UNIVERSITY OF KERALA

Syllabus

MSc Geology with specialization in Geoinformatics

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University of Kerala

M.Sc. Degree Course in Geology with specialization in Geoinformatics

(Outcome-based education OBE syllabus)

(Effective from 2020 Admissions)

About the course

Need

In this time of global uncertainty over the Covid19 pandemic, and the disruptions in higher education it has wrought, through reduced ability to travel, and fewer opportunities for classroom teaching and learning, it is imperative that the young generation should be offered courses which are unconventional, but needed in today's world. The M.Sc. Degree Course in Geology with specialization in Geoinformatics is an outcome of such a thought process. Young geologists who are trained to tackle geological problems, offer solutions on the go and also make use of the latest spatial planning tools are an urgent need. This is especially so in the context of depleting natural resources, and multiplying natural disasters, amidst the philosophy of sustainable development. Also the course will bring in geoinformatics firmly into geology education, thereby enhancing the skill set of students.

Objectives

- Creation of a pool of skilled and technically qualified geologists who would be industry-ready, both in core geology as well as in IT-oriented geology fields like geoinformatics etc.
- Creation of skilled geologists who can meld core geology with IT skills, thereby contributing directly to the Make-in-India endeavour
- Creation of resourceful geologists who would be grounded in science, but technically equipped to tackle geological challenges, adopt spatial planning techniques in problem solving, and disaster management.

Philosophy

This Masters in Science in Applied Geology and Geoinformatics is unique in Kerala. The curriculum brings within its ambit the best of basic geology and trains the students to apply it in real life geology – ranging from resource exploration and exploitation using core geological tools to disaster mitigation and management to spatial planning and resource management using cutting edge tools of remote sensing, photogrammetry and geoinformatics.

Highlights

Core geology papers with an applied bias is integrated with practicals, thereby reinforcing theoretical geology, aiding in its application in resource exploitation and conservation. This is supplemented by spatial analysis and planning tools like remote sensing and geoinformatics.

Each paper thus would have a practical component in it, and additional skill development is ensured through field work, lab visits and internships, virtual classrooms, mentored dissertations.

Multi-faceted learning is ensured through regular lectures, participatory learning, peer teaching, group tasks, expert interactions, key laboratory visits and internships with professional organizations.

Course participants would be trained to present at conferences and workshops. Student-convened clubs will cater to skill enhancement programs, and the faculty will ensure visits to the campus by firms active in the area of geological as well as geoinformatics-related instrumentation and investigation. This will enhance the capabilities of students by keeping them abreast of industry standards. Stress will be laid campus placements for students.

Acronyms used

PO – Program outcomes

PSO – Program Specific Outcomes

CO – Course Outcomes

Knowledge categories: F – Factual C – Conceptual P – Procedural

Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

Program specific outcomes (PSO) of MSc Geology with specialization in Geoinformatics program in the colleges under University of Kerala

The MSc Geology with specialization in Geoinformatics program comprises 12 theory courses, 4 practical courses, and dissertation.

PSO 1: Understand the basic concepts of physical geology, geomorphology, structural geology, engineering geology and environmental geology and apply this knowledge to analyze geological formations and structures for effective human use.

PSO 2: Understand the minerals, and the economic significance of mineral deposits, apply the concepts of exploration geology to analyze the formation and significance of ore deposits

PSO 3: Understand how rocks are formed, the underlying geochemical and petrological principles and apply this knowledge to analyze sedimentary, igneous and metamorphic rocks for unravelling earth history and economic utilization, understand how water behaves within the Earth, and apply this knowledge to analyze groundwater resources.

PSO 4: Understand the principles of stratigraphy and palaeontology, and apply this knowledge to analyze the evolution of the Earth and life on it.

PSO 5: Understand how Earth can be sensed remotely, resources mapped and analysed, with the aid of geoinformatics tools, and how disasters can be mitigated and managed.

PSO 6: Analyze and apply the knowledge gained through studies into a thesis that incorporates scientific planning and execution of work, methodology, analyses, and presentation of results, all within the ambit of research ethics, possibly leading to the creation of new knowledge in geosciences.

M.Sc. Degree Course in Geology with specialization in Geoinformatics: Structure and Mark Distribution (Outcome-based education syllabus, 2020 admission onwards)						
Paper Code	**Title of the paper**	**Distribution of hours**		**Marks**		
		Lecture	**Practical**	**CA**	**ESA**	**Total**
GL 211	Physical Geology and Geomorphology	4		25	75	**100**
GL 212	Mineralogy & Geochemistry	5		25	75	**100**
GL 213	Remote Sensing and Photogrammetry	6		25	75	**100**
GL 224	**[@]Practical I :** Geomorphology, Mineralogy and Remote Sensing & Photogrammetry		10	25	75	**100**
GL221	Structural Geology & Engineering Geology	5		25	75	**100**
GL 222	Hydrogeology	5		25	75	**100**
GL 223	Digital Image Processing and Global Navigational Satellite Systems	5		25	75	**100**
	Dissertation/Field work or Field Visit or laboratory internship		2			
GL 225	**[@]Practical II :** Structural Geology, Hydrogeology, Digital Image Processing and Global Navigational Satellite Systems		8	25	75	**100**
GL 231	Sedimentology, Stratigraphy and Palaeontology	4		25	75	**100**
GL 232	Igneous and Metamorphic Petrology	5		25	75	**100**
GL 233	Geographical Information Systems	6		25	75	**100**
GL 244	**[@]Practical III :** Sedimentary, Igneous and Metamorphic Petrology and Geographical Information Systems		10	25	75	**100**
GL 241	Economic Geology	5		25	75	**100**
GL 242	Advanced Mapping Techniques & Exploration Geology	4		25	75	**100**
GL 243	Geoinformatics Applications in Geology and Disaster Management	6		25	75	**100**
	Dissertation/Field work/Group Mapping/Laboratory internship		2			
GL 245	**[@]Practical IV :** Economic Geology, Advanced Mapping Techniques & Exploration Geology, Geoinformatics Applications in Geology and Disaster Management		8	25	75	**100**
GL 246	**Dissertation**					**100**
	Comprehensive Viva Voce (Includes 10 marks for Group Mapping)**					**100**
	Grand total marks					**1800**

Note: ***** Dissertation work commences in 2nd Semester with 2 hours per week. Field visit or field work or laboratory internship in 2nd Semester refers to a period of maximum 10 days duration (10 x 5 = 50 Hours) and is a compulsory part of the curriculum. Dissertation topics can be chosen as per the interests of the faculty and student, though it is suggested that remote sensing and GIS tools be used in the work as far as possible.

Dissertation work continues in 4th Semester with 2 hours per week and an additional Field work component for a period of maximum 10 days duration (10 x 5 = 50 Hours).

** Group Mapping includes field training in geological mapping, oriented towards ground truthing of remote sensing images for a period of maximum 10 days duration (10 x 5 = 50 Hours) and is a compulsory part of the curriculum to be carried out in the 3rd semester.

@ Practical Examinations of 1st and 2nd Semesters will be conducted at the end of second semester and that of 3rd and 4th Semesters will be conducted at the end of 4th Semester and each practical examination will be of four (4) hours duration.

Eligibility

1. BSc in Geology, with any combination of subsidiaries as applicable for admission to MSc Geology course of University of Kerala, or equivalent qualifications. Additionally subsidiaries like GIS, Geoinformatics, Remote Sensing, Water Resources Management can also be accepted as subjects at BSc level.
2. BSc Geology and Digital Surveying (Dual Main).

Intake

Suggested intake is 12 students.

Faculty

Faculty qualifications will be the same as that for recruitment to the position of Assistant Professor in Geology, through the Kerala Public Service Commission or the University of Kerala.

THEORY SYLLABUS (practical syllabus starts on p.35)

SEMESTER I

GL 211: PHYSICAL GEOLOGY AND GEOMORPHOLOGY

AIM

To familiarize students with the basic concepts of physical geology and geomorphology, and to equip them to decipher the pattern of landforms representative of various geological processes.

OBJECTIVES

To make the student understand the various surficial and internal processes which shape the surface of the earth and be able to evaluate the role of each in sculpting the earth. Students can gain an understanding of the past and present processes operated by different geomorphologic agents.

Course outcomes

CO1: Understand the basics of geochronology and the different dating techniques and their limitations

CO2: Understand the geophysical characteristics of Earth and how palaeomagnetism and plate tectonics are related to these

CO3: Understand the philosophy and different schools of thoughts of environmental dynamism and passivism and compare and analyse different landscape evolution models.

CO4: Understand the origin of various landforms, the concept of morphogenetic regions and influence of climate and structure on it and evaluate the Land forms and structures as geomorphic indicators of neotectonic movements. Understand the geological work of rivers, oceans, wind, glaciers

CO5: Understand the drainage pattern and network characteristics of drainage basin and understand the Soil Formation and classification in Kerala and India

CO6: Understand the geomorphological features of Kerala and India and also understand the basics of tectonogeomorphology.

CO-PSO map

CO No.	CO Statements	Cognitive Level	Knowledge Category	PSO
CO1	Understand the basics of geochronology and the different dating techniques and their limitations	U & E	F & C	PSO1
CO2	Understand the geophysical characteristics of Earth and how palaeomagnetism and plate tectonics are related to these	U & E	F & C	PSO1
CO3	Understand the philosophy and different schools of thoughts of environmental dynamism and passivism and compare and analyse different landscape evolution models.	U & E	F & C	PSO1
CO4	Understand the origin of various landforms, the concept of morphogenetic regions and influence of climate and structure on it and evaluate the Land forms as geomorphic indicators of neotectonic movements. Understand the geological work of rives, oceans, wind	U & E	F & C	PSO1
CO5	Understand the drainage pattern and network characteristics of drainage basin and understand the Soil Formation and classification in Kerala and India	U	F, C & P	PSO1
CO6	Understand the geomorphological features of Kerala and India and also understand the basics of tectonogeomorphology.	U	F & C	PSO1

Knowledge category: F – Factual C – Conceptual P – Procedural
Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

UNIT I

Geochronology and age of the Earth – Relative and absolute ages – Principles of isotope dating. Types of decay and half life – Brief idea of U-Pb, K-Ar, and Rb-Sr dating methods and their significance – Fission track dating.

UNIT II

Shape and mass of the earth, density vs depth profile of Earth – Brief idea of Gravity, gravity anomalies and their interpretation – Isostasy – Earth's magnetic field and its origin – palaeomagnetism – Plate tectonics and its components – destructive, constructive and conservative plate margins and their characteristic features.

UNIT III

Development of geomorphic thoughts – Catastrophism – Gradualism – Brief idea of the models of landscape evolution by Davis, King, Penck, JT Hack and Gilbert. Rate of erosion over space and time. Geomorphic indicators of neotectonic movements.

UNIT IV

Influence of climate and structure on geomorphic processes and landforms – Concept of morphogenetic regions. Evolution of hill slopes – brief idea.

