

**MAHARAJA GANGA SINGH UNIVERSITY, BIKANER**

**SCHEME OF EXAMINATION AND  
COURSES OF STUDY**

**SYLLABUS**

**FACULTY OF SCIENCE**

**M.SC.**

**GEOLOGY**



**M.Sc. Previous Examination - 2021**

**M.Sc. Final Examination – 2022**

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## Scheme of Teaching, Examination and Courses of Study (Syllabus) in Geology

### M.Sc. (P) – 2021 & M.Sc. (F)- 2022

There will be four theory Papers of three hours duration, carrying 75 marks each and practicals of 16 hours duration, distributed in 4 days in M.Sc. Previous and four theory Papers of three hours duration, carrying 75 marks each and practicals of 16 hours duration, distributed in 4 days in Final of M.Sc. (Final) in the annual examination of MGS University, Bikaner.

In accordance with the nature of the practicals in Geology and in conformity with other University Departments of Geology, a batch of practical in M.Sc. (Previous and Final) shall consist of not more than six students.

In each of M.Sc. Geology classes (i.e. Previous and Final), there will be two compulsory Geological Field-Training Programmes as prescribed in the syllabus for all students. Students, not attending the training programmes shall not be eligible to appear in the annual University examination.

### Teaching and Examination Scheme

Paper No.	Theory Paper (Nomenclature)	Theory Hours per week	Practical Hours per week	Theory Exam. Hours	Maximum Marks
I	Structural Geology ,Geotectonics & Geomorphometry	6	6	3	75
II	Geochemistry, Crystallography& Mineralogy	6	6	3	75
III	Stratigraphy & Palaeontology	6	6	3	75
IV	Economic Geology & Mineral Economics	6	6	3	75

**Minimum Passing Marks in theory: – 108 out of Total 300 Marks.**

### **DISTRIBUTION OF MARKS AND TIME DURATION FOR PRACTICAL EXAMINATION**

(Practicals: Exam Duration- 16 Hours, distributed in 2 Parts in 4 days.)

**Max Marks: 150**

**Min Pass Marks: 54**

**Part-I** - Geochemistry, Crystallography & Mineralogy and  
.Economic Geology

8 Hrs in 2 days 75Marks

- General Geological Tour and Submission of Report and Viva- voce

**Part-II** - Structural Geology, Geotectonics & Geomorphometry and

Stratigraphy &Palaeontology

8 Hrs in 2 days 75Marks

-Geological Mapping of a selected Area & Submission of report and Viva- voce

### **Paper I- Structural Geology, Geotectonics & Geomorphometry**

**Note:** – Each Theory paper is divided into 5 units. The question paper is divided into three parts,Part A,Part B and Part C. Part A (20 Marks) is compulsory and contain one question containing 10 parts ,two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice,one from each unit.Candidate is required to attempt all five questions, each question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from

each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

#### **Unit - I**

Mechanical Principles- Analysis of stress, component of stress, stress ellipsoid. Types and Analysis of deformation, strain ellipsoid. Homogeneous and inhomogeneous deformation, progressive strain, strain paths. Factors controlling behaviour of rock materials. Determination of Strain in deformed rocks. Ductile behaviour of rocks.

#### **Unit - II**

Morphology of folds. Geometric and genetic classification of folds. Mechanism of folding. Superimposed folding and interference patterns. Structural analysis in terrains with multiple deformations. Types of Linear structures and their tectonic significance. Deformation of linear structures.

#### **Unit - III**

Types and origin of Cleavages; cleavage fans and axial plane cleavage; refraction of cleavage; relation of cleavage to major structures. Fractures and Joints- their nomenclature, age relationship, origin and significance.

Nomenclature of faults; minor structures associated with faults; effects of faulting on outcrop pattern; classification of faults; mechanics of faulting; recognition of faults.

Geometry & mechanics of shear zones; shear zone structures; shear zone indicators; folding in shear zones. Mylonites and pseudotachylite.

#### **Unit - IV**

Crust: composition, seismic, gravity and magnetic characters. Crustal types: shields, platforms, mountain chains, rift valleys, mid oceanic ridges, trenches, island arcs and ocean basin.

Heat flow; Gravity & Magnetic Anomalies. Crustal Provinces. Mantle: different zones; seismic characters; gravity anomalies; Core.

Orogeny and epeirogeny. Tectonic theories: Isostasy, Geosynclines; Sea-floor spreading, Palaeomagnetism.

Continental drift. Plate Tectonics. Structure and evolution of the Himalaya and Indogangetic alluvial plains.

#### **Unit - V**

Fundamental concepts of Geomorphology. Analysis of geomorphic process: Exogenic, Endogenic and Extra-terrestrial Processes. Concept of morphogenetic regions. Fluvial geomorphic Cycle: Streams and valleys, Classification of valleys; Stages in drainage system evolution, their pattern, textural implications; rejuvenation.

Peniplaination concept. Erosional and depositional features associated with fluvial cycles.

Landforms, their types and nature of development. Landforms in relation to structure and tectonics.

Karst topography.

Glaciers: types & characteristics. Erosional and depositional features associated with glacial cycles.

Arid cycles: origin and types of desert, eolian landforms; expansion and control of desertification in India.

Geomorphology of coasts. Geomorphology of shorelines and ocean floors, geomorphometric analysis and modeling. Major geomorphological sub division of India, their characteristics and evolution.

