

**M. Sc. APPLIED GEOCHEMISTRY  
SYLLABUS  
(CHOICE BASED CREDIT SYSTEM)  
(From the Academic Year 2016-17)**



**DEPARTMENT OF APPLIED GEOCHEMISTRY  
UNIVERSITY COLLEGE OF SCIENCE  
OSMANIA UNIVERSITY  
HYDERABD - 500 007**

**DEPARTMENT OF APPLIED GEOCHEMISTRY**  
**M.Sc. Applied Geochemistry, Scheme of the Examination (from the Academic Year 2016 - 17)**

S. No.	Subject Code	Subject (Title)	Instruction hrs/ week	Duration of Exam	Max. Marks		Total Marks	Credits
					Internal Assessment	Semester Exam.		
<b>I SEMESTER THEORY</b>								
1.	AG 101 T	Essentials of Geology	4	3	20	80	100	4
2.	AG 102 T	Fundamentals of Geochemistry	4	3	20	80	100	4
3.	AG 103 T	Mineralogy & Mineral Geochemistry	4	3	20	80	100	4
4.	AG 104 T	Geomorphology & Remote Sensing	4	3	20	80	100	4
		Field work	2					
<b>PRACTICALS</b>								
5.	AG 151 P	Field techniques	4	3		50	50	2
6.	AG 152 P	Image Processing and Interpretation	6	3		75	75	3
7.	AG 153 P	Mineragraphy	6	3		75	75	3
<b>Total Marks/Credits</b>			<b>34</b>		<b>80</b>	<b>520</b>	<b>600</b>	<b>24</b>
<b>II SEMESTER THEORY</b>								
1.	AG 201 T	Igneous Petrology & Geochemistry	4	3	20	80	100	4
2.	AG 202 T	Metamorphic Petrology & Geochemistry	4	3	20	80	100	4
3.	AG 203 T	Sedimentary and Organic Geochemistry	4	3	20	80	100	4
4.	AG 204 T	Energy Resources	4	3	20	80	100	4
		Field work	2					
<b>PRACTICALS</b>								
5.	AG 251 P	Petrography	6	3		75	75	3
6.	AG 252 P	Lithogeochemical Analysis	6	3		75	75	3
7.	AG 253 P	Pedogeochemical Analysis	4	2		50	50	2
<b>Total Marks/Credits</b>			<b>34</b>		<b>80</b>	<b>520</b>	<b>600</b>	<b>24</b>
<b>III SEMESTER THEORY</b>								
1.	AG 301 T	Mineral Deposits and Ore Geochemistry	4	3	20	80	100	4
2.	AG 302 T	Analytical Geochemistry	4	3	20	80	100	4
3.	AG 303 T	<b>Elective</b>	4	3	20	80	100	4
		1. Environmental Geochemistry						
		2. Drainage Geochemistry						
4.	AG 304 T	Mineral Exploration and Mineral Economics	4	3	20	80	100	4
5.		Seminar	2					
<b>PRACTICALS</b>								
6.	AG 351 P	Ore Identification	6	3		75	75	3
7.	AG 352 P	Ore Reserve Estimation	4	2		50	50	2
8.	AG 353 P	Geochemical Computations & Data Processing	6	3		75	75	3
<b>Total Marks/Credits</b>			<b>34</b>		<b>80</b>	<b>520</b>	<b>600</b>	<b>24</b>
<b>IV SEMESTER THEORY</b>								
1.	AG 401 T	Exploration Geochemistry	4	3	20	80	100	4
2.	AG 402 T	Hydrogeology and Hydrogeochemistry	4	3	20	80	100	4
3.	AG 403 T	<b>Elective:</b>	4	3	20	80	100	4
		1. Geochemistry in Hydrocarbon Exploration						
		2. Biogeochemistry						
4.		Seminar	2					
<b>PRACTICALS</b>								
5.	AG 451 P	Groundwater & Geochemical Exploration and Modelling	6	3		75	75	3
6.	AG 452 P	Hydrogeochemical analysis	6	3		75	75	3
7.	AG 453PJ*	Project Oriented Dissertation	8			150	150	6
<b>Total Marks/Credits</b>			<b>34</b>		<b>60</b>	<b>540</b>	<b>600</b>	<b>24</b>
<b>Grand Total Marks/Credits</b>			<b>136</b>				<b>2400</b>	<b>96</b>

\*At the end of III semester 2 to 3 weeks of field /Instrumentation training is compulsory  
Project Oriented Dissertation: in lieu of One theory + One practicals

## I SEMESTER

### *THEORY*

#### **PAPER-I (AG 101 T): ESSENTIALS OF GEOLOGY**

- UNIT-I:** Stratigraphy: Stratigraphic principles – definition, order of Super position, Strata types-stratigraphic classification and nomenclature; Stratigraphic units-lithostratigraphic, Biostratigraphic, and Chronostratigraphic; Stratigraphic correlation Geologic Time Scale; Indian Stratigraphy – review, Standard Geological Divisions; paleogeography and Paleoclimate .
- UNIT-II:** Indian Stratigraphy: Geological Succession in Type areas of Major Geological Formations of India - Precambrian Stratigraphy: Proterozoic Cuddapah Super Group: Kurnool group, Vindhyan System, Gondwana Super Group; Triassic, Jurassic, Cretaceous-, Cretaceous rocks of East and West coast; Deccan traps-Sediments associated with them.
- UNIT-III:** Structural Geology: Objectives of Structural Geology, Mechanical principles- lithostatic or confining pressure, Concept of Stress and strain; Nomenclature and classification of folds, Faults and Joints; Cleavage and Schistosity relation to major structures; Types, recognition and significance of Unconformities; Shear zones; concepts of salt domes and diapir, plastic deformation and petrofabrics, Structure and tectonic map of India.
- UNIT-IV:** Geotectonics; Concept of Plate tectonics, Mid Oceanic Ridges, Sea floor Spreading, Island arcs, oceanic islands, and volcanic arcs; Concepts of Isostasy, orogeny-epiorogeny, continental drift-geological and geophysical evidence; Major tectonic features of the oceanic and continental crust; Palaeomagnetism, Present Tectonic divisions of Indian shield.

