M.Sc. (Geology)
Two Years (Four Semester Course)
SYLLABUS
w.e.f. SESSION 2017-18

Centre of Advanced Study
Department of Geology
Banaras Hindu University
Varanasi 221005
M.Sc. (Geology) REVISED SYLLABUS, SEMESTER SYSTEM w.e.f. SESSION 2017-18

Candidates who have passed the three year B.Sc. (Hons.) examination of the Banaras Hindu University or any other equivalent examination of other universities with Geology as one of the subject will be considered eligible for admission to the Four Semester M.Sc. course in Geology.

The M.Sc. course in Geology shall be imparted to the students for two academic sessions consisting of four semesters as given below. Candidates will be examined and evaluated on grade basis at the end of each semester in the different courses of theory and practical as per the credits given against each course. The M.Sc. Geology will consist of (a) Core Courses (b) Major Elective Courses and (c) Minor Elective Courses.

(a) The Core courses will be compulsory for all the students admitted to M.Sc. Geology. There will be fourteen core courses covering major branches of Geology and two sessions of two to three weeks of geological field training and viva-voce examination in the field. The attendance in the geological field training will be compulsory for all the students. The field training and viva-voce examination will be conducted by at least two internal examiners (faculty members) during first and third semesters. For the geological field training 2 credits (70 marks) shall be assigned to evaluation of the report while 1 credit (30 marks) shall be assigned to viva-voce examination in the field. The semester breaks can also be utilized for the geological field training. After the field training, the students will be required to submit a detailed field report to the concerned teachers for evaluation.

(b) The Core and the Major Elective Courses shall be part of the Project Oriented Dissertation in a specialized field of Geology. The area of Dissertation shall be assigned to the students before the commencement of the classes for the first semester based on the merit of PET and the choice the students and expertise available in the Department. The Project oriented Dissertation must be submitted by the end of fourth Semester with a Seminar presentation in the presence of faculty members and the board of examiners for the purpose of evaluation. During the course of completion of the Dissertation work the students will be required to complete various assignments given to them by their respective supervisors for the purpose of their evaluation. The dissertation shall be of 8.5 credits (250 marks). The distribution of credits and marks will be as under:

(i) Dissertation Evaluation of 5 credits (equivalent to 150 marks) by the supervisor.

(ii) Seminar presentation and viva-voce of 3.5 credits (equivalent to 100 marks) by the Board of Examiners and one External Examiner.

(c) The students shall select the Major and Minor Elective Courses after the end of 2nd Semester and 3rd Semester. They have to select one major elective in semester III and two major and one minor electives and complete the Project Oriented Dissertation in semester IV.

Marks for theory and practical examinations shall be as per the following.

<table>
<thead>
<tr>
<th>Exam. Components</th>
<th>Marks for Semester Exam.</th>
<th>Sessional (Theory) Mid Semester Test + class assessment/presentation/quiz</th>
<th>Sessional (Practical) Intra-semester practical assessment/assignment + class assessment/presentation/quiz</th>
<th>Total Marks</th>
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<tbody>
<tr>
<td>Theory</td>
<td>70</td>
<td>30 (20+10)</td>
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<td>100</td>
</tr>
<tr>
<td>Practical</td>
<td>70</td>
<td>-</td>
<td>30 (20+10)</td>
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## Syllabus Structure of M.Sc. 2 years Geology Course

### SEMESTER-I

<table>
<thead>
<tr>
<th>Course No.</th>
<th>Core Courses</th>
<th>Credit for</th>
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<tbody>
<tr>
<td>GLM 101</td>
<td>Structural Geology</td>
<td>2</td>
</tr>
<tr>
<td>GLM 102</td>
<td>Mineralogy, Optical mineralogy &amp; Crystallography</td>
<td>2</td>
</tr>
<tr>
<td>GLM 103</td>
<td>Igneous Petrology</td>
<td>2</td>
</tr>
<tr>
<td>GLM 104</td>
<td>Sedimentology</td>
<td>2</td>
</tr>
<tr>
<td>GLM 105</td>
<td>Metamorphic Petrology &amp; Thermodynamics</td>
<td>2</td>
</tr>
<tr>
<td>GLM 106</td>
<td>Practical connected with GLM101</td>
<td>1.5</td>
</tr>
<tr>
<td>GLM 107</td>
<td>Practical connected with GLM102</td>
<td>1.5</td>
</tr>
<tr>
<td>GLM 108</td>
<td>Practical connected with GLM103</td>
<td>1.5</td>
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<tr>
<td>GLM 109</td>
<td>Practical connected with GLM104</td>
<td>1.5</td>
</tr>
<tr>
<td>GLM 110</td>
<td>Practical connected with GLM105</td>
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</tr>
<tr>
<td>GLM 111</td>
<td>Geological Field Work</td>
<td>3</td>
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### SEMESTER-II

<table>
<thead>
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<th>Core Courses</th>
<th>Credit for</th>
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<tbody>
<tr>
<td>GLM 201</td>
<td>Geomorphology &amp; Geotectonics</td>
<td>2</td>
</tr>
<tr>
<td>GLM 202</td>
<td>Geochemistry</td>
<td>2</td>
</tr>
<tr>
<td>GLM 203</td>
<td>Stratigraphy</td>
<td>2</td>
</tr>
<tr>
<td>GLM 204</td>
<td>Micropaleontology &amp; Oceanography</td>
<td>2</td>
</tr>
<tr>
<td>GLM 205</td>
<td>Ore Geology</td>
<td>2</td>
</tr>
<tr>
<td>GLM 206</td>
<td>Practical connected with GLM201</td>
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<tr>
<td>GLM 207</td>
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<td>GLM 209</td>
<td>Practical connected with GLM204</td>
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<tr>
<td>GLM 210</td>
<td>Practical connected with GLM205</td>
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<tr>
<td>GLM 211M</td>
<td>Minor Elective-Earth System Frontier Areas <em>(For students for other P.G. Programme)</em></td>
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### SEMESTER-III

