

University of Pune

Two Year M. Sc. Degree Course in

GEOLOGY

M.Sc. Part II Syllabus (Credit System)

(To be implemented from Academic Year 2014-15)

Equivalence of previous syllabus along with proposed syllabus.

EQUIVALENCE				
Semester	Present Course		Proposed Course	
	Course code	Course Name	Course code	Course Name
III	GL-301	Indian Stratigraphy - Compulsory (Departmental)	GL 301	Indian Stratigraphy Compulsory (Departmental)
	GL-302	Exploration methods	GL 302	Exploration Methods
	GL-303	Petroleum Geology	GL 303	Petroleum Geology
	GL-304	Engineering Geology and Geotechniques	GL 304	Engineering Geology and Geotechniques
	GL-305	Computer Applications in Geology and GIS	GL 308	Application of GIS& Statistics in Geology (2 Credits)
	GL-306	Natural Resource Management & Oil field Services	GL 310	Natural Resource Management (2 Credits)
			GL 311	Oil field Services (2 Credits)
GL-307	Practicals related to above courses –Compulsory (Departmental)	GL 305	Practicals related to remaining theory subject totaling to 8 theory credits. (4 Credits)	
IV	GL-401	Economic Geology	GL401	Economic Geology (4 Credits)
	GL-402	Mining Geology, Gemmology and Industrial Mineralogy	GL402	Mining Geology (2 Credits)
			GL 409	Gemmology (2 Credits)
	GL-403	Environmental Geology	GL403	Environmental Geology (4 Credits)
	GL-404	Hydrogeology, Water Shed Development & Management	GL404	Hydrogeology, Watershed Development and Management (4 Credits)
GL-405	Dissertation	GL408	Dissertation (4 Credits)	

	GL-406	Field Work Component – Compulsory (Departmental)	GL 107 GL 207 GL 307 GL 407	Fieldwork component (1 credit) Fieldwork component (1 credit) Fieldwork component (1 credit) Fieldwork component (1 credit)
	GL-407	Practicals related to above courses- Compulsory (Departmental)	GL-405	Practicals related to GL-401 (4 theory credits) and those chosen subjects totaling to 4 theory credits.(4 Credits)

M.Sc. Geology - Course structure & Credit Distribution

Semester I (All courses compulsory)

GL 101: Mineralogy (4 Credits)

GL 102: Principles of Stratigraphy and Paleontology (4 Credits)

GL 103: Physics and Chemistry of the Earth (4 Credits)

GL 104: Sedimentology (4 Credits)

GL 105: Practical related to courses GL 101 & GL 102 (4 Credits)

GL 106: Practical related to courses GL 103 & GL 104 (4 Credits)

GL 107: Fieldwork component (1 credit)

Semester II (All courses compulsory)

GL 201: Igneous Petrology (4 Credits)

GL 202: Metamorphic Petrology (4 Credits)

GL 203: Structural Geology and Tectonics (4 Credits)

GL 204: Geomorphology and Remote Sensing in Geology (4 Credits)

GL 205: Practical related to courses GL 201 & GL 202 (4 Credits)

GL 206: Practical related to courses GL 203 & GL 204 (4 Credits)

GL 207: Fieldwork component (1 credit)

M.Sc.II Proposed Syllabus

Semester III

- GL 301: Indian Stratigraphy (4 Credits) **(Compulsory)**
- GL 302: Exploration Methods (4 Credits)
- GL 303: Petroleum Geology (4 Credits)
- GL 304: Engineering Geology and Geotechniques (4 Credits)
- GL 305: Practicals related to GL-301 (4 theory credits) and those chosen subjects totaling to 4 theory credits.(4 Credits) **(Compulsory)**
- GL 306: Practicals related to remaining theory subject totaling to 8 theory credits. (4 Credits) **(Compulsory)**
- GL 307: Fieldwork component (1 credit)
- GL 308: Application of GIS& Statistics in Geology (2 Credits) **(Compulsory)**
- GL 309: Marine Geology and Oceanography (4Credits)
- GL 310: Natural Resource Management (2 Credits)
- GL311: Oil field Services (2 Credits)

Semester IV

- GL 401: Economic Geology (4 Credits) **(Compulsory)**
- GL 402: Mining Geology (2 Credits)
- GL 403: Environmental Geology (4 Credits)
- GL 404: Hydrogeology, Watershed Development and Management (4 Credits)
- GL 405: Practicals related to GL-401 (4 theory credits) and those chosen subjects totaling to 4 theory credits.(4 Credits) **(Compulsory)**
- GL 406: Practicals related to remaining theory subject totaling to 8 theory credits. (4 Credits) **(Compulsory)**
- GL 407: Fieldwork component (1 credit) **(Compulsory)**
- GL 408: Dissertation (4 Credits)
- GL-409: Gemmology (2 Credits)

GL 410: Applied Micropalaeontology (2 Credits)

GL 411: Sequence Stratigraphy (2 Credits)

M.Sc.-II: GEOLOGY- SEMESTER-III

GL-301: INDIAN STRATIGRAPHY (4 Credits)

Unit-1: PRECAMBRIAN STRATIGRAPHY OF PENINSULAR INDIA: (15)

Part-I: Archaeans:

Precambrian Stratigraphic framework of India.

Archaean Stratigraphy of Dharwar Craton.

Archaean Stratigraphy of Bastar Craton.

Archaean Stratigraphy of Singbhum Craton.

Archaean Stratigraphy of Aravalli Craton

South Granulitic Terrain

Precambrian Mobile belts

Unit-2: PRECAMBRIAN STRATIGRAPHY OF PENINSULAR INDIA: (15)

Part-II: Proterozoic

Archaean –Proterozoic boundary.

Stratigraphy, tectonics , Depositional Environment and Correlation of the following Proterozoic basins/ Purana formations in India:

Aravalli Supergroup ,

Delhi Supergroup

Singbhum Group

Sausar Group

Sakoli Group

Vindhyan Basin

Cuddapah Basin

Pranhita-Godavari Basin

Bhima Basin

Kaladgi Basin

Unit-3: STRATIGRAPHY OF THE EXTRA PENINSULAR REGION: (15)

Archaean of the Extra Peninsular Region

Paleozoic sequences of Himalaya from Spiti, Kumaon region.

Triassic of Spiti & Pin Valley.

Geology of the Indus –Suture Zone,

Geology of the Shyok –Suture Zone,

Stratigraphy of North-Eastern region of India

The Trans-Himalayan and Karakoram Granite Batholith.

