



Geology Department
Osmania University
Continuous and Comprehensive Evaluation (CCE)
As per Choice Based Credit System (CBCS)

M.Sc. Geology
Scheme of Instruction and Examination (2023-2025)

Semester – I

S. No	Code No.	Paper	Paper Title	Hours / Week	Internal Assessment 40+10=50	Semester Exam	Total Marks	Credits
Theory								
1	GL 101 T	I	Crystallography, Optical Mineralogy & Mineralogy	3	50 Marks	50 Marks	100 Marks	3
2	GL 102 T	II	Structural Geology & Geotectonics	3	50 Marks	50 Marks	100 Marks	3
3	GL 103 T	III	Paleontology & Stratigraphy	3	50 Marks	50 Marks	100 Marks	3
4	GL 104 T	IV	Geomorphology & Field Geology	3	50 Marks	50 Marks	100 Marks	3
Practical								
5	GL 105 P	I	Crystallography, Mineralogy & Optical Mineralogy	6	-	75 Marks	75 Marks	3
6	GL 106 P	II	Geomorphology & Paleontology	4	-	50 Marks	50 Marks	2
7	GL 107 P	III	Field Geology & Structural Geology	4	-	50 Marks	50 Marks	2
8	GL 108 P	IV	Geological report writing	2	-	25 Marks	25 Marks	1
			Total	28	200	400	600	20



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Semester – II

S. No	Code No.	Paper	Paper Title	Hours / Week	Internal Assessment 40+10=50	Semester Exam	Total Marks	Credits
Theory								
1	GL 201 T	I	Igneous Petrology & Geochemistry	3	50 Marks	50 Marks	100 Marks	3
2	GL 202 T	II	Metamorphic Petrology & Thermodynamics	3	50 Marks	50 Marks	100 Marks	3
3	GL 203 T	III	Sedimentology & Petroleum Geology	3	50 Marks	50 Marks	100 Marks	3
4	GL 204 T	IV	Ore Genesis & Mineral Deposits	3	50 Marks	50 Marks	100 Marks	3
Practical								
5	GL 205 P	I	Igneous Petrology, Metamorphic Petrology & Geochemistry	6	-	75 Marks	75 Marks	3
6	GL 206 P	II	Sedimentology & Petroleum Geology	4	-	50 Marks	50 Marks	2
7	GL 207 P	III	Ore Genesis & Mineral Deposits	4	-	50 Marks	50 Marks	2
8	GL 208 P	IV	Computation Techniques in Geology	2		25 Marks	25 Marks	1
				28	200	400	600	20



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Semester – III

S. No	Code No.	Paper	Paper Title	Hours / Week	Internal Assessment 40+10=50	Semester Exam	Total Marks	Credits
Theory								
1	GL 301 T	I	Mineral Exploration	3	50 Marks	50 Marks	100 Marks	3
2	GL 302 T	II	Hydrogeology	3	50 Marks	50 Marks	100 Marks	3
3	GL 303 T	III	Remote Sensing & GIS	3	50 Marks	50 Marks	100 Marks	3
4	GL 304 T	IV	CB – 1. Disaster Management CB – 2. Watershed Management	3	50 Marks	50 Marks	100 Marks	3
Practical								
5	GL 305 P	I	Mineral Exploration (Geological Exploration; Geophysical Exploration & Geochemical Exploration)	6	-	75 Marks	75 Marks	3
6	GL 306 P	II	Hydrogeology	4	-	50 Marks	50 Marks	2
7	GL 307 P	III	Remote Sensing & Geographic Information Systems (GIS)	4	-	50 Marks	50 Marks	2
8	GL 308 P	IV	Personality Development	2		25 Marks	25 Marks	1
			Total	28	200	400	600	20



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Semester – IV

S. No	Code No.	Paper	Paper Title	Hours / Week	Internal Assessment 40+10=50	Semester Exam	Total Marks	Credits
Theory								
1	GL 401 T	I	Environmental Geology	3	50 Marks	50 Marks	100 Marks	3
2	GL 402 T	II	Mining Geology & Engineering Geology	3	50 Marks	50 Marks	100 Marks	3
3	GL 403 T	III	Mineral Economics & Fuels	3	50 Marks	50 Marks	100 Marks	3
4	GL 404 T	IV	CB1-Mineral Chemistry CB 2– Precambrian Geology & Crustal Evolution	3	50 Marks	50 Marks	100 Marks	3
Practical								
5	GL 405 P	I	Mining, Engineering Geology & Environmental Geology	6	-	75 Marks	75 Marks	3
6	GL 406 P	II	Precambrian Geology & Fuels	4	-	50 Marks	50 Marks	2
7	GL 407 P	III	Project Work	4	-	50 Marks	50 Marks	2
8	GL 408 P	IV	Seminar	2		25 Marks	25 Marks	1
			Total	28	200	400	600	20

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Osmania University
Continuous and Comprehensive Evaluation (CCE)
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M.Sc. Geology

Scheme of Instruction and Examination (2023-2025)
Subjects offered in III & IV Semester, M. Sc. Geology at Department of Geology University College
of Science (UCS), Saifabad, Hyderabad-4

Semester – III

S. No	Code No.	Paper	Paper Title	Hours / Week	Internal Assessment 40+10=50	Semester Exam	Total Marks	Credits
Theory								
1	GL(S) 304 T	IV	Watershed Management	3	50 Marks	50 Marks	100 Marks	3
Practical								

Semester – IV

S. No	Code No.	Paper	Paper Title	Hours / Week	Internal Assessment 40+10=50	Semester Exam	Total Marks	Credits
Theory								
1	GL 401 T	I	Chemical Geology	3	50 Marks	50 Marks	100 Marks	3
Practical								
5	GL(S)401 T	I	Chemical Geology, Mining Geology & Engineering Geology	6	-	75 Marks	75 Marks	3

Syllabus of M. Sc. GEOLOGY (CCE as per CBCS) with effect from 2023-25
I Semester

Paper - I (GL 101 P): Crystallography, Optical Mineralogy & Mineralogy

Unit – I

External symmetry of crystals: Symmetry Elements, methods of projection, derivation of 32 classes, Hermann Mauguin notation. Internal symmetry of crystals: Derivation of 230 space groups, diffraction of crystals by X-rays, Bragg's law. Introduction to mineralogy: Definition and classification of minerals. Structural and chemical principles of crystals / minerals, chemical bonds, ionic radii, coordination number (CN) and polyhedron.

Unit –II

Principles of optical mineralogy: Optical mineralogy, polarized light, behavior of isotropic and anisotropic minerals in polarized light, refractive index, double refraction, birefringence, sign of elongation, interference figures, 2V, dispersion in minerals. Optic sign, pleochroic scheme and determination of fast and slow vibrations and accessory plates.

Unit – III

Structure, chemistry, physical and optical characters and paragenesis of mineral groups: Feldspar, quartz, feldspathoid, aluminum silicates, epidote and garnet groups. Accessory minerals: Apatite, calcite, corundum, scapolite, sphene and zircon. Earth mineralogy: Average mineralogical composition of crust and mantle, mineral transformations in the mantle with depth. Structure, chemistry, physical and optical characters and paragenesis of mineral groups: Olivine, pyroxene, amphibole, mica and spinel groups.

Practicals

Crystallography and Mineralogy

1. Study of important crystal models corresponding to Normal Class of cubic system.
2. Study of important crystal models corresponding to Normal Class of orthorhombic system.
3. Study of important crystal models corresponding to Normal Class of monoclinic system.
4. Study of important crystal models corresponding to Normal Class of triclinic system.
5. Study of important crystal models corresponding to Normal Class of tetragonal system.
6. Study of important crystal models corresponding to Normal Class of hexagonal system.
7. Stereographic projections on the Wulff's Stereonet.
8. Megascopic study of rock forming minerals: Olivines, pyroxenes, amphiboles and micas.

9. Megascopic study of rock forming minerals: Feldspars, feldspathoids, silica minerals and alumino silicates.
10. Megascopy of accessory minerals: Apatite, zircon, magnetite, ilmenite, calcite, epidote, sphene etc

Optical Mineralogy

1. Centering and, orthoscopic and conoscopic arrangement of the petrological microscope.
2. Microscopy of rock forming minerals: Olivines, pyroxenes, amphiboles and micas.
3. Microscopy of rock forming minerals: Feldspars, feldspathoids, silica minerals and alumino silicates.
4. Microscopy of accessory minerals: Apatite, zircon, magnetite, ilmenite, calcite, epidote, sphene etc.
5. Determination of relative relief (RI) of minerals by Becke-line test.
6. Determination of sign of elongation of minerals.
7. Determination of pleochroic scheme of minerals.
8. Determination of optic sign of uniaxial minerals.
9. Determination of optic sign of biaxial minerals.
10. Determination of anorthite content of plagioclase by Michel Levy Method.

Books Recommended

Crystallography, Mineralogy & Optical Mineralogy

1. Deer, W., Howie, R.A. & Zussman, J., 1996; The Rock forming minerals. Longman.
2. Klein, C and Hurlbut, Jr., C.S. 1993; Manual of Mineralogy. John Wiley.
3. Putnis Andrew, 1992; Introduction to Mineral Science, Cambridge University Press.
4. Spear, F.S. 1993; Mineralogical Phase Equilibria and Pressure – Temperature – Time paths. Mineralogical society of America Publisher.
5. Phillips, Wm, R. & Griften, D.T 1986. Optical Mineralogy, CBS edition.
6. Hutchison, C.S., 1974 laboratory handbook of Petrographic Techniques. John Wiley.

