

Mahakaushal University, Jabalpur (M.P.)



Scheme & Syllabus

For

B.Sc. with Research/honors

Geology

2022-23

Duration of Course: 4 Years

Examination Mode: Semester

Examination System: CBCS

**Mahakaushal University
Village-Aithakheda, Mukunwara Road, Post- Tilwara Jabalpur (M.P.) 482003**

Earth System Science

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Unit-I

(10 Lectures)

Earth as a planet: Holistic understanding of dynamic planet 'Earth' through Astronomy, Geology, Meteorology and Oceanography. Introduction to various branches of Earth Sciences. General characteristics and origin of the Universe, Solar System and its planets. The terrestrial and jovian planets. Meteorites and Asteroids, Earth in the solar system - origin, size, shape, mass, density, rotational and revolution parameters and its age.

Unit-II

(10 Lectures)

Earth's magnetic field: Earth's magnetic field, Formation of core, mantle, crust, hydrosphere, atmosphere and biosphere, Convection in Earth's core and production of its magnetic field, Mechanical layering of the Earth.

Unit-III

(16 Lectures)

Plate Tectonics: Concept of plate tectonics, sea-floor spreading and continental drift, Geodynamic elements of Earth- Mid Oceanic Ridges, trenches, transform faults and island arcs, Origin of oceans, continents, mountains and rift valleys, Earthquake and earthquake belts, Volcanoes- types, products and their distribution.

Hydrosphere and Atmosphere: Oceanic current system and effect of Coriolis force, Concepts of eustasy, Land-air-sea interaction, Wave erosion and beach processes, Atmospheric circulation, Weather and climatic changes, Earth's heat budget.

Unit-IV

(12 Lectures)

Soil: Soils- processes of formation, soil profile and soil types.

Understanding the past from stratigraphic records: Nature of stratigraphic records, Standard stratigraphic time scale and introduction to the concept of time in geological studies, Introduction to geochronological methods and their application in geological studies, History of development in concepts of uniformitarianism, catastrophism and Neptunism, Laws of

superposition and faunal succession, Introduction to geology and geomorphology of Indian subcontinent.

Unit-V

(12 Lectures)

Cosmic abundance of elements: Distribution of elements in solar system and in Earth, Chemical differentiation and composition of the Earth, General concepts about geochemical cycles and mass balance, Properties of elements, Geochemical behaviour of major elements, Mass conservation of elements and isotopic fractionation.

Reference Books:

- Duff, P. M. D., & Duff, D. (Eds.). (1993). *Holmes' principles of physical geology*. Taylor & Francis.
- Emiliani, C. (1992). *Planet earth: cosmology, geology, and the evolution of life and environment*. Cambridge University Press.
- Gross, M. G. (1977). *Oceanography: A view of the earth*.

Earth System Science Lab

Practical:

1. Study of major geomorphic features and their relationships with outcrops through physiographic models.
2. Detailed study of topographic sheets and preparation of physiographic description of an area
3. Study of soil profile of any specific area
4. Study of distribution of major lithostratigraphic units on the map of India
5. Study of distribution of major dams on map of India and their impact on river systems
6. Study of major ocean currents of the World
7. Study of seismic profile of a specific area and its interpretation

Reference Books:

- Duff, P. M. D., & Duff, D. (Eds.). (1993). Holmes' principles of physical geology. Taylor & Francis.
- Emiliani, C. (1992). Planet earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press.
- Gross, M. G. (1977). Oceanography: A view of the earth.

Mineral Science

L T P
4 0 2

Unit-I

(16 Lectures)

Definition of Mineral and Mineraloid, Scope of Mineralogy - Chemical elements and Periodic Table - Bonding of atoms and their types – Structure and classification of silicates - Isomorphism, polymorphism and pseudomorphism in minerals - Physical properties of minerals – Optical properties of minerals - Determination of specific gravity of minerals - Jolly balance and Beam balance methods – Outline of blow pipe tests.

Unit-II

(10 Lectures)

Mineralogy, structure, chemical composition, optical and physical properties, modes of occurrence and industrial uses of the following group of minerals: Quartz - Feldspar - Feldspathoid - Zeolite.

Unit-III

(12 Lectures)

Mineralogy, structure, chemical composition, optical and physical properties, modes of occurrence and industrial uses of the following group of minerals: Pyroxene – Amphibole – Mica - Olivine - Garnet.

Unit-IV

(12 Lectures)

Physical and optical properties, chemical composition, uses and modes of occurrence of the following minerals: Epidote, Chlorite, Scapolite, Cordierite, Talc, Serpentine, Steatite, Calcite, Dolomite, Andalusite, Kyanite, Sillimanite, Topaz, Staurolite, Beryl, Tourmaline, Wollastonite, Fluorite, Apatite, Zircon, Rutile, Sphene and Corundum.

Unit-V

(10 Lectures)

Mineralogy, mode of occurrence, uses and distribution in India of the minerals required for the following industries: Abrasives, Fertilizer, Paint, Refractory, Glass, Ceramic and Cement - Mineral wealth of Madhya Pradesh.