**Suggested Books:**

1. Ragan, D.M. – Structural Geology (J. Wiley & Sons)
2. Badgley, P.C. – Structural Geology for Exploration Geologists (Oxford Univ. Press)
3. Spencer, E.W. – Introduction to the Earth's Crust (McGraw Hill)
4. Wylie, P.J. – Dynamic Earth (J. Wiley & Sons)
5. Billings, M.P. – Structural Geology
6. Hobbs, B.E. Means, W.D. & Williams P.F. – An outline of Structural Geology (J.Wiley & Sons)
7. Ramsay, J.G. – Folding & Fracturing of Rocks (McGraw Hill)
8. Holmes A.– Physical Geology (Nelson)
9. Strahler – Physical Geology.
10. Summerfield, M.A. – Geomorphology and Global Tectonics. Springer Verlag.
11. Moores, P. and Twiss, R.J., - Tectonics. Freeman.
12. Davis, G.R.,- Structural Geology of Rocks and Region. John Willey.
13. Ramsay, J.G. and Huber, M.I. – Modern Structural Geology. Vol I &II. Academic Press.
14. Price, N.J.and Cosgrove, J.W.- Analysis of Geological Structure. Cambridge University Press.
15. Ghosh, S.K. - Structural Geology Fundamentals of Modern Developments. Pergamon Press.
16. Bloom, A. – Geomorphology (Prentice Hall)
17. Thornbury, W.D. – Principles of Geomorphology (J. Wiley & Sons)
18. Lobeck, A.K. – Geomorphology (Mc-Graw Hill)

**Paper II– Geochemistry, Crystallography & Mineralogy**

**Note:** – Each Theory paper is divided into 5 units. The question paper is divided into three parts, Part A, Part B and Part C. Part A (20 Marks) is compulsory and contain one question containing 10 parts ,two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice,one from each unit.Candidate is required to attempt all five questions, each question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

**Unit -I**

Elements of Geochemistry. Geochemical classification of elements. geochemical cycle, geochemical anomaly, geochemical tracers and indicators. Isotope Geochemistry: stable isotopes, oxygen isotopes, sulphur isotopes, carbon isotopes, hydrogen isotopes.

**Unit -II**

Crystallography: crystal growth, symmetry operations.Laws of crystallography. Goniometry. Thirty two crystal classes. Crystal projections: spherical, stereographic and gnomonic.Twinning. Space lattices. Elements of symmetry in internal structure. X– Ray crystallography: Bragg's equation; powder and single crystal methods, Laue method.

### Unit -III

Mineralogy; classification of mineral kingdom. Physical & Optical properties of minerals; determination of refringence, birefringence; vibration direction, interference figures, optic sign, optic axial angle; indicatrix; dispersion; universal stage and Berek compensator.

Systematic Mineralogy of native elements, sulphides, sulfosalts, oxides, hydroxides and carbonates.

### Unit -IV

Silicate structures. Detailed study of the following rock forming mineral groups with respect to their chemical constitution, crystal structure & forms, physical and optical properties, mode of origin, association, occurrence and alteration:

Neso silicates– Olivine group, Garnet group, Kyanite, Andalusite, Sillimanite.

Soro silicates– Epidote group. Cyclo Silicate- Beryl, Tourmaline, Axinite, Cordierite

Ino- silicates– Pyroxene group, Pyroxinoid group and Amphibole group.

### Unit -V

Detailed study of the following rock forming mineral groups with respect to their chemical constitution, crystal forms, physical and optical properties, mode of origin, association, occurrence and alteration:

Phyllo silicates– Mica group, Chlorite, Talc.

Tecto silicates– Feldspar group, Feldspathoid group, Zeolite group, Quartz, and other forms of Silica.

Gem minerals: gem properties and varieties.

### **Suggested Readings:**

1. Phillips, F.C. – An Introduction to Crystallography (ELBS)
2. Burger, M.J. – Elementry Crystallography (J. Wiley & Sons)
3. Evans, R.C. – Crystal Chemistry (Cambridge University Press)
4. Dana, E. Ford W.E. – A Text book of Mineralogy (Asia Public House)
5. Deer, Howie & Zussman – Introduction to Rock Forming Minerals (ELBS)
6. Winchel & Winchel – Elements of Optical Mineralogy (ELBS)
7. Mason, B. – Principles of Geochemistry (McGraw Hill)
8. Kraushopf – Introduction to Geochemistry (McGraw Hill)
9. Fyfe – Geochemistry (Clereton Press Oxford)
10. Read, H.H. – Rutley's Elements of Mineralogy (Thomas Murby & Co.)
11. Mason, Berry – Minerology. (Asian Pub.)
12. Sharma, N.L. – Determinative Tables (ISM, Dhanbad).
13. Klein, C.and Hurlbut, Jr., C.S.,- Manual of Mineralogy. (J. Wiley & Sons)
14. Mason, Brian - Principles of Geochemistry.
15. Mason, B. and Moore, C.B. - Introduction to Geochemistry. Wiley Eastern.
16. Krauskopf, K.B. - Introduction to Geochemistry. McGrew Hill.
17. Faure, G. - Principles of Isotope Geology. John Wiley.
18. Govett, G.J.S. - Hand Book of Exploration Geochemistry. Elsevier.

### **Paper III – Stratigraphy & Palaeontology**

**Note:** – Each Theory paper is divided into 5 units. The question paper is divided into three parts, Part A, Part B and Part C. Part A (20 Marks) is compulsory and contains one question containing 10 parts, two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice, one from each unit. Candidate is required to attempt all five questions, each question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

#### **Unit - I**

Development of stratigraphy and founding of geologic systems, Stratigraphic relationships- lithosome, shape, vertical and lateral relationship. Principles of stratigraphic classification. Principles of correlation. Time stratigraphic units. Standard stratigraphic scale and its equivalents in Indian sub- continent.

Code of stratigraphic nomenclature. Geochronology: Radio isotopes and measuring geological time.