Paper – II (GL 102 T)

Structural Geology & Geotectonics

Unit – I

Concept of stress and strain: Stress-strain relationships of elastic, plastic and viscous materials, measurement of strain in deformed rocks, behaviour of minerals and rocks under deformation conditions. Folds: classification and causes of folding, diapirs and salt domes. Foliations and Lineations: classification, origin and significance. Petrofabric analysis (micro fabrics): Data collection, plotting, symmetry and interpretation, concept of symmetry of fabric of tectonites.

Unit – II

Geotectonics: Introduction, tectonic framework of earth's crust, interior of earth, Isostasy, Convection currents, Wilson cycle. Continental Drift: Computer fitting, geological and paleontological evidences in support of continental drift and insitu theories. Sea-floor spreading: Hess's concept and evidences of sea-floor spreading. Vine-mathew's magnetic tape recorder. Shear zones: Recognition of shear zones and faults in field, mechanics of shearing and faulting. Geometry of thrust sheets: Block faulted and rifted regions. Wrench faults and associated structures.

Unit – III

Plate tectonics: Concept of plate and plate movements, plate model of Morgan, nature of convergent, divergent and conservative plate margins, transpression and transtension. Plate tectonics in relation to igneous, sedimentary and metamorphic processes and mineralization. Triple junctions, aulocogens, plume theory, island arcs. Nature and origin of earth's magnetic field. Tectonic mélanges, Dome and basin structures, Structural behavior of igneous rocks.

Practicals

Structural Geology

1. Reconstruction of folds, determination of the depth at the end of the section.
2. Reconstruction of folds, determination of the height at the end of the section.
3. Vertical fault problems
4. Inclined fault problems; standard geological maps.
5. Maps with uniformly dipping beds / unconformable beds.
6. Maps with beds dipping with different dips.
7. Maps with folded formations.
8. Maps with faulted formations.
9. Maps with intrusives / unconformities.
10. Maps of geotechnical importance.

Books Recommended

Structural Geology & Geotectonics

1. An outline of Structural Geology By John Wiley:: Hobbs, Means and Williams,
2. Outline of Structural Geology By Mathuen, London:: E S Hills,
3. Structural Geology of rocks and regions By John Wiley:: H. Davis,
4. Foundations of structural geology By Blakie:: R.G.Park,
5. Structural Geology By McGraw Hill:: L.U.De Sitter,
6. Structural Geology By P.H.I.: M.P.Billings,
7. Fundamentals of modern structural geology By S.K. Ghosh., Elsevier Publication,
8. T.M.H.: Aspects of tectonics of SE Asia: K.S.valdiya Understanding the earth By Artemis Press:: Gass, Smith and Wilson,
9. Physical Geology By P.H.I.: Judson, Deffeyes & Hargraves,
10. Plate tectonics and crustal evolution By K.C.Condie Pergomon press,
11. Holmes principles of Physical Geology. By D.Duff Chapman& Hall,
12. The evolving continents: By B. F. Windley J.W.,
13. Crustal evolution and orogeny By S.P.h.Sychanthavong. Oxford & IBH.,
14. The evolving earth By Sawkins and others. Mac Millan,
15. The evolving Earth by L A M Cocks. Cambridge University Press,
16. Plate tectonics and magnetic reversals. Allan Cox. Freeman,
17. Basic problems in Geotectonics. V V Belousov. Mc Graw Hill,
18. Development in Geotectonics. Series from Vol.1 to 6. Elsevier,
19. Continental deformation By Paul Hancock. Oxford Publication House.

Paper – III (GL 103 T)

Palaeontology & Stratigraphy

Unit – I

Micro-palaeontology: Origin and evolution of life. Classification and uses of micro fossils. Detailed study of microfossils such as Foraminifera, Radiolaria, Conodonts, Ostracoda, Bacteria, Diatoms, Dinoflagellata and Charophyta. Plant fossils: Gondwana flora and their significance. Vertebrate palaeontology: General characters, classification, evolution of Fishes including Agnathans, Placoderms, Chondrichthyes and Osteichthyes. General characters, age of Amphibians, Reptiles and Mammals. General characters, classification, evolution, age and extinction of Dinosaurs. General characters, classification and evolution of Horse, Elephant and Man.

Unit - II

Principles of Stratigraphy: Nomenclature and the modern stratigraphic code. Litho-, bio- and chrono-stratigraphic units and their inter-relationships. Geological time scale. Magneto-Stratigraphy. Dating of rocks. Modern methods of stratigraphic correlation. Precambrian Stratigraphy: Achaean stratigraphy -tectonic frame-work, geological history and evolution of Dharwar, and their equivalents; Eastern Ghats mobile belt; Proterozoic Stratigraphy -tectonic framework, geological history and evolution of Cuddapahs and their equivalents.

Unit -III

Paleozoic Stratigraphy: Paleozoic formations of India with special reference to type localities, history of sedimentation, fossil content. Mesozoic Stratigraphy: Mesozoic formations of India with special reference to type localities, history of sedimentation, fossil content. Palaeogeography and Gondwana system. Cenozoic Stratigraphy: Cenozoic formations of India, Rise of the Himalayas and evolution of Siwalik basin. Deccan volcanic. Stratigraphic boundaries: Stratigraphic boundary problems in Indian geology.

Practicals

Palaeontology

1. Morphology, classification, geological age and stratigraphic position of important fossils of Protozoa and corals.
2. Morphology, classification, geological age and stratigraphic position of important fossils of Gastropod.
3. Morphology, classification, geological age and stratigraphic position of important fossils of Cephalopoda.
4. Morphology, classification, geological age and stratigraphic position of important fossils of Lamellaebranchia.
5. Morphology, classification, geological age and stratigraphic position of important fossils of Brachiopoda.

6. Morphology, classification, geological age and stratigraphic position of important fossils of echinodermata.
7. Morphology, classification, geological age and stratigraphic position of important fossils of Arthropoda.
8. Morphology, classification, geological age and stratigraphic position of important plant fossils.
9. Morphology, classification, geological age and stratigraphic position of important microfossils
10. Morphology, classification, geological age and stratigraphic position of important vertebrate fossils.

Books Recommended

Palaeontology & Stratigraphy

1. Outline of palaeontology - H.H.Swinnerton
2. Principles of invertebrate palaeontology-Shrock and Twenhofell.
3. Introduction to evolution-Paul Ames Moody
4. Evolution of the invertebrate-Jean chaline
5. Palaeobotany - Arnold
6. Elements of Micropalaeontology by G. Bignot
7. Microfossils by M.D. Brasier
8. Palaeobiology of Plant protests by Helen Tappen
9. Palaeontology – Evolution and Animal distribution by P.C. Jain & M.S. Anantharaman
10. A text book of Stratigraphy and Micropalaeontology and Palaeobotany by S.K. Tiwari
11. Sedimentation and stratigraphy - Krumbein and Sloss L.L.
12. Principles of stratigraphy - Dunbars & Rodgers
13. Principles and practices in Stratigraphy - Marvin Weller
14. Geology of India & Burma- M.S.Krishnan,
15. Geology of India- D.N. Wadia,
16. Fundamentals of Historical geology & stratigraphy of India- Ravindra Kumar.

Paper – IV (GL 104 T) Geomorphology & Field Geology

Unit – I

Geomorphology: Definition and fundamental concepts of geomorphology, Geomorphic processes: Exogenic processes -gradation, degradation and aggradation; Endogenetic processes -diastrophism, and volcanism. Extraterrestrial process -fall of meteorites. Weathering: physical weathering, chemical weathering and differential weathering, formation of soil, soil profile and mass wasting and its types. Fluvial cycle: Streams and valleys, drainage patterns and their significance, stream deposition, Peneplain concept, topography on domal, folded and faulted structures. Groundwater cycle: Origin of limestone caverns. Landforms of karst regions and karst topography. Geographic positioning system (GPS): Introduction, definition and scope of GPS, advantages and uses of GPS in different fields.

Unit – II

Glacial cycle: Features resulting from glaciers, development of landforms, effects of glaciation beyond ice caps and interglacial deposits. Arid cycle: Origin of deserts and its landforms, topographic effects of wind erosion. Volcanism: Landforms resulting from eruption and deposition of volcanism. Geomorphology of coasts: Topographic features resulting from marine deposition. Topography of ocean floors: Landforms related to shelves, slopes and deep sea. Applied geomorphology: Application of geomorphology to various fields of earth sciences. Surveying: Principles and methods of surveying, chain survey, prismatic survey, plane table survey and theodolite survey. Dumpy's level and Abney's level. Methods of representation of survey-data.

Unit – III

Field Geology: Introduction, Toposheet: Definition, Scale –definition, small scale and large scale, reading various components of a toposheet. Geological map -definition, various components of a geological map including scale, legend, structures etc. Field work and sampling: Field work, geological items to be carried to the field, Use of clinometer compass, Brunton compass, strike and dip measurements; Sampling and oriented sample and its significance, and sampling for isotopic and geochronological studies and its significance; Geological mapping procedures: Geological mapping of igneous terrains, geological mapping of sedimentary terrains, geological mapping of metamorphic terrains.

