PROPOSED SEMESTER-WISE STRUCTURE, REGULATIONS AND DETAILED SYLLABUS OF M.Sc. (GEOLOGY) PROGRAM IN CBC SYSTEM

THE UNIVERSITY OF BURDWAN,
RAJBATI, BURDWAN,
WEST BENGAL

Course Structure of M.Sc. (Geology) of the University of Burdwan, Burdwan, West Bengal

SEMESTER – I

Sl. No.	COURSE NO.	COURSE	L-T-P	CREDIT POINTS	EXAM DURATION (HRS.)	MAXIMUM MARKS
1.	PGGEOL 0101	Mineralogy & Geochemistry	4-0-0	4	2	50
2.	PGGEOL 0102	Igneous Petrology	4-0-0	4	2	50
3.	PGGEOL 0103	Sedimentology	4-0-0	4	2	50
4.	PGGEOL 0104	Metamorphic Petrology	4-0-0	4	2	50
PRACTICALS:						
5.	PGGEOL 0105	Mineralogy & Igneous Petrology	0-0-4	2	3	50
6.	PGGEOL 0106	Sedimentary & Metamorphic Petrology	0-0-4	2	3	50
		TOTAL	16-0-8	20		300

SEMESTER – II

Sl. No.	COURSE NO.	COURSE	L-T-P	CREDIT POINTS	EXAM DURATION (HRS.)	MAXIMUM MARKS
1.	PGGEOL 0201	Structural Geology & Geotectonics	4-0-0	4	2	50
2.	PGGEOL 0202	Palaeontology	4-0-0	4	2	50
3.	PGGEOL 0203	Advanced Stratigraphy	4-0-0	4	2	50
4.	PGGEOL 0204	Hydrogeology	4-0-0	4	2	50
PRACTICALS:						
5.	PGGEOL 0205	Structural Geology	0-0-4	2	3	50
6.	PGGEOL 0206	Palaeontology	0-0-4	2	3	50
7.	PGGEOL 0207	Field Geology	0-0-0	2		25
		TOTAL	16-0-8	22		325

SEMESTER – III

Sl. No.	COURSE NO.	COURSE	L-T-P	CREDIT POINTS	EXAM DURATION (HRS.)	MAXIMUM MARKS
1.	PGGEOL 0301	Economic Geology	4-0-0	4	2	50
2.	PGGEOL 0302	Fuel Geology	4-0-0	4	2	50
3.	PGGEOL 0303	Mining & Engineering Geology	4-0-0	4	2	50
4.	PGGEOL 0304	Major Elective I (any one) • Remote Sensing & GIS • Geostatistics • Rock deformation & Structural analysis • Computer System & Programming • Advanced Metamorphic Petrology • Palaeobiology: Modern Concepts	4-0-0	4	2	50

5.	PGGEOL 0305	Minor Elective (any one) • Environmental Geology • Natural hazards and mitigation • Photogeology and Remote Sensing • Hydrogeology	2-0-0	2	1	25
PRACTICALS:						
6.	PGGEOL 0306	Ore Geology	0-0-4	2	3	50
7.	PGGEOL 0307	Major Elective I (as Chosen in Course No. 304)	0-4-4	4	3	50
		TOTAL	18-4-8	24		325

SEMESTER – IV

Sl. No.	COURSE NO.	COURSE	L-T-P	CREDIT POINTS	EXAM DURATION (HRS.)	MAXIMUM MARKS	
1.	PGGEOL 0401	Mineral Exploration and reserve estimation	4-0-0	4	2	50	
2.	PGGEOL 0402	Major Elective II (any one) • Sedimentary Environment & Sedimentary basin analysis • Petroleum Exploration • Micropalaeontology: Application to exploration sector • Oceanography • Applied Coal Petrology • Applied Geophysics • Mineral Beneficiation & Mineral Economics	4-0-0	4	2	50	
PRACTICALS							
3.	PGGEOL 0403	Major Elective II (as Chosen in Course No. 402)	0-4-4	4	3	50	
4.	PGGEOL 0404	Dissertation and Social Outreach Programme Thesis (4) Viva-voce (1) Seminar (1) Social Outreach Programme (1) Internal Assessment (1)	0-0-0	8		 75 10 20 15 30	150
		TOTAL	08-4-4	20		300	

REGULATIONS

1. In M.Sc. (Geology) program the evaluation of the candidate shall be based on continuous assessment. Thus, each semester may be divided in three discrete component viz. C_1, C_2 and C_3. The outline for continuous assessment activities of different components will be proposed by the teacher(s) concerned before the commencement of the course and will be discussed and decided in appropriate forum. The students should be informed about the modalities well in advance. The first component (C_1) of assessment is for 10% of total marks of semester. This will be based on class test or assignment or seminar etc. During the first half of each semester, 50% of the syllabus will be completed. The continuous assessment and the scores of first half, C_1 will be consolidated during the 8^{th} week of the semester. The second component (C_2) of assessment is for 10% of total marks. This will also be based on class test or assignment or seminar etc. C_2 will be consolidated during the 16^{th} week of the semester. During 18^{th} to 20^{th} week of semester, a semester end examination (c_3) shall be conducted for each course. The total marks for C_3 is 80%. The result for each course in a semester will be based on the performance of C_1, C_2 and C_3 and it will be on the basis of grade point as fixed by the University of Burdwan.
2. In Semester II, there will be a compulsory field work that will cover structural and petrological studies of poly-deformed terrain.
3. There will be two major electives one each in Semester III & IV. There will be both tutorials and practicals in major electives.
4. In Semester III, students of Geology have to choose a minor elective course from a pool of courses from other departments of the University of Burdwan.
5. In Semester IV, every student has to submit a dissertation on the basis of his or her observations in the field and/or in the laboratory in any branch of Geology under the guidance of teacher(s). The dissertation thesis will be evaluated by the internal and external examiners separately. The dissertation also includes viva-voce conducted jointly by the external and internal examiners and a departmental seminar. Each student will have to present the dissertation work in an open seminar and will be evaluated by a panel of internal examiners. The Social Outreach Programme will be evaluated by one Internal Adjudicator.

PROGRAMME OUTCOME- PROGRAMME SPECIFIC OUTCOME- COURSE OUTCOME

1. Programme Outcome:

A. **Post-Graduate Attributes:** the particular quality and feature or characteristics of an individual, including the knowledge, skills, attitudes and values that are expected to be acquired by a post-graduate through studies at the higher education institution.
Some of the characteristic attributes that student should demonstrate:
i) Disciplinary knowledge ii)
Communication Skills iii)
Critical thinking
iv) Problem solving
v) Analytical reasoning
vi) Research-related skills vii)
Cooperation/Team work viii)
Scientific reasoning
ix) Reflective thinking
x) Information/digital literacy
xi) Self-directed learning
xii) Multicultural competence
xiii) Moral and ethical awareness/reasoning xiv)
Leadership readiness/qualities
xv) Lifelong learning

B. **Qualification descriptors:** the generic outcomes and attributes expected for the award of a particular type of qualification.
Some of the expected learning outcomes that a student should be able to demonstrate on completion of a programme may include the following:

- Demonstrate (i) a fundamental/systematic or coherent understanding of an academic field of study, its different learning areas and applications, and its linkages with related disciplinary areas/subjects; (ii) procedural knowledge that creates different types of professionals related to the disciplinary/subject area of study, including research and development, teaching and government and public service; (iii) skills in areas related to one's specialization and current developments in the academic field of study.
- Use knowledge, understanding and skills required for identifying problems and issues, collection of relevant quantitative and/or qualitative data drawing on a wide range of sources, and their application, analysis and evaluation using methodologies as appropriate to the subject(s) for formulating evidence-based solutions and arguments;
- Communicate the results of studies undertaken in an academic field accurately in a range of different contexts using the main concepts, constructs and techniques of the subject(s);
- Meet one's own learning needs, drawing on a range of current research and development work and professional materials;
- Apply one's disciplinary knowledge and transferable skills to new/unfamiliar contexts, rather than replicate curriculum content knowledge, to identify and analyse problems and issues and solve complex problems with well-defined solutions.
- Demonstrate subject-related and transferable skills that are relevant to some of the job trades and employment opportunities.

2. Programme Specific/ Learning Outcome:

M.Sc. in Geology course:

The student pursuing M. Sc. (Honours) Geology should be able to

 Acquire
a) a fundamental/systematic or coherent understanding of the academic field of Geology, its different learning areas and applications in basic Geology like Mineralogy, Petrology, Stratigraphy, Palaeontology, Economic geology, Hydrogeology, etc. and its linkages with related interdisciplinary areas/subjects like Geography, Environmental sciences, Physics, Chemistry, Mathematics, Life sciences, Atmospheric sciences, Remote Sensing, Computer science, Information Technology;
b) procedural knowledge that creates different types of professionals related to the disciplinary/subject area of Geology, including professionals engaged in research and development, teaching and government/public service;
c) skills in areas related to one's specialization area within the disciplinary/subject area of Geology and current and emerging developments in the field of Geosciences.

 Demonstrate the ability to use skills in Geology and its related areas of technology for formulating and tackling geosciences-related problems and identifying and applying appropriate geological principles and methodologies to solve a wide range of problems associated with geosciences.

 Recognize the importance of RS&GIS, mathematical modeling simulation and computing, and the role of approximation and mathematical approaches to describing the physical world.

 Plan and execute Geology-related experiments or investigations, analyze and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and purpose-written packages, and report accurately the findings of the experiment/investigations while relating the conclusions/findings to relevant theories in Geology.

 Demonstrate relevant generic skills and global competencies such as
a) problem-solving skills that are required to solve different types of geoscience-related problems with well-defined solutions, and tackle open-ended problems that belong to the disciplinary area boundaries;
b) investigative skills, including skills of independent investigation of geoscience-related issues and problems;
c) communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise manner to different groups/audiences of technical or popular nature; d) analytical skills involving paying attention to detail and ability to construct logical arguments using correct technical language related to Geology and ability to translate them with popular language when needed; e) ICT skills; f) personal skills such as the ability to work both independently and in Teams

 Demonstrate professional behaviour such as
a) being objective, unbiased and truthful in all aspects of work and avoiding unethical, irrational behaviour such as fabricating, falsifying or misrepresenting data or committing plagiarism; b) the ability to identify the potential ethical issues in work-related situations; c) appreciation of intellectual property, environmental and sustainability issues; and d) promoting safe learning and working environment.