Coastal geomorphology – sea level changes. Geomorphic significance of waves and currents. Shore line processes and associated landforms.

Desert geomorphology – processes of erosion and transport – erosional and depositional features – dunes, rock varnish, pediment, inselbergs, wadis.

UNIT V

Drainage basin – drainage pattern, network characteristics; morphometric analysis of drainage basins. Fluvial denudational and erosional land forms. Soils – formation, classification, soil profile, soils of Kerala.

UNIT VI

Major geomorphic features of the Indian subcontinent – Geomorphology of Kerala – classification, relief features, geological significance, rivers of Kerala.

Reference books

Ahmad E. Coastal Geomorphology. Orient Longman, 1972.
Cox A. Plate Tectonics and geomagnetic reversals. Freeman, 1973.
Darlrymple B. G. and Lampere M. A. Potassium-Argon dating. Freeman, 1969.
Eicher L. D. Geologic Time. Prentice Hall, 1968.

Hamilton E. I. Applied Geomorphology. Academic Press, 1965.
Holmes A. Principles of Physical Geology. Ronald, 1965.
King C. A. M. Beaches and Coasts. Arnold, 1972.
Lay Thorne, Terry W. C. Modern Global Seismology. Academic Press, 1995.
Leopold L., Wolman C. and Miller J. P. Fluvial processes in geomorphology. Freeman, 1963.
Russell, RD, John Arthur Jacobs, J. Tuzo Wilson. Physics and Geology. McGraw-Hill Inc., US, 1974
Sharma H. S. Indian Geomorphology. Concept Publishing Co., New Delhi, 1990.
Soman K 2014 Geology of Kerala, Geol Soc of India, Bangalore.
Thornbury W. D. Principles of geomorphology. Wiley, 1968.
Turner F. W., Weiss M. P. The Earth. Holt Reinhardt and Winston, 1972.
Windley B. F. The evolving continents. John Wiley, 1977.

GL 212 : MINERALOGY and GEOCHEMISTRY

AIM

The aim of this course is to study the major mineral groups, their occurrences, physical, chemical properties and their possible uses in industry, and additionally get to know the geochemical milieu of earth materials

OBJECTIVES

In this course the students will learn about the structure and chemical makeup of minerals. Focus is given on the physical and chemical properties of minerals, from macroscopic to microscopic. Understand thermodynamic and isotopic fundamentals of geochemistry.

Course outcomes

CO1: Understand the diagnostic and advanced optical properties of common rock forming minerals.

CO2: Understand the mineral chemistry and the advanced instrumental analytical techniques used for minerals.

CO3: Understand the physical characters, optical properties, classification, uses and distribution of gem stones. Understand the basics of gem identification by using invisible spectrum radiation.

CO4: Understand the abundance of elements and behavior of elements in the crust, mantle and core of the earth.

CO5: Understand Chemical Equilibrium, Estimation of ionic concentration and Geochemistry of natural waters – river, sea, brines.

CO6: Understand isotope geochemistry and basic thermodynamic concepts

CO – PSO map

CO No.	CO Statements	Cognitive Level	Knowledge Category	PSO
CO 1	Understand the diagnostic and advanced optical properties of common rock forming minerals.	U	F & C	PSO2
CO 2	Understand the mineral chemistry and the advanced instrumental analytical techniques used for minerals.	U	F & C	PSO2
CO 3	Understand the structure and classification of silicate	U & A	F, C, P	PSO2
CO 4	Understand the abundance of elements and behavior of elements in the crust, mantle and core of the earth.	U	F & C	PSO2
CO 5	Understand Chemical Equilibrium, Estimation of ionic concentration and Geochemistry of natural waters – river, sea, brines.	U	F & C	PSO2
CO 6	Understand isotope geochemistry and basic thermodynamic concepts	U & A	F & C	PSO2

Knowledge category: F – Factual C – Conceptual P – Procedural
Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

UNIT I

Refractive index and birefringence. Interference colours, optical accessories – Berek compensator, Biquartz wedge and Bertrand ocular. Wave surface and indicatrices. Dichroism and Pleochroism. Pleochroism scheme. Conoscopic study and interference figures. Optic orientation, extinction angle, optic axial angle, optic sign and optic anomalies.

UNIT II

Mineralogy – Occurrence of minerals – Isomorphism, polymorphism and polytypism. Bonding in minerals. Solid solution and exsolution. AAS, XRF, ICP-MS, Electron probe micro analysis, scanning and transmission electron microscopy. XRD – powder & single crystal techniques. Mineralogical expression of radioactivity – metamictisation, fracturing, discoloration, pleochroic haloes and fission tracks.

UNIT III

Structure and classification of silicates. – Distinctive chemical and optical characters of the minerals of the following groups – Olivine, garnet, aluminosilicates, pyroxene, amphibole, mica, feldspar and feldspathoid. Clay mineralogy: characterization, classification and structure of clay minerals, clay mineral identification by XRD and DTA. Genesis of clays. Different methods of clay mineral separation.

UNIT IV

Geochemistry –. Cosmic abundance of elements. Geochemical classification of elements. Distribution and behavior of elements in the crust, mantle and core of the earth. Geochemical cycle. REE and its distribution in meteorites and rocks – Chondrite normalization.

UNIT V

Chemical Equilibrium: Le Chatelier's principle – concept of stability. Acids and bases. Ionisation constants of acids, bases and hydroxides. Estimation of ionic concentration. Geochemistry of natural waters – rivers and seas.

Unit VI

Introduction to stable isotope geochemistry. Applications of carbon, oxygen and sulphur isotopes. Basic thermodyanmic concepts: Change of Enthalpy – Entropy - Definition of free energy, its limitations. Free energies of formation. Gibbs free energy. Chemical potential, fugacity and activity. Oxidation-Reduction reactions. Redox potential – limits of pH and Eh in nature. Eh-pH diagrams.

Reference books

Berry L. G. and Mason B. Mineralogy, Freeman, 1959.
Brownlow A. N. Geochemistry, Prentice Hall, 1975.
Kerr, Paul F. Optical Mineralogy. McGraw-Hill, New York, London. 1977
Krauskopf E. B. Introduction to Geochemistry, 1967.
Mason B. Principles of Geochemistry. Wiley, 1966.
Nesse W. D. Introduction to Mineralogy. Oxford University Press, 2008.
Nesse W. D. Introduction to Optical Mineralogy. Oxford University Press, 2004.
Perkins D. and Henke K. R. Minerals in thin section. Pearson Education Inc., 2004.
Perkins D. Mineralogy. Pearson Education, 2002.
Rankama K. Progress in Isotope Geology, Interscience, 1963.
Walther J. V. Essentials of Geochemistry. Jones and Barlett Publishers, 2005.
Wenk H. R. and Bulakh. Minerals: their constitution and origin. CUP, 2004.
Winchell A. N. Elements of optical mineralogy, Pt I, Wiley, 1951.

GL 213 : Remote sensing and Photogrammetry

Unit 1

Introduction to Remote Sensing – Energy sources and Radiation principles, Energy equation, EMR and Spectrum – EMR interaction with Atmosphere – Scattering, Absorption – EMR interaction with Earth surface features reflection, absorption, emission and transmission – Spectral response pattern – Vegetation, Rocks, Soil, Water bodies – Spectral properties and characteristics.

Unit 2

Types of remote sensing with respect to wavelength regions; active and passive remote sensing, Sensor types characteristics: imaging systems, photographic sensors, characteristics of optical sensors; FOV, IFOV; Sensor resolution - spectral, spatial, radiometric and temporal. Introduction- Active, Passive, Optical Remote sensing, Visible, Infrared, thermal, Sensors and characters. Microwave Remote sensing sensors, Concept of Microwave Remote sensing, SLAR, SAR Scatterometer

Unit 3

Data acquisition – Procedure, Reflectance and Digital numbers- Intensity-Reference data, Ground truth, Analog to digital conversion, Detector mechanism-Spectro - radiometer-Ideal remote sensing system – Characters of real and successful remote sensing system- Platforms and sensors- orbit types– Resolution Land observation satellites, characters and applications, IRS series, LANDSAT series, SPOT, series, Sentinel Missions, High resolution satellites, character and applications, CARTOSAT series, IKONOS Series, QUICKBIRD series, INSAT series, GOES

Unit 4

Multispectral and hyperspectral remote sensing, Comparison of Multispectral and Hyperspectral Image Data, Spectral Signatures and BRDF in the Visible, Near Infrared and Shortwave Infrared regions of EMR, Hyperspectral Issues. Sensors and hyperspectral imaging devices - Scanner types and characterization - specifications of various sensors Spectrographic imagers-hyperspectral sensors, Design tradeoffs. Data formats and systems, AVIRIS, CASI, NASA Terra Moderate Resolution Imaging Spectrometer (MODIS), Hyperion. Applications of Hyperspectral Image to Mineral exploration.

Unit 5

Definition and concepts, Photogrammetry:- Based on platform (Ground Based, UAV/drone based, Aerial Photogrammetry, Satellite Photogrammetry) Types of aerial photographs (Vertical, Oblique), Scale of Photographs, Flight height, Flight planning, stereo coverage, Geometric elements of aerial photographs (analog and digital), Scale determination, Source of Distortions and displacement, Relief Displacement, Parallax

Unit 6

Depth perception, steroscopy/ sterovision, viewing sterophotography in analog environment, viewing sterophotography in digital environment, Sterophotogrammetry, Orthorecrification, interior and exterior orientation parameters. DTM generation - Image correlation - Image matching - Digital Orthophoto generation - Automated aero-triangulation - Link between GIS and Digital Photogrammetry.

REFERENCES

Anji Reddy, Textbook of Remote Sensing and Geographical Information systems, BS Publications, Hyderabad. 2011. ISBN: 81-7800-112-8

Chandra A. M and Ghosh S. K. Remote Sensing and Geographical Information Systems. Narosa Publishing House, 2007.
Chandra and Ghosh. Remote Sensing and GIS, Narosa Publishing Home, New Delhi 2009.
Estors J. E. and Senger L. W. Remote Sensing. Hamilton Publishing Company, 1974.
George Joseph , Fundamentals of Remote Sensing Universities Press, Hyderabad 2005.
Gupta R. P. Remote Sensing Geology. Springer, 2003.
Heywood I., Cornelius. S. and Carver S. An Introduction to Geographical Information Systems, Longman Limited
Paul Jude Gibson, Introductory Remote Sensing: Principles and Concepts, Routledge, 11 New Fetter Lane, Landon, UK. 2000. ISBN: 0-415-17024-9
Prithvish Nag, M. Kudrat, Digital Remote Sensing, Concept Publishing Company, India, 1998.
Reddy A. M. Text book of Remote Sensing and Geographical Information Systems. BS Publications, 2006.
Sabins F. F. Remote Sensing – Principles and Applications. Freeman, 1985.
Seigal B. S. and Gillespie A. R. Remote sensing in Geology, John Wiley & Sons, 1980.
Thomas M. Lillesand, Ralph W. Kiefer, Jonathan W. Chipman, Remote sensing and image interpretation John Wiley & Sons, 2008

SEMESTER II

GL 221: STRUCTURAL GEOLOGY AND ENGINEERING GEOLOGY

AIM

To understand the rock deformation and different structures produced by brittle and ductile deformation and analysis of structures. To understand geological properties of materials and earth structures as applied to construction of engineering structures.