Practicals

Geomorphology

1. Intra-conversion of scales of toposheets.
2. Study of contour-variations and elevations on toposheets.
3. Identification and classification of various types of fluvial, Aeolian, glacial and volcanic landforms on toposheets, geological maps, aerial photos and Landsat imageries.
4. Identification, demarcation and classification of folds and faults from the toposheet.
5. Identification, demarcation and classification of lineaments from toposheet.

6. Identification, classification and preparation of drainage basin map on toposheet.
7. Morphometry analysis of the drainage basin on toposheet.
8. Identification and interpretation of gully patterns on toposheet.
9. Preparation of landuse - and landcover - maps from toposheet.
10. Identification and classification of geomorphological units on toposheet, aerial photos, Landsat imageries.

Field Geology

1. Reading of toposheets, geological maps and mine plans.
2. Representation factor of scale, representation of scale on the maps.
3. Chain survey of an object taking offsets.
4. Prismatic compass survey of an object by taking forward and backward bearing
5. Plane-table survey -radiation method
6. Plane-table survey -intersection method
7. Plane-table survey -traversing method
8. Profiling using Abney's level and Levelling using Dumpy's level
9. Theodolite survey -countouring and height measurements.
10. Operation of GPS.

Books Recommended

Geomorphology & Field Geology

1. Principles of Geomorphology by Thornbury, W.D...
2. Photogeology by Miller and Miller
3. Geomorphology by Arthur Bloome
4. Principles of Physical geology by Arthur Holms
5. Analysis of landforms by Twidale, C.R
6. Geomorphology by Lobeck by Lobeck, A.K.
7. Field Geology by Lahee
8. Field Geology by Compton

Syllabus of M. Sc. GEOLOGY (CBCS) with effect from 2022-23

II Semester

Paper – I (GL 201 T) Igneous Petrology & Geochemistry

Unit – I

Igneous Petrology: Origin of magmas: Normal state of mantle, onset of partial melting of mantle, processes of partial melting in mantle, mantle-magmas in relation to degree and depth-level of partial melting. Phase equilibrium in igneous systems: Binary systems including Fo-Si and An-Ab, ternary systems including Di-Ab-An and Fo-Di-An. Bowen's reaction principle: Reaction series and its application to petrogenesis. Magmatic evolution and differentiation: Fractional crystallization, gravitational differentiation, gas-streaming, liquid immiscibility and assimilation. Structures and textures: Definition, description, rock examples and genetic implications of common structures and textures of igneous rocks. Classification of igneous rocks: Mode, CIPW norm, IUGS and Irvine-Baragar classifications; Magmatism and tectonics: Inter-relationship between tectonic settings and igneous rock suites.

Igneous rock suites: Form, structure, texture, modal mineralogy, petrogenesis and distribution of the following igneous rocks: Ultramafic rocks: Dunite-peridotite-pyroxenite suite; kimberlites, lamprophyres, lamproites, komatiites; Basic rocks: Gabbro-norite-anorthosite-troctolite suite, Dolerites; Basalts and related rocks; Intermediate rocks: Diorite-monzonite-syenite suite; Andesites and related rocks; Acidic rocks: Granite-syenite-granodiorite-tonalite suite; Rhyolites and related rocks; Alkaline rocks: Shonkinite, ijolite, urtite, melteigite, malignite, alkali gabbros, alkali basalt, alkali granite, alkali syenite, nepheline syenite and phonolite; Carbonatites; Ophiolite suite.

Unit – II

Geochemistry: Introduction: Definition, scope and objectives. Elements: origin, abundance of elements in the solar system and earth, and its constituents; average mineralogical, petrological and, major and trace elemental composition of crust. Meteorites: Classification, mineralogy, chemical composition, origin and age of meteorites. Primary geochemical differentiation of earth: Original molten system, phases involved, chemical reactions and chemical affinity of elements. Goldschmidt's geochemical classification of elements: Definition, theoretical basis and significance of the classification, siderophiles, chalcophiles, lithophiles and atmophiles with examples. Periodic table: Definition and examples of transition elements, platinum group of elements, rare-earth elements, compatible elements, incompatible elements, high-field strength elements (HFSE), large ion lithophile elements (LILE). Magmatism as geochemical process: Major elemental distribution in igneous rocks: Geochemical trends of Mg, Fe, Mn, Ca, Al, Na, K and Si, Ti and P and, variation of Si / Al, (Na+K) / Al and Ca / Na ratios during differentiation by fractional crystallization of a basaltic magma. Goldschmidt's rules governing distribution of major elements. Trace element distribution in igneous rocks: Goldschmidt's rules governing distribution of trace elements during magmatic crystallization including camouflage, capture and admittance with examples of these substitutions.

Unit – III

Sedimentation as a geochemical process: Chemical breakdown and products of sedimentation, soil geochemistry, major and trace element composition of sandstone, shale and limestone, positive and negative colloids, Eh-pH relations during sedimentation; Metamorphism as a geochemical process: Chemical composition of metamorphic rocks; Isotope geochemistry: Definition, stable isotopes and radiogenic isotopes. Stable isotopes: Variations in abundance of O, S, C and H in minerals, rocks and water with respect to international standards, significance of stable isotope study. Radiogenic isotopes: Geochronology, radioactivity decay schemes and growth of daughter isotopes. Radiometric dating: Brief outline of U-Th-Pb, K-Ar, Sm-Nd and Rb-Sr methods of dating. Atmospheric geochemistry: Zonal structure of atmosphere, variable and non-variable chemical constituents of atmosphere.

Practicals

Igneous Petrology

1. Megascopy of ultramafic, basic, intermediate and acidic igneous rocks.
2. Microscopy of ultramafic, basic, intermediate and acidic igneous rocks.
3. Modal classification of ultramafic, and basic igneous rocks following the IUGS nomenclature.
4. Modal classification of intermediate and acidic igneous rocks following the IUGS nomenclature.
5. Chemical classification of igneous rocks in the (Na₂O+K₂O) vs SiO₂ diagram.
6. Calculation of the CIPW norm of gabbro.
7. Calculation of the CIPW norm of diorite.
8. Calculation of the CIPW norm of granite.
9. Calculation of the CIPW norm of syenite.
10. Calculation of the CIPW norm nepheline syenite.

Geochemistry

1. Mineral formula recalculation of olivine.
2. Mineral formula recalculation of pyroxene.
3. Mineral formula recalculation of amphibole.
4. Mineral formula recalculation of mica.
5. Mineral formula recalculation of feldspars.
6. Mineral formula recalculation of feldspathoid.
7. Whole-rock chemical analysis for major and trace elements following standard procedures.
8. Preparation and interpretation of binary variation diagrams for whole rock major and trace element compositions of igneous rock suites using Harker's and Nockold's indices.
9. Preparation and interpretation of ternary variation diagrams for whole rock major element compositions of igneous rock suites using AFM and Ca-Na-K diagrams.
10. Preparation and interpretation of REE patterns for basic, intermediate and acidic igneous rocks.

Books Recommended,

Igneous Petrology & Geochemistry

1. Igneous petrology – Middlemost
2. Igneous Petrology – Antony Hall
3. Igneous and Metamorphic Petrology- Best,
4. Introduction to Petrology- P.J.Wyllie, Prentice Hall,
5. Petrology – V. Hyndman Ed II
6. The evolution of Igneous Rocks – N.L.Bowen, Princeton University Press,
7. Granite Petrology and Granite Problem – Marino V.Elsevier,
8. Natural History of Igneous rocks – Harker A.Mc.Millan,
9. Basalts Vol I and II Poldervaart and Hess, H.H.,
10. Ultramafic rocks – Wyllie, P.J.Heffer,
11. Petrography, An introduction to the study of rocks in thin sections - Howell, William and Turner, W.H.Freeman,
12. Principles of Geochemistry by B. Mason and C. B. Moore,
13. Principles of isotope geology –Gunter Faure, John Wiley,
14. Petrology, The Study of Igneous, Sedimentary and Metamorphic Rocks by Loren A. Raymond, WCB Publ., 1995,
15. Petrology by Walter T. Huang, McGraw-Hill Publ., 1962,
16. Igneous rocks by Alok K. Gupta, Allied Publ., 1998,
17. Igneous petrogenesis -a global tectonic approach (1989) M. Wilson Unwin Hyman Ltd.,
18. Igneous Rocks and Processes: A Practical Guide by Robin Gill. Wiley-Blackwell Publ., 2010.

Paper – II (GL 202 T)

Metamorphic Petrology & Thermodynamics

Unit – I

Metamorphic Petrology: Definition, scope, historical background, factors and kinds of metamorphism and metamorphic processes; Classification: Classification of metamorphic rocks and nomenclature; Structures and textures: Definition, description and physical conditions of formation of various structures of metamorphic rocks; Concepts of metamorphism: Zones, grades, and facies of metamorphism. Phase relations: ACF, AFM and AKF phase diagrams for metamorphic mineral assemblages.

Contact metamorphism: Definition, physical conditions, distribution, sub-facies and characteristic mineral assemblages of sandinite facies and hornfels facies; Regional metamorphism: Definition, physical conditions, distribution, sub-facies and characteristic mineral assemblages of zeolite facies, greenschist facies, blueschist facies, amphibolite facies, granulite facies, and eclogite facies. Inter-relationship between metamorphism and tectonism.