Courses for M.Sc. (Geology)

Sr No	Learning Outcomes	PGEOL-0301	PGEOL-0302	PGEOL-0303	PGEOL-0304	PGEOL-0305	PGEOL-0306	PGEOL-0307	PGEOL-0401	PGEOL-0402	PGEOL-0403	PGEOL-0404
1	Fundamental understanding of the field	X	X	X	X	X	X	X	X	X	X	X
2	Application of basic Geology Concepts	X	X	X	X	X	X	X	X	X	X	X
3	Linkages with related disciplines	X	X	X	X	X	X	X	X	X	X	X
4	Procedural knowledge for professional subjects	X	X	X	X	X	X	X	X	X	X	X
5	Skills in related fields of specialization	X	X	X	X	X	X	X	X	X	X	X
6	Ability to use in Geological Problems	X	X	X	X	X	X	X	X	X	X	X
7	Skills in Mathematical modeling	X	X	X	X	X	X	X	X	X	X	X
8	Skills in performing analysis and interpretation of data	X	X	X	X	X		X	X		X	X
9	Develop investigative Skills	X	X	X	X	X	X	X	X	X	X	X
10	Skills in problem solving in geology and related discipline	X	X	X	X	X	X	X	X		X	X
11	Develop Technical Communication skills	X	X	X	X			X			X	X
12	Developing analytical skills and popular communication	X	X	X	X	X	X	X	X		X	X
13	Developing ICT skills	X	X	X	X	X	X	X	X	X	X	X
14	Demonstrate Professional behaviour with respect to attribute like objectivity, ethical values, selfreading etc.	X	X	X	X	X	X	X	X	X	X	X

1st. Semester

Theoretical

Course No. PGGEOL 0101
Mineralogy & Geochemistry

Course Objectives:

To understand (1) the characteristics of major rock forming mineral groups (2) crystal symmetry, crystallography, and atomic structure (3) formation environments and associations of rock-forming minerals (4) techniques of mineral characterization.

Geochemistry aims to give an introduction in how chemical principles are used to explain the mechanisms that control the large geological systems such as the Earth´s mantle, crust, ocean and atmosphere, and the formation of the solar system.

Course Learning Outcomes:

1) Identify common rock-forming minerals in hand specimen and in thin section using diagnostic physical, optical, and chemical properties; (2) Infer about the formation environment of a silicate mineral; (3) Analyze the information that minerals can provide about Earth processes and Earth history; (4) Characterize the minerals using basic techniques; (5) Describe the composition of the Earth´s main geochemical reservoirs; (6) Explain element fractionation and how this can be used to understand geochemical processes; (7) Apply radiogenic isotope signatures to trace the source of minerals, rocks and to date magmatic and metamorphic events; (8) Demonstrate their ability to obtain, analyze and synthesize information relevant to Geochemistry.

Group A : Mineralogy

1. Different types of Si- O bond: Electro-neutrality principles (with reference to forsterite); Substitution principles – Review of Goldschmidt's Principles – Controls of element substitution; Common substitution in rock forming minerals.
2. Principles of X-Ray powder method; Bragg's equations and its application: X-ray camera. Diffractogram procedures for identification of minerals from X-ray powder diagram. Use of powder method in determination of "obliquity" of K-feldspar, cell-edge of isometric crystals.
3. Generalized formula, classification and structure of pyroxene, amphibole, olivine, mica and feldspar, phase inversion of pyroxene and olivine. Order-disorder in feldspar. Thermometric application of pyroxene and feldspar.

Group B: Geochemistry

1. Calculation of cation proportions; chemical formula, vacant site from chemical analysis.
2. Earth in relation to solar system and universe. Cosmic abundance of elements, Comparisons of planets and meteorites. Structure and composition of earth and distribution of elements. Trace element geochemistry.
3. Different types of radioactive decay; brief outline of dating by Rb-Sr, K-Ar, Sm-Nd, U-Pb and C-14 methods. Radioactive dating of single minerals and whole rocks. Application of oxygen, carbon and sulfur isotopes.
4. General chemical characteristics of sedimentary rocks; role of ionic potential, H-ion concentration and oxidation-reduction potential in sedimentation. Eh-pH diagrams of Mn-H_2O systems and Fe- H_2O systems with/without CO_2.
5. The evolution of atmosphere, constancy of atmospheric composition; evidences in favour of presence of oxygen in Archean atmosphere. Formation and destruction of ozone layer.

Suggested Readings:

1 Deer,W.A., Howie,R.A., and Zussman, J.(1996): The rock forming minerals: Longman
2 Klein, C. and Hurlbert, C.S. (1993): Manual of mineralogy, John Willy.
3 Putnis, A. (1992): Introduction to Mineral Sciences, Cambridge University Press.
4 Spear, F.S. (1993) : Metamorphic Phase Equilibria and P-T-Time Path, Mineralogical Society of America Publication.
5 Phillips.W.R. and Grieffen, D.T.(1986): Optical Mineralogy, CBS pub.
6 Hutchinson, C.S., (1974), Laboratory Handbook of petrographic techniques: John Willey
7 Mason, B. and Moore,C.(1991)"Introduction to Geochemistry"-Willey Eastern
8 Krauskopf, K.B.(1967))"Introduction to Geochemistry"- Mcgraw-Hill.
9 Brownlow, "Geochemistry".
10 Faure, G.(1986) "Principles of Isotope geology" – John Willey.
11 Hoefs,J.(1980) "Stable Isotope Geochemistry" – Springer-Verlag.
12 Govett, G.J.S. ed. (1983) "Handbook of exploration geochemistry".Elsevier
13 Handerson,P.(1987) "Inorganic Geochemistry" – Pergamon Press.
14 Nordstron, D.K. and Munoz.J.L.(1986) "Geochemistry Thermodynamics – Blackwell.
15 Albarede. F. (2003), "Geochemistry-an Introduction"- Cambridge University Press. U.K.

Course No. PGGEOL 0102:
Igneous Petrology

Course Objectives:

Igneous petrology in the field of geology, the objective of the study is to gain an appreciation for how the final appearance of characteristics of igneous rocks is controlled by chemical and physical properties of magmas and their surroundings. Based on mineral assemblage and textures geologic history can be interpreted.

Course Learning Outcomes:

Study of igneous rocks is a key component of geology curriculum (because these rocks not only abundant throughout the crust of the Earth, but, dominate some crustal and upper mantle environments). Students apply the knowledges of melt generation in the Earth's mantle and crystallization mechanisms, diverse rock types and their link to tectonic settings in different earth processes and can explain the formation of layered mafic intrusions using fractional crystallization model.

Contents:

1. Phase equilibria studies in binary, ternary and quaternary silicate system with reference to petrogenesis; Cryoscopic equation; Solubility of H_2O, CO_2 , S etc. in silicate melts; Role of oxygen fugacity in phase equlibria.
2. Physical state, chemical and mineralogical composition of upper mantle; Partial melting processes in the upper mantle; Segregation and ascent of magma.
3. Variation diagrams and their uses to model magmatic evolution; Stable and radiogenic isotopic composition and their role in igneous petrognenesis; Geochemical criteria to identify palaeotectonic settings; Distribution of igneous rocks in space and time.
4. Mineralogy, geochemical characteristics, mode of occurrences , classification and origin of basalt, granite, andesite, peridotite, anorthosite, kimberlite and carbonatite.

Suggested Readings:

1 Bose;M.K. (1997) Igneous petrology, The World Press Pvt. Ltd.
2 Hall, A.,(1996) Igneous petrology, Longman Group Ltd. England.
3 McBirney.A.R.(1994), Igneous petrology, CBS Pub.& Distributors.
4 Philpotts.A.R.(1994) Principles of igneous and metamorphic petrology, Prentice Hall
5 Wilson.M. (1989) Igneous petrogenesis, Unwin-Hyman.
6 Winter.J.D.(2001) An introduction to igneous and metamorphic petrology,Prentice Hall.

Course No. PGGEOL 0103
Sedimentology

Course Objectives:

Sedimentary rocks are storehouse of many basic necessities of modern civilization viz. water, hydrocarbon etc. Major objective of the course is to make students understand fundamentals of sedimentary processes and their products, formation and filling history of sedimentary basins in different tectonic backdrop and to give a broad understanding of how sedimentary rocks form and evolve as they undergo burial. Nuances of both clastic and chemical sedimentation processes will be covered.

Course Learning Outcomes:

1. To apply the fundamentals of fluid flow, fluid- sediment interaction and formation of bedforms at various scales in different flow regime conditions.
2. To describe scales of sedimentary grain size measurement and statistical analysis of data to interpret provenance, transportation history or depositional environment.
3. To determine the texture and structure of clastic sedimentary rocks; procedure and importance of paleocurrent analysis.
4. To recognize how sediments become sedimentary rocks, how porosity forms and evolves and how they can interpret the diagenetic evolution of ancient sedimentary rocks.
5. To comprehend concept of sedimentary environment and description of processes and products of different sedimentary environments viz. continental, marginal marine and marine.
6. To comprehend relationship between tectonics and sedimentary basin formation vis-a-vis their depositional motif.

Contents:

1 Type of sedimentary rocks and brief description of different terrigenous and carbonate rocks. Distribution of sedimentary rocks in space and time. Scope of sedimentology.
2 Weathering processes, soil- forming processes, Paleosols and its recognition, Fluid flow and sediment transport.
3 Sedimentary structures- types, origin and significance. Paleocurrent analysis from sedimentary structures.
4 Diagenesis of terrigenous and carbonate rocks- Stages and realms of Diagenesis, major diagenetic processes and changes; Dolomitisation.
5 Composition, classification and origin of Evaporite, Chert, Iron-rich sediments and Phosphorite.
6 Depositional Environment : Terrestrial environment, marginal marine environment, siliciclastic marine environment and carbonate environment.
7 Sedimentary facies, cyclic succession, effect of climate and sea level on sedimentation. Patterns; Sequence stratigraphy: principles and its application.
8 Sedimentary basins and basin analysis : Kinds of sedimentary basins, Tectonics and sedimentation, Techniques of basin analysis; Siliciclastic petrofacies studies; Importance of basin analysis.

Suggested Readings:

1 Pettijohn. F.J., Potter, P.E. and Siever.R.(1990) Sand and sandstone, Springer Verlag.
2 R.L.Folk, Petrology of sedimentary rocks.
3 M.E. Tucker, Sedimentary petrology
4 Harvey Blatt, Sedimentary petrology
5 Collinson& Thompson, Sedimentary Structures.
6 SEPM short course, Conglomerate (Chapter-7)
7 Sengupta.S. (1997) : Introduction to sedimentology, Oxford-IBH.
8 Pettijohn, Potter & Siever, Sand and Sandstone.
9 Blatt.H., Murray.G.V. and Middleton, R.C. (1980): Origin of sedimentary rocks.
10 Fritz & Moore, Origin of physical strtigraphy and sedimentology.
11 Allen, J.R.L.(1985) Principles of physical sedimentation, George Allen & Unwin.
12 Reading, H.G.(1996): sedimentary environments. Blackwell.
13 Prothero, D.R. and Schwab, F.(1996) sedimentary Geology, Freeman.
14 Reineck, H.E. and Singh, I.B.(1980) Depositional sedimentary environments. Springer Verlag.
15 M.E.Tucker, Carbonate Sedimentology.

