UNIVERSITY OF PUNE

SYLLABUS OF M.Sc. GEOLOGY

(w.e.f. 2008 - 09)

There will be four theory and one practical course in Sem. I, II and III. There will be 3 theory, 1 practical and 1 field work component course in Sem. IV. All the courses of Semester I & II are compulsory and University. Each course will carry 100 marks. Each theory course will be of 48 hrs. duration and practical course will be of 96 hrs. duration. Candidates are required to pass in the theory and the practical examination separately.

COURSE STRUCTURE

Semester- I (All courses are compulsory)

GL 101: Mineralogy

GL 102: Principles of Stratigraphy and Palaeontology

GL 103: Physics and Chemistry of the Earth

GL 104: Sedimentology

GL 105 Practicals related to the above courses.

Semester- II (All courses are compulsory)

GL 201: Igneous Petrology

GL 202: Metamorphic Petrology

GL 203: Structural Geology and Tectonics .

GL 204: Geomorphology and Remote Sensing in Geology

GL 205: Practicals related to above Courses

Semester: III

GL-301: Indian Stratigraphy - Compulsory (Departmental)

GL-302: Exploration methods

GL-303: Petroleum Geology

GL-304: Engineering Geology and Geotechniques

GL-305: Computer Applications in Geology and GIS

GL-306: Practicals related to above courses –Compulsory (Departmental)

Student shall choose any three courses out of course No. GL302, GL-303, GL 304 and GL 305

Semester IV

GL-401: Economic Geology - Compulsory

GL-402: Mining Geology, Gemmology and Industrial Mineralogy

GL-403: Environmental Geology

GL-404: Hydrogeology, Water shed Development and Management

GL-405: Practicals related to above courses - Compulsory (Departmental)

GL-406: Field Work Component - Compulsory (Departmental)

Student shall choose any two courses out of Course No. GL-402, GL- 403 & GL-404.

EVALUATION OF THE STUDENTS:

There will be an external examination of 80 marks and an internal examination of 20 marks per course except Departmental courses. The Internal examination marks will be given on the basis of continuous assessment of the student, which will be in the form of tutorials, tests, seminars, viva-voce etc. For the departmental theory/practical course the department, at the end of the respective semester will conduct 80 marks examination and 20 marks will be given on the basis of the continuous assessment of the student.

FIELD WORK COMPONENT:

Semester I and II:

Students shall carry out 2 weeks field work in a selected area to learn the geological mapping techniques during first year of M.Sc. degree course. Student should submit report based on the mapping and laboratory work related to the data and samples collected during the field work.

Semester III and IV:

Students should attend a geological excursion of about two weeks duration organized by the department. This will include visits to geologically important areas in India and geological organizations/institutes etc. related to respective theory courses of Sem. III and IV. Students should submit a tour report along with the specimens.

The field work should be treated as a part of course No. GL 406 and will be assessed at the end of the Semester IV.