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<tr>
<td>GLM 301</td>
<td>Fuel Geology</td>
<td>2</td>
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<tr>
<td>GLM 302</td>
<td>General &amp; Invertebrate Paleontology</td>
<td>2</td>
</tr>
<tr>
<td>GLM 303</td>
<td>Hydrogeology</td>
<td>2</td>
</tr>
<tr>
<td>GLM 304</td>
<td>Remote Sensing and GIS in Geology</td>
<td>2</td>
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<td>GLM 305</td>
<td>Practical connected with GLM301</td>
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<td>GLM 306</td>
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<td>GLM 308</td>
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<tr>
<td>GLM 309</td>
<td>Deep Mantle Petrology</td>
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<tr>
<td>GLM 310</td>
<td>Basin Analysis</td>
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<td>GLM 311</td>
<td>Marine Geology</td>
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<tr>
<td>GLM 312</td>
<td>Practical connected with GLM309</td>
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<td>GLM 314</td>
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<tr>
<td>GLM 315</td>
<td>Geological Field training</td>
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<tr>
<td>GLM 316M</td>
<td>Minor Elective-Life through Ages <em>(For students for other P.G. Programme)</em></td>
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<tr>
<td>GLM 401</td>
<td>Environmental Geology &amp; Natural Hazard</td>
<td>2</td>
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<tr>
<td>GLM 402</td>
<td>Engineering Geology &amp; Surveying</td>
<td>2</td>
</tr>
<tr>
<td>GLM 403</td>
<td>Mineral exploration &amp; Mineral Economics</td>
<td>2</td>
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<tr>
<td>GLM 404</td>
<td>Elements of Mining &amp; Ore dressing</td>
<td>2</td>
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<td>GLM 405</td>
<td>Petroleum Exploration</td>
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<td>GLM 406</td>
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<td>GLM 410</td>
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<td>GLM 411</td>
<td>Instrumentation techniques in Geosciences</td>
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<tr>
<td>GLM 412</td>
<td>Sequence Stratigraphy</td>
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<td>GLM 413</td>
<td>Sediment &amp; Organic Matter Geochemistry</td>
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<td>GLM 414</td>
<td>Indian Mineral Deposits</td>
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<td>GLM 415</td>
<td>Soil Geology</td>
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<td>GLM 416</td>
<td>Paleobotany</td>
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**SEMMESTER-IV**

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<tr>
<td>GLM 401</td>
<td>Environmental Geology &amp; Natural Hazard</td>
<td>2</td>
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<td>GLM 402</td>
<td>Engineering Geology &amp; Surveying</td>
<td>2</td>
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<tr>
<td>GLM 403</td>
<td>Mineral exploration &amp; Mineral Economics</td>
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</tr>
<tr>
<td>GLM 404</td>
<td>Elements of Mining &amp; Ore dressing</td>
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<tr>
<td>GLM 405</td>
<td>Petroleum Exploration</td>
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<td>GLM 410</td>
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<td>GLM 411</td>
<td>Instrumentation techniques in Geosciences</td>
<td>2</td>
</tr>
<tr>
<td>GLM 412</td>
<td>Sequence Stratigraphy</td>
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</tr>
<tr>
<td>GLM 413</td>
<td>Sediment &amp; Organic Matter Geochemistry</td>
<td>2</td>
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<tr>
<td>GLM 414</td>
<td>Indian Mineral Deposits</td>
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<tr>
<td>GLM 415</td>
<td>Soil Geology</td>
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<td>GLM 416</td>
<td>Paleobotany</td>
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<tr>
<td>GLM 417</td>
<td>Vertebrate Paleontology</td>
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<tr>
<td>GLM 418</td>
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<td><strong>Total Credit</strong></td>
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**Grand Total:** 80
SEMESTER I

Course No. GLM-101: Structural Geology

Mechanical principles; Properties of rocks and their controlling factors; Concept of Stress; Two dimensional stress analyses, Theories of Rock failure.

Causes and dynamics of faulting; Strike slip faults, Normal faults, Thrust Faults, Thin skinned deformation, Decollement; Mechanics of folding and Buckling, Fold development and distribution of strain in folds; Superposed folding patterns.

Concept of Strain; Two dimensional strain analyses; Types of strain ellipses and ellipsoids- their properties and geological significance; Strain markers and methods of strain measurements in naturally deformed rocks; Brittle and ductile shear zones; Geometry and products of shear zones; Mylonites and cataclasites.

Planar and linear fabrics in deformed rocks, their origin and significance;
Stereographic and equal area projections for presenting different types of fabrics, and π and β diagrams.
Geometrical analysis of simple and complex structures on macroscopic scale
Basic idea about petrofabrics and use of Universal stage.

Course No. GLM-106: Practical Connected with GLM-101

Preparation and interpretation of Geological maps and sections;
Structural problems based on orthographic and stereographic projections;
Recording and plotting of the field data;
Study of the hand specimen of deformed structures;
Strain estimation from the data already collected from the field;
Study of dip-isogons from the fold profiles

Books Recommended:

- Fossen, H. 2010: Structural Geology, Cambridge University Press:
Course No. GLM-102: Mineralogy, Optical Mineralogy and Crystallography

Mineralogy
Structural classification of silicates. Thin section preparation techniques in mineralogy.

