

Courses of Study and Syllabus for M.Sc. Geology (Semester I–IV)
University of Jammu, Jammu

FIRST SEMESTER

Course No.	Title	Credits
Theory		
408	Geomorphology	2
409	Remote Sensing and its Application in Geology	4
410	Structural Geology	2
412	Essentials of Invertebrate Palaeontology	2
416	Stratigraphic Principles and Indian Stratigraphy	2
417	Optical Mineralogy	2
418	Clastic Sedimentology	2
Practical		
414	Practical related to course nos. 409, 416 and 418	4
415	Practical related to course nos. 410, 412 and 417	4

SECOND SEMESTER

Course No.	Title	Credits
Theory		
451	Non-Clastic Sedimentology	2
460	Ore Geology	2
464	Igneous Petrology	2
465	Elements of Hydrogeology	2
468	Applied Sedimentology	2
469	Descriptive Mineralogy	2
470	Geochemistry	2
471	Geotectonics	2
Practical		
466	Practical related to course nos. 464, 469 and 471	4
467	Practical related to course nos. 451, 460, 465 and 470	4

THIRD SEMESTER

Course No.	Title	Credits
Theory		
501	Metamorphic Petrology	2
508	Mining Geology	2
509	Groundwater Exploration and Water Wells	4
512	Vertebrate Palaeontology and Palaeobotany	2
515	Petroleum Geology	4
516	Engineering Geology	2
Practical		
513	Practical related to course nos. 501, 509	4
514	Practical related to course nos. 508, 512 and 515	4

FOURTH SEMESTER

Course No.	Title	Credits
Theory		
553	Environmental Geology	4
558	Oceanography	2
564	Applied Micropalaeontology	2
565	Advance Stratigraphy, Palaeogeography and Palaeoecology	2
566	Geophysical Exploration	2
575	Coal Geology	2
568	Ore Petrology	2
	OR	
571	Computer Application in Geology	2
	OR	
572	Mathematical Geology	2

Practical

573	Practical related to course nos. 558, 564, and 568/571/572	4
574	Practical related to course nos. 566 and 575	4

A student will have to offer courses carrying at least 24 credits in each Semester. However, in Semester – IV a student will have the option to offer Course No. 568 or 571 or 572. The University Department reserves the right to not offer some of the optional courses during a given academic year.

Credits	Semester Examination	Duration of Examination	Sessional Assessment	Duration of Examination
Theory				
4	80 marks	3 hours	20 marks	1½ hour
2	40 marks	2½ hours	10 marks	1 hour
Practical				
4	50 marks	4 hours	50 marks	4 hours

Semester Examination

For 4 credit course the question paper will contain two questions from each unit (total ten questions) and the candidates will be required to answer one question from each unit. Total questions to be attempted will be five i.e. there will be an internal choice within each unit.

For 2 credit course the question paper will contain two questions from each unit (total eight questions) and the candidates will be required to answer one question from each unit. Total questions to be attempted will be four i.e. there will be an internal choice within each unit.

Sessional Assessment

20 % of the marks in each theory paper and 50 % of marks in each practical course shall be reserved for sessional assessment. In case of regular students, sessional assessment received from the Postgraduate Departments shall be added to the marks obtained by them in the University examination and in case of private candidates, marks obtained by them in the University examination shall be increased proportionately in accordance with the University Statutes / Regulations.

DETAILED SYLLABUS**FIRST SEMESTER****Examinations to be conducted in December 2008, December 2009 and December 2010**

Course No.	Title	Credits
Theory		
408	Geomorphology	2
409	Remote Sensing and its Application in Geology	4
410	Structural Geology	2
412	Essentials of Invertebrate Palaeontology	2
416	Stratigraphic Principles and Indian Stratigraphy	2
417	Optical Mineralogy	2
418	Clastic Sedimentology	2
Practical		
414	Practical related to course No's. 409, 416 and 418	4
415	Practical related to course No's. 410, 412 and 417	4

Course No. 408**GEOMORPHOLOGY****Credits 2**

Objectives To introduce the fundamental concepts governing the landforms. Acquaintance with the concept of various geomorphological processes and landform evolution. Introduce the latest concept of chronology based on geomorphological studies in tectonic zones.

UNIT-I

- 1.1 Geomorphological processes, elements-physical, chemical and biological.
- 1.2 Landform in relation to lithology and structure.

- 1.3 Landform evolution by geomorphological agencies, namely fluvial and glaciers.
- 1.4 Qualitative and quantitative analysis of basins and drainage density.

UNIT-II

- 2.1 Landform evolution by geomorphological agencies, namely aeolian and marine.
- 2.2 Landform evolution of soluble rock terrain-processes and features.
- 2.3 Landform evolution by mass movements-process, classification, slope failures, subsidence.
- 2.4 Classification of slopes, forms, slope regression, slope maps and slope evolution.

UNIT-III

- 3.1 Factors of weathering-mechanical disintegration, chemical decomposition.
- 3.2 Determination of weathering indices and ratios
- 3.3 Geomorphology and soil formation-effect of latitude and altitude
- 3.4 Palaeopedology-concept and application

UNIT-IV

- 4.1 Geomorphology and global tectonics-aim and context, Davisian dogma, erosion surfaces, denudational chronology and tectonics, geomorphological evidences of neotectonics in India.
- 4.2 Morphotectonic evolution of Himalaya and Tibetan Plateau.
- 4.3 Evolutionary history of Thar desert of India.
- 4.4 Morphotectonic evolution of Western Ghats of India.

Books Recommended

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|----|------------------|--|
| 1. | F.A. Pitty | Introduction to Geomorphology |
| 2. | Donj-Easterbrook | Principles of Geomorphology |
| 3. | C. Ollier | Tectonics and Landforms |
| 4. | C. Ollier | Weathering |
| 5. | Thornbury | Geomorphology |
| 6. | A. Bloom | Fluvial Geomorphology |
| 7. | C.A.M. King | Introduction to Marine Geology and Geomorphology |
| 8. | K.S. Valdiya | Aspects of Tectonics |

Course No. 409

REMOTE SENSING AND ITS APPLICATION IN GEOLOGY

Credits 4

Objectives Remote Sensing Technology has emerged as an important tool for scientifically managing resources and environment. The technology enhanced our capability of resources exploration, mapping and monitoring on local and global scale. This course has been designed with the objectives to acquaint the students with basic principles of remote sensing, concepts and their application in various fields.

UNIT-I Principles of Remote Sensing

- 1.1 Introduction and scope of remote sensing in assessment and evaluation of natural resources, developments of remote sensing, advantages and limitations of remote sensing.
- 1.2 Define the basic principles of satellite remote sensing: Electromagnetic Radiation (EMR) and electromagnetic spectrum, earth and atmospheric interaction with EMR.
- 1.3 Remote Sensing: data resources, platforms and sensors acquisition of remote sensing data.
- 1.4 Satellite remote sensing, global and Indian space mission. Different satellite exploration programs and their characteristics: LANDSAT, METEOSAT, SPOT, JERS-I, IRS.

UNIT-II Aerial photography

- 2.1 Definition and uses, basic information and specification for aerial photography. Planning and execution of photography flights.
- 2.2 Aerial camera, lens, types of aerial photographs and information records on the aerial photographs.

- 2.3 Geometry of the aerial photographs, stereoscopic vision and stereoscope. Measurement of the height difference from aerial photographs.
- 2.4 Recognition of photo-elements and terrain elements like tone, texture, pattern, shape, size; terrain elements like drainage pattern, density, type, landform characteristics, erosion behavior of rock and soil material, vegetation and landuse.

UNIT-III Thermal and Microwave Remote Sensing

- 3.1 Introduction, TIR region of electromagnetic spectrum, thermal properties of material.
- 3.2 Interpretation of thermal (radiant temperature) imagery, interpretation of day and night thermal image, advantage of thermal imagery.
- 3.3 Introduction, advantage of microwave remote sensing, microwave sensors, radar operating principle.
- 3.4 Spatial resolution of SLAR system, geometric characteristic of SLAR imagery, transmission characteristic of radar signals, radar return and image characteristic, interpretation of radar image and general application microwave remote sensing.

UNIT-IV Remote Sensing interpretation in Geology

- 4.1 Remote Sensing for lithological discrimination and geological structural mapping.
- 4.2 Remote sensing application in geomorphological studies: dynamics of geomorphology processes and resulting landforms and their discrimination on photo and image.
- 4.3 Remote sensing in groundwater investigation: factors affecting groundwater occurrence. Indicators for groundwater on remote sensing products and their application examples.
- 4.4 Role of remote sensing in mineral resources exploration. Main types of mineral deposits. Geological guides for prospecting and their manifestation in remote sensing data.

UNIT-V Digital Image processing and Geographical Information system

- 5.1 Digital image processing: introduction, image rectification and restoration, image enhancements and its application.
- 5.2 Introduction and application of GIS, components of geographical information system (GIS), database structures in raster and vector and its comparison.
- 5.3 Spatial data analysis: introduction to spatial data analysis and various types of spatial data analysis operations in GIS.
- 5.4 Global positioning System (GPS) and its segments, observation principle, parameters effecting the accuracy of result, main components of a GPS receiver and GPS application.

Books Recommended

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|-----|------------------------------|--|
| 1. | P.J. Curran | Principles of remote sensing |
| 2. | S.A. Drury | A guide to remote sensing interpretation images of earth |
| 3. | R.P. Gupta | Remote sensing in geology |
| 4. | T.M. Lillesand & R.W. Kiefer | Remote sensing and image interpretation |
| 5. | V.C. Miller | Photogeology |
| 6. | S.N. Pandey | Principles and application of photogeology |
| 7. | A.N. Patel & S. Sundera | Principles of remote sensing |
| 8. | D.P. Rao | Remote sensing for earth resources |
| 9. | M.A. Reddy | Remote sensing and Geographical Information System |
| 10. | F.F. Sabins | Remote sensing-principles and interpretation |
| 11. | E.S. Seigel & A.R. Gillespie | Remote sensing in geology |
| 12. | W.L. Smith | Remote sensing in geology |

Course No. 410

STRUCTURAL GEOLOGY

Credits 2

Objectives To impart knowledge about the behaviour of rocks under stress and strain, foliation-lineation fabric elements and mechanics of folding and faulting.

UNIT-I

- 1.1 Mechanical principles and behavior of rocks under stress.
- 1.2 Concept of stress and strain, components of stress, state of stress at a point.
- 1.3 Concepts of stress and strain ellipses and ellipsoids.

1.4 Strain markers in naturally deformed rocks.

UNIT-II

2.1 Translations, rotation, dilation and distortion, measurement of strain, displacement.

2.2 Strain analysis by Moh's Circle Technique and Wellman Diagram.

2.3 Concept of petrofabrics and the role of symmetry, indicator minerals and fabric diagrams.

2.4 Rock fabric field relations, planar and linear fabric elements (foliation and lineation), tectonic significance.

UNIT-III

3.1 Mechanics of folding and buckling.

3.2 Fold development and distribution of strain in folds.

3.3 Geometry of boundinage structure and its significance.

3.4 Geometrical relation of boundins with folds.

UNIT-IV

4.1 Nomenclature and age relationship of joints and faults.

4.2 Joints in relation to stresses and their geometrical relationship with folds and faults.

4.3 Orientation analysis and their relationship with tectonic cycle.

4.4 Mechanical aspects of faulting.

Books Recommended

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|----|-----------------------------------|--|
| 1. | Bagley, P.C. | Structure and Tectonics |
| 2. | Ramsay, J.G. | Folding and fracturing of Rocks |
| 3. | Hobbs, B., Means W. & William, P. | An Outline of Structural Geology |
| 4. | Gosh, S.K. | Structural Geology: Fundamentals & Modern Developments |
| 5. | Dennis, J.G. | Structural Geology: An Introduction |

Course No. 412

ESSENTIALS OF INVERTEBRATE PALAEOONTOLOGY

Credits 2

Objectives To understand the basic principles of organic evolution and their application in palaeontology. To have an extensive knowledge of evolution and distribution of the important invertebrate fossil organisms. Application of international code of nomenclature for taxonomic studies.

UNIT-I

1.1 Diversity of life on the earth with major adaptive events – origin of metazoan, skeletalizations, predation, terrestrialization, trees and forests, flight and consciousness.

