorphic Rocks, CBS Publishers and Distributors, New Delhi.
9. Winkler Helmut G.F. (1987), Petrogenesis of Metamorphic Rocks (Fifth Edition), Narosa Publishing House, New Delhi.

M.Sc. Geology Course: M.S.Geo.2.04

Title: Sedimentary Petrology

Course Objectives:

Understanding different sedimentary processes, rocks and structures and their associated environment.

Application of Sedimentary petrology in understanding different geological processes.

Number of lectures: 60

Unit-1 (15 lectures)

Sediment transport and deposition, fundamentals of fluid dynamics

Sedimentary textures: grain size, sorting, shape, etc.

Sedimentary structures: lamination, ripples, cross-bedding etc.

Unit-2 (15 lectures)

Siliciclastic sedimentary rocks, classifications, Siliciclastic diagenesis

Siliciclastic marine environments

Fluvial depositional environments

Unit -3 (15 lectures)

Carbonate sedimentary rocks, classification and diagenesis

Carbonate marine environments

Biochemical and evaporitic rocks

Unit-4 (15 lectures)

Eolian and lacustrine environments

Glacial environment

Deltaic and beach barrier island environments

Estuarine, lagoonal and tidal environments

Practical Course:

Sedimentary petrology

Rock Specimens of different sedimentary rocks and structures

Thin section of sedimentary rocks

Grain Size analysis

Paleocurrent analysis

List of Recommended Reference Books

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

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

3. Reading, H.G. (1997): Sedimentary Environments and facies, Blackwell Scientific Publication.

4. Reineck, H.E. and Singh, I.B. (1973): Depositional Sedimentary Environments, Springer-Verlag.

5. Selley, R. C. (2000) Applied Sedimentology, Academic Press.

6. Tucker, M.E. (2001): Sedimentary Petrology: An Introduction, Wiley and Sons, New York.
7. Tucker, M.E. (1990): Carbonate Sedimentology, Blackwell Scientific Publication
8. Stow Dorrik A.V(2011): Sedimentary Rocks in the Field , A Colour guide. Manson Publishing House Ltd.
9. Nichols Gary (2009): Sedimentology and Stratigraphy., Wiley India.



St. Xavier's College – Autonomous Mumbai

Syllabus for IIIrd Semester Courses in **M.Sc. Geology** (June 2013 onwards)

Courses:

M.S.Geo.3.01 – General and Invertebrate Paleontology

M.S.Geo.3.02 – Hydrogeology

M.S.Geo.3.03 – Geophysical Prospecting

M.S.Geo.3.04 – Coal and Petroleum Geology

Practical Course:

M.S.Geo.3.01. PR, M.S.Geo.3.02. PR, M.S.Geo.3.03. PR and
M.S.Geo.3.04. PR. (Pertinent to the above mentioned theory
courses)

M.Sc-II Geology Course: M.S.Geo.3.01

Title: General and Invertebrate paleontology

Learning Objectives: To understand scope and applications of paleontology and to learn morphology and classification of invertebrate fossil fauna. To understand trace fossils and taphonomic record with Indian examples

Unit -1: (15 lectures)

Introduction

Paleontology, definition, subdivisions and scope, its relationship with other sub-disciplines of geology; Fossils, definition, characters, kinds (body and trace fossils); Conditions of fossilization; Incompleteness of fossils record; Bathymetric distribution of organisms. Modern systematics; Concept and kind of type specimens; Trans-specific evolution, speciation and radiation.

Unit -2: (15 lectures)

Invertebrate paleontology-1

Chief characteristics, Evolutionary trends and geological history of following groups:

Brachiopoda

Mollusca (Bivalvia, Gastropoda, Cephalopoda)

Echinoidea

Unit -3: (15 lectures)

Invertebrate paleontology-2

Chief characteristics, Evolutionary trends and geological history of following groups:

Trilobita, Cnidaria (Corals), Graptoloidea.

Ichnofossils, their modes of preservation, behavioral classification and ichnofacies.

Unit -2: (15 lectures)

Paleoecology paleoenvironment

Approaches to paleoecological and paleoenvironmental studies based on benthic communities, trace fossils and taphonomic record with Indian examples; Micro and macroevolution.