Stratigraphy and tectonics of the Siwaliks.

Unit-4: PHANEROZOIC STRATIGRAPHY OF THE PENINSULAR REGION: (15)

Gondwana Sequence

Jurassic of Kachchh & Rajasthan

Cretaceous of Narmada valley/ Bagh Beds,

Cretaceous of Tamilnadu and Meghalaya

Cretaceous-Tertiary Boundary

Deccan Volcanic Province.

Cenozoic of Western India(on shore –off shore) & Assam

Quaternaries of Peninsular India.

GL-302: EXPLORATION METHODS (4 Credits)

Unit-1: GRAVITY AND MAGNETIC METHODS: (15)

Gravity method- Introduction to Gravity Method and gravity Anomalies, Principles behind gravity method ,Relative measurement of earth's gravity,Types of Gravimeters-Field procedure corrections to gravity data- Concept of Bouguer Anomaly- Generalised interpretation of Gravity data- Salient Case Studies.

Magnetic Method- Introduction to Magnetic Method and magnetic Anomalies, Principles of magnetic method- Magnetic field associated with the earth- Concept of total field

intensity, Intensity of magnetization and magnetic susceptibility, measurement of magnetic field- Types of magnetometers- Magnetic anomalies and their interpretation- Salient Case Studies.

Unit-2: SEISMIC AND ELECTRIC METHODS (I): (15)

Seismic Method- Introduction to Seismic Method and Seismic Anomalies, Principles of seismic method, Types of seismic waves, movement of seismic waves within subsurface- Seismic instruments and field procedures.

Seismic Reflection Method- Principles of reflection method- Zero offset time- NMO-CDP and Multiple coverage techniques.

Seismic Refraction Method- Principles of refraction method, Single and multiplayer refraction, Measurement of Seismic velocities and layer thickness.

Processing of Seismic data- Salient Case Studies.

Electric Method- Introduction to Electric Method and Geophysical Anomalies Principles of Electrical method- Electrical properties of rocks.

Resistivity Method-, Factors controlling resistivity of rocks, measurement of resistivity- Electrode configurations and field procedures- Interpretation of resistivity data- Salient Case Studies.

Self-potential Method- Origin of self-potential instrumentation and field procedure- Salient Case Studies

Unit-3: ELECTRICAL METHODS II: (15)

Induced polarization method- Electrolytic and electrode polarization- Instruments and field procedure- Salient Case Studies.

Electromagnetic method- Principles- Instruments- Parallelline and Horizontal loop method Salient Case Studies.

Magnetotelluric Methods- Principal, Instruments-field Procedure –Salient Case Studies.

Ground Penetrating Radar- Principal, Application.

Unit-4: GEOCHEMICAL METHODS: (15)

Geochemical methods- introduction to geochemical prospecting

Concept of geochemical Anomaly

Geochemical cycle- Primary and secondary environments, Dispersion patterns.

Geobotanical indicators of minerals.

Surface and subsurface methods of sampling-e.g. Soil sampling for Hydrocarbon.

Case studies – e.g.Diamond ,Oil etc

GL-303: PETROLEUM GEOLOGY (4 Credits)

Unit-1: ORIGIN AND OCCURRENCE OF PETROLEUM: (15)

Origin of Petroleum (Kerogen & Biomass) ,

Organic and inorganic occurrence.

Chemical Classification and composition of Petroleum, oilfield water

Physical properties of petroleum.

Unit- 2: SOURCE, MIGRATION, RESERVOIR, TRAPS AND SEALS : (15)

Nature of source rock.

Reservoir rock, pore space and fluids.

Reservoir, types of traps and seals.

Origin, migration and accumulation of petroleum.

Unit 3: GLOBAL SCENARIO OF PETROLEUM INDUSTRY: (15)

Overview of all Petroliferous basins of the world

Economics of Petroleum industry

Energy Scenario and unconventional resources- CBM, Shale Gas.

Unit-4: PETROLOIFEROUS BASINS OF INDIA (15)

Oil bearing basins of India (in brief).

India's position as regards to petroleum and natural gas and its future prospects.

GL-304: ENGINEERING GEOLOGY AND GEOTECHNIQUES (4 Credits)

Unit-1: INTRODUCTION TO ENGINEERING GEOLOGY: (15)

Scope of Engineering Geology.

Engineering properties of rocks.

Methods of determining engineering properties of rocks.

Behavior of rocks under stress.

Rock failure mechanisms.

Engineering properties of soils.

Methods of soil investigations.

Unit -2: GEOTECHNICAL STUDIES (15)

Introduction to following methods and concepts.

Types of bits, Drilling in geotechnical field, core boxes

Rock Quality Designation (RQD) and Core Recovery (CR)

Core logging and bore logging ,RMR(Rock Mass Rating) (Bienawiski, 1989)

Types of foundations and Safe Bearing Capacity ,Introduction to Piling

Packer Permeability Test (P.P.T)., Standard Penetration Test and its types.(S.P.T.)

California Bearing Ratio (C.B.R.) and Proctor Density ,Plate Load Test (P.L.T.)

Electric Resistivity Test (E.R.T.) ,Laboratory Equipments and their uses

Uniaxial compressive strength.(U.C.S.), Point Load. (P.L.), Triaxial Apparatus for Soil/Rock., Uses of oven,C.B.R. Equipments ,Drilling Equipments.

Unit-3: GEOLOGY OF ENGINEERING STRUCTURES (15)

Geological considerations for the selection of sites.

Dam sites and types of Dams and Spillways.

Forces acting on Dam wall.

Reservoir competency.

Silting of reservoirs.

Tunnels: Tunnel sites and Tunnel alignment.

Bridges, Y ducts Roads and similar structures.

Unit-4: GEO-TECHNIQUES

(15)

Slope Stability Analysis

Applications Remote Sensing in Engineering Geology

Types of Synthetic materials used as remedial measures.

Estimation of Over-burden thickness and Rock strata classification.

Preparation of Report and Presentation of Engineering data.

Building Stones and Road Material

Aggregates: Classification, Aggregate resources development, Requirement of Primary fragmentation. Planning of quarry, Hill slope or open pit, Removal of over-burden and its disposition at suitable site, Selection of drilling, blasting method for main blasting and secondary breaking for given size fragmentation, Selection of equipments for drilling, hauling to crusher site.

