

**Courses of Studies for M. Sc. Examination in Applied Geology  
(From the academic session 2019-20 onwards till further revision)**

**M. Sc. Applied Geology  
(Semester System)**

<b>PART – I Semester - I</b>		<b>Credit Hour</b>	<b>Mark</b>
<b>Course- AG. C. 411</b>	Crystallography and General Geology	4 CH	100
<b>Course- AG. C. 412</b>	Mineralogy and Optical Mineralogy	4 CH	100
<b>Course- AG. C. 413</b>	Geomorphology, Geostatistics and Remote Sensing	4 CH	100
<b>Course- AG. C. 414</b>	(Practical corresponding to AG. C. 411 & 412)	2CH	50
<b>Course- AG. C. 415</b>	(Practical corresponding to AG. C. 413)	2CH	50
<b>Course- AG. C. 416</b>	Seminar	2CH	50
<b>Add on Non Credit Course (Optional)</b>			
<b>1. Communicative Skill in English</b>			
<b>2. Leadership and Personality Development</b>			
<b>Grand total</b>		<b>18CH</b>	
<b>Semester - II</b>			
<b>Course- AG. C. 421</b>	Igneous Petrology	4 CH	100
<b>Course- AG. C. 422</b>	Sedimentary Petrology and Metamorphic Petrology	4 CH	100
<b>Course- AG. C. 423</b>	Structural Geology and Geotectonics	4 CH	100
<b>Course- AG. C. 424</b>	Meteorology, Environmental Geology and Marine Geology	4 CH	100
<b>Course- AG. C. 425</b>	Practical corresponding to AG. C. 421 & 422	2CH	50
<b>Course- AG. C. 426</b>	Practical corresponding to AG. C. 423 & Report on Geological Mapping	2CH	50
<b>Course- AG. C. 427</b>	Seminar	2CH	50
<b>Grand total</b>		<b>22CH</b>	

<b>PART - II Semester - III</b>			
<b>Course- AG. C. 511</b>	Hydrology and Engineering Geology	4 CH	100
<b>Course- AG. C. 512</b>	Geochemistry, Theories of Mineral Formation, Mineral Exploration and Surveying	4 CH	100
<b>Course- AG. C. 513</b>	Metallic Minerals/ Ores and Industrial Minerals	4 CH	100
<b>Course- AG. C. 514</b>	(Practical corresponding to AG. C. 511 & 512)	2CH	50
<b>Course- AG. C. 515</b>	(Practical corresponding to AG. C. 513 )	2CH	50
<b>Course- AG. C. 516</b>	Seminar	2CH	50
<b>Add on Non Credit Course (Optional)</b>			
<b>1. Soft skill and IT Skill</b>			
<b>2. Diploma in Entrepreneurship and Development</b>			
<b>Grand total</b>		<b>18CH</b>	
<b>Semester - IV</b>			
<b>Course- AG. C. 521</b>	Paleontology	4 CH	100
<b>Course- AG. C. 522</b>	Stratigraphy	4 CH	100
<b>Course- AG E. 523</b>	Fossil Fuels, Nuclear Minerals, Mineral Economics, Environmental Laws and Mining Laws	4 CH	100
<b>Course- AG. C. 524</b>	Elective	4 CH	100
<b>Course- AG. C. 525</b>	Practical corresponding to AG. C. 521 & 522	2CH	50
<b>Course- AG. C. 526</b>	Practical corresponding to AG. E. 523 & 524 Dissertation/ Field Report	2CH	50
<b>Course- AG. C. 427</b>	Seminar	2CH	50
<b>Grand total</b>		<b>22 CH</b>	

<b>Semester - I</b>	12 CH Theory	4 CH Practical	2 CH Seminar	18 CH
<b>Semester - II</b>	16 CH Theory	4 CH Practical	2 CH Seminar	22 CH
<b>Semester - III</b>	12 CH Theory	4 CH Practical	2 CH Seminar	18 CH
<b>Semester - IV</b>	16 CH Theory	4 CH Practical	2 CH Seminar	22 CH
<b>Grand total</b>			<b>80 CH</b>	

## PART – I

## Semester - I

**Course- AG. C. 411(4CH)****Objectives of the course:**

The aim of this course is to study the crystals through external elements of symmetry, crystal classes and systems, and the relations of symmetry to the internal structure using the chemical and physical properties of the minerals. The course aims also to study the major mineral groups, their occurrences, physical, chemical and crystallographic properties and their possible uses in industry. General geology part can give an idea about endogenetic process operating inside the earth and its resultant land forms.

**Expected outcome:**

The said courses will make the students to understand about crystal chemistry and the interior of earth.

**a) Crystallography**

Symmetry and symmetry elements, Miller Indices, zonal relations, lattice network. Bravais lattices; Twin crystals and laws of twinning, types of twinning in crystal systems; crystal projections, X-ray study of crystals by different methods

**Objectives and expected outcome:** In this unit, the structure and different crystal types are mentioned. The pupil can identify the crystals from x-ray study.

**b) General Geology**

General characteristics of solar system, origin of earth (cataclastic and evolutionary hypothesis; seismic waves, interior of the earth (historical perspective, crust, mantle and core; concept of lithosphere, asthenosphere and mesosphere), discontinuities and its classification, shadow zone, Earth quake (cause, types), vulnerability of Odisha to earth quake, Hypothesis of Isostasy (Pratt's hypothesis, Airy's hypothesis, Heiskanen hypothesis).

**Books recommended:**

1. Phillips, F. C. (1977) An Introduction to Crystallography, Longman Higher Education, page no. 1-295.
2. Evans, R. C. (1939) An Introduction to Crystal chemistry, 2nd edition, Cambridge University press, page no. 1-410.
3. Dana, E. S. (2006) A Text Book of Mineralogy, CBS; 4 edition page no. 1-156.
4. Kerr, P. F. (1977) Optical Mineralogy, McGraw-Hill College; 4 edition page no. 1-492.
5. Belousov, V. V. (1974) Basic Problems in Geotectonic, McGraw-Hill Book Company page no. 1-312.
6. Valdiya, K. S. (1985) Aspects of Tectonics, McGraw-Hill Education page no. 1-304.

**Course- AG. C. 412 (4CH)****Objectives of the course:**

In these units, the physical, chemical and optical properties of the minerals are described. One should know them to identify the types of rocks.

**Expected outcome:** The students will be equipped with the knowledge of identifying different minerals with their possible varieties and their occurrence in different types of rocks as a combining unit.