OBJECTIVES

The objectives of this course are: (i) to develop an understanding of rock deformation and factors involves in it. (ii) how the classification of structures based on geometry and origin (iii) analysis of structures based on stereographic projection.

Course outcomes

CO1: Understand the concepts of rock deformation, types of Stress and strain, its use in studying the stages of deformation and factors affecting deformation.

CO2: Understand the brittle and shear failure including fault, lineaments, deep fractures, Joints and Shear zone, tectonites, petrofabrics, foliation and lineation.

CO3: Understand the concept, classification and mechanism of fold. Understand Superposed fold and interference patterns.

CO4: Understand Structural and geometric analysis. Application of stereographic and equal area projections in the representation of structures and geometric analysis of folds and lineations.

CO5: Understand the interpretation of geologic maps. Analyse the Trigonometric, graphic and stereographic problems.

CO6: Understand the engineering properties of rocks and their use in locating engineering structures

CO – PSO map

CO No.	CO Statements	Cognitive Level	Knowledge Category	PSO
CO 1	Understand the concepts of rock deformation, types of Stress and strain, its use in studying the stages of deformation and factors affecting deformation.	U	F & C	PSO2
CO 2	Understand the brittle and shear failure include fault, lineaments, deep fractures, Joints and Shear zone, tectonites, petrofabrics, foliation and lineation.	U	F & C	PSO2
CO 3	Understand the concept, classification and mechanism of fold. Understand Superposed fold and interference patterns.	U,	F, C	PSO2
CO 4	Understand Structural and geometric analysis. Application of stereographic and equal area projections in the representation of structures and geometric analysis of folds and lineations.	U, Analyze	F, C &P	PSO2
CO5	Understand the interpretation of geologic maps. Analyse the Trigonometric, graphic and stereographic problems.	U, Analyze	F, C &P	PSO2
CO6	Understand the engineering properties of rocks and their use in locating engineering structures	U, Analyze	F, C &P	PSO2

Knowledge category: F – Factual C – Conceptual P – Procedural
Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

UNIT I

Fundamental concepts of rock deformation. Stress – hydrostatic, lithostatic and deviatoric stress. Stress ellipsoid. Dilation and distortion. Strain – homogeneous, inhomogeneous, rotational and irrotational strain. Strain ellipsoid. Simple and pure shear. Types of homogeneous strain. Stress-Strain diagrams and their use in studying the stages of deformation and factors affecting deformation. Progressive deformation and finite strain. Measurement of strain in two dimensions.

UNIT II

Brittle and shear failure – Faults and fractures. Mohr circle, fault geometry and nomenclature. Features of fault planes. Lineaments and Deep fractures. Joints, Analysis of fractures. Ductile and Brittle-Ductile shear zones. Stress and strain ellipsoids and their application in the study of fractures.

UNIT III

Geometric and genetic classification of cylindrical folds. Canoe fold and inverted canoe fold. Minor folds and their use in determining the major fold structure. Pumpelly's rule. Mechanics of folding. Superposed folding, simple fold interference patterns. Fold classification of Donath and Parker, and Ramsay – Dip isogons.

UNIT IV

Tectonites – classification, tectonic fabric. Foliation – axial plane foliation and its origin, fracture cleavages, crenulation cleavage. Transposed foliation. Use of axial plane foliation and fracture cleavages and the determination of major structures. – Lineation – types, classification and origin. Introduction to Structural Analysis and Fundamentals of geometric analysis. Application of stereographic and equal area projections in the representation of structures.

UNIT V

Engineering Geology – Role of geology in Civil Engineering – Engineering properties of rocks and soil – Geotechnical investigation for Civil Engineering projects – Rock mechanics – strength and deformation properties of rocks and soils – Rock as building material – Dimension and decorative stones. Aggregates. Building stones of Kerala.

UNIT VI

Dams: Classification, foundation, abutment and reservoir problem. Geological aspects of dam investigations – Tunnels: Classification, Geological factors in tunneling – Landslides: Types, causes and prevention – Stability of slopes – Aseismic design of buildings. Geological considerations in investigations for construction of highways, bridges and shoreline structures.

Reference books

Billings, M. P. Structural Geology Prentice Hall, 1974

Marshak S. and Gautam Mitra. Basic methods of Structural Geology. Prentice Hall Inc. 1988.

Ragan M. D. Structural Geology, Wiley 1969.

Philips F. C. Stereographic projection in Structural Geology. Arnold 1960.

Lisle R. J. and Leyshon P. R. Stereographic Projection Techniques for Geologists and Civil Engineers. Cambridge University Press. 1994.

Turner F.J. and Weiss L.E. Structural Analysis of Metamorphic Tectonites. Mc Graw Hill, 1963.

Hobbs B.E., Means W.B. and William P. F. An Outline of Structural Geology. John Wiley 1976.

Krynine and Judd. Principles of Engineering Geology and Geotechniques. Mc Graw Hill 1957

Bell F. G. Engineering Geology. Elsevier 2007.

Waltham T. Foundations of Engineering Geology. Spon Press. 1994..

GL 222: HYDROGEOLOGY

AIM

To understand the various aspects of origin, occurrence, distribution, movement, hydraulics, quality, pollution, recharge and over-exploitation, and the groundwater conditions in India and Kerala.

OBJECTIVES

The objectives of this course are:

i) to study the origin, occurrence, distribution of groundwater; aquifer types, properties and parameters in relation to groundwater hydraulics, groundwater movement and application of Darcy's law, pumping test data analysis.
ii) to understand and describe groundwater exploration and prospecting methods, methods of drilling for groundwater and well design and maintenance criteria.
Iii) to understand and infer groundwater quality for domestic and industrial uses using standard graphs and diagrams like Hill-Piper Trilinear diagram and U.S. Salinity diagram.
iv) to understand the concepts and methods of groundwater recharge, problems related to groundwater pollution and over-exploitation, groundwater legislation; and groundwater provinces of India and groundwater conditions in Kerala.

Course outcomes

CO1: Understand and describe the origin, occurrence, distribution and movement of groundwater in relation to hydrological cycle and aquifers.

CO2: Understand aquifer properties, and types of aquifers, vertical distribution of water in aquifers, and the application of radioisotopes in hydrogeology.

CO3: Understand groundwater hydraulics with reference to Darcy's law, aquifer parameters and describe the procedures of pumping test and data analysis for determination and quantification of aquifer parameters

CO4: Understand the various methods of groundwater exploration and prospecting with special emphasis on geo-electrical – electrical resistivity method; describe the methods of drilling for groundwater and explain water well construction and maintenance of production wells.

CO5: Understand groundwater quality studies related to well inventory, collection and analysis of water samples and interpretations of water quality for domestic and agricultural purposes based on standard graphs and diagrams like Hill-Piper Trilinear diagram and U.S. Salinity diagram; and to understand groundwater contamination and pollution.

CO6: Understand the concepts and methods of groundwater recharge, problems related to over-exploitation of groundwater, groundwater legislation; and groundwater provinces of India and groundwater conditions in Kerala.

CO – PSO map

CO No.	CO Statements	Cognitive Level	Knowledge Category	PSO
CO1	Understand and describe the origin, occurrence, distribution and movement of groundwater in relation to hydrological cycle and aquifers.	U	F & C	PSO5
CO2	Understand aquifer properties, and types of aquifers, vertical distribution of water in aquifers, and the application of radioisotopes in hydrogeology.	U	F & C	PSO5
CO3	Understand groundwater hydraulics with reference to Darcy's law, aquifer parameters and describe the procedures of pumping test and data analysis for determination and quantification of aquifer parameters	U, Analyze	F & C	PSO5
CO4	Understand the various methods of groundwater	U, Analyze	F, C, P	PSO5

	exploration and prospecting with special emphasis on geo-electrical – electrical resistivity method; describe the methods of drilling for groundwater and explain water well construction and maintenance of production wells.			
CO5	Understand groundwater quality studies related to well inventory, collection and analysis of water samples and interpretations of water quality for domestic and agricultural purposes based on standard graphs and diagrams like Hill-Piper Trilinear diagram and U.S. Salinity diagram; and to understand groundwater contamination and pollution.	U, Analyze	F & C	PSO5
CO6	Understand the concepts and methods of groundwater recharge, problems related to over-exploitation of groundwater, groundwater legislation; and groundwater provinces of India and groundwater conditions in Kerala.	U	F & C	PSO5

Knowledge category: F – Factual C – Conceptual P – Procedural
Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

UNIT I

Introduction – definition and classification of subsurface water. Elements of surface hydrology: formation of precipitation, measurement and depth of precipitation over an area. Evaporation and transpiration – factors affecting evaporation and transpiration

Measurement of evaporation Consumptive use – infiltration, run off. Types of water – meteoric, juvenile, connate, magmatic and sea water. Hydrological cycle and its components – Groundwater in the hydrologic cycle. Origin of ground water.

UNIT II

Water bearing properties of rocks – interstices and porosity, permeability, specific yield and specific retention. Aquifers, aquicludes, aquitard and aquifuge. Vertical distribution of subsurface water; zone of saturation and zone of aeration. Types of aquifers – unconfined, confined, semi-confined and semi-unconfined. Geological material as aquifers – unconsolidated materials and consolidates rocks. Water table and piezometric surface; their fluctuations.

Radioisotopes in hydrogeological studies.

UNIT III

Groundwater Hydraulics: Movement of groundwater – Darcy's law; Range of validity; its experimental verification. Hydraulic conductivity of geologic materials. Determination of hydraulic conductivity – formula, laboratory methods and field tests. Flow nets; Flow in relation to groundwater contours. Aquifer parameters – transmissivity, storativity, drainage factor. Pumping tests – objectives, layout of the tests, measurements and interpretation. Methods of

analyzing pumping test data. Theim's equilibrium method. Theis method, Theis recovery method, Jacob and Cooper-Jacob methods.

UNIT IV

Groundwater Exploration: Use of aerial photographs and Landsat imageries in groundwater exploration. Hydrogeomorphic and lineament mapping.

Prospecting for groundwater – geological aspects. Surface geophysical methods – geo-electrical – electrical resistivity and seismic refraction methods. Drilling for groundwater – cable tool, hydraulic rotary, reverse rotary and down the hole hammer drilling.

Water Well Construction – Water well design criteria and specifications. Well production tests – well loss, specific capacity. Maintenance of production wells.