Course No. PGGEOL 0104
Metamorphic Petrology

Course Objectives:

The study of metamorphic rocks encompass the chemical and physical transformations that take place in response to changing pressure, temperature, and chemical environments in the Earth's interior. Textural study in association with deformation mechanism gives the clue to identify the metamorphic facies as well as the pressure temperature condition of metamorphism. In this course, different petrogenetic processes involving mineral reactions will be explored using equilibrium thermodynamics.

Course Learning Outcomes:

1. Identifying equilibrium mineral assemblages through textural and mineralogical observations.
2. Plotting the quantitative as well as qualitative mineral and mineral assemblage data to interpret the discontinuous reactions and to infer the nature of continuous reactions.
3. Apply the basics of Schreinemakers geometric plots for a set of reactions.
4. Apply thermodynamic principles related to metamorphism to infer different orogenic events in time and space.

Contents:

1. Concepts of metamorphic zones and metamorphic facies
2. ACF,AKF and AFM diagrams
3. Regional and thermal metamorphism of some common rocks
4. Paired metamorphic belts
5. Concepts of metamorphic equilibrium and disequilibrium
6. Metamorphic differentiation and metasomatism
7. Interpretations of some metamorphic textures and structures
8. Anatexis and migmatites
9. Eclogites
10. Metamorphism in relation to magma and orogeny

Suggested Readings:

1 Miyashiro,A. (1973), Metamorphism and Metamorphic Belts. George Allen and Unwin.

2 Phipotts.A.R. (1994) Principles of Igneous Metamorphic Petrology, Prentice- Hall
3 Spry. A.,(1969), Metamorphic Textures, Pergamon Oxford.
4 Turner, F.J. and Verhoogen.J.,(1960) Igneous and Metamorphic Petrology, McGrow-Hill.
5 Winter. J.D.(2001) An introduction to Igneous and Metamorphic Petrology, Prentice-Hall.
6 Yardley. B.D.(1989) An introduction to metamorphic petrology, Longman.

Practical

Course No. PGGEOL 0105
Mineralogy and Igneous Petrology

Course Objectives:

In mineralogy the objectives are to characterize different minerals based on hand specimen studies and optical properties under thin section. This course aims to enable students to understand the various geological contexts of the rock forming process closely related to the occurrences of the minerals.

Igneous Petrology provides a key to understand the generation of magma and thus the genesis of different types of igneous rocks. Hand specimen and thin section study with detailed textural and structural observation help to determine the crystallization behavior of magma and the mineral paragenesis.

Course Learning Outcomes:

i) Recognize the principal types of rocks and hand specimen and petrographic observation to build a genetic theory based on texture.
ii) Relating each type of rock to its genesis and the temporal dimension.

Contents:

1. Determination of optic sign in oriented and un-oriented mineral grains. Study of inter-eraltionship of optical directions and the crystallographic axes in a few rock forming minerals. Study of pleochroism and absorption in a few rock minerals.
2. Study of common important rocks and rock associations in hand s specimens and in thin section with special reference to texture and structure.

Course No. PGGEOL 0106
Sedimentology & Metamorphic Petrology

Course Objectives:

The sedimentology practical will provide a broad background to
i) The description of sedimentary rocks and recognition of sedimentary structures.
ii) The processes by which sediments are transported, deposited and converted into rocks.
iii) The tectonic settings and features of environments in which sediments accumulate.
iv) Use of stratigraphy as a tool in Earth history.

Metamorphic petrology practical helps to develop petrological knowledge by extracting and interpreting mineral textural information in thin section, and coupling this to a theoretical understanding of metamorphic processes. Regional tectonic setting can be interpreted from deformational history by thorough textural study.

Course Learning Outcomes:

A student in this course is able to

i) Interpret the processes responsible for the deposition of the sediment and sedimentary structures present within the sedimentary rock.

ii) Determine the depositional environment of a sedimentary rock package based on recognition of facies associations.

iii) Recognize and explain the methodology of carrying out scientific research in the field of sedimentary geology.

Thin section study in metamorphic petrology practical make the students able to assign metamorphic grade based on mineral assemblages. Textural criteria and the relationship between these mineral assemblages help to determine the relative timing of metamorphic mineral growth relative to deformation. The P-T condition and the involvement of fluid phase can also be demonstrated from the textural study.

Contents:

1. Description and interpretation of primary, secondary and biogenic sedimentary structures in hand specimen.
2. Study of sandstones (with special emphasis on diagnosis and provenance) and lime stones (with special emphasis on components and diagenesis).
3. Exercises related to paleocurrent and granulometic data.
4. Detail studies of some metamorphic rocks under microscope.

2nd. Semester

Theoretical

Course No. PGGEOL 0201
Structural Geology and Geotectonics

Group A: Structural Geology

Course Objectives:

Due to the dynamic instability of the lithosphere, continuous and discontinuous deformation takes place within the rocks in solid or semi-solid state, at different scales, which manifests in a variety of complex structures in these rocks. The present course will teach the student how to unravel the underlying deformation processes and mechanisms through an accurate geometric and kinematic analysis of these natural structures.

Course Learning Outcomes:

(List of outcomes in terms of learnings which student will be able to acquire due to this course)

1. Accurate geometric description of the structures observed in natural deformed rocks.
2. Measurement of various orientation data from the structures, plotting them in suitable diagrams and make a quantitative analysis.
3. Basic concepts of the rheological properties of rocks and their control on the deformation processes

Contents

Group A: Structural Geology (PGGEOL201A)

1. Rheology : Behaviors of rocks under stress; Rheological models; Flow law for steady state creep ; factors; influencing flow of rocks; Deformation mechanism; Estimation of paleostress;
2. Stress ; Basic concept of stress; Analysis of stress in 3 – Dimensions; stress filed description; Equilibrium condition; Trajectory patterns and boundary condition.
3. Strain: Infinitesimal strain; Measurement of strain; Progressive deformation
4. Folds; Fold mechanics for single and multilayer bodies; Distribution of strain in fold; Fold interference in single and multilayer; Structural analysis for areas of superposed folding.
5. Shear Zone ; Fault; Fractures; Joints; Origin, Mechanics and significance.
6. Foliation; Lineation; Boudinage; Origin and significance

Suggested Readings:

1 Twiss,R.J. and Moore, E.M.(1992): Structural Geology, Freeman & Co.
2 Ramsay,J.G. and Huber, M.L.(1983): The techniques of Modern Structural Geology Vol.-1,2,3 Academic Press.
3 Ramsay.J.G.(1967): Folding and Fracturing of rocks, McGraw Hill.
4 Means.W.D.(1979): Stress and Strain, Springer and Verlag.
5 Passchier.C.W. and Trouw.R.A.J. (1996): Microtechtonics, Springer-Verlag,Berlin.
6 Ghosh,S.K. (1993): Structural Geology-Fundamentals and Modern Developments. Pergamon Press.

Group B: Geotectonics (PGGEOL201B)

1. Methods of study of Geotectonics including study of earthquake, volcanism, plutonism, paleomagnetism etc.
2. Geology of the plate margins with an introduction of the concept of super continent
3. Elements of Neotectonics

Suggested Readings:

1 Condie,K.C. Plate Tectonic and Crustal Evolution.
2 Wilson,M.: Igneous Rocks.
3 Moores and Twiss, Tectonics.
4 Keary and Vine, F.J., Global Tectonics

Course No PGGEOL 0202

Palaeontology

Course Objectives:

To understand the Invertebrate, Vertebrate and Micropalaeontology in the light of their morphology, adaptation, ecology and Evolution. The present course will also teach on the evidences and records of the earliest life on the earth, world's past biodiversity, and new ideas about evolution and ecology. Phylogenetic and systematic studies provide the key information for understanding how organisms lived. Knowledge gained from the age of the rocks within which fossils are found provides the sequence of change that has encompassed the history of life. Only by examining the evolutionary histories of species and communities through many different rock sequences, the information for consistencies and similarities that reveal the processes of evolution and ecology that have governed the pattern of life's history can be delineated.

Course Learning Outcomes:

1. Identification of older life forms with their external and internal features.
2. Application of morphological modifications to deduce the ecology.
3. Application of principles of speciation and evolution.
4. Interpretation of the modes of life of fossil organisms.
5. Reconstruction of the taphonomic history of a given fossil or fossil assemblage.

Contents:

1 Species concept
2 Growth and allometry
3 Evolutionary Systematics
4 Evolution theories, modes, patterns, processes and trends
5 Functional morphology
6 Palaeoecology and Palaeobiogeography
7 Biostraigraphy
8 Micropalaeontology: introduction, micro vs. mega palaeontology, importance
9 Foraminifera: morphology, palaeocology, evolution
10 Palynology: introduction, palynomorphs, morphology of spores and pollens
11 Terrestrial habitat- challenges met by vertebrates
12 Dinosaur: major subdivision, a broad account through ages, Indian occurrences, causes of extinction
13 Evolution of Ammonoidea and Equidae as examples of studying evolution
14 Emargence of life: different theories, present status, evidence of Precambrian life, Indian occurrences, paleontology of Precambrian –Cambrian boundary, origin of hard part, Cambrian exploration, Ediacaran fauna, Burgess Shale fauna,SSF.

Suggested Readings:

1 Raup, D.M. and Stanley, S.M.(1985):Principles of Palaeontology CBS Publishers & Dist.
2 Stern,C.W. and Carroll,R.L. (1989):Palaeontology- the record of life. John Wiley.
3 Prothero,D.R.(1998) : Bringing fossils to life- an introduction to palaeobiology McGrow Hill
4 Brasier, M.D.(1980): Microfossils, George Allen & Unwin, London
5 Bignot,G.(1985): Elements of Micropalaeontology Graham & Trotman Ltd. London
6 Haq. B.U. and Boersma. A.(Eds).(1978): Introduction to Marine Micropalaeontology, Elsevier, New York.

Course No. PGGEOL 0203
Advanced Stratigraphy

Course Objectives:

The course is intended to familiarise the student with stratigraphic principles and nomenclature, major stratigraphic units, methods of stratigraphic correlation, depositional environments and tectonostratigraphic framework of various lithostratigraphic units of India spanning Archaean to Holocene, and mass extinction boundaries.