Reference Books:

- Berry, L.G., Mason, B.H and R.V. Dietrich (1983). Mineralogy: Concepts, Descriptions, Determinations. W.H. Freeman & Co., 612p.
- Dana, E.S (2011). A Text-Book of Mineralogy, Read Books Design Publishers, London.
- Dana, J.D (2012). Manual of Mineralogy, Merchant Books Publilshers, New York.
- Erni, H (2010). Mineralogy Simplified, Forgotten Books Publishers, London, 436 p.
- Mason, B and Berry, L.G (1978). Elements of Mineralogy, W.H. Freeman & Co.
- Nesse, W.D (2014). Introduction to Mineralogy, Oxford University Press, USA. Rutley, F (2012). Rutley's Elements of Mineralogy, Springer Science & Business Media, New Delhi, 560p.
- Klein, C., Dutrow, B., Dwight, J., & Klein, C. (2007). The 23rd Edition of the Manual of Mineral Science (after James D. Dana). J. Wiley & Sons.
- Kerr, P. F. (1959). Optical Mineralogy. McGraw-Hill.
- Verma, P. K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt Ltd.
- Deer, W. A., Howie, R. A., & Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman

Mineral Science Lab

Practical:

1. Qualitative Observation and documentation on symmetry of crystals
2. Study of physical properties of minerals in hand specimen
Silicates: Olivine, Garnet, Andalusite, Sillimanite, Kyanite, Staurolite, Beryl, Tourmaline, Augite, Actinolite, Tremolite, Hornblende, Serpentine, Talc, Muscovite, Biotite, Phlogopite, Quartz, Orthoclase, Plagioclase, Microcline, Nepheline, Sodalite, Zeolite
3. Quartz varieties: Chert, Flint, Chalcedony, Agate, Jasper, Amethyst, Rose quartz, Smoky quartz, Rock crystal.
4. Native Metals/non-metals, Sulfides, Oxides- Copper, Sulfur, Graphite, Pyrite, Corundum, Magnetite
5. Hydroxides, Halides, Carbonates, Sulfates, Phosphates: Psilomelane, Fluorite, Calcite, Malachite, Gypsum, Apatite.
6. Study of some key silicate minerals under optical microscope and their characteristic properties

Reference Books:

- Klein, C., Dutrow, B., Dwight, J., & Klein, C. (2007). The 23rd Edition of the Manual of Mineral Science (after James D. Dana). J. Wiley & Sons.
- Kerr, P. F. (1959). Optical Mineralogy. McGraw-Hill.
- Verma, P. K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt Ltd.
- Deer, W. A., Howie, R. A., & Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman

Elements of Geochemistry

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Unit-I

(12 Lectures)

Introduction of Geochemistry and Cosmochemistry. Chemical composition and properties of Earth's layers. Atmosphere: its layers, chemical composition and evolution of Atmosphere. Meteorites. GoldSchmidt geochemical classification.

Unit-II

(12 Lectures)

Isotope geochemistry; kinds of isotopes; Radiogenic isotopes. Decay scheme of K-Ar, U-Pb, V-Pb, SmNd and Rb-Sr; Radioactive dating of single minerals and whole rocks; Stable isotope geochemistry of Carbon and Oxygen and its application in Geology. Geochemistry of Uranium and Lithium.

Unit-III

(12 Lectures)

Concept of enthalpy, free energy; chemical potential; fugacity, Structure and types of atoms. Internal structure of atoms, atomic weights. Types of chemical bonding. Ionic radii. Coordination number. Lattice energy. Ionization potential. Electronegativity. Pauling's rule. Isomorphism and polymorphism. Principles of ionic substitution in minerals.

Unit-IV

(12 Lectures)

Eh and pH diagrams, limits of Eh and pH in nature;; oxidation and reduction in sedimentation. Geochemical cycle; Minor cycle and Major cycle. Geochemical classification of elements. distribution of elements in igneous, metamorphic and sedimentary rocks. Periodic table with special reference to rare earth elements and transition elements.

Unit-V

(12 Lectures)

Concept of geochemical- biogeochemical cycling and global climate; Hydrosphere: the hydrological cycle, composition of natural waters, some characteristics of river waters and ground water; Biosphere: Introduction: the mass of the biosphere: composition of the biosphere: biogenic deposits; geochemical cycle of carbon.

Reference Books:

- Mason, B. and Moore, C.B.: - Introduction to Geochemistry
- Faure, G.: -Principles of Isotope Geology
- Hoefs, J.: -Stable Isotope Geochemistry
- Marshal, C.P. and Fairbridge, R.W.: -Encyclopedia of Geochemistry
- Govett, G. J.S.: -Handbook of Exploration Geochemistry
- Kraustopf, K.B.: - Introduction to Geochemistry

Elements of Geochemistry Lab

Practical:

1. Types of geochemical data analysis and interpretation; of common geochemical plots.
2. Geochemical analysis of geological materials.
3. Geochemical variation diagrams and its interpretations.

Reference Books:

- Mason, B. and Moore, C.B.: - Introduction to Geochemistry
- Faure, G.: -Principles of Isotope Geology
- Hoefs, J.: -Stable Isotope Geochemistry
- Marshall, C.P. and Fairbridge, R.W.: -Encyclopedia of Geochemistry
- Govett, G. J.S.: -Handbook of Exploration Geochemistry

Structural Geology

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Unit-I

(12 Lectures)

Structure and Topography: Effects of topography on structural features, Topographic and structural maps; Importance representative factors of the map.

Unit-II

(12 Lectures)

Stress and strain in rocks: Concept of rock deformation: Stress and Strain in rocks, Strain ellipses of different types and their geological significance. Planar and linear structures; Concept of dip and strike; Outcrop patterns of different structures.