**a) Mineralogy**

Silicate structure, Study of important silicate groups: Isomorphism and Polymorphism; Olivine, Pyroxene, Amphibole, Feldspar, Silica, Garnet, Alumino- silicates, Mica,

Feldspathoids and Clay minerals. Study of oxides, sulphides, sulphates, phosphates, carbonates, halides and native elements.

#### **b) Optical mineralogy**

Properties of light- reflection, refraction, total internal reflection and double refraction. Nicol Prism. Polarisation of light. Refractive index and its measurement; Birefringence; Extinction angle- types and their determination. Interference colour, Pleochroism, Use of accessory plates; Uniaxial and biaxial Optical indicatrix, Study of anisotropic minerals under microscope orthoscopic (polarized) and conoscopic (convergent light) set-up.

#### **Books recommended:**

1. Dana, E. S. (2006) A Text Book of Mineralogy, CBS Publishers & Distributors; 4th edition, page no. 1-156.
2. Rutley, (2005) Elements of Mineralogy, CBS; 27th edition page no. 1-482.
3. Barry and Mason. (1958) Elements of Mineralogy, W.H. Freeman & Co Ltd; 1st edition page no. 1-630
4. Deer, W. A., Howaie. R. A. and Zussmann, (2013) Rock forming Minerals, Mineralogical Society of Great Britain and Ireland; Third edition, page no. 1-498.
5. Kerr, P. F. (1977) Optical Mineralogy, McGraw-Hill College; 4 edition, page no. 1-492.
6. Mitra, S. (1989) Fundamentals of optical, spectroscopic and X-ray mineralogy, Wiley-Blackwell, page no. 1-236.

#### **Course- AG. C. 413 (4CH)**

##### **Objectives of the course:**

In this unit, different types of earth features and their causative geological agents have been described. The students can analyse the type of agents that has shapes a particular zone of the earth surface.

##### **Expected outcome:**

In this unit, the students are introduced with the concepts of statistics and satellite data. While statistics is a part and parcel of every science subject, remote sensing has become very helpful for resolving so many geological problems.

#### **a) Geomorphology**

Geomorphic principles and processes; Concept of weathering and erosion cycle; Concept of fluvial, Aeolian and glacial processes; Drainage pattern and drainage analysis; River basins in India; Methods of analysis of landform; Major geomorphological divisions of India, Tectonic geomorphology.

#### **b) Geostatistics and Computer Application**

Method of sampling, Frequency distribution and frequency tables. Graphical representation of frequency data (i. e. Histogram, Frequency curve and Cumulative frequency curve), Mean, Standard deviation.

#### **c) Remote Sensing**

Fundamentals of computers, Benefits of Remote Sensing over conventional method of resource survey. Components of Remote Sensing System. Electromagnetic Radiation (EMR), Nature and generation of EMR; Effects of atmosphere on EMR and its interaction with rocks minerals vegetation, water, soil etc. Platform, Role of platform in Remote Sensing, Types of platform with their specific uses. Fundamental properties of sensors and

their functions. Basic features of different types of sensors in use, RS data products, Principles of RS data analysis and their application.

Aerial photography, Types of aerial photographs. Characteristic features of aerial photography- scale, overlap, side lap, vertical-exaggeration etc. Photo/image features - form, shape, texture, tone, drainage pattern etc., Stereoscopic perception, Conditions for stereoscopic vision. Advantages of Remote sensing data products (satellite images and aerial photographs). Uses of Remote sensing data products in different branches of geology.

**Books Recommended:**

1. Thurnbury, W. D. (2004) Principles of Geomorphology, CBS; 2 edition Page no. 1-213.
2. Majid Husain, (2010) Fundamentals of Physical Geography, Rawat Publication, Page no. 1-784.
3. Strahler, A. (2010) Physical Geography, Wiley; 5 edition Page no. 1-656.
4. Lillesand, M., Thomas and Ralph., Kiefer, W. (2007) Remote Sensing and Image Interpretation, John Wiley & Sons, New York.
5. Jensen, R., John, (2006) Remote Sensing of the Environment: An Earth Resource Perspective, Pearson Education Pvt. Ltd., Delhi, page no. 1-736.
6. Anji Reddy, M. (2006) Geoinformatics for Environmental Management, BS Publications, Hyderabad, page no. 1-435.

**Course- AG. C. 414 (2 CH)**

**(Practical Corresponding to Course No. AG. C.411 and AG. C.412)**

Study of symmetry elements and identification of crystal models of 32 classes, Stereographic projections, Determination of axial ratio and face symbol.

Megascopic and microscopic identification of minerals; Determination of specific gravity.

Determination of extinction angle, sign of elongation, optical sign and order of interference colours, pleochroic schemes.

Viva and Practical record

**Course- AG. C. 415 (2 CH)**

**(Practical Corresponding to Course No. AG. C.413 )**

Drainage maps and drainage analysis. Study of toposheets, geomorphic models. Visual interpretation of aerial photographs and satellite imageries.

Sample statistics, Histogram, frequency curve, Cumulative frequency curve. Application of statistics to geological problems Preparation of scatter diagram, histogram, pie-diagram; Computer application in solving geological problems

**Course- AG. C. 416 (2 CH) Seminar**

## Semester II

### Course- AG. C. 421(4CH)

#### Objectives of the course:

In these units, the students can know the characteristic properties of igneous rocks (those formed from molten material) as well as their origin and types.

#### Expected outcome:

The students shall have the potential to know the mechanism of formation of different types of igneous rocks. They will be in a position to classify the igneous rocks basing on various parameters.

#### a) Igneous Petrology - A (Principles of Igneous rock formation)

Concept of magma and its generation in mantle and crust, Primary and secondary magma, correlation of magma genesis and plate tectonics, introduction to silicate melt equilibria involving forsterite, enstatite, diopside, plagioclase, K- feldspar, leucite and silica minerals, Reaction principles and Bowen's reaction series. Variation diagrams, Magmatic differentiation, assimilation; Global consanguineous association; Steady-state geotherms. Genesis, properties, emplacement and crystallization of magmas. Phase equilibrium studies of simple systems, effect of volatiles on melt equilibria. Magma-mixing, mingling and immiscibility.

#### b) Igneous Petrology - B (Classification and petrogenesis igneous rocks)

Classification of igneous rocks- mineralogical, chemical and tabular classification with special reference to IUGS classification; Petrology and geotectonic evolution of granites, basalts, andesites and alkaline rocks. Petrology of syenite, ultramafics, anorthosites and carbonatite.