#### **References:**

- Marvin Weller, J. 1960: Stractigraphic Principles and Practice. Harper and Row Publishers, Universal Book Stall, Delhi, Kanpur.
- Krishnan, M.S. 1982: Geology of India and Burma, CBS Publications
- Wadia, D.N. 1998 Geology of India, Tata, McGraw, Hill Publishing Co.
- Ramakrishnan,K., & Vaidyanadhan, R.,2008: Geology of India, Vol. 1, and 2; Geological Society of India, Bangalore
- MarlandP.Billings 1977: Structural Geology. Prentice Hall of India Private limited.
- Badgley.P.C., 1998: Structure and Tectonics. Harper and Row

#### **PAPER-II (AG 102 T) : FUNDAMENTALS OF GEOCHEMISTRY**

- UNIT-I:** Introduction: Earth in relation to the universe. The nature and age of the universe, nature and origin of solar system, composition of the universe, sun, planets and meteorites, cosmic abundance of elements. Geochemical cycle. Energy changes in the geochemical cycle.
- UNIT-II:** Composition of the earth: the internal structure and composition of earth, composition of crust, composition of earth as a whole. Primary distribution of elements, geochemical classification of elements, distribution of elements in igneous, metamorphic and sedimentary rocks, partition coefficients.
- UNIT-III:** Internal structure of atoms, nuclear systematics, atomic weights, and isotopes, nuclear stability and abundance. Decaying mechanism-Beta decay, positron decay, electron capture decay, alpha decay, nuclear fission. Decay laws and half-life. Geochronology-K-Ar, Rb-Sr, Sm-Nd, and U-Pb dating.
- UNIT-IV:** The hydrological cycle, inter relationship of surface and ground water, physico-chemical properties of water and its structure and bonding. Solution and solubility, composition of

natural waters, some characteristics of river waters and ground water. The mass of the biosphere: composition of the biosphere: biogenic deposits; geochemical cycle of carbon.

**REFERENCES:**

- Brain Mason, Carleton B. Moore (1982): Principles of Geochemistry, 4<sup>th</sup> edition, John Wiley and Sons  
Konard B. Krauskopf (1979): Introduction to Geochemistry, 2<sup>nd</sup> edition. Mc Graw Hill publication  
Stephen F. Mason (1991): Chemical Evolution. Clarendon press, Oxford  
James I. Drever (1982): The Geochemistry of natural waters, Prentice Hall Inc.  
David Keith Todd, (1980): Ground water Hydrology. 2<sup>nd</sup> edition, John Wiley and sons  
Arthur H. Brownlow (1979): Geochemistry. Prentice Hall Inc.  
Faure Gunter, (1986): Principles of Isotope Geology, W.I.E. II edition.  
U. Ashwathanarayan, (1985): Principles of Nuclear Geology, Oxonian Press.  
Durrance, Eric Michael, (1986): Radioactivity in Geology, Principles and Applications. Halsted Press.  
W. M. White (2007); Geochemistry

**PAPER-III (AG 103 T) : MINERALOGY & MINERAL GEOCHEMISTRY**

- UNIT-I:** Principles of crystal structure, the structure of silicates, the lattice energy of crystals, isomorphism, atomic substitution, and polymorphism, twinning and twinned crystals.  
**UNIT-II:** Physicochemical properties and paragenesis of ortho and ring silicates (olivine, garnet, epidote groups) and chain silicates (pyroxene, amphibole groups).  
**UNIT-III:** Physicochemical properties and paragenesis of sheet silicates (mica group). Framework silicates, Feldspar group, Nepheline group, Zeolite group.  
**UNIT-IV:** Physicochemical properties paragenesis of non-silicates, oxides, sulphides, sulphates, carbonates, phosphates, halides.

**REFERENCES:**

- Deer, W.A., Howie, R.A. and Zussman, J. 1992. An Introduction to the Rock forming Minerals, Vol.1-5, ELBS  
Brain Mason, Carleton B. Moore (1982): Principles of Geochemistry, 4<sup>th</sup> edition, John Wiley and Sons  
Dexter Perkins, Mineralogy, Prentice Hall of India.

**PAPER IV (AG 104 T) : GEOMORPHOLOGY AND REMOTE SENSING**

- UNIT-I:** Introduction and concepts in Geomorphology, Geomorphic processes- Epigene process: gradation-degradation and a gradation. Hypogene processes- Diastrophism and volcanism. Extra terrestrial processes-meteorites and tektites, Weathering – mechanical, chemical, biological weathering. Conditional factors. for weathering. Soil formation–soil profile, classification and geomorphic significance. Slope: Slope stability, slope profiles, hill slope development.  
**UNIT-II:** Drainage basin: Initiation of channels and drainage network, basin morphology, basin denudation and evolution. Fluvial processes: River channels, sediment in channels, the Quasi – equilibrium condition, channel patterns, rivers, equilibrium and time. Fluvial land forms: Flood plain, fluvial terrain, fans and pediments, deltas. Wind processes and landforms: Erosional and depositional land forms. Glacial erosion deposition and landforms, Erosional processes and depositional features. Karst process and landforms: Processes and controls drainage characteristics, surficial landforms and limestone caves. Coastal processes and landforms: processes, beaches coastal topographic, shore line changes, basin islands. Morphology of Indian sub – continent.

**UNIT-III:** Fundamental concepts about electromagnetic energy, electromagnetic spectrum and their properties. Spectral signatures- characteristics of vegetation, water and soil. Remote sensing platforms- ground, airborne and space borne- satellite systems and orbits. Sensors systems- imaging and non -imaging types of sensors, optical sensors. Types of scanners – multi –spatial scanners push broom scanner. Characteristics of remote sensors: Resolution- spatial, spectral, radiometric and temporal. IRS mission. Visual interpretation techniques of images. Application of remote sensing in geology- lithological discrimination, structural mapping. Application in geomorphology and water resource studies.

