UNIVERSITY OF MUMBAI
No. UG/200 of 2016-17

CIRCULAR:-

A reference is invited to the Syllabi relating to the B.Sc. degree course , **vide** this office Circular No. UG/14 of 2013-14, dated 4th May, 2013 and the Principals of affiliated Colleges in Science are hereby informed that the recommendation made by the Board of Studies in Geology at its meeting held on 28th June, 2016 has been accepted by the Academic Council meeting held on 14th July, 2016 **vide** item No. 4.58 and that in accordance therewith, the revised syllabus as per the Choice Based Credit System for M.Sc. programme in Geology (Sem. I & II), which is available on the University's web site (www.mu.ac.in) and that the same has been brought into force with effect from the academic year 2016-17.

(Dr.M.A.Khan)
REGISTRAR

MUMBAI – 400 032
3 December, 2016

To,

The Principals of the affiliated Colleges in Science.

A.C/4.58/14.07.2016

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No. UG/200 -A of 2016 MUMBAI-400 032 3 December, 2016

Copy forwarded with Compliments for information to:-

1) The Co-ordinator, Faculties of Science,
2) The Chairman, Board of Studies in Chemistry,
3) The Professor-cum-Director, Institute of Distance & Open Learning (IDOL)
4) The Director, Board of College and University Development,
5) The Co-Ordinator, University Computerization Centre,
6) The Controller of Examinations.

(Dr.M.A.Khan)
REGISTRAR

PTO..

AC 14-07-2016
Item No. 4.58

University of Mumbai

Syllabus (Proposed)
for Ist Semester Courses in
M.Sc. Geology
(June 2016 onwards)

Courses:
PSGE101 – Stratigraphy and Geology of India
PSGE102 - Geochemistry
PSGE103 – Structural Geology
PSGE104 – Mineralogy : Descriptive and Optical
Practical Course:
PSGEP101, PSGEP102, PSGEP103 and PSGEP104

M.Sc-I Geology Course: PSGE101
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 Course: PSGEP101

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: PSGE102
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, $^{40}Ar/^{39}Ar$.
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: PSGEP101
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, Prenctice 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: PSGE103
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: PSGEP103

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: PSGE104
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: PSGEP104

Practicals in : determination of magnification of petrological microscope, calibration of eyepiece, calculating Birefringence, thickness of mineral grain, optical orientation, optic sign, 2V, R.I measuremant, 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" (27^{TH} 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.

University of Mumbai

Syllabus
for IInd Semester Courses in
M.Sc. Geology
(November 2016 onwards)

Courses:

PSGE201 – Remote Sensing and Image Interpretation

PSGE202 - Igneous Petrology

PSGE203 – Metamorphic Petrology

PSGE204 – Sedimentary Petrology

Practical Course:

PSGEP201, PSGEP202, PSGEP203, PSGEP204

M.Sc-I Geology Course: PSGE201
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.

Practical Course: PSGEP201

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

M.Sc-I Geology Course: PSGE202
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 Earths 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: PSGEP202

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: PSGE203
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: PSGEP203
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 terraines; 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: PSGEP204
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: PSGEP204
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.

University of Mumbai

Syllabus
for IInd Semester Courses in
M.Sc. Geology
(November 2016 onwards)

Courses:

PSGE201 – Remote Sensing and Image Interpretation

PSGE202 - Igneous Petrology

PSGE203 – Metamorphic Petrology

PSGE204 – Sedimentary Petrology

Practical Course:

PSGEP201, PSGEP202, PSGEP203, PSGEP204

M.Sc-I Geology Course: PSGE201
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

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

Practical Course: PSGEP201

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

M.Sc-I Geology Course: PSGE202
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 Earths 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: PSGEP202

4. Megascopic and Microscopic identification of igneous rocks.
5. CIPW normative calculation of igneous rocks.
6. Application of trace elements in igneous petrology.

List of Recommended Reference Books :

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

M.Sc-I Geology Course: PSGE203
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: PSGEP203
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 terraines; 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: PSGEP204
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: PSGEP204
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.