1.2 Classification of organisms on land and sea, distribution and dispersal of organisms.

1.3 Mass extinctions – patterns, selectivity, timing, periodicity and causes of mass extinction.

1.4 Type specimens, fixing and nature of type specimens, methods of fossil identification and description, law of priority, homonymy and synonymy, statistical methods and their limitations.

UNIT-II

2.1 Ichnology – history of invertebrate ichnology, realms of ichnology, classification of trace fossils.

2.2 Groups of trace fossils, borings as trace fossils and bioerosion, traces of predation, fossil tracks and impressions of vertebrates.

2.3 Palaeontological and stratigraphical significance of trace fossils.

2.4 Palaeoecological and environmental significance of trace fossils.

UNIT-III

3.1 Arthropods groups – classification, ontogenic developments, evolution, enrollment and coaptative structures, cephalic sutures and vision in trilobites. Faunal provinces and stratigraphical use of trilobites.

3.2 Brachiopoda – classification, ontogeny, evolutionary history, ecology, faunal provinces and stratigraphical use of brachiopods.

3.3 Bryozoa – classification, evolution, ecology and distribution, shallow water bryozoans, reef-dwelling bryozoans, living bryozoans.

- 3.4 Mollusca – classification, evolution and ecology of bivalves, cephalopods and gastropods. Predation of molluscs.

UNIT-IV

- 4.1 Echinoderms – classification, morphological characters and evolution in echinoids, earliest echinoderms and their radiations.
- 4.2 Graptolites – classification, biological affinities, evolution in the shape of rhabdosomes - proximal end - thecal structure, graptolite faunal provinces, graptolites as stratigraphical indicators.
- 4.3 Cnidarians – classification, evolution and ecology of rugosa and tabulate corals. Geological use of corals as stratigraphical indicators and as geochronometers.
- 4.4 Geological history and stratigraphic significance of Ediacara fauna and Burgess shale fauna.

Books Recommended

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|-----|-----------------------------------|--|
| 1. | Morley Davis & Stubblefield, S.J. | In Introduction to Palaeontology |
| 2. | Shrock, R.R & Twenhofel, W.H. | Principles of Invertebrate Palaeontology |
| 3. | Black, R.M. | The Elements of Palaeontology |
| 4. | Fairbridge & Jablonski | The Encyclopedia of Palaeontology |
| 5. | Babin, C. | Elements of Palaeontology |
| 6. | Clarkson, E.N.T. | Invertebrate Palaeontology and Evolution |
| 7. | Raup, D.M. & Stanley, S.M. | Principles of Palaeontology |
| 8. | Lull, R.S. | Organic Evolution |
| 9. | Benton, M.J. & Harper | Basic Palaeontology |
| 10. | Dodd, J.R. & Stenton, R.J. | Palaeoecology-Concept and Applications |
| 11. | Frey, R.W. | The study of trace fossils |
| 12. | Bromley, R.G | Trace Fossils |
| 13. | Seilachers | Trace Fossils |

Course No. 416

STRATIGRAPHIC PRINCIPLES AND INDIAN STRATIGRAPHY

Credits 2

Objectives To impart knowledge about litho. bio. and chronostratigraphic classification, code of stratigraphic nomenclature, facies variations, Precambrian shield areas, Palaeozoic, Mesozoic and Cenozoic strata with faunal and floral elements and the Gondwana successions.

UNIT-I

- 1.1 Stratigraphic classification, litho. bio. and chronostratigraphy, code of stratigraphic nomenclature.
- 1.2 Stratification, lateral, vertical and thickness variations and facies variations. Unconformities and their recognition.
- 1.3 Major Precambrian shield areas of the world, their distribution and tectonic setting.
- 1.4 Evolution of Indian shield – major Precambrian belts of India and their tectonic setting.

UNIT-II

- 2.1 Precambrian of Tethyan basement-Salkhala, Vaikrita and Bhimphedi Groups. Tectonic history and Palaeozoic life.
- 2.2 Indian Palaeozoic formations, their distribution, successions, fauna and correlation.
- 2.3 Gondwanaland – concept of Gondwana and the occurrence of Gondwana outcrops in peninsular and extra-peninsular region of India.
- 2.4 Age limits, flora and climatic fluctuations during the Gondwana period.

UNIT-III

- 3.1 Tectonic history, fauna and flora during Mesozoic times.
- 3.2 Correlation of Mesozoic successions of peninsular and extra-peninsular India.
- 3.3 Marine transgressions and regressions during Mesozoic and the development of coastal facies in India.
- 3.4 Cretaceous volcanism in the peninsular part and in the Himalayan region of India and its impact on fauna and flora.

UNIT-IV

- 4.1 Classification and correlation of Cenozoic successions of Himalaya.
- 4.2 Geology of Ladakh with special emphasis on Indus Tsangpo Suture belt.
- 4.3 Siwalik Group, its classification and fauna.
- 4.4 Pleistocene climatic fluctuations in India.

Books Recommended

1. Weller Stratigraphic Principles and Practice
2. Pasco (Vol. I – III) Geology of India and Burma
3. Ravinder Kumar Fundamentals of Historical Geology
4. Alen Goodwin Principles of Precambrian Geology
5. Naqvi & Rogers Precambrian Geology of India
6. G S I Misc. Publ. No.20

Course No. 417

OPTICAL MINERALOGY

Credits 2

Objectives To impart knowledge about the concepts and mechanism of various optical properties of crystals.

UNIT-I

- 1.1 Elements of optics: Nature of light, electromagnetic spectrum, total internal reflection and critical angle, wave and wave front.
- 1.2 Lenses used in petrological microscopes, aberrations in lenses.
- 1.3 Linear, circular and elliptical polarized light; Methods of obtaining plane polarized light.
- 1.4 Phase difference, retardation, interference of light.

UNIT-II

- 2.1 Index of refraction and relief, determination of indices of refraction: Becke line method, central illumination method, oblique illumination method, dark field immersion method, method of minimum deviation.
- 2.2 Pleochroism and determination of pleochroic schemes for uniaxial and biaxial minerals.
- 2.3 Optical accessories and their uses, interference colours, abnormal interference colours.
- 2.4 Extinction and its categories, measurement of extinction angle, uses of extinction angle.

UNIT-III

- 3.1 Optical indicatrix: uniaxial and biaxial indicatrix and their principal sections, optic orientation of biaxial indicatrix.
- 3.2 Conoscopic illumination, formation of isogyres and isochromes in uniaxial minerals, optic axis and off centered optic axis interference figures, determination of optic sign.
- 3.3 Biaxial interference figures: acute and obtuse bisectrix figures, determination of optic sign.
- 3.4 Optic angle determination: Mallord's method, Tobi's method, Kamb's method and Wright's method.

UNIT- IV

- 4.1 Universal Stage, its construction and uses.
- 4.2 Dispersion in biaxial minerals, anomalous dispersion.
- 4.3 Nature of X-ray, generation and spectra of X-rays, filters, Bragg's Law.
- 4.4 X-ray diffraction: single crystal (stationary and moving) method and powder method.

Books Recommended

1. Whalstrom, E. E. Optical Crystallography
2. Nesse, W.D. Introduction to Optical Mineralogy
3. Dana, E.S. A Textbook of Mineralogy
4. Mitra, S. Fundamentals of Optics Spectroscopic & X-ray Mineralogy
5. Ehelrs, E.G. Optical Mineralogy
6. Kerr, P.G. Optical Mineralogy
7. Naidu, P.R.J. Optical Mineralogy
8. Philips, W.R. Mineral Optics
9. Sholley, P. Manual of Optical Mineralogy

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| 10. | Winchel, A.N | Elements of Optical Mineralogy |
| 11. | Mckie, D. & Mckie, C. | Crystalline Solids |
| 12. | Wolfson M.M. | X-Ray Crystallography |

Course No. 418

CLASTIC SEDIMENTOLOGY

Credits 2

Objectives To impart knowledge about the processes operating in clastic sedimentology.

UNIT-I

- 1.1 Concept of grain size, grade-scale, phi-scale; Techniques of size analysis: sieve and pipette analysis.
- 1.2 Graphic presentation of grain size data; Textural parameters and their significance.
- 1.3 Particle morphology; shape forms, sphericity, roundness, surface textures and their significance.
- 1.4 Primary grain fabric: orientation of sand grains, pebbles and fossils.

UNIT-II

- 2.1 Classification of Conglomerates and sandstones.
- 2.2 Sandstone petrography and diagenesis.
- 2.3 Mineralogical and textural maturity in sedimentary rocks.
- 2.4 Heavy minerals and their significance.

UNIT-III

- 3.1 Basic properties of fluids, laminar and turbulent flows, rapid and tranquil flows.
- 3.2 Sole marks: types, mode of formation, significance.
- 3.3 Mode of formation and types of ripple marks and cross beddings.
- 3.4 Graded beds; deformational sedimentary structures and their significance.

UNIT-IV

- 4.1 Concept of lithofacies and facies association, molasse and flysch facies.
- 4.2 Facies models: braided and meandering rivers.
- 4.3 Application of sedimentary structures for palaeocurrent analysis.
- 4.4 Sandstone composition and plate tectonic settings.

Books Recommended

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|-----|------------------------------------|--|
| 1. | Miall, Andrew D. | Principles of Sedimentary Basin Analysis |
| 2. | Lindholm, R. C. | A Practical Approach to Sedimentology |
| 3. | Collinson, J. D. & Thompson, D. B. | Sedimentary Structures |
| 4. | Reineck, H. E. & Singh, I. B. | Depositional Sedimentary Environments |
| 5. | Allen, J.R.L. | Physical processes of Sedimentation |
| 6. | Reading, H.G. | Sedimentary Environments |
| 7. | Petijohn, F.J. & Potter | Sand and Sandstone |
| 8. | Petijohn, F.J. | Sedimentary rocks |
| 9. | Friedman, M.Gorale & Sanders | Principles of Sedimentology |
| 10. | Selley, R.C. | Applied Sedimentology |
| 11. | Bjorlykke, K. | Sedimentology and Petroleum Geology |

Course No. 414

PRACTICAL RELATING TO COURSE NO'S. 409, 416 AND 418

Credits 4

UNIT-I Course No. 409 (Remote Sensing & its application in Geology)
Stereo test. Study of Aerial Photographs, resolution, mosaics, symbols, gully pattern and drainage analysis, image parallax. Determination of scale, height, dip, slope vertical exaggeration and image distortion. Visual interpretation of satellite imagery for geological structural geomorphic and hydromorphical mapping. Exercises on digital image processing.

UNIT-II Course No. 416 (Stratigraphic Principles and Indian Stratigraphy)

Preparation of stratigraphic columns, facies diagram, correlation of charts from field data.

UNIT-III Course No. 418 (Clastic Sedimentology)
Preparation of histograms, frequency curves from grain size data, calculation of grain size parameters. Measurement of sphericity and roundness. Megascopic study of clastic sedimentary rocks. Microscopic examination of clastic sedimentary rocks.

UNIT-IV Field work and submission of field report (**An essential component of fifteen marks**).

UNIT-V Viva – Voce.

Course No. 415 PRACTICAL RELATING TO COURSE NO'S. 410, 412 AND 417 Credits 4

UNIT-I Course No. 410 (Structural Geology)
Geometric methods used to interpret geological structures, strain analysis.

UNIT-II Course No. 412 (Essentials of Invertebrate Palaeontology)
Application of zoological code of nomenclature for taxonomic studies. Study of mega and microfossils of various invertebrate groups. Univariate and bivariate analysis of fossils using regression analysis and major axis equations. Study of methods of preservation and determining the data retrieval from fossils.

UNIT-III Course No. 417 (Optical Mineralogy)
Methods of determination of optical properties of minerals such as pleochroic scheme, extinction angle and optical sign.

UNIT-IV Field work and submission of field report (**An essential component of fifteen marks**).

UNIT-V Viva – Voce.

SECOND SEMESTER

Examinations to be conducted in May 2009, May 2010 and May 2011

Course No.	Title	Credits
Theory		
451	Non-Clastic Sedimentology	2
460	Ore Geology	2
464	Igneous Petrology	2
465	Elements of Hydrogeology	2
468	Applied Sedimentology	2
469	Descriptive Mineralogy	2
470	Geochemistry	2
471	Geotectonics	2
Practical		
466	Practical related to course No's. 464, 469 and 471	4
467	Practical related to course No's. 451, 460, 465 and 470	4
Course No. 451	NON-CLASTIC SEDIMENTOLOGY	Credits 2

Objectives To impart knowledge about the genesis of carbonate rocks. To study the sedimentary structures in carbonate rocks. To discuss the microfacies concept and techniques used for staining the carbonate minerals.