Distribution, migration and dispersal of organisms applied to paleobiogeography and plate tectonics with Indian examples.

Practical Course:

General and Invertebrate paleontology

Study of the morphological characters of some important invertebrate fossils belonging to Brachiopoda, Bivalvia, Gastropoda, Ammonoidea, Trilobita, Echinoidea and corals; Study of ammonoid suture pattern.

List of Recommended Reference Books

- 1) Clarksons, E.N.K. (1998): Invertebrate Paleontology and Evolution, Allen and Unwin, London.
- 2) Prothero, D.R. (2004): Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.), McGraw Hill.
- 3) Raup, D.M. and Stanley, S.M. (1985): Principles of Paleontology ,CBS Publ..
- 4) Smith, A.B.(1994): Systematics and Fossil Record – Documenting Evolutionary Patterns, Blackwell.
- 5) Streat, C.W. and Carroll, R.L. (1989): Paleontology – the record of life, John Wiley.
- 6) Shrock, Robert R. and Twenhofel, William H. (2002): Principles of Invertebrate Paleontology, (McGraw Hill) Dist. CBS Publishers.
- 7) Benton, Michael J. and Harper, David A.T. (2009): Introduction to Paleobiology and fossil record, John-Wiley & Sons.

M.Sc-II Geology Course: M.S.Geo.3.02

Title: Hydrogeology

Learning Objectives: To understand origin, occurrence and movement of groundwater and to study surface and subsurface methods of groundwater exploration. To study impact of geology on groundwater distribution in India.

Unit -1: (15 lectures)

Origin and occurrence of groundwater

Groundwater in Hydrologic Cycle

Origin and age of Groundwater

Vertical Distribution of Groundwater

Impact of Geologic formations and structure, on groundwater flow

Groundwater distribution of India

Movement of groundwater:

Origin and types of springs and hot springs

Darcy's law

Permeability

Determination of Hydraulic Conductivity

Unit -2: (15 lectures)

Well Hydraulics:

Pumping test

Field and lab analysis of hydraulic conductivity

Steady and Unsteady flow

Radial and Unidirectional flow to well,

Saline water intrusion in Aquifers- Ghyben-Herzberg relation between Fresh and Saline water

Unit -3: (15 lectures)

Environmental influences on groundwater

Causes for Fluctuation in water table

Artificial Recharge of Groundwater

Quality of groundwater:

Chemical Analysis and Graphical Representation for Quality of Groundwater

Water-Quality Standards and collection of Water Samples

Ground-Water Monitoring

Ground-Water Contamination

Unit-4 (15 lectures)

Surface and subsurface methods for investigation of groundwater:

Surface investigation of groundwater

Resistivity Method

Seismic Method

Gravity and Magnetic Method

Resistivity Logging
Spontaneous Potential Logging

Practical Course:

Hydrogeology

Groundwater contour maps and flow nets
Analysis of rainfall data
Resistivity data interpretation
Groundwater flow problems

List of Recommended Reference Books

1. Nath, Sankar Kumar, Patra, Hari Pada, & Shahid, Shamsuddin [2000] Geophysical Prospecting for Groundwater. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
2. Mazof s, E., (1988) Applied Chemical Groundwater Hydrology McGill.
3. Ingebritsen, Steve, Stanford, Ward & Neuzil, Chris (2006) Groundwater in Geologic Processes. 2nd edition, Cambridge University Press, U.K.
4. Assad, Fakhry, LaMoreaux, Phillip E., & Hughes, Travis H. ed. (2003) Field methods for Geologists and Hydrogeologists. Springer-Verlag, Berlin.
5. Brassington, R., (1988) Field Hydrogeology John Wiley & Sons, Chichester.
6. Todd, D.K. (1995) Groundwater Hydrology John Wiley & Sons, London.
7. Walton, W.C. Groundwater Resource Evaluation latest Ed., McGraw Hill.
8. Micheal, P., (1985) Introduction to Groundwater George Allen & Unwin, London.
9. Fetter, C.W., (1994) Applied Hydrogeology MacMillan Pub. Comp. New York.
10. Ragunath, H.M., (1992) Groundwater Wiley Eastern Ltd. New Delhi.
11. Bouwer, Herman (1978) Groundwater Hydrology. McGraw Hill, Inc., New Delhi.