GL 305: Practicals related to GL-301 (4 theory credits) and those chosen subjects

Totaling to 4 theory credits. (4 Credits)

(Compulsory)

GL 306: Practicals related to remaining theory subject totaling to 8 theory

Credits. (4 Credits)

(Compulsory)

A) Practicals for GL-301: (2Credit)

Study of typical hand specimens of rocks from different lithological units of Indian Stratigraphy.

Study of Palaeogeographical maps of India for different geological periods.

Study of geological maps of different units of Indian Stratigraphy.

Interpretation of regional geological maps.

B) Practicals for GL-302: (2Credit)

Study of patterns of geophysical responses from various geological mediums.

Plotting a Drift curve for an observed gravity data to which an elevation correction is applied, Plotting and interpretation of gravity profiles, Simulations of causative bodies.

Study of maps related to Gravity and Magnetic anomalies

Analysis of seismic refraction data for velocities and thickness of sub-surface layers.

Plotting, collection and interpretation of resistivity data.

Analysis of self-potential data.

Simple interpretation of geophysical well logs.

C) Practicals for GL-303: (2Credit)

Ratio maps.

Preparation of Structural contour maps.

Preparation of Isopach maps.

Preparation of Carbonate concentration maps with lithology.

Correlation of electrical logs.

Interpretation of different geological cross-sections from well data.

Study of Porosity and Permeability.

D) Practicals for GL-304: (2Credit)

Various methods of Surveying used in engineering geology.

Plane table surveys, use of dumpy level and theodolite.

Magnetic Compass Survey.

Demonstration of engineering properties of geological materials.

Interpretation of bore-hole data.

Preparation of bore logs/ lithologs/RQD/RMR.

E) Practicals for GL-308: (1Credit)

Statistical data analysis in Geosciences.

Computation of various statistical parameters for a given data; student test, chi-square test; least square method; Statistical models;

Demonstration of Toposheet Projection

Demonstration of Image Processing, Unsupervised and Supervised Classification.

Preparation of vector database and maps:

Preparation of a raster database and map

Corrections of errors in GIS database

Geo processing of Vector data- clip, merge, union, intersect

Digital Terrain Model

Buffer Analysis- Point, Line, Polygon

F) Practicals for GL-309: (2Credit)

Reading coastal toposheets and hydrographic sheets

Preparing bathymetric cross-sections using Hydrographic sheets

Study of rocks of ocean floor

Plotting of distribution of major bathymetric and tectonic features in the global oceans

Identification of oozes and authigenic sediments

Study of hand-specimens and thin sections of beach rocks

Distribution and plotting of carbonate and siliceous oozes, glacio-marine, pelagic clay and volcanogenic sediments in global oceans

Grain-size analysis using pipette method

Assigning different kinds of marine sediments to different bathymetric settings

Study of important global surface and deep water currents, with special emphasis on the 'Conveyor Belt'

G) Practicals for GL 310: (1Credit)

Introduction to the methods of Environmental Impact assessment- geological aspects

Assessment of Soil – Water – Energy Mineral Resources

Delineation of natural resources by using remote sensing techniques

Study of physical properties of Coal

Study of physical properties of Atomic/Radioactive Minerals

H) Practicals for GL-311: (1Credit)

Description and identification of well cuttings based on physical properties, calcimetry and fluorescence.

Percentage lithology and Master log preparation.

Gas curve identification and gas ratio plotting.

Description of core samples.

Wire line log interpretation.

Well hydraulic calculations such as annular volume, lag time calculations.

Calculations of Shale factor and shale density.

GL-307:- Fieldwork Component (1credit)

GL-308: APPLICATION OF GIS & STATISTICS IN GEOLOGY (2 Credits)

Unit-1: Introduction to Statistical Analysis (15)

Introduction to Probability: random experiments, events, sample space, definition of probability. Baye's theorem; Random variables, discrete and continuous probability distributions; Binomial, Poisson, Normal, Gamma, Exponential, Hypergeometric, Multinomial, Chi-square, t and F distributions; Introduction to statistical inference: sampling distributions, point and interval estimation; Linear models: ANOVA; Linear and multiple regression; Introduction to multivariate techniques; PCA, factor analysis, linear discriminant analysis, classification; Application of statistical techniques to earth sciences.

Unit-2: INTRODUCTION AND APPLICATION OF GIS (15)

Definition, Scope, History

GIS Technology & Applications

Conceptual model of Spatial information

Conceptual model of Non-spatial information

Digitization, editing & structuring of map data

Map Projections.

GIS data modes- Vector and Raster.

Vector based spatial analysis.

Raster based spatial analysis.

Digital Elevation Model and Application.

GL 309: MARINE GEOLOGY AND OCEANOGRAPHY (4 Credits)

Unit-1: Morphology, Stratigraphy and Tectonics of Oceans (15)

Geophysics & Ocean Morphology- Introduction and brief history of marine geology; Principal Topographic Features (Continental Margins, Continental Shelf, Continental Slope, Continental Rise, Abyssal Plains, Oceanic Ridges, Abyssal Hills, Trenches, Volcanic Arcs); Driving Mechanisms of Plate Tectonics; Seismicity and Plate Tectonics; Volcanism and Plate Tectonics

Marine Environments- Reefs, Estuaries & Coasts (Supratidal, intratidal, intertidal); Neritic and Oceanic Systems; Photic and Aphotic zones; Benthic Realm (Intertidal, Subtidal, Bathyal, Abyssal, Hadal); Pelagic Realm (Epi-, Meso-, Bathy-, abysso- and hado- pelagic).

Marine Stratigraphy- Primary objectives of marine stratigraphy; Lithostratigraphy, Biostratigraphy, Sequence Stratigraphy; Magnetostratigraphy (Oceanic Magnetic Stripes, The Palaeo-magnetic time scale, Age of Oceanic Crust, Magnetic Quiet Zone and Spreading Rate Differences and Temporal Oscillations); Oxygen-Carbon Isotope Stratigraphy; Chronostratigraphy (Varve Chronology, Tephrochronology)

Tectonic history of Oceans- How different oceans evolved over time (In brief)

Unit-2: Ocean Circulation (15)

Ocean Crust- Structure, Petrology and Sources of Oceanic crust; Origin and Differentiation of Magmas; Crustal changes after formation; Magnetization of Oceanic crust)

Ocean Circulation- Vertical and lateral stratification of the water column (Temperature, Salinity, Density distribution); Thermocline-Pycnocline; Oxygen Minimum Zone; Carbonate Compensation Depth, Aragonite Compensation Depth, Importance of Wind; Coriolis Effect; Geostrophic Currents; Ekman Spiral and Upwelling; Convergence and Divergence of winds; Surface Currents; Bottom water circulation (The Conveyor Belt)