**UNIT-IV:** Digital Image Processing: Objectives, radiometric correction, geometric correction, image registration image enhancement, rotating, filtering techniques, Image classification- supervised, unsupervised, geological applications, image processing systems. Fundamentals of GIS - Introduction to basic concepts including definition of GIS, Principles, techniques, procedures and terminology of GIS and digital representation and data acquisition. Coordinate systems and projections, GIS data models: Raster based GIS, Spatial referencing in raster based GIS: definition and representation of raster data, concepts of raster based GIS data structure, and capture and basic operations of spatial analysis with raster GIS. Vector based GIS: Definition, concepts of vector based GIS, data structures, data capture and operations of spatial analysis with vector GIS. Advantages and Disadvantages in raster and vector based GIS. Overview of GPS and its applications.

**References:**

- Willam. D, Thornbury, 2004: Principles of Geomorphology. Wiley Eastern.
- Drury, G.H. 2006: Essays in Geomorphology, Heinman Educational Books Ltd.
- Sabbins. F.F., 1985: Remote Sensing Principles and Applications. Freeman.
- Drury.S.A., 2002: Image Interpretations in Geology. Allen and Unwin.
- Lillesand. T.M. and Kieffer, R.W., 2005: Remote Sensing and Image Interpretation. John Willey.

**PRACTICALS**

**PAPER-I (AG 151 P): FIELD TECHNIQUES**

Geologic map symbols – Standard lithological symbols, lithological contacts, Bedding, Folds, Faults, Strike and Dip, Joints, Foliation and cleavage Interpretation of topographic maps, map scales; Geological mapping techniques, interpretation of geological maps, identification of geological structures and litho units. Selection of target areas.

Sampling Techniques; Pedo, Litho, Hydro and Stream sediments; Geo-botanical Sampling Techniques; sampling and precautions, sample preparations in the field. Selective methodology for various sampling media.

Surveying - Use of compass and clinometers, Chain Survey, Prismatic compass survey, Abney's Level survey, Plane Table Survey.

Report writing incorporating all the observations made in the field training/field visits. Report submission.

**PAPER II (AG 152 P) : IMAGE PROCESSING AND INTERPRETATION**

Study and Interpretation of SoI Toposheets. Visual interpretation of Satellite Image (Lithology, Geomorphology, structures, land use/land cover, hydrology. Digital Interpretation.

**PAPER III (AG 153 P) : MINERAGRAPHY**

1. Megascopic identification of minerals: Olivine group, Pyroxene group, Amphibole group, Garnet group, Mica group, Quartz group, Feldspar group
2. Microscopic identification of minerals: Olivine group, Pyroxene group, amphibole group, Garnet group, Mica group, Quartz group, Feldspar group

## II SEMESTER

### ***THEORY:***

#### **PAPER-I (AG 201 T): IGNEOUS PETROLOGY & GEOCHEMISTRY**

- UNIT-I:** Introduction, classification and nomenclature of igneous rocks, primary and secondary textures, phase equilibrium and the phase rule, one-component systems, two- component systems, three- component systems.
- UNIT-II:** Major element geochemistry – analytical methods and results, major and minor elements in the crust, variation diagrams, magma series; trace element geochemistry – classification, element distribution, solid-melt processes, REE, PGE, normalized trace element diagrams, application of trace elements to igneous systems, geochemical criteria for discriminating between tectonic environments.
- UNIT-III:** Definition of a magma, constitution of magmas, generation of magmas, source rock compositions - upper mantle and lower crust, generation of magma from solid rock, magmatic differentiation, magma mixing, assimilation, tectonic igneous associations.
- UNIT-IV:** Petrology, geochemistry and genesis of ultramafic rocks, peridotites, serpentinites, ophiolites, basalts, gabbros, anorthosites, andesites, granitoids, alkaline rocks, kimberlites, carbonatites and lamprophyres.

#### ***REFERENCES:***

- Anthony R. Philpotts, (1990): Principles of Igneous and Metamorphic Petrology, Prentice Hall India.
- Myron G. Best, (1986): Igneous and Metamorphic Petrology. CBS publishers.
- Anthony Hall, (1988): Igneous Petrology. ELBS.
- Faure Gunter, (1992): Principles and Applications of Inorganic Geochemistry, Macmillan Pub.
- Chatterjee, S.C.(1974): Petrography of the Igneous and Metamorphic rocks of India, the Macmillan Co. India Ltd

#### **PAPER-II (AG 202 T) : METAMORPHIC PETROLOGY & GEOCHEMISTRY**

- UNIT-I:** Definition and types of metamorphism, factors of metamorphism, metamorphic fabrics, metamorphic mineral paragenesis and their graphical representation (ACF, AFK, AFM diagrams), metamorphic facies, metamorphic grade and metamorphic zones, paired metamorphic belts, fundamental concepts of thermodynamics – I law, II law and III law, Gibb's free energy, fugacity and activity.
- UNIT-II:** Mineralogical and Chemical aspects of metamorphic systems: Intensive variables and energy, classification of reactions, solid- (fluid + solid) reactions, interpretive analyses of mineral assemblages, metasomatism.
- UNIT-III:** Material transport during metamorphism: Introduction, evidence for mass transfer during metamorphism, mechanisms of mass transfer, dissolution of minerals in supercritical H<sub>2</sub>O, mass transfer mechanisms at a metamorphic isograd, metasomatic zonation, estimating volumes of fluid flux during metamorphism, effect of fluids on metamorphism.
- UNIT-IV:** Pressure-temperature-time paths in regional metamorphic rocks: Charnockites and Khondalites, textural relationships, kinetics of metamorphic mineral reactions, metamorphic field gradients, pressure-temperature- time paths, observed P-T-t paths

#### ***REFERENCES:***

- Philpotts, A.R., 1994, Principles of Igneous and Metamorphic Petrology, Prentice Hall of India Private Limited.

Best, M.G., 1986, Igneous and Metamorphic Petrology, CBS Publishers and distributors, New Delhi

Miyashiro, A. Metamorphic Petrology, Research press, New Delhi

Chatterjee, S.C. (1974): Petrography of the Igneous and Metamorphic rocks of India, the Macmillan Co. of India Lt.