Unit – II

Thermodynamics: Introduction: Definition, scope, and objectives of thermodynamics, inter-relationship between petrogenetic processes and thermodynamics; Role of thermodynamics in geochemistry; Phase rule: Gibb's phase rule and study of phase relations in Al_2SiO_5 system; Goldschmidt's mineralogical phase rule, 'pressure-temperature-depth relations' among various metamorphic facies and ultra metamorphism; Paired metamorphic belts: Definition, characteristics and distribution, case study of Sanbagawa-Ryoke paired metamorphic belt, Japan; Pressure vs metamorphic minerals: Metapelitic and metabasic minerals and mineral assemblages characteristic of various baric types of metamorphism.

Unit – III

Chemical processes: Reversible and irreversible processes; Internal energy: Definition and expression of internal energy of a system, First law of thermodynamics; Entropy: Definition and expression of entropy of a system, Second law of thermodynamics, Enthalpy: Definition and expression of enthalpy of a system; Free energy: Gibb's free energy and Helmholtz free energy of a system; Chemical potential: Fugacity and activity of a solute, activity coefficient; P-T diagrams: Petrogenetic grids, univariant reaction curves for important metamorphic reactions, geothermobarometry, pressure(P)-temperature(T)-time(t) paths.

Practicals

Metamorphic Petrology

1. Megascopy of metamorphic rocks: slates, phyllites, schists and gneisses.
2. Megascopy of metamorphic rocks: amphibolites, charnockites, khondalites, eclogites.
3. Megascopy of metamorphic rocks: marbles and quartzites.
4. Microscopy of metamorphic rocks: slates, phyllites, schists and gneisses.
5. Microscopy of metamorphic rocks: amphibolites, charnockites, khondalites and eclogites.
6. Microscopy of metamorphic rocks: marbles and quartzites.
7. Construction and interpretation of ACF diagrams.
8. Construction and interpretation of AFM diagrams.
9. Construction and interpretation of AKF diagrams.
10. Calculation, plotting and interpretation of Niggli values for metamorphic rocks.

Books Recommended

Metamorphic Petrology & Thermodynamics

1. Elementary Thermodynamics for Geologists by B. J. Wood and D. G. Fraser.
2. Principles of Igneous and Metamorphic Petrology by A. R. Philpotts.
3. Igneous and Metamorphic Petrology by G. M. Best.
4. An Introduction to Metamorphic Petrology by V. W. Yardly

Paper – III (GL 203 T)

Sedimentology & Petroleum Geology

Unit – I

Sedimentology: Sedimentary environments: Definition and classification, non-marine environments including fluvial, glacial, eolian and lacustrine environments, transitional environments including deltaic, beach and tidal flats, marine environments including shelf (clastic and non-clastic) and deep sea sedimentary environment.

Evolution of sedimentary basins: Sedimentary basins, geosynclinal concept, plate tectonics, pre-flysch, flysch, molasses and turbidites; Tectonic setting of sedimentary basins: Sedimentary basins in various tectonic environments including divergent-, convergent-, transform fault-, hybrid- and intraplate-tectonic settings.

Unit – II

Petroleum Geology: Definition, nature and origin of petroleum hydrocarbons; Constitution: Composition of petroleum and natural gas; Origin: Genesis of hydrocarbons, conversion of organic matter to petroleum, variety of petroleum hydrocarbons and gas hydrates; Reservoir rocks: Migration and accumulation of oil; Oil traps: Different types of traps including structural traps, stratigraphic traps and combination traps, salt domes.

Unit – III

Exploration and exploitation of petroleum: Surface indications, direct detection of hydrocarbons including geological, geophysical (electrical and seismic), geochemical and remote sensing methods. Distribution: Geographic and stratigraphic distribution of oil and gas, global distribution, petroliferous basins in India.

Practicals

Sedimentology

1. Megascopy of clastic sedimentary rocks (conglomerates, breccias, sandstones and shales) and non-clastic sedimentary rocks (limestones, fossiliferous limestones including stromatolitic limestones and dolomites).
2. Microscopy of clastic and non-clastic rocks as given above.
3. Grain size analysis by sieving method.
4. Heavy mineral (zircon, rutile and tourmaline, ZRT) analysis using bromoform.
5. Estimation of sphericity and roundness of grains.
6. Identification of sedimentary structures and interpretation of depositional environments.

7. Construction and interpretation of rose diagrams using palaeocurrent data.
8. Classification of sedimentary rocks by plotting the modal and whole rock chemical compositions in relevant triangular diagrams.
9. Study and interpretation of lithofacies maps.
10. Classification of stromatolites (algal bioherms) using Logan et al (1964) scheme.

Books Recommended

Sedimentology & Petroleum Geology

1. Sedimentary Rocks by Pettijohn, F. J., Harper & Row, N. Y.
2. Origin of Sedimentary Rocks By Blott, H., Middleton and Murray, R.
3. Procedures in Sedimentary Petrology By Carver, R.C.
4. Sedimentology Process and Product By Leader, M. R.
5. Sand and Sandstones by Pettijohn, F.J., & Potter, P.E.
6. Palaeocurrents and Basin analysis By Potter, P.E., & Pettijohn, F.J.
7. Depositional Sedimentary Environments by Rieneck, H.E., Singh, I.B.
8. An Introduction to Sedimentology by Shelly, R.C.
9. Practical Manual of Sedimentary Petrology By Babu, S.K., & Sinha, D.K.
10. Petrology of Sedimentary Rocks by Folk, R.L.
11. Practical Manual of Sedimentology by Lindholm, R.
12. Sedimentary Structures: CBS Publications
13. Petroleum Geology (Paperback - 2003) by Jon Gluyas and Richard Swarbrick. Publisher: Blackwell Publishers. flipcart.com
14. Elements of Petroleum Geology. (Paperback - 1998) by Richard C. Selley. Publisher: Academic Press. flipcart.com
15. Petroleum Geology (Paperback - 2003) by Jon Gluyas and Richard Swarbrick. Publisher: Blackwell Publishers. flipcart.com
16. Geostatistics and Petroleum Geology. (Hardcover - 1998) by Michael Edward Hohn and M. E. Hohn. Publisher: Kluwer Academic Publishers.
17. Elements of Petroleum Geology by Selley, R.C. 100 / 998 Academic Press.
18. Petroleum Geology by North, F.K.
19. Petroleum Geology by Chapman, R.C, 20. Petroleum Geology by Levenson, A.I., 21. Sedimentation and Stratigraphy by Krumbein and Sloss, 22. Petroleum Formation and Occurrence by Tissot, B.A & Welte, D.A 1984. Springer Verlag.

Paper – IV (GL 204 T) Ore Genesis and Mineral Deposits

Unit – I

Ore genesis: Introduction: Modern concept of ore genesis, *Ore mineral groups:* Detailed study of all principal ore mineral groups, plate tectonics and ore deposits; *Metallogeny:* Metallogeny through geological time. *Ore textures:* Advanced study of ore textures. Scientific application of ore textures and ore genesis; *Paragenesis:* Paragenetic sequences and zoning in metallic ore deposits. *Ore microscopy:* Application of ore microscopy in mineral technology, *P-T estimation:* Application of geothermobarometry, *Fluid inclusion study:* Principles, assumptions, limitations and applications of fluid inclusions in ores; *Isotopic ore genesis:* Role and application of stable isotopes in ore genesis.

Unit – II

Ore associations: Petrological ore associations with Indian examples, orthomagmatic ores of mafic-ultramafic association, diamonds in kimberlites, REE in carbonatites, chromite in chromitites and basic rocks, PGE in ultramafic and basic rocks; Cyprus type Cu-Zn, ore of silicic igneous rocks -Kiruna type Fe-P and Kuroko type Zn-Pb-Cu.

Ores of sedimentary affiliation: Chemical and clastic sedimentation, stratiform and stratabound ore deposits (Mn, Fe, non-ferrous ores), placer concentrations; *Ores of metamorphic affiliation:* Ores related to weathering and weathered surfaces, laterite, bauxite and manganese nodules.

Unit – III

Ore deposits: Study of geology, nature of occurrence and the genesis of the following ore deposits with special reference to India: 1. Iron ore formations and deposits, 2. Chromite deposits. 3. Manganese deposits. 4. Copper deposits. 5. Lead and Zinc deposits. 6. Bauxite deposits. 7. Magnesite deposits. 8. Barite deposits. 9. Mica deposits. 10. Asbestos deposits. 11. Dimension and decorative stones; *Mineral based Industries:* Iron and steel; *Refractories:* Ceramic, electrical and insulators, glass.

Practicals

Ore Genesis

1. Demonstration and study of ore microscope with respect to the nature of reflected light and magnifications by objectives,
2. Ore sample preparation for ore petrography: polishing, mounting and cleaning with xylene,
3. Identification, classification of textures and paragenesis of pyrite ores under ore microscope,
4. Identification, classification of textures and paragenesis of Pb ores under ore microscope,
5. Identification, classification of textures and paragenesis of sphalerite and bornite ores under ore microscope,
6. Identification, classification of textures and paragenesis of arsenopyrite and chalcocite ores under ore microscope,
7. Identification, classification of textures and paragenesis of pyrrhotite ores under ore microscope,
8. Identification, classification of textures and paragenesis of Fe ores under ore microscope,
9. Identification, classification of textures and paragenesis of Mn ores under ore microscope,
10. Identification, classification of textures and paragenesis of Cr ores under ore microscope.