Early history of the Earth. Nature of early crust; Formation and Evolution of greenstone, granite and granulite terrains.

Origin of life. Evolution of life. Evidences of Evolution of life. Nomenclature of organisms. Classification of organisms. Distribution, migration, dispersal and extinction of animals and plants. Palaeozoogeographic provinces. Major events in Precambrian and Phanerozoic life.

Fossil: Techniques of collection, preparation, preservation & nomenclature of fossils.

Elements of palaeoecology. Dating of rocks and fossils. Imperfection of geological records.

#### **Unit - II**

Precambrian geochronology and early crustal evolution. Archaean and Proterozoic tectonic patterns.

Precambrian provinces of India – their stratigraphy and correlation. Precambrian- Cambrian boundary problem. Succession, fauna, flora, sedimentation, palaeogeography, age problems and regional correlation of the Palaeozoics of Indian sub- continent. Nomenclature, extent, division, succession, sedimentation, structures, palaeogeography; flora, fauna and regional correlation of the following: Triassics, Jurassics, Cretaceous of India. Cretaceous –Tertiary (K-T) boundary problem.

#### **Unit – III**

Detailed study of Gondwana Supergroup: Succession, fauna, flora, sedimentation, palaeogeography, age problems and regional correlation of the Gondwana Group of rocks, Deccan Traps: Succession, fauna, flora, age problems and regional correlation, Intertrappean and Infratrappean beds.

Tertiary of Extra Peninsular India with special reference to Assam Lesser Himalayas. Tertiary of coastal region -Tertiaries of Rajasthan. Neogene- Quarternary boundary Problem. Quarternary Geology of Rajasthan.

#### **Unit – IV**

Palaeobotany –Study of Indian flora of the past with special reference to the Gondwana plant life.

Micropalaeontology, micro fossils–their classification, techniques of collection, separation, preparation and preservation. Environmental & geological significance of micro– fossils.

Foraminifera: Morphology, classification and geological history. significance of foraminifera in palaeo-ecological studies & oil exploration. Ostracoda : Morphology, classification, ecology and geological history.

Conodonts: Morphology, classification, ecology and geological history. Nannofossils: morphology and geological distribution. Elementary ideas about Pollens and Spores.

Invertebrate Palaeontology-Graptolites: their systematic position, evolution and geological history.

Anthozoa: Morphology and geological history of Tetracoralla, Hexacoralla and Tabulata; appearance of septa in Tetracoralla.

Echinoidea: Change in symmetry, variation in oculogenital system; ambulacral areas and compound plates, classification and geological history. Trilobita: Growth stages, evolutionary trends and geological history.

### **Unit -V**

Brachiopoda: Variation in Brachial skeleton, pedicle opening and commissure, classification and geological history. Bivalvia: Evolution of hinge and dentition, adaptive modification, classification and geological history. Gastropoda: Forms, twisting of nervous system, aperture, classification and geological history. Cephalopoda: variation in shape of Conch of nautiloidea, ornamentation and siphuncle of ammonoidea and geological history.

Vertebrate Palaeontology– classification of vertebrates and their sequence through geological time.

Introductory knowledge of Pisces, Amphibia, Reptilia, Aves and Mammalia. Study of Indian vertebrate fauna with special reference to Siwaliks. Evolutionary trends of Horse, Elephant, Man and Giraffe

### **Suggested Readings:**

1. Krumbein and Sloss – Stratigraphy and Sedimentation (WH Freeman & Co.)
2. Dunbar, C.O. & Rodgers, J. – Principles of Stratigraphy ( J.Wiley & Sons)
3. Krishnan, M.S. – Geology of India & Burma (CBS)
4. Pascoe, E.H. – A Manual of Geology of India & Burma (GSI)
5. Ravindra Kumar – Introduction of Historical Geology and Principles of Stratigraphy (CBS)
6. Rankama, K. – The Geologic Systems-The Pre cambrian Vol.-III Ed.(J. Wiley & Sons)
7. Eicher, Don, L. – Geologic Time (Prentice Hall)
8. Sinha Roy, S. Malhotra, G & Mohanty, M. – Geology of Rajasthan (Geol. Soc. Ind.)
9. Naqvi, S.M. and Rogers, J.J. – Precambrian Geology of India Shrock & Twenhofel – Principles of Invertebrate Palaeontology (McGraw Hill)
10. Moore, Laliker & Fisher – Invertebrate fossils (McGraw Hill)
11. Colbert, E.H. – Evolution of the Vertebrates (J.Wiley & Sons)
12. Woods, H. – Invertebrate Palaeontology (CBS)
13. Glaessener, M.F. – Principles of Micropalaeontology( Hafner Press)
14. Cushman, J.A. – Foraminifera (Cambridge University Press)
15. Pockorny – Principles of Zoological Micropalaeontology Vol. I & II
16. Kathal, P.K. – Microfossils & their applications (CBS).
17. Jain and Anantharaman – Introduction to Palaeontology Vishal Publications. Jalandhar.
18. Black, R.M. - The Elements of Palaeontology. Cambridge University Press.

## **Paper IV – Economic Geology & Mineral Economics**

**Note:** – Each Theory paper is divided into 5 units. The question paper is divided into three parts, Part A, Part B and Part C. Part A (20 Marks) is compulsory and contains one question containing 10 parts, two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice, one from each unit. Candidate is required to attempt all five questions, each question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

### **Unit I**

Magma and its relation with the mineral deposits. The development of the modern theories of ore deposition. Physical and chemical characteristics of ore bearing fluids and their genesis. Migration of ore bearing fluids and deposition of ores. Fluid inclusion. Geothermometry and isotope studies in relation to ore deposits. Concept of ore microscopy. Classification of ore deposits, stratiform and stratabound ore deposits. Structural controls of mineralisation. Metallogenic epoch and provinces; Global metallogeny related to crustal evolution.