#### Books Recommended:

1. Turner, F. J. and Verhogen (2002) Igneous and Metamorphic Petrology, CBS; 2 edition page no. 1-185.
2. Best. (2002) Igneous and Metamorphic Petrology, Wiley-Blackwell; 2 edition, page no. 1-752.
3. Mc Birney, A. R. (2006) Igneous Petrology Jones & Bartlett Learning; 3 edition, page no. 1-550.
4. Hall, A. (1996) Igneous Petrology, Prentice Hall; 2 edition page no. 1-568.
5. Gupta, A. K. (2007) Igneous Rocks, Narosa Pub House page no. 1-450.
6. Tyrell, G. W. (1926) The Principles of petrology, Chapman and Hall; New edition page no. 1-364.

### Course- AG. C. 422 (4CH)

#### Objectives of the course:

In this paper, the students can know the characteristic properties of the stratified rocks (formed by deposition of sediments) and the metamorphic rocks together with their knowledge on the origin and types of the said rocks.

**Expected outcome:** The students shall have the potential to know the mechanism of formation of different types of sedimentary and metamorphic rocks. They will be in a position to classify the said rocks basing on various parameters.

**a) Sedimentary Petrology:**

Processes of formation of sedimentary rocks; Texture and structures (mechanical, chemical and biogenic) of sedimentary rocks, Classification and description of Sandstone, Shale and Limestone; Depositional environments - Marine, Estuarine, Lacustrine and Eolian, Concept of sedimentary facies.

**b) Metamorphic Petrology:**

Concept of metamorphism; Types, causes and agents of metamorphism; Metasomatism; Texture and structure of metamorphic rocks, Concept of equilibrium and mineralogical phase rule. Mineral paragenesis, Graphic (ACF, AKF and AFM) diagrams and their application. Classification of metamorphic rocks, concept of zones, grades and facies. Plate tectonics and metamorphism; Important metamorphic rocks of India - Khondalite, Charnockite, Marble.

**Books Recommended:**

1. Pettijohn, F. J. (1983) Sedimentary rocks, HarperCollins; 3 edition, page no. 1-526.
2. Pettijohn, F. J., Potter. P. E. and Siever, R. (1987) Sand & Sandstones, Springer; 2nd edition, page no. 1-553.
3. Sengupta, S. M. (2007) Introduction to Sedimentology, CBS; 2 edition, page no. 1-339.
4. Turner, F. J. and Verhogen, (1960) Igneous and Metamorphic Petrology, McGraw-Hill; 2nd Edition, page no. 1-694.
5. Miyashiro, A. (1973) Metamorphism & Metamorphic Belts, Springer, page no. 1-492.
6. Bhaskar Rao, B. (1986) Metamorphic Petrology, 1st Edition CRC Press, page no. 1-190.

**Course- AG. C. 423 (4CH)**

**Objectives of the course:** In these units, the students can know the characteristic properties, origin and types of various structural features found in rocks.

**Expected outcome:**

The above knowledge will enable the students to study the history and relative age of rocks. They shall have the knowledge of the mechanism of formation of continents, sea and mountain ranges.

**a) Structural Geology**

Concept of stress and strain; Elastic, plastic and brittle deformation. Classification and genesis of fold, fault, shearzone, joint, foliation, lineation and unconformities and recognition of the above structures in field. Tectonites.

**b) Geotectonics**

Continental drift hypothesis (Wegener's concept of drift theory) and its supporting evidences (geometric, structural, palaeontological, lithological, stratigraphical, glaciological, climatic, paleomagnetic evidences) Concept of sea floor spreading, Mid-oceanic ridges, Island arcs, Plate tectonics (Plate boundaries: divergent plate boundary, convergent plate boundary, transform plate boundary, plate boundary zones), concept of Wadati-Benioff zone, Triple junction, Hot spots.

**Books Recommended:**

1. Billings, M. P. (1972) Structural Geology, Pearson College Div; 3 editions page no. 1-606.
2. Ghosh, S. K. (1993) Structural Geology, Pergamon, page no. 1-598.
3. Park, R. G. (1989) Fundamentals of Structural Geology, Chapman & Hall; 2nd edition page no. 1-148.

4. Davis, G. H. and Reynolds, S. J. (1997) *Geology of Rocks and Regions*, 2<sup>nd</sup> (second) Edition Wiley, John & Sons page no. 1-669.
5. Valdiya, K. S. (1985) *Aspects of Tectonics*, McGraw-Hill Education page no. 1-304.
6. Condie, K. C. (1989) *Plate tectonics and Crustal development*, Pergamon; 3 edition, page no. 1-504.

### **Course- AG. C. 424 (4CH)**

#### **Objectives of the course:**

The objective to teach this paper is to offer basic knowledge on different sphere such as atmosphere; hydrosphere and lithosphere. The meteorology part will provide a general knowledge of a range of atmospheric phenomena and applications, and have expertise in one or more program sub-disciplines or related interdisciplinary areas. Also to produce graduates who are equipped to contribute to solving problems in the atmospheric sciences and related disciplines, through service in business or as educators, researchers, and leaders in academia, government, the private sector, and civil society.

The marine geology course has been designed primarily for students in applied geology and other relevant disciplines. However, it also meets the need of students in other fields, as a course that provides introduction to world oceans, basic understanding in the physical, chemical and biological aspects of these oceans and various geological processes that is going on in the oceans. As a course that integrates theory and practical, the purpose is to expose the students to a better understanding of the world oceans and impart useful skills on the mineral resources of the ocean, how these minerals could be accessed and management of coastal environment. Topics to be covered include world ocean and physical, chemical and biological oceanography; physiographic of world oceans; plate tectonics as it relates to oceans; ophiolite complexes; coastal processes, deep sea sediments; mineralization in the oceans and methods of ocean floor sampling.

#### **Expected outcome:**

This paper will provide quality scientific and technical education with increased focus on research and innovation in the fields of earth sciences and environment to cater to the need of the country. To pursue creative research and strive for new innovations in the fields of earth sciences and environment in order to serve the nation for a sustainable future.

#### **a) Meteorology**

Weather and Climate; Structure and chemical composition of the atmosphere, Heat budget of the earth; Temperature and pressure belts of the world; Atmospheric circulation; jet streams and its affect on Indian monsoon; Planetary and local winds; Cloud formation and precipitation processes, Types and distribution of precipitation; Air masses (Source Region, Classification, its affect on world weather), fronts (general characteristics, frontogenesis, classification).