M.Sc-II Geology Course: M.S.Geo.3.03

Title: Geophysical Prospecting

Learning Objectives: To understand basic concepts, scope and applications of geophysical prospecting. To learn methods of logging and log interpretation.

Unit-1

(15 Lectures)

Introduction

Introduction to Geophysical Prospecting and historical background
Overview of Geophysical Prospecting methods

Seismic Methods

Fundamentals of Seismic prospecting
Seismic instruments, measurements and field operations
Seismic refraction method
Seismic reflection method
Geological interpretation of refraction and reflection data

Unit-2

(15 Lectures)

Gravity Methods

Fundamentals of Gravity prospecting
Instruments, measurements and field operations
Geological interpretation of Gravity Data

Magnetic Methods

Fundamentals of Magnetic prospecting
Instruments, measurements and field operations
Geological interpretation of Magnetic Data

Unit-3

(15 Lectures)

Electrical Methods

Electrical properties of rocks and minerals
Methods employing Natural Electrical sources:
 (a) Self-potential (b) Telluric and Magnetotelluric
Resistivity method
Induced Polarization method
Geological interpretation of Electrical Data

Electromagnetic Methods

Fundamentals of electromagnetic surveys
Instruments and field settings
Geological interpretation of EM Data

Unit-4

(15 Lectures)

Radioactivity methods

Fundamentals of radioactivity surveys

Instruments and field settings

Geological interpretation of Radioactivity Data

Geophysical Well Logging

Introduction to well logging

General aspects well logging and historical background

Common logging methods:

- | | | |
|-----------------------|------------------------|-----------------|
| (a) Resistivity log | (b) Self-potential log | (c) Sonic log |
| (d) Neutron log | (e) Gamma-ray log | (f) Density log |
| (g) Well bore seismic | (h) Image logs | |

Well-log interpretation

List of Recommended Reference Books:

1. Dobrin, Milton B. (1960): Introduction to Geophysical Prospecting, McGraw-Hill Book Company, Inc.
2. Milsom, J. and Asger, E. (2011): Field Geophysics, 4th edition, Wiley and Sons Ltd.
3. Committee on Geodesy, National Research Council (1995): Airborne Geophysics and Precise Positioning: Scientific Issues and Future Directions, National Academics Press.
4. Gadallah, M. and Fisher, R. (2009): Exploration Geophysics, Springer-Verlag Berlin Heidelberg.
5. Kalyan Kumar Roy (2008): Potential Theory in Applied Geophysics, Springer-Verlag Berlin Heidelberg.
6. Kearey, Brooks and Hill (2002): An Introduction to Geophysical Exploration, Third Edition, Blackwell Science.
6. W. M. Telford, L. P. Geldart and R. E. Sheriff (2004): Applied Geophysics, Second Edition, Cambridge University Press.

Practical Courses:

1. Calculations and interpretation based on Seismic Data
2. Calculations and interpretation based on Gravity Data
3. Calculations and interpretation based on Electrical Data
4. Exercises on Log interpretation
5. Exercises on Log correlation

M.Sc-II Geology Course: M.S.Geo.3.04

Title: Coal and petroleum geology

Learning Objectives: To understand origin, properties, classification of coal and petroleum. Learning exploration methods, and coal/petroleum bearing rock formations in India.

Unit-1

(15 lectures)

Generation and migration of petroleum

Physical and chemical properties of petroleum

i) Natural gases

ii) Gas hydrates

iii) Crude oil

Classification of petroleum

Generation and migration of petroleum

Origin of petroleum: Organic or Inorganic

Modern organic processes on the earth's surface

Formation of kerogen

Petroleum migration

Petroleum system

Unit-2

(15 lectures)

Reservoir and cap rocks

The Reservoir

Porosity, Permeability, Capillary pressure, Relationship between Porosity, Permeability and

Texture, Effects of diagenesis on reservoir quality

Reservoir continuity and characterization

Reserve calculations and Production methods

Traps and Seals

Nomenclature of a trap

Distribution of petroleum within a trap

Seals and cap rock

Classification of traps

Unit-3

(15 lectures)

Origin and distribution of coal

The origin of coal

Sedimentation of coal and coal bearing sequences

Structural effects on coal

Age and occurrence of coal

Plate tectonics

Stratigraphy

Coal as a substance
Physical description of coal
Coalification (Rank)
Coal quality
Classification of coals