UNIT-I

- 1.1 Physical components of carbonate rocks and their origin.
- 1.2 Nomenclature and Classification of carbonate rocks (Folk and Dunham).
- 1.3 Petrogenesis of biogenic silica deposits.
- 1.4 Petrogenesis of phosphate deposits.

UNIT-II

- 2.1 General diagenetic considerations.
- 2.2 Diagenesis and porosity evolution of carbonate rocks.

- 2.3 Significance of chemically formed sedimentary structures.
- 2.4 Significance of biogenic sedimentary structures.

UNTI-III

- 3.1 Introduction to modern carbonate sedimentation environments.
- 3.2 Carbonate evaporate shorelines, shelves and basins.
- 3.3 Introduction to evaporates and Subkha Model.
- 3.4 Dolomitization models.

UNIT-IV

- 4.1 Staining techniques for carbonate minerals.
- 4.2 Microfacies concept and techniques.
- 4.3 Cathodoluminescence principles and techniques.
- 4.4 Plate tectonics and oil prospecting.

Books Recommended

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|-----|------------------------------|---|
| 1. | Balatt, Middleton and Murray | Carbonate sediments and their origin |
| 2. | Bathurst, R.G.C. | Carbonate sediments and their diagenesis |
| 3. | Knut Bjorlykke: | Sedimentology and Petroleum Geology |
| 4. | Carozzi, A.V. | Carbonate rock depositional models: A microfacie approach |
| 5. | Wilson, J.L. | Carbonate rocks in Geologic History |
| 6. | Carver, R.F. | Procedures in Sedimentary Petrology |
| 7. | Leeder, M.R. | Sedimentology: Process and Product |
| 8. | Prothero and Schwab | Sedimentary Geology |
| 9. | Reading, H.G. | Sedimentary Environments |
| 10. | Collinson and Thomson | Sedimentary Structures |

Course No. 460

ORE GEOLOGY

Credits 2

Objectives To impart the knowledge and understanding about the various processes of the ore formations. To introduce the modern concepts of the ore genesis. To understand the formation, mode of occurrences and types of various petrological ore associations.

UNIT-I

- 1.1 Spatial and temporal distribution of ore deposits – a global perspective.
- 1.2 Mode of occurrences of ore bodies – morphology of ore body, attitudinal relation with host rock and secondary structures in the host rocks.
- 1.3 Concept of ore bearing fluids – their origin and migration, physico-chemical and stratigraphic controls of ore localization.
- 1.4 Classification of ore deposits – genetic and associated parameters, important scheme of classification.

UNIT-II

- 2.1 Orthomagmatic ores of mafic and ultramafic associations – (Chromite, Fe ± Ti ± V oxides, Cu-Ni + Co sulfides and PGE ores), their types, mode of occurrences and genetic models.
- 2.2 Mineralization associated with Kimberlites and Carbonatites, their characteristics and genetic models.
- 2.3 Ores of silicic igneous rock association – disseminated and stockwork deposits, porphyry type of deposits, types, alterations and process of formation.
- 2.4 Hydrothermal deposits – classification, general characteristics, zoning and associated wall rock alterations.

UNIT-III

- 3.1 Placers and paleoplacers – process and mechanism of development, tectonic and temporal aspects of placer deposition and origin of ores.
- 3.2 Sedimentary and symsedimentary ore deposits (iron and manganese)– types, general characteristics and origin.
- 3.3 Symsedimentary to post-lithification non-ferous ore deposits (sandstone type Cu ± Zn ± Pb and Uranium) – general characteristics and origin.

- 3.4 Stratabound carbonate hosted base metal deposits – types, general characteristics and genetic models.

UNIT-IV

- 4.1 Volcanic hosted massive sulfide deposits – types, characteristics and mode of occurrences.
4.2 Ores related to weathering processes – bauxite, laterite and Ni/Au-laterite deposits, general characteristics and process of formation.
4.3 Supergene enrichment of ores and protores – process, development of alteration zones and their characteristics.
4.4 Ores of metamorphic affiliations – metamorphic and metamorphosed ores. Skarn deposits, their types and process of formation.

Books Recommended

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|-----|--------------------|---|
| 1. | Barnes | Geochemistry of Hydrothermal Ore Deposits |
| 2. | Edwards & Atkinson | Ore Deposit Geology |
| 3. | Evans | Ore Geology and Industrial Minerals |
| 4. | Evans | An Introduction to Ore Geology |
| 5. | Klemm & Schneider | Time and Strata Bound Deposits |
| 6. | Mukerjee | Ore Genesis: A Holistic Approach |
| 7. | Park & Macdiarmid | Ore Deposits |
| 8. | Smirnov | Geology of Ore Deposits |
| 9. | Mishra | Understanding Mineral Deposits |
| 10. | Pirajna | Hydrothermal Mineral Deposits |

Course No. 464

IGNEOUS PETROLOGY

Credits 2

Objectives To acquaint the students of varied types of igneous rocks, their tectonic environment and petrogenesis.

UNIT-I

- 1.1 Classification schemes of igneous rocks, Hierarchy of classification, IUGS classification of plutonic and volcanic rocks.
1.2 Generation of magma in mantle and crust.
1.3 Magmatic gases and volatile components, Oxygen fugacity, Factors for magma crystallization (nucleation and crystal growth).
1.4 Phase equilibrium studies of binary system with eutectic (Di-An), peritectic (Fo-Silica) and solid solution relation (Ab-An) and ternary system (Di-Ab-An) and their significance.

UNIT-II

- 2.1 Classification of basalts: IUGS, Kuno, Yoder and Tilley, Macdonald and Katsura, Chayes, Pearce and Cann.
2.2 Generation of basalts: parent materials, primary origins, secondary origins.
2.3 Petrogenesis of basalts in relation to tectonic environment: ORB (OFB), WPB (IPB), IAB and OCMB (subduction zone).
2.4 Lunar basalts; Ophiolite suite; Andesites and their petrogenesis.

UNIT-III

- 3.1 Petrology, textures and classification of granites (I, S, M, A types).
3.2 Granite in various tectonic environments.
3.3 Petrogenesis of granites: source materials, sediments and metasediments, basalt or andesites.
3.4 Petrological and geochemical characters of pegmatites and their petrogenesis.

UNIT-IV

- 4.1 Petrological characters, classification and petrogenesis of Lamprophyres.
4.2 Mineral composition, classification and petrogenesis of Carbonatites and Nepheline Syenites.
4.3 Mineralogy of Kimberlites and their petrogenesis.
4.4 Petrography, composition and petrogenesis of Komatiite and Anorthosites.

Books Recommended

1	Alexander McBirney	1993	Igneous Petrology. <i>Jones and Bartlett Publications</i>
2	Anthony Hall	1988	Igneous Petrology. <i>Longman Group</i>
3	Anthony R. Philpotts	1994	Principles of Igneous and Metamorphic Petrology. <i>Prentice-Hall Inc</i>
4	Daniel S. Barker	1983	Igneous Rocks. <i>Prentice-Hall Inc</i>
5	Loren A. Raymond	2002	Petrology. <i>McGraw-Hill Higher Education</i>
6	Marjorie Wilson	1989	Igneous Petrogenesis. <i>Unwin Hyman Ltd</i>
7	Mihir K. Bose	1997	Igneous Petrology. <i>The World Press Private Ltd</i>
8	Myron G. Best	2003	Igneous and Metamorphic Petrology. <i>Blackwell Publishing</i>

Course No. 465

ELEMENTS OF HYDROGEOLOGY

Credits 2

Objectives To study the origin and causative factors, occurrence, distribution, quality and general behaviour of groundwater under varying geological and geographical conditions.

UNIT-I Origin occurrence and distribution of water

- 1.1 Origin of water – magmatic, metamorphic, juvenile, connate, marine, volcanic plutonic water. Subsurface movement and vertical distribution of groundwater and governing physical laws, surface and ground water relationship, renewable and non-renewable groundwater resources.
- 1.2 Hydrological properties of formations, porosity and permeability, their determination in the laboratory. Physical properties of the reservoir rocks-intrinsic permeability. Hydraulic conductivity, transmissivity, storativity, specific yield, specific retention, formation constants. Genetic and hydrologic classification of reservoir rocks and boundary conditions.
- 1.3 Hydrostratigraphic units, water table contour maps and flow net analysis. Concept of drainage basin and groundwater basin. Hot water springs, their origin, distribution and economic importance.
- 1.4 Mode of occurrence of groundwater in unconsolidated and semi-consolidated formations. Hydrogeology of arid and wet land zones of Indian Sub-continent.

UNIT-II Hydrometeorology

- 2.1 Precipitation – process, causes, types and measurements. Computation of average rainfall.
- 2.2 Evapotranspiration – process, causes, factors influencing and measurements in the field and of empirical equations.
- 2.3 Infiltration – process, factors effecting, measurements, relation to runoff and computation of runoff. Hydrographs.
- 2.4 Elements of snow hydrology – factors influencing snow melt and determination of runoff (snow melt).

UNIT-III Groundwater quality

- 3.1 Physical and chemical properties of water. Quality criteria for domestic, irrigation and industrial use. Graphic presentation of water quality data.
- 3.2 Groundwater quality in different provinces of India. Water contaminants and pollutants, arsenic, fluorides and nitrates. Relationship of water quality to use. Change in water quality.
- 3.3 Sea water intrusion in coastal aquifers and remedial measures. Upconing Ghyben-Herzberg relation.
- 3.4 Influence of aquifer material on groundwater quality. Water quality estimation and methods of treatment for various uses.

UNIT-IV Groundwater resource behaviour

- 4.1 Fluctuations in groundwater – briefs and causative factors.
- 4.2 Groundwater recharging methods.
- 4.3 Consumptive and conjunctive use of surface and groundwater.
- 4.4 Radioisotopes in hydrological studies.

Books Recommended

- | | | |
|----|---------------|--|
| 1. | Todd, D.K. | Groundwater Hydrology |
| 2. | Harinarayan | Exploration techniques for groundwater |
| 3. | Davis & Wiest | Hydrology |
| 4. | Chow | Handbook of Applied Hydrology |
| 5. | Johnson | Groundwater and Wells |
| 6. | Walton | Groundwater Resource Evaluation |
| 7. | Fetter, C.W. | Applied Hydrogeology |

8. Subramaniam, V. Water
 9. Alley, W.M. Regional Groundwater Quality

Course No: 468

APPLIED SEDIMENTOLOGY

Credits 2

Objectives To impart knowledge about applied aspects of sedimentology.

UNIT-I Physical Properties of Sediments

- 1.1 Porosity and permeability, controls on permeability, porosity enhancement by solution.
- 1.2 Pore morphology, origin of primary porosity, flow in porous medium.
- 1.3 Particle fabrics, kinds of packing, controls on packing.
- 1.4 Compaction, compaction flow and other flow mechanisms.

UNIT-II Fluid Flow and Sediment Transport

- 2.1 Fluid properties, streamlines and flow visualization.
- 2.2 Pressure changes and energy budget, the Reynold Number, Froude Number.
- 2.3 Laminar and turbulent flows, flow regimes, flow separation and secondary currents, initiation of particle motion.
- 2.4 Sediment transport modes; sediment gravity flows: grain flows, liquefied flows, turbidity flows.

UNIT-III Change of State

- 3.1 Causes of change of state, forces causing deformation.
- 3.2 Growth faults and slumps, appearance and internal structure of bed forms.
- 3.3 Bed form movement, Bed forms and flow conditions.
- 3.4 Bed forms and structure formed by water waves, water flows.

UNIT-IV Tectonics and Sedimentation

- 4.1 Sedimentation in extensional and convergent sedimentary basins.
- 4.2 Filling of sedimentary basins and sea level changes.
- 4.3 Tectonics and sediment supply.
- 4.4 Sedimentation model for continental margins (shelf sedimentation).

Books Recommended

- | | |
|--|---|
| 1. Physical sedimentology | J. R. Allen, George Allen and Unwin |
| 2. Applied Sedimentology | R. C. Selley |
| 3. Sedimentology: Process and Product | M. R. Leeder |
| 4. Sedimentary Basins and Tectonics | G. Einsele |
| 5. Sedimentology and Petroleum Geology | K. Bjorlykke |
| 6. Shelf Sand and Sandstone Bodies | D.J.P. Swift, G.F. Oertal, R.W. Tillman & J.A. Thorne |

Course No. 469

DESCRIPTIVE MINERALOGY

Credits 2

Objective To impart the knowledge about the rock forming minerals.

