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**University of Mysore**  
(Estd.1916)

**M.Sc. APPLIED GEOLOGY**

**Choice Based  
Credit System  
(CBCS)**




Programme Details



**UNIVERSITY OF MYSORE**  
**Department of Studies in Earth Science**  
**Manasagangothri, Mysuru-570006**

**Regulations and Syllabus**  
**Master of Science in Applied Geology (M.Sc.)**  
**(Two-year semester scheme)**

**Under**  
**Choice Based Credit System (CBCS)**

  
**Prof. K.G. ASHAMANJARI**  
Professor  
DOS in Earth Science  
Manasagangothri, UOM  
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## UNIVERSITY OF MYSORE

### GUIDELINES AND REGULATIONS LEADING TO MASTER OF SCIENCE IN APPLIED GEOLOGY (TWO - YEAR SEMESTER SCHEME UNDER CBCS)

#### Programme Details

<b>Name of the Department</b>	:	Department of Studies in Earth Science
<b>Subject</b>	:	Applied Geology
<b>Faculty</b>	:	Science and Technology
<b>Name of the Programme</b>	:	Master of Science in Applied Geology (M.Sc.)
<b>Duration of the Programme</b>	:	2 years course consisting of 4 semesters.

#### Programme Outcomes

Shall be able to:

1. Apply fundamental geological principles and concepts in theoretical, practical and vocational situations.
2. Solve geological problems using logical scientific methods and creative thinking.
3. Synthesize geological data on a range of spatial and temporal scales to make interpretations that allow for scientific uncertainty.
4. Communicate geological information concisely and accurately using written, visual and verbal means appropriate to the situation.
5. Employ new and established technologies to collect and interpret geological data, recognizing their strengths and limitations.
6. Acquire geological knowledge and expertise from a range of sources in a variety of situations.
7. Appreciate international perspectives on geoscience and recognize the importance of global standards for collecting and reporting geological data.
8. Recognize the need for sustainable use of Earth resources indigenously with constraints on environment protection and other community perspective on geological activities.

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- Work ethically and professionally alone and as part of a team, complying with applicable legislation and managing time and other resources efficiently and effectively.

**Programme Specific Outcome (PSO)**

- Demonstrate knowledge of: the geologic time and earth history; and crustal materials and dynamics in the context of plate tectonic theory.
- Demonstrate competence in fundamental geological skills and quantitative analysis including interpretation of topographic and geological maps and cross-sections with basics of three-dimensional conceptualization and the ability to collect and interpret field and laboratory observations.
- Effectively communicate knowledge and interpretation using written, oral and graphical skills both on a formal and extemporaneous basis.
- Gain an understanding of the societal relevance of earth systems

**Scheme of Examination and Details of Course Pattern for M.Sc. Degree Course (CBCS)**

First Semester							
Sl. No.	Code	Title of the Paper	Credit pattern in			Credit value	Teaching hours/week
			L	T	P		
1	16441	Advanced Palaeontology	3	0	1	4	
2	16442	Applied Hydrology	3	0	1	4	
3	16443	Fuel Resources & Sequence Stratigraphy	4	0	0	4	
4	16444	Marine Geoscience	2	0	0	2	
5	16445	Environmental Geology	2	0	0	2	
6	16663	Climatology	1	1	0	2	

Second Semester							
Sl. No.	Code	Title of the Paper	Credit pattern in			Credit value	Teaching hours/week
			L	T	P		
1	16401	Advanced Mineralogy	2	0	2	4	

2	16403	Economic Geology	3	0	1	4	
3	16421	Stratigraphy Of India	3	1	0	4	
4		Minor Projects (Field Work & Technical Report)-FWTR	0	0	4	4	
5	16645	Analytical Techniques in Geology	1	1	0	2	
6	16455	Soil & Water Conservation	2	0	0	2	
7	16630	Basics Of Earth Science	4	0	0	4	

Third Semester							
Sl. No.	Code	Title of the Paper	Credit pattern in			Credit value	Teaching hours/week
			L	T	P		
1	16461	Geo-Exploration & Mining Methods	3	0	1	4	
2	16462	Advanced Petrology	3	0	1	4	
3	16463	Geomorphology, Geotectonic & Surveying	3	0	1	4	
4	16464	Gemology	2	0	0	2	
5	16465	Mineral Economics	1	1	0	2	
6	16466	Engineering Geology	2	0	0	2	
7	16467	Industrial Mineral Resources	4	0	0	4	

Fourth Semester							
Sl. No.	Code	Title of the Paper	Credit pattern in			Credit value	Teaching hours/week
			L	T	P		
1	16471	Application of Remote Sensing And GIS	2	0	2	4	
2	16472	Geochemistry & Geochronology	3	0	1	4	
3		Major Project (Dissertation)	0	0	4	4	
4	16473	Precambrian Crustal Evolution	2	0	0	2	

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## FIRST SEMESTER

### COURSE-I: ADVANCED PALAEOONTOLOGY

It is a study of fossils preserved in the earth's crust by natural process, which is used as reference of large chunk of the relative age of the earth in terms of time. Palaeontology encompasses study of micro-fossils, plant fossils, vertebrate and invertebrate fossils and their evolution. These primary aspects are important not only to geology and stratigraphy but to inter-disciplinary fields of palaeobotany, palaeozoology and evolutionary biology.

### COURSE OUTCOME

- The study of Palaeontology covers the aspects of the age of the earth, chronological arrangement of rocks and evolution of life through the geological time.
- The knowledge of Palaeontology would enable the students to understand the changes that happened in the course of history of the earth and relate them to their field observations.
- The students will absorb skills of identifying and characterization of fossils and their taxonomic classification. They will also be introduced to interpretation of palaeoclimate and palaeoenvironment conditions.

### PEDAGOGY

- Classroom teaching supported with presentation for enabling better understanding of the subject.
- Application oriented assignments.
- Class room lectures will be supplemented with field related examples.

### COURSE CONTENT

#### Unit 1: Origin and Evolution of Life; INVERTEBRATE AND VERTEBRATE FOSSILS

*Invertebrates* – Classification, morphology, evolutionary trends, paleoecology and stratigraphic distribution of the following groups – Brachiopods, Pelecypods, Cephalopods, Trilobites and Graptolites. *Vertebrates* –

Evolution and geological significance of the following

- Fish, Amphibians, Reptiles, and Man. PLANT, - Palaeobotany -

Plants through geological ages – Precambrian Algae and Stromatolites; Paleozoic, Mesozoic and Cenozoic plants –

Bryophytes, Pteridophytes, Gymnosperms and Angiosperms their stratigraphic significance.

**Unit 2:** Introduction to Microfossils and Micropaleontology; Classification and Applications of Microfossils and micropaleontology; Separation of various Microfossils: Morphology, stratigraphic significance and applications of - Foraminifera, Ostracoda, Palynofossils, Acritarchs, Bryozoa, Chitinozoa, Conodont, Scleroconodonts, Diatom, Radiolarians, Dinoflagellates, and Nanoplanktons. Application of microfossils in fossil fuel exploration,

paleoclimate interpretation and maturation of sediments. Oxygen and Carbon Isotope studies on Fossils.

**Tutorial: 1** Assignments/Seminar/Test/Discussion

**Practical: 1** Identification, Diagnosis and Geological distribution of the following Groups: Invertebrate – Brachiopods – 5 genera, Cephalopoda: 5 genera, Pelecypoda: 5 Genera, Trilobita: 5 genera, Graptozoa: 2 genera, Plant fossils: 6 genera, Microfossils- Foraminifera: 8 genera, Ostracoda: 3 genera, Palynofossils: 6 genera. Problems on biostratigraphy, Palaeoecology and Interpretation of Seismic Profile.

### References

1. Clarkson, E.N.K., 1998, *Invertebrate Palaeontology and Evolution*, 4th Edition, published by Blackwell
2. Stearn, C.W. & Carroll R.L. 1989, *Paleontology - the Record of Life*, published by John Wiley.
3. Smith, A.B., 1994, *Systematics and the Fossils Record - Documenting Evolutionary Patterns*, published by Blackwell
4. Prothero, D.R., 1998, *Bringing Fossils to Life - An Introduction to Palaeobiology*, published by McGraw Hill
5. D.J. Jones, 1956. *Microfossils*
6. F.T. Banner and A.R. Lord., *Aspects of Micropaleontology*
7. M.P. Glaessner, *Principles of Micropalaeontology*
8. M.D. Brasier, 1955, *Microfossils*, published by George Allan and Wiley & Sons
9. Romer, A., *Vertebrate Palaeontology*
10. Colbert, *Introduction to Vertebrate Palaeontology*
11. Sukla., A.C. & Misra S.P., 1975, *Study of Palaeobotany* Vikar Publ. House
12. Sripad, N. Agashe, *Palaeobotany*
13. Maohotra, A.K., *Ocean Science and Technology*
14. Tchernia, P., *Descriptive regional oceanography*
15. K. Siddhartha, *Oceanography - A brief Introduction*
16. William A. Nikoichine and Richard W. Stenberg, *The World Ocean - An Introduction to oceanography*
17. Cuchlaine A M King, *Oceanography for Geographers*
18. H V. Thurman, *Introduction to oceanography*

### COURSE-II: APPLIED HYDROLOGY

Water is a basic life supporting system. The rise in global population and the quest for better living standard has put great stress on water resources. Course content primarily focuses on groundwater, which being easily available accounts for greater exploitation. Thus this course aims to enable students to acquire knowledge about the physical and chemical parameters, occurrence, movement and exploration of the groundwater resources.

#### Course outcome

The anticipated knowledge, skills and/or attitude to be developed by the student are:

- The students will learn about groundwater occurrence, water bearing

properties of rocks, aquifer types and aquifer parameters.

- The course imparts knowledge about construction, design and development of water wells, aquifer parameter estimation and the science of groundwater flow under different conditions.
- The students will learn about groundwater exploration in an integrated way and also understand about ground water chemistry.

### **Pedagogy**

- Classroom teaching supported with presentation for enabling better understanding of the subject.
- Application oriented assignments.
- Class room lectures will be supplemented with field related examples.

### **COURSE CONTENT**

#### **Unit-**

**1:** Methods of analyzing rainfall, runoff, infiltration, evaporation and transpiration data. Hydrological properties of rocks. Classification of aquifers. Groundwater distribution and Watertable fluctuations. Preparation and interpretation of watertable contour maps. Darcy's Law and its applications. Types of wells, Drilling methods, construction, design, development and maintenance of wells. Optimum yield, Specific capacity and its determination.

**Unit-2: Theory of groundwater flow.** Types of groundwater flow- Unconfined, confined, steady, unsteady and radial flow conditions. Aquifer parameter evaluation. Pumps tests – methods, data analysis and interpretation. Influence of hydrogeologic boundaries. Evaluation of aquifer parameters using Thiem, Theis, Jacob and Walton methods. Groundwater modeling – numerical approach and electrical resistance capacitance network. Salt-water intrusion in coastal aquifers. Rock-Water Interaction and geochemical models. Modeling saltwater intrusion.

**Unit-3: Groundwater Exploration:** Geological – lithological and structural mapping. Role of lineament and fracture trace analysis. Hydrogeomorphic units. Problems relating to occurrence and distribution of groundwater. Methods of groundwater exploration.