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

1. Analyze basic principles of stratigraphy, different types of stratigraphic units and how they are named.

2. Appreciate how plate tectonic movements separated India from contiguous landmasses and shaped the depositional basins of the Indian Phanerozoic, and what were their effects on climate and life.

Contents:

Group A: Precambrian Stratigraphy (PGGEOL203A)

1 Method in stratigraphy: Building-up of regional stratigraphy and its positioning in geological time scale.
2 Evolution of crust in Precambrian as reflected in the geology of Singhbhum- Orissa Iron Ore Craton.
3 Temporal transition in rock records across Archaean-Proterozoic (A-P) boundary.
4 General characteristics of the Proterozoic Purana Basin of India.
5 Evolution of the Precambrian atmosphere, hydrosphere and their change across Proterozoic-Paleozoic (P-P) boundary.

Group B: Phanerozoic Stratigraphy (PGGEOL203B)

1 Introduction: overview of Indian Phanerozoic stratigraphic architecture in the light of modern concepts of eustasy and global tectonics.
2 Continental vis-à-vis marine sedimentation in relation to global tectonics and eustasy in Peninsular India during the Phanerozoic time.
3 Comparison and correlation of the Phanerozoic successions in different parts of the extra- Peninsular India in terms of environmental setup, eustasy and collisional tectonics.
4 Phanerozoic igneous activity and its relation with northward advent of the Indian plate.
5 Boundary problems and their critical evaluation in the context of Indian Phanerozoic stratigraphy of the following boundaries: P-T, K-T and Palaeogene – Neogene.

Group C: Quaternary Stratigraphy (PGGEOL203C)

1 Definition, scope and methods of quaternary Geology.
2 Quaternary Environments: An introduction & Milankovitch Hypothesis and quaternary Environments.
3 Quaternary Sea-level changes; Oxyzen isotope chronostratigraphy.
4 Magneto-Stratigraphy; Amino acid Diagenesis; Glacial varves; Dendrochronology; Tephrochronology.
5 Outline of significant fossil records of the Quaternary; Pollen analysis, Mammalian fauna, Deep sea Biostratigraphy.
6 Outline of Quaternary deposits- Indian examples.

Suggested Readings:

1 Krisnan, M.S. (1982) Geology of India and Burma, CBS India
2 Naqvi & Rogers (1987) Precambrian of India, Oxford University Press
3 Roy, A.B.(1998) Precambrian of India, Oxford University Press.
4 Roy, A.B. (1998) Precambrian of the Aravalli Mountain, Rajasthan, India, Geological Society of India, Memoir-7
5 Radhakrishnan, B.P. & Baidyanathan, M. Geology of Karnataka, Geological Society of India, Memoir.
6 Saha, A.K. Geology of Singbhum, Monograph.
7 Condie K.C.(1989) Plate tectonics and Crustal evolution, 3rd. Edition, Pergamon Press.
8 Bowen, D.Q.(1978) Quartenary Geology. Pergamon Press. Ltd. UK.
9 Willams, M.Dunkerley, D.De Dekkar, P. Kershaw, P. Chappel,J.(1998). Quarternary Environment, Arnold London, 2nd. Edition.

Course No. PGGEOL 0204
Hydrogeology

Course Objectives:

The main aim of the course is to present the water cycle on and under the Earth's surface. Students must understand the characteristics of the appearance of water and the hydrogeologic cycle processes. The course focuses on groundwaters, which represent the most important source of drinking water. The quality and quantity of water available for various purposes are of great importance. Students develop the skills to identify and understand various ways of water's appearance and flow. Knowledge of hydrogeology is essential for the sustainable management of water sources.

Course Learning Outcomes:

1. The students can access the occurrence of groundwater, water bearing properties of formations, aquifer types and aquifer parameters.
2. They can develop an idea about construction, design and development of water wells, aquifer parameter estimation and the science of groundwater flow under different conditions.
3. The students will use the concepts of groundwater exploration.

Contents:

1 Groundwater : Origin, types, Importance, Reservoirs and movement.
2 Hydrogeologic properties of rocks, Water table contour map, Hydrostratigraphic units.
3 Groundwater quality, Estimation and methods of treatment for various uses, Groundwater provinces of India. Groundwater contaminants and pollutants, Problem of Arsenic and Fluorite with special reference to Indian conditions.
4 Artificial recharge of groundwater, Consumptive and conjunctive use of surface and groundwater, Problems of over exploitation, Groundwater legislation and management.
5 Well hydraulics: Confined, unconfined, steady, unsteady and radial flow. Water level fluctuations : Causative factors and their measurements. Methods of pumping tests and analysis of test data.
6 Water well technology: Water management in rural and urban areas; Salt water intrusion in coastal areas, Remedial measures.
7 Groundwater prospecting: Remote sensing technique, Geological and geophysical methods.

Suggested Readings:

1 Todd, D.K.: Groundwater Hydrology, John Willey & Sons. Inc.
2 Wilson, E.M. : Engineering Hydrology, ELBS with Macmillan.
3 Raghunath, H.M.: Willey Eastern Ltd.

Practical

Course No. PGGEOL 0205

Structural Geology

Course Objectives:
Structural Geology and tectonics examines the deformation of Earth's crust and lithosphere. The practical

course aims to introduce the deformation features at different levels of the lithosphere. Students develop a basic appreciation of rock deformation at different temperatures and pressures and at various scales and understand the difference between brittle and ductile deformation regimes.

Course Learning Outcomes:
On completion of the course the students can demonstrate a basic understanding of stress, strain and rheology of Earth's lithosphere. They comprehend how to describe and classify brittle and ductile structures including faults and folds. The field work makes them able to correlate different aspects of structural geology and tectonics with respect to the local geology of the field area.

Contents:

1 Use of the stereographic projection and graphical methods to solve advanced structural problems.
2 Analysis of stress orientation on the basis of fracture data
3 Interpretation of outcrop patterns of different kinds of mesoscopic folds and faults involving polyphase deformation on flat and undulating topography.
4 2D and 3D strain analysis
5 Field Work and Field Report (20Marks): There will be one compulsory geological field work for 2 weeks and training will be imparted on structural and petrological studies of a poly- deformed terrain.

Course No. PGGEOL 0206

Palaeontology

Course Objectives:

This practical course helps the students

i) To reconstruct the taphonomic history of a given fossil or fossil assemblage.
ii) To reconstruct the biological trails of extinct organisms.
iii) To interpret the modes of life of fossil organisms.
iv) To gather and analyze phylogenetic information and to determine evolutionary relationships among a set of organisms.

Course Learning Outcomes:

i) Students can estimate the approximate age of a sequence of rocks from the assemblage of fossils present.
ii) Students can evaluate data in the context of major events and trends in the evolutionary history of plants and animals.
iii) They can defend the importance of paleontology to other realms of knowledge including biology, other subdisciplines of the geosciences, and climate change.

Contents:

1 Exercise on ontogenetic growth patterns by biometric analysis
2 Exercise on numerical techniques to study populations
3 Exercise on phonetic and cladistic analysis
4 Functional morphological analysis of invertebrates and vertebrates
5 Study of microfossils

Course No. PGGEOL 0207

Field Geology

Course Objectives:

Geology is an applied subject that largely depends on data collection and its interpretation to develop an idea on the evolution of the earth starting from local to regional to global level. Field work in Geology gives a first-hand experience of data acquisition and its application from a complex terrain.

Course Learning Outcomes:
Students will be able to unfold the complex history of evolution of a complex terrain.

Content:

Structural and petrological studies in a polydeformed terrain. Preparation of lithological and structural map and its interpretation. field report and viva voce.

3rd. Semester

Theoretical

Course No. PGGEOL 0301
Economic Geology

Course Objectives:
The objectives of this course are to: (a) familiarize with common ore minerals and their identifying criteria at various scales of study, (b) to understand the genetic controls exerted by physical and chemical processes on ore formation in various geologic settings.

Course Learning Outcomes:

Upon successful completion, students will have skills to:

- Recognize common ore minerals in hand samples and under the microscope
- Demonstrate familiarity with a wide range of mineral deposits, including recognizing the overall geometry, zonation and alteration patterns associated with specific classes of metallic mineral deposits.
- Relate overall geometry, zonation and alteration patterns of rock associations to specific classes of metallic mineral deposits.
- Evaluate different processes of element enrichment by fluids and melts to from ore bodies.

Content:

Group A : Ore Geology

1 Spatial and temporal distribution of ore: Metallogenic Epoch, Metallogenic Province and ore mineralization in relation to plate tectonics.
2 Systematic study of ore deposits (Mode of occurrence and its importance, ore textures and their genesis, Sulphide and oxide phase equilibria and its significance)

3 Important ore-associations and their genetic models, Applications of geochemistry in ore deposit modeling (Orthomagmatic ores of mafic-ultramafic association, Ores of silicic igneous rock association, Ores of sedimentary association: Sedimentary deposits, placer deposits, Ores of volcanic- Volcano-sedimentary association, Ores of metamorphic association, Ores associated with weathering surfaces)

4 Indian scenario of Fe, Mn, Cu, Pb, Zn, Cr, Ni, Sn and W deposits.

Group B : Non-metallic deposits

Mode of Occurrence, Lithoassociation, Genesis of the following non-metallic minerals : diamond, graphite, barite, gypsum, phosphorite, mica and asbestos.

Course No. PGGEOL 0302
Fuel Geology

Course Objectives:

To make students understand fundamentals of coal, coal forming environments and processes, coal: petrography, classification, analytical techniques of coal. Concept of macerals and its application in climate and paleogeography and coal seam correlation will be covered. Application of coal for various industries will be discussed. Understanding will be developed for coal as an unconventional source of energy viz. CBM and synthetic crude oil and its environmental impact. This will also introduce the composition, origin of Petroleum, Organic Petrology and Petroleum Formation and Occurrence. To understand the geochemistry and distribution of radioactive minerals.

Course Learning Outcomes:

1. To understand fundamentals of coal and petroleum, definition and coal and petroleum forming sedimentary environments, effect of tectonics and sea-level changes on coal and petroleum formation.
2. To describe the basis of coal classification, concept of grade, type and rank in coal.
3. To understand analytical techniques in coal and its importance in coal classification and utilization for various industries.
4. To comprehend concept of macerals its gross diagnostic properties under microscope and implications in climate and paleogeography.
5. To understand concept of underground coal gasification, clean coal technology, carbonization etc. coal as unconventional source of energy (CBM, Coal liquefaction) and its potential in Indian and environmental impact.
6. To understand the plate tectonic and supercontinent configuration in terms of coal deposits in India vis-a-vis rank, grade and their geological and geographical distribution and utilization.
7. To comprehend concept of kerogen and its type and its control on origin of fossil fuel.
8. To understand the petroleum system from origin to accumulation.