Helmuty GF Winkler (1987): Petrogenesis of Metamorphic Rocks, Narosa Publishing house, New Delhi

### **PAPER III (AG 203 T): SEDIMENTARY AND ORGANIC GEOCHEMISTRY**

**UNIT-I:** Classification of sedimentary rocks, textures, structures, lithification and diagenesis.

**UNIT-II:** Chemical weathering, General nature of weathering reactions, changes in rock composition, sequence of silicate mineral alteration, agents of chemical weathering, dissolution of carbonates, hydrolysis of silicates. Oxidation and Reduction, redox reactions in the environment, balancing redox half reactions in the environment. Hydrogen ion activity (pH), limits of Eh and pH in natural environments,.

**UNIT-III:** Formations of Deep Sea Sediments, redox environments, Interstitial water inputs to the ocean. Phosphatic nodules and ferromanganese nodules. Sub-Surface Sea Bed Deposits: Source rocks, Kerogen Types, and Hydrocarbon potential, Petroleum and natural gas deposits below the sea bed. Calcareous oozes, red clay deposits.

**UNIT-IV:** Organic Geochemistry: Chemical properties of organic molecules, production and preservation of organic matter, the carbon cycle, trace element cycles and trace elements in marine colloids, organic matter of fresh water and soils, major contributors to sedimentary organic matter; sedimentary organic matter and coal and petroleum formation, diagenesis of marine aquatic sediments.

### **REFERENCES**

F.J. Pettijohn, (1984): Sedimentary Rocks, III edition, CBS publishers

Konrad B. Krauskopf, (1995): Introduction to Geochemistry III Ed. McGraw Hill Co.

Arthur H. Brownlow (1996): Geochemistry, Prentice Hall Inc

Brian Masson (1983) Principles of Geochemistry, 4<sup>th</sup> edition McGraw Hill Co.

John K. Joseph (2006) Organic Geochemistry, Campus Books International.

### **PAPER IV (AG 204 T) : ENERGY RESOURCES**

**UNIT I:** Humic material, coal and kerogen: Diagenesis – Microbial degradation or organic matter, Geopolymer formation, Humic material - Occurrence, classification, composition, structure, formation. Coal – Classification, composition, maceral groups, formation, peatification, coalification (Biochemical and Geochemical stages), structural changes during coal formation, coal bed methane.

**UNIT II:** Development of petroleum geochemistry – Petroleum generative Depressions; carbon and the origin of life – The primitive Earth, Primitive Life, Carbon in Sedimentary rocks; Petroleum and its products- The composition and uses of petroleum. Origin of natural gas- sources of Natural Gases; Migration and accumulation- primary migration, secondary migration, petroleum traps and seals. Gas from coal, oil from coals and coaly shales, oil shales and other terrestrial source rocks, absorption – migration of hydrocarbons from coal and terrestrial kerogen.

**UNIT III:** Mineralogy of uranium, thorium, Zr, Be, Li and REE minerals, uranium distribution in the Earth Crust, uranium deposit types, their distribution in time and space, uranium exploration guides and methodology, geochemical and radiometric techniques, chromogram test, CN film autoradiography, SSNTD and fission track studies, uranium

and thorium decay series, radiation detection and measurement techniques, gross gamma ray and spectrometry techniques of uranium estimation, radon emanometry, Nuclear reactor theory, types of reactors, Nuclear Fuel Cycle and environmental issues.

**UNIT IV:** Renewable energy sources, solar energy – utilization for heating applications; wind energy, geothermal energy, tidal energy, biomass energy, biodiesel, ocean thermal energy, hydel energy.

**REFERENCES:**

Coal and Coal – bearing strata: Recent Advances, by A.C.Scott (Ed), Blackwell Scientific, Oxford, 1987.

Petroleum Geochemistry and Geology by 2<sup>nd</sup>ed, J.M.Hunt, (1996)Freeman, Newyork,

Radioactive Minerals by R.Dhana Raju,(2005) Geological Society of India, Bangalore, 65p.

P.D. Wilson (Editor) 1996, The Nuclear Fuel Cycle from Ore to Wastes, Oxford University Press.

**PRACTICALS**

**PAPER I (AG 251 P) : PETROGRAPHY**

Megascopic and Microscopic identification of rocks:

Igneous rocks - Volcanic rocks, Hypa-byssal rocks and Plutonic rocks.

Sedimentary rocks: Clastic rocks and Nonclastic rocks.

Metamorphic rocks

**PAPER II (AG 252 P) : LITHOGEOCHEMICAL ANALYSIS**

1. Sample preparation:
  - a. crushing, coning and quartering
  - b. grinding
  - c. sieving
2. Digestion techniques:
  - a. fusion techniques: preparation of "A" solution
  - b. Total acid digestion: preparation of "B" solution
  - c. partial acid digestion: HCl digestion, aquaregia digestion
3. Colorimetry/Spectrophotometry:
  - a. determination of SiO<sub>2</sub>
  - b. determination of Al<sub>2</sub>O<sub>3</sub>
  - c. determination of total iron as Fe<sub>2</sub>O<sub>3</sub>
4. Titrimetry:
  - a. determination of MgO
  - b. determination of CaO

**PAPER III (AG 253 P) : PEDOGEOCHEMICAL ANALYSIS**

1. Partial Decomposition Techniques with different acids
2. Soil and Sediment Sample Preparation Procedure and removal of organic material
3. pH, Ec and TDS determination of soils and their relationship
4. Atomic Absorption Spectrophotometry: Analysis of trace elements in water and soils of - 80 mesh
5. Determination of Trace elements in -120 mesh Stream sediments
6. Determination of Fluoride in Soils



### III SEMESTER

#### ***THEORY:***

#### **PAPER-I (AG 301T): MINERAL DEPOSITS AND ORE GEOCHEMISTRY**

- UNIT-I:** Introduction and Terminology: definitions of ore, gangue, tenor, grade, specifications etc. Textures and structures of ore and gangue mineral, wall-rock alterations and their types;
- UNIT-II:** Some major theories of Ore Genesis: origin due to internal processes. Magmatic segregation, hydrothermal, metamorphic processes; origin due to surface processes-mechanical accumulation. Processes of formations of mineral deposits: Magmatic deposits. Sublimation. Contact metasomatism. Evaporation, residual and mechanical concentration. Oxidation and supergene enrichment.
- UNIT-III:** Geochemistry of mineral deposits of sedimentary affiliation, banded iron deposits, manganese deposits. Geochemistry of Stratiform and stratabound ore deposits. Copper-lead-zinc deposits of marine volcanic association. Stratabound limestones. Lead-Zinc association, sandstone type, uranium, vanadium-copper associations.
- UNIT-IV:** Geochemistry of mineral deposits in the igneous habitat. a. Mineral deposits of acidic, mafic ultramafic rock affiliation, Chromite deposits, Gold and Platinoids. Diamondiferous Kimberlites. Magma related mineralization through Geological Time. Geochemistry of mineral deposits of metamorphic affiliation - asbestos formation, graphite formation, talc-soap stone formations, skarns, ores of metasomatic associations, ores associated with dislocation metamorphism.