#### **b) Environmental Geology and Marine Geology:**

Renewable and non renewable natural resources, Harnessing solar energy, its merits and limitation, solar devices: solar cooker, solar water heater, solar cells, wind energy (wind flour mill, wind mill pump), Hydroelectricity, Tidal energy, Environmental problem due to mining activities and their mitigation, Sustainable mining, conservation of minerals. Natural hazards- Earthquake, volcanic eruptions, landslides, tornado, flood, and coastal erosion

Ocean Bottom Relief - continental shelf, continental slope, continental rise and abyssal plains. marine sediments and their classification (Lithogenous, Biogenous, Hydrogenous,

Cosmogenous), sea water density, salinity (role of salinity and distribution of salinity), marine resources and their utilization (biotic resources and mineral resources of the ocean floor)

#### **Books Recommended:**

1. Trewarta, G. T. (1968) An introduction to Climate, McGraw-Hill; Fourth Edition, page no 1-408.
2. Menon, P. A. (2005) Way of The Weather, National Book Trust, India, page no. 1-109.
3. Miller, A, and Thompson, J. C. (1983) Elements of Meteorology, Merrill Pub Co; Subsequent edition page no. 1-448.
4. Hobbes, J. E. (1980) Applied Climatology, Butterworth-Heinemann, page no. 1-222.
5. Valdiya, K. S. (2004) Environmental Geology-Indian context, Orient Blackswan Private Limited - New Delhi page no. 1-240.
6. Keller, E. A. (2010) Environmental Geology, Pearson; 9 edition page no. 1-624.

#### **Course - AG. C. 425**

##### **Practical corresponding to Course AG. C. 421 and AG. C. 422**

Megascopic and microscopic identification of igneous, sedimentary and metamorphic rocks, CIPW normative calculation, Use of ACF, AKF and AFM diagrams for the study of metamorphic rocks. Mechanical analysis of supplied sediment sample. Graphical plotting of given size data and determination of sample statistics. Determination of paleocurrent direction with the help of rose diagram drawn from supplied data.

##### **Practical Record and Viva**

#### **Course – AG. C. 426**

##### **Practical Corresponding to Course AG. C. 423 and 424 Report on geological mapping.**

Topographic map study, Measurement of attitude of planar and linear structures, Profile and cross section. from given geological map. Outcrop completion, Three point problem, Geometric and trigonometric methods of calculation of orientation and thickness of beds, Equal area projection of planar and linear structural data. Two dimensional strain analysis from the supplied specimen and data.

Analysis of meteorological data and preparation of maps

##### **Report on geological mapping, Viva and Practical Record**

#### **Course- AG. C. 427 (2 CH) Seminar**



## Part –II

### Semester –III

#### Course- AG. C. 511 (4CH)

**Objectives of the course:** In this course, the students can know the characteristic properties, origin, movement and types of groundwater. The students can also know the requirement of geology for the construction of various engineering structures such as bridge, tunnel etc.

#### **Expected outcome:**

This knowledge will enable the students to use groundwater properly and will have the knowledge to install various types of wells. They shall have the knowledge to utilize the geological skills in the construction of various engineering structures.

#### **a) Hydrology**

Water on earth; Types of water meteoric, juvenile, magmatic and sea water; Hydrological Cycle and its components; Water balance; Water-bearing properties of rocks porosity, permeability, specific yield and specific retention; Vertical distribution of water; Zone of aeration and zone of saturation; Classification of rocks according to their water bearing properties; Aquifers; Classification of aquifers; Aquifer parameters- transmissivity and storage coefficient; Water table and piezometric surface; Fluctuations of water table and piezometric surface; Geologic and geomorphic controls on groundwater; Groundwater provinces of India, Theory of groundwater flow; Darcy's law and its applications.

Geologic and hydrogeologic methods of ground water exploration; Role of remote sensing in groundwater exploration; Surface geophysical methods - seismic, gravity, geo-electrical and magnetic methods; Types of water wells and methods of construction; Design, development, maintenance and revitalization of wells; Sub-surface geophysical methods

Physical and chemical properties of water; Quality criteria for different uses; Graphical presentation of groundwater quality data.

#### **b) Engineering Geology**

Engineering properties of rocks and soil. Geological investigation of dam site, reservoir site, tunnels and bridges, Landslides and stability of hill slopes; Properties and selection of construction material.

#### **Books Recommended:**

1. Todd, D. K. (2015) Ground water Hydrology, page no. 1- 656.
2. Davis, S. N. and Dewiest, (1966) Hydrogeology, John Wiley & Sons, page no. 1- 464.
3. Garg, S. P. (1979) Ground water and Tube wells, Oxford and IBH Publishing Co., page no. 1-348.
4. Krynine and Judd, (2005) Principles of Engineering Geology, CBS Publishers & Distributors; 1<sup>st</sup> edition, page no. 1-425.
5. Stagg & Zeinkiewics, (1968) Rock mechanics in Engineering Practice, Wiley-Blackwell, page no. 1-442.
6. Jager and Cook, (2012) Fundamentals of Rock mechanics, Wiley India Pvt. Ltd; Fourth edition, page no 1-488.

#### Course- AG. C. 512 (4CH)

**Objectives of the course:** In these units, the students can know the characteristic properties, origin and distribution of ore minerals.

**Expected outcome:**

After the study, the student will have the knowledge of exploring them by sampling and geophysical methods.

**a) Geochemistry**

Principles of crystal chemistry; Chemical bonds, Coordination principle, Radius ratio, Crystal structure; Cosmic abundance of elements, Geochemical classification and distribution of elements in the earth; Geochemical cycle (Sulphur cycle, Nitrogen cycle, Phosphorous cycle) Primary geochemical differentiation of the earth; Composition of the Earth's core, mantle and crust; Composition of hydrosphere and atmosphere. Role of Eh-pH in ore formation; Phase rule and its application

**b) Theories of Mineral Formation, Mineral exploration and Surveying**

Processes of formation of economic minerals; Controls of ore localization; Metallogenic provinces and epochs; Geological, geophysical and geochemical methods of prospecting; Principles of sampling, assaying, drilling, core logging. Chain and Compass, Plane Table and Theodolite survey. GPS survey.