UNIT-I

- 1.1 Oxides and Hydroxides minerals : Structure, Chemistry, classification, Distinguishing features and paragenesis of Spinel Group of minerals, Hematite, ilmenite, rutile, gibbsite and diaspore.
- 1.2 Sulphide and sulphate minerals : Structure, Chemistry, Distinguishing features and paragenesis of common minerals (pyrite, chalcopyrite, sphalerite, baryte, gypsum, and anhedrite).
- 1.3 Carbonate Minerals : Structure, Chemistry, Distinguishing features and paragenesis of calcite, dolomite, and aragonite
- 1.4 Phosphate and halide minerals : Apatite, monazite, fluorite and halite.

UNIT-II

- 2.1 Olivine Group : Structure, Classification, Chemistry, Distinguishing features and paragenesis.
- 2.2 Garnet Group : Structure, Classification, Chemistry, Distinguishing features and paragenesis.

- 2.3 Pyroxene and Pyroxenoid Group: Compositional changes and nomenclature; Structure and paragenesis of ortho- and clino-pyroxenes; Pyroxene thermometry.
- 2.4 Amphibole Group : Nomenclature, structure, chemistry and paragenesis of amphibole minerals. Exsolution textures in amphiboles.

UNIT-III (Phyllosilicates/Sheet Silicates)

- 3.1 Mica Group : Classification and Structure, Compositional variation and paragenesis.
- 3.2 Chlorite and chlorotoids : Classification and Structure, Compositional variation and paragenesis.
- 3.3 Clay Mineralogy : Classification, Structure, Identification and paragenesis.
- 3.4 Hydrous magnesian silicate minerals : Talc, Serpentine, vermiculite

UNIT-IV (Tecto-and cyclo-silicates)

- 4.1 Feldspar Group : Classification, structure, morphology and twinning, chemical characteristics and paragenesis of alkali feldspar, plagioclase and barium feldspar.
- 4.2 Feldspathoid Group : Structure, phase relations and paragenesis.
- 4.3 Mineralogy of silica minerals : quartz, tridimite, cristobalite, coesite and stishovite.
- 4.4 Cyclo- silicates : cordierite, beryl, tourmaline, axinite their structures, chemistry, distinguishing features and paragenesis.

Books Recomendaded

- | | | |
|----|---------------------------|--|
| 1. | Dana | A text book of mineralogy |
| 2. | Deer, Howie & Zussman, J. | An introduction to the rock forming minerals |
| 3. | Cerreyes | Introduction to mineralogy |
| 4. | Berr and Messon | Mineralogy |
| 5. | Kestov | Mineralogy |
| 6. | Batchkhtin | Mineralogy |

Course No. 470

GEOCHEMISTRY

Credits 2

Objectives To impart the knowledge about the concept of geochemistry and classification of elements.

UNIT-I

- 1.1 Concept of geochemistry, geochemical classification of elements.
- 1.2 Geochemical constitution of earth; Washington's, Goldschmidt's, Kuhn and Ritmann Hypothesis.
- 1.3 Meteorites: mineralogy and classification.
- 1.4 Geochemical cycles; endogenic and exogenic cycles.

UNIT-II

- 2.1 Geochemistry of the lithosphere.
- 2.2 Geochemistry of the hydrosphere.
- 2.3 Geochemistry of the atmosphere; structure and composition of atmosphere.
- 2.4 Geochemistry of the biosphere; geochemical role of bacteria, organaogenic sediments.

UNIT-III

- 3.1 Radiogenic isotopes, isotopic decay and growth of daughter isotopes, cosmogenic radionuclides.
- 3.2 Radiometric dating of single mineral and whole rock by various methods and their limitations.
- 3.3 Stable isotopes, nature, abundance and fractionation.
- 3.4 Oxygen, hydrogen, sulfur and carbon isotopes and their application in geology.

UNIT-IV

- 4.1 Significance of crystal chemistry in geochemistry, isomorphism and diadochy, camouflage, capturing and admission of trace elements.
- 4.2 Laws of thermodynamics, entropy and enthalpy, Gibb free energy.
- 4.3 Elemental partitioning in minerals/rocks, partition coefficient, simple and exchange reactions, application in petrogenetic studies.
- 4.4 Rare earth geochemistry, general geochemical properties of REE's and their abundance and mobility in crust.

Books Recommended

1.	Barnes	Geochemistry of Hydrothermal Ore Deposits
2.	Faure	Principle of Isotope Geology
3.	Henderson	Inorganic Geochemistry
4.	Henderson	Rare Earth Element Geochemistry
5.	Wedepohl	Handbook of Geochemistry
6.	Mason & Moore	Introduction to Geochemistry
7.	Alborede	Geochemistry: An introduction
8.	Ottonello	Principles of Geochemistry

Course No. 471**GEOTECTONICS****Credits 2**

Objectives To introduce the advanced ideas of internal structure of earth. To introduce the latest concept of geomagnetism and its application. To equip with the latest knowledge on tectonic evolution of Himalaya and Indian craton.

UNIT-I Internal structure and mechanics of earth

Seismic investigations of the earth's interior, waves velocity, velocity curves, density distribution, elastic properties, pressure and temperature within the earth.

Bulk composition of the earth and of its various zones.

Composition of the earth's crust and upper mantle and crust-mantle relationship.

1.4 Gravity anomalies.

UNIT-II Sea floor spreading and plate movement

2.1 Concept of continental drift, evidences of movement of continents, modern concept of plate tectonics, fitting of continents together, palaeoclimatic units.

2.2 Evidences of sea floor spreading, magmatic anomaly patterns, age of ocean sediments, oceanic ridges and trenches, benioff zone.

2.3 Geomagnetism-magnetization, types, magnetic field reversals, polar wandering curve, application in geology.

2.4 Nature of plate margins, constructive and destructive geometry of plate motion, mosaic of plates, direction of motion, causes of plate motion, convection plumes and other classical hypothesis.

UNIT-III Tectonic evolution of Himalaya

3.1 Convergence of continents, pre-Himalayan sedimentation, closing of continents, rotation of continental block, phases of deformation, shifting of depositional basins, vertical tectonics.

3.2 Drift and subduction of Indian plate, Andaman subduction zone, Andaman sea spreading centre and Makran subduction zone.

3.3 Indus-Tsangpo suture zone, Main Central Thrust, Main Boundary Fault, Siwalik structure, Himalayan Frontal Fault, evolution of Himalaya.

3.4 Neotectonic evidences in parts of Himalaya.

UNIT-IV Tectonic evolution of Indian craton

4.1 Evolutionary history and structural layout South Indian craton.

4.2 Evolutionary history and structural layout Central Indian craton.

4.3 East Indian region, evolutionary history.

4.4 Gravity conditions in Indian craton.

Books Recommended

1.	Condie	Plate Tectonics and Crustal Evolution
2.	Cox	Plate Tectonics and Geomagnetic Reversals
3.	Balanssov	Basic problems in Geotectonics
4.	Wadia	Geology of India
5.	Gansser	Geology of the Himalaya
6.	Valdiya	Aspects of Geotectonics
7.	Wyllia	Dynamics of Earth

Course No. 466 PRACTICAL RELATING TO COURSE NO'S. 464, 469 AND 471 Credits 4

- UNIT-I Course No. 464 (Igneous Petrology)
Megascopic study of important representative igneous rocks. Microscopic description of standard sections of igneous rocks.
- UNIT-II Course No. 469 (Descriptive Mineralogy)
Megascopic description and spotting of minerals. Microscopic identification and description of minerals.
- UNIT-III Course No. 471 (Geotectonics)
To draw cross section showing position and displacement of various beds of a given geological map and to write geological history represented by the map.
- UNIT-IV Viva – Voce.

Course No. 467 PRACTICAL RELATING TO COURSE NO'S. 451, 460, 465 AND 470 Credits 4

- UNIT-I Course No. 451 (Non-Clastic Sedimentology)
Preparation of rose diagrams from primary and secondary structures. Megascopic identification of non-clastic sedimentary rocks. Microscopic examination of limestones and dolomites. Staining and its application in identification of non-clastic minerals. Identification of carbonate minerals using X-ray and DTA data. Analysis of insoluble residues.
- UNIT-II Course No. 460 (Ore Geology)
Megascopic examination of economic ore minerals. Microscopic identification of polished ore sections.
- UNIT-III Course No. 465 (Elements of Hydrogeology)
Basic exercises in hydrometeorologic processes-evapotranspiration, average rainfall and runoff. Computation and climatic water balance study. Determination of water equivalent in snow hydrology. Presentation of hydrogeochemical data, flow net analysis.
- UNIT-IV Course No. 470 (Geochemistry)
Calculation of C I P W Norms
- UNIT-V Viva – Voce.

THIRD SEMESTER

Examinations to be conducted in December 2009, December 2010 and December 2011

Course No.	Title	Credits
Theory		
501	Metamorphic Petrology	2
508	Mining Geology	2
509	Groundwater Exploration and Water Wells	4
512	Vertebrate Palaeontology and Palaeobotany	2
515	Petroleum Geology	4
516	Engineering Geology	2
Practical		
513	Practical related to course No's. 501, 509	4
514	Practical related to course No's. 508, 512 and 515	4

Course No. 501 METAMORPHIC PETROLOGY Credits 2

Objectives To discuss the process of metamorphic reactions and paragenesis. To study the various aspects of metamorphic facies. To acquaint the students with latest metamorphic processes. To introduce the students to concept of metamorphic convergence.

UNIT-I

- 1.1 Metamorphic reactions, polymorphic transition, solid-solid, solid-gas application to geothermo-barometry.
- 1.2 Composition-paragenesis diagrams, ACF and AKF diagrams, AFM projections.
- 1.3 Metamorphic differentiation and anatexis in metamorphic rocks and granite magmas.
- 1.4 The process of metasomatism and its types.

UNIT-II

- 2.1 The concept and system of metamorphic facies.
- 2.2 Systematic description and characteristics of Sanidinite Facies.
- 2.3 Systematic description and characteristics of Amphibolite Facies.
- 2.4 Systematic description and characteristics of Green Schist and Eclogite Facies.

UNIT-III

- 3.1 Ocean floor metamorphism and its types.
- 3.2 Shock metamorphism.
- 3.3 Paired metamorphic belts and their significance.
- 3.4 Plate tectonics and regional metamorphism.

UNIT-IV

- 4.1 Mineralogy, texture, chemical composition, types and petrogenesis of Amphibolites.
- 4.2 Characters, composition, classification and genesis of Eclogites.
- 4.3 Characters, composition, types and origin of Charnokites.
- 4.4 Characters, types and origin of Migmatites.

Books Recommended

- | | |
|-------------------------|---|
| 1. Turner, F.J. | Metamorphic Petrology |
| 2. Bhaskar Rao, B. | Metamorphic Petrology |
| 3. Best, M.G. | Igneous and Metamorphic Petrology |
| 4. Bowes, D.R. | Encyclopedia of Igneous and Metamorphic Petrology |
| 5. Philipots, A. | Igneous and Metamorphic Petrology |
| 6. Yardley, B.W. | An Introduction to Metamorphic Petrology |
| 7. Bucher, K & Frey, M. | Petrogenesis of Metamorphic Rocks |
| 8. Miyashiro, A. | Metamorphic Petrology |

Course No. 508

MINING GEOLOGY

Credits 2

Objectives To impart the basic knowledge about the methods and techniques involved in mining, evaluation and exploration of the economic deposits.

UNIT-I **Mineral exploration**

- 1.1 Geological guides for the prospecting of mineral deposits; mineralogical, lithological and structural guides, gossans and capping.
- 1.2 Geochemical exploration; mobility and geochemical association of elements, primary and secondary geochemical dispersion patterns.
- 1.3 Geobotanical survey and biogeochemical method of mineral exploration.
- 1.4 Radioactive method of prospecting.

UNIT-II **Ore deposit evaluation**

- 2.1 Methods of sampling - channel, bulk, grab, chip, car, core and sludge. Trenching and pitting method.
- 2.2 Grade and methods of average grade calculation, assaying the sample.
- 2.3 Classification of resources and reserves.
- 2.4 Methods of estimation of the reserves for ore deposits.