Mineral Deposits

1. Megascopic description with diagnostic physical properties, identification, classification of the Fe ore minerals,
2. Megascopic description with diagnostic physical properties, identification, classification of the Mn ore minerals
3. Megascopic description with diagnostic physical properties, identification, classification of the Cr ore minerals,
4. Megascopic description with diagnostic physical properties, identification, classification of the Al ore minerals,
5. Megascopic description with diagnostic physical properties, identification, classification of the Cu ore minerals,
6. Megascopic description with diagnostic physical properties, identification, classification of the Pb ore minerals,
7. Megascopic description with diagnostic physical properties, identification, classification of the Zn ore minerals,
8. Megascopic description with diagnostic physical properties, identification, classification of the micas and asbestos,
9. Megascopic description with diagnostic physical properties, identification, classification of cassiterite, pitchblende, molybdenite, orpiment, realgar and cinnabar,
10. Megascopic description with diagnostic physical properties, identification, classification of gemstones, apatite, gypsum, fluorite, graphite, limestone, dolomite and aluminosilicates.

Books Recommended, Ore Genesis and Mineral Deposits

1. An introduction to the ore geology. By Anthony M Evans 1987 ELBS Books, Wiley Scientific Publication, New York,
2. Economic Mineral Deposits. By Bateman Alan M. and Jenson 1981, John Willey & sons,
3. Ore Deposits. By Park C.G. McDiarmid 1972,
4. The geology of ore deposits. By John M. Golbert & Charles Park: W.H. Freeman & Co New York,
5. Geology of Mineral Deposits. By Smirnov, V.I 1972 ,
6. Ore Petrology. By L. Stanton. 1972,
7. Atlas of ore minerals. By Picot:
8. Ore minerals and their intergrowths. By Ramdhor, P. Permagaon Press,
9. Plate tectonics and crustal evolution. By R.C. Kondie 1983,
10. Ore Petrography and Mineralogy. By Craig.J.M. & Vaughjan, D.J. 1981 John Wiley,
11. Metal deposits in relation to plate tectonics By Sawkins, F.J. 1984 Springer Verlag,
12. Economic Geology and Geotectonics. By Toriling, D.H. 1981. Blackwell Sci. Publ.,
13. Geochemistry of Hydrothermal ore deposits By Barnes, H.L. 1979, John Wiley,
14. Time and strata Bound Ore Deposits. By Klemm, D.D. and Schneider, H.J. 1977 , Springer Verlag,
15. Ore genesis – a Holistic approach. By Mookherjee, A. 2000 Allied publisher,
16. Ore deposits and related to structural features. By W.H. New House.

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III Semester Paper – I (GL 301 T) Mineral Exploration

Unit – I

Geological exploration: Introduction: Definition, scope and objective of geological exploration, controls of mineralization; Guides to ore deposits: Physiographic guides, lithologic guides, stratigraphic guides, structural guides and mineralogical guides.

Geologic techniques and procedures of exploration: Evaluation of outcrop, trenching, pitting, channeling; Methods of sampling; Drilling and its application: Types of drills and drill bits, core / sludge recovery, core logging; Resources and reserves: Calculation of average grade classification of ore reserves, UNFC classification.

Unit – II

Geophysical exploration: Concepts, objectives and significance of geophysical exploration; Geophysical instruments: Simple types of measuring instruments; Methods of geophysical prospecting: Field procedures and interpretation of data from various methods of geophysical prospecting including gravimetric, magnetic, electrical and radiometric methods; Logging: Well logging techniques and interpretation of data.

Unit – III

Geochemical exploration: Introduction: Definition, scope and objectives of geochemical exploration, geochemical environments, dispersion, mobility, geochemical associations, and, pathfinders and their application. Primary environment: Primary dispersions and halos. Secondary environment: Chemical weathering, significance of Eh and pH, absorption, mobility of elements in secondary environment, geochemical anomalies including significant, non-significant and displaced anomalies.

Practicals

Geological Exploration

1. Calculation of assay values of the ore deposit,
2. Calculation of tonnage by grid pattern,
3. Calculation of tonnage of vein-type ore with regular intervals,
4. Calculation of tonnage of vein-type ore with irregular intervals,
5. Study of area of influence of ore samples,
6. Estimation of restricted and non- restricted lease holds by triangular method.
7. Estimation of restricted and non- restricted lease holds by polygonal method,
8. Ore reserve estimation by geometrical method,
9. Ore reserve estimation by cross-sectional method,
10. Ore reserve estimation by graphical method.

Geophysical Exploration

1. Study of gravity map of India,
2. Geological interpretation of gravity survey data,
3. Study of magnetic map of India,
4. Geological interpretation of magnetic survey data,
5. Study of seismic map of India,
6. Study of seismic profiles of across southern India,
7. Study of seismic profiles of Bombay-high,
8. Geological interpretation of seismic survey data,
9. Electrical resistivity survey: Wenner and Schlumberger methods,
10. Plotting and interpretation of electrical resistivity survey data.

Geochemical exploration

1. Calculation of threshold value of Cu from stream sediments,
2. Calculation of threshold value of Pb from stream sediments,
3. Calculation of threshold value of Zn from stream sediments,
4. Preparation and interpretation of geochemical map of Au from data,
5. Preparation and interpretation of geochemical map of Ag from data,
6. Preparation and interpretation of geochemical map of Pt from data,
7. Preparation of cross sections and determination of local threshold, regional threshold and geochemical anomaly from the geochemical map of Cu,
8. Preparation of cross sections and determination of local threshold, regional threshold and geochemical anomaly from the geochemical map of Mn,
9. Preparation of cross sections and determination of local threshold, regional threshold, and geochemical anomaly from the geochemical map of Pb.
10. Preparation of cross sections and determination of local threshold, regional threshold and geochemical anomaly from the geochemical map of Ag.

Books Recommended

1. Ore deposits and related to structural features By W.H. New House,
2. Courses in Mining Geology By Arogyaswamy,
3. Introduction to exploration geochemistry By Levinson, A.S.,
4. Mining geology By Mckcnistry,
5. Exploration geology By Peters,
6. Geochemistry in mineral exploration By Rose, A. W., Hawkes H. E and Webb, J. S,
7. Geochemistry in mineral exploration By Govett. G. J Rock,
8. Introduction to geophysical prospecting By Dobrin, M.B.,
9. Ore deposits and related to structural features By W.H. New House,
10. Geochemistry in mineral exploration By Rose, AW. Hawkes H. E and Webb, J. S .

Paper – II (GL 302 T)

Hydrogeology

Unit – I

Hydrology: Introduction: Origin, type, age and importance of groundwater, hydrological cycle. Hydrographs, water table contour maps; Rock properties affecting groundwater: Porosity, permeability, specific yield, specific retention, hydraulic conductivity, transmissivity, storage coefficient.

Unit – II

Well hydraulics: General flow equations, steady unidirectional flow, steady radial flow to a well, unsteady radial flow in a confined and unconfined aquifer.

Water level fluctuation: Causative factors; Pumping tests: Methods of pumping tests and analysis of test data, evaluation of aquifer parameters. Recharge: Artificial recharge of groundwater, groundwater legislation.

Unit – III

Water well technology: Well types, drilling methods, construction, design, development and maintenance of wells; Exploration: Surface and subsurface geophysical and geological methods of groundwater exploration, groundwater modeling.

Ground water quality: Sources of salinity, estimation of major elements, reporting of chemical analysis; Groundwater pollution: Problems of arsenic and fluoride, groundwater quality map of India, quality criteria for groundwater use, salt water intrusion in coastal aquifers and remedial measures.

Practicals

1. Determination of flow direction of water.
2. Determination of porosity of rocks.
3. Determination of permeability of rocks.
4. Analysis and interpretation of hydrographs.
5. Estimation of infiltration capacity.

6. Chemical analysis of water.
7. Pumping test – time drawdown and time recovery tests and evaluation of aquifer parameters. Step drawdown tests.
8. Resistivity survey for groundwater exploration.
9. Study of well logs.
10. Groundwater modeling.

Books Recommended

1. Groundwater Hydrology By Todd, D. K., 1980. John Wiley.
2. Hydrogeology. Davies, S. N & De Wiest, R.J.M., 1966. John Wiley.
3. Groundwater. Freez, R. A & Cherry, J.A., 1979. Prentice Hall
4. Applied Hydrogeology. Fetter, C.W., 1990. Merrill Publishing.
5. Groundwater. Raghunath, N. M., 1982. Wiley Eastern
6. Groundwater Assessment-Development and Management. Karanth, K.R., 1987. Tata McGraw Hill
7. Regional Groundwater Quality. Alley. W. M., 1993:. VNR, New York.
8. Water. Subramaniam, V., 2000. Kingston Publ. London.
9. Geophysical Prospecting for Groundwater. Shankar Kumar Nath, Hari Pada Patra and Shamsuddin Shahid., 2000. Oxford IBH Publishing Co.Pvt.Ltd., New Delhi.

Paper – III (GL 303 T)

Remote Sensing (RS) & Geographic Information Systems (GIS)

Unit-I

Aerial photography: Introduction: Definition, scope and objectives, photogrammetry definition, cameras, lenses, flight planning, scale of photographs, overlap and sidelaps. Types of aerial photographs, geometry, stereopairs and mosaics. Study and interpretation of aerial photographs. Identification of different landforms, terrain evaluation for strategic purposes, recent advancements and application.