A detailed study of the important silicate mineral groups (listed below) with reference to general and structural formulae, classification atomic structure, polymorphs/structural states, chemistry including substitution of elements/solid solution and experimental work on pressure-temperature stability of the minerals, modes of occurrence and alterations.

a) Nesosilicates: Olivine Group, Garnet Group, Aluminosilicate Group (Kyanite, Andalusite and Sillimanite).
b) Cyclosilicates: Beryl
c) Inosilicates; Pyroxene Group; Amphibole Group.
d) Phyllosilicates: Kaolinite Group, Serpentine Group, Pyrophyllite, Talc, Mica Group, Chlorite.
e) Tectosilicate: Feldspar Group, Cordierite.

Optical Mineralogy
Optical crystallography of uniaxial and biaxial crystals, Indicatrix, pleochroism, Interference figures, crystal orientation, 2V and 2E.

Crystallography
32 crystals classes and description of the different normal classes.

Different types of crystal projections – spherical and stereographic and their uses.

Twinning and Twin Laws: common types of twins and their examples in minerals.

Space Lattice and Symmetry of internal structures – 14 Bravais Lattice. Introduction to space group.


Course No. GLM-107: Practical Connected with GLM-102

Mineralogy
Identification of rock-forming minerals in hand specimens.

Optical Mineralogy
Determination of length fast and length-slow characters of minerals
Scheme of pleochroism and absorption of a given mineral in thin section.
Determination of extinction angle and composition of plagioclase.
Study of interference figures of uniaxial and biaxial crystals, determination of optic signs.

Crystallography
Goniometer and its use in measuring interfacial angle of crystals and calculation of axial ratio.
Representation of symmetry elements of crystals belonging to 32 classes of symmetry and study of their stereograms.

Books Recommended

- Kerr, P.F (1977) : Optical Mineralogy McGrew Hill
Course No. GLM-103: Igneous Petrology


Concept of primary and secondary magma. Magma series, Dynamics, differentiation, emplacement and crystallization of the magma. Magma mixing, mingling and immiscibility.

Plume magmatism and hot spots. Mantle metasomatism. Mantle heterogeneities.

Partial melting (batch and fractional melting), crystal fractionation (equilibrium and fractional (Rayleigh) crystallization), contamination (AFC process) and dynamic melting.

The Phase equilibrium of binary (Ab-An, Ab-Or, Di-An, Fo-Si) and ternary (Di-Ab-An, Di-Fo-Si, Di-Fo-An, Ne-Ks-Si, Fo-An-Si) systems and their relation to magma genesis and crystallization in the light of modern experimental works. Interpretation of igneous textures in terms of rate of nucleation and crystal growth.

IUGS classification of the Igneous rocks. CIPW Norm.

Petrology & petrogenesis of the following igneous rocks with suitable Indian examples:
- Peridotites, komatiites, gabbros, basalts, anorthosites komatitites, ophiolites.
- Large igneous Provinces, Mafic dyke swarms, boninites and layered complexes.
- Alkaline rocks, carbonatites, kimberlites, lamproites, kamafugites and lamprophyres
- Granitoids, adakites and sanukitoids

Course No. GLM-108: Practical Connected with GLM-103

Megascopic and microscopic study of different igneous rocks.
Calculation of CIPW Norms.

Books recommended:

Course No. GLM-104: Sedimentology

Origin of sedimentary rocks. Types of sandstones and their petrogenesis; Gravacke and Gravacke problem, plate tectonics and sandstones composition. Argillaceous rocks, their classification and genesis. Volcaniclastic sediments and their characteristics. Limestone and dolomites: classification and petrography, Models of dolomitization. Study of evaporites such as gypsum, and anhydrite.

Diagenesis of sandstones, mudrocks and carbonate rocks.

Tectonic classification of sedimentary basins; Sedimentary facies and facies models with Indian analogues; Processes and characteristics of depositional environments like Fluvial, Estuarine, Deltaic, Tidal flat, Lagoonal, Barrier beach and Deep-Sea environments. Concise approach to regional unconformities, parasequences and systems tracts; Allogenic and autogenic controls on sedimentation. Introduction to Quaternary Sedimentology

**Course No. GLM-109: Practical Connected with GLM-104**

Study of Clastic and Non-clastic Rocks in Hand Specimens

Microscopic Examination of Important Sedimentary Rocks.

Grain-size Analysis by sieving Method: Plotting of size-distribution data as Frequency and Cumulative Curves; Computation of Statistical Parameters and Interpretation.

Assemblages of Sedimentary Structures and their Palaeoenvironmental significance.

Palaeocurrent Analysis.

Study of Vertical Profile Sections of some Selected Sedimentary Environment.

**Books Recommended:**


**Course No. GLM-105: Metamorphic Petrology and Thermodynamics**


Isograds and Reaction Isograds, Advantages of Reaction Isograd concept over the concept of Isograd, Schriemakers Rule and Construction of Petrogenetic Grids: their application to petrological problems, Metamorphic Differentiation, Anatexis and Origin of Migmatises in the light of experimental studies : its implications for petrological problems, Regional Metamorphism and Paired Metamorphic Belts in relation to Plate Tectonics, Pressure – temperature – time paths from a plate tectonic view.

Course No. GLM-110: Practical Connected with GLM-105

A detailed study of textures in Rock Sections with reference to time relations between the phases of deformation and recrystallization of minerals. Calculation of ACF, AKF and AFM values from chemical and structural formulation of minerals and their graphical representation. Study of Metamorphic Rocks in thin sections belonging to different facies with emphasis on texture/structure, mineral composition, parent rock, metamorphic facies/subfacies/zone to which the rock can be assigned and graphical representation of the assemblage in ACF, AKF and AFM diagrams. Study of metamorphic rocks of different metamorphic facies in Hand Specimens. Estimation of Pressure and Temperature from important models of Geothermobarometry.

Books Recommended:


Course No. GLM-111: Geological Field Training

Students will be required to carry out fieldwork for 2-3 weeks in suitable geological areas to study various aspects of field geology and submit a report thereon.