Unit-III

(12 Lectures)

Fold: Fold morphology; Geometric and genetic classification of folds; Introduction to the mechanics of folding: Buckling, Bending, Flexural slip and flow folding.

Unit-IV

(12 Lectures)

Foliation and lineation: Description and origin of foliations: axial plane cleavage and its tectonic significance Description and origin of lineation and relationship with the major structures.

Unit-V

(12 Lectures)

Fractures and faults: Geometric and genetic classification of fractures and faults Effects of faulting on the outcrops Geologic/geomorphic criteria for recognition of faults and fault plane solutions.

Reference Books:

- Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley
- Billings, M. P. (1987) Structural Geology, 4th edition, Prentice-Hall.
- Park, R. G. (2004) Foundations of Structural Geology. Chapman & Hall.
- Pollard, D. D. (2005) Fundamental of Structural Geology. Cambridge University Press.
- Ragan, D. M. (2009) Structural Geology: an introduction to geometrical techniques (4th Ed). Cambridge University Press (For Practical)
- Lahee F. H. (1962) Field Geology. McGraw Hill

Structural Geology Lab

Practical:

1. Basic idea of topographic contours, Topographic sheets of various scales.
2. Introduction to Geological maps: Lithological and Structural maps
3. Structural contouring and 3-point problems of dip and strike
4. Drawing profile sections and interpretation of geological maps of different complexities
Exercises of stereographic projections of mesoscopic structural data (planar, linear, folded etc.)

Reference Books:

- Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley
- Billings, M. P. (1987) Structural Geology, 4th edition, Prentice-Hall.
- Park, R. G. (2004) Foundations of Structural Geology. Chapman & Hall.
- Pollard, D. D. (2005) Fundamental of Structural Geology. Cambridge University Press.
- Ragan, D. M. (2009) Structural Geology: an introduction to geometrical techniques (4th Ed). Cambridge University Press (For Practical)
- Lahee F. H. (1962) Field Geology. McGraw Hill

Igneous Petrology

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Unit-I

(10 Lectures)

Definition of Petrology – Earth zones. Composition and constitution of magmas – Primary and Parental Magmas. Forms of Intrusive igneous rocks: Concordant forms - Sill, Laccolith, Lopolith and Phacolith, Discordant forms - Dykes, Cone Sheets, Volcanic neck, Ring dyke, Batholiths, Stocks, Bosses and Psymaliths. Forms of Extrusive igneous rocks: Lava flows, Pyroclastic deposits - Agglomerate, Lapilli, volcanic ash and volcanic froth.

Unit-II

(12 Lectures)

Structures vesicular and Amygdaloidal structures – block lava – Ropy lava – pillow structure – flow structure – sheet joints- mural jointing – columnar jointing – rift and grain. Textures: Definition and description - crystallinity: crystallites and microlites – Devitrification – Granularity – shapes of crystals, mutual relations – Equigranular textures: allotriomorphic hypidiomorphic, Panidiomorphic. inequigranular Textures: porphyritic and Intergrowth texture – Trachytic texture – Intergrowth texture structures orbicular structure Spherulitic structure – Perlitic fracture, Directive textures, Overgrowth textures, Reaction textures - Micro Structures.

Unit-III

(12 Lectures)

Classification: bases of classification – megascopic classification – classification based on colour index – based on the proportion of Alkali to plagioclase feldspars. Based on silica saturation – based on alumina saturation – A short account of CIPW classification, Normative minerals, salic and femic groups – mention of the main divisions, classes, orders, suborders, rangs and subrangs only. Merits and defects of CIPW classification – Tyrrels tabular classification.

Unit-IV

(12 Lectures)

Texture, Mineralogy, Classification, and Modes of occurrence of: Granite, Granodiorite, Syenite, Diorite, Gabbro, their hypabyssal and volcanic equivalents. Petrographic characters,

distribution in India and origin of Pegmatites, Lamprophyres, Alkaline rocks, Dunite, Peridotite and Anorthosites.

Unit-V

(14 Lectures)

Crystallization of Unicomponent magma – Crystallization and petrogenetic significance of Binary magmas: Diopside – Anorthite Eutectic system, Albite – Anorthite Solid-Solution system, Forestrite – Silica incongruent melting system and Ternary system (Ab – An – Di). Reaction principle and Bowen's reaction series - Causes for the diversity of Igneous rocks – Magmatic Differentiation: Fractional Crystallization, Liquid immiscibility, Assimilation - Short notes on: Consanguinity, Variation diagrams and petrographic provinces.

Reference Books:

- Tyrrel, G.W. (1978) The principles of petrology – Chapman and Hall Ltd., London.
- Bowen, N.L. The Evolution of the Igneous Rocks – Dover publication, Inc, New York.
- Barth, FW. (1962) Theoretical petrology - Wiley.
- Walstrom, E.E. (1961) Theoretical Igneous petrology, Wiley.
- Turner.F.J and Verhoogen.J –1960.- Igneous and Metamorphic petrology – McGraw Hill.
- Hatch, F.H. Wells, A.K.(1949),Petrology of Igneous Rocks, Thomas Murby & Wells, M.K. 7.Johannesen, A (1962) Descriptive petrography of Igneous Rocks.