Remote Sensing: Definition, methods, scope and limitations, energy source and its interaction with atmosphere and earth features; Electromagnetic spectrum: Laws of radiation, black body radiation. Remote sensing platforms: Active and passive systems; Satellites: High level and low level satellites, geosynchronous and sunsynchronous satellites; types of sensors and scanners; Space missions: Global and Indian space missions. Resolutions: Spectral, spatial, radiometric and temporal resolutions

Unit II

Exploration programmes: IFOV, swath, satellite orbits, different satellite exploration programmes and their characteristics, LANDSAT, METEOSAT, SEASAT, SPOT, IRS. Imageries: Types of imageries, visual interpretation; GIS: Principles and application of geographic information system, introduction, definition and scope, components of GIS (hardware and software requirement for GIS application); Maps: Maps and their different features / themes / layers, map projections-different types and their properties, GIS software in use; Satellite images: Raster and vector images, digitization, topology and their attributes, overlays and analysis; Map generation and composition.

Unit-III

Database: Definition and types of database, vector and raster data and their relative merits; Data management: Data quality, data manipulation and analysis, advantages and disadvantages of database approach; GIS Project: Planning and implementation; Utility of GIS and GPS: Application of GIS and GPS, advantages, uses in different fields.

Practicals

Remote Sensing

1. Study of Satellite data; Digital image techniques; Software etc
2. Interpretation of satellite images – False Colour Composites.
3. Visual image interpretation and extraction of thematic layers.
4. Identification of structures and lineaments.
5. Delineation of land forms, study of geomorphology and hydrogeomorphology.
6. Study of land use and land cover and demarcation of drainage basin.
7. Identification of rock types and minerals.
8. Integration of various thematic layers, ground truthing.

9. Aerial photo interpretation: scale, height, and slope from aerial photos; study of inclined and vertical photographs.
10. Report writing for reconnaissance survey; detailed survey and targeting.

Geographic Information System (GIS)

1. Introduction to computers, data input devices, key board, scanner, output devices, monitor, printer and plotter.
2. Auto-CAD, digitization techniques, Auto-CAD software, import of images, creation of layers, digitization etc.
3. GIS, softwares, ARC INFO, ARC-GIS, ILWIS.
4. Exploring and planning data sets for GIS.
5. Preparing data sets for input in GIS environment.
6. Integration of spatial and temporal data
7. Analysis and manipulation of data in GIS.
8. Graphical representation of data.
9. Modeling and extrapolation of data.
10. Report writing.

Books Recommended

Remote Sensing & GIS

1. Analysis of landforms By Twidale, C.R., 2. Photogrammetry by Moffitt, F.H and Mikhail, E.M., 3. Photogeology by Miller and Miller, 4. Elements of Photogrammetry By Wolfe, P.R., 5. Aerial photography and image interpretation for resource management by Pandey, S.N., 6. Remote sensing and GIS By Anji Reddy, 7. Remote sensing and image interpretation By Lillesand and Kiefer, 8. Image interpretation in Geology. By Drury, S.A., 9. Image interpretation By Lender, 10. Remote sensing in geology By Gupta, R.P., 11. Remote sensing – Principles and applications By Sabins, F.F., 12. Geographic Information Systems By Stan Arnoff., 13. Principle of Geographical Information Systems for Earth Resources Assessment. By Burrough, P.A.

Paper – IV (GL 304 T) Disaster Management

Unit – I

Introduction: Disasters, Types, Natural Disasters, Impact of disasters on environment, Infrastructure, Livestock, Human, Housing, Communication, Food, Shelter, Medicine. Rehabilitation hazards, Vulnerability, Risk analysis (assessment of hazard, nature of vulnerability), Basic Principles and elements of disaster mitigation, Disaster management, organization and methodology, cost benefit considerations, Progress in International disaster, reduction and mitigation.

Unit – II

Earthquakes: Introduction to earthquakes, Earthquake prediction, Intensity scales, Seismic activity in India, Earthquakes in A. P., Action plan for Earthquakes, visibility of earthquake situation, Actions to be taken before earthquake, Do'' & Don'ts after and during Earthquakes action during Earthquakes, Recovery and rehabilitation after earthquake.

Unit – III

Floods: Flood mitigation practice, flood management and community perspectives, (Flood control – disaster management, A study in cost benefit analysis), Vulnerability analysis, Risk assessment, Action to be taken before, after and during floods, Recovery and rehabilitation after floods, Visibility of flood situation, Psychological factors, Cyclone management in coastal area.

Drought, Characteristics of drought, Impact on environment, economy, contingency action plans, cost benefit analysis, vulnerability studies. Cost studies in disaster management of floods, Earthquakes, Wind and drought disasters, Relief operations to mitigation approach of natural disaster, i.e. floods, earthquakes, drought and cyclones.

Books Recommended

Disaster Mangement

1. Vinod K. Sharma (1999) Disaster Management. National Centre for Disaster management, IIPe, New Delhi,
2. Alexander David (1993) Natural Disaster, UCC Press, London.
3. Kathkali S Bagchi (1991) Problems and Perspectives –Drought Prone India. New Delhi,

Paper – IV (GL-S) 304 T) Watershed Management

Unit – I

Introduction: Definition, concepts of watershed; *Effects of watershed on community:* a) topography b) channel networks c) geology and soils d) vegetation and landuse; *Soils:* Types of rocks, weathering of rocks, factors of soil formation, soil forming processes, soil profile, physical properties, types of the soils in India; *Soil erosion:* Basic processes, factors affecting soil erosion, types of soil erosion; *Watershed development:* Land capability classification, concept, objectives and need for watershed development.

Unit – II

Hydrologic processes: Hydrologic cycle, precipitation (liquid / solid), interception, evaporation and transpiration, infiltration and run-off; *Participatory rural appraisal (PRA) in watershed programme:* Basic principles, assumptions, basis, important types, benefits, tools, maps and models of PRA programmes; *Erosion control measures on agricultural land:* Contour cultivation, contour bunding, graded bunds, bench terracing, grassed water ways; *Mechanical erosion control measures for non agricultural land:* Contour trenching, gully control measures, vegetative control measures, checkdams, brush dams, semi permanent gully, control structures, permanent control structures.

Unit - III.

Water conservation and Harvesting: Rainwater harvesting, catchment harvesting, harvesting structures, soil moisture conservation, check dams, artificial recharge, farm ponds, percolation tanks; *Groundwater management in watershed:* Types of aquifers, vertical distribution of groundwater, conjunctive use of surface and use of groundwater; *Remote sensing,* thematic maps, geological and hydrogeological maps.

Ecosystem Management: Role of ecosystem, crop husbandry, soil enrichment, inter-, mixed- and strip-cropping, cropping pattern, sustainable agriculture, bio-mass management, dryland agriculture, Silvopasture, horticulture, social forestry and afforestation; *Grassland management,* Joint forestry management Monitoring and evolution of watershed; *planning of watershed management activities:* Preparation of action plan, administrative requirements.

Books Recommended

Watershed Management

1. Watershed Management by JVS Murthy, - New age International Publishers.
2. Water Resource Engineering by R.Awurbs and WP James, - Prentice Hall Publishers.
3. Integrated watershed management – Rawat publications by – Rajesh Rajora.
4. Land and Water Management by VVN Murthy, - Kalyani Publications.
5. Irrigation and Water Management by D.K.Majumdar, Printice Hall of India.

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IV Semester

Paper – I (GL 401 T) Environmental Geology

Unit – I

Fundamental concepts of Environmental Geology-Environmental geoscience—its scope, objectives, and aims. Earth's thermal environment and Climates. Global warming. Greenhouse effect. Ozone depletion—Ice sheets and fluctuation in sea levels. Concepts of ecosystem. Earth's major ecosystems terrestrial and aquatic. Meteorology as environmental science. Earth resources – Air pollution sources, Ambient, Workplace, and Pollution due to dust, waste disposal. National and International standards. Environmental health hazards.

Unit – II

Mining, opencast, underground, solid waste, generation, dumping stacking, rehandling, management, mineral processing, tailing ponds, acid mine drainage, siltation, case studies Mining below water table, mine water discharges, regional effects on water regime. Noise levels- national standards, mining machinery, ill effects. Air sampling techniques – respirable dust samplers, high volume air samplers, personal sampling pumps, weather monitoring equipments, automatic recorders. Fundamental concepts—of geological hazards and crisis management.

Unit – III

Elements of Environmental Impact Assessment – impacts, primary, secondary, prediction, assessment, base-line data generation, physical, biological, cultural, socio-economic aspects. Carrying capacity based developmental planning – Assimilative capacity – supportive capacity – Resource based planning – Institutional strategies. Concept of EHIA, Concept of Regional Environmental Assessment (REA) – Strategic Environmental Assessments (SEA) – Its relevance to Indian Mining Industry. Sustainable Developmental Planning - Applications of GIS in Environmental Management.

Environmental Legislation – Air Act, Water Act, Environmental Protection Act, Environmental Protection Rules, Hazardous Waste Management Rules, Forest Act, Wildlife Act, Factories Act, Mines Act, Mineral Conservation & Development Rules, Metalliferous Mines Regulations, Coal Act etc.

Practicals

Environmental Geology

1. Drainage basin analysis and terrain features evaluation based on topsheet and satellite imageries.
2. Preparation of rose diagram.
3. Preparation of ergograph, relative humidity, temperature, rainfall data interpretation.
4. Field survey techniques in environmental sampling, base-line data generation.
5. Water quality monitoring, collection of water samples and analysis.
6. Electrochemical methods and volumetric analysis for few parameters.
7. Air quality monitoring, demonstration of instruments, collection of air samples and analysis.
8. Noise level monitoring, dispersion models.
9. Environmental impact assessment (EIA).
10. Environmental management plan (EMP).