**Books Recommended:**

1. Mason, B. (1968) Principles of Geochemistry, John Wiley & Sons; 3rd International edition, page no. 1-330.
2. Goldschmidt, V. M. (1954) Geochemistry, Oxford University Press, page no. 1-742.
3. Rankama and Sahama, T. G. (1950) Geochemistry, University of Chicago Press page no. 1-928.
4. Krauskopf, K. B. (1994) Introduction to Geochemistry, McGraw-Hill College; Subsequent edition, page no. 1-640.
5. Bateman, A. M. (1981) Economic Mineral deposits, John Wiley & Sons Inc; 3rd edition, page no. 1-604.
6. Arogyaswamy, R. H. P. (1973) Courses in Mining Geology, Oxford & IBH Pub. Co. page no. 1-916.

**Course- AG. C. 513 (4CH)**

**Objectives of the course:** In these units, the students can know the characteristic properties, origin and distribution of economic minerals.

**Expected outcome:**

After the study, the student will have the knowledge of various uses of minerals, exploiting them by many means such as beneficiation etc.

**a) Metallic Minerals/ Ores**

Mineralogy, uses, mode of occurrence, genesis and Indian distribution of ores Iron, Manganese, Aluminium, Copper, Lead, Zinc, Tin, Gold and Chromite, Strategic, critical and essential minerals. Need and methods of mineral ore beneficiation of iron, copper, bauxite, chromite, gold.

**b) Industrial Minerals**

Mineralogy, uses, mode of occurrence, genesis and Indian distribution of Limestone and Dolomite, Mica, Gypsum, Asbestos, Graphite, Magnesite, Gemstone, Raw materials for ceramic, cement, refractory, abrasive and fertiliser industry.

**Books Recommended:**

1. Krishnaswamy, S. (1988) Mineral Resources of India, Oxford & IBH, page no 1-613.

- Banerjee, D. K. (2010) Mineral Resources of India, Vikas Publishing House, Technology & Engineering, page no. 1-672.
- Deb, S. (1980) Industrial Minerals and Rocks of India, Allied Publishers, page no. 1-603.
- Sharma, N. L., and Ram, K. S. V.: (1964) Introduction to India's Economic Minerals, Dhanbad Publications, Mines and mineral resources, page no. 1- 258.
- Gokhle, K. V. G. K. and Rao. (1978) Ore Deposits of India, Thomson Press (India), Ore deposits, page no. 1-226.

**Course- AG. C. 514 (2CH)**

**Practical Corresponding to Course No. AG. C. 511 and AG. C. 512**

Determination of pH, Temperature, TDS and other parameters for ground water quality assessment. Graphical representation of supplied ground water quality data. Resistivity survey for ground water. Engineering geological problems. Blowpipe analysis of mineral powder, Titration methods to determine the composition of minerals. Chain and Compass, Plane Table and Theodolite survey. GPS survey

**Viva and Practical record**

**Course- AG. C. 515 (2CH)**

**Practical Corresponding to Course No. AG. C. 513**

Megascopic identification of ores and industrial minerals, identification of common ores (Hematite, magnetite, pyrite, galena, chromite, chalcopyrite, pyrolusite and psilomelane etc. ) under reflected light. Maps showing distribution of mineral and ore deposits. Viva and Practical Record

**Course- AG. C. 516 (2 CH) Seminar**

## Semester-IV

**Course- AG. C. 521**

**-100 marks**

**Objectives of the course:** In these units, the students can know the characteristic properties, origin and classification of fossils.

**Expected outcome:**

This knowledge will enable the students to find out the age of various strata and also to interpret the palaeoenvironment.

**a) Invertebrate Paleontology**

Mode and conditions of preservation of fossils, a review of life through ages. Morphology, classification and evolution of Corals, Trilobites, Brachiopods, Lamellibranchs, Cephalopoda, Gastropods, Echinoids, Graptolites.

**b) Paleobotany, Paleopalynology, Vertebrate Paleontology and Micropaleontology**

Classification of plant fossils; Gondwana flora of India, study of *Glossopteris*, *Gangamopteris*, *Verebraria*, *Nilsonia* and *Ptylophyllum*, Basic concepts of paleopalynology,. Evolution history of man, horse and elephant. Methods of separation and classification microfossils. Morphology and classification of Foraminifera, Elementary idea about radiolaria and ostracoda.

**Books Recommended:**

- Moor, Lalicker and Fisher, (1952) Invertebrate Fossils, McGraw-Hill Book Company, page no. 1-766.
- Shrock and Twenhofel, (1953) Principles of Invertebrate Paleontology, McGraw-Hill Book Company; 2nd Revised & Enlarged edition page no. 1-816.

3. Woods, H. (1961) Invertebrate Paleontology, Cambridge University Press; Eighth Edition page no. 1-123.
4. Jones. D. J. (1969) Introduction to Microfossils, Hafner Publishing Co Ltd page no. 1-406.
5. Taylor (2009) Paleobotany, Academic Press; 2 edition page no. 1-1252.

### **Course - AG. C. 522**

#### **Objectives of the course:**

In these units, the students can know the logical deposition of strata according to geological time. They shall come to know about the distribution of rocks of various time period in different parts of India.

#### **Expected outcome:**

This knowledge will enable the students to find out the age, lithological constitution and economic importance of various strata.

#### **a) Precambrian Stratigraphy**

Principles and code of stratigraphic nomenclature. Standard geological time scale, Stratigraphic correlation; Precambrian stratigraphy of Karnataka, Orissa, Central India, Rajasthan, Eastern Ghats; Stratigraphy of Vindyan basin, Cuddaph basin and Chhattisgarh basin. Proterozoic rocks of Himalayan belt.

#### **a) Phanerozoic Stratigraphy**

Cambrians of Peninsular area; Paleozoic rocks of Extra Peninsular area; Triassic rocks of Spiti, Jurassic of Kachh, Cretaceous of Trichinopoly and their equivalents, Deccan Traps, Tertiary rocks of Assam, Siwaliks, Quaternary stratigraphy of India

### **Books Recommended:**

1. Weber. (2004) Principles of Stratigraphy, Wiley-Blackwell; 1 edition page no. 1-340.
2. Krumbein and Sloss. (1951) Stratigraphy and sedimentation, San Francisco, CA: W. H. Freeman & Company, page no. 1-497.
3. Dunbar. C. O. (1960) Historical Geology, Wiley; Chapman & Hall, page no. 1-500.
4. Krishnan, M. S. (2009) Geology of India and Burma, CBS; 6 edition page no. 1-536.
5. Wadia. D. N. (1975) Geology of India, McGraw Hill Education India Pvt Ltd; 4 edition page no. 1-560.
6. Ravindra Kumar (1998) Historical Geology and Stratigraphy of India, NEW AGE; First edition, page no. 1-268.