SEMESTER –I

GL 101: MINERALOGY

UNITS	TOPICS	NO. OF LECTURES
UNIT- 1	**Crystallography** ➢ Definition of Crystal – Classification of crystal into Crystal Systems ➢ Concept of unit cell – Proper and improper symmetry operations ➢ Concept of Point Group – Classification of crystals into 32 Point Groups ➢ Concept of Space lattice – Derivation of 14 Bravais lattices – HCP ➢ Concept of Space Group – Symmorphic and Asymmorphic Space Groups ➢ X- ray diffraction methods in mineralogical investigations ➢ Mineral Chemistry – Concepts and examples of Isomorphism, solid solutions	**12**
UNIT- 2	**Mineral Optics** ➢ Plane polarized and cross polarized light – Isotropic and Anisotropic minerals, Behaviour of minerals in cross polarized light ➢ Birefringence – Uniaxial minerals – Uniaxial and Biaxial Indicatrices – Orientation of indicatrices as per the section ➢ Interference of light waves – Passage of light through doubly refracting minerals, Generation of interference colours ➢ Conoscopic or convergent polarized light – Generation of Uniaxial and Biaxial interference figures – Forms of interference figures related to sections – Optical accessories like mica, gypsum and quartz plates – determination of Optic sign of uniaxial and biaxial minerals. ➢ Absorption of light by minerals – Scheme of pleochroism	**12**
UNIT- 3	**Descriptive Mineralogy -1** ➢ Structure, relation of Chemical composition with optical, physical properties, alteration products and paragenesis of following group of minerals. ➢ Olivine, Pyroxenes, Amphiboles, Gartnet, Mica, Alumino silicate, Epidote	**12**
UNIT- 4	**Descriptive Mineralogy –II** ➢ Structure, relation of Chemical composition with optical, physical properties, alteration products and paragenesis of following group of minerals. ➢ Feldspar, Feldspathoid, Zeolite and Clays	**12**
	Total number of Lectures	**48**

GL 102: PRINCIPLES OF STRATIGRAPHY AND PALAEONTOLOGY

UNIT-1 **Principles of Statigraphy** **24**

- History and Development of Statigraphy
- Stratigraphic procedures (Surface and Subsurface)
- Concept of Lithofacies and Biofacies
- Stratigraphic Correlation (Litho, Bio- and Chronostrarigraphic Correlation)
- Study of standard stratigraphic code (Lithostratigraphic, Biostratigraphic and Chronostratigraphic)
- Concepts of Magnetostratigraphy, Chemostratigraphy, Event stratigraphy, and Sequence stratigraphy

UNIT-2 **Palaeontology** **24**

- Scope of Palaeontology and Organic evolution
- Techniques in Palaeontology mega fossils- microfossils – nannofossils ichnofossils – collection, identification and illustration – binomial nomenclature
- Invertebrate Palaeontology – A brief study of morphology, classification, evolutionary trends and distribution of Bivalves, cephalopoda.and Gastropods, Echinoids, Corals and Brachiopods.
- Vertebrate Palaeontology – Brief study of vertebrate life through ages. Evolution of reptiles and mammals.
- Palaeontological perspective : Use of palaeontological data in a) Stratigraphy b) Palaeoecology and evolution
- Introduction to Micropalaeontology
- Types of Microfossils
- Palaeopalynology
- Foraminifera and Ostracods

Total number of Lectures **48**

GL 103 : PHYSICS AND CHEMISTRY OF THE EARTH

UNIT-1 **Universe, Solar System and Comparative Planetary Geology** **12**

- Origin and components of solar system
- Galaxies their classification, Stars and star formation processes
- Meteorites and their classification
- Theories of origin of solar system
- Abundance of elements
- Nucleosynthesis and stellar evolution
- Orbital dynamics of earth-moon system

UNIT-2 **Seismology and Interior of the Earth** **12**

- Seismic waves and their velocities
- Internal structure of earth
- Structure composition and evolution of the crust, mantle and core
- Geochemical classification and distribution of elements in the earth
- Structure and atomic properties of elements
- The Periodic table

- Laws of Thermodynamics and phase diagrams

UNIT-3 **Geochronology and age of the Earth** **12**

- Law of Radioactivity
- Principles of isotopic dating, Decay schemes and Derivation of equation of age.
- Rb/Sr, U- Th –Pb methods of dating the rocks.
- Age of the Earth

UNIT-4 **Gravity, Magnetism and Thermal History of the Earth** **12**

- Density distribution, shape and mass of the earth, density vs depth profile**.**
- Gravity and gravitational mechanics, gravity anomalies and their interpretation
- The earth as Magnet, Earth's magnetic field, changes in magnetic field, origin of geomagnetic field, palaeomagnetism