### **Unit- II**

Study of the processes of formation of mineral deposits:

Magmatic concentration, Sublimation, Contact metasomatism, Metamorphism, Hydrothermal, Sedimentation, Bacteriogenic, Submarine exhalative & Volcanogenic, Evaporation, Residual and Mechanical concentration, Oxidation and supergene sulphide enrichment.

### **Unit- III**

The study of metallic mineral deposits with reference to geology, mode of occurrence, origin, uses and distribution in India of Gold, Copper, Lead-Zinc, Iron, Manganese, Aluminium, Magnesium, Chromium and strategic minerals of India.

### **Unit- IV**

The study of non-metallic mineral deposits with reference to geology, mode of occurrence, origin, uses and distribution in India of Mica, Asbestos, Barytes, Gypsum, Limestone Garnet, Corundum, wollastonite, calcite, quartz, feldspar, clays, Kyanite, Sillimanite, Graphite, Talc, Fluorite, Beryl and Rock phosphate, Gem minerals and radio-active minerals. Non-metallic minerals used in refractories, abrasives, ceramics, glass making materials, fertilizers, natural paints & pigments and cement

Classification of Energy Resources and Geoenergy Resources.

Mineral fuels: Coal- nature, characteristics, Rank, grade and type of coal. Classification of coal.

origin, distribution, classification and commercial uses of coal. Coal fields of India, conservation and utilisation of coal. Coal based industries in India. Coal bed methane.

Geothermal resources: classification of geothermal waters, geothermal system, geothermal regions of India and world, geothermal water deposits associated with thermal springs, industrial uses of Geothermal Energy.

### **Unit- V**

Mineral Economics: Concept and scope of mineral economics. Global status of Indian Mineral Resources.



Peculiarities inherent in mineral industry

Mining & Mineral Legislation of India: Categories of minerals for grant of concessions; Minor & Major Minerals; Procedure for obtaining Mineral concessions. Claim system. Restrictions. Termination, surrender & Determination of Mining Lease. Royalty & Dead Rent. Various Laws & Acts related to Mines & Minerals. Mineral taxation & Incentive Measures. Marketing.

**Suggested Readings:**

1. Bateman, A.M. – Economic Mineral Deposits (J. Wiley & Sons)
2. Smirov, V.I. – Geology of Mineral Deposits (M.R. Pub)
3. Park C.F. and McDiarmid R.A. – Ore Deposits (W.H. Freeman & Co.)
4. Stanton R.L. – Ore Petrology (McGraw Hill)
5. Krishnaswami – Mineral Resources of India (CBS)
6. Sinha, R.K. – Treatise on Industrial Minerals of India.
7. McKinstry, H.E. – Mining Geology (Asia Pub. House)
8. Stach, E. et al. – Coal Petrology. Gebruder Borntraeger, Stuttgart
9. Lybach, L., Muffer, L.J.P. – Geothermal systems (J. Wiley & Sons)..
10. S. Eanga Raja Rao – Coal Preparation and use (Oxford IBM Pub. Co.)
11. Armstrong, H.C. – Geothermal Energy (Span London)
12. Singh, R.D. – Principles and Practices of Modern coal Mining.
13. Taylor, G.H. et al. – Organic Petrology. Gebruder Borntraeger, Stuttgart.
14. Chandra, D., Singh, R.M. and Singh, M.P., - Text Book of Coal. Tara Book Agency, Varanasi.
15. Dahlkamp, F.J. - Uranium Ore Deposits. Springer verlag.

**M.Sc. (Previous) Practicals**

**Maximum Marks: 150**

**Exam Duration: 16 Hrs in 4 days for 4 Parts of Practicals**

**Part I:**

(Practicals of Geochemistry, Crystallography, Mineralogy and Stratigraphy & Palaeontology and Submission of Report and Viva-voce on General Geological Tour)

**Marks: 75**

**Exam Duration: 8 Hours in 2 days**

**Geochemistry, Crystallography & Mineralogy**

**25 Marks**

1. Identification of important rock forming minerals by physical examination.
2. Identification of important rock forming minerals by optical examination.
3. Determination of 2V and pleochroic schemes of important rock forming minerals.
4. Identification and description of crystal models in hand specimens.
5. Construction of Stereographic projections and determination of axial Ratio.
6. Problems related to stereographic projection of crystals.

**Economic Geology & Mineral Economics**

**25 Marks**

1. Study of economic minerals in hand specimens, their distribution and genesis.
2. Determination of important ore minerals under reflected light.

3. Distribution of important minerals in the maps of India and Rajasthan

**Practical Record**

**5 Marks**

**Viva Voce**

**5 Marks**

**Field Work:** General Geological Field Training Programme (2 weeks duration)

**15 Marks**

The report of the field work has to be submitted and viva voce will be conducted during the practical exam.

**Part II:**

(Practicals of Structural Geology, Geotectonics & Geomorphology and Economic Geology & Mineral Economics and Submission of report and Viva- voce on Geological Mapping of a selected Area)

**Marks: 75**

**Exam Duration: 8 Hours in 2 days**

**Geomorphology, Geotectonics & Structural Geology**

**30 Marks**

1. Solution of structural problems by stereographic and orthographic projection methods.
2. Identification of structural elements and their chronology in hand specimens.
3. Completion of outcrop patterns.
4. Study of Geological Maps, Preparation of Geological sections, determination of Thickness of beds, Geological History.
5. Completion of outcrops on maps.
6. Study of topographic maps and their interpretation.
7. Representation of geomorphic features.
8. Geomorphic surveys, leveling and contouring.