UNIT V

Quality of groundwater – methods of collection and analysis of water samples as related to groundwater investigations. Physical, chemical and bacterial measures of water quality. Problems of groundwater contamination by As and F – Remedial measures for their treatment. The general occurrence of various constituents in groundwater. Graphical representation of groundwater quality data – Collin's diagram. Quality of groundwater for domestic, irrigational and agricultural uses.

UNIT VI

Groundwater recharge – natural and artificial recharge. Groundwater management. Rainwater harvesting and managed aquifer recharge. Groundwater conditions and problems in urban areas. Over-exploitation of groundwater and groundwater mining. Coastal aquifers, sea water intrusion and remedial measures. Groundwater provinces of India. Groundwater conditions in Kerala. Consumptive and Conjunctive use of surface and groundwater – 2019 Guidelines to regulate and control Ground Water Extraction in India

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GL 223: Digital Image Processing and Global Navigational Satellite Systems

AIM

To familiarize students with the basic concepts of Digital Image Processing and Global Navigational Satellite Systems

OBJECTIVES

Train students in the core concepts of Digital Image Processing and Global Navigational Satellite Systems, and lay the foundation for studying spatial data acquisition and image processing.

Course outcomes

CO1: Understand the principles of digital image processing

CO2: Understand how remotely sensed images can be enhanced.

CO3: Understand how images are classified and features extracted.

CO4: Understand the characteristics and uses of different remote sensing sensors

CO5: Understand the basic concepts of Global Navigational Satellite Systems (GNSSs).

CO6: Understand the use of GPS and GPS systems

CO-PSO map

CO No.	CO Statements	Cognitive Level	Knowledge Category	PSO
CO1	Understand the principles of digital image processing	U & E	F & C	PSO1
CO2	Understand how remotely sensed images can be enhanced.	U & E	F & C	PSO1
CO3	Understand how images are classified and features extracted.	U & E	F & C	PSO1
CO4	Understand the characteristics and uses of different remote sensing sensors	U & E	F & C	PSO1
CO5	Understand the basic concepts of Global Navigational Satellite Systems (GNSSs).	U	F, C & P	PSO1
CO6	Understand the use of GPS and GPS systems	U	F & C	PSO1

Knowledge category: F – Factual C – Conceptual P – Procedural
Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

Unit 1

Digital Number/pixel value, Image Rectification: Sources of errorsin RS data- Geometric and Radiometric- Types of Geometric and Radiometric errors (Dark Pixel, Pixel Dropping, Line Dropping, Atmospheric errors-Geometric Corrections - Image resampling- Resampling techniques (Nearest neighbor, Bilinear and Cubic Convolution), Radiometric Correction (Dark pixel subtraction, Destripping, Pixel filling, Atmospheric correction (MODTRAN Algorithm). Computation of radiance and reflectance

Unit 2

Image Registration; Image Enhancements, Spatial Enhancement (Spatial Filtering: High pass and Low pass), Radiometric Enhancement (Contrast Stretch, Histogram Equalization, Special stretches), Spectral Enhancement (Band Ratio, Indices (NDVI, NDWI etc), Principal Component Analysis, IHS Transformation)

Unit 3

Image Classifications, Digital Supervised classification (Minimum distance to Means Classifiers, Parallelepiped Classifiers, Gaussian Maximum Likelihood Classifier); Unsupervised (Cluster building, Cluster Labeling, Reclassification Processing and Feature Extraction. Data merging.

Unit 4

Image Processing Software Introduction; Introduction to Envi Image Processing Software, Introduction to ERDAS Image Processing Software.

Unit 5

Basic concepts of Global Navigational Satellite Systems (GNSSs): History and timeline, overview. Components of GNSSs (Space Segment, Control Segment, User Segment),GPS working principle, -GPS (Global positioning System), - GLONASS, Galileo, BeiDou, NavIC, GPS signals (L1 and L2 Frequencies)/ Coarse Acquisition (C/A), Code Precision (P) codes.

Unit 6

Source of GPS Errors and biases, Selective Availability, Dilution of Precision (DOP), Advantages and disadvantages of GPS surveying GPS positioning types – absolute positioning, differential positioning;GPS Positioning Service- Precise Positioning Service (PPS), Standard Positioning Service (SPS)-Wide Area Augmentation System (WAAS), GPS Aided Geo Augmented Navigation (GAGAN), European Geostationary Navigation Overlay Service (EGNOS), Japanese Multi-functional Satellite Augmentation System (MSAS), DGPS measuring Techniques(Static, Rapid Static, Kinematic, Real Time Kinematic), Application of DGPS.

Reference books

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Sabins F. F. Remote Sensing – Principles and Applications. Freeman, 1985.
Seigal B. S. and Gillespie A. R. Remote sensing in Geology, John Wiley & Sons, 1980.

SEMESTER III

GL 231: SEDIMENTOLOGY, STRATIGRAPHY AND PALAEONTOLOGY

AIM

Understand how sediments formed, different rock and sediment strata on Earth was developed, how it can be interpreted to arrive at theories on the evolution of Earth and the vertebrate and invertebrate life on it.

OBJECTIVES

Study the types of sediments and sedimentary rocks, major theories underpinning stratigraphy, and the techniques used to decipher information from strata. Understand the evolution of life and decipher its record in the strata.

Course outcomes

CO1: Understand the different types of sedimentary rocks and their composition

CO2: Understand stratigraphic principles and its history, and gain deeper understanding of select stratigraphic systems. Understand the different types of stratigraphic analytical techniques and gain an understanding of boundary problems

CO3: Understand the models of crustal evolution with special reference to the Indian shield

CO4: Examine the patterns of evolution of invertebrates, to understand palaeoclimatic and palaeographic dispositions

CO5: Understand the evolution of vertebrates and extinction events, and the record of plant fossils and its significance

CO6: Understand microfossils, their morphology, palaeoecology and applications in petroleum exploration

CO – PSO map

CO No.	CO Statements	Cognitive Level	Knowledge Category	PSO
CO 1	Understand the different types of sedimentary rocks and their composition	U	F & C	PSO4
CO 2	Understand the different types of stratigraphic analytical techniques and gain an understanding of boundary problems	U	F & C	PSO4
CO 3	Understand the models of crustal evolution with special reference to the Indian shield	U	F, C, P	PSO4
CO 4	Examine the patterns of evolution of invertebrates, to understand palaeoclimatic and palaeographic dispositions	U	F & C	PSO4
CO 5	Understand the evolution of vertebrates and extinction events, and the record of plant fossils and its significance	U	F & C	PSO4
CO 6	Understand microfossils, their morphology, palaeoecology and applications in petroleum exploration	U	F & C	PSO4

Knowledge category: F – Factual C – Conceptual P – Procedural
Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

UNIT I

Provenance and diagenesis of sediments. Sedimentary textures: Framework, matrix and cement of terrigenous sediments. Frequency distribution of grain size. Size, shape and fabric of sediments (textures). Sedimentary structures. Mass flows and Turbidity currents. Penecontemporaneous deformation, Biogenic sedimentary structures. Clastic and non clastic rocks – introduction Sedimentary petrology – classification, terminology, chemical composition – of limestone and sandstone.

UNIT II

Stratigraphy: Evolution of Stratigraphic principles. Contributions of Steno, Lehmann, Werner, Hutton, Darwin, Smith and Holmes. Evolution of Geological Time Scale. Code of Stratigraphic Nomenclature. Stratigraphic procedures (surface and sub-surface). A brief study of the stratotypes. Global Boundary Stratotype Sections & Points (GSSP) and major occurrences of the following systems: Cambrian, Carboniferous, Cretaceous, Tertiary and Quaternary.

UNIT III

Application of stratigraphy in palaeoenvironmental reconstructions. Major climatic events of the Phanerozoic eon. Boundary problems in Stratigraphy with special reference to Vindhyans and

Saline series. Chronostratigraphy – an introduction – Concepts and Elements of Sequence stratigraphy, Cyclostratigraphy and Chemostratigraphy.

UNIT IV

Precambrian Geology: Models of crustal evolution Craton-mobile belt concept. Granulite and Greenstone terrains – origin, rock associations, structure, metamorphism and models of evolution. Evolution of high grade mobile belts. Precambrian shield of India – special reference to the Dharwar craton.

UNIT V

Palaeontology – nature of fossil record. Distribution of main groups in time. Importance of fossils in palaeoclimatic and palaeogeographic studies, origin and early evolution of life. Patterns of evolution. Invertebrates – trends in the evolution of the following: Brachiopods, Ammonoidea, Trilobita.

UNIT VI

Vertebrate Palaeontology – General characteristics and evolution of reptiles, birds and mammals (horse, elephant and man – basic morphologic features). Siwalik vertebrate fauna. Mass extinction events – PT & KT extinctions.

UNIT VII

Micropalaeontology: importance and types of microfossils, collection and preparation of microfossils for study. Foraminifers, Ostracods, Conodonts – their general morphology and palaeoecology. Application of micro fossils in petroleum exploration. Plant fossils: Gondwana flora and their significance.

Reference books

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Moore R.C., Lalicker C.G., Fisher A.G. Invertebrate fossils. Mc Graw Hill, 1952.
Weller J. M. Stratigraphic principles & Practice. Harper & Row, 1959.
Woods H. Invertebrate Palaeontology. Cambridge University Press, 1961.

GL 232: IGNEOUS AND METAMORPHIC PETROLOGY

AIM

To understand igneous and metamorphic rocks, their structure, texture, chemistry and processes that generate and transform the rocks of the Earth as well as the tectonic settings of these rock types.

OBJECTIVE

Understand the thermal and tectonic history of the earth in association with igneous petrogenesis, evolution of magmas and their products. Understand how phase rule applies to metamorphic mineral paragenesis and how metamorphic rocks are formed, and analyse the textures and structures of metamorphic rocks.

COURSE OUTCOMES

CO1: Understand the application of thermodynamics and reaction principle in the petrogenesis of different igneous rocks, and evaluate the role of phase rule in the study of binary and ternary silicate systems

CO2: Understand the physical properties, chemical composition and evolutionary mechanisms of magmas

CO3: Evaluate the different schemes of classification and nomenclature of igneous rocks and their tectonic associations

CO4: Understand limits, factors and types of metamorphism and application of Phase rule in Chemographic diagrams

CO5: Understand classification of metamorphic rocks and textures and structures of metamorphic rocks

CO6: Understand baric types of metamorphism, thermobarometry, and metamorphism of carbonate, pelitic, mafic rocks

CO- PSO MAP

CO No.	CO Statements	Cognitive Level	Knowledge Category	PSO
CO1	Understand the application of thermodynamics and reaction principle in the petrogenesis of different igneous rocks, and evaluate the role of phase rule in the study of binary and ternary silicate systems	U, Analyse	F & C	PSO3
CO2	Understand the physical properties, chemical composition and evolutionary mechanisms of magmas. Evaluate the different schemes of classification and nomenclature of igneous rocks and their tectonic associations	U	F & C	PSO3
CO3	Evaluate the different schemes of classification and nomenclature of igneous rocks and their tectonic associations	U, Evaluate	F & C	PSO3

CO4	Understand limits, factors and types of metamorphism and application of Phase rule in Chemographic diagrams	U, Apply	F, C, P	PSO3
CO5	Understand classification of metamorphic rocks and textures and structures of metamorphic rocks	U	F & C	PSO3
CO6	Understand baric types of metamorphism, thermobarometry, and metamorphism of carbonate, pelitic, mafic rocks	U	F, C, P	PSO3

Knowledge category: F – Factual C – Conceptual P – Procedural
Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

UNIT I

Reaction principles in petrogenesis – continuous and discontinuous reaction series. Heterogenous equilibrium and phase rule. Application of phase rule in the study of silicate systems – binary and ternary. Study of the following systems. Diopside-Anorthite, Albite-Anorthite, Forsterite-Silica, Forsterite-Anorthite-Silica and Othoclase-Anorthite-Albite. Simple basalt systems of Barth.