Total number of Lectures **48**

GL – 104 : SEDIMENTOLOGY

UNIT-1 **Procedures** **12**

- Field procedures in Sedimentary Petrology
- Geologic cycle
- Sedimentary textures (Granulometric analysis, shape and roundness studies, surface textures)
- Heavy mineral and Insoluble residue analysis

UNIT-2 **Petrography** **12**

- Petrography of rocks of clastic, chemical and biochemical origin (Conglomerates, Sandstone, Mudstone, Limestone and Dolomite)
- Evaporite, Phosphorite, Chert, Iron and Manganese rich sediments
- Volcanogenic sedimentary rocks

UNIT-3 **Hydraulic and Structure** **12**

- Classic transport and fluid flow (fluid flow in theory and in nature, Reynold's Numbers, Froude Number, Sediment lift, transport, deposition, Sedimentary gravity flow)
- Sedimentary structures (Physical structures, Biogenic sedimentary Structures, Diagenetic structures)

UNIT-4 **Environment and Facies** **12**

- Concept of Sedimentary facies association models (Marine, Nonmarine and Mixed Depositional Environment)
- Sedimentation and Tectonics
- Paleocurrents and Basin Analysis

Total number of Lectures **48**

Text books for Semester –I

- Dana: Elements of Mineralogy
- Winchell: Elements of Optical Mineralogy
- Kerr: Optical Mineralogy
- Whalstrom: Optical Crystallography
- Deer, Howie Zussman: Rock forming minerals, Vol. I – IV
- Cracknell: Crystals and their structure
- Frye Keith: Modern Mineralogy
- Read: Beginners Guide to Gemmology
- Webster Anderson: Gems
- Anderson B.W. Gem Testing
- Webster R. : Practical Gemmology
- Bates : Geology of Industrial Rocks and Minerals
- Roy: Indian Mineral Resources
- Baungart, Dunham and Amstutz : Process Mineralogy of Ceramic Materials
- Krumbein and Sloss: Stratigraphy and Sedimentation
- Dunbar and Rogers: Principles of stratigraphy
- Hedberg: International Stratigraphy guide
- Harland et., al.: A geological time scale
- Lemon Roy R.: Principles of Stratigraphy
- Weller: Stratigraphic principles and practice
- Brenner and Mc Hargue: Integrative Stratigraphy
- Boardman R.S., Cheetham A.H., Rowell A.J.: Fossil invertebrates
- Clarkston E.N.K.: Invertebrate Palaeontology and Evolution
- John R. Haynes, Hohn Wiley and Sons : Foraminifera
- M.D. Brasier: Microfossils
- Swinnerton; Outline of Palaeontology
- Moore Lalicker and Figher: Invertebrate Palaeontology
- Remer: Vertebrate Palaeontology
- Shrock and Twenhofel : Principles of invertebrate Palaeontology
- Arnold : Introduction to Palaeobotany

- Bignot G: Elements of Micropalaeontology. The microfossils, their Geological and Palaeobiological applications
- Clobert E.H.: Evolution of the Vertebrates
- Brown and Mussett: The inaccessible Earth
- Jackson (ed.): The Earths Mantle
- Stacy: Physics of the Earth
- Melchior: The physics of the Earths Core: An Introduction
- Jacobs, Russels and Wilson: Physics and Geology
- Sheidegger: Principles of Geodynamics
- Van Bemmelen: Developments in Geotectonics No.2 (Geodynamics Model: An evaluation and synthesis)
- Jeffreys: The Earth: Its origin, History and Physical constitution
- Kauls: An Introduction to Planetary Physics
- Paragon Press: Physics and Chemistry of the Earth
- Takanaki and Kanamori: Debate about the Earth
- Pettijohn: Sedimentary Rocks
- Blatt, Middleton and Murry: Origin of Sedimentary Rocks
- Reineck and Singh: Sedimentary Depositional Environments
- Carozzi: Patrography of Sedimentary Rocks
- Carver: Procedures in Sedimentary petrology
- Potter and Pettijohn: Palaeocurrents and Basin analysis