Groundwater problems related to foundation work, mining, canals and tunnels. Problem of over exploitation and groundwater mining. Groundwater development in urban and rural areas. Artificial recharge methods. Groundwater problems in arid regions and remediation. Groundwater balance and the methods of estimation. Groundwater legislation. Fundamentals of Hydrogeochemistry. Physical, chemical and biological properties of water, Quality criteria for different uses, Methods of calculating Water quality parameters. Graphical

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presentation of water quality data. Problems of arsenic and fluoride in groundwater. **Practical: 1** Rainfall patterns of distribution, methods of preparing isohyetal map and Thiessen polygon maps and interpreting volumes of rainfall. Methods of computing runoff volumes-manning coefficient- flow velocity and discharge calculations, wading method. Analysis of water level fluctuation data- Preparation of water level fluctuation data-Preparation of water table contour maps and interpretation. Analysing pumping test data using Jacob's straight line method. Preparation of Iso-resistivity maps and delineating groundwater potential zones. Interpretation of water quality data using numerical and graphical approaches.

### Reference

1. Groundwater-C.F.Tolman
2. Groundwater Hydrology-D.K.Todd
3. Hydrology-S.N.Davis and R.J.M.Dewiest
4. Groundwater studies-R.H.Brown and others
5. Groundwater Hydrology-Herman Bouveré
6. Hydrology-C.W.Fetter
7. Hand book of Applied hydrology-Van teChew
8. Groundwater and wells-Hohnson Publications
9. Applied Hydrology-Chow M.Mays.Mac.Graw Hill Publication
10. Hydrology and wetland conservation-Gulam
11. Groundwater survey and investigation-Guatham Mahajan
12. Hydrology-Raghunath
13. Hydrogeology-Karant
14. Ecology, Environment and Pollution – A Balasubramanian

### COURSE-III: FUEL RESOURCES & SEQUENCE STRATIGRAPHY

Coal is one of the largest fossil fuel derived from subsidence of vegetation. Carbon and organic matters are a potential source of information on climate, tectonics and palaeogeography. Major objective of the course is to make students understand origin of coal, petrography and its classification. 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. Sequence Stratigraphy is a combination of tectonics and subsidence, Eustasy, sediment supply and evolutionary history of any sedimentary basin and basin analysis deals with subdivision of sedimentary basins into genetic packages bounded by unconformities and their correlative conformities. A student will understand and learn about the basic concepts of fuel resources with respect to sequence stratigraphy to work in the field of Petroleum

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exploration. The study of natural radioactivity has experienced a substantial revival in recent years. The reason is the general increase in importance and popularity of all aspects of nuclear science, with this branch partaking of its share. The practical importance as raw materials for nuclear energy of uranium and thorium, which are the parents of most of the known natural radionuclides, has stimulated a study of the properties and occurrences of the later.

### Course outcome

- The students will be appraised about the origin, migration and accumulation of petroleum; it will also provide basic skills in prospecting, drilling and logging operation in oil exploration.
- The students will be capable about the origin of coal; it will also provide basic skills in prospecting, drilling and logging operation in coal exploration.
- The students will be trained to assess about the radioactive minerals and its prospecting and exploration.
- To understand fundamentals of coal, definition and coal forming sedimentary environments, effect of tectonics and sea-level changes on coal formation and its quality.
- To describe the basis of coal classification, concept of grade, type and rank in coal.
- To understand analytical techniques in coal and its importance in coal classification and utilization for various industries.
- To understand key concepts of Base level, Basin Accommodation Space, Eustatic and Relative Sea level change, Transgression/Regression and Stratigraphic cyclicity.
- To describe geometries of stratal surfaces, their terminations and key role in defining facies packaging
- To understand concepts of Systems Tracts, patterns of facies packaging within Systems Tracts and their bounding surfaces
- The students will be appraised of identification, distribution, occurrence, importance of radioactive minerals and nuclear waste disposal

### Pedagogy

- Class room teaching supported with presentation for enabling better understanding of the subject.
- Application oriented assignments.
- Class room lectures will be supplemented with field related examples.

### COURSE

### CONTENT

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**Unit1:** Definition and origin of coal. Stratigraphy of coal measures. Fundamentals of coal petrology, peat, lignite, bituminous and anthracite coal. Microscopic constituents of coal. Indian coal deposits.

**Unit2:** Origin, migration and entrapment of hydrocarbons. Characters and source and reservoir rocks. Structural, stratigraphic and mixed traps. Geographical and geological distributions of onshore and offshore petroliferous basins of India.

**Unit3:** Mineralogy and geochemistry of radioactive minerals. Instrumental techniques of detection and measurement of radioactivity. Radioactive methods of prospecting and assaying of mineral deposits. Distribution of radioactive minerals in India. Nuclear waste disposal and geological constraints.

**Unit 4:** Introduction to Stratigraphy, branches of Stratigraphy. Terms and concepts of Sequence Stratigraphy and its relationship with other branches of Stratigraphy. Sedimentary basin analysis through sequence Stratigraphy. Outcrop and subsurface procedures. Global sea level changes/ eustatic sea level. Applications of sequence stratigraphy in petroleum exploration with case studies

**Reference Books:**

1. Nuclear geology and Atomic mineral Resources – S.N. Virnave. Published by Bharati Bhawan 1995.
2. Mineral Resources of India – D.K. Banerjee. Published by the world press.
3. Radioactive minerals – R. Dhanaraju – 2005 published by Geological Society of India.
4. Economic Mineral deposits – A.M. Bateman
5. Geology of Mineral deposits – Smirnov U.G.
6. Indian Mineral Resources – Krishna Swamy. S.
7. Introduction to India Economic Mineral deposits – Sharma, N.L. & Ram, K.S.
8. Basic Petroleum Geology – P.K. Link
9. Petroleum Stratigraphy – R.L. Breuner
10. World Oil Energy Economics – H.A. Kerklelin
11. Jaharia Coal Field – D. Chandra
12. Petroleum Formation and Occurrence – B.P. Tissot
13. Petroleum Geology – Levorsen
14. Sequence stratigraphy – BHP petroleum (America) Inc – Michael Yeaman, Lavy Holcomb, Gill Tailor 1990
15. Sequence stratigraphy – BP Exploration. Stockley Park UK Bridge London, Publ. Blackwell science
16. Sea Level Changes – An Integrated Approach Spl. Pbln. 42, Barbara H. Lidz, Editor of Spl. Publ. Oklahoma USA 1998
17. Sequence in Layered Rocks – Blatt Middleton & Humay
18. Sedimentary Petrology – Pettijhon

## **COURSE-IV: MARINE GEOSCIENCE**

This course explores the fundamentals of ocean science, and emphasizes the climatic and environmental importance of the oceans. It helps to understand the underlying mechanism in the formation of ocean basins, the physical structure of the ocean, the dynamics of ocean and its relation to atmospheric processes, and how they influence marine productivity and biology, and climate.

### **Course outcome**

- A student will understand and learn about the basic concepts of oceanography and marine geology with respect to geology to enable them to work as a marine researcher.
- The students will equip themselves with knowledge and skills related to dealing with the physical and chemical components and phenomena related to oceanography and marine geology.

### **Pedagogy**

- Class room teaching supported with presentation for enabling better understanding of the subject.
- Application oriented assignments.
- Class room lectures will be supplemented with field related examples.

## **COURSE CONTENT**

### **Unit-**

**1:** Introduction Marine Geology. Continental margins and ocean floors. Plate boundaries and movements. Sea-floor spreading and subduction zones. Classification of submarine topography. Physiographic features of the ocean floor. Oceanographic exploration instruments. Seamounts. Submarine canyons. Mid-ocean ridges. Oceanic trenches.

Physicochemical characteristics of seawater. Depth-wise distribution of temperature, salinity and density of sea water. Marine life and marine environment.

**Unit-2:** Ocean water Circulation. Factors and Mechanisms. Ocean Waves - their causes and distribution. Ocean Tides - their causes and effects. Oceanic Currents - their types, patterns of distribution and their significance. Tsunamis. Ocean sediment deposits - sources - their Types and distribution. Marine natural resources. Types of marine mineral resources and their distribution. Marine energy resources. Marine Placer deposits. Manganese nodules and the methods of exploitation.

### **Reference:**

1. Maohotra, AK, Ocean Science and Technology
2. Tchernia, P, Descriptive regional oceanography
3. K. Siddhartha, Oceanography - A brief Introduction
4. William A Anikouchine and Richard W Stenberg, The world Ocean - An Introduction to oceanography
5. Cuchlaine A M King, Oceanography for Geographers

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6. H V.Thurman, Introduction tooceanography
7. WillamAAnikouchineandRichardWStenberg, TheworldOcean-  
AnIntroductionto oceanography
8. Cuchlaine A M King, Oceanography forGeographers
9. H V.Thurman, Introduction tooceanography.
10. MarineGeology,JamesP.Kennett,Prentice-Hall,1982-Science-813pages
11. MarineGeology,H.Kuenen,ReadBooks,01-Mar-2007-Science-592pages

## **COURSE-V: ENVIRONMENTAL GEOLOGY**

The lecture part of the course begins with a brief overview of the earth's systems, processes and environmental pollution of different types. The succeeding discussion of natural hazards includes earthquakes, volcanoes, floods, and coastal zones allows for more focused discussions on processes, observations, and interpretations, which, as a whole, demonstrate the procedure of collecting, reducing, and interpreting data and applying model to better understand the interrelationships.

### **Course outcome**

- Students should be able to predict potential hazards for any given area by knowing basic inherent geologic materials and characteristics of a given area.
- Students should be able to both predict and analyze the impacts of the occurrence of a natural hazard in a given area.
- Students should be able to evaluate the compatibility of a given area to proposed uses of the land given the necessary geologic data.
- Students should be able to synthesize multiple data sets into a viable analysis of environmental impacts of both human-induced and naturally-occurring events.
- Students should be able to evaluate the validity of various reports and models concerning global changes, including global climate.

### **Pedagogy**

- Class room teaching supported with presentation for enabling better understanding of the subject.
- Application oriented assignments.
- Class room lectures will be supplemented with field related examples.

## **COURSE CONTENT**

**Unit 1: Introduction to Environmental Geology.** Man and environment. Earth's system, Interactions among lithosphere, hydrosphere, atmosphere and biosphere. Geological process affecting the environment. Environmental hazards created by man's activities such as mining and industrial activities. Disasters Management, Environmental Risk Assessment, Environment hazard, Risk safety. Impact of climate on various earth systems, Flood hazard zonation mapping and risk analysis and relief aspects. Public perception of risk,

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communication. Environmental Impact Assessment. Causes of Environmental degradation. Environmental law and ethics.

**Unit 2: Land pollution:** Water, land and soil pollution. Causes and effects of urban and industrialization. Land use planning and terrain evaluation for environmental management. Solid Wastes and their methods of Management. Sewage sources and their treatment methods. **Marine pollution:** Causative factors – land based sources – marine based sources – types of pollution – oil spills – process of oil spill process and its effects on marine and continental environment. Global warming causes and its effects.