Igneous Petrology Lab

Practical:

1. Study of important igneous rocks in hand specimens and thin sections- granite, granodiorite, diorite, gabbro, anorthosites, ultramafic rocks, basalts, andesites, trachyte, rhyolite, dacite.

Reference Books:

- Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
- Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
- Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation Routledge.
- Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
- McBirney, A. R. (1984). Igneous Petrology. San Francisco (Freeman, Cooper & Company) and Oxford (Oxford Univ. Press),
- Myron G. Best (2001). Igneous and Metamorphic Petrology,
- K. G. Cox, J. D. Bell. (1979). The Interpretation of Igneous Rocks. Springer/Chapman & Hall.
- Bose M.K. (1997). Igneous Petrology.
- G W Tyrrell. (1926). Principles of Petrology. Springer

Sedimentary Petrology

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Unit-I

(8 Lectures)

Introduction to Sedimentology: Scope of sedimentology, origin of sediments, classification of sedimentary rocks based on composition and texture.

Unit-II

(10 Lectures)

Granulometry: Textural parameters of clastic sediments: Grain size: concept and size scale; particle shape and fabric; sedimentary textures. grain size analyses and environmental connotation.

Unit-III

(14 Lectures)

Basic Hydraulics and Sedimentary Structures: sediment transport mechanism:

Fluid flow: flow rheology, fluid gravity flow, sediment gravity flow, flow regime, laminar and turbulent flow, particle entrainment in fluid flow.

Mass flow: types and deposits

Sedimentary structure: primary and penecontemporaneous deformation structures, biogenic structures. Paleocurrent analysis: data acquisition, methodology, different paleocurrent patterns.

Unit-IV

(16 Lectures)

Sedimentary rocks: Siliciclastic rocks: components and classification(s) of conglomerates, sandstones, mud rocks. General introduction to carbonate rocks, BIF, chert; Components and classifications of limestone, dolomites and dolomitization.

Sedimentary environments: Classification, sedimentary facies. Facies models for glacier, meandering, fluvial, deltaic, and shelf depositional settings.

Unit-V

(12 Lectures)

Diagenesis Concepts of diagenesis Stages of diagenesis: diagenetic changes in sand and carbonate deposits, lithification.

Reference Books:

- Allen, J.R.L. (1985). Principles of Physical Sedimentology. George Allen and Unwin, London.
- Prothero, D. R. and Schwab, F. (2004). Sedimentary geology. Macmillan.
- Tucker, M. E. (2001). Sedimentary Petrology, Third Edition Blackwell Science.
- Collinson, J. D. and Thompson, D. B. (1988). Sedimentary structures. Unwin- Hyman, London.
- Nichols, G. (2009). Sedimentology and Stratigraphy. Second Edition. Wiley Blackwell.
- Folk, R. L. (1974). Petrology of Sedimentary Rock. Hemphill Publishing Company, Austin, Texas.

Sedimentary Petrology Lab

Practical:

1. Exercises on sedimentary structures
2. Particle size distribution and statistical treatment
3. Paleocurrent analysis
4. Petrography of clastic and non-clastic rocks through hand specimens and thin sections

Reference Books:

- Allen, J.R.L. (1985). Principles of Physical Sedimentology. George Allen and Unwin, London.
- Prothero, D. R. and Schwab, F. (2004). Sedimentary geology. Macmillan.
- Tucker, M. E. (2001). Sedimentary Petrology, Third Edition Blackwell Science.
- Collinson, J. D. and Thompson, D. B. (1988). Sedimentary structures. Unwin- Hyman, London.
- Nichols, G. (2009). Sedimentology and Stratigraphy. Second Edition. Wiley Blackwell.
- Folk, R. L. (1974). Petrology of Sedimentary Rock. Hemphill Publishing Company, Austin, Texas.

Palaeontology

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Unit-I

(12 Lectures)

Definition of Palaeontology – organic world- Animal Kingdom – classification of animals – Habitats and Habits of animals. Definition of fossils – nature and modes of preservation of fossils: Body fossils and; Unaltered hard parts, Altered hard parts : Petrification , permineralisation , carbonisation, recrystallisation, silicification; trace fossils- mould, casts, tracks , trails, borings; Uses of fossils – stratigraphic indicators – climatic indicators- indicators of palaeogeography – indicators of evolution and migration of life forms – indicators of new deposits of coal and petroleum – life through ages.

Unit-II

(12 Lectures)

Phylum Arthropoda: - Class – Trilobita- General morphology: classification – geological history. Phylum Porifera – A short account of sponges. Phylum coelentrata – class Anthozoa – zoological features – General morphology: classification – tabulate corals – Rugose corals geological distribution – stratigraphic importance. Sub phylum Hemichordata – class Graptozoa: order Dendroidea and Graptoloidea – general morphology, classification, geological distribution and stratigraphic importance.

Unit-III

(12 Lectures)

Phylum Mollusca: Class Pelecypoda - General characters – ornamentation, classification , geological history. Class Gastropoda:- General morphology , shell forms – types of coiling – Dextral and sinistral – ornamentation , classification and geological history. Class Cephalopoda:- General morphology , (Nautilitic , Goniotitic , Ceratitic and Ammonitic) – shell forms – ornamentation – classification, geological history- morphology of a Belemnite shell.