**Stratigraphy & Palaeontology**

**20 Marks**

1. Study of rocks in Hand specimens from Precambrian terrain of India.
2. Showing boundaries of the Precambrian terrains of India on map.
3. Stratigraphic and Palaeogeographic maps with special reference to India.
4. Identification of stratigraphic rocks in hand specimen.
5. Preparation of Lithology and their correlation, correlation problems.
6. Identification, drawing and description of common representatives of Fossil groups covered in theory syllabus.
7. Sketching of evolutionary trends of important fossils groups.

**Practical Record**

**5 Marks**

**Viva Voce**

**5 Marks**

**Field Work:** Geological mapping of selected area (Two weeks duration)

**15 Marks**

and report there on.

## Teaching and Examination Scheme

### M.Sc. (Final) Geology – 2022

#### Scheme

per No.	Theory paper (Nomenclature)	Theory Hours per week	Practical Hours per week	Exam. Hours	Maxi. Marks
V	Igneous & Metamorphic Petrology	6	6	3	75
VI	Sedimentology & Petroleum Geology	6	6	3	75
VII	Environmental Geology, Hydrogeology & Remote sensing	6	6	3	75
VIII	Mining Geology & Engineering Geology	6	6	3	75

Minimum Passing Marks in theory: – 108 out of Total 300 Marks.

#### DISTRIBUTION OF MARKS AND TIME DURATION FOR PRACTICAL EXAMINATION

(Practicals: Exam Duration- 16 Hours, distributed in 2 Parts in 4 days.)

**Max Marks: 150**

**Min Pass Marks: 54**

#### Distribution of marks and time duration for practical examination

<b>Part-I</b>	- Igneous & Metamorphic Petrology - Mining Geology & Engineering Geology - Mining Training Camp and Report there on.	8 Hrs.	60Marks
<b>Part-II</b>	- Sedimentology & Petroleum Geology and Environmental Geology Hydrogeology & Remote Sensing - General Geological Tour and Report there on.	8 Hrs.	60Marks
<b>Part III-</b>	Field Based Case Study related to theory papers, presented in handwritten form		30 Marks

**Practical :** Minimum Passing Marks - 54, Out of Total 150 Marks

### M.Sc. (Final) – 2022

#### Paper V – Igneous and Metamorphic Petrology

**Note:** – Each Theory paper is divided into 5 units. The question paper is divided into three parts, Part A, Part B and Part C. Part A (20 Marks) is compulsory and contains one question containing 10 parts, two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice, one from each unit. Candidate is required to attempt all five questions, each question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

### Unit-I

Composition, constitution & behaviour of magma. Magma types and their classification. Origin of magma. Differentiation and assimilation of magma. End-stage crystallisation of magma. Magma generation and its relation with plate margins. Fabric study of plutonic and volcanic rocks. Classification of Igneous rocks. Petrographic provinces of India.

### Unit-II

Crystallisation process in silicate melts including system: Albite- Anorthite, Albite-Anorthite-Orthoclase, Foresterite- Silica, Leucite-Silica, Diopside- Anorthite-Albite, Diopside- Foresterite-Silica, Nepheline-Kaliophyllite-silica, Foresterite- Faylite-Silica; Reaction principles. Forms, structure and textures of igneous rocks.

### Unit-III

Petrography, mode of occurrence and petrogenesis of the following rock groups and associations: Basic and Ultrabasic plutonic association; Granite and Granodiorite plutonic association; Nepheline Syenite, Ophiolites and cumulates, Anorthosite and Pegmatite; Tholeites and alkali Olivine basalt. Dacite and Rhyolite association of Orogenic regions.

### Unit-IV

Element analysis of rocks and minerals. Principles and geological applications of cathodoluminescence, thermoluminescence, atomic absorption spectrophotometry, XRF spectrometry and XRD.

Working knowledge of AAS, Flame- photometer, DTA, ICP spectrometer, UV- IR spectrophotometer and working techniques.

Metamorphism: concept, factors and types. Texture and structure of metamorphic rocks. Phase rule.

Concept of the depth zone, zone of progressive metamorphism. Retrogressive metamorphism; stress and anti stress minerals. Anatexis and migmatites. ACF, AKF, & AFM diagrams and their significance.

### Unit- V

Detailed study of facies of contact and regional metamorphism. Paired metamorphic belts.

Mineralogical and textural changes accompanying progressive regional metamorphism of mafic and ultramafic rocks, pelites and carbonate rocks. Metasomatism and metamorphic differentiation.

Petrographic and petrogenetic study of important metamorphic rocks; granulites, charnockites and eclogites etc; Ultra-high temperature, ultra-high pressure and ocean floor metamorphism and their significance.

#### **Suggested Readings:**

1. Bowen, N.L. – Evolution of Igneous rocks (Princeton University Press)
2. Jackson – Text book of Lithology
3. Best – Igneous and Metamorphic Petrology (CBS)
4. Winkler H.G.F. - Petrogenesis of Metamorphic Rocks (Springer-Verlog)
5. Miashiro – Metamorphism and metamorphic Rocks (George Allen University)
6. Moorehouse – A study of Thin Sections (CBS)
7. Ghose, M.K. – Igneous Petrology (World Press Pvt. Ltd., Kolkata)
8. Chatterjee, S.C. – Igneous & metamorphic Rocks
9. Johanneson, A – A Descriptive Petrology of Igneous Rocks –Vol. I-IV (University of Chicago Press).