**Reference:**

1. Environmental Geology – Peter TP Flawn
2. Environmental geosciences – Arthur H Strahler & Alan Strauler
3. Geology in Environmental planning – A.D. Howard & I. Ramson
4. Focus on Environmental Geology – R Turk
5. Environmental Science – S C Santra
6. Environmental geology by Waldia K.S

**COURSE-VI: CLIMATOLOGY**

Consequences of global climate change already include: increased drought, heat waves, flood intensity, glacial retreat, and sea level rise. Solutions are needed to reduce human impact on our climate system and to respond to climate change impacts across sectors vital to humanity (food, water, health). This course examines climate change at global and local scales. Students can explore climate challenges faced by local experts. They reflect on implications for future problem solving.

**Course outcome**

- Students will analyze figures to understand natural and human-influenced drivers of our climate system and implications
- Students will be able to assess the credibility of scientific information
- Students will communicate locally-relevant climate change solutions to a non-science audience
- Students will make informed & responsible decisions with regard to our climate system.

**Pedagogy**

- Classroom teaching supported with presentation for enabling better understanding of the subject.
- Application oriented assignments.
- Class room lectures will be supplemented with field related examples.

**COURSE CONTENT**

**Unit-1:** Definition of Climate and weather. Climatology, its meaning, aims and

methods. Climatology as distinguished from meteorology. The Climatic elements. Order of treatment of climatic elements. Earth's Atmosphere- Structure and properties of Atmospheric layers. Solar Climate and Physical Climate. Continental and Marine Climate. Temperature as a climatic element. Atmospheric Moisture, humidity, precipitation, and cloudiness. Types of clouds and Fogs. Major circulation of air as local winds. Atmospheric distribution of pressure. Climatic factors on Evaporation and Condensation. Factors influencing global climate. Dust content in air and principles of atmospheric visibility. Climatic zones and their subdivisions. Classification of climates, - Koppen's and Thornthwaite's scheme of climatic Classifications. Characteristics of various climatic zones.

#### **Unit-2: Changes of Climate-Natural factors-**

Geological and secular changes, periodic variations and Role of Anthropogenic activities in climatic changes with case studies . Climate

Observations, stations and networks. Climate data management. Instruments and climatic

measurements. Thermometers, barometers, hygrometers, rain and snow gauges, Sunshine recorders. Weather maps and charts. Extreme climatic events- Cyclones, Jet Streams, Western Disturbances, Ozone Depletion, Storms, Hurricanes and Tornadoes. Droughts. Elements of Weather forecast and methods. Global Climate Models. General Weather Systems of India. Monsoon systems. Green house effect,

#### **References:**

1. Climatology: An Atmospheric Science, 2/e, Pearson Education India, 1993-423p.
2. Encyclopedia of World Climatology, John E. Oliver, Springer Science & Business Media, 2008, 854p.
3. Climatology, Majid Husain, Anmol Publications, 1994 - 376p.
4. Advances in Meteorology, Climatology and Atmospheric Physics, Costas Helmis, Panagiotis T. Nastos, Springer Science & Business Media, 2012, 1278 p.
5. Remote Sensing Applications in Meteorology and Climatology, Robin A. Vaughan, Springer Science & Business Media, 2012, 480p.
6. Applied Climatology: An Introduction, John F. Griffiths, Oxford University Press, Incorporated, 1976, 136p.
7. Principles of climatology: a manual in earth science, Hans Hermann Neuberger, John Cahir, Holt, Rinehart and Winston, 1969, 178p.
8. Climatology, an introduction, John E. Oliver, John J. Hidore, Merrill, 1984, 381p.
9. Global Physical Climatology, Dennis L. Hartmann, Academic Press, 1994, 411p.
10. Weather, radar and Flood forecasting, Collings. V. K (1987) John Wiley and sons.
11. General Climatology, Crithfield. H. J., (1996) Prentice Hall, New Jersey.
12. Climatology by Miller, Austin A Publication: London Methuen and company 1961. xii, 320p.
13. General climatology by Flohn, H [ed.] Publication: Amsterdam Elsevier Publishing company 1969 . xi, 266p.
14. company 1969 . xi, 266p.

15. Climatology by Miller, A. Austin Publication: London Methuen and Co 1938. x, 304 pp
16. Climatology by Haurwitz, Bernhard Publication: New York McGraw-Hill 1944. xi, 409 p.
17. Methods in climatology by Conrad, Victor Publication: Cambridge Harvard University Press 1946. xx, 228 p.
18. Climatology by Kendrew, W.G. Publication: Oxford The Clarendon Press 1957. xv, 400 p.
19. Climatology by Blair, Thomas A. Publication: New York Prentice-Hall 1942. xvi, 484 p.

## SECOND SEMESTER

### COURSE-I: ADVANCED MINERALOGY

You will have a basic insight to the inner structure of crystals, chemical bonding and classification. Theoretical and practical study of the most important rock forming minerals, where they are found, their quality and how they are formed; theoretical and practical insight to the most important processes that leads to the formation of the different types of magmatic and metamorphic rocks. Use of theory to understand the chemical and mineralogical differences between rocks formed in different tectonic environment and under different pressure-temperature conditions.

#### Course outcome

- Students are able to understand the classification of minerals and how their chemical composition and structure influence this
- identify the commonest minerals and be able to say whether the rock is magmatic, sedimentary or metamorphic

#### Pedagogy

- Class room teaching supported with presentation for enabling better understanding of the subject.
- Application oriented assignments.
- Class room lectures will be supplemented with field related examples.

### COURSE CONTENT

**Unit 1: Crystallography:** Form theory of Crystals, Projections, Derivation of 32 point groups. Zone and Zone Laws, Atomic and ionic radii, Bond length and measurement so f Radius, Radius ratio and coordination polyhedra, Coordination Number, Pauling's Rules, Spheres in Closest packing, Packing Index. Voids in closest packing, Classification & Coordination of voids, Derivative Structures. Crystal Defects/Crystal Imperfections

**Unit 2: Mineralogy:** Structure, Chemistry, Paragenesis. Classification of Minerals. Optical

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and physical properties of Olivine, Garnet,  $Al_2SiO_5$  group, Epidote, Pyroxene, Amphibole, Mica, Feldspar and Silica group of Minerals.

**Practical 1: Crystallography:** Determination of Grades of symmetry in Crystals and their projections. Determination of Axial Ratios and angle between the faces by using Stereonet.  
**Practical 2: Mineralogy:** Identification of rock forming minerals. Determination of mineral formula based on mineral analysis. Plotting mineral compositions in a trilinear diagram.

## COURSE-II: ECONOMIC GEOLOGY

This course covers the distribution, geological setting and genesis of metalliferous mineral deposits. Factors controlling the formation of these deposits and the linkages with many other geologic processes covered in other courses are explored. Practical work involves mineralogy and study of a range of mineral deposits. Ore is natural rock or sediment that contains desirable minerals, typically metals that can be extracted from it. The grade of ore refers to the concentration of the desired material it contains. The value of the metal an ore contains must be weighed against the cost of extraction to determine whether it is of sufficiently high grade to be worth mining.

### Course outcome

Upon successful completion, students will have the knowledge and skills to:

1. Recognize common ore minerals in hand samples and under the microscope.
2. 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.
3. Relate overall geometry, zonation and alteration patterns of rock associations to specific classes of metallic mineral deposits.
4. Evaluate different processes of element enrichment by fluids and melt to form ore bodies.
5. Inform peer students and the wider public how the knowledge of formation of ore bodies is important in the current debates about global resources.

### Pedagogy

- Class room teaching supported with presentation for enabling better understanding of the subject.
- Application oriented assignments.
- Class room lectures will be supplemented with field related examples.

### COURSE CONTENT

**Unit 1: Ore – bearing fluids:** magma, hydrothermal fluids, meteoric waters, seawaters, connate waters, metamorphic fluids. Depositional textures: exsolution, replacement, colloidal



– colloform and open-space filling textures. Wall rock alteration: reaction between wall rocks and fluids, alteration assemblages and types of alteration. Paragenesis and zoning in mineral deposits. Classification of ore deposits. Deposits related to ultramafic-mafic rocks (layered intrusions, anorthosites, kimberlites, carbonates, komatiites). Deposits related to intermediate to felsic rocks (Iron deposits, porphyry Mo, pegmatites, granitic Tin and U, skarn deposits with typical examples).

**Unit 2:** Deposits related to weathering – Nickel laterite deposits, Deposits related to clastic sedimentation: placer deposits – Witwatersrand gold and U deposits. Chemical sedimentation: phosphate deposits, evaporates, manganese nodules, Ore deposits related to subaerial (Epithermal gold–Au) and submarine volcanism (Kuroko Cu–Zn, Japan, BIFs). Ore deposits related to metamorphism, metallogenic provinces, Epochs and plate tectonic – classification of ore deposits.

**Unit 3:** Metallic deposits of India: Iron, Manganese, Copper, Chromium, Gold, Lead, Zinc and Bauxite deposits, Non-metallic deposits (Industrial minerals) – Minerals used as fertilizers, refractories, abrasives, pigments, ceramic and glass-making materials.

**Practical:** Optical methods in minerals: Determination of pleochroic scheme and optics in minerals. Birefringence.

Identification of ore minerals based on optical properties: chromite, ilmenite, Ti-magnetite, hematite, pyrite, sphalerite, galena, chalcopyrite, covellite, Bornite, pyrrotite, Arsenopyrite, Pyrolusite.

#### Reference:

1. The geology of ore deposits - John M. Guilbert and Charles F. Park, Jr. W.H. Freeman and Co., New York. 1986.
2. Interpretation of ore textures - Bastin, E.S.
3. Economic Mineral deposits by Jenson and Bateman, A.M.
4. Ore microscopy - Cameron, E.N.
5. Textures of the ore minerals - Edwards, A.B.
6. Ore deposits - Park, Jr. C.F.
7. Geology of Mineral deposits - Smirnov, U.J.
8. The ore minerals and their intergrowths - Ramhor, Dr. Paul.
9. Ore Petrology - Stanton, R.L.
10. India's mineral resources – Sinha and Krishnaswamy, S.
11. Metallic and Industrial minerals - Lamey Carl, A.
12. Introduction to India's economic minerals - Sharma, N.L. & Ram. K.S.
13. A treatise on industrial minerals of India - Sinha, R.L.
14. Mineral deposits of India, Mukerjee 1999: Allied publications.

#### COURSE-III: STRATIGRAPHY OF INDIA



Stratigraphy and Palaeontology, the two branches of Geology works together in discovering thesecretsofagefromrocksoftheearthcrust.Itallowsstudyingthecompositionandarrangementof layeredorstratifiedrocks.Palaeontologistsstudytheremainsofplantsandanimalswhichhavebeen preservedintheearth'scrustbynaturalprocesses.Withtheseobjectivesinminditbecomes pertinent to understand the basic concepts of Stratigraphy and Palaeontology.

### Course outcome

- The study of stratigraphy and Palaeontology encompasses the aspects of the age of the earth, chronological arrangement of rocks and appearance and evolution of life through the geologic time.
- The knowledge of the concepts in stratigraphy, correlation, and paleontology would enable the students to understand the changes that occurred in the history of the earth and relate them to their field observations and also, in understanding the framework of the stratigraphy of India.
- The students will be exposed to the principles of stratigraphy including order of superposition. They will also be able to identify primary sedimentary structure and their depositional environments.

### Pedagogy

- Class room teaching supported with presentation for enabling better understanding of the subject.
- Application oriented assignments.
- Class room lectures will be supplemented with field related examples.