SEMESTER- I

GL105: PRACTICALS RELATED TO GL 101 to GL 104

Unit 1: <u>Practicals for GL 101</u>:

1. Study of interference figures – determination of optical sign of minerals, determination of composition of plagioclase feldspars by Michel Levy method – determination of birefringence of minerals with the help of Berek Compensators – Scheme of Pleochroism
2. Construction of Stereograms and Gnomonograms
3. Study of rock forming minerals in thin sections
4. Study of rock forming minerals in hand specimens

Unit 2: <u>Practicals for GL 102</u>:

1. Construction of rank charts for lithostratigraphy, biostratigraphy & chronostratigraphy.
2. Construction of graphical logs for text descriptions.
3. Exercises in correlation from given data or logs.
4. Study of morphology of Bivalves, Gastropods, Cephalopods, Echinoids, Brachiopods.
5. Separation, processing, wet sieve analyses, preparation of slides of microfossils. (Demonstration only)
6. Morphology and morphological descriptions of planktonic & benthonic foraminifera, Ostracodes.
7. Morphology of Radiolaria , Diatoms, pollen and spores
8. Construction of range charts,

Unit 3: <u>Practicals for GL 103</u>:

1. Rapid analyses of rocks for determination of major oxides by volumetric /gravimetric/colorimetric methods.
2. Introduction to the use of instrumental technique of analyses of rocks, soil & water.
    a. Spectrophotometry
    b. Flame photometry
    c. Atomic Absorption Spectrophotometry (Demonstration only)
    d. High Performance Ion Chromatography (Demonstration only)
3. Plotting of chemical data on variation diagrams.
4. Problems related to seismic, geomagnetic, gravity data & its interpretation.
5. Problems related to use of isotopic methods & determinations of age of the rocks.

Unit 4: <u>Practicals for GL- 104</u>:

1. Size Analysis (Procedures, Cumulative carve, Histogram, Visher's curve and Statistical calculation)
2. Shape analysis (Calculation and Classification)
3. Heavy mineral analysis (Procedure and identification)
4. Megascopic studies of conglomerate and breccia
5. Megascopic and microscopic study of sandstone.
6. Megascopic and microscopic study of limestone
7. Sedimentary structure (Identification and classification)
8. Paleocurrent and basin analysis calculation

SEMESTER- II

GL-201: IGNEOUS PETROLOGY

UNITS:	*TOPICS*	*No. of Lectures*

Unit 1: <u>Role of magma in Geological processes</u> 12

- Magma definition and source of magma
- Anatomy of the earth
- Geochemical and Geophysical jargon
- Magmatism and plate tectonics
- Physical properties of magma-Geochemical gradient,
- Heat source
- Igneous activity of the present day
- Textures and structures of Igneous rocks
- Classification of Igneous rocks-historic perspective and the IUGS system.

Unit 2: <u>Geochemical tracers of mantle processes</u> 12

- Introduction
- Continental & oceanic mantle lithosphere
- MORB and depleted mantle
- Evolution of depleted mantle
- OIB and Enriched mantle
- Evolution of Enriched mantle – metasomatic processes
- Island arc basalts
- Concept of hot spots
- Mantle Plumes-Theory and structure
- Re-Os Isotope systematics
- Trace element characterizations of mantle domains

Unit 3: <u>Magma Crystallization and Evolution</u> 12

- Phase relations of the silicates and silicate melts
- Binary and Ternary systems
- Partial melting
- Magmatic differentiation – Crystal fractionation, gravitational
- Settling, flow differentiation, flow crystallisation, filter pressing, liquid immiscibility.
- Zone melting
- Contamination
- Mixing of magmas
- Role of volatile components

Unit 4: Petrogenetic provinces 12

- Continental areas: Volcanic- Flood basalts- Tholeiites(Deccan Trap, Columbia River basalts, Parna basalts)
- Layered gabbroic intrusions: The Bushveld complex,skaergaard intrusion, Still water complex.
- Plutonic: Carbonatites and alkaline rock complexes of India
- Oceanic Rift valleys: MORB- Tholeiites-Ophiolites
- Granites, andesites, kimberlites, anorthosites.