Books Recommended

Environmental Geology

1. Environmental Geology - Indian Context By Valdiya, K. S. 1987. McGraw Hill Publ.
2. Environmental Geology By Keller, E. C. Bell and Howell, Columbus.
3. Environmental Concerns and Strategies By Khoshoo, T. L. 1988. Ashish Publ., New Delhi.
4. Environmental Geology By Bennett, M. R. B., Doyle, P. 1997. John Wiley & Sons, New York.
5. Environmental Geology –Geoecosystems Protection in Mining Areas. Rekha Ghosh and D. S. Chatterjee. Capital Publ. Co., New Delhi.
6. Environmental Assessment Source Book 1991 Vol. I, II & III. Environment Department, The World Bank, Washington DC.
7. Pollution and Health By Ray, P. K. and Prasad, A. K. 1995. Wiley Eastern Publ., New Delhi.
8. Principles of Environmental Sampling By Keith, L. H. 1996. ACS Professional Reference book, Amer. Chem. Soc., Washington DC.

Paper I GL (S) 401 T

Chemical Geology

Unit – I

Introduction: Petrological nomenclature of major element oxides, abundance of major elements in the continental crust, Chemical analysis of rocks: A summary on how rocks are analysed, sampling methods, sample preparation; Instrumentation: XRF (X-Ray fluorescence), EPMA (Electronprobe microanalysis), AAS (atomic absorption spectroscopy), ICPMS (inductively coupled plasma mass spectrometry); Whole rock chemical compositions: Major and trace elements including rare earth element (REE) distribution in typical igneous rocks such as granite, nepheline syenite, gabbro, anorthosite, dunite, pyroxenite, carbonatite, lamprophyre and basalt; Reflection of petrochemistry in mineralogy; Chemical indexes: Silica content, principle of silica saturation, alumina saturation, agpaitic coefficient, agpaicity and miaskicity; Variation diagrams: Binary and ternary variation diagrams for major and trace elements, characteristic REE patterns of important igneous rocks.

Unit – II

Petrological model for upper mantle: Mineralogy, chemical composition, evidences from xenoliths in kimberlites, evidences from xenoliths in alkali basalts, evidences from xenoliths in meteorites, high P-T experiments; Partial melting processes: Normal state of mantle, P-T conditions necessary for the onset of partial melting, causes of partial melting, types of partial melting, trace element behaviour; Trace elemental fractionation: Geochemical fractionation of trace elements in magmatic processes, REE in igneous petrogenesis; Nature of melts: Basaltic magma spectrum in relation to partial melting, primary magma spectrum, definitions of primary, parental and primitive magmas, eutectic nature of the melts.

Unit – III

Igneous petrogenesis and global tectonics: Geochemical criteria for identification of paleotectonic settings, tectonomagmatic discrimination diagrams; Petrography and chemical composition of magmas from constructive plate margins; Chemical composition of erupted magmas; Petrography and chemical composition of magmas from destructive plate margins; Chemical compositions of island arc volcanic rocks; Chemical compositions of continental flood basalt provinces; Chemical compositions of magmas in continental rift zones.

Chemical petrology of igneous complexes: Petrology, petrogenesis of the following igneous complexes: Elchuru and Purimetla nepheline syenite complexes, Ravipadu gabbro-anorthosite pluton, Wajrakarur kimberlite pipes, Lamprophyres of Prakasam alkaline province, Lamproites and carbonatites of southern India.

Practicals

Chemical Geology

1. Plotting and interpretation of WR chemical data against Harker's and Nockold's indices.
2. Plotting and interpretation of WR chemical data against Thornton and Tuttle's index.
3. Plotting and interpretation of WR chemical data against Macdonald's fractionation Index.
4. Plotting and interpretation of WR chemical data against Kuno's Solidification Index.
5. Plotting of WR chemical data in AFM and Ca-Na-K diagrams and study of liquid-lines of descent of tholeiitic and calc alkaline suites.
6. Preparation of chondrite-normalised REE patterns for fractionated and accumulated rocks.
7. Plotting and interpretation of tectonomagmatic discrimination diagrams based on trace elements including Ti-Mn-P, Nb-Zr-Y and Hf-Th-Ta variations.
8. Modeling igneous petrogenesis by partial melting.
9. Preparation and deciphering tectonic settings from multi-element spidergrams.
10. Calculation of ages of rocks from radiogenic isotope data.

Books Recommended

Chemical Geology

1. Igneous petrogenesis -a global tectonic approach (1989) M. Wilson Unwin Hyman Ltd.,
2. By Using geochemical data; evaluation, presentation and interpretation (1992) H.Rollinson.,
3. Igneous petrology - Developments in Petrology, C.J. Hughes (No.7). Elsevier Publications,
4. Igneous petrology – Middlemost, 5. Igneous Petrology – Antony Hall,
6. Igneous and Metamorphic Petrology- Best,
7. Introduction to Petrology- P.J.Wyllie, Prentice Hall,
5. Petrology – V. Hyndman Ed II,
8. The evolution of Igneous Rocks – N.L.Bowen, Princeton University Press,
9. Granite Petrology and Granite Problem – Marino V.Elsevier,
10. Natural History of Igneous rocks – Harker A.Mc.Millan,
11. Basalts Vol I and II Poldervaart and Hess, H.H.,
12. Ultramafic rocks – Wyllie, P.J.Heffer,
13. Petrography, An introduction to the study of rocks in thin sections - Howell, William and Turner, W.H.Freeman,
14. Principles of Geochemistry by B. Mason and C. B. Moore.

Paper – II (GL 402 T)

Mining Geology & Engineering Geology

Unit - I : Mining Geology: Introduction: Definition, basic concepts, terminology, broad classification of mining methods, planning, exploration and exploratory mining of surface and underground mineral deposits; Geological factors considered for the selection of mining method viz.- Alluvial / Surface mining, Quarrying, Open-cast mining, and Underground mining methods; Geological conditions for- Types of openings, their position, shape and size -adits, inclines, shafts, levels, cross-cuts, winzes and raises. Types of drilling methods.

Unit – II : Alluvial mining / placer mining methods – panning, batea, sluicing, longtom, hydraulicking, dredging and fore poling; Quarrying – controls of topography, structural features and methods of working; Opencast / open pit / pit mining – Methods – bench cut, glory hole, strip mining. Factors considered for mechanization and transportation. Advantages and disadvantages; Underground mining methods for epigenetic and bedded deposits, advance and retreat mining, shaft sinking, drifting, crosscutting, winzing, stopping, top-slicing, sub-level caving and block caving. Production and retreat stages, bord and pillar, room and pillar, long wall mining. Mine supports-factors considered for types of supports used. Mine ventilation- planning, its significance and effects; Drainage- planning, its significance and its effect. Mining hazards: mine inundation, fire and rock burst; Mines & Minerals Regulation & Development Act, Mineral Concession Rules, Procedure for grant of mining leases, mining plan preparation and mine closure plans.

Unit – III : Engineering Geology: Physico-mechanical properties of rocks-porosity, water absorption, specific gravity, abrasive hardness, compressive strength, tensile strength, shear strength, Modulus of elasticity; Physical characters of building and decorative stones, concrete aggregates; Road aggregates. Engineering properties of soils. Groundwater implications on civil engineering constructions.

Types of dams. Geological considerations for the selection of dam sites. Case histories of some major dams. Geological considerations and investigations in reservoir site selection, leakage problems and silting of reservoirs. Geological considerations in the selection of tunnels and their alignment. Soil and rock slope failures—causes, effects, and stabilization techniques.

Practicals

Mining Geology

1. Determination of direction and dip of sub-surface mineral deposit
2. Determination of persistence of coal seam at depths.
3. Determination of true dip based on apparent dips.
4. Determination of true dip and direction of the mineral in a quarry face.
5. Determination of vertical thickness of dipping mineralization in different directions.

6. Determination of true dip, dip direction, thickness and distance of outcrop from the nearest borehole.
7. Estimation of reserves in underground mine using borehole data.
8. Alignment of adit, shaft and incline in a moderately dipping ore body and in a steeply dipping ore body
9. Mine Planning – Open-cast mining exercise on geological section.
10. Mine Planning – Underground mining exercise on geological section.

Engineering Geology

1. Preparation of rock specimen for laboratory testing as per the method of IS: 9179 (1979),
2. Determination of unconfined compressive strength of some important rocks as per the method of IS: 1121, Part I (1974) and IS: 13030 (1991)
3. Determination of water absorption, apparent specific gravity and porosity of some important rocks as per the method of IS: 1974,
4. Determination of tensile strength of rocks by indirect test – Brazilian Test as per IS: 10082 (1981),
5. Determination of aggregate abrasion value as per the method of IS: 2386, Part IV (1963),
6. Petrographic examination of aggregates for concrete as per the method of IS: 2386, Part VIII (1963),
7. Calculation of shear strength of rocks,
8. Study and interpretation of geological maps pertaining to the major dam sites of India,
9. Study of Geotechnical Map of India published by GSI,
10. Study of geological maps pertaining to some important Indian tunnels.