Unit-4

(15 lectures)

Sampling and analysis of coal

Coal sampling and analysis

In situ coal sampling

Non *in situ* coal sampling

Coal analysis

Geology and coal mining

Underground mining

Open cast or surface mining

Practical courses

Coal and petroleum geology

Isopach and isolith maps

Outcrop completion, fault and borehole problems

Reserve estimation problems

Seismic profile interpretation

Borehole correlation

List of Recommended Reference Books

1. Thomas L. (2012), Coal Geology, Wiley India Pvt. Ltd.
2. Francis W. (1964), Coal its formation and composition, Edward Arnold (Publishers) Ltd.
3. Deshpande B.G. (1992), The world of petroleum, Wiley Eastern Ltd. New Delhi.
4. Selley R.C. (1998), Elements of petroleum geology, Academic Press.
5. Ashcroft, W. (2011), A geologist's guide to seismic reflection, John Wiley and sons
6. Leverson, A.I (2006): Geology of Petroleum, CBS publications



St. Xavier's College – Autonomous Mumbai

Syllabus for IVth Semester Courses in **M.Sc. Geology** (November 2013 onwards)

Courses:

M.S.Geo.4.01 – Micropalaeontology and Oceanography

M.S.Geo.4.02– Engineering Geology

M.S.Geo.4.03 – Economic Geology

M.S.Geo.4.04* – Dissertation

Practical Course:

M.S.Geo.4.01. PR, M.S.Geo.4.02. PR, M.S.Geo.4.03. PR

(Pertinent to the above mentioned theory courses)

M.Sc-II Geology Course: M.S.Geo.4.01

Title: Micropalaeontology and Oceanography

Learning Objectives: To give an insight of the various microfossils with respect to their morphology, shell composition and their habitats. To emphasize on the applications of various microfossils in the field of paleoclimatology, paleoceanography and biostratigraphy.

Number of lectures: 60

Unit 1:

(15 lectures)

Definition and scope of the subject; Relationship of micropaleontology with ocean sciences; Modern field and laboratory techniques in the study of microfossils (collection, sampling and processing techniques, scanning electron microscopy and mass spectrometry).

Types of Microfossils

Calcareous Microfossils:

(i) Foraminifera - planktic foraminifera, their modern biogeography, outline of morphology, significance in Cenozoic oceanic biostratigraphy and paleoceanographic, paleoclimatic interpretations.

Benthic foraminifera – outline of morphology; application in deep-water paleoceanography and paleobathymetric reconstructions.

Larger foraminifera- their outline of morphology and application in stratigraphy;

(ii) Calcareous nannofossils - outline of morphology, modern biogeography and their application in oceanic biostratigraphy and paleoceanographic, paleoclimatic reconstructions.

(iii) Pteropoda - a brief introduction, application of pteropods in reconstruction of the Quaternary oceanography and climate;

Organic Walled Microfossils:

Organic walled microfossils and their significance, significance of spores, pollen, in biostratigraphy, Concept of palynofacies and its application in paleoenvironment interpretation.

Unit 2:

(15 lectures)

Types of Microfossils

Siliceous Microfossils:

Radiolaria and diatoms - outline of morphology, modern biogeography, their environmental significance and application in biostratigraphy.

Phosphatic Microfossils:

Conodonts - outline of morphology, paleoecology, geological significance and biological affinities; Stratigraphic significance of conodonts with special reference to India.

Micropaleontology in petroleum exploration; Environmental significance of microfossils;

Geochemical study of microfossil tests (stable isotopes, radiocarbon isotopes and elemental composition) and its application in paleoceanography and paleoclimatology; Application of palynology in identifying ancient coast lines; Role of micropaleontology in marine geology and oceanography.