### COURSE CONTENT

**Unit 1: Precambrian Era** – Introduction, Physical features, Physiographic features and Tectonic features of India. Brief studies on – Dharwar Craton, Baster Craton, Singhbhum Craton, Bundelkhand Craton and Aravalli Craton. A brief account on – Eastern Ghats Mobile Belt, Pandyan Mobile Belt and Satpura Mobile Belt. Precambrian of Himalaya. Proterozoic Sedimentary Basins - Bijawar and Sonari, Gwalior, Abujhmar, Papaghni subbasin, Vindhyan, Chhattisgarh, Khariar, Ampani, Indravati, Sabri, Pranhita-Godavari, Cuddapah, Kaladgi and Bhima.

**Unit 2: Paleozoic Era:** Introduction, Tethyan Basin, Paleozoic Life, Trace fossils and Stromatolites. Precambrian/Cambrian boundary, pC/C boundary in Himalayan basins. Cambrian – Jammu and Kashmir, Himachal Pradesh, Tal Basins and Uttaranchal. Ordovician and Silurian - Jammu and Kashmir, Himachal Pradesh and Uttaranchal. Devonian - Jammu and Kashmir, Himachal Pradesh and Uttaranchal. Carboniferous - Jammu and Kashmir, Eastern Karakoram, Himachal Pradesh and Uttaranchal. Permian - Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Bhutan Arunachal Pradesh

and Peninsular India-Cauvery Basin. *Gondwana Supergroup* – Introduction, Characteristics, Stratigraphy and Structure, Classification and Age, Life in Gondwana, Coastal Gondwana Basins, Gondwana in Extra - Peninsular India, Environmental of deposition and Economic Significance.

**Unit 3: Mesozoic Era** – Introduction, Life of Mesozoic Era, *Triassic* - Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Sikkim, Rajasthan and Kutch. Permo-Triassic Boundary.

*Jurassic* – Kutch, Rajasthan, Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Jharkhand and Bhutan. *Cretaceous* – Gujarat, Rajasthan, Jammu and Kashmir, Himachal Pradesh, Uttaranchal, East Coast, Trichinopoly, Narmada Basin, Lameta Formation,

Jharkhand, Assam/Meghalaya, Andaman and Nicobar Islands. Cretaceous/Tertiary Boundary. *Deccan Volcanic Province* – Introduction, Regional Stratigraphy, Subprovinces, Volcano- Plutonic Complexes, Petrology and Petrogenesis, Inter-Trappean beds, Distribution and its age.

**Unit 4: Cenozoic Era** – Introduction, Distribution, Climate, Correlation, Fauna and Flora,

Classification and Stratigraphy. *Paleogene* – Introduction, Fauna and Flora, Stratigraphy and Distribution. *Neogene* – Introduction, Fauna and Flora, Stratigraphy and Distribution.

*Quaternary* –

Introduction, Distribution, Quaternary climatic changes, Quaternary Sea level changes. Siwalik – Stratigraphy and Sedimentation, Distribution and Fauna of Siwalik. Geology of Offshore Basins. Morphology and Evaluation.

#### References:

1. Geology of India Vol.1 & 2. M. Ramakrishnan and R Vaidyanathan
2. Geology of India – Wadia, D.N., McMillan and Co.
3. Geology of India and Burma – Krishnan M.S. Higginbotham, Madras.
4. A handbook of the Geology of the Mysore State – B. Rama Rao, Bangalore press.
5. Precambrian Stratigraphy and Geochronology of the Peninsular India – Sarkar, S.N. Dhanbad Publishers.
6. Review paper on the Stratigraphy of India – Rec. Geol. Surv. India Vol. 101, Part 2. 1972 Cretaceous Tertiary formations – Geol. Soc. India, seminar Vol. 1958.
7. Paleozoic of Himalayas. HPC publ.
8. Reconnaissance Rb-Sr dating of the Precambrian of Southern Peninsular India - Crawford, A.R., J.G.S.I 1972. 117-126.

#### COURSE-IV: MINOR PROJECTS (FW & TECHNICAL REPORT)

It is an opportunity to work on a 15 days minor project or Technical report in geosciences under the direct supervision of a faculty member in University/Institute or Government Organisation. Students will carry out data collection using field and/or laboratory

studies, and complete a final report/presentation. Field studies, Laboratory studies / data processing, reference work will be used for preparation and presentation of the report of the course.

#### **Course outcome**

- To inculcate a culture of research and innovation at the postgraduate level so that the students are exposed to the gritty-gritty of the Scientific Research in their fields.
- The basic aim is to expose the students at an early stage to field and laboratory techniques and sophisticated instrumentation.

#### **Pedagogy**

- Class room teaching supported with presentation for enabling better understanding of the subject.
- Application oriented assignments.
- Class room lectures will be supplemented with field related examples.

### **COURSE-V: ANALYTICAL TECHNIQUES IN GEOLOGY**



This course provides students with advanced training in analytical techniques. This includes a detailed theoretical background, practical training and a critical understanding of the laboratory-based

techniques they will apply during their research projects. The course will deliver an in-depth examination of the specific analytical techniques relevant to their research projects.

#### **Course outcome**

- Upon successful completion, students will have the knowledge and skills to:
- Explain the theoretical aspects of key analytical techniques and instruments used in geochemistry, including but not limited to electron microscopy, X-ray diffraction, mass spectrometry and spectroscopy (including synchrotron techniques).
  - Strategically plan analytical campaigns to apply various techniques to different types of samples and research objectives, including selection of the most appropriate technique/instrumentation for the students' research project.
  - Undertake the correct sample preparation and characterization prior to analysis by the chosen techniques or instruments.
  - Design an analytical work-flow to acquire data and achieve the research objectives of their project.
  - Process data from the chosen instruments and demonstrate understanding of the limitations and quality of the data. Justify the approach taken to data processing.
  - Write a clear and concise justification and description of the analytical techniques employed, suitable for publication in a scientific journal.

#### **Pedagogy**

- Class room teaching supported with presentation for enabling better
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- understanding of the subject.
- Application oriented assignments.
- Class room lectures will be supplemented with field related examples.

### **COURSE CONTENT**

**Unit 1** Introduction to instrumental methods of chemical analysis, Spectroscopy photometry and spectrophotometer, Infrared spectroscopy – FTIR. Atomic Absorption spectroscopy (AAS), and Inductively coupled Plasma (ICP-MS) analysis technique, Thermal analysis techniques – DTA, TGA, DSC etc., Electron Microscopy – SEM, TEM, AFM; X-Ray powder diffraction techniques (XRD), X-ray Fluorescence (XRF) technique, Electro probe micro analysis technique, (EDAX, WDS).

**Unit 2 Tutorial:** Assignments/Seminar/Test/Discussion

#### **Reference:**

1. Silicate analysis by Potts
2. Petrographic techniques by Hutchinson

### **COURSE-VI: SOIL & WATER CONSERVATION**

This course covers topics in soil and water management and conservation important to students of agriculture, viticulture, horticulture and environmental sciences. Processes that degrade the soil and water resources of India (e.g. erosion, salinity, alkalinity as well as acidification, water repellence and degradation of soil structure) are examined, and their measurement, mitigation and management are discussed. There is a strong focus on quantitative theory and practice of measuring and managing soil water using commercially available technology, particularly in relation to interception, storage and movement of water in dryland and irrigated agro-ecosystems. Broader issues in soil and water conservation (e.g. State and Commonwealth legislation) are also covered.

#### **Course outcome**

- How to solve quantitative problems in soil water management, specifically how to:
  - \*conduct simple calculations of water content, porosity, density and hydraulic conductivity.
  - \*Analyze and interpret data on infiltration, available water and storage of water.
- The primary causes and consequences of a wider range of soil degradation problems, including soil acidity and alkalinity, erosion, salinity and nutrient loss.
- The impact of soil management on soil organic matter, soil structural stability, water quality and other important soil properties.
- Where soil conservation and management fit into the broader context of the South Australian Natural Resource Management Act.

#### **Pedagogy**

- Class room teaching supported with presentation for enabling better understanding of the subject.
- Application oriented assignments.

- Class room lectures will be supplemented with field related examples.

## **COURSE CONTENT**

**Unit-1:** Definition of Soil. Soil genesis and morphology. Factors of Soil Formation. Processes of Soil Formation. The Soil profile- Nature of Soil Profile.. Concept of Pedon and Landforms. Components and Composition of Soils. Physical Properties of Soils. Soil Structure. Chemical Properties of Soils. Soil pH. Soil Mineralogy. Ion-exchange Capacity of Soils. Soil Salinity. Acid Soils. Alkaline soils. Engineering properties of soils. Soil Moisture . Role of Nutrients in Soils . Soil Microbiology & Organic Matter. Soil testing and surveys. Soil Classification systems & Soil Taxonomy. Soil related problems. Soil pollution . Soil erosion- causes and effects. Soil loss measurements. Universal Soil Loss Equation and its application. Soils surface management and soil stabilization practices. Sediment traps. Soil conservation practices- Tillage methods. Biological soil conservation. Mechanical conservation works including terracing methods. Irrigation and Engineering Practices.

### **Unit-**

**2:** Definition of water conservation. Water Conservation Practices. Water Resources in Watersheds and River Basins. Water Use and Consumption. Water management. Improving Drainage and reclaiming salt-affected soils. Technological options for drainage. Choice of method. Design principles. The effect of scale. Methods of Irrigation- modern techniques. In-situ conservation of soil water. Runoff management- Decreasing runoff amount (contour farming, strip cropping, contour barriers, vegetative hedges). Water Erosion Control practices. Reducing runoff velocity (slope management, waterways, diversion channels, engineering structures, etc). Flood control- Inundation methods and Flood diversion. Water storage- Small earth dams, Weirs, Sand dams. Losses of stored water- seepage/ evapotranspiration and its controlling methods.

### **References:**

1. Principles of Soil Conservation and Management- Humberto Blanco-Canqui, Rattan Lal, Springer, 16-Sep-2008 - 617 pages
2. Soil and Water Conservation Policies and Programs: Successes and Failures, Ted L. Napier, Silvana M. Napier, Jiri Tvrdoň, CRC Press, 24-Nov-1999 - Technology & Engineering - 656 pages
3. Advances in Soil and Water Conservation, Francis J. Pierce, CRC Press, 01-Feb-1998- Technology & Engineering - 300 pages
4. Soil and water conservation engineering, Richard K. Frevert, Glenn Orville Schwab,

- Wiley, 1966 - Nature - 683 pages
5. Soil And Water Conservation Handbook: Policies, Practices, Conditions, and Terms, Paul W. Unger, Haworth Food & Agricultural Products Press, 23-Oct-2006 - Political Science - 248 pages
  6. Soil Erosion and Conservation, R.P.C. Morgan, John Wiley & Sons, 05-Feb-2009 - Science - 320 pages
  7. Soil Erosion: Processes, Prediction, Measurement, and Control, Terrence J. Toy, George R. Foster, Kenneth G. Renard, John Wiley & Sons, 27-May-2002 - Science - 338 pages
  8. Soil Erosion by Water: Some Measures for Its Control on Cultivated Lands, Food and Agriculture Organization of the United Nations, Food & Agriculture Org., 01-Jan-1965 - Nature - 284 pages
  9. Water Conservation, Management and Analysis, Madireddi V. Subba Rao, Readworthy, 2011 - Water - 144 pages
  10. Soil and Water Conservation Policies and Programs: Successes and Failures, Ted L. Napier, Silvana M. Napier, Jiri Tvrdon, CRC Press, 24-Nov-1999 - Technology & Engineering - 656 pages
  11. A Practical Approach to Water Conservation for Commercial and Industrial Facilities, Mohan Seneviratne, Elsevier, 11-Jul-2007 - Technology & Engineering - 400 pages
  12. Soil and Water Conservation in Semi-arid Areas, Issue 57, Norman Hudson, Food & Agriculture Org., 01-Jan-1987 - Arid regions - 172 pages

## **COURSE-VII: BASICS OF EARTH SCIENCE**

The students will understand the origin of our solar system and planets, including earth. The students are exposed to the Geological time scale and be able to appreciate the dynamics of earth evolution through time. The study of this paper strengthens students' knowledge with respect to understanding the essentials of the structural dynamics of the earth. The course presents an understanding of the processes in action on the earth surface and their impact on man and his institutions.