UNIT-III **Mining method**

- 3.1 Classification of mining methods, introductory geological and economic aspects of mine planning, developmental works for underground mining, mode of entry in mines, drift, crosscuts, winz, raise, ore bin and ore chuites.
- 3.2 Surface mining methods; placer mining methods and open pit methods, ground sluicing, hydraulic mining, dredging, drift mining, shovel mining and multi bench, lateral advance mining method, their advantages and disadvantages.
- 3.3 Underground mining methods; open stopes mining methods, supported stopes mining methods, shrinkage, cut and fill and square set mining methods, caving methods- top slicing sublevel caving and block caving, their advantages and disadvantages.
- 3.4 Coal mining methods; coal stripping, room and pillar method, long wall mining methods, other miscellaneous methods, their advantages and disadvantages.

UNIT-IV **Mining operations**

- 4.1 Mining supports; support types with their merits and demerits.
- 4.2 Stowing methods; subsidence – causes and prevention.
- 4.3 Methods of breaking and blasting the rocks, types of explosives used, arrangements of drill holes for blasting in surface and underground mines.
- 4.4 Mining atmosphere; ventilation in underground mines, types and arrangements of directing ventilations in underground mining.

Books Recommended

- | | | |
|----|---------------------|---|
| 1. | Arogyaswami, R.N.P. | Course in Mining Geology |
| 2. | Beky, B. | Mining |
| 3. | Brooks | Geobotanical and Biogeochemical Exploration |
| 4. | Clarke & Lewis | Elements of Mining |
| 5. | Deshmukh, D.J. | Elements of Mining Technology |
| 6. | Forester | Field and Mining Geology |
| 7. | Mckinstry | Mining Geology |
| 8. | Nelson & Nelson | Applied Geology |

Course No. 509

GROUNDWATER EXPLORATION AND WATER WELLS

Credits 4

Objectives To acquaint the students with various methods employed in the groundwater exploration, water well conduction, development and completion, well hydraulics and varying problems being faced in the field under different climatological conditions.

UNIT-I

- 1.1 Surface indicators of groundwater, fracture trace analysis.
- 1.2 Surficial features indicating groundwater on aerial photographs and satellite images. Morphological and spectral characteristics of different rock groups. Hydrolithological, hydrostructural and hydromorphological classes and hydrogeological rating.
- 1.3 Electrical and seismic surface geophysical methods of groundwater exploration.
- 1.4 Subsurface geophysical methods-well logging techniques for delineating aquifer thickness and estimation of groundwater quality; electric, radiational both natural and induced, caliper and temperature logs.

UNIT-II

- 2.1 Effluent and influent streams, laminar and turbulent flow, Reynold's number and Manning equation. Darcy's law - assumptions, derivation, applications and limitations.
- 2.2 Differential equation governing groundwater flow.
- 2.3 Unconfined, confined, steady, unsteady and radial flow to the well. Theim's, Thies equation.
- 2.4 Evaluation of aquifer parameters using Theim's, Thies, Cooper-Jacob and Walton methods. Pump tests methods data analysis and interpretation of hydrogeologic boundaries.

UNIT-III

- 3.1 Determination of aquifer parameters - Pump test; Step-draw down test (SDT), formation and well characteristics; Slug test.
- 3.2 Partially penetrating well, well interference and criteria for spacing of wells. Aquifer-well relationships.

- 3.3 Volume elasticity of confined aquifer, $BE+TE=1$.
- 3.4 Groundwater basin management and perennial (safe) yield determination.

UNIT-IV

- 4.1 Different drilling methods used in the construction of shallow and deep wells. Various groundwater structures.
- 4.2 Different well development and completion methods.
- 4.3 Maintenances of water wells, their abandonment and sanitary protection.
- 4.4 Over pumping and land subsidence.

UNIT-V

- 5.1 Groundwater problems in arid regions and urban areas. Rainwater harvesting.
- 5.2 Groundwater balance and utilization.
- 5.3 Groundwater legislation.
- 5.4 Watershed management.

Books Recommended

- | | | | |
|-----|---------------------------|------|--|
| 1. | D. K. Todd | 1980 | Groundwater Hydrology. <i>John Wiley and Sons</i> |
| 2. | R.J. Lynch | 1976 | Formation Evaluation. <i>English Book Depot</i> |
| 3. | S.N. Davis & R.J.M. Wiest | 1966 | Hydrogeology. <i>John Wiley and Sons</i> |
| 4. | V. Chow | | Handbook of Applied Hydrology |
| 5. | E.E. Johnson | 1982 | Ground Water and Wells. <i>Johnson Division, UOP Inc</i> |
| 6. | W.C. Walton | 1970 | Groundwater Resource Evaluation. <i>Mc-Graw Hill Inc</i> |
| 7. | H. Bouwer | 1978 | Groundwater Hydrology. <i>Mc-Graw Hill Inc</i> |
| 8. | C.W. Fetter | 1990 | Applied Hydrogeology. <i>CBS Publishers and Distributors</i> |
| 9. | S.P. Garg | 1987 | Groundwater and Tube Wells. <i>Oxford and IBH Publishing Co. Pvt. Ltd.</i> |
| 10. | H.M. Raghunath | 1983 | Ground Water. <i>Wiley Eastern Limited</i> |
| 11. | H.M. Raghunath | 1986 | Hydrology. <i>Wiley Eastern Limited</i> |
| 11. | Harinarayan | | Exploration Techniques for Groundwater. <i>COSTED</i> |
| 12. | O.P. Handa | 1988 | Water Well Technology. <i>Oxford and IBH Publishing Co. Pvt. Ltd.</i> |
| 13. | Karant | 1989 | Hydrogeology. <i>Tata Mc-Graw Hill Publ. Comp. Ltd.</i> |
| 14. | US Department | 1985 | Ground water Manual of the Interior |

Course No. 512

VERTEBRATE PALAEOLOGY AND PALAEOBOTANY

Credits 2

Objectives To provide conceptual knowledge of the evolutionary processes of vertebrates as evidenced from the fossil record. To have detailed knowledge of the evolution of saurischian and ornithischian reptiles, proboscideans, perissodactyls, and primates with an emphasis on fossil distribution of these groups in India. To have a working knowledge of plant fossils with special reference to those of Gondwana Group and their geological significance.

UNIT-I

- 1.1. Evolutionary process and the fossil record: Micro- and Macro-evolution, heterochrony, punctuated equilibrium, Hennigian systematics, molecular clocks and estimation of divergence time.
- 1.2. Origin of vertebrates; general characters of vertebrates; function and evolution of bone and teeth.
- 1.3. Nature of vertebrate fossil record, methods of collection and preparation of vertebrate fossils; vertebrate life through ages and important landmarks in their evolution.
- 1.4. Classificatory characters and divisions of vertebrates at the level of class; the vertebrate transition from water to land.

UNIT-II

- 2.1. Classification of reptiles; origin of dinosaurs; origin of birds, anatomy of *Archaeopteryx*, birds as dinosaurs.
- 2.2. Endothermy versus ectothermy in dinosaurs; extinction of dinosaurs.
- 2.3. Palaeobiogeographic significance of Gondwana and Deccan intertrappean vertebrates of India.
- 2.4. Brief classification of mammals; habitat shift in whales - the fossil record from the Indian subcontinent.

UNIT-III

- 3.1. Interrelationships of major groups of primates; evolution of man and lithic cultures associated with various stages of human evolution.
- 3.2. Cenozoic distribution of horses; classic trends in the evolution of horses; evolutionary implications of climatic changes.
- 3.3. Evolution of proboscideans; Pleistocene extinction of mammoths.
- 3.4. Siwalik vertebrate faunal changes and their relation to tectonic and eustatic events.

UNIT-IV

- 4.1. Modes of preservation of plant fossils; modern techniques used in palaeobotanical studies, classification of plants.
- 4.2. Origin and highlights in the evolution of plants; dispersal and migration of plants.
- 4.3. Study of flora of past geological periods with special reference to Gondwana flora of India.
- 4.4. Application of palaeobotany in biostratigraphic correlation and palaeoclimatic studies; dendrochronology

Books Recommended

1. Romer, A.S. 1966 Vertebrate Paleontology (3rd edition). *Chicago University Press*
2. Carroll, R.L. 1988 Vertebrate Paleontology and Evolution. *W.H. Freeman and Company*
3. Colbert, E.H. 1955 Evolution of Vertebrates. *John Wiley & Sons*
4. Lull, R.S. 1976 Organic Evolution. *Macmillan Publishing Co. Inc*
5. Benton, M.J. 1990 Vertebrate Palaeontology. *Unwin Hyman Ltd*
6. Doyle, P. 1996 Understanding of Fossils. *John Wiley and Sons Ltd*
7. Fastovsky, D.E. & Weishampel, D.B. 1996 The evolution and extinction of dinosaurs. *Cambridge University Press*
8. Shukla, A.C. 1975 Essentials of Palaeobotany. *Vikas Publishing House Pvt. Ltd*
& Mishra, S.P.
9. Tschudy, R.H. 1969 Aspects of Palynology. *John Wiley & Sons*
& Scott, R.A.
10. Briggs, D.E.G 2001 Palaeobiology II. *Blackwell Science Ltd*
& Crowther, P.R.

Course No. 515

PETROLEUM GEOLOGY

Credits 4

Objectives To impart knowledge about the genesis, exploration, geological and spatial distribution of oil and gas.

UNIT-I

- 1.1 Origin of petroleum-organic and inorganic theories, limiting conditions; source material.
- 1.2 Transformation of organic matter into petroleum (bacterial activity, heat and pressure, catalytic reaction, radioactivity).
- 1.3 Kerogen, transformation of kerogen, factors influencing maturation of kerogen.
- 1.4 Surface and subsurface occurrence of petroleum.

UNIT-II

- 2.1 Physical and chemical properties of crude oil, composition of natural gas.
- 2.2 Extraction of petroleum products from crude oil; crude oil refining.
- 2.3 Reservoir rocks: classification, characteristics, relationship between porosity and permeability.
- 2.4 Reservoir fluids (water, oil and gas): distribution and classification in the reservoir, Characters of oilfield waters.

UNIT-III

- 3.1 Structural Traps for oil and gas accumulation: traps caused by folding, faulting and fracturing.
- 3.2 Primary and secondary stratigraphic traps.
- 3.3 Combination traps, salt domes, cap rock.
- 3.4 Primary and secondary migration of oil and gas.

UNIT-IV

- 4.1 Geological and geographical distribution of oil and natural gas in India.
- 4.2 Geology of Assam oil fields.

- 4.3 Geology of Gujarat oil fields.
- 4.4 Geology of Bombay High oilfields.

UNIT-V

- 5.1 Exploration of oil and gas: remote sensing, geological, geochemical and geobotanical studies.
- 5.2 Geophysical methods for oil prospecting: gravity, seismic and electrical methods.
- 5.3 Onshore and off-shore drilling for oil and gas.
- 5.4 Environmental impact of oil extraction, land subsidence caused by petroleum withdrawal, environmental concerns regarding use of petroleum.

Books Recommended

- | | | |
|-----|---------------------------------------|-----------------------------------|
| 1. | Mc.Cray, A.W & Frank, W.C. | Oil Well Drilling Technology |
| 2. | Chapman, R.E. | Petroleum Geology |
| 3. | Landes, K.K. | Petroleum Geology |
| 4. | Russel, W.L. | Principles of Petroleum Geology |
| 5. | Chandra, D. & Singh, R. M. | Petroleum (Indian Context) |
| 6. | Hager, D. | Practical Oil Geology |
| 7. | Levorson, A.I. | Geology of Petroleum |
| 8. | Amyx, J.W., Ban, D.M. & Whiting, R.L. | Petroleum Reservoir Engineering |
| 9. | Deshpande, B.G. | The World of Petroleum |
| 10. | Holson, G.D. & Tiratsoo, E.N. | Introduction to Petroleum Geology |
| 11. | Selley, R.C. | Elements of Petroleum Geology |

Course No. 516

ENGINEERING GEOLOGY

Credits 2

Objectives To impart knowledge about the materials of construction and their physical properties. To understand the impact of geologic conditions on foundation and design of buildings. To impart knowledge about the engineering consideration of seismicity and geological consideration for the construction of dams, bridges, tunnels and roads.