10. Turner, F.J. - Metamorphic Petrology. Mc Graw Hill.
11. Philipots, A. - Igneous and Metamorphic Petrology. Prentice Hall.
12. Mason, Brian - Principles of Geochemistry.
13. Hutchinson, C.S. - Laboratory Hand Book of Petrographic Techniques. John Wiley.
14. Mason, B. and Moore, C.B. - Introduction to Geochemistry. Wiley Eastern.
15. Krauskopf, K.B. - Introduction to Geochemistry. McGraw Hill.
16. Faure, G. - Principles of Isotope Geology. John Wiley.
17. Govett, G.J.S. - Hand Book of Exploration Geochemistry. Elsevier.

### **Paper VI– Sedimentology & Petroleum Geology**

**Note:** – Each Theory paper is divided into 5 units. The question paper is divided into three parts, Part A, Part B and Part C. Part A (20 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice, one from each unit. Candidate is required to attempt all five questions, each question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

#### **Unit-I**

Introduction, scope, history of development of sedimentology.

Processes of sedimentation. Post depositional changes in sediments. Surface processes and rock weathering. Mineral stability. Provenance sources of sediments.

Mineral composition: quartz, feldspar, rock fragments, clay minerals, heavy minerals, carbonates, cement and matrix. Soil forming processes, soil profile. Identification of clay minerals by X-Ray diffraction method.

Texture and structures of sedimentary rocks. Trace fossils—introduction, classification, identification and description.

#### **Unit-II**

Transportation of sediments. Settling velocity of spheres. Stock's law. Impact law. fluid flow movements of particles, suspension and traction transport, saltation movement, selective transportation, particle weathering during transport, sediment maturity.

Deposition of clastic and non-clastic sediments. Classification of sedimentary rocks.

Study of common sedimentary rocks: Clastic sedimentary rocks – deposits of gravels, conglomerates, breccia, sandstone, graywacke, shale, siltstone etc.

Non-clastic sedimentary rocks— limestone, dolomite, evaporites. Organic sediments.

#### **Unit-III**

Sedimentary environment and facies: continental alluvial- fluvial, lacustrine, desert – Aeolian and glacial sedimentary systems. Shallow coastal clastics. Marine and continental evaporates. Shallow water carbonates.

Deep sea basins. Volcanoclastics: onland and marine. Tectonics and sedimentation. Stratigraphy and sedimentation; Reconstruction of palaeoenvironment. Basin analysis.

#### **Unit-IV**

Petroleum- chemical and physical properties. Origin of Petroleum. Migration and accumulation of Petroleum. Reservoir rock: Classification – fragmental, chemical & bio-chemical and micellaneous rocks; well logs; marine & non-marine reservoir rocks.

Reservoir Pore Space: Porosity; permeability; Classification & origin of pore space; relation between Porosity & permeability.

Reservoir fluids (water, oil & gas): Fluid content – source of data, distribution of gas, oil & water, classification of waters, character of oil-field water, oil field brine; Oil – measurement, chemical & physical properties; Gas - measurement, composition, impurities.

Reservoir Traps: Anticlinal theory; classification; structural traps; stratigraphic traps (primary & secondary); fluid traps; combination traps; salt domes.

Reservoir pressure and temperature. Reservoir mechanics.

Types of reservoirs of oil and gas, oil and gas traps.

#### **Unit- V**

Principles and techniques of petroleum exploration.

Application of subsurface mapping in Petroleum exploration – Structural maps & sections, isopach maps, facies maps, paleogeologic & subcrop maps, geophysical maps, geochemical maps; Dry Holes.

Elements of well drilling and logging. Various types of drilling in petroleum.

Geology of the petroliferous basins of India.

Prospects of new discoveries of petroleum in the Indian mainland and the adjoining seas.

Distribution of Petroleum deposits of the World.

#### **Suggested Readings:**

1. Sengupta, S.M. – Introduction of Sedimentology (Oxford & IBH)
2. Pettijohn, F.J. – Sedimentary Rocks (CBS)
3. Slley, R.C. – Introduction to Sedimentary Rocks (Academic Press London)
4. Folk, R.L. – Petrology of Sedimentary Rocks (Hemphill Pub. Co.)
5. Allen – Sedimentary Structures
6. Thomson – Sedimentary Structures
7. Green smith – Sedimentary Petrology(CBS)
8. Krumbein and Sloss – Stratigraphy and Sedimentation (W.H. Freeman & Co.)
9. Reineck and Singh – Depositional Environments.
10. Landes, K.K. – Petroleum Geology (Robert, Kraieger Pub. Co.).
11. Kinghorn, R.R.F. – An Introduction to the Physics and chemistry of Petroleum (J. Wiley & Sons).
12. Levorson – Petroleum Geology
13. Selley, R.C. - Elements of Petroleum Geology. Academic Press.

## **Paper VII – Environmental Geology, Hydrogeology & Remote Sensing**

**Note:** – Each Theory paper is divided into 5 units. The question paper is divided into three parts, Part A, Part B and Part C. Part A (20 Marks) is compulsory and contains one question containing 10 parts, two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice, one from each unit. Candidate is required to attempt all five questions, each question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

### **Unit -I**

Fundamental concepts of Environmental Geology. Geologic Cycles-Tectonic cycle, hydrologic cycle, rock cycle. Earth materials- minerals, rocks, soils, water, and air. Environmental Degradation. Pollution- types, Factors. Air pollution.

Wastes: Solid wastes, Hazardous Chemical wastes, Radio-active wastes, Liquid- Semi liquid (sewerage & waste water) Wastes and their disposal. Environmental Impact Assessment (EIA).

Hazardous Earth Processes: River flooding: Nature & extent of hazard: Perception of River flooding.

Landslides: Identification, prevention and correction (control) of LS; Snow Avalanche; Subsidence; Perception of LS hazard. Earthquakes: Perception to EQ. Volcanoes: Perception of Volcanic Hazard.