Unit 3:

(15 lectures)

History of development of oceanography; Sampling of modern ocean biogenic flux including sediment trap sampling; Methods of measuring properties of sea water; Temperature and salinity distribution (horizontal and vertical) in ocean waters; Dissolved gases in sea water, factors affecting the concentration of gases in sea water; Carbon dioxide equilibria, precipitation and dissolution of carbonates; Biological - chemical - physical interactions in the oceans; Oxygen minimum layer in the ocean. Scientific ocean drilling and its major accomplishments

Unit 4:

(15 lectures)

Concept of mixed layer, thermocline, pycnocline halocline, and pycnocline, Coriolis force and Ekman spiral, upwelling, El Niño and La Nina, Ocean circulation- surface circulation; deep ocean circulation (concept of thermohaline circulation, formation of bottom waters, water masses of the world oceans, oceanic sediments).

Practical Course

Micropaleontology

Types of microfossils - calcareous, siliceous, and organic walled microfossils; Microscopic study of important planktic and benthic foraminifera; Study of larger benthic foraminifera.

Oceanography

Depth biotopes; Identification of planktic foraminifera characteristic of warm and mixed layer, thermocline and deep surface water of the modern oceans;

Quantitative study of planktic foraminifera and their interpretation in relation to paleoclimatology.

List of Recommended Reference Books

1. Kennett, J.P. and Srinivasan, M.S. (1983): Neogene Planktonic Foraminifera- a phylogenetic atlas, Hutchinson Ross Publishing Company.
2. Bignot, G., Grahm and Trotman (1985): Elements of Micropaleontology, Micropaleontology Press, London.
3. Armstrong, H.A. and Brasier, M. (2005): Microfossils, Blackwell Publishing, Australia.
4. Pinet, Paul R. (2006): Invitation to Oceanography, Jones & Bartlett Learning.
5. Grant Gross, M. (1995): Oceanography; A view of the Earth (7th Ed.), Prentice Hall.
6. Garrison, T. (2007): Oceanography: an invitation to marine sciences, Cengage Learning.
7. Haq, Bilal and Boersma, Anne (Ed.) (1998): Introduction to Marine Micropaleontology, Elsevier.
8. Bradley, R.S. (Ed.) (1999): Paleoclimatology (2nd Ed.), Elsevier.
9. Marcel, C.H. and Vernal, A.D. (Ed.) (2007): Proxies in Late Cenozoic Paleoceanography, Elsevier.

M.Sc-II Geology Course: M. S.Geo.4.02

Title: Engineering Geology

Learning Objectives: To understand the engineering properties of rocks. Detailed study of various geological and geotechnical investigations for various civil engineering projects.

Number of lectures: 60

Unit 1:

(15 lectures)

Rock and soil mechanics

Techniques of determining properties of rocks and soil:

Specific Gravity

Porosity

Sorption

Compressive Strength

Tensile Strength

Elasticity of Rocks

Residual Stress and Shear Stress in Rocks.

Soil mechanics

Rocks as construction material

Unit 2:

(15 lectures)

Geological and Geotechnical investigations for Civil Engineering Projects:

1. **Geotechnical investigations-** Sounding, Drilling equipment and methods, Wash borings, core samples, borehole logs.

2. **Building site exploration-** Types of foundations, load tests, groundwater problem. Commercial, residential and industrial building site investigation

3. **Tunnels:** Terminology, Geological conditions for tunnel sites, Tunnels in folded rocks and bedded rocks. Influence of divisional planes, Effects of faults, Crushed zones, Tunnels near slopes, Role of Groundwater in tunneling.

4. **Bridges and pavements-** Abutments and piers, foundations, cofferdams, Caissons, rigid and flexible pavement. Site exploration.

Unit 3:

(15 lectures)

Tunnels and shoreline engineering

1. **Tunnels-** Terminology, technical classification, roof bolting, arching, effect of bedding orientation on tunnels. Gases and water in tunnels, geothermal gradient. Methods of tunnel excavation and site exploration

2. **Shoreline engineering-** Beach and shorelines, construction of shore cliffs and steep banks, Littoral barriers, harbour location, sedimentation in harbours and jetties.

3. **Earthquakes and Aseismic design of buildings**

Unit 4:

(15 lectures)

Dams, reservoirs and landslides

1. **Dams and Reservoirs:** Geological conditions for the selection of dam and reservoir sites.

Terminology associated with dams. Types of dams: Masonary Dams (Gravity Buttress and Arch types), Earthen dams. Types of spillways. Case studies of dam construction and failures.

2. **Landslides-** Causes, types and prevention of landslides.