UNIT II

Magma – Physical properties – temperature, density, viscosity and melting behavior. Plume magmatism and Hot spots. Magmatic evolution and differentiation – Chemical composition Evolutionary mechanisms – crystal settling in magma, magma convection, igneous cumulates, liquid immiscibility, diffusion processes, magmatic assimilations, mixing of magmas, assimilation of fractional crystallization, trace element trends in magmatic evolution. Variation diagrams – significance and interpretation.

UNIT III

Classifications of igneous rocks – mode, norm, CIPW, Schand and IUGS, igneous rock names. Igneous rock textures and their genetic significance. Tectonic association of igneous bodies. Large layered igneous complexes. Intrusive rocks of Kerala.

UNIT IV

Concept of metamorphism – Beginning of metamorphism – High temperature and high pressure limit of metamorphism. Types of metamorphism. Factors of metamorphism: P, T, fluid phase (CO2, H2O and CH4). Application of phase rule in metamorphic mineral paragenesis. Equilibrium thermodynamics in metamorphic petrology – Gibb's free energy, enthalpy, entropy, Clasius–Clapeyron equation, buffering, redox buffers, Schreinemaker's rule and bundle. Chemographic diagrams – principles of ACF, A'KF and Thompson's AFM diagrams.

UNIT V

Classification of metamorphic rocks. Concepts in metamorphism – Grubenmann's depth zone concept, metamorphic zone concept – isograd and reaction isograd, metamorphic facies concept and facies series, Winkler's grade concept, Miyashiro's paired metamorphic belts and baric types of metamorphism, P-T-t paths – isobaric cooling (IBC) and isothermal decompression (ITD) paths. Prograde and retrograde metamorphism; Regional metamorphism of carbonate, pelitic and mafic rocks.

UNIT VI

Structure and texture of metamorphic rocks – mega and microscopic – textures of contact, regional and cataclastic metamorphism - foliation, lineation, porphyroblast and clast, snowball garnet. Becke Crystalloblastic series. Retrograde metamorphism. Metasomatism and metasomatic zonation, metamorphic differentiation, migmatites and anatexis, charnockite and incipient charnockite, khondalite, leptynite.

Reference books

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Blatt, J., Tracy J. R. and Owens B.E. 2006 Petrology: Igneous, Sedimentary, and Metamorphic. Edition3, W. H. Freeman.

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GL 233: Geographical Information Systems

AIM

To familiarize students with the basic concepts of Geographical Information Systems and the related software

OBJECTIVES

Train students in the core concepts of Geographical Information Systems, and lay the foundation for geospatial thinking and usage of software.

Course outcomes

CO1: Understand GIS data formats and software

CO2: Understand GIS data properties and data processing

CO3: Understand GIS vector analysis

CO4: Understand GIS raster analysis

CO5: Understand the basic concepts of maps and map making

CO6: Understand the various flavours of GIS and GIS portals

CO-PSO map

CO No.	CO Statements	Cognitive Level	Knowledge Category	PSO
CO1	Understand GIS data formats and software	U & E	F & C	PSO1
CO2	Understand GIS data properties and data processing	U & E	F & C	PSO1
CO3	Understand GIS vector analysis	U & E	F & C	PSO1
CO4	Understand GIS raster analysis	U & E	F & C	PSO1
CO5	Understand the basic concepts of maps and map making	U	F, C & P	PSO1
CO6	Understand the various flavours of GIS and GIS portals	U	F & C	PSO1

Knowledge category: F – Factual C – Conceptual P – Procedural
Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

Unit 1

Definition - Usefulness of GIS - Components of GIS - Data Structure in GIS –Spatial and Non Spatial Data, Database Management in GIS- RDBMS, Geometry of Data (Points, Lines and Polygons)- Data storage formats in GIS(Raster and Vector) – Vector and Raster file formats in GIS- Advantages and Disadvantages, Data Conversion, (Vector to Raster and Raster to Vector), Introduction to proprietary and open source GIS.

Unit 2

Spatial Data Input Processes and Devices (Sources of data, - Different Types of Data Entry methods, viz., Manual input, Run length code, Digitization, Automated Scanning, etc. - Vector to Raster conversion - Raster to Vector conversion - Input devices) - Entry of non-spatial data - Linking of Spatial & Non- spatial data - Data Verification (Sources of Errors - Errors due to Natural Variation - Errors during measurement - Errors during entry - Errors during measurement - Errors during Process & Analysis) - Correction (Rubber Sheet Transformation,

Bilinear interpolation, Cubic Convolution, etc.) - Topology in GIS- Basic Elements of Topology Connectivity, Containment, Contiguity- Data output (Types of Output, GIS Capabilities for output, Output devices).

Unit 3

Vector analysis in GIS; Data Conversion techniques, Vector data Exploring – Find, Measure, Graphs, Reports- Querying – Spatial, Non-spatial (Arithmetic and Boolean Operations)- Overlay analysis: UNION, IDENTITY, INTERSECT, SYMDIFF, CLIP, ERASE, SPLIT- Management operations: DISSOLVE, ELIMINATE, MERGE, MOSAIC- Network analysis, Linear Referencing and Dynamic segmentation

Unit 4

Raster analysis in GIS: Surface modelling and analysis- Triangular Irregular Network (TIN), Digital Elevation Model (DEM)- Slope, Aspect, VIewshed, Hillshade, Line of Sight- -Digital Terrain Model (DTM), - Digital Surface Model (DSM)- Raster based modelling and analysis - Interpolation techniques (Thiessen polygon, Inverse Distance Weighted (IDW), Krigging), Distance analysis: Straight-line Euclidean, Cost Weighted Distance

Unit 5

Map Elements- Map Characteristics- Compilation process- Generalization- Map Design and Symbolization: Map content, design and implementation- Pattern creation; feature attributes, point, line, areas and volumes; Qualitative and Quantitative symbols. Thematic Mapping-Layout and Display-Map elements- typography and lettering; portraying land surface form .

Unit 6

Various type of GIS, Desktop, Mobile, Web (WMS/ WFS), Internet GIS, Open source GIS concept: OGC standards in GIS, various open source web GIS platforms: Bhuvan, NSDI-IndiaGeoportal, NNRMS portal, BhooSampada, IBIN, BIS, Sahyadri, GoogleEarth, NOEDA, UN Spider, WorldClim etc.

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Cromley, R. G., Digital Cartography. Prentice-Hall of India, New Delhi, 1992.

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SEMESTER IV

GL 241: ECONOMIC GEOLOGY

AIM

To understand the mode of occurrence, genesis and structure of mineral deposists and fossil fuels in India and the laws that govern their sustainable utilization.

OBJECTIVES

The objectives of this course are: (i) to develop an understanding of how the National Mineral Policy evolved (ii) how the mineral deposits of the oceans are managed and exploited (iii) how the various economic mineral deposits are distributed in India and (iv) the geological characteristics of the deposits and (v) to understand the importance of industrial minerals

Course outcomes

CO1: Understand the physicochemical properties of ore deposits, and theories, controls and age of ore formation.

CO2: Understand the classification of ore deposits, the origin of different rock – ore associations and the important characteristics of ore deposits formed in different geological environments

CO3: Understand metamorphic, metasomatic, volcanic, sedimentary, hydrothermal ore formation processes

CO4: Understand how global tectonics influences ore mineralization and understand ore microscopy to analyze ore textures and genesis.

CO5: Understand the National Mineral Policy and the origin and properties of U, Th, Cu, Al, Fe-bearing and other important mineral deposits of India

CO6: Understand the physico-chemical properties, origin and distribution of fossil fuels in India

CO – PSO Map

CO No.	CO Statements	Cognitive Level	Knowledge Category	PSO
CO1	Understand the physicochemical properties of ore deposits, and theories, controls and age of ore formation.	U	F & C	PSO2
CO2	Understand the classification of ore deposits, the origin of different rock – ore associations and the important characteristics of ore deposits formed in different geological environments	U	F & C	PSO2
CO3	Understand metamorphic,	U	F & C	PSO2

	metasomatic, volcanic, sedimentary, hydrothermal ore formation processes			
CO4	Understand how global tectonics influences ore mineralization and understand ore microscopy to analyze ore textures and genesis.	U, Analyze	F, C, P	PSO2
CO5	Understand the National Mineral Policy and the origin and properties of U, Th, Cu, Al, Fe-bearing and other important mineral deposits of India	U	F & C	PSO2
CO6	Understand the physico-chemical properties, origin and distribution of fossil fuels in India	U	F & C	PSO2

Knowledge category: F – Factual C – Conceptual P – Procedural
Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

UNIT I

Nature and morphology of principal types of ore deposits. Textures and structures of ore and gangue minerals. Fluid inclusion studies in ore deposit 1s. Ore forming solutions and their migration. Wall rock alteration. Major theories of ore genesis. Paragenetic sequences, zoning. Magmatic processes of mineralization.

UNIT II

Classification of ore deposits. Environments of ore formation – genetic relationship between rocks and ore deposits. Diamond in kimberlite, ores in pegmatite. Cr, Pt, Ti, Cu and Ni deposits associated with basic and ultrabasic rocks.

UNIT III

Skarn deposits, disseminated sulphide, oxide and sulphate deposits of sedimentary and volcanic environments. Salient characteristics of hydrothermal, stratiform, stratabound, sedimentary, residual and supergene ore deposits with examples. Metamorphism of ore deposits.

UNIT IV

Metallogenic epochs and provinces; metallogeny and mineral belts. Plate tectonic controls in mineralization. Ore mineralization through geologic time. Principles and applications of ore microscopy. Ore textures and their genetic significance.

UNIT V

Atomic minerals – geochemistry of U and Th deposits; genetic classification of U and Th deposits. Geology and genesis of U deposits of Jaduguda. Pb-Zn deposits of Rajasthan, Cu deposits of Singhbhum and Malanjkhand, East Coast Bauxite, Iron ore deposits of Bailadila and Kudremukh. Strategic, critical and essential minerals of India. National Mineral Policy of India.