#### ***REFERENCES:***

- James R. Craig, and David J. Vaughan, (1981): Ore Microscopy and Ore Petrography, John Wiley and Sons
- Anthony M. Evans, (1987): An Introduction to Ore Geology, 2nd edition, Blackwell Scientific publication (ELBS) edition
- Anthony M. Evans, (1993): Ore Geology and Industrial Minerals. 3rd edition, Oxford Black Scientific publications
- Beck Richard, (1994): The Nature of Ore Deposits. Translated and revised by Walter Harvey Reed. S.B.W. Publishers. Vol.I & II New Delhi
- Mead L. Jensen and Allan M. Batemen, (1981): Economic Mineral Deposits. 3<sup>rd</sup> Edition. John Wiley and sons, New York. (Chapter 1.13)
- A.W.Rose, H.E.Hawkes and J.S.Webb, (1979): Geochemistry in Mineral Exploration. 2nd edition. Academic Press, New York
- H.L.Barnes, (1979): Geochemistry of Hydro-thermal Ore Deposits. 2nd Edition. John Wiley (10, 11, 12, 13, 14)
- S.N. Virnave, (1999): Nuclear Geology and Atomic Mineral Resources. Bharathi Bhavan Publications and Distributors, Patna, 226p

#### **PAPER-II (AG 302 T) : ANALYTICAL GEOCHEMISTRY**

- UNIT-I:** Concepts in analytical geochemistry; terms and definitions in analytical geochemistry, units of measurement, the international system of (SI) of units, precision and accuracy, detection limits, sampling strategies, inhomogeneity effects, potential contaminations from laboratory materials, effects, standard additions calibrations, rock reference materials.
- UNIT-II:** Classical and rapid methods of analysis; Rock dissolution techniques, acid attack, rock dissolution procedures, fusion with alkali salts, classical methods of rock analysis, evolution of rapid methods of analysis, photometry, flame photometry, titration's involving ethylene di-amine tetra acetic acid (EDTA).

**UNIT-III:** Optical spectrometry; principles and instrumentation; Principles, the nature of light, atomic spectroscopy, the absorption of light, the emission of light, instrumentation of optical spectroscopy, monochromator, optical filters, slits, photon detectors.

**UNIT-IV:** Principles and application of direct current emission spectrometer (DC-ES), inductively coupled plasma methods (ICP-ES) and (ICP-MS), X-ray Fluorescence analysis (XRF), X-ray diffraction methods (XRD), UV fluorimetry and laser fluorimetry. Atomic absorption spectrophotometer (AAS), Neutron activation analysis (NAA), Electron micro-probe analysis, Scanning electron microscope (SEM), Ion selective electrodes.

**REFERENCES:**

Potts,P.J. (1996): A handbook of silicate a rock analysis. Blackie Academic & Professional (An imprint of Chapman and Hall)

Brain Mason, Carleton B. Moore (1982): Principles of geochemistry 4<sup>th</sup> edition, John Wiley & sons

Konard B. Krauskopf (1979): Introduction to Geochemistry, 2<sup>nd</sup> edition. McGraw Hill

James I. Drever (1982): The Geochemistry of natural waters, Prentice Hall Inc.

David Keith Todd (1980): Ground water Hydrology, 2<sup>nd</sup> edition, John Wiley & sons.

K. Fletcher (1981): Analytical methods geochemical prospecting (Hand book of Exploration Geochemistry. Vol. I. GJS Govett. Ed.) Elsevier Scientific Pub. Co.

Chris Riddle (Ed) (1993): Analysis of Geological Materials. Marcel Dekker, Inc., New York

**PAPER III (AG 303 T) - ELECTIVE:**

**1. ENVIRONMENTAL GEOCHEMISTRY**

**2. DRAINAGE GEOCHEMISTRY**

**PAPER III (AG 303 TE 1) : ENVIRONMENTAL GEOCHEMISTRY**

**UNIT-I:** Principles of Environmental Geochemistry: types of chemical reactions, oxidation-reduction processes in natural systems, the distribution of elements in rocks and some geochemical associations, re-distributions of chemical elements by weathering. Sources of trace elements in soils, trace element problems in crops and livestock. Assessment of metal pollution in soils, sources and types of metal pollution.

**UNIT-II:** Geochemistry and water quality, measures of water quality, chemical analysis, physical and , Biological analysis, COD,BOD, Water quality criteria, factors influencing ground water quality, Bioremediation, Types of bioremediation, approaches to bioremediation, bioremediation of contaminated soils & aquifers, bio-indicators.

**UNIT-III:** Geochemistry and man, health and disease, essential elements, toxic and other elements, special problems of health and environment, health effects of silica, asbestos exposure, biological interactions trace elements and diseases, natural trace element poisoning, health implications of coal development.