Desertification and environmental impact.

Anthropogenic Impact and Environmental planning to open cast mining & quarrying, river valley projects, urbanization & urban air environment, global climatic change.

### **Unit- II**

Hydrogeology- Introduction: scope, historical background and utilization of groundwater.

Hydrological cycle. Sources of groundwater; Rock properties affecting groundwater; Porosity and Permeability. Vertical distribution of groundwater; Aquifers and their types. groundwater Basins.

groundwater movement. Darcy's law. Coefficient of permeability. Measurement of permeability.

Tracing groundwater. movement and dating; flow lines.

Water wells: their types and construction methods; collector wells and infiltration galleries.

groundwater level fluctuation. Hydrogeologic characteristics of common rock types.

Ground water quality: Measures of water quality; physical, chemical & bacteriological analysis; water quality criteria for drinking, irrigation & industrial purposes. Groundwater Pollution and Restoration; collection of water samples, analysis of groundwater. Groundwater monitoring, Basin wide groundwater development: Safe yield & overdraft.

### **Unit -III**

Equations of hydrologic equilibrium. Data collection for basin investigation; method of computing safe yield; variability of safe yield. Conjunctive use of surface & groundwater Reservoirs.

Groundwater Exploration: Geologic and hydrogeologic methods; Geophysical exploration; Test drilling.

Hydrogeologic and geophysical well logging.

Artificial recharge: need and benefits, methods of artificial recharge: induced recharge, recharge well method, recharge through pits and shafts.

G.W. Development & Potentials in India. G.W. Potentials of Rajasthan.

#### Unit –IV

Introduction to Photogeology & Remote sensing. Remote sensing from air and space. Electromagnetic spectrum, emission range, films and filters, multispectral sensors and scanners,

Maps and aerial photographs; Aerial photographs- types, errors and distortion. Instruments used in Photo interpretation, plotting & measurements from aerial photographs. Rectification. Vertical exaggeration and its estimation.

Flight procedure and computation of flight lines, mosaic, preparation of base map by radial triangulation methods.

Geometric characteristics of aerial photograph. Simple relative orientation, displacement in single photograph and in stereo-pairs and their corrections. Stereoscopic vision, pseudoscopic vision, measuring instrument and their uses, calculation of height of an object by parallax method. Remote sensing. Aero visual survey. Infrared photography, multiple band photography. Imageries.

#### Unit – V

Types of satellites. Satellite remote sensing and its limitations. Global and Indian space missions.

Advantages, limitations and factors affecting photo interpretation.

Application of aerial photographs in the interpretation of geomorphology, geological structures/ lithologies, soils, mineral exploration, petroleum exploration and ground water exploration.

Application of Remote sensing in the interpretation of geomorphology, geological structures/ lithologies, soils, mineral exploration, petroleum exploration and ground water exploration.

Geographic Information System (GIS): Principles and Applications. Vector and Raster Analysis

Remote sensing and GIS.

#### **Suggested Readings:**

1. Todd, D.K. – Ground Water Hydrology (J.Wiley & Sons)
2. Karanth, K.R. – Ground water Assessment
3. Garg, S.P. – Ground water & Wells.
4. Arogyaswami, R.N.P. – Courses in Mining Geology (Oxford & I.B.H.).
5. Mckinstry, H.E. – Mining Geology (Asia Publishing House).
6. Haekes R. & Webb – Geochemistry in Mineral Exploration (Academic Press).
7. Levinson – Introduction to Exploration Geochemistry (Applied Publishers).
8. Robinson and Courch – Basic exploration Geophysics.
9. Sinha, R.K. and Sharma, N.L. – Mineral Economics (oxford & IBH).
10. Chatterjee, K.K. – An introduction to mineral economics (willey eastern).Gaudin- Ore dressing.
11. Miller, V.C. – Photogeology. (McGraw Hill)
12. Pandey, S.N. – Principles of Photo interpretation and Remote Sensing. (McGraw Hill)
13. Allum – Photogeology & Regional Mapping.
14. Jhanwar, M.L and Chouhan, T.S. – Remote sensing and photogrammetry (Vigyan Prakashan).
15. Ray. R.G. - Aerial Photographs in Geologic Interpretations. (USGS)



16. Sabbins, F.F. - Remote sensing- Principles and Applications. (Freeman)
17. Drury, S.A. - Image Interpretation in Geology. (Allen and Unwin)
18. Lilesand, T.M. and Kieffer, R.W., - Remote sensing and Image Interpretation. (John Willey)
19. Gupta, R.P. - Remote sensing Geology. (Springer Verlag)

**Paper VIII– Mining Geology & Engineering Geology**

**Note:** – Each Theory paper is divided into 5 units. The question paper is divided into three parts, Part A, Part B and Part C. Part A (20 Marks) is compulsory and contains one question containing 10 parts, two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice, one from each unit. Candidate is required to attempt all five questions, each question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

**Unit- I**

Exploration and its types. Surface exploration.

Topographic surveying – chain, compass and tape, plane table, theodolite; leveling and contouring. Geologic mapping- reconnaissance and detailed surface mapping- Base map and topo sheet, mapping techniques for lithologies, field data collection. Subsurface mapping.

Guides to ores: Targets, loci, regional guides. Classification of guides; geochemical guides; physiographic guides; mineralogical guides; stratigraphic and lithologic guides; structural guides- fractures, folds, faults.

Persistence of ore in depth. Sampling and tonnage: Sampling and types; average assays.