### **Course- AG. C. 523 (4 CH)**

**Objectives of the course:** In this course, the students can know the characteristic properties, origin and distribution of coal, petroleum and nuclear minerals. After the study, the student will have the knowledge of their conservation and management.

#### **Expected outcome:**

The students can have the knowledge of various environmental laws related to mining of minerals. This knowledge will enable them to deal with issues relating to environmental pollution.

#### **a) Fossil Fuels, Nuclear Minerals and Mineral economics**

Mode of occurrence, genesis and Indian distribution of Coal and Petroleum. Mode of occurrence, genesis and Indian distribution of Nuclear Minerals. Need and methods of resource evaluation and reserve calculation of economic mineral deposits. National Mineral policy

## **b) Environmental Laws and Mining Laws**

**Mining Legislations-** Relevant sections/rules for restoration of Environment-The Mines Act 1952, The Mines Rules 1955, The Mines and Minerals (Development and Regulation) Act 1957; The Coal Mines Regulations 1957, The Metaliferous Mines Regulations 1966, The Mineral Conservation and Development Rules, 1988, The Mineral Concession Rule, 1960

**Environmental Act-** Salient features of The Water Act, 1974 (Area of Jurisdiction, Constitution of Pollution Control Boards, Power and Function of Central and State Boards); The Air Act, 1981 (Area of Jurisdiction, Constitution of Pollution Control Boards, Power and Function of Central and State Boards); The Water Cess Act, 1977, The Environment Protection Act, 1986 (Powers of Central Government)

### **Books Recommended:**

1. Krishnaswamy, S. (1988) Mineral Resources of India, Oxford & IBH, 1988 -Mines and mineral resources, page no. 1-613.
2. Banerjee, D. K. (1998) Mineral Resources of India, Calcutta: World Press Private Limited, 6<sup>th</sup> Edition, page no. 1-415.
3. Deb, S. (1980) Industrial Minerals and Rocks of India, Allied Publishers, page no. 1-603.
4. Chandra, D., Singh, R. M. and Singh, M. P. (2000) Textbook of Coal (Indian context), Tara Book Agency
5. Francis, W. (1961) Coal-its formation and composition, Edward Arnold, page no. 1-806.
6. Levorsen. A, I. (2004) Geology of Petroleum, CBS Publishers & Distributors Pvt. Ltd., second edition.

### **Course - AG. C. 525 (2 CH)**

#### **Practical Corresponding to Course AG. C. 521 and AG. C. 522**

Identification and labelling of invertebrate, vertebrate, plant and micro- fossils. Construction of stratigraphic sequence from given fossils and rock assemblage, Paleogeographic maps of different geologic periods.

Viva, Practical record

### **Course - AG. E. 526 (2 CH)**

#### **Practical Corresponding to Course AG. E. 523 and 524 dissertation/ field Report.**

Block diagram, fence diagram, isopach maps from supplied data, Ore reserve calculation.

Calculation of grade/ assay value from the supplied data, Flow charts of mineral beneficiation.

### **Course- AG. C. 527(2 CH) Seminar**

### **Course- AG. E. 524 Elective (any one)**

- i) Geoinformatics
- ii) Digital image processing and Geographic information system
- iii) Coal Geology
- iv) Isotope Geology
- v) Surface and sub-surface water resource management
- vi) Environmental Geology
- vii) Applied Micropaleontology
- viii) Ore Genesis:
- ix) Clay Mineralogy & Soil Geology
- x) Management of Mineral Resources

### **i) Geoinformatics**

Concept of resources and reserve and their classification. Mineral resources and National economy- concept and future. Ground and surface water resources of India; Sustainable development of Mineral and water resources; Geostatistical methods for reserve calculation, Computer application in Groundwater studies; Geostatistical methods for the interpretation of geochemical data to study genesis of igneous rocks, ore deposit modeling, quality of water, correlation of borehole data; Mine area planning and environmental management; Geographic Information system and its use in natural resource management.

#### **Practical:**

Sampling techniques; Sample statistics; Statistical methods of presentation of analysed sample data. Histogram; frequency curve, Cumulative frequency curve. Application of statistics to geological problems; Programming in C/ C++ for presentation of data; Computer application in solving geological problems. Extraction of statistical data from digital data.

#### **Books recommended:**

1. Bloom, A. L. (2003) *Geomorphology - A systematic analysis of Late Cenozoic landforms*. Pearson Education, New Delhi, Page no.1-415.
2. Chorley, R. J., Schumm, S.A. and Sugden, D.E. (Eds) (1985) *Geomorphology*. Methuen, Page no.1-620.
3. Kale, V. S. and Gupta, A. (2001) *Introduction to geomorphology*. Orient Longman Page no.1-836.
4. Thorn, C. E. (1998) *Introduction to theoretical geomorphology*. Unwin Hyman, Page no.1-529.
5. Thornbury, W. D. (1996) *Principles of geomorphology*. John Wiley, Page no.1-620.
6. Summerfield, M. A. (Ed) (1999) *Geomorphology and global tectonics*. John Wiley Page no.1-911.

### **ii) Digital image processing and Geographic information system**

Image processing system characteristics, CPU, Arithmetic coprocessor, RAM, Operating system and compiler, Basic features of digital images. Image display system; Black and white image display. Video image display; transforming video displays to hard copy displays. Data input, verification, correction and storage data quality and errors, image analysis and pattern recognition image enhancement reduction and magnification, contrast enhancement. Rastering. Spatial filtering, Edge enhancement. Special transformation. Thematic information extraction, Classification scheme. Training site selection; Supervised classification. Map accuracy assessment Introduction of Geographic information system, Advantages of GIS, Data structure of GIS, Raster and vector data for geographical entities. Data encoding, data manipulation, Data analysis and spatial modelling. Data quality, Errors and natural variation and interpretation.

#### **Practical:**

Study of the nature and characteristic features of digital images; Methods of digital image collection; Interpretation of digital images; Brightness contrast; Image Analysis; Supervised and unsupervised classification; Preparation of Mosaic; preparation of maps using GIS software.