**UNIT-IV:** Heavy metal contamination from base metal mining and smelting, implication for man and environment, metal mining and human health. Radioactivity in the environment, radioactive elements in rocks, radio-elements in soils and water, environmental aspects of radionuclides. Environmental pollution on global nature, acid rain, greenhouse effect, ozone layer, CFCs, atmospheric pollution, sampling and analysis. Industrial pollution

**REFERECES**

Iain Thornton, (1983): Applied Environmental Geochemistry, Academic press

Iain Thornton, (1986): Applied Geochemistry in 1980's. Graham and Trotman limited

S.H.U.Bowie and J.S.Webb,(1980): Environmental Geochemistry and Health, The Royal Society, London

David K. Todd, (1980): Ground Water Hydrology, 2nd edition. John Wiley & Sons.  
B.K.Sharma&H.Kaur (1997) Environmental Chemistry- Goel pub. House, Meerut  
G.NelsonEby (2004) Principles of Environmental Geochemistry, Thomson Learning Academic center  
Agarwal, S.K., (1998). Environmental Biotechnology, APH publishers

### **PAPER III (AG 303 TE-2): DRAINAGE GEOCHEMISTRY**

- UNIT-I** Concept of Primary and Secondary Environments; Drainage patterns, Mobility of Trace Elements in Secondary Environment; Adsorption Phenomena – Hydrous Fe and Mn Oxides; Chemical Phases present in Drainage Sediment; Primary Secondary and Tertiary (First, second, third and fourth order streams) Streams; Drainage Geochemistry in Exploration and Mapping; Modern Methods in Drainage Geochemistry; Advantages of Regional Geochemistry; Ultraviolet minerals in Exploration; Geomorphology and development of drainage systems – Influence of Topography on dispersion.
- UNIT-II:** Drainage Geochemistry in Sample Media: 1. Stream sediments in Mineral Exploration: Definition of Stream Sediments; Stream Sediment as an exploration tool, Applications of Stream Sediment Geochemistry, Size fractions and physical and chemical subsamples of Stream sediment; 2. Heavy Mineral Concentrates in Geochemical Exploration: Panning Technique, Characterisation of lithologies and Element assemblages with heavy mineral concentrates, Pathfinder minerals; 3. Lake sediment sampling in mineral exploration: pH, Carbon dioxide, dissolved solids, Element mobility, Composition of Lake Sediment, Sampling method, preparation and analysis; 4. Natural waters as sampling medium in Drainage Geochemistry: a. Major Element solutes- Major element abundances in natural waters as reflections of lithologies in the drainage path, b. Trace Element Solutes – Trace Elements leached from ore and associated minerals
- UNIT-III:** Major Sources of Contamination and their impact on drainage samples: Drainage Geochemistry in Contaminated Terrain: Urban Development, Transport, Metalliferous Mining and Smelting, Extraction and Combustion of Fossil Fuel, Agriculture and Forestry; Identification and discrimination of Contaminated samples; Diagnostic Signatures of Contaminants. Application of Drainage Geochemistry: Drainage Geochemistry in A. Gold Exploration; B. Uranium Exploration C. Diamond Exploration
- UNIT-IV:** Geochemical Drainage Surveys: A. Orientation Surveys: Water (Hydrogeo-chemical dispersion patterns), Fine Drainage Sediment (Hydromorphic Dispersion Patterns), Coarse Sediments (Mechanical dispersion patterns) and contamination; B. Choice of Material to be sampled: Water Seepage soils, Stream Sediments, Heavy minerals, Organic Sediment, Lake sediment and Water; C. Sample Layout – Groundwater Patterns, Drainage Channel Patterns; D. Collection and Processing Samples: Water, Stream and Seepage Sediment, Lake Sediment, Heavy Minerals; E. Preparation of Maps; D. Interpretation of Data; G. Data Reduction and Presentation – Single Element Data Reduction, Multi Element Data Reduction F. Follow up Techniques.

### **REFERENCES**

Arthur W.Rose, Herbert E.Hawkes and John S.Webb, (1979): Geochemistry in Mineral Exploration. 2nd edition. Academic Press.  
A.A.Levinson, (1974): Introduction to Exploration Geochemistry, Applied Publishing Ltd. USA.  
Hale, M., Plant, J.A., 1994. Handbook of Exploration Geochemistry – Drainage Geochemistry, vol 6, Elsevier Scientific Publishing company  
W.K.Govett, S.J.Hoffman, M.B.Merthens, A.J.Sinclair and I.Thomson, (1987): Exploration Geochemistry, Design and Interpretation of Soil Survey, Reviews in Economic Geology, Vol.4

Sinha, R.K, 2004: A treatise on industrial minerals of India. CBS Publishers, New Delhi  
K.K.Chatterjee, (1993): An Introduction to Mineral Economics. Wiley Eastern limited  
H.S. Ranawath: Mineral Specifications

#### **PAPER IV (AG 304 T): MINERAL EXPLORATION & MINERAL ECONOMICS**

- UNIT-I:** Geological Exploration: Geological prospecting methods and indications: Geological Ground prospecting methods – Prospecting for outcrops(Gossans), Important features for the identification and distinguishing between true gossans, false gossans and laterite based on colour, structural and textural characters, Prospecting for mechanical aureoles (haloes) of ore fragments; Importance of Geological mapping and prospecting; Fluorescent minerals under short Wavelength (2,500 A) Ultraviolet light; Geological Criteria for ore prospecting – Stratigraphical, lithological Structural, magmatogenic, Metamorphogenic, Geomorphologic criteria
- UNIT II:** Geochemical Exploration: Basic principles: Geochemical Environment - dispersion – mobility; geochemical reactions – Dispersion of Elements under deep seated conditions, mobility under surficial conditions; association of elements; patterns of Geochemical Distribution – Normal Background values,; Statistical distribution of background values, threshold values, geochemical anomalies; principles of Interpretation; pathfinder elements and minerals and geochemical signatures
- UNIT III:** Geophysical Exploration: The role of Geophysics in recognition of potential areas; Geophysical Methods and targets; Airborne, Magnetic, Gravity, Radiometric, Resistivity, Electromagnetic, Seismic, SP, IP surveys; Environmental Geophysics
- UNIT-IV:** Mineral Economics: Introduction, concept and importance; Minerals significance in National Mineral economy, demand and supply; Conservation and substitution of minerals; International status of mineral trade, supply, demand, monopolies, embargo and cartels; Strategic, Critical, and Essential Minerals; Mineral legislation-NMDR-2016, Mineral concession rules (MCR)2016, Mineral Evidence Rule -2016, NMET Rules etc., taxation system, Mineral Exploration policy.