SEMESTER II

Course No. GLM-201: Geomorphology and Geotectonics

Basic concepts and significance of Geomorphology; Cycle of erosion, Fluvial landforms and drainage patterns; Evolution of landforms in Aeolian, marine, glacial and karst landscapes. An elementary idea about morphogenesis and morphography; Morphometric analysis; Morphochronology,

Neotectonics: Geomorphological indicators, active faults, drainage changes, recurrent seismicity.

Introduction to geotectonics; Continental drift, seafloor spreading and convection current hypotheses; Paleomagnetism, polar wandering and reversal of earth’s magnetic field; Geomagnetic time scale; Principal Geotectonic features: Features of the Ocean, Continent and Continental margins

Plates and plate boundaries; Principles of Plate Tectonics; Force Balance and Mantle Plume models of plate movements; Orogeny and Epeirogeny; Anatomy of orogenic Belts; Geodynamic Evolution of Himalaya

Course No. GLM-206: Practical Connected with GLM-201

Drainage and Slope Morphometry, Hypsometry, Geomorphology through topo-sheets, Geomorphology through aerial photos and satellite Imagery, Terrain aspect mapping.

Study of Geotectonics maps of major plates and their movements, mid-oceanic ridges, aseismic ridges, island arcs, trenches, subduction zones, fracture zones, hot spots and triple junctions, modern continental margins and orogenic belts; Study of plate tectonic maps of different geological times

Books recommended:

**Geomorphology:**
- Summerfield M.A 2011: Geomorphology and Global Tectonics, Wiley India Pvt Ltd.

**Geotectonics:**
- Burbank D W and Anderson R S 2016 : Tectonic Geomorphology. Wiley India.

Course No. GLM-202: Geochemistry


Sampling procedures and introduction to important analytical techniques used in geochemistry.

Stable isotope geochemistry of carbon and oxygen and its applications to Geology. Radiogenic isotopes. Decay scheme of K-Ar, U-Pb, Rb-Sr and Sm – Nd. Radiometric dating of single minerals and whole rocks. Petrogenetic implications of Sm-Nd, Rb-Sr systems.


Principles of ionic substitution in minerals. Crystal structure of some simple compounds – AX structures (NaCl, CsCl, ZnS, NiAs), AX₂ structure (Fluorite, Rutile). A brief idea about some other compounds such as A₂X₃ (Corundum), ABX₃ (Calcite, Ilmenite) and AB₂X₄ (Spinel).

Course No. GLM-207: Practical Connected with GLM-202

Rock analyses (Rapid method of silicate analysis)  
Mineral formula calculations  
Preparation of classificatory and variation diagrams and their interpretation; plotting of REE data and their interpretation.

Books Recommended:

- Gunter Faure (1977) Principles of Isotope Geology by John Wiley & Sons Ltd.

Course No. GLM-203: Stratigraphy

Approaches to measurement of geological time; Concept of sequence stratigraphy; brief ideas of magneto-seismic- chemo- and event stratigraphy and stratigraphic correlation

Precambrian geochronology; Precambrian chronostratigraphy of Rajasthan, Dharwar craton, Eastern Ghat belt, Southern Granulite belt and Singhbhum-Chotanagpur-Orissa belt; Proterozoic stratigraphy of Son valley, Cuddapah and Kurnool basins; Precambrian/Cambrian boundary.

Stratigraphy of the marine Palaeozoic rock formations of India, Permian/Triassic boundary, Classification, depositional characteristics, fauna and flora of Triassic, Jurassic and Cretaceous systems in principal basins of India.

Cretaceous/Tertiary boundary, Classification, depositional characteristics, fauna and flora of the Palaeogene and Neogene systems in their type localities and their equivalents in India; Epoch boundaries of the Cenozoic in India.
Course No. GLM-208: Practicals Connected with GLM-203

Study of rocks in hand specimens from known Indian stratigraphic horizons and type localities; Exercises on stratigraphic classification and correlation, sequence, and magneto stratigraphic interpretations.

Books Recommended:


Course No. GLM-204: Micropaleontology and Oceanography

Micropaleontology

Definition and scope of the subject; Relationship of micropaleontology with ocean sciences; Modern field and laboratory techniques in the study of microfossils (collection, sampling and processing techniques, scanning electron microscopy and mass spectrometry); A brief account of the concepts and methods for the development of micropaleontological indicators useful in reconstruction of history of past, environmental changes and biostratigraphic correlation.

Types of Microfossils. Calcareous Microfossils: (i) Foraminifera - planktic foraminifera, their modern biogeography, outline of morphology, significance in Cenozoic oceanic biostratigraphy and paleoceanographic, paleoclimatic interpretations; Benthic foraminifera - their brief morphology and application in bottom water paleoceanography and paleobathymetric reconstructions; Larger foraminifera, their outline of morphology and application in Indian stratigraphy; (ii) Calcareous nannofossils - outline of morphology, modern biogeography and their application in oceanic biostratigraphy and paleoceanographic, paleoclimatic reconstructions; (iii) Ostracoda - outline of morphology and wall structure, their significance in environmental studies and oceanic biostratigraphy; (iv) Pteropoda - a brief introduction, application of pteropods in reconstruction of the Quaternary oceanography and climate; A brief introduction of calpionellids and calcareous algae.

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

Phosphatic Microfossils: Conodonts - outline of morphology, paleoecology, geological significance and biological affinities; Stratigraphic significance of conodonts with special reference to India. Introduction to Organic walled microfossils and their biostratigraphic and palaeoenvironmental significance.

Application of Micropaleontology in hydrocarbon exploration. Geochemical study of microfossil tests (stable isotopes and elemental composition) and its application in paleoceanography and paleoclimatology and tracing history of marine pollution. Determination and correlation of paleofacies by microfossils; Interpretation of sea floor tectonism from micropaleontological evidence.