Sea Level History and Seismic Stratigraphy- Importance of Sea-level changes and its causes; Quaternary Sea Level History; Coastal sea level changes and records; Seismic Sequence Stratigraphy and relative sea level changes

Near shore geological processes and the continental shelf- Sediment disequilibrium in coastal zone; Coastal dynamics (Waves, Tides Currents coastal environments of deposition and erosion (estuaries, lagoons, beaches); Continental Shelf (Topography and Sedimentation)

Unit-3: Ocean Margins and Oceanic Sediments (15)

Continental margin types: Divergent, Convergent and Transform margins, their development, characteristics and geographic distribution

Terrigenous deep sea sediments: Size Classification and Compositional classification; global distribution; Gravity Transport (Fluidized sediment flow, grain flow, debris flow, turbidity flow); Submarine Canyons; Deep Sea Depositional Sites (Turbidity Fans, Deep Sea Fans, Abyssal Cones, Abyssal Plains); Hemipelagic Sediments; Deep Sea Clays; Wind-blown sediments; Volcanic Marine Sediments; Glacial Sediments; Extra-terrestrial sources of sediments

Biogenic and authigenic oceanic sediments: Carbonate Oozes and pelagic carbonate; Siliceous Oozes and Chert; Factors controlling distribution, preservation and dissolution of biogenic sediments; Sinking of Pelagic Sediments; Metal rich sediments and oxides; Poly-metallic nodules and Manganese Nodules, their formation and distribution; Phosphorites; Zeolites; Marine Barites

Unit-4: Trends in Geological Oceanography and Scope (15)

Techniques in marine sampling and mapping: Grab Sampling, Core Sampling (Box Coring, Gravity, Piston, Hydraulic Piston, Multi-coring, Vibro-coring); Seismic Mapping (Echo-sounding, Multi-beam echo-sounding), DSDP-ODP Programmes (Objectives and Agencies involved, accomplishments and future directions); Data Buoys and Early Warning Systems

Palaeoceanography & Quaternary Climate Change- Objectives, Deep sea records, Climatic change over geological time, concepts and proxies, Climatic cycles and their causes (Solar cycles, sea level variations, glaciations deglaciation); Patterns and causes of Quaternary Climate Change, Pleistocene Ice Sheets, LGM, Younger Dryas, Solar Cycles, Milankowich Cycle), Climatic variations in the Holocene

Coastal Hazards & Marine pollution- Tsunamites and climatic disasters, CRZ and geological implications of man-made changes (Industrial effluents and coastal development, Reclamation and habitat conversion of coastal land, coastal erosion, oil slicks and shipwrecks, environmental impact assessment); Placer and sand mining

Exclusive Economic Zones and status of mineral resources- (Oil & Natural Gas, Gas Hydrates, Poly-metallic nodules and Placer mineral deposits) and techniques and agencies involved in their exploration/exploitation

GL-310: Natural Resource Management (2 Credits)

Unit-1-INTRODUCTION TO NATURAL RESOURCES: (15)

Description of the Resources-soil, water, Mineral

Classification of the Natural Resources

Exhaustible resources- Minerals and Mining

Energy Resources- Oil, Natural Gas, Atomic minerals

Function and values of the resource

Supply and demand

Conflicts concerning the resource

Polices and legislation concerning natural resources

Unit-2-DEVELOPEMNT AND MANAGEMENT OF NATURAL RESOURCES: (15)

Management tools and techniques

Wetland definitions, classification, restoration, protection and construction

Wastewater treatment

Soil as resource, types of soils and methods of soil conservation

Coastal resources and Coastal Process

Coastal Zone Management

Application of Remote Sensing Techniques in resource Management

Environmental Impact Analysis

Mineral Resources: Conversation and Management

GL-311: Oil field Services (2 Credits)

Unit-1-Introduction to Oil Well Drilling: (15)

Types oil wells and geotechnical order

Methods of Oil well drilling: Cable tool drilling and rotary drilling

Components of rotary drilling system

Monitoring of drilling process i.e depth ROP, WOB, sampling.

Concept of Subsurface pressure.

Types of Drilling Rigs: Onshore and offshore rigs

Controlled Directional Rotary Drilling, Horizontal Drilling

Drilling Mud: Mud hydraulics, uses and functions of drilling mud.

Coring: Introduction, Techniques and Applications of Coring in Petroleum Geology.

Well logging- Techniques- Principles and instrumentation of electrical, radioactive, sonic, caliper logging techniques interpretation of logs.

Unit-2-Formation Evaluation: (15)

Wire line logs: Introduction Basic Principles, tools of SP, gamma ray, Neutron, Density, Caliper, Dipmeter, Temperature and Sonic Logs and their interpretation.

Mud logging: Principle, techniques and tools of mud logging. Interpretation of gas, drilling and mud parameters.

MWD (Measurement While Drilling)/LWD (Logging While Drilling): Principle and tools of MWD/LWD, data analysis and interpretation.

Formation (Drillstem) Testing: Introduction, Tools and Techniques of DST.

TEXT BOOKS FOR SEMESTER-III

Wadia: Geology of India and Burma.

Krishnam: Geology of India.

Naqui and Rogers: Precambrian Geology of India.

Saha A.K.: Crustal Evolution of Singhbhum North Orissa.

Geological Society of India: Purana Basins of India.

Geological Society of India: Quaternary of India.

Geological Society of India: Precambrian of the Aravalli Mountain.

Geological Society of India: Geology of the Central and Western India.

Geological Society of India: Geology of Karnataka.

Todd, D.K.: Groundwater Hydrology.

Karant, K.R.: Groundwater Assessment Development and Management.

Raghunath, H.M.: Groundwater.

Davis S.N. and Dewiest R.J.M.: Hydrogeology.

Freeze and Cherry: Groundwater.

Leverson: Geology of Petroleum.

Russel: Petroleum Geology.

Brown and Day: India's Mineral Wealth.

Dobrin: Introduction to Geophysical Prospecting.

Kearey and Brooks: An Introduction to Geophysical Exploration.

Soroie: Geology for Engineers.

Krynine and Judd: Principles of Engineering Geology and Geotechniques.

Rise and Wateson: Elements of Engineering Geology.

Faure: Principles of Isotope Geology.

Panigrahi D.C.: Mine Environment and Ventilation.

Singh B.: Blasting in Ground Excavation and Mines.