Practical Course:

Engineering Geology

- ☐ Correlation of borehole data
- ☐ determining uniaxial compressive strength of rock
- ☐ Equal-area net- Determining slope stability and rotation problems.

List of Recommended Reference Books

1. Waltham, T. (2009): Foundations of engineering geology, 3rd edition, CRC press
2. Vallejo, L.G, Mercedes, F., Freitas, M. (2011): Geological Engineering, 1st edition, CRC press
3. West, T.R (2010): Geology applied in Engineering, Waveland Pr Inc; 1 edition
4. Narayanswami S.B.S. (2000), Engineering Geology, Dhanpat Rai & Co, India.
5. Legget F. R and Hatheway A.W. (1988), Geology and Engineering., 3rd ed. McGraw-Hill.
6. Gupte R.B. (1992), A Textbook of Engineering Geology. 2nd ed. Pune Vidyarthi Griha Prakashan.
7. Krynine D.P. And Judd W.R (2003), Principles of Engineering Geology and Geotechniques, CBS Publishers.
8. Wahlstrom E.E. (1974), Dams, Dam Foundations and Reservoir Sites. Elsevier Scientific.
9. Dunn I.S., Anderson L.R and Kiefer F.W. (1980), Fundamentals of Geotechnical Analysis, John Wiley.
10. Maslov N.N. (1987), Basic Engineering Geology and Soil Mechanics. Mir Publishers.
11. Gokhale K.V.G.K and Rao D.M. (1981), Experiments in Engineering Geology. Tata McGraw-Hill

M.Sc-II Geology Course: M.S.Geo.4.03

Title: Economic Geology

Learning Objectives: To understand the various processes of ore formation, with special reference to the distribution in India.

Number of lectures: 60

Unit 1: (15 lectures)

Concept of ore bearing fluids, their origin and migration; Processes of formation of ore deposits- metasomatic, hydrothermal and supergene enrichment; Controls of ore localization; Ore deposits and plate tectonics.

Unit 2: (15 lectures)

Mineralogy, classification and genesis of ore deposits associated with mafic-ultramafic rocks; Ores of felsic-silicic rocks; Ores of sedimentary affiliation; Ores of metamorphic affiliation; Placer and residual concentration deposits.

Unit 3: (15 lectures)

Study of ore minerals related to the following metals with special reference to their mineralogy, genesis, specification, uses and distribution in India:
Iron, Manganese, Base Metals, Chromium, Gold, Tin and Tungsten.

Unit 4: (15 lectures)

Study of important Indian ore deposits with reference to their geology, stratigraphy and reserves; A few case studies of occurrence of economic mineral deposits from provinces other than Indian sub-continent.

Practical Course:

Identification of important ore minerals in hand specimens.
Ore microscopy- textures, microstructures, optical properties of ores.

List of Recommended Reference Books

1. Branes, H.L. (1979): Geochemistry of Hydrothermal Ore Deposits, John Wiley.
2. Cuilbert, J.M. (1986): The Geology of Ore Deposits, Freidman.
3. Evans, A.M. (1993): Ore Geology and Industrial Minerals, Blackwell.
4. Jensen M.R. and Bateman A.M. (1981), Economic mineral deposits, John Wiley & Sons.
5. Craig, J.R. and Vaughan, D.J. (1994): Ore Microscopy and Petrography.
6. Klemm, D.D. and Schnieder, H.J. (1977): Time and Strata Bound Ore Deposits, Springer-Verlag.
7. Wolf, K.H. (1976-1981): Handbook of Stratabound and Stratiform Ore deposits, Elsevier.
8. Mookherjee, A. (1999): Ore Genesis- A Holistic Approach., Allied Publishers.

M.Sc.II Geology Course: M.S.Geo.4.04

DISSERTATION

(Topic for dissertation will be assigned during the 3rd semester.)

Evaluation of Dissertation: (CIA - 40%, Dissertation report and Viva - 60%)

CIA I: (30 marks):Reference work - pre-field / pre lab literature survey, preparation of field material (toposheet, satellite imagery etc)

CIA II: (30 marks): Field work , Lab work, Geological mapping, Sample collection, field diary.

End Semester Examination: Dissertation Report and Open Viva: (90 marks)

Dissertation report - 60 marks

Viva voce - 30 marks