### **Course outcome**

- Students will apply skills such as inductive, deductive and mathematical reasoning to solve Earth science problems.
- Students will integrate data from field work, laboratory measurements, library research and / or their coursework to formulate or evaluate a geoscientific hypothesis.
- Students will apply mathematical models and analysis to quantitatively describe and predict the behavior of Earth phenomena.
- Students will acquire a solid foundation in statistical analysis and learn how to apply probabilistic reasoning to the Earth system, learning to discriminate between competing hypotheses based on factual evidence.
- Students will learn how to critically evaluate scientific information in visual and written forms.

### **Pedagogy**

- Class room teaching supported with presentation for enabling better

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- understanding of the subject.
- Application oriented assignments.
- Class room lectures will be supplemented with field related examples.

## **COURSE CONTENT**

### **Unit 1: Physical Geology-**

Introduction to geology. Origin of the Earth. Age of the earth. Interior of the Earth. Geomorphologic processes and cycles, Geological action of wind, water, glaciers. Volcanoes and earthquakes. Morphology of Oceans, Principles of Isostasy and uniformitarianism.

### **Unit 2: Structural Geology-**

Rock deformation. Earth forces. Folds and Foldings, Fault and Faulting, Joints, Cleavage, Unconformities, Concepts of plate tectonics, sea floor spreading and geosynclines.

### **Unit 3: Stratigraphy-** Introduction, Definition of Stratigraphy, Branches of Stratigraphy and

its relation with other branches of Geology, Principles of Stratigraphy- Law of Uniformitarianism, Law of order of superposition, Law of Faunal Succession. Geological Record and its nature Eon, Era, Period. Geological Time Scale. Classification of Standard Stratigraphic scale. Nomenclature and units- Litho, Bio and Chronostratigraphic units, Correlation- Lithostratigraphic and Biostratigraphic

**Unit 4: Paleontology** -Introduction, Definition of Paleontology, Classification of Plants, Invertebrate and Vertebrate fossils. Fossils- Toponymy (Burial Law), Types of Fossilization, Mode of preservation- Mummification, Carbonization, Silification, Casts, Moulds, Tracks and Trails. Application of Fossils. General morphological characters and Geological age of the following Invertebrate and Plant Fossils: Brachiopoda, Cephalopoda, Pelecypoda and Trilobita. Plant fossils: Glossopteris, Gangamopteris, Ptillophyllum, Calamites and Lepidodendron

### **References:**

1. Physical Geology by Arthur Holmes
2. Structural Geology by Billings
3. General Geology By P.K. Mukerjee
4. Physical Geology By Strahler
5. Stratigraphic Principles and Practice- Weller
6. Stratigraphy- Kumberlein and Sloss
7. Paleontology of the Invertebrates- Taschen Publ. John Wiley and Sons
8. Paleontology- Henry Wood
9. Fossils Plants- Arnold
10. The Elements of Paleontology Black, R.M. Pub. Cambridge university press

## **III SEMESTER**

## **COURSE-I: GEO-EXPLORATION & MINING METHODS**

This course will introduce a series of geological and geophysical techniques that can be applied to determine the physical characteristics of the Earth's lithosphere, with direct application to the detection and mapping of mineral and energy resources in three dimensions. We will take a generic view, that economic concentrations of mineral and energy resources are geological anomalies that are defined by extreme localised enrichments (of specific elements, minerals, liquids, gases or heat) and are recognisable by steep gradients in a range of measurable geophysical properties. The course will be divided into modules covering geophysical exploration techniques commonly used in mineral and energy exploration (gravity, magnetic, electrical, electro-magnetic and seismic surveys). We will examine the theoretical basis of each technique, the methods of data collection, presentation and analysis and appropriate geologically constrained interpretation of the data. Students will explore an industry style data base and software's with an aim of developing an exploration and targeting model for hydrocarbon resources.

### **Course outcome**

This course aims to introduce students to the techniques used to measure and map geological, geophysical and geochemical characteristics of the lithosphere, with applications to mineral and energy exploration.

It also aims to provide students with the theoretical background to each technique (including its strengths and limitations), the methods of data collection, analysis and interpretation and an appreciation of the exploration scenarios in which each technique may apply.

The anticipated knowledge, skills and/or attitude to be developed by the student are:

- Demonstrated proficiency in common practical skills in resource exploration.
- The scientific basis of mineral, energy and natural resource exploration.
- The generic characteristics of economic mineral and energy resources – geological, geophysical and geochemical anomaly.
- The geophysical techniques (seismic, gravity, magnetic, electrical and electro-magnetic)
- The geochemical techniques (sampling media, sampling strategies, analytical techniques)
- Field based data collection – sampling strategies
- Demonstrated understanding of the importance of data quality – collection, analysis, process techniques.

### **Pedagogy**

- Class room teaching supported with presentation for enabling better understanding of the subject.
- Application oriented assignments.



- Class room lectures will be supplemented with field related examples.

## COURSE CONTENT

**Unit 1: Geological Exploration-** Mode of occurrence of commercial-grade deposits of Fe, Mn, Ag-(W), Cu, Pb-Zn, Ti, Ni, Mo, Sn, Al, Pt-group, U-Th. Geological criteria for mineral prospecting. Indications of ore. Geological prospecting methods. Small and large scale geological mapping. Methods of geological exploration - exploratory grids, location and documentation of exploratory workings (pits, trenches, underground workings), drilling, core logging. Sampling techniques and evaluation of grade. Mining terminology, methods of open cast, underground and alluvial mining. Definition and scope of mineral processing, comminution, crushers and classifiers. Froth flotation techniques of separation.

**Unit 2: Geochemical Exploration:** Geochemical cycle, mobility of elements and geochemical anomaly. Mode of occurrence of trace elements. Primary dispersion patterns of deep seated origin, syngenetic and epigenetic. Geochemical rock surveys. Weathering and its products. Mobility of elements in the surficial environment and surficial dispersion patterns and forms. Anomalies in residual and transported overburden. Anomalies in waters and drainage sediments. Uptake of mineral matter by plants. Biogeochemical anomalies and survey techniques. Vapour geochemistry.

**Unit 3: Geophysical exploration:** Geophysical anomalies, Electrical prospecting: Resistivity method, important electrode arrangements, instruments, interpretation and application of electrical methods in ground water investigation. Magnetic prospecting: Magnetic properties of rocks and minerals, Earth's magnetic field, instrument and measurements, interpretation of magnetic anomalies.

Gravity prospecting: Earth's gravity field, regional and local gravity anomalies, instruments, interpretation of gravity anomalies. Seismic prospecting: Elastic properties of rocks and minerals, refraction and reflection technique time-distance relation for horizontal interfaces, seismic instruments and records. Radiometric methods: Radioactivity of rocks and minerals, instruments and measurements of radiation, Well logging: Different techniques of logging.

**Practical: Geological Exploration-** Delineation of ore deposit based on exploration data. Classification of reserves. Economic evaluation of ore deposit. Preparation of technical report.

**Geochemical Exploration:** Geochemical methods in mineral exploration and choice of materials and methods. Interpretation of Geochemical maps for locating ore mineralization. Preparation of geochemical anomaly maps.

**Geophysical exploration:** Resistivity methods: Curvematching techniques and -line method.

### REFERENCE BOOKS

1. Introduction to geophysical prospecting - Milton B Dobrin
2. Exploration geophysics – Jakaosku JJ
3. Outlines of geophysical prospecting - A manual for geologists – M B Ramachandra Rao
4. Geophysical Methods in Geology – P V Sharama
5. Exploration Geophysics for geologist and Engineers – Bhimasanakaran and Gaur
6. Principles of Applied Geophysics – D S Paransis
7. Introduction to Geophysics – C H Howel
8. Geochemistry in mineral exploration Rose, A. W Hawkes. H. E & Webb J. S. 1979. Academic press.
9. Principles of geochemical prospecting. Ginzburg. I. I. Petgamon Press, N. Y. London.
10. Biochemical methods of Prospecting - Malyuga, D. P.
11. Principles of Mining Geology, Arokiaswamy.
12. Geological prospecting and exploration – Kreiter, V. M.
13. Rock geochemistry in Mineral Exploration. G. J. S. Govett. Elsevier Publication. 1983.

### COURSE-II: ADVANCED PETROLOGY

Petrology is the science of rocks. It involves understanding of the processes involved in the formation of igneous and metamorphic rocks, their textures, structures, classifications and their importance.

The course will help the students to exhibit an improved and understanding of fundamental petrologic processes and common rock types.

#### Course outcome

- Predict what suites of igneous and metamorphic rocks should be found in different plate tectonic settings.
- Explain magma differentiation and observation of layered mafic intrusions using a fractional crystallization model.
- Describe the types and relative abundances of phases in a rock based on observations from hand specimens and thin sections.
- Interpret the geologic history of rocks based on mineral assemblage and textures using both hand sample and microscopet techniques.
- Use rock mineral assemblages and textures to constrain deformation history and P-T conditions.
- Integrate their research findings with those of peers in developing a consensus model that (a) explains mineral occurrences and interplay (micro- and macroscopic) in field samples, and



- (b) holds up to public scrutiny (as a consensus model and as individual components) at a departmental mini-poster symposium
- Design and implement a field sampling campaign

### **Pedagogy**

- Class room teaching supported with presentation for enabling better understanding of the subject.
- Application oriented assignments.
- Class room lectures will be supplemented with field related examples.

### **COURSE CONTENT**

**Unit 1: Igneous Petrology:** Mineralogical and Chemical classification of Igneous rocks. Classification, origin and petrogenetic importance of Granite, Syenite, Gabbro and Layered Igneous Complex, Kimberlite, Anorthosite, Carbonatites and Peridotite. Add a note on their economic importance and Indian occurrence. Classification and origin of Pegmatite, Dolerite, Lamprophyre, Basalt, Rhyolite, Trachyte, Andesite. Add a note on their economic importance and Indian occurrence.