Total No. of Lectures 48

GL-202: METAMORPHIC PETROLOGY

Unit 1: Concepts and Theory 12

- Historical background
- Types of Metamorphism and their controlling factors
- Common minerals of metamorphic rocks
- Field observations, petrographic classification of common metamorphic rocks
- Metamorphic facies and facies series

Unit 2: Effects of Metamorphism 12

- Phase diagrams and graphic representation of mineral assemblages
- Prograde and retrograde metamorphism, Matasomatism
- Deformation textures and textures related to recrystallisation
- Metamorphic reactions, elemental exchange and Pressure – Temperature conditions of Isograds

Unit 3: Metamorphism types and products 12

- Regional and thermal metamorphism of pelitic rocks.
- Regional and thermal metamorphism of basic and ultrabasic rocks
- Regional and thermal metamorphism of impure,silicious carbonate rocks
- Metamorphism of Granitoides, Charnockites and Migmatites

Unit 4: Metamorphism in space and time 12

- Plate tectonics and metamorphic processes
- Paired metamorphic belts, Archaean and Proterozoic terrains
- Extraterrestrial Metamorphism (Impact and Shock Metamorphism) polymetamorphism

Total No. of Lectures 48

GL-203: STRUCTURAL GEOLOGY AND TECTONICS

Unit 1: Structural Geology 24

- Behaviour of rock material under stress, strain analysis
- Classification and genesis of folds, faults, lineations, foliations, joints and fractures
- Scope of structural analysis, concept of Tectonite fabric and Tectonite symmetry
- Structural analysis on microscopic , mesoscopic and macroscopic scales

Unit 2: Tectonics 24

- Structure and physical characters of continental and oceanic crust
- Continental drift, seafloor spreading and Plate Tectonics, Structure and Tectonics of divergent margins, transform faults, convergent margins
- Tectonic framework of India
- Neotectonics – Features and evidences – Characteristic landforms, methods of analysis
- Case studies of Orogenic belts

Total No. of Lectures 48

GL204: GEOMORPHOLOGY AND REMOTE SENSING IN GEOLOGY

Unit 1: Geomorphology 24

- Introduction : Development, Scope, Geomorphic concepts, Types and Tools
- Landforms: Role of Lithology, peneplaination, endogenous and exogenous forces responsible, climatic and Tectonic factors and rejuvenation of landforms
- Denudational processes : Weathering , erosion, transportation, weathering products and soils – profiles, types, duricrusts
- Hillslopes : Their characteristics and development, fluvial processes on hillslopes
- River and drainage basin: Drainage pattern, network characteristics, Valleys and their development, processes of river erosion, transportation and deposition
- Landforms produced by geomorphic agents: Fluvial, Coastal , Glacial and Aeolian landforms
- Geomorphic indicators of neotectonic movements : Stream channel morphology changes , drainage modifications, fault reactivation, Uplift – subsidence pattern in coastal areas
- Applied Geomorphology : Application in Geohydrology, Engineering Geology and Environmental studies
- Geomorphology of India: Geomorphical features and zones

Unit 2: Remote Sensing 24

- Electromagnetic radiation – types and sources
- Interaction of EMR with earth, reflectance – absorption – emittance and transmittance
- Black, white and grey bodies
- Different methods of Remote Sensing based on atmospheric windows
- Aerial photographs – classification, types
- Principles of photogrammetry
- Calculations of heights and slopes from aerial photographs
- Aerial photointerpretation – photo recognition elements of black and white aerial photographs
- Interpretation of different geological features on B/W aerial photographs
- Remote sensing from space – space crafts and sensors
- Landsat, Skylab, Seasat and other foreign systems of satellites and their interpretation for geological and other studies
- Space research in India – Bhaskara and IRS systems and their applications,Thermal IR remote sensing and its applications, Microwave remote sensing and its applications