Unit-IV

(12 Lectures)

Phylum Brachiopoda:- General morphology – Brachial skeleton – morphometric details, ornamentation , classification , geological history. Phylum Echinodermata: Class Echinoidea:

General morphology, corona (Ambulacra, interambulacral) – peristome – regular and irregular echinoids – classification– geological history. Class Crinoidea: - General morphology , classification, geological history. Class Blastoidea: General morphology.

Unit-V

(12 Lectures)

Phylum protozoa – Order; Foraminifera: General morphology – dimorphism – classification , geological history and stratigraphic importance. Class Crustacea:- Sub class: Ostracoda – morphology – classification and geological history. A brief outline of the classification of vertebrates. A short account of Devonian fishes, Mesozoic Reptiles, Siwalik mammals. General classification of plant kingdom – plant fossils from India – A brief account of the following plant fossils :- Glossopteris , Gangamopteris , Ptilophyllum , Calamites , Lepidodendron and Sigillaria. Applications of Micro palaeontology.

Reference Books:

- Henry woods: Invertebrate palaeontology – Cambridge.
- Romer , A.S.: Vertebrate palaeontology, Chicago press.
- Arnold, C.A., : An introduction to Palaeobotany., MC-Graw Hill.
- B.U. Hag and A. Boersma (1978) : Introduction to marine Micropalaeontology. Elsevier, Netherlands
- Jain, P.C., and Anatharaman, M.S.,: An introduction to Paleontology, Vishal Publications.

Palaeontology Lab

Practical:

1. Study of fossils showing various modes of preservation
2. Study of diagnostic morphological characters, systematic position, stratigraphic position and age of various invertebrate, vertebrate and plant fossils.

Reference Books:

- Henry woods: Invertebrate palaeontology – Cambridge.
- Romer, A.S.: Vertebrate palaeontology, Chicago press.
- Arnold, C.A., : An introduction to Palaeobotany, MC-Graw Hill.
- B.U. Hag and A. Boersma (1978) : Introduction to marine Micropalaeontology. Elsevier, Netherlands
- Jain, P.C., and Anatharaman, M.S. : An introduction to Paleontology, Vishal Publications.

Metamorphic Petrology

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Unit-I

(12 Lectures)

Metamorphism: controls and types. Definition of metamorphism. Factors controlling metamorphism Types of metamorphism - contact, regional, fault zone metamorphism, impact metamorphism.

Unit-II

(14 Lectures)

Metamorphic facies and grades, Index minerals, metamorphic zones and isograds. Structure and textures of metamorphic rocks. Concept of metamorphic facies and grade. Mineralogical phase rule of closed and open system. Composition-paragenesis diagrams. ACF, AKF and AFM diagrams. Metamorphic products of pelitic, carbonate and mafic igneous rocks.

Unit-III

(12 Lectures)

Metamorphism and Tectonism, Relationship between metamorphism and deformation, Metamorphic mineral reactions (prograde and retrograde).

Unit-IV

(10 Lectures)

Migmatites and their origin, Metasomatism and role of fluids in metamorphism. Brief idea of crustal anatexis. Migmatites and its origin. Metamorphic differentiation.

Unit-V

(12 Lectures)

Metamorphic rock associations- Regional occurrence and tectonic significance of metamorphic rocks: metamorphism along convergent plate margins, in continent-continent collisions, in rifting terrains and sea floor metamorphism. Metamorphic belts of India.

Reference Books:

- Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
- Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
- Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation Routledge.
- Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks McGraw-Hill Science Engineering.
- Yardley, B. W., & Yardley, B. W. D. (1989). An introduction to metamorphic petrology. Longman Earth Science Series.

Metamorphic Petrology Lab

Practical:

1. Megascopic and microscopic study (textural and mineralogical) of the following metamorphic rocks:

Low grade metamorphic rocks: serpentinites, albite-epidote-chlorite-quartz schist, slate, talc-tremolite-calcite-quartz schist.

Medium to high grade metamorphic rocks: Gneisses, amphibolite, hornfels, garnetiferous schists, sillimanite-kyanite-bearing rocks, Granulites, eclogite, diopside-forsterite marble.

Laboratory exercises in graphic plots for petrochemistry and interpretation of assemblages

Reference Books:

- Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
- Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
- Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.
- Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
- Yardley, B. W., & Yardley, B. W. D. (1989). An introduction to metamorphic petrology. Longman Earth Science Series.

Department Specific Elective

Stratigraphic Principles and Indian Stratigraphy

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Unit-I

(10 Lectures)

Principles of stratigraphy, Fundamentals of litho-, bio- and chrono-stratigraphy, Introduction to concepts of dynamic stratigraphy (chemostratigraphy, seismic stratigraphy, sequence stratigraphy).

Unit-II

(10 Lectures)

Code of stratigraphic nomenclature, International Stratigraphic Code – development of a standardized stratigraphic nomenclature. Concepts of Stratotypes. Global Stratotype Section and Point (GSSP). Brief introduction to the concepts of lithostratigraphy, biostratigraphy, chronostratigraphy, seismic stratigraphy, chemostratigraphy, Magnetostratigraphy, Sequence stratigraphy and their subdivisions with Indian examples.

Unit-III

(14 Lectures)

Principles of stratigraphic analysis Facies concept in stratigraphy, Walther's Law of Facies. Concept of paleogeographic reconstruction.