Contents:

1. **Coal**
   Origin of coal, Macroscopic ingredients and Microscopic constituents, concept of macerals and micro lithotypes, Physical properties and chemical characterization : Proximate and ultimate analysis, Rank and grade of coal, Indian and International classification, Biochemical and dynamo chemical changes in coal formation, Distribution of coal in space and time with special reference to India. Brief idea about Coal Bed Methane (CBM).
2. **Petroleum**
   Composition of petroleum and natural gas, Kerogen and their types. Origin and migration of natural hydrocarbons, Characters of source and reservoir rocks. Traps : Structural, stratigraphic and combination traps, Techniques of exploration, Petroliferous basins of India.
3. **Nuclear Fuels**
   Minerology, Geochemistry and mode of occurrence of radioactive minerals. Techniques of detection and measurements of radioactivity, Distribution of radioactive minerals in India.

Suggested Readings:

1 Durrance E.M. (1986) Radioactivity in Geology. Principles and applications. Ellis Hoorwool.
2 Francis W. 1961, Coal its formation and composition, Edward Arnold Publishers Ltd. London
3 Huni J.M., 1995, Petroleum Geology and Geochemistry.
4 Levvorsen A.I. 1985,Geology of petroleum, CBS Publishers and Distributors, Delhi.
5 North F.K., 1985, Petroleum Geology, Allen and Unwin, London.
6 Ross C.A., Ross J.R.P., 1983, Geology of coal, a benchmark book.
7 Stach E. Mackowsky M.T.H., Teichmuller M., Taylor G.H. Chandra D., Teichmuller R., 1982, Coal petrology, Gebruder Borntraeger, Stuttgart.

Course No. PGGEOL 0303
Mining and Engineering Geology

Course Objectives:

Mining Geology unravel the relationship between geology and ore formation and localisation of mineral resources. It also helps for assessing and analysing geological data in order to advise on short-term and long-term mine production plans. The subject Engineering Geology is aimed at studying the geology of an area for the purpose of assuring that the geological factors regarding the location, design, construction, operation and maintenance of engineering works, are perfect for the project implementation. It is also done during post-construction and forensic phases of the projects.

Course Learning Outcomes:

The students will learn to make design of creating safe and effective means to extract metals and minerals for industrial, commercial and scientific purposes. They are also expected to have an advanced and dynamic understanding of geological sciences. The study of engineering geology helps the students to properly plan a project when considering the design, location, and other important geological factors.

Contents:

Group A : Mining Geology

1 Methods of mining- Placer/alluvial, opencast & underground mining for metallic, non metallic. Placer/ alluvial deposits. Environmental impacts in mining industries with special emphasis on coal mining.
2 Mining terminologies. Shaft sinking , drifting, cross-cutting, sloping, Mine subsidence, mine support, room & piller, top slicing, caving (sublevel caving & block caving), mining hazards, mine inundation, fire & rock blast.
3 Drilling methods (percussion, rotary, core drilling- diamond drilling)
4 Sampling, bench mapping, underground mine mapping, preparation of plans & sections, ore reserve estimation, mineral beneficiation & mineral economics.
5 Planning, exploration and exploratory mining of surface and underground deposits.
6 Mine hazards.

Suggested Readings:

1 McKinstry, H.E., 1962: Mining Geology.2nd. Ed. Asia Publishing House
2 Clark, G.B., 1967: Elements of Mining 3rd. Ed. John Wiley
3 Arogyaswami, R.P.N., 1996: Courses in Mining Geology 4th. Ed. Oxford IBH.

Group B : Engineering Geology

1. Role of Engineering Geology in civil construction & mining industry. Various stages of engineering geological investigation for civil engineering projects. Engineering properties of rock & their measurements.
2. Slope stability & mass movements, classifications, detailed study of landslides, factors influencing different mass movements in nature & their remedial measures. Studies of the processes responsible for the evolution of typical structures such as solifluction, liquefaction etc. Study of typical landslides of India & the world.
3. Concept of Building materials/ dimension stones- its different properties,. Study of occurrence of good building materials/dimension stones in different stratigraphic horizons of India.
4. Dams & reservoir, different types of dams, different parts of dams & reservoirs, stability of dams & reservoir, seepage & leakage, factors responsible for dam & reservoir failure & their remedial measures, criteria for selecting sites for construction of dams & reservoirs in nature & geo-environmental considerations.
5. Tunnels & their different types, different parts of a tunnel, stability of tunnel, factors responsible for tunnel failure & their remedial measures, criteria for selecting sites for construction of tunnels in different geological situation & geo-environmental considerations.
6. Role of geophysical techniques in engineering geological investigation

Suggested Readings:

1. Krynine, D.H. and Judd, W.R.: Principles of Engineering Geology, CBS Publ. & Dist.
2. Legget, R.F. and Hatheway, A.W.: Geology and Engineering. McGraw-Hill Int. Edn.
3. Bowen, R.: Geology in Engineering. Elsevier Applied Science Publ. Ltd.
4. Ries, H. and Watson, T.L.: Engineering Geology, John Wiley & Sons.

Course No. PGGEOL 0304
Major Elective I (any one of the following courses)

REMOTE SENSING AND GIS

Course Objectives:

To introduce the students about the application of some advanced techniques in geology that are helpful in unraveling the complexities more accurately (e.g. covering large areas with ease as in RS-GIS or by advanced techniques of rock deformation and deducing PTT path). Oceanography will introduce the students about the treasure of oceans, human dependence on ocean, the processes of ocean that regulate the physical, chemical and biological vistas of the earth. Palaeobiology will introduce the students about the advanced techniques to learn the evolution and extinction in a better way.

Course Learning Outcomes:
The students will be able to apply different techniques in natural systems for the better understanding of an area or life forms. They will learn the importance of ocean as a modifier of the earth systems as well as its potentiality of future resource.

Contents:

1. Remote Sensing: Definition, scope and purpose. Types or classification of Remote Sensing (RS). Digital imagery vs. conventional photography. Different stages or requirements for the successful execution of the remote sensing operation.
2. Electromagnetic spectrum (EM-spectrum) :Fundamental concepts and theories. Subdivisions of the

EM- spectrum. Basic laws governing the behavior of the EM-radiation, and the interrelationships among these laws in view of remote sensing. The common wavelength bands used in RS and their characteristic purposes.

3 Different interactions of energy or radiation with matter in different scales. Role of atmosphere in remote sensing. Concept of atmosphere windows.

4 Basic ideas about the working principles of various sensors : Simple cameras, Vidicon cameras, Push broom system using charge-coupled devices (CCDs). Line scanners, Multi-spectral scanners, Microwave imaging system (using LASER and RADAR). Thermal infra-red imagers, Spectroradiometers.

5 Basic knowledge about the different satellite exploration programmes of the world and their characteristics (viz. LANDSAT, SEASAT, SPOT, TRS, IKONOS etc.) Introducing satellite images (both Hard- copy and Soft-copy formats)

6 Aerial photography and aerial photographs. Features air-photos, scale, photomosaics, air- photo stereo-pairs, Stereoscopic vision and pseudoscopic vision. Stereoscopic study of air-photos, parallax, vertical exaggeration and its various factors. Hands-on use of mirror and pocket stereoscopes. Ideas about possible sources of errors in aerial photography and/or satellite imagery.

7 Different elements of air-photo (or image) interpretation. Photogeology, Elementary practical exercises on photogeological mapping.

8 Photogrammetry, Use of parallax bar. Basic idea about how to measure height, area, dip/slope, vertical exaggeration, image distortion etc. from air-photos.

9 Digital remote sensing : Pixel and resolution. DN-code. Digital remote sensing images. False colour composite (FCC). Computer assisted (i.e.digital) image processing techniques. Digital classification-unsupervised and supervised. Hands-on training of digital image interpretation using easily available packages and images(PC-mode). Application of RS techniques for terrain analysis (Geomorphological). Land- use detection, litho-mapping, structural mapping, mineral exploration, environmental hazards assessment, groundwater prospecting.

10 Geographical Information System (GIS) : Introduction, components, data presentation, digitization and scanning, vector and raster methods, input and output device, software and definition/description of equipments. Database designing and structure. Data analysis and cartographic modeling. Data representation and techniques of data integration. Application of integrated GIS. Data updating and merging. Multilayer data products.

11 Global Positioning System (GPS) : Definition, scope and purpose. Advantage of GPS: Principles of GPS position determination, receiver types, and survey techniques, Geodetic implication. RS-GIS-GPS integration. Special discussion and practical demonstration of such integration in Geoscientific arena and in our day-to-day socio-economic activities.

Suggested Readings:

1 Miller.V.C. 1961: Photogeology, McGraw Hill.
2 Sabbins, F.F. 1985: Remote Sensing- Principles and applications, Freeman.
3 Ray.R.G. 1969: Aerial photographs in geologic interpretations. USGS Prof. Paper 373.
4 Drury.S.A. 1987: Image interpretations in geology. Allen and Unwin.
5 Lillesand, T.M. and Kieffer. R.W. 1987: Remote sensing and image interpretation. John Wiley.
6 Panday.S.N. 1987: Principles and applications of photogeology. New Age International.
7 Gupta.R.P. 1990: Remote sensing geology- Springer Verlag
8 Siegal.B.S. and Gillespie.A.R. 1980: Remote sensing in geology. John Wiley.
9 Allum.J.A.E. 1985: Photogeology and regional mapping Pergamon press.

GEOSTATISTICS

Course Objectives:

The main objectives of the course are

i) To acquire knowledge of the fundamental concepts of geostatistics.
ii) To become familiar with standard statistical techniques with applications for spatial analysis.

Course Learning Outcomes:
Students can choose proper statistical procedures, make interpolation maps using various methods, compute and interpret landscape indicators.

Contents:

1 Role of mathematical and numerical techniques in geological sciences.
2 Classical statistics : Population, Sample; Measures of central tendency- Mean, median and mode; Measures of variability- variance standard deviation, skewness and kurtosis; Correlation and regression- simple linear model; Analysis of multivariate data- discriminant function, factor analyses- geological application; Trend surface analysis, inverse distance square method; Concept of probability; Population distribution- normal, binomial and Poission; Principles of statistical tests and their use in geology. Chi-square test, F-test, t-test and Kolmogorov- Smirnov test; ANOVA; Analysis of sequential data- Markov chain, auto- correlation and cross-correlation.
3 Geostatistics : Definition purpose and scope; Regionalised variable theory, schools of geostatistics; Definition of semi-variogram-characteristics, relation between semi-variaogram and co-variogram, graphical and numerical calculation of semi-variogram, mathematical models of semivariogram; Krigging- definition, point and block estimation procedure.