Sinha R.K.: Mineral Economic.

Goulelin: Ore Dressing.

Banter & Parks: Examination and Valuation of Mineral Property.

Macnestry: Mining Geology.

IADC: Primer of Oil Well Drilling.

Bhagwan Sahay: Mud Logging.

Person: Geological Well Drilling Technology.

Cray and Cole: Oil and Well Drilling Technology.

Kennedy: Fundamentals of Drilling.

Hearst and Nelson: Well Logging for Physical Properties.

Shenk T.M. and A.M.Franklin: 2001, Modeling in Natural Resource Management Development, Interpretation and Application, Island Press.

Wondolleck J.M. and S.L. Yaffee: 2000, Making Collaboration Work Lessons from Innovation in Natural Resource Management, Island Press.

Paine D.P.: 1981, Aerial Photography and Image Interpretation for Resource Management, John Wiley and Sons, New York, 571 p.

Richason B.F., Jr.: ed. 1978, Introduction to Remote Sensing of the Environment, Kendall/ Hunt Publishing Company, Dubuque, Iowa, 496 p.

Spurr S.H.: 1960, Photogrammetry and Photo-Interpretation. The Ronald Press Co., New York, 472 p.

Burroughs P.A.: (1986), Principles of Geographical Information Systems for Land Resources Assessment, Oxford University Press.

Environmental Systems Research Institute: (1993), Understanding GIS: The Arc Info Method Training Course for GIS for Resource Management and Development Planning

Government of India: Lecture Notes, VI: GIS Fundamentals and Techniques.

Berhardsen, Tor: (1999), Geographic Information Systems: An Introduction, John Willey and Sons.

Clarke, Keith C.: (1999), Getting Started with Geographic Information Systems, Prentics Hall.

Dermrs, Michael N.: (2000), Fundamentals of Geographic Information Systems, John Willey.

Haywwod, Ian: (2000), Geographical Information Systems, Longman.

Chang, Kang-taung: (2000), Introduction to Geographic Information Systems, Tata McGraw-Hill.

Rajaraman V.: Fundamentals of Computers.

Shrivastava C.: Fundamentals of information Technology.

Sinha Pradeep: Computer Fundamentals.

Pitman, J. (1993) Probability, Springer Verlag, (also Narosa Publishers).

Creighton, J.H.G. (1994) First course in probability models and statistical inference, Springer Verlag.

Davis, J.G. (1986) Statistics and data analysis in geology, John Wiley.

Walpole, R.E. and Myers, R.H. (1989) Probability and statistics for engineers and scientists, Macmillan Publ. Co.

Johnson, R.A. and Wichern, D.W. (1982) Applied multivariate statistical analysis, Prentice Hall Inc., New Jersey.

Cooley, W.W. and Lohnes, P.R. (1971) Multivariate data analysis, John Wiley and Sons.

Morrison, D.F. (1967) Multivariate statistical methods, McGraw-Hill.

Pandalai, H.S. and Saraswati, P.K. (Eds.) (2000) Geological data analysis: Statistical Methods. Hindusthan Publishing Corporation (India), New Delhi.

Spiegel, M.R. (1982) Probability and Statistics, Schaums Outline Series, McGraw-Hill Int., Singapore, Asian Student Edn.

Kubackova, L., Kubacek, L. and Kukuca, J. (1987) Probability and Statistics in Geodesy and Geophysics, Elsevier.

M.Sc.-II: GEOLOGY-SEMESTER-IV

GL-401: ECONOMIC GEOLOGY (4 Credits)

(Compulsory)

Unit-1: ORE FORMING PROCESS (I):

(15)

Scope and Application of economic geology.

Genetic classification of ore deposits- stratiform, stratabound, porphyry, VMS, sedex deposits.

Concept of the terms ore, gangue, grade, tenor, resources, reserves etc.

Mineralisation related to Plate tectonics, Structural controls on ore localization.

Broad tectonic setting magmatism associated with various types of ore deposits.

Magma and its relation to mineral deposits.

Ore forming fluids: Origin, Types, Nature and Migration and oxygen fugacity.

Magmas as ore forming fluids.

Hydrothermal fluids, Types, Composition and Transport, Wall rock alteration.

Physico-chemical principles of ore-deposition.

Primary and secondary ore forming process-Metallic & non-metallic Deposits ,Skarn and Greisen deposits

Unit-2: INDIAN ORE DEPOSITS (I):

(15)

Mode of occurrence, geological and geographic distribution, classification of the following mineral deposits.

Chromium

Iron

Manganese

Base metals- Lead and Zinc ,Copper, Molybdenum

Unit-3: INDIAN ORE DEPOSITS (II):

(15)

Mode of occurrence, geological and geographic distribution and of the following mineral deposits:

Gold

Aluminum (Bauxite)

Magnesite ,

Asbestos

Barite

Uranium

Coal

Carbonatites and rare earth elements

Introduction to Mineral Economics

Unit-4: INDUSTRIAL MINERALOGY: (15)

Industrial Mineralogy- Introduction to industrial specifications of raw materials used in following industries:

Ceramics , Cement, Refractories, Abrasive, Building Materials and Dimension Stones, Fertilizers, Paint & Pigments, Gemstones , Glass ,Electronics etc.- Outline of techniques used in testing raw materials.

GL-402: MINING GEOLOGY (2 Credits)

Unit I : GUIDES TO ORE AND DRILLING METHODS (15)

Ringed Target and Intersecting loci ,Regional and Topographical Guides-Pediments, Ranges, Oxidational Subsidence, Physiographic relation of Placer deposit, Residual deposits, Misleading outcrops

Mineralogical Guides- Rock alteration, Hydrothermal Alterations, Alterations due to intrusive bodies, Zoning, Epigenic hydrothermal zoning, Syngenetic hydrothermal zoning, Sedimentary Syngenetic sulphur zoning, Geochemical Zoning, Mineral Association, Oxidation Product, Significance of gangue minerals.

Structural Guides-Contact as guides, Fold as guides, Fault and fissures as guides

Stratigraphic Guides-Uranium mineralization, Time bound characteristics of Iron

Percussion Drills – Jumper bar drills- Pneumatic drills - Churn drills - Down hole drills

Rotary Drills –Auger drills -Colyx drills- Rotary drills using rock roller bit- Diamond drills

Miscellaneous Drills –Jet drills-High temp. flame drills- Banka drills (Empire drills)- Burnside drills, Soil sampling drills

Unit II: MINING METHODS – OPEN CAST AND UNDERGROUND CAST (15)

Alluvial Mining -Pan and beta method, Rocker method,Long Tom method ,Ground sluicing method, Hydrauliclicking, Dreadinging.