Total No. of Lectures 48

Text Books for Semester – II

- Barker – Igneous rock
- Magmatic rocks – Middle most
- Igneous rocks – Rock
- Philpot – Igneous and Metamorphic Petrology
- Jackson (ed) –Earths Mantle
- Davis – Earth Dynamics
- Yoder - Basalt
- Yoder& Tilly – Basaltic Magnetism
- Jackson Lan (ed) –The Earths Mantle : Composition , Structure and Evolution
- Davis G.F. – Dynamic Earth : Plates , Plumes and Mantle Conviction
- Turner & Varhoogen : Igneous and Metamorphic Petrology
- Philpotts : Principles of Igneous and Metamorphic Petrology
- Harker : Metamorphism
- Turner : Metamorphic Petrology
- Wrinkler : Petrogeneous of Metamorphic Rock
- Miyashiro : Metamorphism and Metomorphic Belts
- Yardly : An Introduction to Metamorphic Petrology
- Spry: Metamorphic Structures
- Best: Igneous and Metamorphic Petrology
- Patwardhan : The Dynamic Earth System
- E.M.Moores & R.J. Twiss : Tectonics
- Valdiya : Aspects of Tectonics – Focus on South Central Asia
- V.V. Beloussov: Geotectonics
- Condie : Plate Tectonics and Crystal Evolution
- Billings : Structural Geology
- Badgley : Structural and Tectonics Principles
- Turner & Weiss: Analysis of Metamorphic Tectonic
- Ramsay : Folding and Fracturing of Rock
- Desittar : Structural Geology
- Sander: Introduction to Deformation of Geologic bodies
- Miller & Miller : Photogeology
- Ramsay : Trends in Geological Remote Sensing
- Lillysand & Kaifer : Remote Sensing and Image interpretation
- Pandey : Photogeology
- Thombury : Principles of Geomorphology
- Rice : Fundamentals of Geomorphology
- Kale & Gupta : Introduction to Geomorphology
- A.D. Howward and I Remson : Geology in Environmental Planning

SEMESTER- II

GL205: PRACTICALS RELATED TO GL 201 TO GL-204

Unit 1: Practicals for GL-201

1. Characterisation of Igneous rocks, textures and structures
2. Characterisation of following rock type under microscope
    a. Ultrabasic rocks
    b. Basic Igneous rocks
    c. Intermediate Igneous rocks
    d. Acid Igneous rocks
    e. Alkaline Igneous rocks
3. CIPW normative calculations for Igneous rocks
4. Use of trace elements in Igneous rock petrogenesis

Unit 2: Practicals for GL-202

1. Study of metamorphic rocks in hand specimens and thin sections : Metamorphic mineral assemblages with respect to metamorphic facies and grades
2 Use of ACF, AKF and AFM diagrams
3. Use of rock composition diagrams
4. Calculation of Pressure – Temperature conditions from the composition of co-existing minerals assemblages serving as geothermometers and geobarometers

Unit 3: Practicals for GL-203

1. Solution to structural geology problem by orthographic and stereographic methods
2. Completion of outcrops, construction of structural sections and interpretation of geological maps
3. Plotting and interpretation of mesoscopic structural data

Unit 4: Practicals for GL-204

1. Determination of photo scale
2. Determination of height of objects, dip of bed , slope and thickness of beds by parallax bar
3. Study of landforms and interpretation of lithology and structure from aerial photograph and satellite images
4. Tracing of lineament and rosettes and their interpretation
5. Drainage basin and network morphometry
6. Relief and slope analyses – profiles and maps
7. Identification of landform on toposheets, aerial photographs and satellite images