#### **Books Recommended:**

1. Lillesand M. Thomas and Ralph W. Kiefer (2007) *Remote Sensing and Image Interpretation*, John Wiley & Sons, New York, Page no.1-736 .
2. Arthur H. Robinson (2002) *Elements of Cartography*, John Wiley & Sons, New York, Page no.1-428
3. Dennis P. Curtin, Kim Foley, Kunal Sen & Cathleen Morin (1999) *Information Technology - The Breaking Wave*, Tata McGraw Hill Ed Page no.1-830.

4. M. Anji Reddy (2004) Geoinformatics for Environmental Management, BS Publications, Hyderabad, Page no.1-472
5. Sharma V.K. (1991) Remote Sensing for Land Resources Planning, Concept Publishing Company, New Delhi, Page no.1-586.

### **iii) Coal Geology**

Origin of coal. Geological and geographical distribution of coal, Geological aspects of strata control and vary methods of coal prospecting and exploration, coal mining methods. Evaluation of coal characteristics, Application of coal petrology. Beneficiation of coal, coal washing, blending, Desulphurization of coal. Carbonisation, gasification of coal. Fertiliser from coal, Environmental problems due to coal mining and its use in different industries, use of fly ash. Future prospect and conservation coal.

#### **Practical:**

Megascopic identification of coal; study of coal under reflected light; Proximate analysis of coal. Preparation of maps showing Indian distribution of coal; sketch map of different coal fields of India. Reserve calculation methods for coal.

#### **Books Recommended:**

1. Francis, W. (1961) Coal-its formation and composition, Edward Arnold, Page no.1-806.
2. Stach, E. (1982) Text book of Coal Petrology, Lubrecht & Cramer Ltd; Subsequent edition Page no.1-611.
3. Van Krevelen, D. W. and Schuyer (1957) Coal science, Elsevier Cleaver-Hume, Page no:1-352.
4. Fettweis, G. B. (1979) World Coal resources- methods of assessment and results, Elsevier Scientific , Page no.1-415.

### **iv) Isotope Geology**

Internal structure of atoms; Atomic weight, Nuclear stability and abundance; Isotopes; Decay mechanics of radioactive elements - positron decay, electron capture decay, branchel decay. Beta decay, alpha decay. Decay of a radioactive parent to a stable daughter; Principle of mass spectrometry. K-Ar, Sm-Nd, U Pb and C14 method of dating. Sulphur and Oxygen isotopes and their application in geological studies,

#### **Practical:**

Study of radioactive minerals under microscope. Theoretical methods of age calculation. Measurement of oxygen and sulphur isotopes.

#### **Books Recommended:**

1. Faure, G. (1986) Principles of Isotope Geology, Wiley; 2 edition, page no. 1-608.
2. Rankama, K. (2013) Progress in Isotope Geology, Literary Licensing, LLC, page no. 1-724.

### **v) Surface and sub-surface water resource management**

Water cycle; measurement of surface run off; infiltration and evaporation; Ground water flow (steady, unsteady and radial); Darcy's Law; Storage equation; Fresh and salt water interaction in coastal and inland areas; Ground water conditions in different parts of India r Design and construction of tube wells; Pumping tests;. Ground water recharge; Quality of ground and surface water. Surface and ground water pollution and their management, Geological and Geophysical prospecting of ground water. Concept of watershed and their management.

#### **Practical:**

Sampling of water; Determination of pH, Temperature, TDS and other parameters for ground water quality assessment. Graphical representation of supplied ground water quality data. Resistivity survey for ground water.

**Books Recommended:**

1. Todd, D. K. (2011) Groundwater Hydrology, Wiley India Pvt Ltd; Third edition, page no. 1-656.
2. Raghunath, H. M. (2007) Groundwater, New Age International Publishers; Third edition, Page no. 1-520.
3. Davis, S, N. and Dewiest. (1966) Hydrogeology, John Wiley & Sons, Page no. 1- 464.
4. Karanth, K. R.: (1989) Hydrogeology, Tata McGraw-Hill Publishing Company, Page no. 1-458.

**vi) Environmental Geology**

Ecology and Environment. Anthropogenic changes in Ecosystem; Dynamics of human, Population, Non-renewable natural resources. Mineral consumption. Conservation of mineral resources. Impact of mining activities on environment; Energy resources & their consumption. Energy crisis. Alternative energy resources; Natural hazards. Environmental security and hazard -zoning; Risk assessment analysis; Strategies for hazard mitigation; Seismic hazards; Seismic condition in India; Management of Seismic hazards; Stability of hill slopes and Land Slide; Controlling landslides; Causes of floods; Flood scenario in India; Management of Floods. Environmental and mining laws. National Mineral Policy.

**Practical:**

Sampling of water, soil, dust from environmentally polluted areas; Analysis of water, soil, and dust. Determination of pH, Temperature, TDS and other parameters for ground water quality assessment. Graphical representation of the analysed samples. Resistivity survey for ground water. Determination of heavy metals in the soil and dust samples. Preparation of hazard zonation maps.

**Books Recommended:**

1. Valdiya, K. S. (2004) Environmental Geology-Indian context, Orient Blackswan Private Limited - New Delhi page no. 1-240.
2. Keller E. A. (2010) Environmental Geology, Pearson; 9 edition, page no. 1-624.
3. Coates, D.R. (1981) Environmental Geology, John Wiley & Sons, Inc. page no.1-701.
4. Betz, F. Jr (Ed) (1976) Environmental Geology John Wiley & Sons Inc, page no. 1-119.
5. Dasmann, R. F. (2011) Environmental Conservation, Wiley India, page no.1-127.
6. Bolt, B. A. et al. (1975) Geological Hazards, Springer, page no.1-328.

**vii) Applied Micropaleontology, Palaeobotany, Palynology**

Applications of palaeontology, objective of micropalaeontology, microfossil groups; **Foraminifera** (test morphology, life style, food, symbiosis, life cycle, wall structure and composition, Chamber growth and development, Evolution of Foraminifera, General classification, Foraminiferal bioenvironmental indicators, Palaeoecological significance of Foraminifera, Distribution of planktonic foraminifera; **Ostracods** (morphology of the ostracod carapace, ontogeny, articulation, distribution and ecology of ostracods, ecological variables, applications of ostracods; classification, geological history of Ostracod), **Coccolithophores** (Introduction; Coccolith morphology; Coccolith Life-Style, Ecology and Reproduction; Coccoliths and Sedimentation; Geologic history of coccoliths); **Diatoms** (Introduction; living diatom, Cell contents of living diatom; Structure and morphology of a diatom [Diatom frustule; diatom symmetry planes; diatom ornamentation); Taxonomy; Growth and reproduction; Diatom distribution and ecology; Geologic record and evolution; Applications and importance of diatoms, and **Radiolaria, Palynology** (introduction, history of Palynology;



method of study, applications), **Gondwana flora** (Glossopteris flora, Dicroidium flora, Ptillophyllum flora) and their significance, important Gondwana plant fossils

**Practical:**

Identification of microfossils. Preparation of paleogeographic maps, identification of plant fossils.