**Unit 2: Sedimentary petrology:** Aims and Scope of Sedimentology, Development growth and Prospects of Sedimentology in India, Sedimentary facies and environment. Detailed petrographic parameter of Gravels and Conglomerates, Sands and Sandstones, Shales, and Argillite, Limestone and Dolomite, Evaporites, Provenance studies, Heavy mineral studies, Grain size parameter Modes and Mechanism controls of sedimentation, Stock's law, Sedimentary structures, Tectonics and sedimentation, Cyclic sediments purpose and scope of basin analysis

**Unit 3: Metamorphic Petrology:** Definition, Factors and Limits of Metamorphism (Temperature, Pressure & types). Fabric Changes, Geothermal Gradient, Metamorphic Fluids (recrystallization, pressure, and its type of pressure). Structure and Texture of Metamorphics- Terminology for high strain shear zones related structure and textures. Types of metamorphism based on principal process (Orogenic, Hydrothermal, Burial, regional, fault zone, Prograde- Retrograde, progressive Retrograde). Regional and Contact Metamorphism of Pelitic and impure Calcareous rocks. Major metamorphic rocks. Metamorphism of mafic rocks. Protoliths and types- Zones of Metamorphism. Metamorphic reactions- Types of Metamorphic Reaction- PTX Conditions- Metamorphic rocks Components and Developments- Development of Metamorphic Mineral Nucleation- Mineral assemblages equilibrium/Reaction Texture and geothermobarometry. Metamorphic Reactions. Characteristics of different grades and facies of metamorphism. Metasomatism and

granitization. Migmatites. Plate tectonics and Metamorphic Zones. Paired metamorphic belts.

**Practical:** Identification of Igneous rocks in hand specimens and thin Sections.

Identification of microstructures and textures in igneous rocks. Significance of micro textures in understanding magmatic and tectonic process.

Identification of Sedimentary rocks in hand specimens and thin sections. Identification of structures in Sedimentary rocks.

Metamorphic: Megascopic and Microscopic identification of different types of metamorphic rocks and significance of micro structures and textures in understanding metamorphic and tectonic process.

#### References:

1. Petrology of Igneous and Metamorphic rocks by Hyndman
2. Principles of Igneous and Metamorphic rocks by Anthony R. Philpotts.
3. Igneous petrology by Anthony Hall
4. Petrology of Igneous and Metamorphic rocks by Best.
5. Petrography—An introduction to the study of rocks in thin sections—H. Kowell, Williams and Turner.
6. The Study of Rocks in Thin Sections- W.W. Moorhouse
7. Migmatites - Ashworth.
8. Metamorphism - A. Methuen & Co.
9. Migmatites and the origin of granitic rocks - Mehnert K.R. Elsevier & Co.
10. Metamorphism and Metamorphic rocks - Miyashiro, A. George, Allen and Unwin.
11. Petrogenesis of metamorphic rocks- Winkler, H.G.F. Springer, verly.

### COURSE-III: GEOMORPHOLOGY, GEOTECTONICS & SURVEYING

The study of the origin and evolution of topographic and bathymetric features created by physical, chemical or biological process on the Earth surface. Structural geology is the study of the deformation of the surface and subsurface of the Earth and other planetary bodies. This deformation reflects past changes in local and regional stress and strain, and can be used to reconstruct past crustal

movements and dynamics. Surveying or land surveying is the technique, profession, art and science of determining the terrestrial or three-dimensional positions of points and the distances and angles between them. Surveying has been an element in the development of the human environment since the beginning of recorded history. The planning and execution of most forms of construction require it. It is also used in transport, communications, mapping, and the definition of legal boundaries for land ownership. It is an important tool for research in many other scientific disciplines.

#### Course outcome

- Students are capable to understand why landscapes look the way they do, to understand landform history and dynamics and to predict changes through a combination of field observations, physical experiments and numerical modeling.
- Students will be able to describe and interpret geologic structures in unfamiliar geologic maps



and aerial/satellite images, to construct cross sections, to infer geologic history from map and image data, and to interpret structures in the context of regional tectonic history.

- Students will be able to make appropriate observations of structures at different scales, ask relevant questions, collect and/or evaluate appropriate data, and make evidence-based interpretations about the processes and histories by which the rocks reached their present form.
- Students will be able to combine the tools and concepts of structural geology with other geologic and geodetic data sets to evaluate the context, setting, cause, and risk of damaging earthquakes and associated hazards in a particular area and make related informed decisions.
- Gain the ability to use modern survey equipment to measure angles and distances
- Gain a basic understanding of the principles and operation of the Global Positioning System

### Pedagogy

- Class room teaching supported with presentation for enabling better understanding of the subject.
- Application oriented assignments.
- Class room lectures will be supplemented with field related examples.

### COURSE CONTENT

**Unit 1:** Rock deformation: Earth forces, Static and dynamic conditions, Mechanical

characters of the rock. Kinds of Rock deformation: Mechanics of rock deformation.

Relationship between Stress and Strain in rock compressive strength, tensile strength, Shear strength in rock; Mechanics of Plastic deformation, Stress and strain ellipsoids.

**Unit 2:** Folds and Foldings, Fault and Faulting, Unconformities, Plutons, Joints, Cleavage and Schistosity Lineation and Foliation, Mylonites and Pseudotachyllites.

**Unit 3:** Principles of Geomorphology, 1st order, 2nd order Relief features of earth.

Geomorphic processes and landforms. Depositional and erosional landforms developed as a result of fluvial, glacial, Aeolian, coastal and karst cycle. Terrain classification and

applications, Role of geomorphologists in construction of irrigation projects in arid and

semi arid conditions and interpretation of drainage patterns.

#### **Practical: Geotectonics-**

Construction of geological cross section, Structure contour maps,

Tracing of outcrops, Interpretation of underground structure from borehole data, Solution to

fault problems, Use of stereographic projection in structural calculation, Construction of rose diagram for structural data.

**Surveying:** Chain survey, Compass survey, Plane table survey, Dumpy level survey

,GPS survey, Total Station Survey

**Reference:**

1. Billings, M.P. (1978) Structural geology – Prentice – Hall of India Private Ltd. New Delhi.
2. Suppe, J. (1985) – Principles of structural geology – Prentice – Hall.
3. Price, N.J. and Cosgrove, J. W. (1990) Analysis of Geological structure. Cambridge Univ. Press.
4. Hobbs, B.E. Means and Millions, P.F. (1976) an outline of structural geology. Wiley
5. Ramsay, J.G. (1967) – Folding and fracturing of rocks. Mc. Graw Hills New York.
6. Badgley P.C. – Structural Geology for the exploration geologist.
7. Whitten, T – Structural Geology.
8. Ramsay, J.G. Structural Analysis of Metamorphic Tectonites.
9. Thornbury, W.D – Principles of Geomorphology
10. Dayal. P – A Text book of Geomorphology
11. Surveying and Levelling – Late T.P. Kanetkar and S.V. Kulkarni.
12. Surveying – Punmia.
13. Geomorphology by William D. Thornbury.
14. Modern Physical Geography by Arthur N. Strahler & Alan H. Strahler.
15. Applied Geomorphology by Hails.

**COURSE-IV: GEMMOLOGY**

Gemology is to give students all required knowledge about gemstones, their occurrences, their physical and chemical properties and the internationally employed scientific methods for the identification and grading of Gemstones.

**Course outcome**

After the completion, of course, you will be able to analyze the market value of gems, gemstone quality, diamond and other precious gem stone identification.

**Pedagogy**

- Class room teaching supported with presentation for enabling better understanding of the subject.
- Application oriented assignments.
- Class room lectures will be supplemented with field related examples.

**COURSE CONTENT**

**Unit 1:** Introduction to Gemology, classification of gemstones, detailed study of different

physical and optical properties of minerals with special reference to gem minerals. Physical- optical effects in gemstones. Colour and Cause of colour in gems, Colour enhancement in gems.

**Unit 2:** Cutting and polishing of gemstones. A detailed study of important precious and semi precious

gem minerals, their characters and occurrences, World occurrences in general and Indian occurrences in particular (i) Precious varieties 1. Diamond 2. Gem corundum 3. Topaz  
4. Emerald (ii) Semi-



precious varieties Garnets, Quartz, Lapis lazuli, Turquoise and Organic gems.

**References:**

1. Gems and Gem industry in India-GSI Memoir 45- R.VKaranth.
2. Gem and Gem Minerals – EH Kvens and CBSlawsan
3. Encyclopedia of Minerals and Gemstones - Edited by Michael O'Donoghue.
4. Precious stones-by Max-Bauer Vol. I and II. Publisher Dover publications Ink. New York.
5. Gems and precious stones-Simon and Schuster, Publ. Fireside book publishers.
6. Gems and precious stones- Cally Hall, the apple press publishers
7. Gemmological instruments-Peter.G.read, Butterworth publ.
8. Gem stone enhancement-Kurt Nassau, Butterworth publ.
9. Rutley's Elements of Mineralogy- by H.H. Read, CBS publication
10. Dana's Manual of Mineralogy
11. GEMS by R. Webster - Butter work and co. Ltd., London
12. Gemstones - Herbert Smith - Published by Methuen co. Ltd., London
13. Introduction to Rock forming minerals-Deer, Howie and Zussman.
14. Physical Geology-P.K.Mukherjee
15. Geology of India-R.Vaidyanathan and M.Ramakrishnan
16. Geology of Karnataka-B.P.Radhakrishna
17. Mineral Resources of Karnataka-B.PRadhakrishna

**COURSE-V: MINERAL ECONOMICS**

This course examines economic, legal, social and environmental factors affecting the mine cycle. It is presented in three sections. The first section, Mineral Economics, examines global metal markets and project economic evaluations. This section includes applications of mineral property valuation and risk management. The second section covers Mining Law, legislation, environmental and socio-economic legislation. The third section introduces sustainability, addresses present and future mineral resource use and development in light of social and environmental factors. This also includes few case studies.

**Course outcome**

Upon successful completion of the course, students will be able to

- Describe the importance and relevance of accurate economic forecasts and financing plans throughout the mine lifecycle.
- Assemble cash flow information and determine the economic feasibility of a mineral project.
- Analyze the financial impact of risks associated with a mineral project and carry out cost- analysis calculations.
- Indian laws and legislations related to mineral extraction and mining industry.
- Recognize sustainability perspectives related to the mineral industry and describe a project's impact on the economy, the environment and society.

**Pedagogy**



- Class room teaching supported with presentation for enabling better understanding of the subject.
- Application oriented assignments.
- Class room lectures will be supplemented with field related examples.

## **COURSE CONTENT**

**Unit 1:** Introduction and concepts of mineral economics. Peculiarities in mineral deposits. Concepts in mineral exploration and mineral resource estimation. Classification of Indian mineral resources. Role of mineral industry in national economy. Strategic, critical and essential minerals. India's status in mineral production. Changing patterns of mineral consumption. National Mineral Policy. Mineral Concession Rules. Mineral legislation in India. Mineral production, processing, coproducts and byproducts. Mineral inventory. Consumption and substitution of minerals. Demand Analysis and market survey. Mineral conservation and environment. Mineral information system. Marine mineral resources and Law of Sea.

**Tutorial:** Assignments/Seminar/Test/Discussion

### **Reference:**

1. Mineral Economics by Truscot, John Wiley and Sons, Inc, 1987.
2. An introduction to mineral Economics—K.K. Chatterjee. publisher:- Wiley Eastern. 1993.
3. Mineral Economics:-R.K. Sinha and N.L. Sharma. Oxford and IBH publication

## **COURSE-VI: ENGINEERING GEOLOGY**

To impart sufficient knowledge of engineering geology so as to be able to anticipate the technical problems related to geology of various engineering sites and suggests possible remedial measures. The student will be educated on geological site investigations for engineering structures and will provide skills in geological mapping and making geotechnical measurements.