Books Recommended

1. Mining geology. Mckenistry.
2. Mineral deposit Modelling By R.V. Kirkham and W.D. Sinclair, R.I. Thorpe and J.M. Duke. Geological association of Canada special paper 40 1997.
3. Principles of Mine Planning By Jayanth Bhattacharya. Allied Publ.
4. Mining Geology By R. N. P. Arogya Swamy.
5. Techniques in Underground Mining By Richard E. Gertsch and Richard L. Bullock. Society for Mining, Metallurgy and Exploration Inc. Littleton Co., USA.
6. Geology for Engineers By F.G.H. Blyth Defritas.
7. Geology for Engineers By Trefthen.
8. Engineering Geology and Geotechnics By F. G. Bell. Butterworth Publ. 1980.
9. Engineering Geology By Krynine and Judd.
10. Geology for Engineers By D.S. Arora.

Paper – III (GL 403 T)

Mineral Economics and Fuels

Unit – I

Mineral Economics: Introduction: Definition-mining_lease and regulations in brief; National mineral policy, conservation of minerals. Renewable and non-renewable resources. Recoverable reserves. Status of India in Mineral Resources.

Unit – II

Atomic Fuel: Mode of occurrence and association of atomic minerals in nature. Atomic minerals as source of energy, Methods of prospecting and productive geological horizons in India. Beach sand deposits of India; Nuclear power plants of the country and future prospects. Atomic fuels and environment.

Unit – III

Coal: Origin of Coal-drift and insitu theories. Brief sedimentology of coal bearing strata. Rank, grade and type of coal. Indian and international classifications. Chemical characterization: proximate and ultimate analyses. Concept of ‘maceral’ and ‘microlithotypes’. Coal forming epochs in the geological past. Geological and geographical distribution of coal deposits in India. Detailed geology of Son-Damuda-Mahanadi- Godavari coalfields.

Methods of coal prospecting and estimation of coal reserves; Coal production and problems of coal industry in India; Coal bed methane: a new energy resource. Maturation of coal and generation of methane in coal beds. Coal as reservoir. Fundamentals of coalbed methane exploration and production. Principles of Coal petrology. Preparation of coal for industrial purposes, coal carbonization (coke manufacture), coal gasification and coal hydrogenation.

Books Recommended

1. Text Book of Coal (Indian Context) By Chandra, D., Singh, R.M. and Singh, M.P., 2000 Tara Book agency, Varanasi
2. Coal and Organic Petrology. By Singh M.P. 1998, Hindustan Publication Corporation New Delhi.
3. Text Book of Coal Petrology By Stach,E. Mackowsky, M.T.H. Taylor G.H., Chadra, D., Teichmuller, M., and Teichmuller, R., 1982 By Bebruder Borntraeger, Stuttgart.
4. Geochemical Prospecting for Thorium and Uranium Deposits By Boyle, R.W. 1982 Elsevier

Paper IV, (GL 404 T) CB1

Mineral Chemistry

UNIT-I

Ortho- and ring silicates: Mineral chemistry and paragenesis of olivines: Mg- and Fe-rich olivines. Phase relations in MgO-SiO₂ system and stability of Fo. Mineral chemistry of olivines from south India. Mineral chemistry and paragenesis of zircon and garnet.

UNIT-II

Chain silicates: Mineral chemistry and paragenesis of ortho- and clinopyroxenes: enstatite-orthoferrosilite, diopside-hedenbergite, augite-ferroaugite-aegirine augite. Distribution of Mg-Fe between coexisting pyroxenes-K_D. Mineral chemistry of Fe-rich ortho- and clinopyroxenes from south India with special reference to Andhra Pradesh.

Mineral chemistry and paragenesis of amphiboles: hornblende, glaucophane-riebeckite, arfvedsonite and aenigmatite. Mineral chemistry of amphiboles from charnockites of Kondapalli.

UNIT-III

Sheet silicates: Mineral chemistry and paragenesis of micas: biotite, muscovite and phlogopite. Stability curves of muscovite. Variation of chemical composition of phlogopite and biotite in different igneous rocks. Mineral chemistry of phlogopites from gabbros of Ravipadu.

Framework silicates: Mineral chemistry and paragenesis of feldspars: alkali feldspars and plagioclase series. Solid solution in feldspars. A review of plagioclase compositions of the Precambrian anorthosites from Peninsular India.

UNIT-IV

Mineral chemistry and paragenesis of silica minerals (quartz-tridymite-cristobalite-coesite), colour of quartz as function of chemical composition. Mineral chemistry and paragenesis of feldspathoids: nepheline, leucite and sodalite. Liquidus relationships in a part of the system NaAlSiO₄-KAlSiO₄-SiO₂-H₂O at PH₂O=1 kb. Mineral chemistry of nephelines from nepheline syenites of the Eastern Ghats belt. Oxides: Mineral chemistry and paragenesis of spinel group.

Books Recommended

1. Deer, W. A., Howie, R. A. and Zussman, J. (1985) An Introduction to the Rock-forming Minerals. English Language Book Society (ELBS)-Longman Publ., London.
2. Philpotts, A. R. (1989) Petrography of igneous and Metamorphic Rocks. Prentice-Hall Publ., New Jersey.
3. For case histories refer to relevant literature in books / professional journals.

Paper IV (AGL 404 (S) T) CB2: Precambrian Geology and Crustal Evolution

Unit I

Tectonic divisions of India. Cratons: Stratigraphy, geochronology and evolution of cratonic nuclei including Dharwar, Bastar, Sighbhum, Bundelkhand and Aravalli cratons. Granite-greenstone belts: Lithological, geochemical and stratigraphic characteristics of granite-greenstone belts of southern India.

Mobile belts: Structure, metamorphism, zonation and evolution of the Eastern Ghats, Pandyan, and Satpura mobile belts. Precambrians of the Himalayas.

Unit II

Proterozoic sedimentary basins: Palaeoproterozoic basins: Structure, lithology and evolution of Papaghani, Bijawar, Sonrai, Gwalior, Abujmar basins. Meso-Neoproterozoic basins: Structure, lithology and evolution of Cuddapah, Vindhyan, Pranhita-Godavari, Pakhal, Kaldgi, Bhima, Chhattisgarh, Khariar, Indravati and Sabari basins. Boundary problem: Precambrian-cambrian boundary with special reference to India.

Unit III

Precambrian igneous intrusions: Locations, associated rock types and ages of the Precambrian anorthosites, alkaline rocks and carbonatites in coastal- and southern granulite terrains. Precambrian igneous intrusions in Purana basins: Locations, associated rock types and ages of igneous rocks in Vindhyan, Khariar, Indravathi and Cuddapah basins. Evolution: Evolution of lithosphere, hydrosphere, atmosphere, biosphere and cryosphere. Life in Precambrian.

Books Recommended

1. Ramakrishnan, M and Vaidyanathan, R. (2010) Geology of India (Vol.1) Geological Society of India, Bangalore, 552pp
2. Vaidyanathan, R. and Ramakrishnan, M. (2010) Geology of India (Vol.2) Geological Society of India, Bangalore, 438pp.
3. Naqvi, S. M. and Rogers, J. J. W. (1990) Precambrians of South India. Geological Society of India, Bangalore, Mem.4.
4. Radhakrishna, B.P. and Ramakrishnan, M. (1983) Archaean Greenstone belts of South India, Mem.19, (Eds.) Geological Society of India, Bangalore.
5. Pitchamuthu, C.S. (1985) Archaean Geology. Oxford and IBH Publ.

ANNEXURE -I
Model Template for Internal Assessment

Max Marks: 30

1st Internal Assessment (15 Marks)	2nd Internal Assessment (15 Marks)
<ul style="list-style-type: none">1) 10 Questions - ½ Marks each MCQ – 5 Marks2) 10 Questions – ½ Mark each Fill in the blanks – 5 Marks.3) Short answer questions 5 Questions- 1 Mark each. - 5 Marks.	<ul style="list-style-type: none">1) Report Writing/ Assignment (or) Paraphrasing /Book Review/ Article review/Reflective Journal – 10 Marks2)one Seminar Presentations- 5 Marks

MODEL QUESTION PAPER (THEORY)
M. Sc. Geology
(I, II, III & IV Semester Examinations)
Papers – I, II, III, and IV

Time: 2¹/2Hrs

Max. Marks: 50

Note: Answer all questions from Part A and Part-B.
Each question carries 2 marks in Part-A and 8 marks in Part-B.

Part-A (5 x 2 = 10 Marks)
(Short Answer Type)

1. Unit I
2. Unit I
3. Unit II
4. Unit II
5. Unit III

Part-B (5 x 8 = 40 Marks)
(Essay Answer Type)

6. Question No. 6: Application of Fundamental Concepts

- a. Question – 1 - Application - 6 Marks
- or**
- b. Question – 2 - Analysis - 6 Marks

7. Question No. 7: Critical Thinking

- a. Question – 1 - Analysis - 6 Marks
- or**
- b. Question – 2 - Evaluation - 6 Marks

8. Question No. 8: Practical Problem Solving

- a. Question – 1 - Application - 6 Marks
- or**
- b. Question – 2 - Synthesis - 6 Marks

9. Question No. 9: Case Study Examination

- a. Question – 1 - Analysis - 6 Marks
- or**
- b. Question – 2 - Evaluation - 6 Marks

10. Question No. 10: Synthesis of Knowledge

- a. Question – 1 - Synthesis - 6 Marks
- or**
- b. Question – 2 - Evaluation - 6 Marks

M. Sc (Geology) Syllabus

Continuous and Comprehensive Evaluation (CCE)
As per Choice Based Credit System
with effect from 2023-2025



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