UNIT-I

- 1.1 Properties of rocks – road stones and concrete aggregate, abrasion value, impact value, attrition tests, crushing strength, adherence to tar, porosity and sorption, other physical features of stone, shear, modulus rupture, modulus of elasticity, poisson’s ratio, residual stress, spalling, defects in concrete, some physical and chemical features of rock forming minerals.
- 1.2 Materials of construction and their physical properties – puddle clay, bricks, tiles and other structural clay products, building stones and their properties, limes and plasters, cements, sands, crushed rock, concrete.
- 1.3 Various stages of geological investigations for civil engineering projects, preliminary investigation, construction ways and means of investigation, geological surveying, exploratory excavations, trenching, shaft sinking and tunneling, boring, soil mechanics studies, geophysical methods of exploration.
- 1.4 Building foundations – influence of geologic conditions on foundation, influence of groundwater on foundation design, preliminary work and exploratory work, cooperative subsurface investigations, subsidence of buildings, building regulations.

UNIT-II

- 2.1 Mass movements – causes of hill slope instability, monitoring and control of mass movements.
- 2.2 Landslides – types, creep of debris, bending of beds, sheet slides, earth flows, debris flows, landslides caused by the out washing of sands, landslides in politic rocks, slides of solid rocks, specific types of slope movements i.e. solifluction and sensitive clays.
- 2.3 Earthquakes – terminology, classification, causes and distribution, engineering consideration of seismicity, aseismic design of building structures, earthquake problems in India.
- 2.4 Case history of engineering projects and geological causes for mishaps and failures of engineering structures.

UNIT-III

- 3.1 Dams – types of dams; geotechnical conditions of dam sites; engineering properties, strength parameters, porosity and permeability, slaking test, forces acting on dams, weight of the dam, water pressure, uplift

- pressure, earthquake forces, relative suitability of different rocks i.e. igneous, metamorphic and sedimentary rocks. Major dams and their specifications.
- 3.2 Foundation of dams – review of dam construction, general preliminary work, exploratory work during construction, soundness of bed rock, possibility of earth movement, permeability of bed rock, grouting of foundation beds, dams on permeable foundation beds, materials of construction, construction problems, dams failures, inspection and maintenance.
 - 3.3 Geological consideration for evaluation of catchment areas and reservoir sites–catchment areas, reservoir sites, hydrological conditions when a reservoir is filled, causes of leakage, leakage through residual soils, leakage through transported superficial deposits, leakage through rock aquifers lining a reservoir, landslips causing leakage, fractured rocks and joints as means of leakage, instability of sides of reservoir, silting in reservoirs and their remedial measures.
 - 3.4 Shoreline engineering – sea water movements, erosional features of shorelines, types of shorelines, control of wave and current action, coast and shore protection, sea walls and bulk heads, revetments, groynes and jetties, replenishment.

UNIT-IV

- 4.1 Tunnels - classification and utility; geological investigations in tunneling projects - selection of tunnel route (alignment), selection of excavation methods, selection of design for the tunnel, assessment of cost and stability, assessment of environmental hazards.
- 4.2 Methods of tunneling in soft soils – Fore poling method, Needle beam method, Army method, American method, English method, Belgian method, Linear plate method, Compressed air method. Methods of tunneling in rocks – Drift method, Heading and bench method, Full face method.
- 4.3 Geological considerations for the construction of roads – lithological characters, geological structures, weathering, ground water considerations. Complicated regions for the construction of roads – roads in hilly regions, roads in marshy regions, roads in water logged areas, roads in permafrost regions, geological problems after road construction.
- 4.4 Geological consideration for the construction of bridges – terminology, stability of bridges, foundation of bridges.

Books Recommended

- | | | |
|-----|------------------------------|---|
| 1. | Trefethen, J.M. | Geology for Engineers |
| 2. | Richey, J.E. | Elements of Engineering Geology |
| 3. | Legget, R.F. | Geology and Engineering |
| 4. | Zaruba, Q. & Mencl, V. | Landslides and their control |
| 5. | Jaeger, C. | Rock Mechanics and Engineering |
| 6. | Srinivasan, R. | Harbour, Dock and Tunnel Engineering |
| 7. | Parbin Singh | A Text Book of Engineering and General Geology |
| 8. | Jai Krishna & Chandrasekaran | Elements of Earthquake Engineering |
| 9. | Bangar, K.M. | Principles of Engineering |
| 10. | Krynine, D.P. & Judd, W.R. | Principles of Engineering Geology and Geotechnics |
| 11. | Gupta, H.K. | Dams and Earthquakes |
| 12. | Brown, E.T. | Rock characterization, Testing and Monitoring |

Course No. 513

PRACTICAL RELATING TO COURSE NO'S. 501 & 509

Credits 4

- | | |
|----------|--|
| UNIT-I | Course No. 501 (Metamorphic Petrology)
Megascopic description and spotting of different metamorphic rocks. Microscopic description of thin sections of metamorphic rocks. |
| UNIT-II | Course No. 509 (Groundwater Exploration and Water Wells)
Computation of aquifer parameters from SDT and APT data. Identification of aquifer boundaries. Computation of intergranular pressure changes with declining water table. |
| UNIT-III | Two to three weeks field work / industrial training and submission of field report (An essential component of fifteen marks). |
| UNIT-IV | Viva – Voce. |

Course No. 514**PRACTICAL RELATING TO COURSE NO'S. 508, 512 AND 515****Credits 4**

- UNIT-I Course No. 508 (Mining Geology)
Exercises on determination of tenor, cut-off grades and ore reserves. Surveying by chain and tape and plane table methods.
- UNIT-II Course No. 512 (Vertebrate Palaeontology and Palaeobotany)
Megascopic and microscopic study and identification of important vertebrate fossils. Identification and description of important plant fossils.
- UNIT-III Course No. 515 (Petroleum Geology)
Exercises on calculation of oil and gas reserves. Evaluation of bore hole data and their interpretation. Logging exercises and their application in petroleum exploration.
- UNIT-IV Two to three weeks field work / industrial training and submission of field report (**An essential component of fifteen marks**).
- UNIT-V Viva – Voce.

FOURTH SEMESTER**Examinations to be conducted in May 2010, May 2011 and May 2012**

Course No.	Title		Credits
Theory			
553	Environmental Geology		4
558	Oceanography	2	
564	Applied Micropalaeontology		2
565	Advance Stratigraphy, Palaeogeography and Palaeoecology		2
566	Geophysical Exploration		2
575	Coal Geology	2	
568	Ore Petrology	2	
	OR		
571	Computer Application in Geology		2
	OR		
572	Mathematical Geology		2
Practical			
573	Practical related to course No's. 558, 564, and 568/571/572		4
574	Practical related to course No's. 566 and 575		4

Course No. 553**ENVIRONMENTAL GEOLOGY****Credits 4**

Objectives To introduce the concept and role of geology in the study of environment. To study the various aspects of Geo-hazards and their mitigation. To impart knowledge about pollution and their remedial measures. To introduce the awareness and legislative measures in the mitigation of environmental problems. To impart knowledge about the atmospheric system i.e. climate, air pressure, temperature and weather changes.

UNIT-I Earth system and biosphere

- 1.1 Inter-relationship of Earth, Man and Environment - population and environment, population and limited resources, disruption of natural system, causes and consequences of growth rates, population and carrying capacity, population control strategies. Earth's support to mankind.
- 1.2 Ecological spectrum - biotic communities; food chains, stratification in biotic communities, community stability, species diversity. Anthropogenic changes in ecosystem. Preserving gene pools and conserving endangered species.
- 1.3 Components of the geosphere and environment - lithosphere, biosphere, hydrosphere and atmosphere.
- 1.4 Biogeochemical cycles – nitrogen cycle, carbon cycle and phosphorous cycle.

UNIT-II Earth processes and geological hazards

- 2.1 Conditions promoting the hill slope instability, rockslides and avalanches, monitoring mass movements, slope control and stabilization.
- 2.2 Factors governing floods, flood characteristics, flood hazards and urbanization, flood management, flood forecasting.

- 2.3 Seismic hazards - causes and consequences, awareness and public response, coping with seismic hazards. Seismic conditions in India - Himalayan and Peninsular India. Tsunami generation mechanism and its impact on the coasts.
- 2.4 Volcanic hazards - volatiles, pyroclasts, flows, lahars, toxic gases, Nature, prediction and mitigation of volcanic hazards.

UNIT-III Energy / water resources and environmental problems

- 3.1 Energy resources- consumption and production trends of energy resources, environmental effects of various energy resources i.e. petroleum, natural gas, nuclear, hydropower, wind and solar.
- 3.2 Mineral resources and reserves. Environmental impact of exploitation, processing and smelting of minerals. Conservation of mineral resources.
- 3.3 Soil as a resource - soil-formation, soil profile, soil classification and soil erosion. Strategies to reduce soil erosion.
- 3.4 Water use and water supply, water quality, water management and conservation.

UNIT-IV Pollution and environment

- 4.1 Global warming - increase of CO₂ and N₂O due to industrialization, urbanization, burning of fossil fuels, volcanic activity and deforestation. Magnitude of ozone depletion and its impact. Suggestive measures.
- 4.2 Hydrology and pollution - human use of surface and subsurface water and connected problems of water pollution. Ocean pollution through addition of toxic waste.
- 4.3 Waste and its disposal - surface and subsurface disposal of toxic, metallic and radioactive wastes. Planning and management of hazardous waste. Domestic refuse and landfill.
- 4.4 Medical Geology – trace elements and health; controls on elemental intake, iodine, fluorine, zinc, selenium. Radioactivity and cigrates, regional variations in heart disease.

UNIT-V Environmental management

- 5.1 Environmental impact of mining - hazards of opencast and underground mining, effects on air, water and land. Disposal of mining waste, environmental management of mining.
- 5.2 Land use planning and environment - land use options; multiple use and sequential use. Land use and land cover with regard to global environmental change.
- 5.3 Desertification - causes and extant. Drylands of the Indian subcontinent - Thar desert, aggregation of desertic conditions. Signs of desertification in Himalaya. Measures to combat desertification.
- 5.4 Environmental Laws – Water Reserves Law, Mineral and Fuel Resources Law, Pollution Control Law, Natural Hazard Mitigation Law, International Resources Dispute i.e. Law of the Sea and Antarctica.

Books Recommended

- | | | |
|-----|---|---|
| 1. | Environmental Geology | Montgomery, C.W. |
| 2. | Natural Disaster and Sustainable Developments | Casale, R. & Margottini, C. |
| 3. | Introduction to Environmental Studies | Turk, J. |
| 4. | Exploitation-Conservation-Preservation:
A geographic perspective on natural resource use | Cutter, S.L. & Renwick, W.H. |
| 5. | Environmental Geotechnology | Hsai – Yang Fang |
| 6. | Environmental Geology | Keller, E.A. |
| 7. | Environmental Geology | Valdiya, K.S. |
| 8. | Environmental Geology | Merritts, D., Wet, A.D. & Menking, K. |
| 9. | The Atmosphere: An introduction to meteorology | Lutgen, F.K. & Tarbuck, E.J. |
| 10. | Encyclopedia of Global Change: Environment
Change and human society Vol 1 and Vol 2 | Gaudie, A.S. & Cuff, D.J. (Editors) |
| 11. | Natural Resources | Holechek, J.L., Cole, R.A., Fischer, J.T. &
Valdez, R. |
| 12. | Environmental Science | Santra, S.C. |

Course No. 558

OCEANOGRAPHY

Credits 2

Objectives To study the modern concepts regarding the topographic features of ocean basins their evolution in space and time. To study the dynamics of ocean water and sedimentation. To study the stratigraphy and geochronometry of marine sediments. To study the physical and biological resources of the marine realm.

UNIT-I

- 1.1 Origin and evolution of ocean basins; Palaeoceanography - Mesozoic, Palaeogene, and Neogene palaeoceans, sea-level fluctuations and their environmental response.
- 1.2 Topographic features of the ocean floor; continental margin provinces, ocean basin provinces; coral reefs.
- 1.3 Classification of marine sediments, sediment budget, sediment transport, accumulation of sediments in the ocean; sedimentation processes on continental shelves - physical processes, sediment response; sediment - organism interaction, deep-sea sediments.
- 1.4 Stratigraphic correlation and geochronology of deep-sea sediments.