Oceanography

History of development of oceanography; Sampling of modern ocean biogenic flux including sediment trap sampling; Methods of measuring properties of sea water; Temperature and salinity distribution (horizontal and vertical) in ocean waters; Dissolved gases in sea water, factors affecting the concentration of gases in sea water; Carbon dioxide equilibria, precipitation and dissolution of carbonates; Biological - chemical - physical interactions in the oceans; Oxygen minimum layer in the ocean. Ocean circulation, surface circulation; Concept of mixed layer, thermocline and pycnocline, Coriolis force and Ekman spiral, upwelling, El nino, deep ocean circulation, concept of thermohaline circulation, formation of bottom waters, water masses of the world oceans.
Course No. GLM-209: Practicals Connected with GLM-204

Techniques of separation of microfossils from matrix; Types of microfossils - calcareous, siliceous, phosphatic and organic walled microfossils; SEM applications in micropaleontology; Study of surface ultrastructures of foraminifera; Study of important planktic foraminifera useful in surface water, paleoceanography and oceanic biostratigraphy; Study of larger benthic foraminifera useful in Indian stratigraphy with special reference to Cenozoic petrolierous basins of India; Important palynomorphs of Cretaceous and Paleogene age.

Depth biotopes and estimation of paleoldepth of the ocean using benthic foraminiferal assemblages; Identification of modern and ancient surface water mass with the help of planktic foraminiferal assemblages; Identification of benthic foraminifera characteristic of Low oxygen environment; Identification of Planktic foraminifera characteristic of warm and mixed layer, thermocline and deep surface water of the modern oceans; Study of modern surface water, mass assemblages of planktic foraminifera from Indian ocean, Atlantic ocean and Pacific ocean.

Books recommended:


Course No. GLM-205: Ore Geology

Concept of ore bearing fluids, their origin and migration; Wall rock alteration; Structural, physicochemical and stratigraphic controls of ore localization; Ore deposits in relation to plate tectonics; Organic matters in ores and their significance; Fluid inclusions in ore - principles, assumptions, limitations and applications.

Mineralogy, classification and genesis of ore deposits associated with orthomagmatic ores of ultramafic-mafic rocks; Ores of felsic-silicic igneous rocks; Ores of sedimentary affiliation - biochemical, chemical and clastic sedimentation, placers and residual concentration deposits; Ores of metamorphic affiliations.

Study of ore minerals related to the following metals with special reference to their mineralogy, genesis, specification (if any), uses and distribution in India: Fe, Mn, Cr, Cu, Pb, Zn, Al, Mg, Sn, and W.

Introduction to ore microscopy, techniques, methods, textures and microstructures of ores, interpretation of ore texture and optical properties of common sulphide, oxide ore minerals; Industrial application of ore microscopy.

Course No. GLM-210: Practicals Connected with GLM-205

Megascopisc study of Indian metallic ores and industrial minerals in hand specimens; Study of ore structures in hand specimens; Study of optical properties and identification of important ore minerals under ore-microscope; Preparation of maps showing distribution of metallic and industrial minerals in India and also classical world mineral deposits.

Books Recommended:

- Branes, H.L. (1979): Geochemistry of Hydrothermal Ore Deposits, John Willey.
Course No. GLM-211M: Earth System – Frontier Areas (minor elective for students of other P.G. Programmes)

Geology and its perspective; Earth in the solar system - origin, size, shape, mass, density; Formation of core, mantle, crust, hydrosphere, atmosphere and biosphere and elemental abundance in each constituent.

Convection in the earth’s core and production of earth’s magnetic field; Magnetic polarity reversal; Radioactivity and age of the earth; Earthquakes and volcanoes.

Orogenic and epiorogenic phases, evidence of continental drift, and sea floor spreading; Origin and significance of mid oceanic ridges and trenches.

Plate Tectonics, nature and types of plate margins, evolution of oceans, continents and mountains.

Books Recommended:


SEMESTER III

Course No. GLM-301: Fuel Geology

**Coal Geology**
Definition and origin of coal. Sedimentology of coal bearing strata, types of seam discontinuities and structures associated with coal seams. Chemical characteristics of coal.


Geological and geographical distribution of coal and lignite deposits in India. Coal exploration and estimation of coal reserves. Indian coal reserves and production of coal in India.

**Petroleum Geology**
Petroleum – its composition. Origin (Formation of source rocks-kerogen, organic maturation and thermal cracking of kerogen) and migration of petroleum. Reservoir rocks-porosity and permeability. Reservoir traps –

Course No. GLM-305: Practical Connected with GLM-301


Macroscopic and microscopic study of cores and well cuttings. Study of geological maps and sections of important oilfields of India. Calculation of oil reserves.

Books Recommended:


Course No. GLM-302: General and Invertebrate Paleontology

Modern systematics, concept and kind of type specimens, species, speciation and adaptive radiation. Ichnofossils - modes of preservation, classifications and ichnofacies.

Micro- and macro-evolution, types of heterochrony in evolutionary lineages, application to biochronology with Indian examples. Evolutionary trends and geological history of Ammonoidea and Trilobita.

Classification of Brachiopoda and Bivalvia. Approaches to palaeoecological and palaeoenvironmental studies based on benthic communities, trace fossils and taphonomic record with Indian examples.

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

Course No. GLM-306: Practicals Connected with GLM-302

Study of the morphological characters of some important invertebrate fossils belonging to Brachiopoda, Bivalvia, Gastropoda, Ammonoidea, Trilobita, Echinoidea and corals; Determination of valves and dental formula of heterodont bivalves; Shell petrography of bivalves and brachiopods; Study of an assorted group of trace fossils; Study of ammonoid suture pattern, coiling, whorl section and ontogenic variation; Measurements of dimensional parameters and preparation of elementary bivariate growth curves and scatter plots.
Books Recommended:

Course No. GLM-303: Hydrogeology

Hydrological cycle and role of groundwater in the hydrological cycle.