Physiographic and tectonic subdivisions of India, Brief introduction to the physiographic and tectonic subdivisions of India. Introduction to Indian Shield, Introduction to Proterozoic basins of India. Geology of Vindhyan and Cudappah basins of India.

Unit-IV

(14 Lectures)

Phanerozoic Stratigraphy of India, Paleozoic Succession of Kashmir and its correlatives from Spiti and Zaskar Stratigraphy, Structure and hydrocarbon potential of Gondwana basins.

Mesozoic stratigraphy of India: a. Triassic successions of Spiti, b. Jurassic of Kutch, c. Cretaceous, successions of Cauvery basins

Cenozoic stratigraphy of India: a. Kutch basin, b. Siwalik successions, c. Assam, Andaman and Arakan basins.

Stratigraphy and structure of Krishna-Godavari basin, Cauvery basin, Bombay offshore basin, Kutch and Saurashtra basins and their potential for hydrocarbon exploration

Unit-V

(12 Lectures)

Volcanic provinces of India a. Deccan, b. Rajmahal, c. Sylhet Trap

Stratigraphic boundaries, Important Stratigraphic boundaries in India - a. Precambrian-Cambrian boundary, b. Permian-Triassic boundary, and c. Cretaceous-Tertiary boundary.

Reference Books:

- Krishnan, M. S. (1982) Geology of India and Burma, CBS Publishers, Delhi
- Doyle, P. & Bennett, M. R. (1996) Unlocking the Stratigraphic Record. John Wiley
- Ramakrishnan, M. & Vaidyanadhan, R. (2008) Geology of India Volumes 1 & 2, Geological society of India, Bangalore.
- Valdiya, K. S. (2010) The making of India, Macmillan India Pvt. Ltd.

Hydrogeology

L T P
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Unit-I

(12 Lectures)

Introduction and basic concepts, Scope of hydrogeology and its societal relevance, Hydrologic cycle: precipitation, evapo-transpiration, run-off, infiltration and subsurface movement of water. Rock properties affecting groundwater, Vertical distribution of subsurface water, Types of aquifer, aquifer parameters, anisotropy and heterogeneity of aquifers.

Unit-II

(12 Lectures)

Groundwater flow, Darcy's law and its validity, Intrinsic permeability and hydraulic conductivity, Groundwater flow rates and flow direction, Laminar and turbulent groundwater flow.

Unit-III

(12 Lectures)

Well hydraulics and Groundwater exploration, Basic Concepts (drawdown; specific capacity etc), Elementary concepts related to equilibrium and non-equilibrium conditions for water flow to a well in confined and unconfined aquifers. Surface-based groundwater exploration methods, Introduction to subsurface borehole logging methods.

Unit-IV

(12 Lectures)

Groundwater chemistry, Physical and chemical properties of water and water quality, Introduction to methods of interpreting groundwater quality data using standard graphical plots, Sea water intrusion in coastal aquifers.

Unit-V

(12 Lectures)

Groundwater management, Surface and subsurface water interaction, Groundwater level fluctuations, Basic concepts of water balance studies, issues related to groundwater resources development and management, Rainwater harvesting and artificial recharge of groundwater.

Reference Books:

- Todd, D. K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.
- Davis, S. N. and De Weist, R.J.M. 1966. Hydrogeology, John Wiley & Sons Inc., N.Y.
- Karanth K.R., 1987, Groundwater: Assessment, Development and management, Tata McGrawHill Pub. Co. Ltd.
- Ramakrishnan, S (1998). Groundwater. K.G. Graph Arts, Chennai.
- Ragunath, H.M (2007). Groundwater, New Age International Publishers, Delhi .
- Freeze, R.A. and Cherry, J.A. (1971): -Groundwater
- Fetter, C.W. (1990): -Applied Hydrology

Economic Geology

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Unit-I

(10 Lectures)

Ores and gangues: Ores, gangue minerals, tenor, grade and lodes, Resources and reserves- Economic and Academic definitions.

Unit-II

(12 Lectures)

Mineral deposits and Classical concepts of Ore formation: Mineral occurrence, Mineral deposit and Ore deposit, Historical concepts of ore genesis: Man's earliest vocation- Mining, Plutonist and Neptunist concepts of ore genesis.

Unit-III

(12 Lectures)

Mineral exploration: Exploration and exploitation techniques, Remote Sensing, Geophysical and Geochemical Explorations, Geological mapping at different scales, drilling, borehole logs and transverse sections.

Unit-IV

(14 Lectures)

Structure and texture of ore deposits: Concordant and discordant ore bodies, Endogenous processes: Magmatic concentration, skarns, greisens, and hydrothermal deposits Exogenous processes: weathering products and residual deposits, oxidation and supergene enrichment, placer deposits.

Unit-V

(12 Lectures)

Ore grade and Reserve, assessment of grade, reserve estimation

Metallic and Nonmetallic ores Metallogenic provinces and epochs, Important deposits of India including atomic minerals, Non-metallic and industrial rocks and minerals, in India. Introduction to gemstones.

Reference Books:

- Guilbert, J.M. and Park Jr., C.F. (1986) The Geology of Ore deposits. Freeman & Co.
- Bateman, A.M. and Jensen, M.L. (1990) Economic Mineral Deposits. John Wiley.
- Evans, A.M. (1993) Ore Geology and Industrial minerals. Wiley
- Laurence Robb. (2005) Introduction to ore forming processes. Wiley.
- Gokhale, K.V.G.K. and Rao, T.C. (1978) Ore deposits of India their distribution and processing, Tata-McGraw Hill, New Delhi.
- Deb, S. (1980) Industrial minerals and rocks of India. Allied Publishers.
- Sarkar, S.C. and Gupta, A. (2014) Crustal Evolution and Metallogeny in India. Cambridge Publications..