UNIT VI

Coal – physical and chemical properties of coal; coal petrography: - macroscopic and microscopic components of coal and their mode of origin. Coal deposits of Raniganj and Jharia. Lignite deposits of Neyveli and Palana. Tertiary coal fields of Assam. Coal Bed Methane. Industrial uses of coal.

Petroleum – source rocks; process of transformation of organic matter to petroleum; migration and accumulation of petroleum. Some of the important petroliferous basins of India such as Assam shelf, Bombay offshore, Cambay basin, Cauvery basin, Krishna-Godavari basin, and Lakshwadeep basins.

Reference books

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GL 242 Advanced Mapping Techniques and Exploration Geology

AIM

To familiarize students with RADAR, LIDAR and hyperspectral remote sensing & exploration geology

OBJECTIVES

Impart capability to students to use RADAR, LIDAR and hyperspectral remote sensing in geological mapping and problem solving.

Course outcomes

CO1: Understand RADAR remote sensing and its applications

CO2: Understand advanced remote sensing images, like hyperspectral images

CO3: Understand LIDAR remote sensing

CO4: Understand exploration activities, drilling and sampling

CO5: Understand geophysical survey techniques

CO6: Understand techniques for groundwater exploration

CO-PSO map

CO No.	CO Statements	Cognitive Level	Knowledge Category	PSO
CO1	Understand RADAR remote sensing and its applications	U & E	F & C	PSO1
CO2	Understand advanced remote sensing images, like hyperspectral images	U & E	F & C	PSO1
CO3	Understand LIDAR remote sensing	U & E	F & C	PSO1
CO4	Understand exploration activities, drilling and sampling	U & E	F & C	PSO1
CO5	Understand geophysical survey techniques	U	F, C & P	PSO1
CO6	Understand techniques for groundwater exploration	U	F & C	PSO1

Knowledge category: F – Factual C – Conceptual P – Procedural
Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

Unit 1

Radar-Real and synthetic aperture radars, - Principles - different platforms and sensors, System parameters, Target parameters, Radar equation measurement and discrimination, Airborne Data products and selection procedure - SEASAT, SIRA, SIRB, ERS , JERS, RADARSAT missions. Radar data processing - Radar grammetry, Image processing, SAR Interferrometry – Polarimetry- Interpretation of microwave data - Physical mechanism and empirical models for scattering and emission, volume scattering. Applications of microwave remote sensing - Geological interpretation of RADAR –sites-default-files, Application in Agriculture -forestry, Hydrology - ice studies – land use mapping and ocean related studies. Introduction to Thermal Remote Sensing

Unit 2

Multispectral and hyperspectral remote sensing, Comparison of Multispectral and Hyperspectral Image Data, Spectral Signatures and BRDF in the Visible, Near Infrared and Shortwave Infrared regions of EMR, Hyperspectral Issues. Sensors and hyperspectral imaging devices - Scanner types and characterization - specifications of various sensors Spectrographic imagers-

hyperspectral sensors, Design tradeoffs. Data formats and systems, AVIRIS, CASI, NASA Terra Moderate Resolution Imaging Spectrometer (MODIS), Hyperion.

Unit 3

LIDAR remote sensing platforms - Introduction to the LIDAR remote sensing platform - Historical development of LIDAR remote sensing platforms Airborne platforms, Laser Scanning, Fixed- Wing Platforms, Rotary-Wing Platforms - Terrestrial, airborne, and spacebar types – Space borne platforms. Introduction to UAV/drone-based sensing

Unit 4

Stages of exploration – Reconnaissance survey; criteria for exploration method (guides to ores). Collection and processing of exploration data. Field work in sedimentary, igneous and metamorphic terrains. Maps of different scales used in exploration, Trenching and pitting – selection of trench sites, logging and sampling of trenches and pits. Drilling – design of a drilling programme, drilling methods – vertical and inclined drill holes. Types of drilling, logging of bore holes, borehole deviations. Preparation of sections and level plans, mineral maps of the area, fence diagrams. Subsurface mapping – floor and roof contouring. Sampling –Purpose of sampling. Sample types, methods of sampling; Sample preparation and errors in sampling.

Unit 5

Geophysical survey, surface investigation, subsurface investigation, Gravity survey, Seismic survey, refraction methods, reflection methods, applications, Magnetic survey and Electrical resistivity survey, self potential methods, potential drop methods, resistivity values, data interpretation, Curve fitting.

Unit 6

Groundwater Exploration: GIS & remote sensing integration in groundwater mapping. Hydrogeomorphic and lineament mapping. Prospecting for groundwater – geological aspects. Surface geophysical methods – geo-electrical – electrical resistivity and seismic refraction methods.

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GL 243: Geoinformatics Applications in Geology and Disaster Management

AIM

To familiarize students with the basic concepts of Geographical Information Systems and the related software

OBJECTIVES

Train students in the core concepts of Geographical Information Systems, and lay the foundation for geospatial thinking and usage of software.

Course outcomes

CO1: Understand spectral properties of earth objects

CO2: Understand interpretation of images to delineate geological structures

CO3: Understand lithological mapping

CO4: Understanding disasters – hydrological and geological

CO5: Understanding post-disaster reconstruction

CO6: Understanding geoinformatics use in all phases of disasters

CO-PSO map

CO No.	CO Statements	Cognitive Level	Knowledge Category	PSO
CO1	Understand spectral properties of earth objects	U & E	F & C	PSO1
CO2	Understand interpretation of images to delineate geological structures	U & E	F & C	PSO1
CO3	Understand lithological mapping	U & E	F & C	PSO1

CO4	Understanding disasters – hydrological and geological	U & E	F & C	PSO1
CO5	Understanding post-disaster reconstruction	U	F, C & P	PSO1
CO6	Understanding geoinformatics use in all phases of disasters	U	F & C	PSO1

Knowledge category: F – Factual C – Conceptual P – Procedural
Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

Unit 1

Spectral properties of rocks and minerals - Reflectance Properties of Rocks, minerals in visible, NIR, MIR, SWIR, TIR and Microwave regions Laboratory spectroscopy - laboratory and field spectral data comparative studies, Spectral reflection curves for important Rocks, Minerals. Hyperspectral sensors in Mars and Moon Missions

Unit 2

Geological structure and applications - Significance of Geological structures, Role of aerial photographs, Photo interpretation characters of photographs and satellite images, structural mapping, Fold, fault, Lineaments, Direction circular features. Intrusive rocks, rock exposure, Fractures and Joints, Rose diagram. Digital image processing for structural mapping. Watershed Management using geoinformatics.

Unit3

Lithological mapping - Introduction on Igneous rocks, sedimentary rocks, metamorphic rocks, mapping of regional scale lithological units, Image Characters of igneous rocks, sedimentary and metamorphic rocks, examples. Digital image processing of various rock types, resolution and Scale of lithological mapping and advantages.

Unit 4

Hydrological & geological disasters - Basic concepts and principles - Hydrological and geological disasters, Role of Government administration, NGOs - International disaster assistance - Sharing technology and technical expertise.

Unit 5

Cyclones & floods - Dams, Bridges, Hospitals, Industrial structures, Disaster resistant structures - Low cost housing for disaster prone areas - Cyclone shelter projects and their implications - Reconstruction after disasters.

Unit 6

Remote sensing monitoring & analysis - Remote Sensing Application - Risk assessment - Damage assessment – Land use planning and regulation for sustainable development - Use of Internet - Communication Network – Various Early Warning Systems - Post disaster review – Case studies. Role of GIS in disasters - Vulnerability analysis of infrastructure and settlements -

Pre-disaster and post disaster planning for relief operations - Potential of GIS application in development planning and disaster management plan - Case studies. Role of NIDM, INCOIS, IMD, NRSC, CWC in disaster management.

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PRACTICAL SYLLABUS

GL 224: Practical I (Semester I)

GEOMORPHOLOGY, MINERALOGY and REMOTE SENSING & PHOTOGRAMMETRY

GEOMORPHOLOGY

Interpretation of topographic maps and identification of salient geomorphic features. Morphometric studies.

AIM

To study and interpret topographic sheets and indentify salient geomorphic features and to carry out morphometric analysis of drainage basins.

OBJECTIVES

1) To study the basic information from toposheets, viz., Scale, Index, Grid reference, Area location and Contour interval.

2) To make measurements from toposheets and determine distances between places, slopes, lengths of natural and man-made features and areas.
3) To identify and describe the salient geomorphic features such as hills, valleys and drainage networks and patterns.
4) To carry out morphometric analysis of drainage basins.

Course outcome GL 224: Practical I GEOMORPHOLOGY

CO 1: Identify and describe basic information of toposheets like Scale, Index, Grid reference, Area location and Contour interval; and make measurements, determine parameters like distances between places, slopes, lengths of natural and man-made features and areas.

CO 2: Identify and describe salient geomorphic features like hills, valleys and drainage networks and patterns in toposheets.

CO 3: Execute the various steps involved in morphometric analysis of drainage basins like stream ordering and determine the parameters like drainage area, basin length, length of streams, drainage density, stream frequency, bifurcation ratio and estimate relationships of parameters using regression analysis.

CO – PSO map

CO No.	CO Statements	Cognitive Level	Knowledge Category	PSO
CO 1	Identify and describe basic information of toposheets like Scale, Index, Grid reference, Area location and Contour interval; and make measurements, determine parameters like distances between places, slopes, lengths of natural and man-made features and areas.	Apply & Analyze	F, C & P	PSO1
CO 2	Identify and describe salient geomorphic features like hills, valleys and drainage networks and patterns in toposheets.	Apply & Analyze	F, C & P	PSO1
CO 3	Execute the various steps involved in morphometric analysis of drainage basins like stream ordering and determine the parameters like drainage area, basin length, length of streams, drainage density, stream frequency, bifurcation ratio and estimate relationships of parameters using regression analysis.	Apply & Analyze	F, C & P	PSO1

Knowledge category: F – Factual C – Conceptual P – Procedural
Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

MINERALOGY : OPTICAL MINERALOGY

Determination of the following optical characters of minerals by classical methods:

Relative refringence, order of interference colour, sign of elongation, birefringence, scheme of pleochroism and pleochroic formula, optic orientation, extinction angle, anorthite content.

MINERALOGY : MINERAL CHEMISTRY

Mineralogical calculations: garnet, olivine, pyroxene, feldspar and feldspathoid.

AIM

To develop skills in determining diagnostics optical properties of rock forming minerals in thin sections and to determine mineral formula using mineral chemical data.

OBJECTIVES

Understand how optical properties of minerals are diagnostic of each mineral and also to determine the mineral formula from chemistry of minerals

Course outcomes

CO1: Understand and evaluate important optical parameters of minerals using polarising microscope and optical accessories.
CO2: Understand and evaluate mineral chemistry by stoichiometric calculations, using chemical analysis data of members of important mineral families.