Suggested Readings:

1 Davies, J.C. (1973): Geostatistics and data analysis in geology, John Wiley & Sonlnc., New York.
2 Krumbien and Graybill, An Introduction to Statistical Methods in Geology
3 Clark Isobel (1979): Practical Geostatistics, Applied Science Publishers Ltd., London.

ROCK DEFORMATION & STRUCTURAL ANALYSIS

Course Objectives:

The main objective is to enable the students to use different methods to measure rock geometries, and reconstruct their deformational histories. Then, the stress field that resulted in the deformation is calculated.

Course Learning Outcomes:

The students can recognize various structures in different deformation regimes. They can measure, plot and interpret simple structural field data and can relate these to geological maps and profiles.

Contents:

1 Techniques in structural analysis (Advanced fieldwork and mapping techniques including outcrop pattern analysis in relation to topography, litho contacts and traverse selection; Data types and its collection, and sampling; Structure contour and cross section; Regional and global correlation; Stereographic projection and its significance; Fold shape analysis, Fourier analysis, Flattened folds,

fold section and profile, down plunge projection of folds)

2 Experimental studies (Deformation of natural rocks; Determination of fabrics in deformed rocks; Fabric interpretation; Use of X-ray texture goniometer and U-stage)
3 Deformation mechanisms (Inter and Intra-crystalline slip; associated microstructures)
4 Folds and folding (small scale structures in folds; Deformed lineation in superposed fold system).
5 Faults (analysis of movement on fault surfaces by graphical method; Palaeostress estimation; Balanced cross section)
6 Shear zones (Ductile and brittle shear zones; Shear and dilational components in different profiles)
7 Heterogeneous finite strain (Classification and interpretation of simple and general shear zones, C-, P- and F- bands, Conjugate shear zones, Rotation of objects in shear zones; Superposed strain fields in shear zones and shear folds; Strain trajectories and cleavage patterns; 3-dimensional strain, basic theory and signification).

Suggested Readings:

1 Ramsay, J.G. and Huber,M.I.: Modern Structural Geology, Vols. I & II
2 Ramsay, J.G. and Lisle, R.J.: Modern Structural Geology, Vols. III
3 Passchier and Trouw: Microtechtonics
4 Ghosh, S.K.: Structural Geology- Fundamentals and modern developments.
5 Ramsay, J.G. : Folding and Fracturing of rocks.
6 Turner, F.J. and Weiss, L.E. : Structural Analysis of Metamorphic Techtonics.
7 Price, N.J. and Cosgrove, J.W.: Analysis of Geological Structures

COMPUTER SYSTEM & PROGRAMMING

Course Objectives:

The objectives of the course are

i) To provide opportunity for the study of modern methods of information processing and its applications.
ii) To acquaint students with knowledge of the computer systems with emphasis on their usage and limitation.

Course Learning Outcomes:

i) Students can apply the knowledge of computing and mathematics appropriate to the discipline.
ii) They can identify, formulate and develop solutions to computational challenges.

Contents:

Historical development of computers; Computer architecture (Different parts of computer and their function, Data representation, Logic gates); Elements of data structure with pseudo-codes; Flow diagrams; Computer programming language BASIC/ Visual Basic/C/Visual C++ ; Application of different relevant software's for solving elementary geological problems.

Suggested Readings:

1 E.Balaguruswamy: Programming in BASIC
2 Gottfried Byron: Programm with C
3 Horrwitz & Sahani: Data structures in Pascal
4 M. Lotia, P. Nair, P. Lotia: Modern all about GW- BASIC
5 Rogger Hunt & John Shelly: Computers and commonsence

6 Sen, Sarma, Sarma: Foundations of computer science and programming
7 V. Rajaraman: Computer oriented numerical methods

ADVANCED METAMORPHIC PETROLOGY

Course Objectives:

The main objective is to encompass the physical and chemical transformation in reponse to changing pressure, temperature and fluid conditions. Different petrogenetic processes involving mineral reactions can be explored using equilibrium thermodynamics. The thermodynamic principles related to metamorphic petrology can be applied to derive the different pressure-temperature conditions during orogenesis.

Course Learning Outcomes:

i) Students can interpret deformation-metamorphism relationship from the textural study.
ii) They can construct different metamorphic reactions based on mineral assemblage and their respective chemical compositions.
iii) They can estimate pressure-temperature condition of metamorphism using quantitative geothermobarometric study.
iv) They can construct stability fields of specific assemblage in P-T space by pseudosection modeling from whole rock composition and thereby depict a plausible P-T-t path of metamorphism.

Contents:

1 Ultrahigh temperature (UHT) and ultrahigh pressure (UHP) metamorphism calculation of Metamorphic Phase Equilibria through P-T-X-M (mineral mode) relations. The origin and interpretation of zoned metamorphic minerals: Characterization of chemically zoned crystals, Growth zonation-P-T-X-M phase relation. Diffusion during cooling of high and low grade rocks; P-T path from zoned minerals.
2 Metamorphic P-T paths and tectonics evolution: Interpretation of textural and mineral chemical data in inferring P-T path; Subduction zone metamorphism, Continental collisional zone metamorphism; Metamorphic core complex, Granulites and interpretation of P-T paths from the granulites.

Suggested Readings:

1 Miyashiro, A.(1973): Metamorphism and Metamorphic Belts. George Allen and unwin.
2 Philpotts, A.R.,(1994): Principles of Igneous and Metamorphic Petrology, Prentice-Hall.
3 Spry, A.,(1969): Metamorphic Textures, Pergamon, Oxford.
4 Turner, F.J. and Verhoogen, J.,(1960): Igneous and Metamorphic Petrology, McGrow-Hill.
5 Winter, J.D., (2001) An Introduction to Igneous and Metamorphic Petrology, Prentice-Hall.
6 Yardley, B.D.(1989). An Introduction to Metamorphic petrology, Longman.
7 Spear, F.S.(1993): Metamorphic phase equilibria and Pressure- Temperature-Time paths. Mineralogical Society of America, Monograph Series.

PALAEOBIOLOGY : MODERN CONCEPTS

Course Objectives:

i) To understand the biological requirements and limitations of common fossil organisms and use this information to interpret the depositional history and paleoenvironment of the surrounding rock.
ii) To explore the contributions that studies of fossil organisms have made to diverse fields of geology and

biology, including paleoecology, biostratigraphy, biogeography and evolutionary taxonomy.

Course Learning Outcomes:

Upon completion of this course

i) The students can recognize and classify fossil plant organs and animal traces.
ii) They can reconstruct the taphonomic history of a given fossilor fossil assemblage.

Contents:

Theoretical and functional morphology- Use of modern techniques: Evolution- gradualism and punctuated equilibria, rate of evolution; evolutionary trend, Cope's rule- recent views; Paleobiogeography and plate tectonics. Cladistic biogeography

Suggested Readings:

1 Briggs, D.E.G. and Crowther, D., 1990: Paleobiology: A synthesis, Blackwell, Oxford.
2 Skelton, P.(Ed.): 1993: Evolution, Addison-Wesley, Harlow.
3 Gould, S.J., : Ontogeny and Phylogeny. Belhnap Press of Harvard University Press, Cambridge, Massachusetts, USA.
4 Humpphries, C.J. and Parenti, L.R., 1986, Cladistic Biogeography. Clarendon Press, Oxford.

Course No. PGGEOL 0305
Minor Elective I (any one of the following courses to be offered to the students of other

Departments: ENVIRONMENTAL GEOLOGY

Course Objectives:
To introduce the students of other courses about the earth processes, interdependence of human and nature, land or water use- its depletion and degradation and use of different techniques to mitigate natural hazards for sustainable development.

Course Learning Outcomes:
Students will be able to apprehend the dynamic natural processes, learn the human activities that are responsible for degradation and depletion of earth resources and different techniques to address the problems and their solutions.

Contents:

1 Our place in the environment, global degradation of environment, human as agents of geological change, Fundamental concepts of environmental geology.
2 Hazardous geological processes: Types, prediction and warning
3 Land-its use and management, assessment of impact of land-use
4 Mineral resources: Mineral consumption on reserves, conservation of mineral resources, impact of mining activity on the environment, environmental managemental in mining.
5 Alternative sources of energy: Energy crisis, strategies of planning our energy, future alternatives to fossil fuels, nuclear energy option.
6 Nature and effects of air and water pollution, disposal of solid wastes and nuclear wastes.
7 Concepts of E I A

Suggested Readings:

1 Anjaneyulu, Y. Introduction to Environment Science (2004), BS Publishing, Hyderabad.
2 Keller, E.A. Environmental Geology (6th.edition, 1988), Macmillan Publishing Company, New York.
3 Bell, F.G. Environmental Geology(1998), Blackwell Science, London.

NATURAL HAZARDS AND MITIGATION

Course Objectives:

The objectives of this course are

i) To increase the knowledge and understanding of the disaster phenomenon, its impacts and public health consequences.
ii) To ensure skills and abilities for implementing the strategies to minimize the effects of the disaster.

Course Learning Outcomes:

i) The students can evaluate different aspects of disaster events at a local and global levels.
ii) They can analyze the environmental, social, cultural economic, legal and organizational aspects of the disaster.
iii) They acquire the capacity to work theoretically and practically in the process of disaster management.

Contents:

Floods, Earthquakes, Cyclones, Landslides and disaster management

PHOTOGEOLOGY AND REMOTE SENSING

Course Objectives:

Photogeology is the use of aerial photographs in geological studies. Its main use is to be made of the information available from aerial photographs for the purpose of geological mapping. There should be a planned integration of the photogeological work with the field and laboratory investigations.

The main objective of remote sensing is to systematically discuss the specific requirements and use different techniques for data collection and interpretation and to integrate the techniques into geoexploration.

Course Learning Outcomes:

i) The students can interpret the aerial photographs.
ii) They can compile the interpretations on the maps.
iii) They can use the aerial photographs in the field and for the production of the final geological map.
iv) They can integrate photogeology into remote sensing.
v) They can use remote sensing as a tool in geoexploration.

Contents:

1 Remote Sensing: Definition, scope and purpose. Types or classification of Remote Sensing (RS). Digital imagery vs. conventional photography. Different stages or requirements for the successful execution of the remote sensing operation.
2 Electromagnetic spectrum (EM-spectrum) :Fundamental concepts and theories. Subdivisions of the

EM- spectrum. Basic laws governing the behavior of the EM-radiation, and the interrelationship among these laws in view of remote sensing. The common wavelength bands used in RS and their characteristic purposes.