Water level fluctuations: Causative factors and their measurements. Artificial recharge of water - Recharging by surface water and rain water harvesting. Consumptive and conjunctive use of surface and ground water; problem of overexploitation; ground water legislation.


Course No. GLM-307: Practical Connected with GLM-303


Books Recommended:

Course No. GLM-304: Remote Sensing and GIS in Geology

Remote sensing; principles and significance; Electromagnetic Radiation – Characteristics and Remote Sensing Regions and bands; Spectra of common natural objects – soil, rock, water and vegetation; General Orbital characteristics of satellites; Concepts of radiometric, spectral, spatial and temporal resolutions of satellite sensors; Sensor characteristics of remote sensing satellites: Landsat, IRS, ASTER, Quickbird.
Aerial photography: Planning and Execution, types of aerial photography; Aerial photos: classification, scale, resolution, stereoscopic parallax, image displacement; Properties of vertical and inclined aerial photographs; Elements of image and photo interpretations, Interpretations keys

Earth Model: Geoid, Authalic sphere and ellipsoid and their uses in GIS; Concept of datum: geocentric and local geodetic, horizontal and vertical; Co-ordinate systems: Geographic and planar; Concept of Map projections: Principal scale and scale factor, Concept of cylindrical, conical and planar map projections; Brief idea about commonly used map projections: Mercator, Transverse Mercator, Universal Transverse Mercator (UTM), Lambert Conformal, Conic and Polyconic; Digital Image Processing: Geometric and radiometric Corrections of satellite images; Image enhancement and classification

Concept of GIS: Definition and components of GIS; Object based and field based GIS data model; Raster, vector, Spatial and non spatial data structures; Data Based Management Systems and Model; Spatial Analysis: Spatial elements and analysis, local, focal, zonal and global operations; GIS query and output, Digital Elevation Model (DEM) and its derivatives; Utility of GIS in Geological projects

Course No. GLM-308: Practical Connected with GLM-304

Scale determination of the aerial photographs with help of toposheets. Practical exercises for interpretations and mapping related to landuse, geomorphology, lithology, structure, hydrogeology and engineering geology with help of aerial photographs and satellite imageries using pocket stereoscope, mirror stereoscope and satellite imageries. Hands on exercises on Digital Image Processing techniques and GIS.

Books Recommended:

- Drury, S.A. 1987: Image Interpretation in Geology. Springer

Course No. GLM-309: Deep Mantle Petrology

Petrology of the mantle. Mantle melting and various types of melting. Mantle plumes and superplumes and their role in continental break-ups.

Large igneous provinces- oceanic and continental - and their relevance to metallogeny and mass extinctions. Carbonatites and various theories of their origin with focus on Indian occurrences.

Mantle metasomatism and various types. Mantle heterogeneties. Alkaline rocks including kimberlites, orangeites, lamprophyres, kamaufugites- their mineralogy, geochemistry and genesis. Alkaline magmatism and regional structures.

Course No. GLM-312: Practicals Connected with GLM-309

1. Megascopic identification of important deep-mantle derived rocks.
2. Microscopic identification of important deep-mantle derived rocks and their xenoliths.
5. Mineral formula calculation of garnet and pyroxene and their relevance to diamond prognostication.

Books Recommended:

- K.G. Cox, J.D. Bell and R.J. Pankhurst (1979) . The Interpretation of Igneous Rocks Chapman and Hall publishing

Course No. GLM-310: Basin Analysis

Concept of basin analysis; Tectonic classification and geothermal evolution of sedimentary basins; Allogenic and autogenic controls on sedimentation.

Sedimentary facies and facies models with Indian analogues; Paleocurrent analysis and sediment dispersal patterns; Quaternary Sedimentology.

Processes and characteristics of depositional environments such as fluvial, estuarine, deltaic, lagoonal, barrier beach, tidal flats and deep-sea environments.

Concept of sequence stratigraphy, transgression, regression, regional unconformities, systems tracts and parasequences.

Course No. GLM-313: Practicals Connected with GLM-310

Study of isopach and facies maps.
Study of facies assemblages of different sedimentary environments
Preparation of lithologs from facies maps.
Correlation of lithological profiles of important Indian sedimentary basins.
Preparation of rose diagrams and statistical analysis of the paleocurrent data.
Detailed study of seismic profiles in a sequence stratigraphic framework.

Books Recommended:


Course No. GLM-311: Marine Geology

Historical development of marine geology; Origin of ocean basins; A brief account of tectonic history of the oceans; Oceanic crust; Deep ocean-floor topography; Morphology of ocean margins. Classification of coasts.

Marine sediments; sources, composition and distribution. Coastal processes and sedimentation. Deep sea sediments and their relation to oceanic processes such as productivity, solution and dilution; sedimentation rates; Calcite and aragonite compensation depth. Methods and instruments for exploring the ocean floor; Deep Sea Drilling Project (DSDP), Ocean Drilling Program (ODP) and International Ocean Discovery Program (IODP); their objectives and major accomplishments. Sediment distribution in time and space as related to tectonic models; Marine stratigraphy, correlation and chronology; Deep sea hiatuses and their causes.