CO No.	CO Statements	Cognitive Level	Knowledge Category	PSO
CO1	**Understand and d**etermine important optical parameters of minerals using polarising microscope and optical accessories.	U, Analyse, Apply, Evaluate	F & C	PSO2
CO2	**Understand mineral chemistry** by stoichiometric calculations, using chemical analysis data of members of important mineral families.	U, Analyse, Apply, Evaluate	F & C	PSO2

Knowledge category: F – Factual C – Conceptual P – Procedural

Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

Remote Sensing

1. Elements of Visual Interpretation of satellite and Aerial Photographs

2. Delineate various geomorphic features from satellite data (Hardcopy FCC)
3. Landuse/Landcover mapping (Hardcopy FCC)
4. Identification of drainage pattern (Hardcopy FCC)
5. **Georeference toposheets and derive basic parameters**

AIM

To underatke visual interpretation of satellite and aerial photographs, and develop capabilities in geomorphological mapping

OBJECTIVES

Develop skills in image interpretation and geomorphological mapping

Course outcomes

CO 1: Identify, describe and interpret drainage features, land use patterns, geomorphological features, environmental features, lineaments, lithologies and litho-contacts, and geological structures from aerial and satellite photos.

CO 2: Describe the basic information from satellite imagery like source, year, reference grids, area imaged, etc. and do landuse/landcover mapping

CO – PSO map

CO No.	CO Statements	Cognitive Level	Knowledge Category	PSO
CO 1	Identify, describe and interpret drainage features, land use patterns, geomorphological features, environmental features, lineaments, lithologies and litho-contacts, and geological structures from aerial and satellite photos.	Apply & Analyze	F, C & P	PSO5
CO 2	Describe the basic information from satellite imagery like source, year, reference grids, area imaged, etc. and do landuse/landcover mapping	Apply & Analyze	F, C & P	PSO5

Knowledge category: F – Factual C – Conceptual P – Procedural
Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

GL 225: Practical II (Semester II)

Structural Geology, Hydrogeology, Digital Image Processing and Global Navigational Satellite Systems

STRUCTURAL GEOLOGY

Interpretation of geologic maps. Trigonometric, graphic and stereographic solution to problems in structural geology. Geometric analysis of planar and linear structures.

AIM

To understand and analyse geological maps, structural problems and stereographic projections.

OBJECTIVES

The objectives of this course are: (i) to develop an understanding of geological maps and to develop how to draw the cross section of map. (ii) to know how to solve different structural problems. (iii) analysis of structures based on stereographic projection.

Course outcomes

CO1: Application of stereographic and equal area projections in the representation of structures and geometric analysis of folds and lineations.

CO2: Understand the interpretation of geologic maps. Analyse the Trigonometric, graphic and stereographic problems.

CO – PSO

CO No.	CO Statements	Cognitive Level	Knowledge Category	PSO
CO 1	Application of stereographic and equal area projections in the representation of structures and geometric analysis of folds and lineations.	U, Analyze	F, C &P	PSO2
CO2	Understand the interpretation of geologic maps. Analyse the Trigonometric, graphic and stereographic problems.	U, Analyze	F, C &P	PSO2

Knowledge category: F – Factual C – Conceptual P – Procedural

Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

HYDROGEOLOGY: Solution of problems based on Darcy's law. Preparation and interpretation of water table contour maps. Computation of aquifer parameters from pumping data. Collection of well inventory data. Graphical representation of hydrochemical data. Hill-Piper Trilinear diagram and U.S. Salinity diagram.

AIM

To solve problems and execute practical exercises related to the occurrence, distribution and movement of groundwater, determine the aquifer parameters from pumping test data to quantify aquifers and to determine the quality of groundwater for domestic and agricultural purposes using typical graphical representations.

OBJECTIVES

1) To study the occurrence, distribution and movement of groundwater using figures, water table contours and solve problems related to Darcy's law.

2) To determine the aquifer parameters from pumping test data to quantify aquifers.

3) To determine the quality of groundwater for domestic and agricultural purposes using typical graphical representations like Hill-Piper Trilinear diagram and U.S. Salinity diagram.

Course outcome GL 244: Practical II HYDROGEOLOGY

CO 1: Describe and sketch the information related to the occurrence, distribution and movement of groundwater using figures like hydrological cycle, vertical distribution of groundwater, and water table contours; and solve problems based on Darcy's law.

CO 2: Quantify aquifers by computing aquifer parameters like Hydraulic conductivity, Transmissivity and Storativity, using pumping test data.

CO 3: Determine groundwater quality for domestic and agricultural purposes using graphical representation like Hill-Piper Trilinear diagram and U.S. Salinity diagram.

CO – PSO map

CO No.	CO Statements	Cognitive Level	Knowledge Category	PSO
CO 1	Describe and sketch the information related to the occurrence, distribution and movement of groundwater using figures like hydrological cycle, vertical distribution of groundwater, and water table contours; and solve problems based on Darcy's law.	Apply & Analyze	F, C & P	PSO5
CO 2	Quantify aquifers by computing aquifer parameters like Hydraulic conductivity, Transmissivity and Storativity, using pumping test data.	Apply & Analyze	F, C & P	PSO5
CO 3	Determine groundwater quality for domestic and agricultural purposes using graphical representation like Hill-Piper Trilinear diagram and U.S. Salinity diagram.	Apply & Analyze	F, C & P	PSO5

Knowledge category: F – Factual C – Conceptual P – Procedural

Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

Digital Image Processing and Global Navigational Satellite Systems

Digital Image processing

1. Layer stacking and Various band combinations

2. Image rectification
3. Image classification, supervised and unsupervised classifications
4. Image Fusion
5. Stitching of Images
6. Change Detection from Multi-Temporal imagery

Global Positioning System

1. Introduction to GPS and initial setting
2. Creating codes and attribute table for GPS receiver
3. Point Data collection using GPS with different datum
4. Line data collection using GPS and measurements
5. GPS data collection for area calculation
6. Familiarization of DGPS

AIM

To understand image processing. To become thorough with the use of GPS and DGPS

OBJECTIVES

The objectives of this course are: (i) to develop skills in image processing and information extraction (ii) to learn the various uses of GPS and to practically use it for data generation.

Course outcomes

CO1: Understand image rectification, supervised and unsupervised classification, image fusion, change detection

CO2: Understand use of GPS, point – line data collection, and area calculation

CO – PSO

CO No.	CO Statements	Cognitive Level	Knowledge Category	PSO
CO 1	Understand image rectification, supervised and unsupervised classification, image fusion, change detection	U, Analyze	F, C &P	PSO2
CO2	Understand use of GPS, point – line data collection, and area calculation	U, Analyze	F, C &P	PSO2

Knowledge category: F – Factual C – Conceptual P – Procedural

Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

GL 244: Practical III (Semester III)

SEDIMENTARY, IGNEOUS AND METAMORPHIC PETROLOGY AND GEOGRAPHIC INFORMATION SYSTEMS

SEDIMENTOLOGY: Textural analysis of sediments – Sieve analysis, settling analysis, thin section size analysis, measurement and calculation of shape parameters, plotting and interpretation of such data. Heavy mineral separation.

Study of thin sections and hand specimens of limestone, sandstone, shale, conglomerate, breccia and arkose. Study of grain mounts of magnetite, ilmenite, monazite, garnet, quartz and chromite.

AIM

To determine and analyze the sediment texture, heavy mineral assemblages and, properties of sedimentary rock and placer minerals

OBJECTIVES

To determine and analyze the i) how the sediment texture and heavy mineral assemblage changes in sediments ii) how the sedimentary rock characteristics changes in hand specimen and thin section iii) how the placer mineral characteristics changes in grain mounts.

Course outcomes

CO1: Determine the sediment texture using sieve, settling and microscopic methods, and shape parameters, and analyzes of such data
CO2: Determine the mineral assemblage using heavy mineral separation and analyze of such data
CO3: Determine the hand specimen and thin section properties of sedimentary rocks and analyzes of such data
CO4: Determine the grain mount properties of placer minerals and analyzes of such data

CO – PSO map

CO No.	CO Statements	Cognitive Level	Knowledge Category	PSO
CO 1	Determine the sediment texture using sieve, settling and microscopic methods, and shape parameters, and analyzes of such data	Apply & Analyze	F, C & P	PSO3
CO 2	Determine the mineral assemblage using heavy mineral separation and analyze of such data	Apply & Analyze	F, C & P	PSO3
CO 3	Determine the hand specimen and thin section properties of sedimentary rocks and analyzes of such data	Apply & Analyze	F, C &P	PSO3
CO 4	Determine the grain mount properties of placer minerals and analyzes of such data	Apply & Analyze	F, C & P	PSO

Knowledge category: F – Factual C – Conceptual P – Procedural
Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

IGNEOUS AND METAMORPHIC PETROLOGY: Megascopic and microscopic study of igneous and metamorphic rocks. Textures and microstructures and their genetic significance. Graphical representation of metamorphic mineral paragenesis – ACF, AKF and AFM diagrams.

Determination of modal composition, calculation of CIPW norms. Niggli values. Variation diagrams of Harker, Larsen, Niggli and Nockold and Allen. Spider diagrams. Calculation of differentiation index, Peacock's alkali-lime index, Mg number, A/CNK values, use of triangular diagrams in the classification of igneous rocks. Construction of phase diagrams from experimental data in the following systems. Diopside-Anorthite, Anorthite-Albite, Forsterite-Silica. Computations of the course of crystallisation of magmas of various compositions in the above systems consequent on fractional crystallisation and assimilation.

AIM

To understand igneous and metamorphic processes, types and genesis of igneous and metamorphic rocks through study of mineralogy and geochemical plotting.

OBJECTIVE

The objective of this course are to develop an understanding of the mineralogy and textures of igneous and metamorphic rocks, and how phase rule applies to metamorphic mineral paragenesis, and the use of variation diagrams and traingular plots in deciphering the evolution of these rocks

COURSE OUTCOME

CO1: To analyze the texture, microstructure, mineralogy and genetic significance of different igneous rocks in hand specimen and under the microscope
CO2: Calculation of CIPW Norm and their interpretation using the different indices and ratios of magmatic differentiation
CO3: The preparation of variation diagrams of Harker, Larsen, Niggli and Allen- Nockolds for the given geochemical data
CO4: The preparation of some common triangular diagrams in the classification of igneous rocks
CO5: Identify metamorphic rocks and analyse metamorphic mineral paragenesis using chemographic diagrams

CO-PSO Map

CO	CO Statements	Cognitive Level	Knowledge Category	PSO
CO1	To analyze the texture, microstructure, mineralogy and genetic significance of different igneous rocks in hand specimen and under the	U	F, C	PSO2

	microscope			
CO2	Calculation of CIPW Norm and their interpretation using the different indices and ratios of magmatic differentiation	U	F,C	PSO2
CO3	The preparation of variation diagrams of Harker, Larsen, Niggli and Allen- Nockolds for the given geochemical data	U	F,C,	PSO2
CO4	The preparation of some common triangular diagrams in the classification of igneous rocks	U	F,C	PSO2
CO5	Identify metamorphic rocks and analyse metamorphic mineral paragenesis using chemographic diagrams	A	F,P,A	PSO2

Knowledge category: F – Factual C – Conceptual P – Procedural

Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

Geographical Information System

1. Introduction to GIS Software
2. GIS entities and feature data; point, line and polygon feature
3. Topology creation and database creation
4. Proximity analysis
5. Overlay analysis
6. Comma-separated values text file (CSV) to feature generation

AIM

To understand the use of GIS software in spatial data processing.