Geomorphology

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Unit-I

(12 Lectures)

Definition of Geomorphology. Evolution of geomorphic concepts. Principles/laws of geomorphology. Endogenic and exogenic driving forces. Resisting forces. Dynamic equilibrium of driving and resisting forces and Threshold. Modern concepts, quantitative geomorphology and process geomorphology.

Unit-II

(12 Lectures)

Role of tectonics, climate, slope, lithology, vegetation, land cover/land use and human in landscape evolution. Spatio-temporal scale of geomorphic processes. Mineral stability series. Physical, chemical and biological weathering. Soil profiles, Types of soils. Erosional and Depositional landforms. Agents of geomorphic processes – Volcanism, Gravity, glaciers, wind, rivers, tides, waves, currents.

Unit-III

(12 Lectures)

Classification of mountains, Types of volcanoes. Volcanic landforms. Isostasy, Tectonic landforms, Gravity land forms. Climate zones of the World. Genesis, distribution and types of glaciers. Land forms in glaciated regions. Aeolian process as a geomorphic agent. Aeolian land forms. Characteristics of dry and wet deserts.

Unit-IV

(12 Lectures)

Overland and subsurface flow. Fluvial process. Types of drainage pattern. Fluvial landforms. Types of Deltas. Classification of coast lines, Depositional and erosional coast lines. Coastal and marine landforms.

Unit-V

(12 Lectures)

Geomorphic sub-divisions of Indian sub-continent – Himalayan landscape, Indo Gangetic plains, Deccan Plateau, Coastal low lands. Application of Geomorphology in groundwater

exploration, environmental and natural resource management. Geomorphic mapping methods and tools.

Reference Books:

- Richard Huggett. (2007) Fundamentals of Geomorphology. II Edition. Routledge N. Y.
- Ritter, D.F., Kochel, R.C., Miller, J.R., (2002) Process Geomorphology, Waveland press.
- H.S. Sharma (1990). Indian Geomorphology. Concept Pub. Co., New Delhi.
- Robert, S.A. and Suzanne, P.A., (2010) Geomorphology – The mechanics and chemistry of landscapes. Cambridge University Press.
- Thornbury, W.D., (2004) Principles of Geomorphology. II edition. Wiley Eastern Ltd. New Delhi.

Engineering Geology

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Unit-I

(14 Lectures)

Definition and scope of Engineering Geology. Engineering properties of rocks. Soils: definition and engineering properties. Geological Investigations in engineering sites. Slope stability: definition, slope failure and safety, geological factors, groundwater conditions and remedial measures.

Unit-II

(12 Lectures)

Dams: definition, types, geological conditions, and site investigations. Short note on dam foundations and geological conditions. Outline of important Indian Dams.

Unit-III

(12 Lectures)

Reservoirs: definition, selection of reservoir sites, and groundwater conditions. Problems in reservoirs: sedimentation, slope control, leakage and seismicity. Short account of Indian reservoirs.

Unit-IV

(10 Lectures)

Tunnels: definition, parts of a tunnel, types, tunnelling in hard and soft rocks, geological investigations, and groundwater conditions.

Unit-V

(12 Lectures)

Foundations: definition, geological investigations, and ground water problems. Outline of support structures: rods, bolts, anchors, arches, rings, linings, and retaining walls.

Reference Books:

- Bell,F.G.(2005).Fundamentals of Engineering Geology. B.S.Publications. Hyderabad.
- Krynine,P.D. & W.R. Judd.(1956). Principles of Engineering Geology & Geotechnics. CBS. Delhi.
- Legget,R.F. & A.W.Hatheway.(1988). Geology and Engineering. 3 rd ed. McGraw Hill. New York.
- Blyth,F.G.H. & M.H.De Freitas.(1984).A Geology for Engineers. 7th ed. Elsevier. New Delhi.
- Parbin Singh,B.(2005). A Textbook of Engineering and General Geology. S.K.Kataria & Sons.Delhi.

Remote Sensing & GIS

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Unit-I

(16 Lectures)

Photogeology: Types and acquisition of aerial photographs; Scale and resolution; Principles of stereoscopy, relief displacement, vertical exaggeration and distortion Elements of air photo interpretation, Identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms.

Unit-II

(10 Lectures)

Remote Sensing, Concepts in Remote Sensing Sensors and scanners, Satellites and their characteristics, Data formats- Raster and Vector.

Unit-III

(14 Lectures)

Digital Image Processing, Image Errors, Rectification and Restoration, FCC, Image Enhancement, Filtering, Image Rationing, Image classification and accuracy assessment. GIS integration and Case studies-Indian Examples.

Unit-IV

(10 Lectures)

GIS, Datum, Coordinate systems and Projection systems, Spatial data models and data editing, Introduction to DEM analysis.

Unit-V

(10 Lectures)

GPS, Concepts of GPS, Integrating GPS data with GIS, Applications in earth system sciences.