**Unit -II**

Geochemical prospecting: geochemical processes- primary and secondary; pathfinder; anomalies; geochemical field techniques and analysis; geobotanical surveys; Subsurface exploration: drilling and types, bore hole problems, bore hole samplings. Preservation and sampling of cores.

Geophysical prospecting- electrical, gravity, magnetic, seismic, radio active method, well logging, aerial geophysical survey.

**Unit- III**

Methods of Estimation of Reserves: Classification of Reserves (International & National); sampling; Spacing of pits, trenches, bore holes & grooves; Assay; Processing & interpretation of Sampling data; reserve calculation; Estimation of reserve by exploratory mining; Economic consideration in Reserve estimation;. Feasibility study. Explosives.

Mining: Mining terminology. Classification of mining methods: Alluvial mining; open cast mining; under ground mining and coal mining.

**Unit- IV**

Principles & Methods of Mineral dressing: approach; preparation; methods- gravity separation, magnetic separation, electrostatic separation, flotation; reagents; Collectors; Frothers; Modifiers; Agglomeration; miscellaneous processes- amalgamation, thickening, filtration, dewatering, drying.

Phases of mineral processing, mineral dressing and hand picking, crushing, grinding, sizing, classification, air sizing, blending, concentration, washing, gravity separation – jigging, tabling, vanners and miscellaneous floatations.

Flow sheets for Chromite, Gold, Copper, Lead, Zinc, Manganese, Gypsum, Clay and Coal.

### **Unit- V**

Application of Geology in Civil engineering.

Engineering properties of rocks. Rocks as construction material.

Importance and stages of geological exploration; including Subsurface & Subsurface exploration for important engineering projects.

Dams: Terminology, Classification & types of Dams, Problems related to Dams, geology of damsite, Foundation & abutment competency; Reservoirs: Reservoir site, Reservoir problems, geology of Reservoir site; Geological Investigation of Dam & Reservoir.

Tunnels: Terminology, Classification of Tunnels; Geologic Parameters & Problems Earth Tunneling; Geologic Parameters & Problems Rock Tunneling;

#### **Suggested Readings:**

1. Singh & Sahni – Advanced Surveying (IBH)
2. Krynine & Judd – Principles of Engineering Geology and Geotectonics (McGraw Hill)
3. Parbin Singh – Engineering and General Geology
4. SathyaNarayan swami, B.S. – Engineering Geology (Dhanpat Rai & Co.)
5. Blyth – Geology of Engineers (ELBS)
6. Keller, E.A. – Environmental Geology (CBS)
7. Valdiya K.S. – Environmental Geology. Tata MGH
8. Coates, D.R. – Environmental Geology
9. Flames, P.T. – Environmental Geology, Conservation land use planning and Resource Development.
10. Cooke and Drunkamp – Geomorphology in Environment Pollution.
11. Horn, B. & Scott, M. – Geological Hazards (Springer Verlag)
12. Tank, R.W. – Focus on Environmental Geology (Oxford)
13. Savindra Singh – Environmental Geography. Prayag Pustak Bhawan.
14. Pratap Singh – Sustainable Development with Renewable Energy Resources. (Yash Publi; Bikaner)
15. Abbasi & Abbasi - Renewable Energy Resources & their Implication. (Prentice Hall India)

#### **M.Sc. (Final) Practicals**

<b>Part-I</b>	- Igneous & Metamorphic Petrology	8 Hrs.in 2 days	<b>60 Marks</b>
	- Mining Geology & Engineering Geology		
	- Mining Training Camp and Submission of Report & Viva voce		

#### **Igneous and Metamorphic Petrology 20 Marks**

1. Description and identification of Igneous and Metamorphic rocks in Hand Specimens and under microscope.
2. Petrographic methods and calculation of CIPW norms and Niggli values and their plotting.

3. Petrochemical calculations and representation (ACF & AKF diagrams)

**Mining Geology & Engineering Geology**

**15 Marks**

1. Calculation of assay value & Ore reserve estimation.
2. Study of flow sheet for ore beneficiation.
3. Lab calculation related to mining and exploration.
4. Survey with chain and tape, compass and plane table.
5. Study of Important Indian Dams, Tunnels and other engineering projects

**Practical Record**

**5 Marks**

**Viva Voce**

**5 Marks**

**Mining Training Camp of Two weeks duration and  
Submission of Report there on**

**15 Marks**

**Part-II** - Sedimentology and Petroleum Geology & Environmental Geology,  
Hydrogeology &, Exploration  
- General Geological Tour and Report there on

**8 Hrs. 60 Marks**

**Sedimentology & Petroleum Geology**

**15 Marks**

1. Study of common sedimentary rocks in hand specimens and in thin section.
2. Graphic representation of grain size data, histograms, cumulative curve, frequency curves, rose diagram etc.
3. Palaeocurrent analysis and their representations.

**Environmental Geology Hydrogeology & Remote Sensing**

**15 Marks**

1. Diagrammatic representation of Geologic cycles- tectonic, hydrological, rock & geo chemical cycles.
2. Laboratory problems related to environmental geology.
3. Application of geological data for environmental purposes.
4. Graphical representation of geo-environmental data etc
5. Geomorphic surveys, leveling and contouring.
6. Interpretation of aerial photographs with the help of stereoscope.
7. Photogrammetric exercises.
8. Study and interpretation of satellite imageries

**Practical Record**

**5 Marks**

**Viva Voce**

**5 Marks**

**- Submission of Report & Viva voce on Compulsory General Geological Field**

**5 Marks**

**Training Programme of Two weeks duration.**

**Part III- Field Based Case Study on the topics related to Petrology/ Mining/ Environmental  
Geology/ Structural Geology/ Applied Geology/Groundwater etc. Presented in  
original manuscript (handwritten)**

**30 Marks**