Open Cast Mining -Bench Mining methods, Open cast mining with loading by machinery (Dragline ,Power shovel, Multibucket excavator/ land dredger,Bucket wheel excavator .

Introduction to the terminologies used in exploration and exploitation of the ore in the mine -Mining methods ,Gophering method, Breast Stoping method, Open underhand stoping method, Open overhand stoping method, Underground glory hole mining, Room and pillar method, Sublevel stoping method, Shrinkage stoping method, cut and fill method

GL-403: ENVIRONMENTAL GEOLOGY (4 Credits)

Unit-1: INTRODUCTION TO ENVIRONMENTAL GEOLOGY AND SCOPE: (15)

Fundamental concepts of environmental geosciences, its scope and necessity.

Definition, structure, composition and general characteristics of lithosphere, hydrosphere, atmosphere and biosphere.

Biogeochemical cycles of carbon, nitrogen, phosphorus and sulfur.

Unit-2: ENVIRONMENTAL ISSUES: (15)

Water pollution and other Issues: Drinking water sources, quality criteria and standards,

Characteristics of water, Types of water pollution, Groundwater pollution source, Pathways and mechanism, Attenuation process, Case histories of natural (arsenic and fluoride poisoning) and manmade water pollution.

Soil pollution: - Soil salinity and alkalinity, Characteristics of saline/ alkali soils, Soil amendments. Soil pollution sources, causes and effects. Soil pollution control measures. Sand Mining, Solid Waste Management ,Rock water interaction, Eutrophication

Unit-3: NATURAL HAZARDS, RISK ASSESSMENT AND MANAGEMENT: (15)

Extreme events and hazards, Catastrophic geological hazards, Study of landslides- Subsidence, Floods, Droughts, Earthquake, Volcanoes, their causes and mitigation. Coastal hazards, cyclones, tsunamis and shoreline and sea level changes. Strategies for hazards mitigation.

Unit-4: MINING AND ENVIRONMENT: (15)

Mining and its impact on environment, Wastes from mining industry, Waste disposal methods, Acid mine drainage, Heavy metal pollution due to mining, Environmental impacts of coal utilization, Fly ash, recycling of resources and management.

GL-404 Hydrogeology, Groundwater Development and Management (4 Credits)

Unit 1: Hydrogeology

(15)

Concept of Hydrosphere, Groundwater and Watersheds- Scope and Importance(Uses) of Groundwater, Age of Groundwater

Hydrosphere -Evaporation, condensation, precipitation, interception, runoff, (surface and subsurface), infiltration

Factors that affect occurrence of Groundwater- Climate, Topography, Geology

Rock properties- Vertical distribution of groundwater, Porosity, Specific. Retention, Specific. Yield, Hydraulic conductivity

Concept of watersheds ,Groundwater Occurrence, Accumulation and Movement

Aquifer and Types of Aquifers

Aquifer Properties and concept of aquifer mapping

Behaviour of Sedimentary, crystalline, volcanic rocks and alluvium as aquifers- Factors controlling accumulation and movement in different rocks

Structural and Stratigraphic control on Groundwater

Unit 2: Well Hydraulics, Groundwater Quality and Distribution in India

(15)

Pumping tests-Principles, procedures, concept of well hydraulics and determination of aquifer properties and well characteristics by different methods

Types of tests: i) Well tests, ii) Aquifer Performance tests,iii) Slug tests.

Quality of Groundwater: Geochemical processes in groundwater, water types, classification-interaction of water, types of interaction-chemical, physical, kinematic, assessment of groundwater quality, Standards of Groundwater Quality

Springs Base flows-Losing and gaining streams

Groundwater in India ,Groundwater provinces in India ,Groundwater in Maharashtra State ,Concept of Groundwater legislation ,Groundwater policy

Unit 3: Groundwater: Exploration Techniques and Development

(15)

Exploration Techniques- Integrated approach in Groundwater exploration: Surface and subsurface logging, geophysical methods, Tracer techniques, Exploratory Bore well programme, Types of drills

Concept of Groundwater Monitoring-Groundwater survey, Well Inventory, Measurement of runoff, discharge, weather parameters etc.

Concept of watershed development in relation to groundwater resources- Salient features of development measures like contour bunding, gully plugs, stream bunds, percolation tanks, subsurface dams, vegetative measures etc. Significance of geology in watershed development measures, non-monsoon recharge techniques

Rainwater and rooftop harvesting codes, Sea water ingress

Unit 4: Groundwater Management (15)

Groundwater Balance equation for watershed (Groundwater assessment in a region)

Groundwater Budget (Village water audit)

Conjunctive use of surface and groundwater resources

Concepts of peoples participation in community based groundwater management, Case studies , Concept of Water User Groups, Case studies

Typology concept in groundwater management, Case studies

Role of NGOs in Groundwater development and management

National and State agencies and their role in Groundwater development and management ,Groundwater Modeling, Use of Computers

GL 405: Practicals related to GL-401 (4 theory credits) and those chosen subjects totaling to 4 theory credits.(4 Credits) (Compulsory)

GL 406: Practicals related to remaining theory subject totaling to 8 theory credits. (4 Credits) (Compulsory)

Practicals for GL-401: (2Credit)

Study of ores in hand specimens.

Preparation of charts showing distribution of importance of ore deposits in India.

Mineralogical and textural study of common ores under microscope.

Chemical analysis of ore minerals and assaying.

Megascopic characterization of banded coals.

Proximate analysis of coal.

Microscopic examination of polished coals (Identification of macerals in coal).

Study of physical properties of industrial minerals and materials required for different industries.

Preparation of charts showing specifications of materials required for different industries.

Practicals for GL-402: (1Credit)

Mine valuation and calculation by uniform spacing on rectangular co-ordinate method.

Included area problems related to valency.

Area influenced methods of combining irregular spaced assay.

Triangle grouping of irregular spaced assayed.

Veins problems (linear groups, minimum stoping widths).

Practicals for GL-403: (2Credit)

Water and Soil analysis.

Preparation of map showing hazards.

Preparation of hazards zonation maps e.g. Landslides, Earthquake

Practicals for GL-404: (2Credit)

Analysis of rainfall data.

Preparation of water level contour maps and their interpretation.

Analysis of pumping test data by simple graphical methods for determination of aquifer and well characteristics.