#### **REFERENCES:**

Mloskuzvart and MiloslarBohmer, 1986. Prospecting and exploration of mineral deposits, Elsevier  
Sterling Gleason, 1972. Ultraviolet guide to minerals  
J.H.Reedman, (1979): Techniques in mineral exploration. Applied Science publishers  
Arthur W.Rose, Herbert E.Hawkes and John S.Webb, (1979): Geochemistry in Mineral Exploration. 2nd edition. Academic press  
A.A.Levinson, (1974): Introduction to Exploration Geochemistry, Applied Publishing Ltd. USA  
W.K.Govett, S.J.Hoffman, M.B.Merthens, A.J.Sinclair and I.Thomson, (1987): Exploration geochemistry, Design and interpretation of soil survey, Reviews in economic geology, Vol.4  
Sinha, R.K., and Sharma, N.L., 2000: Mineral Economics. CBS Publishers, New Delhi  
Sinha, R.K, 2004: A treatise on industrial minerals of India. CBS Publishers, New Delhi  
K.K.Chatterjee, (1993): An Introduction to Mineral Economics. Wiley Eastern limited  
H.S. Ranawath: Mineral Specifications

#### **PRACTICALS:**

##### **PAPER I (AG 351 P) : ORE IDENTIFICATION**

1. Megascopic identification of important ore minerals
2. Microscopic identification of important ore minerals

3. Identification of Fluorescent minerals

**PAPER-II (AG 352 P) : ORE RESERVE ESTIMATION**

- A. Geometric methods –
  1. Extended Area Method
  2. Included Area Method
  3. Polygon Method
  4. Triangular Method
- B. Graphic methods: Isocore maps, Stratum contours, Transverse contours.
- C. Estimation of Hydrocarbon reserves

**PAPER III (AG 353P): GEOCHEMICAL COMPUTATIONS & DATA PROCESSING**

1. CIPW Normative calculations
2. Mineral formula recalculations
3. Interpretation of Geochemical major element data using Tri-linear, Harker type variation diagrams
4. Interpretation of REE data
5. Spider diagrams
6. Estimation and interpretation of univariate statistical parameters
7. Preparation of geochemical maps and interpretation
8. Estimation of inter-element correlations
9. Cluster analysis
10. Principal Component Analysis
11. Factor Analysis

## IV SEMESTER

### ***THEORY:***

#### **PAPER I (AG 401 T) : EXPLORATION GEOCHEMISTRY**

- UNIT-I:** Geochemical Exploration: Basic principles: Geochemical Environment - dispersion – mobility; geochemical reactions – Dispersion of Elements under deep seated conditions, mobility under surficial conditions; association of elements; patterns of Geochemical Distribution – Normal Background values,; Statistical distribution of background values, threshold values, geochemical anomalies; principles of Interpretation; pathfinder elements and minerals and geochemical signatures. General procedure of Geochemical Survey; Geochemical sampling techniques: Litho-pedo-hydro-bio and atmo-geochemical sampling; Stream sediment and Heavy mineral sampling; Geochemical Conceptual Models.
- UNIT-II:** Primary Environment – Introduction, Distribution of Elements in Igneous rocks, Primary halos and Primary Dispersion, Pathfinders-Elemental and Mineral Pathfinders, Indicators, Geochemical Provinces and Associations; Primary Dispersion – Introduction, Primary dispersion on a regional Scale – Geochemical Provinces; Primary dispersion on a local Scale – detailed patterns, Trace Element content of Minerals, Fluid Inclusions, association of Elements
- UNIT-III:** Secondary Environment: Introduction, Chemical and Physical weathering, soil (soil profiles and their trace elements), Application of pH and Eh, Adsorption, Mobility of elements in Secondary Environment, Groundwater Aquifers and trace element transport. Secondary dispersion: Introduction, Displaced anomalies, Physical form and classification of secondary dispersion patterns, Mechanical dispersion, Hydrogeochemical indicator elements for different types of deposits; Concept of Adsorption and importance and application of hydrous Iron and Manganese oxides
- UNIT-IV:** Patterns of Deep seated origin – Ore types, Geochemical Provinces and Productive plutons: Classification of Mineral deposits – ore forming processes, geochemical recognition of ore types; Productive Environment of deep-seated origin; Geochemical and Metallogenic provinces: Ores related to Productive plutons – Ores related to granitic rocks, Basemetal Sulphide deposits, Molybdenum-Tungsten and gold deposits. Geochemical Conceptual Models, Geochemical Signatures

### ***REFERENCES***

- Arthur W.Rose, Herbert E.Hawkes and John S.Webb, (1979): Geochemistry in Mineral Exploration. 2nd edition. Academic press.
- A.A.Levinson, (1974): Introduction to Exploration Geochemistry, Applied Publishing Ltd. USA.
- G.J.S.Govett, (1983):Rock Geochemistry in Mineral Exploration Vol.3. Elsevier Scientific publishing company.
- Hale, M., Plant, J.A., 1994. Handbook of Exploration Geochemistry – drainage geochemistry, vol 6, Elsevier scientific publishing company.
- J.H.Reedman, (1979): Techniques in Mineral Exploration. Applied Science publishers.
- A.P.Solov, (1987): Geochemical prospecting. Mir publishers. Moscow.
- W.K.Govett, S.J.Hoffman, M.B.Merthens, A.J.Sinclair and I.Thomson, (1987): Exploration geochemistry, Design and interpretation of soil survey, Reviews in economic geology, Vol.4
- D. Bhaskar Rao (Editor) 2001, Nuclear Materials Issues and Concerns, Volume 1 & 2, Discovery PublishingHouse, New Delhi.
- International Atomic Energy Agency, Radioactive Waste Management: An IAEA Source Book, IAEA, Vienna (1992).
- U. Aswathanarayana – Principles of Nuclear geology, Oxonian Press Pvt Ltd, New Delhi.

## **PAPER II (AG 402T) : HYDROGEOLOGY & HYDROGEOCHEMISTRY**

**UNIT-I:** Groundwater in Hydrologic cycle, Occurrence of Groundwater: Aquifer, Aquiclude, Aquifuge and Aquitard, Porosity, Effective porosity, Vertical distribution of Groundwater; Zone of aeration, zone of saturation, Division of subsurface water. Specific retention, specific yield, Storage coefficient. Water movement in saturated soils, Darcy's law. Permeability, Intrinsic permeability. Hydraulic conductivity, Transmissivity, Determination of Hydraulic conductivity. Water wells: Dug wells, Bored wells, Driven wells, Jetted wells, Methods for drilling deep wells, Well design, Well completion, Well development, pumping equipment, Protection of wells, Well rehabilitation and Horizontal well.