### **Course outcomes**

- Develop understanding on impact of geological features on civil engineering projects.
- Identify the problems associated with different geological features on civil engineering structures and suggest alternatives.
- Able to understand the geological aspects of construction project.

### **Pedagogy**

- Class room teaching supported with presentation for enabling better understanding of the subject.
- Application oriented assignments.
- Class room lectures will be supplemented with field related examples.

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## COURSE CONTENT

**Unit:1** Engineering properties of rocks. Rocks as construction material, Geological considerations in selecting sites for tunnels, bridges, Dams and reservoirs, highways, Reservoir sedimentation: Causes-effects-basin, channel and geological factors, climatic influence, monitoring-desilting methods.

**Unit:2** Geological investigation of landslides – hazards – hazards zonation mapping – stability analysis mitigation measures. Coastal Erosion: Causes of Coastal Erosion Nearshore dynamics, erosion mechanisms- longshore drift, Effects of coastal erosion – Controlling

methods–

barriers groins, seawalls, Jetties and stone revetments. Geology of soils and elements of soil and soil mechanics.

### Reference:

1. Plate tectonics and crustal evolution – Condie, K.C.
2. Manual of Field geology – Compton.
3. Soil their Origin, constitution and classification – Robinson G.W
4. Soils – Tambane and others
5. Nature and Properties of Soil- Harry O Buckmen Nyle C. Brady
6. Fundamentals of Soil Science – Miling, Truck and Forth. H.D (1984) John Willey
7. Introduction to Physical Geology – Strahler, A.N – 1965 – Willey
8. Climatology – Stringer (1982) Surjeet Publication Soil Atlas of Karnataka, NBSSLUP Publication.

## COURSE-VII: INDUSTRIAL MINERAL RESOURCES

The course reviews the principal types of mineral resources, their distribution and genesis, with particular emphasis on deposits of metals. The first part of the course deals with the basic principles of ore deposits and methods for deciphering their genetic evolution. Following discussion of how deposits can be classified according to commodity and formation mechanisms, the most common types of deposits will be reviewed with respect to their main features and the geological environments in which they occur. The latter part of the course will focus on the underlying reasons for the distribution of ore deposits within a plate tectonic framework, and go on to discuss the economic principles of mining and the current character of the global metal mining industry and the sequence of events from the selection of areas for potential discovery of ore deposits, prospecting and development.

### Course outcomes

- To be able to classify different minerals and rocks relevant to resources
- To be able to understand how and why different types of mineral deposits are formed
- To gain an insight into how environmental problems applicable to mineral deposits and exploitation of natural resources can be minimalised and, if possible, avoided
- Gain a deep knowledge within your own area of interest.



- To be able to identify certain minerals and rocks relevant to natural resources in hand specimens.
- To be able to explain how different types of mineral deposits can be found.
- To be able to evaluate different environmental measures applied to mineral deposits and exploitation of resources.
- To be able to work both independently and in collaboration with others.

### **Pedagogy**

- Class room teaching supported with presentation for enabling better understanding of the subject.
- Application oriented assignments.
- Class room lectures will be supplemented with field related examples.

### **COURSE CONTENT**

#### **Unit 1: Definition of a Mineral. Classification of Minerals –**

Rock forming minerals & Ore forming Minerals, Silicate and Non-Silicate minerals. Physical, Chemical and optical properties of Minerals.

#### **Unit 2: Description of Industrial Minerals: Gold, Silver, Coal, Copper, Diamond, Asbestos,**

Barite, Calcite, Diatomite, Feldspar, Gypsum, Kaolin, Mica, Silica, Talc, Zeolite,

#### **Unit 3: Minerals Used in Paint, Fertilizers, Pesticides, Abrasives, Refractories, Ceramics, Glass, Pharmaceuticals, Petrochemical and Nuclear Energy**

#### **Unit 4: Gem Minerals: (i) Precious varieties 1. Diamond 2. Gem corundum 3. Topaz 4. Emerald (ii) Semi-precious varieties Garnets, Quartz, Lapis lazuli, Turquoise and Organic gems.**

Minerals Used in Civil work: Sandstones, Marbles, Granites, Sand and Gravel  
References:

1. Industrial Minerals and Their Uses: a handbook and formulary. Ed. By Peter A Ciullo, Noyes Publications, 1996,
2. India's Mineral Resources by S. Krishnaswamy, Revised by R.K. Sinha, Oxford & IBH Publishing Co. PVT. LTD.

## **FOURTH SEMESTER**

### **COURSE-**

#### **I: APPLICATION OF REMOTE SENSING AND GIS**

This course teaches students the fundamental principles of Remote sensing and GIS, the use of ERDAS, ArcGIS and cartography with an emphasis on earth science. The course is centered around 8-9 lab exercises each taking 1-2 weeks with a significant final project. Students learn how to solve problems with GIS, communicate results, and troubleshoot GIS issues.

#### **Course outcome**

- Solve problems using GIS from developing appropriate questions that have a spatial analysis component, to locating and acquiring appropriate datasets, and conducting the anal

- ysis in an organized and documented way.
- Communicating the results of the analyses with cartographically accurate and complete maps, and other audience appropriate maps, figures and reports.
- Apply techniques learned in class to consulting-style problems in a team environment
- Troubleshoot issues that arise in all stages of spatial problem solving by working with peers, using help files, and using online forums in a productive and appropriate manner.
- Competence in using the ArcGIS suite of software to solve a variety of problems.
- Exposure and experience writing basic Python scripts, and an understanding of basic computer programming concepts.

### **Pedagogy**

- Class room teaching supported with presentation for enabling better understanding of the subject.
- Application oriented assignments.
- Class room lectures will be supplemented with field related examples.

### **COURSE CONTENT**

**Unit 1: Remote Sensing:** Basic Principles of Remote Sensing. Energy Interactions with the Atmosphere. Radiation and Black Body radiation. Types of Remote Sensing, Sensors. Scanners and their capabilities. Platforms- Types of Platforms, Satellite Remote Sensing. Satellite Data Products- their Characteristics. Resolution and Types of Resolution. Data products and IRS Satellites. Digital Image Processing. Remote Sensing in Indian Scenario. Remote Sensing in Visible, Infrared Rays, Micro Wave and Thermal regions. Application of RS in Geomorphology, Lithological Mapping, Structural mapping, Hydrogeological studies and Mineral Exploration. Remote Sensing for Disaster Management. Global Satellite Data Sources and uses. Hyperspectral Data and their uses.

**Unit 2: GIS:** Definition of Geographic Information System. The nature of geospatial information and data representation. Cartography. Maps and spatial information. Cartographic symbology. GIS and its subsystems. Components of a GIS. Databases used in GIS. Data Structures: Relational, hierarchical and network. RDBMS. Data models used in GIS. Spatial data models. Vector data Model. Raster data Model. DEM. TIN. Vector and raster-

advantages and disadvantages. Attribute data models. Topological relationships of spatial data. Data Sources. GPS. Data input techniques. Digitization of maps and imageries; Coordinate transformation; Attribute data generation. Spatial data layers. Data retrieval and querying. Spatial analysis - Spatial overlay operations, buffering, trend surface mapping.

Network analysis and proximity analysis; 3D models. GIS Modeling for decision support. Applications of GIS in earth's resources evaluation and management.

**Practical: Remote Sensing:** Visual and Digital interpretation of Reading of Topo maps, Visualization and Interpretation of Satellite Imageries, Interpretation and Demarcation of lithological Units, Interpretation Drainage patterns and water bodies, Interpretation and Measurement of Lineaments, Interpretation of Geological Structures, Interpretation of land use/land cover. Interpretation of vegetation, Interpretation of Mining and Mineralized zones

**Practical: GIS:** Methods of digitizing geospatial data (toposheet/satellite image).

2. Methods of creating x,y,z data as database and preparing contour maps, Georeferencing co-ordinates in scanned topo sheets or maps and computing the geometrical properties of digitized zones, Methods of using DEM files, analysing hydrological components, basins, slopes, aspects and other features. Carrying out different kinds of spatial analysis including, buffering, Proximity, split, clip and neighbourhood analysis. Application of GIS model for various spatial analysis.

**Reference:**

1. Textbook of Remote sensing and geographical Information system, 1st & 2nd Ed. By M. Anjireddy, BS Publications, Hyderabad
2. Remote sensing principles and Interpretations, 3rd edition, Floyd. F. Sabins
3. Applications of Remote sensing and GIS by H T Basavarajappa, Et. Al
4. Cartography: Visualization of Geospatial data - Menno-Jan Kraak and Ferjan Ormeling
5. Principles and application of Photogeology - Shiv N Pandey
6. Aerial photographic interpretation, Principles and applications - D.R. Leuder.
7. Photogeology - Miller, J.C.
8. Manual of colour aerial photography - Ed. Smith, J.T. Jr.
9. Manual of photogrammetry - Ed: Morrie M. Thompson.
10. Manual of Remote sensing - Ed: Robert G Reeves.
11. Theory of pattern recognition and modern forecasting - V. Karpin and Wright Pattern.
12. Remote sensing in Geology - Parry S. Siegal & Alan R. Gillespie
13. Manual of photographic interpretation - Ed: Colwell, R.N.
14. Principles of Remote Sensing - Patel Singh; SP publication
15. Digital Remote Sensing - Pritivish Nag M Kudrat ; Concept publication
16. Principles of GIS for land and resources assessment, Burrough, P.A., 1986, Oxford.
17. Introductory cartography, Campbell, 1984, Prentice Hall
18. Map data processing, Freeman and Pieroni, 1980, Academic Press.
19. An introduction to Geographical information systems: Ian Heywood et. al.
20. Geographical information systems and digital image processing - Muralikrishna 1999. Allied Publication
21. Fundamentals of remote sensing and Geoinformatics, by Anjireddy, Hyderabad. 1 and 2.
22. Geographic Information Systems: An Introduction, 3rd Ed, Bernhardsen, John Wiley & Sons, 01-Jan-2007 - 444 pages

23. Geographic information systems and science, Paul Longley, Wiley, 13-Jul-2001 - Education - 454 pages
24. Geographic Information Systems for Geoscientists: Modelling with GIS, Graeme F. Bonham-Carter, Elsevier, 18-May-2014 - Science - 416 pages
25. Geographic Information Systems and Science, Paul Longley, John Wiley & Sons, 22-Mar-2005 - Science - 517 pages
26. Handbook on Geographic Information Systems and Digital Mapping, United Nations. Statistical Division, United Nations Publications, 2000 - Census - 197 pages
27. Introductory Readings in Geographic Information Systems, DJ Pequet, DFM arble, CRC Press, 16-Dec-2003 - Technology & Engineering - 371 pages
28. Geographic Information Systems (GIS) and Mapping: Practices and Standards, Issue 1126, Arnold Ivan Johnson, C. Berni Pettersson, ASTM International, 01-Jan-1992 - Travel - 346 pages
29. Introduction to Geographic Information Systems, Kang-tsung Chang, McGraw-Hill Education, 16-Jan-2015 - Science - 448 pages
30. Fundamentals of Geographical Information Systems, Michael N. DeMers, Wiley, 2009 - Science - 443 pages
31. Textbook of Remote Sensing and Geographical Information Systems, K. Ali Charan Sahu, Atlantic Publishers & Dist, 01-Dec-2007 - 512 pages
32. Geographic Information System, B. Gurugnanam, New India Publishing, 09-Jun-2009 - Geographic information systems - 206 pages
33. Fundamentals of Geographical Information Systems, Michael N. DeMers, Wiley, 2009 - Science - 443 pages

## **COURSE-II: GEOCHEMISTRY & GEOCHRONOLOGY**

The course 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. They focus on chemistry of the natural world and the chemical evolution of the Earth over geological time. We will discuss practical and theoretical geochemistry, with an emphasis on how chemical principles are used to study Earth Sciences. The course is composed of three modules: (a) geochemical fundamentals (b) natural and anthropogenically perturbed aspects of the Earth's hydrosphere and atmosphere and their interactions with rocks, sediments, soils and the biosphere; and (c) the origin and evolution of Earth (crust-mantle-core) through nuclear and high temperature chemical processes.