Plotting and analysis of hydro-geochemical data.

Hydro geological significance of morphometric parameters of a watershed.

Use of computer in groundwater data analysis.

Salient points for the construction of contour bunds, stream bunds, percolation tank subsurface dams etc.

Use of morphometric analysis in planning watershed development.

Calculation of water balance for a given watershed.

Practicals for GL-409: (1Credit)

Study of rough gemstones

Visual observation of gem stones for color, lustre, cut, optical phenomenon

Identification of Anisotropic and Isotropic gem stones by using dichroscope and polariscope

Use of 10 X lens, U.V.lamp and refractometer.

Use of gemological microscope to study inclusions in gemstones.

Study of organic gemstones

Study of rare gemstones

Study of imitations, stimulants, synthetics and composite stones.

Identification of natural gemstones from their simulants, imitations and synthetics.

Practicals for GL-410: (1Credit)

Techniques of separation of microfossils from matrix and preparation of slides.

Microscopic study of Calcareous, Siliceous, Phosphatic and organic walled microfossils.

Study of surface ultra-structures of microfossils.

Depth biotopes and estimation of paleo-depth using microfossil assemblages

Study of some important microfossils useful in Indian Stratigraphy with special reference to Cenozoic petroliferous basins of India.

Practicals for GL-411(1Credit)

1. Description of basic concepts in seismic and sequence stratigraphy.

2. Preparation of facies maps and facies diagrams.

3. Study of vertical profile sections of some selected sedimentary environments.

4. Study of significant system tracts.

GL 407: Fieldwork component (1 credit)**(Compulsory)****GL-408: DISSERTATION (4 Credits)**

Field studies, Laboratory studies/ data processing, reference work and presentation of the thesis are four major components of the course. Students opting for this course should adhere to the following procedure.

Precise title and outline of work is to be submitted to the Head of the Department.

The student shall spend about one week in the field.

The field work shall be carried out only during vacation or holidays, and in no case student will be permitted to remain absent from regular teaching on account of dissertation.

The student shall maintain field diaries and other records relevant to dissertation.

Every month the student shall submit the progress report and laboratory work done, through the supervisor to Head of the Department.

The student shall do dissertation at his own cost. The department will not spare funds for this purpose.

The student shall give a seminar before the submission of the dissertation.

The student shall submit the dissertation before the commencement of practical examination.

Non compliance of any of the above rules will disqualify students for grant of terms.

Three copies neatly typed on thesis size paper, well bound together with maps and illustrations of the Dissertation, on the basis of the work carried out by the student, will be submitted, through the supervisor concerned, to the Head of the Department of Geology, before the commencement of the practical examination, for being forwarded to the Board of Examiners.

In case of student receiving help (training and / or participation in ongoing research activities) from other Institution / Organization for their dissertation work, the associated scientist from that Institute/ Organization will function as co-supervisor.

Assessment of Dissertation will be out 100 marks and shall include a viva voce examination carrying 20 marks. The Dissertation will be examined at the time of the practical examination at the end of IVth Semester, by the board of examiners. The Board of Examiners will consist of supervisor, co-supervisor, Head of the Department and one teaching faculty member appointed by Head of Department in consultation with the supervisor.

GL-409: GEMMOLOGY (2 Credits)

Unit-1: Introduction and Gem Species

(15)

Introduction to Gems- Basic properties of gems- Formation of gems.

Description of following gem species with respect to their varieties (colour wise), Chemical composition, Crystal system, Physical and optical properties, Characteristic inclusions and Geographical Occurrences.

Corundum

Beryl

Garnet

Felspar

Silica

Tourmaline

Topaz

Spinel and Chrysoberyl

Opaque gem varieties.

Rare Gemstones (Peridot, kyanite, iolite, sphene, zircon, apatite etc)

Unit-2: Diamonds, Gem Synthesis, Treatments and Gem Identification (15)

Gem instruments and their use in gem stone identification (Hand lens, Dichroscope, Polariscope, Refractometer, Spectroscope, Microscope, UV light and X-rays)- Causes of colours in gem stones.

Treatments of gem stones and their detection.

Imitation and composite stones.

Gem synthesis and distinction between Synthetic and Natural gem stones.

Advance Techniques of gem Identification

Organic Gemstones

Diamonds

GL 410: APPLIED MICROPALAEONTOLOGY(2 CREDITS)

Unit –1 (15)

Applied Micropaleontology

Definition and scope

Surface and subsurface sampling methods,

Laboratory techniques in the study of microfossils (collection and processing techniques);

Equipments for micropaleontological studies

Latest Geological Timescale.

Calcareous Microfossils:

Foraminifera: Planktic foraminifera, outline morphology, biostratigraphic Significance, application in paleoceanographic and paleoclimatic interpretations; Benthic foraminifera, outline morphology and significance, application in bottom water paleoceanography and paleobathymetric reconstructions.

Calcareous algae: Calcareous algae (Rhodophyta and Chlorophyta): Classification, morphology and biostratigraphic significance; applications in Paleoenvironmental, paleogeographical and paleobathymetric interpretation.

Ostracoda: Brief classification, Outline morphology and biostratigraphic significance, application of Ostracods in Quaternary paleoceanographic and paleoclimatic studies.

Introduction to Bryozoa: Brief classification, Outline morphology and biostratigraphic significance (In brief).

Introduction to Calcareous Nannofossils, Outline morphology; biostratigraphic and paleoclimatic significance (In brief).

Introduction to Pteropods and Calpionellida and their significance (In brief).

Unit:2

(15)

Siliceous Microfossils:

Diatoms: Outline of morphology and classification, significance in paleolimnology/limnology, Paleo-oceanographic and biostratigraphic interpretations; Applications of diatoms in environment, climate study.

Introduction to Silicoflagellates and Radiolaria, their morphology and significance (In brief)

Organic walled Microfossils:

Pollens and Spores: Morphology and classification; Production, dispersal and sedimentation of palynomorphs; Applications of pollens in environmental, climate and forensic science studies.

Introduction to Acritarch , Dianoflagellates and Phytoliths; their morphology and significance (In brief)

Phosphatic Microfossils:

Conodonts: Outline of morphology; biostratigraphic and paleoclimatic significance (In brief)

Industrial and Environmental Applications:

Role of microfossils in hydrocarbon exploration,

Geochemical study of microfossil tests (stable isotopes, radiocarbon isotopes and elemental composition) and its application in paleoenvironment,

Paleolimnology, Paleoceanography and Paleoclimatology.