**UNIT-II:** Introduction to Geophysical exploration – general principles, advantage and disadvantages; Classification of geophysical methods – passive, active methods; Application of geophysical exploration techniques to groundwater exploration their methodology, instrumentation and survey principles (without mathematical treatment). Electrical and Electromagnetic methods: Basic principles and their concepts (without mathematical treatment), instruments and survey principles. Basic concept of profiling and sounding, electrode configurations – Wenner, Schlumberger, dipole-dipole. Curve matching techniques for interpretation – Auxiliary and direct curve matching (without mathematical treatment). VLF and IP methods. Applications of electrical methods for groundwater exploration.

**UNIT-III:** Hydrogeochemistry, The water molecule, isotopic composition of waters-physical and chemical properties of water, geochemical processes, geochemical classification of waters, Mechanisms controlling the groundwater chemistry. Chemical dissolved constituents. Sampling of water from rivers, lakes, ponds, open wells, bore wells. Standard laboratory techniques for the analysis. Bacteriological studies. Interpretation of physical and chemical data of water, plotting on maps, Statistical techniques in presenting hydrochemical data.

**UNIT-IV:** Watershed Management: Watershed: Concept, Characteristics, Size, Shape, Physiography, Climate, Drainage, Land-use, Hydrological parameters. Basic data collection, Integrated Study of Watershed Management. Conditions to develop watershed, types of Watersheds, Integrated studies to develop watersheds. Rain water structures, design and Economic aspects. Floods: flood elevation, Flood discharge, flood volume and duration of floods, Flood estimation, causes of flood, factors affecting flood flow, flood flow determination flood control methods, limitations of flood control measures, Flood routing. Watershed and Agricultural Practices, National projects, Appropriate Technology and action plans, Post-operative problems of watersheds.

### **REFERENCES:**

- Karanth (1980): Courses in Mining Geology, Second Ed, Oxford and IBH Pub. Co.  
Todd David Keith (2008): Ground water Hydrology  
James I Drever (1982): The geochemistry of natural waters- Prentice-Hall-  
Williams J Deutsch- Lewis (1997): Groundwater Geochemistry- Fundamentals and applications to contamination- pub.

## **PAPER III (AG 403 T): GEOCHEMISTRY IN HYDROCARBON EXPLORATION**

**UNIT I:** Surface geochemistry in petroleum exploration-Introduction; History of Surface Geochemistry; Survey design for surface geochemical program- Search area, Targets, and Grid Interrelationships.

Concepts of Microseepage – migrating gases and fluids, reservoir seal rock, groundwater movement, hydrocarbon transport, types of transport-diffusion-compactional/meteoric-colloidal-effusion-permeation, Derived assumptions about vertical migration, conceptual model of microseepage

**UNIT II:** Methods of Microseepage Detection-Direct methods vs. Indirect methods; Soil Gas-methods of collection & analysis, Soil Gas composition, Soil conditions, Gas chromatographs; Soil Gas Onshore Methods- Free air or Soil-probe method; Head space method; Absorbed Hydrocarbons Methods; Time collection methods- Time-Delay method- K-V Finger print method; Groundwater and stream methods; Fluorescence methods; Airborne methods; Offshore Methods- sampling techniques; Soil-Gas Methods-advantages; Hydrocarbon Ratios and Predicting Petroleum Generation.

**UNIT III:** Methods of Microseepage Detection- Radiometrics- Natural Radioactivity; Mobility of Uranium and Thorium; Radiation anomalies, causes of Radiometric anomalies; Detection and measurements of Radiometric anomalies; Airborne method, Point method, Continuous method, Integrated Radon method, Free-Air Radon collection method; Interpretation of Data.

**UNIT IV:** Methods of Microseepage Detection- Halogens, halogen reactions, Process and factors affecting iodine accumulation; Major and minor elements- Trace Metals– stable isotopes. Microbiological methods, microbial activity, methane, ethane, propane – oxidizing bacteria, Iron, sulfide consuming bacteria. Helium Methods; pH/Eh methods.

**REFERECES:**

Hunt John, Petroleum Geochemistry and Geology. W.H. Freeman and company, 2<sup>nd</sup> edition.  
Tedesco A Stevens, Surface Geochemistry in Petroleum exploration. Chapman and Hall Publishing co.

[PROJECT ORIENTED DISSERTATION (in Lieu of One theory (P-IV) and One practical-P-III)]

**PRACTICALS:**

**PAPER I (AG 451P) : GROUNDWATER & GEOCHEMICAL EXPLORATION AND MODELING**

1. Electrical Profiling: Werner and Schlumberger methods
2. EM methods: VLF EM method
3. Geochemical Iso-concentration contour maps
4. Geochemical Exploration problems with Type areas
5. Interpretation of Geochemical data using Probability graphs
6. Half Life Problems
7. Geochemical modeling problems
8. Problems on Isotope Geochemistry
9. Grid sampling

**PAPER – II (AG 452P) : HYDROGEOCHEMICAL ANALYSIS**

1. Samples preservation techniques
2. Preparation of standard solution
3. Determination of pH
4. Electrical Conductivity
5. Dissolved Oxygen,



6. Titrimetric methods,
7. Determination of Carbonates, Bicarbonates
8. Total hardness
9. Chloride, Calcium, Magnesium
10. Determination of Sodium and Potassium by flame photometry
11. Determination of Sulphates by Nephelometer
12. Fluoride, Nitrates by Ion selective electrode method

**PAPER III (AG 454PJ): PROJECT ORIENTED DISSERTATION (150 Marks, 6 Credits)**  
**[in Lieu of One theory(P-IV) and One practical (P-III)]**

Each student should take up an independent dissertation topic and complete under the guidance of a supervisor. The selected topic should be within the scope of specified branches of Applied Geochemistry with clear innovative concept. Each dissertation should consist of suitable objective criteria with relevant methodology followed by the results achieved and meaningful interpretation.

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