3 Different interactions of energy or radiation with matter in different scales. Role of atmosphere in remote sensing. Concept of atmosphere windows.

4 Aerial photography and aerial photographs. Features air-photos, scale, photomosaics, air- photo stereo-pairs, Stereoscopic vision and pseudoscopic vision. Different elements of air-photo (or image) interpretation.

Suggested Readings:

1 Sabbins, F.F. 1985: Remote Sensing- Principles and applications, Freeman.
2 Drury.S.A. 1987: Image interpretations in geology. Allen and Unwin.
3 Gupta.R.P. 1990: Remote sensing geology- Springer Verlag

HYDROGEOLOGY

Course Objectives:

i) To study occurrence, movement and distribution of water that is a prime resource for development of a civilization.
ii) To know diverse methods of collecting the hydrological information, which is essential, to understand surface and ground water hydrology.
iii) To know the basic principles and movement of ground water and properties of ground water flow.

Course Learning Outcomes:

i) The students can manipulate hydrological data and undertake widely-used data analysis.
ii) They can measure, analyze and forecast the variability of hydrological stores.
iii) They can determine the main aquifer properties-permeability, transmissivity and storage to identify geological formations capable of storing and transporting groundwater.

Contents:

1. Groundwater: Origin, types, Importance, Reservoirs and movement.
2. Hydrogeologic properties of rocks, Water table contour map.
3. Groundwater quality, Estimation and methods of treatment for various uses. Groundwater provinces of India. Groundwater contaminants and pollutants, Problems of Arsenic and Fluorite with special reference to Indian conditions.
4. Artificial recharge of groundwater, Consumptive and conjunctive use of surface and ground water.

Suggested Readings:

1 Todd, D.K.: Groundwater Hydrology, John Willey & Sons. Inc.
2 Wilson, E.M. : Engineering Hydrology, ELBS with Macmillan.
3 Raghunath, H.M.: Willey Eastern Ltd.
4 Fetter, C.W. : Applied Hydrology, CBS Publ. & Dist.

Practical

Course No. PGGEOL 0306
Ore Geology

Course Objectives:

i) To identify different ore minerals in hand specimen and thin section and decipher the paragenesis of different minerals.
ii) To depict the mutual relationship of the grains and enumerate the ore forming processes.

Course Learning Outcomes:

i) The students can characterize different ore deposits, occurrence, setting and mineralogy based on hand specimen and thin section study.
ii) They can assess and analyze the setting and genesis of ore textures and their evolution.
iii) They can investigate the distribution of ores and industrial minerals in the various rock assemblages.

Contents:

Study of ores under the microscope with emphasis on mineralogy, texture, structure and paragenesis.

Course No. PGGEOL 0307
Practical related to PGGEOL 0305

Practical/Term Paper/Seminar/Assignment as related to the topic chosen for Major Elective I

Semester IV

Theoretical

Course No. PGGEOL 0401
Mineral Exploration and Reserve Estimation

Course Objectives:
To understand the concept of exploration, different techniques used to find out a hidden mineral treasure, advantages and disadvantages of these techniques and to estimate the content of the treasure.

Course Learning Outcomes:
The students will be able to judge the suitability of a technique for a particular type of deposit and its limitation. They will be aware of the required information that to be collected for reserve estimation.

Contents:

1. Concept of mineral exploration, stages of mineral exploration and tasks accomplished under them. Surface and subsurface methods of exploration.
2. Introduction of various methods of geophysical prospecting – magnetic, gravity, electrical, seismic and radiometric methods. Brief outline of various well logging techniques.
3. Geochemical methods for mineral exploration- lithogeochemical, pedogeochemical, hydrogeochemical, biogeochemical and atmogeochemical methods
4. Geobotanical and photogeochemical methods.
5. Drilling, sampling methods and estimation of reserves.

Suggested Readings:

1. Brooks, R.R., Geobotany and Biogeochemistry in Mineral Exploration, Harper and Row., New York.
2. Ginzburg, I.I., Principles of Geochemical Prospecting, Pergamon Press, London
3. Hawkes, H.E. and Webb. J.S.: Geochemistry in Mineral Exploration, Harper and Row, New York.
4. Levinson, A.A.: Introduction to Exploration Geochemistry, Applied Publishing Ltd. Calgary
5. Malyuga, D.P: Biochemical Methods of prospecting. Cosultants Bureau. New York
6. Reedman, J.H.: Techniques in Mineral Exploration, Applied Science Publishers Ltd. London
7. Benjamin F., Howell, JR.: Introduction to Geophysics, McGraw-Hill Book Co., New York
8. Dobrin, M.B.: Introduction to Geophysical Prospecting, McGraw-Hill Book Co., New York
9. Kearey, P. andBrooks, M. An Introduction to Geophysical Exploration, ELBS, Blackwell Scientific Publication
10. Nettleton, L.L., Geophysical Prospecting for Oil. Mc-Graw-Hill Book Co., New York
11. Parasnis, D.S. Principles of Applied Geophysics. Methuen and Co, London.
12. Telford, W.M. Geldart, L.P., Sheriff, R.E. and Keys, D.A.: Applied Geophysics. Cambridge University Press.
13. William Lawrie. Fundamentals of Geophysics, Cambridge University Press.

Course No. PGGEOL 0402
Major Elective II (any one of the following courses)

SEDIMENTARY ENVIRONMENT & SEDIMENTARY BASIN ANALYSIS

Course Objectives:
To develop the skill of a student so that he/ she can:
apply different concepts of Geology in evaluating ancient depositional setting and its resource potential/ aware of the techniques used in exploration of petroleum/ apprehend the application of microfossils in deducing hydrocarbon potential/ use coal petrology to assess the quality and origin of coal/ understand the applicability of geophysical techniques in groundwater, petroleum and mineral exploration/ understand the use of statistical analysis in different fields of Geology/ learn the process of ore dressing and the economic aspect of mineral deposits, necessity of mineral policy.

Course Learning Outcomes:
Students will be able to:
Deduce the opening and closing of a basin and its resource potential/ apprehend the chances of success and failure of petroleum exploration/ identify microfossils and to apply in hydrocarbon potential assessment/ identify macerals, micro lithotypes in microscope, use different indices to assess coal forming conditions and their control on coal quality/ assess the suitability of a geophysical technique for groundwater, petroleum and mineral exploration/ use statistical analytical methods in the field of Geology/ appreciate the merits and demerits of different ore dressing techniques and justification of mineral policy.

Contents:

1. Modern laboratory techniques in sedimentological studies
2. Detail study of volcanoclastics, chemical precipitates. Clay deposits: mineralogy, physical properties, chemistry and genesis. Processes of dolomitisation and phospatization. Origin of various types of cements.
3. Use of trace fossils, stromatolities, thrombolites and related structures in palaeoenvironment analysis. Methods of palaeocurrent determination and basin analysis.
4. Tectonics and evolution of the sedimentary basins. Sedimentary cycles, rhythms and cyclothems. Analysis of sedimentary facies and preparation of facies maps. Lithofacies, biofacies, dynamics and primary structures associated with the following environments: deserts, alluvial fans, river planes, glaciers, deltas, estuaries, clastic shorelines, clastic shelves, marine evaporate basins, carbonate platforms. Deep sea and ocean bottom, deep sea trench and rise. Sequence stratigraphy.
5. Sedimentation pattern and depositional environment of selected undeformed and deformed sedimentary basins of India representing Precambrian, Phanerozoic and contemporary basins.

Suggested Readings:

1 Allen, J.R.L.(1985): Principles of physical sedimentation, George Allen & Unwin.
2 Allen, P. (1997): Earth surface processes. Blackwell.
3 Nochols, G. (1999): Sedimentology and stratigraphy. Blackwell.
4 Reading, H.G.(1996): Sedimentary Environment, Blackwell
5 Davis, R.A.Jr., (1962): Depositional system. Prentice Hall.
6 Einsele, G.,(1992): Sedimentary basins. Springer Verlag.
7 Reineck, H.E. and Singh, I.B., (1980): Depositional sedimentary environments. Springer Verlag.
8 Prothero, D.R. and Schwab,F.,(1996): Sedimentary Geology. Freeman
9 Miall, A.D.,(2000): Principles of sedimentary basin analysis, Springer Verlag.
10 Pettijohn, F.J., Potter,P.E. and Siever,R.(1990): Sand and sandstone. Springer Verlag.
11 Blatt, H., Murray, G.V. and Middleton, R.C., (1980): Origin of sedimentary rocks.
12 Bhattacharya, A.& Chakraborty, C., (2000): Analysis of sedimentary successions. Oxford- IBH.

13 Boggs, Sam. Jr., (1995) Principles of sedimentology and stratigraphy. Prentice Hall.
14 Sengupta, S., (1997): Introduction to sedimentology. Oxford-IBH.

PETROLEUM EXPLORATION

Course Objectives:

i) To develop knowledge of the tools and techniques used to explore for hydrocarbons and extract them in an efficient manner.
ii) To develop skills to evaluate subsurface geological systems in order to assess value and recovery potential of resources.

Course Learning Outcomes:

On completion of the course
i) The students have knowledge about methods for exploration, development and production of oil and gas fields.
ii) They can contribute to planning for field development and operation.
iii) They can make plans for drilling of onshore and offshore wells.

Contents:

1 Identification and characterization of petroleum source rocks. Amount, type and maturation of organic matter. Oil and source rock correlation. Locating petroleum prospects based on principles of petroleum generation and migration. Quantitative evaluation of oil and gas prospects through geochemical modeling. Reconstruction of the ancient geothermal gradient. Migration modeling. Inputs for the assessment of accumulation of petroleum.
2 Elements of geophysical methods of exploration. Magnetic, gravity and seismic methods. Interpretation of seismic data in basin modeling and preparation of subsurface geological maps.
3 Elements of well drilling. Cable-tool drilling, rotary drilling, various types of drilling units. Elements of logging. Electric, radioactivity and the sonic logs. Nuclear magnetic resonance and di-electric logging. Application of logs in petrophysical analysis and facies analysis

Suggested Readings:

1 North.F.K. (1985): Petroleum Geology, Allen and Unwin.
2 Tissol. B.P. and Welte.D.H. (1984): Petroleum Formation and Occurrence. Springer Verlag.
3 Selley.R.C. (1998): Elements of Petroleum Geology. Academic Press.

Mineral Beneficiation and Mineral Economics

Course Objectives:

The objectives of the course are
i) To enable the students to understand the basic principles and relevant developments for operation and improving mineral plant design.
ii) To know how the different beneficiation processes including flotation, gravity concentration, dense mineral separation, and ore sorting can be configured into effective beneficiation circuits.