Reference Books:

- Demers, M.N., 1997. Fundamentals of Geographic Information System, John Wiley & sons. Inc.
- Hoffmann-Wellenhof, B., Lichtenegger, H. and Collins, J., 2001. GPS: Theory & Practice, Springer Wien New York.
- Jensen, J.R., 1996. Introductory Digital Image Processing: A Remote Sensing Perspective, Springer- Verlag.
- Lillesand, T. M. & Kiefer, R.W., 2007. Remote Sensing and Image Interpretation, Wiley.
- Richards, J.A. and Jia, X., 1999. Remote Sensing Digital Image Analysis, Springer-Verlag.

Exploration Geology

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Unit-I

(14 Lectures)

Mineral Resources: Resource reserve definitions, Mineral resources in industries – historical perspective and present, A brief overview of classification of mineral deposits with respect to processes of formation in relation to exploration strategies.

Unit-II

(8 Lectures)

Prospecting and Exploration: Principles of mineral exploration, Prospecting and exploration-conceptualization, methodology and stages, Sampling, subsurface sampling including pitting, trenching and drilling, Geochemical exploration.

Unit-III

(8 Lectures)

Evaluation of data: Evaluation of sampling data, Mean, mode, median, standard deviation and variance.

Unit-IV

(16 Lectures)

Drilling and Logging: Core and non-core drilling, Planning of bore holes and location of boreholes on ground, Core-logging.

Unit-V

(14 Lectures)

Reserve estimations and Errors: Principles of reserve estimation, density and bulk density, Factors affecting reliability of reserve estimation, Reserve estimation based on geometrical models (square, rectangular, triangular and polygon blocks), Regular and irregular grid patterns, statistics and error estimation.

Reference Books:

- Clark, G.B. 1967. Elements of Mining. 3rd Ed. John Wiley & Sons.
- Arogyaswami, R.P.N. 1996 Courses in Mining Geology. 4th Ed. Oxford-IBH.
- Moon, C.J., Whateley, M.K.G., Evans, A.M., 2006, Introduction to Mineral Exploration, Blackwell Publishing.

Earth and Climate

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Unit-I

(12 Lectures)

Climate system: Forcing and Responses Components of the climate system, Climate forcing, Climate controlling factors, Climate system response, response rates and interactions within the climate system, Feedbacks in climate system.

Unit-II

(10 Lectures)

Heat budget of Earth, Incoming solar radiation, receipt and storage of heat, Heat transformation, Earth's heat budget. Interactions amongst various sources of earth's heat.

Unit-III

(12 Lectures)

Atmosphere – Hydrosphere; Layering of atmosphere and atmospheric Circulation, Atmosphere and ocean interaction and its effect on climate, Heat transfer in ocean, Global oceanic conveyor belt and its control on earth's climate, Surface and deep circulation, Sea ice and glacial ice.

Unit-IV

(12 Lectures)

Response of biosphere to Earth's climate, Climate Change: natural vs. anthropogenic effects, Humans and climate change, Future perspectives, Brief introduction to archives of climate change, Archive based climate change data from the Indian continent.

Unit-V

(14 Lectures)

Orbital cyclicity and climate, Milankovitch cycles and variability in the climate, Glacial-interglacial stages, The Last Glacial maximum (LGM), Pleistocene Glacial-Interglacial cycles, Younger Dryas, Marine isotope stages

Monsoon: Mechanism of monsoon, Monsoonal variation through time, Factors associated with monsoonal intensity, Effects of monsoon.

Reference Books:

- Rudiman, W.F., 2001. Earth's climate: past and future. Edition 2, Freeman Publisher.
- Rohli, R.V., and Vega, A.J., 2007. Climatology. Jones and Barlatt
- Lutgens, F., Tarbuck, E., and Tasa, D., 2009. The Atmosphere: An Introduction to Meteorology Pearson Publisher
- Aguado, E., and Burt, J., 2009. Understanding weather.

**Skill Based: Skill
Enhancement Courses**

Economic Geology field

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Module-I:

- Visit to any mineral deposit
- Mode occurrence of ore, Ore mineralogy
- Ore-Host rock interrelation
- Ore formation process
- Basic techniques of surveying, concept of outcrop mapping

Module-II:

- Visit to underground or open cast mine
- Practical experience of mining methods
- Underground mapping/ Bench mapping
- Isopach and Isochore maps.

Himalayan Geology field

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- Identification and characterization of major structural boundaries in Himalaya viz. MBT, MFT etc.
or
- Field along any suitable transect of Himalayan foreland
or
- Field transects in Siwalik
or
- Identification of Himalayan and pre-Himalayan elements

Precambrian Geology field

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- Field transects in any Precambrian terrain
- Study of craton ensemble including basic intrusive suites
- Precambrian sedimentary basin
- Basement-Cover relation in: a. fold belts, b. sedimentary successions.

Geological Mapping

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- Geological mapping, stratigraphic correlation
- Primary (scalars and vectors) and secondary structures (linear and planar)
- Trend, plunge, Rake/Pitch, Stereo plots of linear and planar structures, Orientation analyses.

Stratigraphy and paleontology-related field

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- Field training along Phanerozoic basin of India
- Documentation of stratigraphic details in the field
- Collection of sedimentological, stratigraphic and paleontological details and their representation
- Facies concept and its spatio-temporal relation (Walther's Law) and concept of facies distribution at basin-scale
- Fossils sampling techniques and their descriptions.