Multidisciplinary approaches to paleoceanographic and paleoclimatic reconstructions. Paleoceanographic changes in relation to earth system history including impact of the oceans on climate change. Record of Ocean Anoxic Events (OAE); chronology and tectonic and paleoceanographic implications. Evolution of oceans through the Cenozoic; ocean gateways and their role in controlling global climates. Sea level changes during Quaternary with special reference to India. Quaternary climatic and oceanographic history on shorter time scales using marine records. Mineral resources of the ocean including polymetallic nodules; Hydrocarbons beneath the sea floor; Marine gas hydrates and their economic potential. Marine pollution and interpreting marine pollution with the help of micropaleontological and geochemical tracers. Law of the Sea Treaty: Introduction to UNCLOS (United Nations Convention on the Law of the Sea); Exclusive Economic Zone.

Course No. GLM-314: Practicals Connected with GLM-311

Study of topographic features of ocean floor; Preparation of bathymetry maps; Study of subsurface geological conditions and structures using seismic depth sections of selected oceanic regions; Evolution of ocean circulation system during the Cenozoic; Estimation of sedimentation rates, exercises on identification of condensed zones, deep sea hiatuses in deep sea sedimentary sections; Determination of physical and textural properties of marine sediments.

Books Recommended:

• Univ. Press, New York.
• Kennett, J.P. (1982): Laboratory Excercises in Oceanography Marine Geology, Prentice Hall,

Course No. GLM-315: Geological Field Training

2-3 weeks of geological field work in some appropriate areas of economic mineral deposits and visit to various laboratories of repute. Submission of report thereon.

Course No. GLM-316M: Life Through Ages (minor elective for students of other P.G. Programmes)

Modern thoughts on the origin of life. Fossils, their kinds and applications. Representative biota during different geological intervals.

Major mass extinction events in the history of earth: their causes and evidences.

Techniques of dating ancient life:-

a. Relative Dating: fossil and sediment records.

b. Absolute Dating: Dendrochronology, Potassium Argon and Radio Carbon dating etc.
SEMESTER IV

Course No. GLM-401: Environmental Geology and Natural Hazards


Role of physical, chemical and biological parameters influencing environment. Riverine and marine environments and their important characteristics. Air, water and noise pollution and their major causes. Pollution in the mining areas. Parameters influencing weathering, development of soils and soil profiles.


Course No. GLM-406: Practical Connected with GLM-401

Preparation of maps of seismic, landslide zonation and flood prone areas of India. Preparation of World distribution maps of volcanoes and earthquakes. Preparation of the air and ocean-circulation pattern maps. Analysis of alkalinity, acidity, pH and conductivity (Electrical) in water samples. Presentation of chemical analysis data and plotting chemical classification diagrams. Demarcation of deforestation, cultivation and building construction in specified areas.

Books Recommended:

- Keller, E.A. (1978) Environmental Geology, Bell and Howell, USA

Course No. GLM-402: Engineering Geology and Surveying

Engineering Geology
Role of engineering geology in civil construction and mining industry. Various stages of engineering geological investigations for civil engineering projects. Engineering properties of rocks: rock discontinuities, physical characters of building stones, concrete and other aggregates. Geological consideration for evaluation of dams and reservoir sites. Dam foundation, rock problems, geotechnical evaluations of tunnel alignments and
transportation routes. Methods of tunneling; Classification of ground for tunneling purposes; various types of support. Geological considerations involved in the construction of roads, railways, bridges and buildings. Improvement of sites for engineering projects.

Mass Movements with special emphasis on landslide and causes of hill slope instability. Seismic designs of buildings influence of geological condition on foundation and design of buildings.

**Surveying:**
Surveying: Fundamental Concepts and principles; Primary division and classification of surveys; Common methods of surveying: Reconnaissance survey, Offsetting, Radiation, triangulation; Open and closed traversing; Leveling. Accuracy and errors in surveying; Basic elements of map preparation and map reading

Working principles and use of different Surveying Instruments: Chain, Plane Table, Prismatic Compass, Dumpy level, Theodolite and Total Station Concept of Global Positioning System (GPS)

**Course No. GLM-407: Practical Connected with GLM-402**

**Engineering Geology**
Study of properties of common rocks with reference to their utility in engineering projects. Study of maps and models of important engineering structures and dam sites and tunnels. Interpretation of geological maps for landslide problems.

**Surveying:**
Laboratory and field exercises by surveying instruments viz. Chain, Prismatic Compass, Plane Table, Dumpy Level, Theodolite and Total Station: Survey of a piece of land by means of common methods of surveying using the suitable survey instruments.

**Books Recommended:**

**Course No. GLM-403: Mineral Exploration and Mineral Economics**

**Mineral Exploration**


**Mineral Economics**
Course No. GLM-408: Practical Connected with GLM-403

Preparation of Geological cross section based on Borehole data; Laying down of stripping boundary on geological cross sections; Calculation of geological and mineable ore reserves, mineable waste, and grade. Interpretation of remote sensing data for mineral exploration. Preparation of mineral maps of India, Graphical representation of production, export and import of important minerals.

Books Recommended:


Course No. GLM-404: Elements of Mining and Ore Dressing

Elements of Mining
Classification of mining methods. Mining Methods: Placer mining methods, open pit methods, Underground mining methods, Coal Mining methods and Ocean bottom mining methods; their advantages and disadvantages.

Ventilation in underground mining: Purpose, types and arrangements of ventilation in underground mining.

Mining hazards and safety measures.

Ore Dressing
Ore dressing and its importance, low grade ores and their beneficiation; Ore-microscopy and its contribution to ore-dressing techniques. Aggregate properties of minerals and rocks and their consideration in ore dressing techniques. Basic ore dressing operations viz. crushing (Primary crushing and Secondary/Tertiary Crushing), grinding, sizing, screening and classification. Concentration processes: Magnetic and electrostatic separation, gravity concentration; Froth Floatation, Amalgamation and Agglomeration. Role of Bacteria in Beneficiation of coal and lean grade ores.

Dressing of Indian Metallic and non-metallic ores, Beach Sand & coal.