UNIT-II

- 2.1. Origin and evolution of the Indian Ocean, structure and physiography of the Indian Ocean, bathymetry and bottom characteristics, sediment distribution on the Indian Ocean floor.
- 2.2. Marine exploration methods, direct methods and indirect methods; sea - bed deposits, oil and gas, petroleum potential of sea-bed provinces beyond the continental slope; petroleum occurrences and exploration activity around the margins of the Indian Ocean.
- 2.3. India's Exclusive Economic Zone (EEZ); marine minerals in the EEZ of India.
- 2.4. Wave dynamics, deep water waves, shallow water waves, wind waves; wave reflection, refraction and diffraction.

UNIT-III

- 3.1 Ocean circulation: forces driving currents; surface currents – flow within a gyre, geostrophic gyres, current within gyres, counter currents and under currents, effects of surface currents on climate; thermohaline circulation - thermohaline circulation patterns, global heat connection.
- 3.2. Wind induced vertical circulation - equatorial upwelling, coastal upwelling, downwelling; Coastal upwelling - its physical, chemical, biological characteristics, physical structure and dynamics, the chemical characteristics of upwelling systems, the biological characteristics of upwelling areas.
- 3.3. Heat budget and Atmospheric Circulation- Composition and properties of the atmosphere, changes in the atmosphere, wind patterns, storms, jet streams, El Nino, land effects on winds.
- 3.4. Tides - equilibrium theory of tides, dynamical theory of tides, tidal currents in coastal areas, observation and prediction of tides.

UNIT-IV

- 4.1 Seawater chemistry - salinity, components of salinity, sources of ocean's salts, processes controlling the composition of sea water, determining salinity, dissolved gases - Nitrogen, Oxygen, Carbondioxide; Density structure of ocean, density stratification and water masses.
- 4.2 Phytoplankton dynamics in the marine food web: inputs of organic carbon, concept of food chain; primary production, measuring productivity, factors limiting productivity-grazing pressure, losses to deep water, factors affecting growth rates - light, temperature, nutrients, physiological adaptations; application of remote sensing.
- 4.3 Marine resources: Physical Resources - Petroleum and Natural Gas, sand and gravel, magnesium and magnesium compounds, salts, manganese and phosphate nodules, metallic sulfides and muds; Biological Resources - fish, crustaceans, molluscs, whaling, fur-bearing mammals, botanical resources, aquaculture.
- 4.4. Marine pollution - pollutants: oil, heavy metals, synthetic organic chemicals, eutrophication, solid waste, sediment, sewage, waste heat, introduced species, the cost of pollution; habitat destruction: bays and estuaries, coral reefs, other habitats; global changes - ozone layer depletion, global warming, acid rain; coastal pollution in India.

Books Recommended

- | | | | |
|----|-----------------------------------|------|---|
| 1. | Garrison, T. | 1996 | Oceanography-An invitation to Marine Science. <i>Wadsworth Publishing Company</i> |
| 2. | Qasim, S.Z. & Roonwal, G.S.(eds). | 1996 | India's Exclusive Economic Zone. <i>Omega Scientific Publishers</i> |
| 3. | Thurman, B.Y. | 1978 | Introductory Oceanography. <i>Charles E. Merill Publishing Company</i> |
| 4. | Gross, M.G. | 1972 | Oceanography - A view of the Earth. <i>Prentice-Hall</i> |
| 5. | S. Davis, R.A. Jr. | 1972 | Principles of Oeanography. <i>Addison - Wesley Publishing Company</i> |
| 6. | Roonwal, G.S. | 1986 | The Indian Ocean: Exploitable mineral and petroleum Resources. <i>Narosa Publishing House</i> |
| 7. | Haq, B.U. & | 1984 | Marine Geology and oceanography of Arabian Sea and |

	Milliman, J.D.		coastal Pakistan. <i>Elite Publishers Limited</i>
8.	Francis P. Shepard		Geological Oceanography
9.	Bhatt, J.J.	1978	Oceanography - Exploring "the planet Ocean. <i>D. van Nostrand Company</i>
10.	Duxbury, A.B. & Duxbury, AC.	1993	Fundamentals of Oceanography. <i>Wm. C. Brown Publishers</i>
11.	Turekian, K.K.		Oceans

Course No. 564

APPLIED MICROPALAEONTOLOGY

Credits 2

Objectives To provide working knowledge of various microfossil groups and their role in hydrocarbon exploration, intercontinental correlation, and in the reconstruction of palaeoecology, palaeoenvironments and palaeogeography.

UNIT-I

- 1.1 Microfossils- Introduction, microfossil record, important microfossils; sampling, techniques for the separation of microfossils from the matrix, preparation and mounting of microfossils.
- 1.2 Morphology of ostracodes, ornamentation and orientation of the carapace, classification of Ostracoda, ostracodes and Sedimentology, significance of ostracodes in palaeoenvironmental reconstruction and petroleum exploration.
- 1.3 Foraminifera-Morphology of the test, test and its fossilization, composition and classification, palaeoecology of Foraminifera, Foraminifera and sedimentology, economic significance of Foraminifera.
- 1.4 Siliceous microfossils: Radiolaria-living radiolarians, classification, distribution and ecology, radiolarians and sedimentology, geological history and applications; Diatoms-general history, classification, ecology and applications.

UNIT-II

- 2.1 Calcareous nannofossils: Coccolithophores-General history, classification, life history, ecology, preservation and distribution in sediments, and application; mineralized plant and animal remains.
- 2.2 Composition of conodonts, conodont apparatus and assemblages, biological affinities and general history of conodonts, morphometrics and analysis of shape in conodonts.
- 2.3 Application of conodonts in correlation: application of conodont colour alteration index (CIA) in hydrocarbon exploration, mineral exploration, and in the interpretation of regional tectonics.
- 2.4 General morphology of spores and pollens, classification of spores and pollens, techniques of pollen analysis - maceration techniques; a brief account on the classification, biological affinities, distribution and ecology, and application of acritarchs, dinoflagellates and chitinozoans.

UNIT-III

- 3.1 Palynofacies analysis: Significance of palynofacies, kerogene, hydrocarbon source rock evaluation, role of detailed palynofacies in palaeoenvironmental analysis, palynofacies parameters for palaeoenvironmental analysis.
- 3.2 Microfossils as a source of sediments: lithogenesis through bioclastic accumulation, concentration of amorphous organic substances, connection between lithogenesis and microbiotic activity.
- 3.3 Microfossil as chronometers, biozones and biozonation, limits and values of biozonation; identification of depositional breaks; application of microfossils in sequence stratigraphic analysis; characterization of formations.
- 3.4 Practical difficulties in biostratigraphic interpretations: Data quality, reworking and caving, age interpretation, taxonomic nomenclature, preparation techniques, microfossil zonal identification, palaeoenvironmental controls.

UNIT-IV

- 4.1 Environmental significance of microfossils-continental environments, mixed environments, marine environments, mixing and displacement of microfossils; determination of palaeofacies by microfaunas; palaeoecological procedure, interpretation of transgressive and regressive events from microfossil evidence; isotopic determination of palaeotemperatures.
- 4.2 Microfossils as palaeogeographic indicators; bioprovinces and movements of continents, palaeogeographic changes of Tethys and Atlantic.

- 4.3 Role of micropalaeontology in hydrocarbon exploration and development; exploration for prospects, well evaluation; drilling problems-setting casing, coring point selection, terminal depth decisions, stratigraphic monitoring.
- 4.4 Appraisal of discoveries- well correlation, reservoir distribution and estimates, trap evaluation and field development.

Books Recommended

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|-----|--------------------------------------|------|---|
| 1. | Gerard Bignot | 1985 | Elements of Micro Palaeontology. <i>Graham & Trotman Limited</i> |
| 2. | David G. Jenkins (Ed) | 1993 | Applied Micropalaeontology. <i>Kluwer Academic Publishers</i> |
| 3. | Danial J. Jones | 1956 | Introduction to Microfossils. <i>Harper & Brothers, Harper Geoscience Series.</i> |
| 4. | Ronald L. Austin (Ed) | 1987 | Conodonts: Investigative Techniques and Applications. <i>Ellis Horwood Limited</i> |
| 5. | B.V. Haq and A. Boersma | 1998 | Introduction to Marine Micropalaeontology. <i>Elsevier</i> |
| 6. | Vladimir Pokorny | 1963 | Principles of Zoological Micro Palaeontology (Volume 1). <i>Pergamon Press</i> |
| 7. | Vladimir Pokorny | 1965 | Principles of Zoological Micropalaeontology (Volume 2). <i>Pergamon Press</i> |
| 8. | Robert H. Tschudy & Richard A. Scott | 1969 | Aspects of Palynology. <i>Wiley Interscience</i> |
| 9. | Bernhard Kummel & David Raup | 1965 | Handbook of Palaeontological Techniques. <i>W.H. Freeman & Company</i> |
| 10. | M.D. Brasier | 1980 | Microfossils. <i>George Allen & Unwin</i> |

Course No. 565 ADVANCE STRATIGRAPHY, PALAEOGEOGRAPHY AND PALAEOECOLOGY Credits 2

Objectives To impart knowledge about the concept of time in stratigraphy, seismic stratigraphy, magnetostratigraphy, facies cycles, sequence stratigraphy, palaeoecology and palaeobiogeography.

UNIT-I

- 1.1 Sequence stratigraphy – trends and terminology, facies cycles and stratigraphic cycles, Milankovitch processes and non-glacial Milankovitch cyclicality.
- 1.2 Identification of sequence boundaries, chronostratigraphy in relation to unconformities, biostratigraphic framework and associated problems.
- 1.3 Global bio-events, boundary problems in stratigraphy with reference to Precambrian-Cambrian, Permian-Triassic and Cretaceous-Tertiary.
- 1.4 Karewa deposits of Kashmir. A study with multidisciplinary approach.

UNIT-II

- 2.1 Palaeoecology – concepts, data base, operational use, nature of fossil record.
- 2.2 Ecosystem – community concept, application of community in palaeoenvironmental reconstruction.
- 2.3 Temporal patterns – causes, successions, environmental and evolutionary variations.
- 2.4 Taxonomic uniformitarian analysis in general and with specific emphasis on foraminifera.

UNIT-III

- 3.1 Palaeobiogeography – concepts, recognition, factors controlling geographic distribution of species.
- 3.2 Presentation of stratigraphic data and interpretation, stratigraphic, structural, isopach and facies maps.
- 3.3 Tephrochronology – techniques with examples.
- 3.4 Chemo-stratigraphy, concept and recognition.

UNIT-IV

- 4.1 Concept of time in stratigraphy – measuring time, radiometric age dating techniques and problems.
- 4.2 Fission-track dating – assumptions and use in stratigraphy.
- 4.3 Seismic stratigraphy – principles and assumptions, techniques for estimating continuity, seismic facies.
- 4.4 Magnetostratigraphy – palaeomagnetism, polarity time scale, magnetic reversals.

Books Recommended

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|----|-------------------------------|--|
| 1. | Brenner & Mc Hargue | Integrative Stratigraphy |
| 2. | Duff, Hallam & Walton | Cyclic Sedimentation |
| 3. | Ager | Principles of Palaeoecology |
| 4. | Imbrie & Newell | Approaches to Palaeoecology |
| 5. | Dodd & Stanton | Palaeoecology, Concepts and Applications |
| 6. | Miall | The Geology of Stratigraphic Sequences |
| 7. | Agrawal et al | Climate and Geology of Kashmir |
| 8. | GSI Misc. Publ. Vol.16 (1988) | Stratigraphic Boundary Problems in India |

Course No. 566

GEOPHYSICAL EXPLORATION

Credits 2

Objectives It is intended to familiarize the post graduate students with the principles, methodology and application of important geophysical methods adopted to investigate the surface and subsurface.

UNIT-I

- 1.1 Introduction to geophysical exploration. Gravity method - basic principles. Earth's gravitational field and its relation to geophysical exploration.
- 1.2 Instruments used in gravity prospecting - pendulum, torsion balance and gravimeters.
- 1.3 Marine, Airborne and Terrestrial gravity measurements.
- 1.4 Reduction of gravity data, separation of regional-residual gravity anomalies and interpretation of gravity data.

UNIT-II

- 2.1 Magnetic method - basic concepts. Geomagnetism.
- 2.2 Instruments used in magnetic surveys – dip needle, Hotchkiss superdip, and magnetometers.
- 2.3 Marine, Airborne and Terrestrial magnetic surveying techniques.
- 2.4 Reduction of magnetic data, separation of regional-residual magnetic anomalies and interpretation of magnetic data.