GL 411: SEQUENCE STRATIGRAPHY (2 CREDITS)

Unit 1: Introduction to sequence stratigraphy (15)

Historical Development, Interdisciplinary nature of sequence stratigraphy, Fundamental concepts of sequence stratigraphy: definitions and terminologies (accommodation space, Absolute and relative sea-level fluctuations, surfaces, system tracts, sequences, parasequences etc). Methods of Sequence Stratigraphic Analysis (introduction facies analysis: outcrops, core, and modern analogues, well logs, seismic data, Age determination, age determination techniques, workflow of sequence stratigraphic analysis)

Unit 2: Basic concepts of Base level changes, accommodation and shoreline

Shifts (15)

Base level cycles, allogenic controls on sedimentation: significance and signatures, sediment supply and energy flux, sediment accommodation (Definitions— Accommodation, Base Level, and Fluvial Graded Profiles, Proxies for Base Level and Accommodation, Changes in Accommodation), shoreline trajectories (Definitions, Transgressions, Forced Regressions, Normal Regressions), Stratigraphic surfaces: types of stratal terminations, sequence stratigraphic surfaces, system tracts (LST, TST, HST, FSST, RST, L&HAST).

TEXT BOOKS FOR SEMESTER-IV

- Craig and Vaughan: (1981) Ore petrography and Mineralogy, John Wiley.
- Mookherjee: (2000), Ore Genesis- A Holistic Approach, Allied Publication, New Delhi.
- Sawkins: (1984), Metal Deposits in relation to Plate Tectonics.
- Stanton: (1972), Ore Petrology, McGraw Hill, New York.
- Guilbert and Park: (1986), Geology of Ore Deposits.
- Taylor, et.al.: (1998), Organic Petrology, Gebruder Borntraeger, Stuttgart.
- Singh (ed): (1998), Coal and Organic Petrology.
- Chandra: (2000), Textbook of Coal (Indian context), Tara Book Agency, Varanasi.
- Dahlkamp: (1993), Uranium Ore Deposits, Springer Verlag, Berlin.
- Kennet: Marine Geology.
- Menard: Marine Geology.
- Krumbin and Graybill: An Introduction to Statistical Methods in Geology.
- Fergusson: Mathematics in Geology.
- Rajaraman V: Fundamentals of Computers.
- Tonge, Fred M.: Computing- Introduction to Procedures.
- Roger C. Parker: MS Office for Windows 95
- Tom Badgett: Compact Guide to Word.
- Dan Gookin: Word for Windows 95.
- Gerg Harvey: Excel for Windows 95.
- Rick Altman: Mastering Corel Draw 6.
- Jinger L. Simon: VB Script Superbible- The Complete Reference to Programming in Microsoft VB Scripting edition.
- Noel Jerke: Visuals Basic 6: The Complete Reference.
- John C. Davis: Statistics and Data Analysis in Geology.
- Association of Indian Universities: Handbook of computer Education.
- James H Earle: Graphics Technology.
- Keller: Environmental Geology.

Tank: Environmental Geology.

A.D. Howard and I. Remson: Geology in Environmental Planning.

Strahler and Strahler: Environmental Planning.

Ordway: Earth Science and Environment.

Turk and Turk: Environmental Geology.

K.S.Valdiya: Environmental Geology.

Bryant E.: Natural Hazards, Cambridge University Press.

Bell F.G.: Geological Hazards.

Smith K.: Environmental Hazards.

Dobrin M.: Introduction to Geophysical Prospecting.

Parasnis D.S.: Principles of Applied Geophysics.

Hawkes and Webb: Geochemistry in Mineral Exploration.

Telford: Applied Geophysics.

Dhravabaraya V.V., Sastry and Patnaik V.S.: Watershed Management.

IGNOU: Books on Disaster Management Course.

Traverse Alfred (1988) Paleopalynology, Unwin Hyman, USA.

Arnold (2002) Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett),

Oxford University Press, New York.

Bergland, B.E. (1986) Handbook of Holocene paleoecology and paleohydrology, John Wiley, NewYork

Bignot, G., Grahm and Trotman (1985) Elements of Micropaleontology, London. Jones, T.P. and Rowe, T.P. (1999) Fossil Plants and Spores Modern Techniques, Geological Society of London

Kathal, P.K. (2011). Applied Geological Micropaleontology, Scientific Publishers, Jodhpur. Kundal, P. and Humane, S.K. (Eds.) (2010) Applied Micropaleontology, Gondwana Geological Society, V. 24 (1).

Pipero, Doluges, R. (1988) Phytolith analysis: An Archaeobiological and Geological perspective, Academic Press.

Prothero, D.R. (2004) Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.), McGraw Hill.

- Seaward, A.C. (1991) Plant fossils, Today's and Tomorrow, New Delhi.
- Wray, J.L. (1977) Calcareous Algae, Elsevier.
- Haq and Boersma (1978) Introduction to Marine Micropaleontology, Elsevier.
- Kennett and Srinivasan (1983) .Neogene Planktonic Foraminifera: A phylogenetic Atlas, by, Hutchinson Ross, USA.
- R.W. Jones (1996) Micropaleontology in Petroleum exploration by R.W. Jones. Clarendon Press Oxford.
- Boggs, S. (2001): Principles of Sedimentology and Stratigraphy, Prentice Hall.
- Coe, Angela, Dan Bosence, Kevin Church, Steve Flint, John Howell and Chris Wilson (2002): The Sedimentary Record of Sea Level Change , Cambridge Univ. Press.
- Emery, D, (1996): Sequence Stratigraphy, Blachwell Scientific Publ.
- Miall, A.D. (1997): The Geology of Stratigraphic Sequence, Springer-Verlag.
- Reineck, H.E., and Singh, I.B. (1980): Depositional Sedimentary Environments, Springer-Verlag.
- Vail, P.R., Mitchum, R. M., Todd, R. G., Widmier, J. M., Thompson, S., Sangree, J.B., Bubb,J.N.andHatlid,
- W.G. (1977): Seismic stratigraphy and global changes of sea level: American Association of petroleum Geologists, Vol.26.
- Robert Webster, Gems,,2008, 6th edition
- P.G. Read ,Gemmology, Robert Hale &co
- R.V.Karant (2000) Gem & gem Industry in India,memoir 45, geological society of India, Bangalore
- Eric Bruton (1979) Dimonds , 2nd edition, chilton book co.
- B.W. Anderson (1979) , Gem Testing.