### **Course outcome**

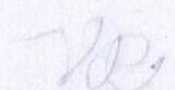
A successful student in this course should be able to:

- Demonstrate proficiency in common practical data handling skills in geochemistry. **Geochronology** & Petrogenesis.
- Plan and carry out appropriate mathematical strategies for solving geochemical problems;
- Synthesize the results of their problem-solving with other work in the form

- of short, well- organized articles;
- Have insight into the origins of earth's atmosphere, oceans and rocks;
  - Critique possible over simplifications in geochemical models.
  - To understand evolution of the early Earth from proto-planetary material and its differentiation to present day state.
  - To describe the composition of the Earth's main geochemical reservoirs.
  - To explain element fractionation and how this can be used to understand geochemical processes.
  - To apply radiogenic isotope signatures to trace the source of minerals, rocks and to date magmatic and metamorphic events.
  - To understand how chemical weathering of minerals and rocks control the composition of sediments/soil and natural water
  - Carbon flux studies to understand the role of geological processes in release of carbon to the atmosphere.

### **Pedagogy**

- Class room teaching supported with presentation for enabling better understanding of the subject.
- Application oriented assignments.
- Class room lectures will be supplemented with field related examples.





## COURSE CONTENT

**Unit 1: Geochemistry:** Earth in relation to solar system and universe, Cosmic abundance of elements, Geochemical classification of elements, Primary differentiation of the earth.

Composition of the planets and meteorites, Structure and composition of earth and distribution of elements. Geochemistry of hydrosphere, biosphere and atmosphere. Carbon

capture and sequestration studies. Role of trace and REE in magmatic processes. Geochemical principles in rock cycle (geochemical cycle).

**Unit 2: Geochronology:** Radioactivity and radioactive decay schemes. Radiometric dating, importance of Pb and Nd isotopes in geological processes. Radiogenic isotopes systems:

U-Pb, Rb-Sr, Sm-Nd and  $C^{14}$  systematics. Stable isotopes: Carbon, Oxygen, Hydrogen and Sulphur.

**Unit 3: Petrogenesis:** Steady state geotherms, Phase, phase diagram, phase rule, Unary system with examples of water and  $Al_2SiO_5$ , binary (Diop-An System & Fo-Fs system) and ternary system. Properties of magma, critical point and super critical fluids, congruent and incongruent melting, eutectic crystallisation, partial melting, miscibility and immiscibility in

solids and liquids, peritectic point, perthites and antiperthites. Exsolution phenomena.

Nucleation and diffusion processes in igneous, metamorphic and sedimentary environments. Redox reactions and Eh-Ph diagrams and their applications.

**Practicals:** P-T calculations and construction of P-

T diagrams. Petrochemical calculations - Niggli verte and Niggli base, CIPW norm calculation, Trilinear plots, construction of Variation/ Discriminant diagrams using major, trace and REE geochemistry data and interpretation. Isotopic age determination of rocks/minerals.

### References:

1. Geochemistry- William.M.White-Wiley black well publications
2. Introduction to carbon capture and sequestration- Berend Smit, Jeffrey.A.Reimer, Curtis M. Oldenburg and Ian.C.Bourg.
3. Rare earth element Geochemistry by Henderson
4. Geochemistry by Rankama and Sahama
5. Petrologic Phase equilibria - W.G.Ernst
6. The Interpretation of Geological Phase diagrams - Ernest Gehlers
7. Petrogenesis - Wilson
8. Solutions, Minerals and Equilibria - Garrels and Christ, 1966
9. Simulating the Earth- J.R. Holloway and B.J.Wood, 1988
10. Basic analytical Petrography - Ragland, 1989
11. Principles of Igneous and Metamorphic Petrology by Antony R Philpotts, 1979.1.
12. Geochemical Thermodynamics by Darrell Kirk Nordstrom and James L. Munoz
13. Chemical Thermodynamics for earth scientists by Philip Fletcher, 1993
14. Chemical Fundamentals of Geology by Robin Gill.

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15. Elementary Thermodynamics by B.J. Wood and D.G. Fraser, 1976
16. Equilibrium Thermodynamics by Roger Powell
17. Principles of Geochemistry – Brain Mason
18. Geochemistry by Anderson
19. Chemical Thermodynamics by Bruce HMahan

### **COURSE-III: MAJOR PROJECT (DISSERTATION)**

An opportunity to work on a 30 days major project or Dissertation report in Earth science under the direct supervision of a faculty member in University/Institute or Government Organisation. Students will carry out data collection using field and/or laboratory studies, and complete a final report/presentation. Field studies, Laboratory studies / data processing, reference work and presentation of the report of the course.



### Course outcome

The anticipated knowledge, skills and/or attitude to be developed by the student are:

- To inculcate a culture of research and innovation at the postgraduate level so that the students are exposed to the gritty of the Scientific Research in their fields.
- The basic aim is to expose the students at an early stage to field and laboratory techniques and sophisticated instrumentation.

### COURSE-IV: PRECAMBRIAN CRUSTAL EVOLUTION

Introduces historical geology which deals with geologic time, fossils, stratigraphic principles, and the geologic history of the India. Develop broader perspective on relationship between crustal evolution, plate tectonics and metallogeny deposits.

### Course outcome

The anticipated knowledge, skills and/or attitude to be developed by the student are:

- Basis concepts of metallogeny epochs and provinces and their linkages with crustal evolution and plate tectonics.
- Familiarity about distribution of ore deposits in India.

### Pedagogy

- Class room teaching supported with presentation for enabling better understanding of the subject.
- Application oriented assignments.
- Class room lectures will be supplemented with field related examples.
- **COURSE CONTENT**
- **Unit 1:** Geological timespan. Early earth features. Mountain Building activity. Era-Breaking
- up of Pangea-the Precambrian-Hadean, Archean, Proterozoic, Structure of the Earth. A
- magma of Ocean-Composition of early Crust-Solidifying Basalt. The earth hotspot and fluid
- basalts. Lithosphere and Mantle reactions. Origin of the crust. Lower crust-first continents.
- early continental crust. growth of crust-Mechanism of continental growth and its growth rate.
- Growth of Continents. Primary Atmosphere. Secondary Atmosphere. Oxygen in atmosphere geologic
- indicators of atmosphere-BIFs of Precambrian. Red beds, sulfates and Detrital
- uraninite and Pyrites, Decreasing Heat in Precambrian Time. paleosols-Biological indicators.
- Ocean prevailing theory, outgassing. Life in Archean Proterozoic orogeny. Earth-Moon
- system. Plate tectonics in the Precambrian.
- **Unit 2:** Precambrian mineral Deposits. Proterozoic life. oldest rocks. Continental foundation.
- Distribution of Precambrian rocks. Proterozoic tectonics. Proterozoic assembly of Laurasia-
- Proterozoic oxygen rocks. atmosphere-Precambrian assembly of Rodinia-

grenville orogeny

- –Proterozoic rifting. Mid-continent rift-snowball earth. Crustal provinces- Precambrian
- provinces of North America. Cratons of Archean and Proterozoic.
- Shield areas- Canadian Shield. Archean rocks. Greenstone belt of South Africa. Cratons-
- Origin of Cratons, Rift Valleys, Mobile belts, Archean mineral Resources and Proterozoic
- Sedimentary Basin in India.
- **Reference:**
- 1. Archean Geology- C.S. Pichamuthu
- 2. Early Precambrian supracrustal of southern Karnataka- Memoir 112. Geol. Surv. Ind
- 3. Geology of Karnataka- B. Pradhakrishna

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- 4. Geology of India (Volume 1 and 2) - R. Vaidyanathan and M. Ramakrishnan
- 5. Geology of India and Burma - M. S. Krishnan
- 6. Geology of India - M. Wadia
- 7. Crustal Evolution and Metalogeny in India - Sanib Chandra Sarkar and Anupendu Gupta

### **Crystal Growth & Materials Science**

The course covers the understanding of theories involved in crystal growth nucleation process and solution, melt and vapour growth techniques and Characterization tools. It is a theoretical lecture component and makes extensive use of examples and exercises to demonstrate the crystal growth methods and characterization.

#### **Course outcome**

Students will learn about the fundamentals of

- Important crystal growth techniques like (Bridgman, Czochralski (Pulling method), solution growth, flux and hydrothermal methods, Physical Vapour and Chemical Vapour Transport).
- Understanding of various characterization techniques of a) Powder and Single crystal XRD  
b) FTIR, Raman, c) UV-Visible and PL, d) TG-DTG, DSC, microhardness and Chemical Etching.

#### **Pedagogy**

- Class room teaching supported with presentation for enabling better understanding of the subject.
- Application oriented assignments.
- Class room lectures will be supplemented with field related examples.
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#### **COURSE CONTENT**

**UNIT1: CRYSTAL GROWTH:** Introduction to crystal growth and growth phenomena. Crystal Growth methods - Melt (Bridgman, Crystal pulling, Czochralski technique, zone melting) Verneuil process from solution, flux growth. CVT/CVD technique, Sol gel technique, Hydrothermal growth (low temperature, low pressure, High temperature, high pressure). Sintering technique.

**UNIT2: MATERIAL SCIENCE:** Nature and Properties of Materials. Structure of Solids. Bonding and structure in Materials, Imperfection in Materials, Linear defects, deformation, Planar defects, Volume defects, Diffusion, Mechanical, Thermal, Magnetic, Electrical & Optical properties of materials, Materials Selection, Material Processing, Synthesis & Design, Characteristics and uses of metals, Polymers, Glass, Ceramics, Composites, semiconductive and biological materials.

At the meeting of the Board of Directors held on the 15th day of January, 1910, the following resolution was adopted:

Resolved, That the Board of Directors do hereby authorize the President of the Company to execute and deliver to the Secretary of the State of New York a certificate of incorporation for the purpose of organizing the Company as a corporation under the laws of the State of New York.

Witness my hand and the seal of the Company at New York, New York, this 15th day of January, 1910.

Very truly yours,  
The Board of Directors

By \_\_\_\_\_ Secretary

Attest:  
The Board of Directors

Very truly yours,  
The Board of Directors

BB