**Books recommended:**

1. Jones, D. J.: (1969) Introduction to Microfossils, Hafner Publishing Co Ltd., page no. 1- 406.
2. Bignot, G. (2008) Elements of Micropaleontology, Springer page no. 1-368.

**viii) Ore Genesis:**

Ore formation as a natural process in the crust; Metallogeny - space-time rationale; Mineralisation in relation to tectonics and crustal evolution; Ores in Mafic ultramafic rock, Classification scheme, immiscible liquid segregation, thermodynamic modelling of partitioning of metals with regard to composition of Cu-Ni- Co-sulfide ores; ores in felsic rocks: end-stage processes during felsic magmatism and their ore genetic significance; Hydrothermal fluids, plurality of sources, fluid inclusions, stable isotope studies, complexing and thermodynamic aspects of solubility and precipitation of minerals. Stratiform and stratabound ores, phase equilibria in simple sulfide systems, Fe-S; Fe-Zn-S, Cu-Fe-S, Fe-Ni-S, their application to natural ores. Ores and metamorphism, cause and effect relations.

**Practical:**

Study of ore minerals in hand specimen. Study of polished ore minerals under reflected light. Micro hardness testing. Etching study. Paragenetic study from mineral assemblage. Chemical analysis of ore minerals. Reserve calculation methods for estimation of reserve.

**Books Recommended:**

1. Mookherjee, A. (199) Ore genesis- a holistic approach, Allied Publishers Pvt. Ltd. page no. 1-324.
2. Spurr, J. E. (1923) The Ore Magmas, McGraw Hill, page no. 1-234.
3. Sawkins, F. J, (1989) Metal deposits in relation to Plate Tectonics, Springer Verlag; Subsequent edition, page no. 1-123.
4. Stanton (1972) Ore Petrology, McGraw Hill Higher Education, page no. 1-713.
5. Wolf, K. H. (1976) Handbook of Strata-Bound and Stratiform Ore Deposits: Part II: Regional Studies and Specific Deposits: Volume 5: Regional Studies, Elsevier Publishing Company, page no. 1-312.

**ix) Clay Mineralogy & Soil Geology**

Introduction, Classification of clay minerals. Structure of I: I layer silicates (Kaolinite group). Structure of 2 :1 layer silicates, (Smectite group, dioctahedralsmectites, trioctahedralsmectites). Structure of 2:1:1 layer silicates. (dioctahedral chlorite, trioctahedral chlorite). Mixed-layer clay minerals, ion exchange of clay minerals; X-ray identification and semi quantitative estimation of major clay mineral groups, origin and diagenesis of clay minerals. Formation of Soil, Soil profile, classification of soil. Soil Chemistry, Classification of Soils. Soil type of India, Soil & vegetation. Soil erosion. Soil conservation. Soil pollution and prevention

**Practical:**

Study of clay minerals in hand specimen. Separation of clay minerals from sedimentary rocks and loose sediments. X-ray, DTA and TGA method of clay mineral analysis. Physical and thermal properties of clay minerals. Classification of soils.

**Books Recommended:**

1. Grim, R. E. (1968) Clay Mineralogy, McGraw-Hill, page no.1-127.

**x) Management of Mineral Resources**

Prospecting criteria and guides to mineral/ ore search, Review of Geological Geophysical, Geochemical, Geobotanical methods of mineral prospecting, changing concepts, approaches, techniques and planning in regional scale mineral exploration, concept of plate tectonics and mineral location, Remote sensing. Methods of data acquisition and RS techniques in Mineral Exploration, Statistical methods and mineral/ore deposit modelling for prospecting and exploration. Methods of resource evaluation and reserve calculation, property valuation. Treatment and marketing of ores. Demand, supply and substitute. Changing pattern of mineral consumption. Strategic, critical and essential minerals, National mineral policy, Mineral concession rules, Marine mineral resources & Law of Sea, Conservation of strategic mineral resources with special reference to India, Monitoring of land degradation due to mining and natural process.

**Practical:**

Techniques of survey of mineral deposits. Preparation of block diagram, fence diagram, isopach diagram etc. Reserve calculation methods. Advance method of mineral survey.

**Books Recommended:**

1. McKinstry (1949) Mining Geology, Prentice-Hall, Inc.; 2nd Printing edition, page no. 1-736.
2. Dorbin, M.S. (1976) Introduction to geophysical prospecting, McGraw-Hill; 3rd edition, page no. 1-630.
3. Hoover (2009) Principles of Mining, BiblioLife, page no. 1- 212.

**Interdisciplinary Course (2 CH)****(Remote Sensing Techniques and Application )**

Definition and Fundamental principles; Advantage of Remote Sensing over conventional method of survey; Components of Remote Sensing System- Electromagnetic Radiation, Platform, Sensor and Target; Classification of EMR), interaction of EMR with vegetation, water, soil, rocks, minerals etc. Types of platform. Classification of sensors; Functioning of whisk broom and push broom type of sensors. RS data products; Principles of RS data analysis and their application in different fields.

**Books Recommended:**

1. Lillesand M. Thomas and Ralph W. Kiefer (2007) Remote Sensing and Image Interpretation, John Wiley & Sons, New York, Page no.1-736 .
2. Arthur H. Robinson (2002) Elements of Cartography, John Wiley & Sons, New York, Page no.1-428
3. Dennis P. Curtin, Kim Foley, Kunal Sen & Cathleen Morin (1999) Information Technology The Breaking Wave, Tata McGraw Hill Ed Page no.1-830.
4. M. Anji Reddy (2004) Geoinformatics for Environmental Management, BS Publications, Hyderabad, Page no.1-472
5. Sharma V.K. (1991) Remote Sensing for Land Resources Planning, Concept Publishing Company, New Delhi, Page no.1-586.