UNIT-III

- 3.1 Seismic method - basic principles, types of elastic waves.
- 3.2 Refraction technique - Time distance relations for horizontal interface, dipping beds and faults. Delay time, shot and detector arrangement and corrections.
- 3.3 Reflection technique - Time distance relations for horizontal and dipping interfaces, shooting procedures and corrections applied to reflection records.
- 3.4 Seismic instruments and records (digital and analog).

UNIT-IV

- 4.1 Electrical method - electrical properties. Principle, field procedures and electrode arrays used in electrical resistivity method and its application in groundwater and engineering problems.
- 4.2 Electromagnetic techniques - natural source and inductive type.
- 4.3 Well logging: Electrical, radiational and allied techniques used in petroleum, mineral and groundwater exploration.
- 4.4 Radiational method - basic principles. Instruments used in the detection and measurements of radiations and operating procedures.

Books Recommended

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|----|-----------------------|--|
| 1. | A.M. Evans (Ed.) 1998 | Introduction to Mineral Exploration. <i>Blackwell Science Ltd.</i> 2 |
| 2. | C. A. Heiland 1940 | Geophysical Exploration. <i>Prentice-Hall Inc.</i> |
| 3. | G. D. Garland 1979 | Introduction to Geophysics. <i>W.B. Saunders Company</i> |
| 4. | Gerhard Dahr 1984 | Applied Geophysics. <i>English Book Depot</i> |
| 5. | L. L. Nettleton 1940 | Geophysical prospecting for oil. <i>McGraw-Hill Book Company Inc.</i> |
| 6. | L. L. Nettleton 1976 | Gravity and Magnetics in oil prospecting. <i>McGraw-Hill Book Company Inc.</i> |
| 7. | M. B. Dobrin 1952 | Introduction to Geophysical Prospecting. <i>McGraw-Hill Book</i> |

8. M. B. Dobrin 1960 *Company Inc.*
Introduction to Geophysical Prospecting. *McGraw-Hill Book Company Inc.*
9. M. B. Dobrin 1988
& C.H. Savit Introduction to Geophysical Prospecting. *McGraw-Hill Company Inc.*
10. M. B. R. Rao 1975
Outlines of Geophysical Prospecting—A Manual for Geologist. *Wesley Press*
11. P. Kearey 1984
& M. Brooks An Introduction to Geophysical Exploration. *Blackwell Publication*
12. T.S. Ramakrishna 2006
Geophysical Practice in Mineral Exploration and Mapping. *Memoir 62, Geological Society of India*
13. W. M. Telford, 1988
L.P. Geldart, R.E. Sheriff & D. A. Keys Applied Geophysics. *Oxford and IBH Publishing Co. Ltd.*
14. William Lowrie 1997
Fundamentals of Geophysics. *Cambridge University Press*
15. E.J. Lynch 1976
Formation Evaluation. *English Book Depot*

Course No 575

COAL GEOLOGY

Credits 2

Objectives To impart knowledge about the genesis and distribution of coal in space and time.

UNIT-I

- 1.1 Origin of coal: accumulation of vegetable matter (insitu and drift theories), formation of coal (humification and coalification processes).
- 1.2 Types of coal, coal-rank, grade; physical properties of coal.
- 1.3 Seyler's Classification of coal, grading of coking and non-coking coals of India.
- 1.4 Chemical characteristics; proximate and ultimate analysis.

UNIT-II

- 2.1 Lithotypes of hard and soft coal; structures in coal seams.
- 2.2 Petrography of coal: lithotypes, macerals and microlithotypes.
- 2.3 Stages and methods of coal exploration; estimation of coal reserves.
- 2.4 Coal preparation for different industrial uses.

UNIT-III

- 3.1 Combustion and carbonization of coal.
- 3.2 Gasification and hydrogenation of coal.
- 3.3 Coal forming epochs, coal and lignite resources of India.
- 3.4 Geological and geographical distribution of coal in India.

UNIT-IV

- 4.1 Detailed geology of Jharia coalfield.
- 4.2 Detailed geology of Raniganj coalfield.
- 4.3 Coal bed methane: new energy resource, maturation of coal and generation of methane in coal beds.
- 4.4 Environmental hazards related to coal.

Books Recommended

1. Chandra, D., Singh, R.M & Singh, M.P. A Text Book of coal
2. Singh, M.P. (Ed.) Coal and Organic Petrology
3. Sharma, N.L. Introduction to the Geology of Coal and Indian Coalfields
4. S.K. Acharyya Coal and Lignite Resources of India

Course No. 568

ORE PETROLOGY

Credits 2

Objectives To introduce the modern concepts of the ore genesis. To understand the concepts used in the ore mineralogy. To understand the advance techniques used in ore genesis.

UNIT-I

- 1.1 General principles of ore mineralogy, Physical and optical properties of ore minerals.
- 1.2 Qualitative and quantitative measurement of reflectance – techniques, procedure and application in mineral identification.
- 1.3 Micro-indentation hardness – measurements, shapes of hardness micro-indentation and factors affecting micro-indentation hardness.
- 1.4 Application of ore microscopy in mineral technology.

UNIT-II

- 2.1 Ore mineral texture – primary, secondary and special textures.
- 2.2 Paragenesis, paragenetic studies and zoning in ore deposits and theory of sequential deposition.
- 2.3 Ore forming fluids – types, magma and magmatic fluid, migration of fluids and deposition of ores. Partitioning of metallic elements to hydrothermal solutions.
- 2.4 Hydrothermal alterations and their characteristics. Alkali metasomatism, greisens systems, skarns and related deposits.

UNIT-III

- 3.1 Chemistry of ore minerals and host rocks; bulk chemistry, trace elements and REEs geochemistry of ore and their significance in ore genesis.
- 3.2 Stable isotopes (O,H,C and S) in ore and host rocks and their application in ore genetic studies.
- 3.3 Radiogenic isotopes of ores and host rocks and their application in ore genetic studies.
- 3.4 Phase equilibria, phase relationships in the selected sulfide systems (Fe-S, Fe-Zn-S, Cu-Fe-S).

UNIT-IV

- 4.1 Geothermometry and geobarometry, fixed scale, geothermometers and sliding scale geothermometers. Use of phase diagrams in geobarometry and geothermometry.
- 4.2 Fluid inclusion studies; principles, characterization, heating and freezing studies and its application in ore genesis.
- 4.3 Metallogeny in different tectonic settings.
- 4.4 Organic matters in ores and their significance.

Books Recommended

- | | | |
|-----|--------------------|---|
| 1. | Barnes | Geochemistry of Hydrothermal Ore Deposits |
| 2. | Cameron | Ore Microscopy |
| 3. | Craig & Vaughan | Ore Petrography and Mineralogy |
| 4. | Edwards & Atinkson | Ore Deposit Geology |
| 5. | Evans | Ore Geology and Industrial Minerals |
| 6. | Klemm & Schneider | Time and Strata Bound Deposits |
| 7. | Mukerjee | Ore Genesis: A Holistic Approach |
| 8. | Park & Macdiarmid | Ore Deposits |
| 9. | Stanton | Ore Petrology |
| 10. | Swaskins | Metal Deposits in relation to plate tectonics |

Course No. 571

COMPUTER APPLICATION IN GEOLOGY

Credits 2

Objectives Introduce the students of geology to the basics of computer and its application in solving the geology related problems.

UNIT-I **Introduction to computer history and hardware**

- 1.1 Historical development and generation of computers.
- 1.2 Computer organization – control unit, arithmetic-logic unit, input / output device.
- 1.3 Memory devices: RAM, ROM, PROM, EPROM, Serial access, Direct access memory.
- 1.4 Data processing concepts-data storage, file organization, file utilities, data base management, advantages and limitations.

UNIT-II **Number Systems**

- 2.1 Positional and non-positional numbers, binary, octal and hexadecimal number system.
- 2.2 Converting from one number system to another system.
- 2.3 Binary arithmetic – addition, subtraction, multiplication division.
- 2.4 Computer codes – BCD, EBCDIC ASCII 7 codes.

UNIT-III **Computer Languages**

- 3.1 Machine language, assembly language, high level language.
- 3.2 High level languages – preliminaries of Fortran, Cobol, Basic, Pascal.
- 3.3 Introduction to Amphibol software, operating and commands.
- 3.4 Petrocal software, operating and commands.

UNIT-IV **Fortran Programming**

- 4.1 Elements of Fortran programming-classes of data, constants and variables.
- 4.2 Problem analysis, algorithm development, quality of algorithms, flow charts and symbols, debugging and testing.
- 4.3 GOTO, IF, DO, LOOP Statements.
- 4.4 Subscript variables, arrays, dimension and Format statements.

Books Recommended

- | | | |
|----|---------------------|---|
| 1. | V. Rajaraman | Fundamentals of Computers |
| 2. | B.B. Bayer | Programming software, designing and problem solving |
| 3. | Krishnamurthy & Sen | Computer based numerical algorithm |
| 4. | D.D. MoGracken | A simplified guide to FORTRAN programming |
| 5. | Ram Kumar | Programming with FORTRAN 77 |
| 6. | P.K. Sinha | Computer Fundamentals |

Course No. 572

MATHEMATICAL GEOLOGY

Credits 2

Objectives To impart knowledge about the use of numerical data in geoscience, parametric and non-parametric tests and linear and multiple regression interpretations.

UNIT-I **Numerical data in Geoscience**

- 1.1 Measure scales in Geosciences.
- 1.2 Frequency distributions and measures of central tendency.
- 1.3 Measures of dispersion.
- 1.4 Measures of skewness and kurtosis.

UNIT-II **Probabilistic treatment in Geoscience**

- 2.1 Introduction to probability and axians.
- 2.2 Normal distribution and characteristics.
- 2.3 Binomial distribution and characteristics.
- 2.4 Extreme value distribution.

UNIT-III **Sampling and Sampling Plan**

- 3.1 Theoretical bias and sampling plan.
- 3.2 Random sampling.
- 3.3 Restricted random sampling.
- 3.4 Designing and conducting a sampling survey.

UNIT-IV **Parametric and Non-parametric tests and Regression**

- 4.1 Student's T-test and its significance.
- 4.2 Chi-Square test and its uses.
- 4.3 Linear regression and Least square method of conducting regression lines.
- 4.4 Multiple regression-a graphic interpretation.

Books Recommended

- | | | |
|----|------------------------|---|
| 1. | Pal, S.K. | Statistics for Geoscientists: Techniques and Applications |
| 2. | Orkin, M. & Drogen, R. | Vital Statistics |
| 3. | Griffiths, R.G. | Scientific methods in Sedimentology |
| 4. | Koch, G.S & Link, F.R. | Statistical analysis in geological data |

Course No. 573 PRACTICAL RELATING TO COURSE NO'S. 558, 564, 568, 571 AND 572 Credits 4

- UNIT-I Course No. 558 (Oceanography)
Study of tectonic features, ocean circulation pattern using ocean and land distribution maps. Exercises on distribution of economic mineral deposition in the world oceans.
- UNIT-II Course No. 564 (Applied Micropalaeontology)
Processing of samples, picking and mounting of fauna. Study of diagnostic morphological characters of selected microfossils. Exercises on biometric analysis of microfossils. Construction of biostratigraphic correlation charts and relative charts.
- UNIT-III Course No. 568 (Ore Petrology) **Optional**
Mineralogical and textural studies of common ore minerals under ore microscope. Exercises on fluid inclusion geothermometry.
- OR**
- UNIT-IV Course No. 571 (Computer application in Geology) **Optional**
Simple problems solving and programming in Fortran-77
- OR**
- UNIT-V Course No. 572 (Mathematical Geology) **Optional**
Basic exercises involving the geostatistical principles and their applicability in structural, geophysical and economic geology.
- UNIT-VI Viva – Voce.

Course No. 574 PRACTICAL RELATING TO COURSE NO'S. 566 AND 575 Credits 4

- UNIT-I Course No. 566 (Geophysical Exploration)
Surface and subsurface geophysical anomalies and their interpretations. Determination of velocities and thickness of layers by seismic refraction survey, time distance graphs.
- UNIT-II Course No. 575 (Coal Geology)
Megascopic examination of representative coal samples. Microscopic examination of coal pellets. Exercises on calculation of coal reserves.
- UNIT-III Viva – Voce.

NOTE: FOR FURTHER CLARIFICATION CONTACT THE TEACHER CONCERNED