OBJECTIVES

The objectives of this course are: (i) develop skills in using GIS software (ii) develop understanding of GIS entities (iii) develop skills at GIS analysis and feature generation

Course outcomes

CO1: Develop skills in using GIS software

CO2: Understand GIS entities and use them in GIS processing

CO3: Understand GIS analysis and feature generation

CO – PSO

CO No.	CO Statements	Cognitive Level	Knowledge Category	PSO
CO1	Develop skills in using GIS software	U, Analyze	F, C &P	PSO2

CO2	Understand GIS entities and use them in GIS processing	U, Analyze	F, C &P	PSO2
CO3	Understand GIS analysis and feature generation	U, Analyze	F, C &P	PSO2

Knowledge category: F – Factual C – Conceptual P – Procedural

Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

GL 245: PRACTICAL IV (SEMESTER IV)

ECONOMIC GEOLOGY, Advanced Mapping Techniques and Exploration Geology, Geoinformatics Applications in Geology and Disaster Management

ECONOMIC GEOLOGY: Collection and display of data on production, consumption and export of important minerals, coal and petroleum in India. Megascopic identification of ore minerals.

AIM

Analyse data on mineral production, use and consumption, as well as identify ore minerals.

Objective

Develop the capability to analyze data on mineral production, use and export as well as the capability to identify ore minerals.

Course outcomes

CO1: Analyze data on mineral production, use and export

CO2: Identify ore minerals

CO – PSO map

CO No.	CO Statements	Cognitive Level	Knowledge Category	PSO
CO 1	Analyze data on mineral production, use and export	Apply & Analyze	F, C & P	PSO2
CO 2	Identify ore minerals	U	F & P	PSO2

Knowledge category: F – Factual C – Conceptual P – Procedural

Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

Advanced Mapping Techniques and Exploration Geology

Advanced Mapping Techniques

Using software develop

1. Familiarization of Microwave and thermal data,
2. Familiarization of Hyperspectral data
3. Familiarization of Lidar/UAV data
4. Advanced GIS analysis: undertake any type of GIS analysis at an advanced level

AIM

Familiarization with Microwave, thermal, hyperspectral and Lidar/UAV data, and also get skilled in advanced GIS analysis.

Objective

Develop the capability to distinguish the relative merits and uuses of Microwave, thermal, hyperspectral and Lidar/UAV data, and get skilled in advanced GIS analysis.

Course outcomes

CO1: Capability to distinguish the relative merits and uses of Microwave, thermal, hyperspectral and Lidar/UAV data

CO2: Skill development in advanced GIS analysis.

CO – PSO map

CO No.	CO Statements	Cognitive Level	Knowledge Category	PSO
CO 1	Capability to distinguish the relative merits and uses of Microwave, thermal, hyperspectral and Lidar/UAV data	Apply & Analyze	F, C & P	PSO2
CO 2	Skill development in advanced GIS analysis.	U	F & P	PSO2

Knowledge category: F – Factual C – Conceptual P – Procedural

Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

EXPLORATION GEOLOGY: Averaging assays, estimation of ore reserves, cut off grade, core logging and interpretations from litholog plotting.

AIM

To develop skills in resource exploitation and reserve estimation

Objective

Develop the capability to determine assays, ore reserves, cut off grade, core logging and litholog interpretations.

Course outcomes

CO1: Capability to determine assays, ore reserves, cut off grade

CO2: Capability of core logging and litholog interpretations.

CO – PSO map

CO No.	CO Statements	Cognitive Level	Knowledge Category	PSO
CO 1	Capability to determine assays, ore reserves, cut off grade	Apply & Analyze	F, C & P	PSO2
CO 2	Capability of core logging and litholog interpretations.	U	F & P	PSO2

Knowledge category: F – Factual C – Conceptual P – Procedural

Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

Applications of GIS in Geology and Disaster Management

1. Flood prone area mapping using satellite images and ancillary data.
2. Forest fire risk mapping using satellite images and GIS.
3. Landslide mapping and risk evaluation.
4. Drought prone area mapping using satellite images
5. Terrain mapping in coastal region for coastal hazards prediction

AIM

Develop understanding of GIS usage in disaster management

Objective

Develop the capability to use GIS to characterise, map and manage floods, forest fires, landslides, drought, and coastal hazards

Course outcomes

CO1: Capability to use GIS to characterise, map and manage floods, forest fires

CO2: Capability to use GIS to characterise, map and manage landslide, drought, and coastal hazards

CO – PSO map

CO No.	CO Statements	Cognitive Level	Knowledge Category	PSO
CO1	Capability to use GIS to characterise, map and manage floods, forest fires	Apply & Analyze	F, C & P	PSO2
CO2	Capability to use GIS to characterise, map and manage landslide, drought, and coastal hazards	U	F & P	PSO2

Knowledge category: F – Factual C – Conceptual P – Procedural

Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

DISSERTATION

Aim

Dissertation is to empower the student to develop critical thinking, innovative research ideas, and deeper knowledge in the subject.

Objective

To develop skills which enable the synthesis of knowledge and improve scientific field work, data collection, analysis and writing skills. To develop and enhance independent research skills.

Course outcomes

CO 1: Understand a specific area of the subject in-depth including deeper insight into current research and development work, through primary, secondary and tertiary sources of information.

CO2: Plan the research, identify the problem, field area, collect data, classify and analyse the data.

CO3: Understand the methodology in the chosen research area and develop the critical thinking ability to choose the most appropriate methodology for the particular research problem.

CO4: Develop capability to use a holistic view to critically, independently and creatively identify, formulate and deal with complex issues.

CO5: Critically and systematically integrate the findings of the research into the current scenario in the area of research, with concern for and conscious of the ethical aspects of research.

CO6: Evaluate the results through writing the thesis and presenting the results to a learned audience.

CO – PSO map

CO No.	CO Statements	Cognitive Level	Knowledge Category	PO	PSO
CO1	Understand a specific area of the subject in-depth including deeper insight into current research and development work, through primary, secondary and tertiary sources of information.	U&A	F & C	F & C	PSO6
CO2	Plan the research, identify the problem, field area, collect data, classify and analyse the data.	U,A&E	F,P & C	F,P & C	PSO6
CO3	Understand the methodology in the chosen research area and develop the critical thinking ability to choose the most appropriate methodology for the particular research problem.	A&E	F,P& C	F,P& C	PSO6
CO4	Develop capability to use a holistic view to critically, independently and creatively identify, formulate and deal with complex issues.	E&C	F,C&P	F,C&P	PSO6
CO5	**C**ritically and systematically integrate the findings of the research into the current scenario in the area of research, with concern for and conscious of the ethical aspects of research.	E&C	F,P & C	F,P & C	PSO6
CO6	Evaluate the results through writing the thesis and presenting the results to a learned audience.	A&C	F&C	F&C	PSO6

Knowledge category: F – Factual C – Conceptual P – Procedural

Cognitive levels: R – Remember, U – Understand , A – Apply, An – Analyze, E – Evaluate, C – Create

Appendix I

Action Verbs associated with Bloom's cognitive levels

Remember

• Recognize/Identify

• Recall/Retrieve: List, mention, state, draw, label, define, name, describe, prove a theorem tell, show, label, collect, examine, tabulate, quote, , who, when, where, etc.

Understand

• Interpret: Translate, paraphrase, represent, describe, express, extend and clarify
• Exemplify: Illustrate and instantiate
• Classify: Categorize and subsume
• Summarize: Generalize and abstract
• Infer: Extrapolate, interpolate, predict, conclude
• Compare: Contrast, match, map, distinguish and differentiate
• Explain: Illustrate, construct a model, confirm, state, write down, associate and discuss

Apply

• Execute: Determine, calculate, compute, estimate solve, use, draw, and carry out (a procedure in known situation)
• Implementing: Determine, calculate, compute, estimate solve, use draw, and carry out (a procedure in unfamiliar situation)

Analyze
• Differentiate: discriminate, select, focus and distinguish (between accurate and inaccurate, cause and effect, consistent and inconsistent, dominant and subordinate, essential and inessential, facts and conclusions, facts and hypotheses, facts and inferences, facts and opinions, facts and value statements, plausible and implausible, possible and impossible, relevant and irrelevant, summaries and conclusions, supportive and contradictory, valid and invalid, verifiable and unverifiable, warranted and unwarranted)
• Organize: Identify (adequacy, assumptions, attributes, biases, causes, central issues, completeness, concepts, consequences, contradictions, criteria, defects, distortions, effects, elements, errors, exceptions, fallacies, inconsistencies, inferences, limitations, main ideas, nature of evidence, organization, plausibility, problems, procedures, reasoning, relationships, relevance, stereotypes, trends, validity, variables), structure, integrate, find coherence, outline and parse.
• Attribute: Deconstruct and ascertain (Assumptions, attitudes, biases, conditions, characteristics, motives, organization, points of view, purposes, qualities, relationships)

Evaluate
• Check/test (Accuracy, adequacy, appropriateness, clarity, cohesiveness, completeness, consistency, correctness, credibility, organization, reasonableness, reasoning, relationships, reliability, significance, usefulness, validity, values, worth), detect, monitor and coordinate.
• Critique/judge (Criteria, standards, and procedures)

Create
• Generate alternatives and hypotheses
• Plan/design
• Produce/construct

(*Source: N.J.Rao, Nov 2010*)

Appendix II

Educational Taxonomy

has four knowledge categories and *six* cognitive levels.

Knowledge categories

Factual
Conceptual
Procedural
Meta cognitive

Cognitive levels
Remember

Understand
Apply
Analyze
Evaluate
Create

Program Outcomes (POs) are those qualities that should be developed in any student by the end of their studies at any institution, and therefore, to be identified by the University/Institution.

Examples

PO1 – Critical Thinking
PO2 – Effective Communication
PO3 – Effective Citizenship
PO4 - Environment and Sustainability
PO5 – Self-directed and Life-long learning
PO6 – Social Interaction
PO7 – Computational Thinking
PO8 – Problem Solving
PO9 – Global Perspective
PO10 – Ethical conduct

Program Specific Outcomes (PSO)
PSOs are specific to a program (e.g., MSc Geology), and are to be identified by the users, e.g., for Geology, the users would be students, teachers, Board of Studies, Academic Council, etc of each University.

Course outcomes (CO)
Course Outcomes constitute the final attainment of POs and PSOs specifically through each course (or paper e.g, Hydrogeology)