Course Learning Outcomes:

At the end of the course the students can

i) Select the correct lab tests for characterizing ore.
ii) Select the appropriate combination of methods for a particular application.
iii) Apply the different methods used to classify particles according to their size.

Contents:

1 Beneficiation- necessity, importance, advantages;
2 Crushing- Construction and operational features of primary and secondary crushers. Jaw and Gyratory crushers, cone and roll crushers.
3 Grinding theory, Ball and Rod mills- construction and operation.
4 Laboratory sizing and industrial screening, rake, spiral and hydrocyclone classifiers.
5 Size, specific gravity and surface property dependent beneficiation processes-gravity concentration-theory and practice of Jigging, heavy media separation and flowing film concentration. Froth flotation. Drying and dewatering.
6 Mineral economics and its concept. Specialities inherent in mineral industry. Strategic, critical and essential minerals. Reserve- resources classification; Conservation and substitution, National Mineral Policy.

Suggested Readings:

1 Barry A. Wills, Mineral Processing Technology, Pergamon Press, New York
2 Gaudin, A.M., Principles of Mineral Dressing. McGraw-Hill, London.
3 Taggart A.F., Handbook of Mineral Dressing. Wiley, New York
4 Chatterjee, K.K. An Introduction to Mineral Economics, Wiley Eastern Limited, Calcuuta.
5 Hussain, A.M.: The Economics and Economic Geology of the Mineral Industries, Applied Publishers.
6 Sinha, R.K. and Sarma, N.L., Mineral Economics. Oxford and IBH Publishing Co.

MICROPALAEONTOLOGY: APPLICATION TO EXPLORATION SECTOR

Course Objectives:

Microfossils should be studied in terms of morphology, structure, chemical and mineralogical composition and taxonomy to discover their origin and systematic affinities. Application of these microfossils in the fields of oil-exploration, biostratigraphy, paleo-biology and paleoclimatology is essential.

Course Learning Outcomes:

i) The students can undergo detailed correlation study and reservoir zonation based on the type, size and abundance of the microfossils.
ii) They can assess reserve estimation, trap evaluation and source rock evaluation.

Contents:

1 Microfossils- definition, occurrence, collection and preparation of samples, methods of study.
2 Common marine microfossils.
3 Usefulness of microfossils in stratigraphic studies and hydrocarbon exploration. Indian examples.

Suggested Readings:

1 Brasier, M.D., (1980): Microfossils. George Allen & Unwin, London.
2 Bignot, G., (1985): Elements of Micropaleontology. Graham & Trotman Ltd., London.
3 Haq, B.U. and Boersma, A. (Eds.), (1978); Introduction to Marine Micropalaeontology. Elsevier, New York.
4 Baker, R., (1979): A primer of Oil well drilling Petroleum extention service, The University of Texas at Austin, Austin.

OCEANOGRAPHY

Course Objectives:

The main objective of the course is to introduce students the basic concepts of Oceanography. The main aim is to understand the chemical, physical, geological and biological processes which act on the ocean's surface and to recognize the submarine forms, the seawater composition and properties.

Course Learning Outcomes:

i) The students can relate the structure of water molecule to the chemical and physical properties of the ocean
ii) They can illustrate the interaction between the oceanic and the atmospheric circulation patterns and explain how it affects the climate patterns of the Earth.
iii) They can describe the factors that generate tides and define the various tidal patterns.
iv) They can apply the scientific methods to comprehend, interpret, analyze and and evaluate oceanographic concepts.

Contents:

1 Definition, Earth and Ocean; The World Ocean: Two views; The origin of life; The ocean world; The distant future of earth; History of marine science; the rise of oceanographic institution.
2 Ocean circulation, forces that drive currents, wind induced vertical circulation, thermohaline circulation, studying currents.
3 Ocean waves and tides; Classifying waves, wave dynamics and wind waves; A word about tidal waves; storm surges, Seiches, Tsunami and Seismic sea waves tides and forces that generate them; The equilibrium and dynamic theory of tides; Tides and marine organisms; Power from the tides.
4 Coastal and estuarine oceanography; classifying coasts, features of primary and secondary coasts, coasts formed by biological activities; Beaches and estuaries; Lagoons and wetlands; Human interferences in coastal processes.
5 Sea water chemistry; Major and minor constituents of sea water and their residence times; Processes controlling the composition of sea water, Dissolved gases in sea water-their sources and sinks, Biogeochemical eye ling and its effects on atmospheric composition and climate. Interrelationships between ocean circulation, primary productivity and chemical composition of the atmosphere and ocean.
6 Marine Geology; Morphological and tectonic domains of the ocean floor; Mid oceanic ridge systems; Hydrothermal vents and seawater- basalt interaction; Modes and rates of sedimentation in the oceans ; Nature of deep sea sediments and processes regulating sedimentary composition;
7 Marine Resources; Types of marine resources; Physical, energy, biological and non extractive resources; Laws of the sea.
8 Marine Biology; Sea as a biological environment; Divisions of marine environment and their characteristic flora and fauna and their adaptations; Community structure and function; Primary,

Secondary and Tertiary Production; Food web and trophic Structure; Living resources of the Indian seas; Mari culture activities.

9 Environmental Concerns; Marine pollution; Pathways of transfer of various pollutants and their fates in the sea; Chemistry of marine natural products; Biomedical potential of marine biota; Habitat distribution; Global changes.

Suggested Readings:

1 Siddhartha, K.,(1999): Oceanography: A brief introduction, Kisalaya Publ. Pvt. Ltd.
2 Gordon Prie, R.,(1997): Oceanography: Contemporary readings in ocean sciences, University of Wisconsin-Milwaukee, Oxford University Press
3 Anderson, R.N.: Marine Geology: A Planet Earth Perspective, John Wiley & Sons.
4 Weisberg, J. and Paris, H.,(1974) : Introduction Oceanography. McGraw-Hill, Kogakusha Ltd.
5 Ghosh, A.K.and Mukherjee, R.,(1999): Mineral wealth of the ocean, Oxford & IBH pub. Co.Pvt. Ltd., New Delhi.
6 Pinet, P.R., (2006): Invitation to oceanography, Jones & Berlett Pub.

APPLIED COAL PETROLOGY

Course Objectives:

The study of macerals aims to make understand about the origin, formation, distribution, resources as well as the chemical and physical characteristics of coal bearing strata. Study of coal petrology helps to determine the mining techniques, beneficiation processes and utilization options of coal.

Course Learning Outcomes:

i) The students can explain how coal is formed
ii) They can determine how coal can be extracted by either surface or underground mines.
iii) They can assess the geological problems and environmental issues surrounding extraction after mining.

Contents:

The concept of maceral and microlithotype. Origin of macerals, methods and tools of microscopic examination of coal, coal seam identification using microscopic methods. Concept of coal rank, microscopic techniques for the evaluation of rank of brown and branded coals. Application of rank studies in determining coalification time and temperature, palaeo-geothermal gradient and burial depth. Coal bed methane: a new energy resource. Generation of coal bed methane. Fundamentals of coal bed methane exploration and production.

Suggested Readings:

1. Chandra.D.Sinsh. R.M. and Singh.M.P. (2000): Textbook of coal. Tara Book Agency, Varanasi
2. Stach.E., Mackowsky.M.T.H., Taylor.G.H., Chandra. D., Teichmuller,M. and Teichmuller, R.(1982): Stach's text book of coal petrology, Gebruder Borntraeger.
3. Fetter, C.W. : Applied Hydrology, CBS Publ. & Dist.
4. Kazmann, R.G. : Modern Hydrology, Harper & Row Publ.

APPLIED GEOPHYSICS

Course Objectives:

This course builds on concepts to demonstrate practical applications of common geophysical tools and methods. Students can learn to encounter geophysical datasets and gather knowledge to make geological insights and decisions based on such datasets.

Course Learning Outcomes:

Upon completing the course students

i) Can critically evaluate geophysical techniques, acquisition procedures, and survey designs for various subsurface targets.
ii) Can process and analyze collected geophysical data.
iii) Employ appropriate modeling methodologies, and evaluate strengths, weaknesses and limitations.
iv) Infer physical properties at depth and formulate geological interpretations from those properties.

Contents:

1. Gravity Method : Gravity and its variation over the surface of the earth. Principles of Gravimeters, Gravity field surveys. Various types of corrections applied to gravity data. Preparation of gravity maps and their interpretation in terms of shape, size and depth.
2. Magnetic Method : Geomagnetic field and basic magnetic properties. Working principle of magnetometers. Field surveys and data reductions. Preparation of magnetic anomaly maps and their qualitative interpretation. Magnetic anomalies due to single pole and dipole. Determination of depth for single pole anomalies. Introduction to aeromagnetic survey.
3. Electrical Method : Basic of electrical properties and principle. Resistively methods: basic properties, field procedures, electrode arrays and equipment. Interpretation of electrical profile and sounding curves. Application of electrical methods in groundwater prospecting and civil engineering problems.
4. Seismic Method : Fundamental principles of wave propagation. Refraction and Reflection seismic surveys for single interface both horizontal and dipping cases. Concept of seismic channel and multi-channel recording of seismic data. End-on-and split spread shooting techniques. CDP method of data acquisition, sorting, gather, stacking and record station. Seismic velocity and interpretation of seismic data. Application petroleum and mineral exploration.
5. Brief outline of application and importance of various well Logging methods. Principle of electrical logging and its application in petroleum, groundwater and mineral exploration.

Suggested Readings:

1 Dobrin, M. B.: Introduction to Geophysical Prospecting. Mc-Graw-Hill Book Co., New York.
2 Kearey, P. and Brooks, M.: An introduction to Geophysical Exploration. ELBS. Blackwell Scientific Publications.
3 Nettleton, L.L. : Geophysical Prospecting for Oil. Mc-Graw-Hill Book Co., New York.
4 Parasnis, D. S.: Principles of Applied Geophysics, Methuen and Co., London.
5 Telford, W. M.,Geldart, L.P., Sheriff, R.E. and Keys, D.A., Applied Geophysics, Cambridge University Press.
6 William Lawrie, Fundamentals of Geophysics, Cambridge University Press.

Practical

Course No. PGGEOL 0403
Practical related to
PGGEOL 0402
Practical/Term Paper/Seminar/Assignment as related to the topic chosen for Major Elective II

Course No. PGGEOL 0404
Dissertation and Social Outreach Programme

Course Objectives:
To give the students an idea of Research Methodology, data acquisition techniques, analysis of data and representation of the data both verbally and printed form.

Course Learning Outcomes:
Students will be equipped with a first-hand training of reproduction of an original work that will make him ready for future whether it is in job to submit a project report or in his research wor

Thesis Viva voce
Seminar
Social Outreach Programme