Course No. GLM-409: Practical Connected with paper GLM-404

Elements of Mining
Study of various methods of metal and local mining and their diagrammatic representation. Exercises on mine sampling and determination of tenor, cut-off grades, ore reserves, etc.

Ore Dressing
Study of flow sheets of important metallic and non-metallic ores and minerals with particular reference to Indian Ores and Minerals.

Books Recommended:

- McKinstry, H.E. Mining Geology, Prentice Hall, Englewood Clifts, N.J.
Course No. GLM-405: Petroleum Exploration


Elementary knowledge of geophysical methods of exploration: Magnetic, Gravity and Seismic methods.

Course No. GLM-410: Practical Connected with paper GLM-405

Megascopic and microscopic study of cores. Preparation of geological maps and sections, and derivation of geological history in relation to petroleum prospects. Calculation of oil reserves. Exercise on maturation studies. Petrographic characterization of petroleum source rocks. Interpretation of electric and porosity logs.

Books Recommended:

- Schlumberger Log Interpretation Principles/Application, Schlumberger Wireline & testing 225 Schlumberger Drive sugar land, Texas 774778.

Course No. GLM-411: Instrumentation Techniques in Geosciences

Role and importance of instrumentation techniques in Geosciences. Sample preparation techniques. Quality, Precision, Accuracy, calibration and standards. Destructive and non-destructive techniques.


Principle and application of following instrumental techniques in Geochemistry: Atomic absorption spectrometer, x-ray fluorescence spectrometer, inductively coupled plasma analyzer, Mass spectrometer and MC- LA-ICP-MS.

An introduction to various mineral dressing and geophysical instruments

Books Recommended:

- Kerr, P.F (1977) : Optical Mineralogy McGrew Hill
Course No. GLM-412: Sequence Stratigraphy

Sequence stratigraphy, its concept and evolution; order and duration of sequences; application and significance of sequence stratigraphy.

Fundamentals of sequence stratigraphy; depositional sequence, boundaries and its types, condensation and starvation, conformity and unconformities; Flooding surface, maximum flooding surface, marine flooding surface; parasequence, parasequence boundary, parasequence set; System tracts - lowstand system tract, transgressive system tract, transgressive surface and highstand system tract, overlap, offlap, toplap and onlap, aggradation, progradation, retrogradation, transgression and regression; sea level changes, sediment supply, basin subsidence rate, and accommodation. Outcrop sequence stratigraphy with Indian examples.

Books Recommended:

- Vail, P.R., Mitchum, R. M., Todd, R. G., Widmier, J. M., Thompson, S., Sangree, J.B., Bubb, J.N.and Hatleid,
- W.G. (1977): Seismic stratigraphy and global changes of sea level: American Association of petroleum Geologists,

Course No. GLM-413: Sediment and Organic Matter Geochemistry


Books recommended:

- Introduction to Geochemistry, Allegre, C J and Michard, CJ (1974); D. Riedel, Holland.
- Principles of Geochemistry – Brain Massan, Wiley eastern limited (1958).
- Biominerals and fossils through time-Cuif J, Dauphin Y, Sorauf, JE (2011); Cambridge Press.
- Stable isotope geochemistry, Hoefs J (2009); Springer
Course No. GLM-414: Indian Mineral Deposits

Importance of Crustal evolution in the metallogenesis; Metallogenic epochs and provinces. An overview of various Indian Mineral deposits in cratons and mobile belts with reference to crustal evolution.

Mineralogy, and genesis of major bauxite, iron ore and manganese deposits of India.

Mineralogy and mode of occurrence of major copper, lead-zinc, chromite and tin deposits of India.

Geology of the gold, silver, and platinum occurrences in India.

Atomic minerals and beach sands in India

Books recommended:

- Publications of the Geological Society of India on Mineral Resources of various states of India.

Course No. GLM-415: Soil Geology

Concept of soil, components of soil, soil profile; Process of soil formation, pedogenic processes; Classification of soil, mineral and chemical composition of soils, mineral stability during weathering; Soil organic matter form and function; A brief introduction to methods of soil conservation.

Fabric analysis - size and shape, concepts of size and shape, grade scale, methods of analysis, presentation of data, analysis and field grading; Concepts of structure fabric: Soil fabric, soil structure, soil texture and field grading units; Peds and pedality, size and shape of peds, pedality, primary, secondary and tertiary structures and their interpretation; Voids - concepts, size, shape, arrangement and morphological classification.

Paleosols - Field recognition, description, origin and causes; Paleosol in stratigraphic records; Significance of paleosol study; Paleosols and human evolution.

Calcrete - definition, classification, calcrete formation, pedogenic calcrete soil profile, macro features in calcretes, micromorphology (petrography), calcretes from Quaternary and ancient sedimentary sequences; significance of calcretes; Laterite - characteristics, genesis, Indian occurrences.

Books Recommended:

- Gerrard, A.J.J.: Soil and Land forms
- Hunt, C.B.: Geology of Soils
- Jeffe, J.S.: The A.B.C. of soils
Course No. GLM-416: Palaeobotany

Introduction and approach to palaeobotany, occurrence of plant fossils, their collection and preparation techniques, principles of nomenclature (concept of genera and form genera), classification of fossil plants and broad characters of major plant groups.


Distribution of pre-Gondwana, Gondwana, Inter-trappean and Tertiary Floras of India and its relationship with other contemporaneous fossil floras of the world.

Books Recommended:

- Alfred Traverse (1988): Paleopalynology, Unwin Hyman, USA.

Course No. GLM-417: Vertebrate Palaeontology

Origin of vertebrates and general characteristics of their skeletons, classification of vertebrate fossils. Collection and preparation of vertebrate fossils, vertebrate life through ages and landmarks in evolution.


Books Recommended:


Course No. GLM-418: PROJECT ORIENTED DISSERTATION

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