M. Sc GEOLOGY SEMESTER-I

GEO 401: Physical Geology and Geomorphology

Credits:2

Course Objective: The objective of this course is to provide students with a foundational understanding of the Earth's physical structure, the materials composing it, and the dynamic processes that shape its surface over time. The course emphasizes the principles of **physical geology**, including mineralogy, petrology, plate tectonics, and Earth's internal processes, as well as **geomorphology**, focusing on landform development, surface processes, and the interpretation of landscapes. Students will develop the skills to analyze geologic features, understand the evolution of Earth's surface, and apply geomorphic principles to real-world environmental and geohazard problems.

Course outcomes: By the end of the course the students will be able to:

- Explain the internal structure of the Earth and the mechanisms driving plate tectonics.
- Analyze geological features such as faults, folds, and volcanoes using maps and cross-sections.
- Describe the physical processes that shape the Earth's surface, including weathering, erosion, sedimentation, and mass movement.
- Interpret various landforms and understand their evolution through geomorphic processes.
- Apply geomorphological knowledge to assess natural hazards such as landslides, floods, and earthquakes.
- Use topographic and geologic maps to analyze and interpret Earth's surface and subsurface features.
- Evaluate the impact of human activities on geological and geomorphological processes.

Course Content:

Unit I: Fundamentals of Physical Geology**;** Introduction to Geology: Scope and branches**;** Origin of the Earth and solar system: Nebular hypothesis, Planetesimal theory**;** Structure and composition of Earth: Crust, mantle, core**;** Earth's magnetic field and gravity anomalies**;** Geological time scale: Concepts of deep time, major geological events**;** Plate tectonics and continental drift**;** Seismic waves and Earth's interior exploration

Unit II: Definition, physical and chemical properties of minerals; Classification of rocks: Igneous, sedimentary, metamorphic; Processes of rock formation: Crystallization, sedimentation, metamorphism; Rock cycle and its significance; Economic significance of rocks and minerals; Weathering and erosion of rocks: Physical, chemical, and biological

Unit III: Introduction to Geomorphology; Definition, scope, and significance of Geomorphology; Fundamental concepts: Uniformitarianism, Catastrophism, Isostasy;

Geomorphic cycles: Davisian cycle, Penck's theory, King's model; Types of landforms: Structural, depositional, and erosional; Concept of morphogenetic regions

Unit IV: Exogenic Processes and Associated Landforms; Fluvial processes and landforms: River erosion, transportation, and deposition**;** Aeolian processes and desert geomorphology**;** Glacial processes and glacial landforms**;** Karst processes and landforms: Solution processes, caves, sinkholes**;** Coastal geomorphology: Wave action, coastal erosion, beaches, spits, bars**;** Mass wasting processes: Landslides, mudflows, debris flows

Unit V: Endogenic Processes, Applied Geomorphology & Techniques; Volcanism: Types of volcanoes, volcanic landforms; Earthquakes and associated geomorphic features; Tectonic geomorphology: Fault scarps, rift valleys, folded mountains; Applied geomorphology: Role in engineering geology, hydrology, and resource exploration; Remote sensing and GIS in geomorphological studies; Principles of geomorphological mapping and interpretation

Recommended Readings:

- "Essentials of Geology" by Frederick K. Lutgens, Edward J. Tarbuck, and Dennis G. Tasa
- "The Dynamic Earth: An Introduction to Physical Geology" by Brian J. Skinner and Stephen C. Porter
- "Understanding Earth" by John Grotzinger and Thomas H. Jordan
- "Foundations of Earth Science" by Frederick K. Lutgens and Edward J. Tarbuck
- "Earth: An Introduction to Physical Geology" by Edward J. Tarbuck, Frederick K. Lutgens, and Dennis G. Tasa
- Geoinformatics in Applied Geomorphology. Anbazhagan, S.; Subramanian, S. K. and Yang X., CRC Press,Taylor & Francis Group, London and New York 2011
- Geomorphology and Global Environmental Change. Slaymaker, O.; Spencer, T. and Hamann, C.E., Cambridge University Press, New York 2009
- Fundamentals of geomorphology. Huggett, R. J.,. Routledge, Taylor & Francis Group, New York 2007
- Seismic Geomorphology: Application to hydrocarbon exploration and production. Davies, R.J.; Posamentier, H.W.; Wood, L. J. and Cartwright J.A,. The Geological Society of London. 2007
- Applied Geomorphology. Allision, R.J, John Wiley and Sons Ltd. England 2002

GEO-402: Crystallography, Mineralogy and Thermodynamics

Credits:2

Course Objectives: The objective of this course is to provide students with a foundational understanding of minerals, their physical and chemical properties, classification, and crystallographic characteristics. The course emphasizes the study of crystal structures, symmetry, crystal systems, and the internal arrangement of atoms in minerals. Students will learn techniques for mineral identification in hand specimen and thin section, and develop the ability to interpret crystallographic data and use it to understand mineral formation and behavior.

Course Outcomes: By the end of this course, students will be able to:

- **Describe** the physical and chemical properties of minerals and their relevance to mineral identification.
- **Classify** minerals based on their chemical composition and crystallographic structure.
- **Explain** the principles of crystallography, including symmetry elements, crystal systems, and lattice types.
- **Identify** minerals in hand specimen and thin section using physical properties and optical characteristics.
- **Analyze** the relationship between crystal form, internal atomic arrangement, and physical properties.
- **Interpret** crystallographic projections, Miller indices, and stereographic plots.
- **Understand** the role of crystal chemistry in controlling mineral stability and formation conditions.
- **Use** optical mineralogy techniques to distinguish between isotropic and anisotropic minerals under the microscope.
- **Apply** knowledge of mineralogy in various geological contexts such as petrology, economic geology, and environmental studies.

Course Content:

Unit I: Fundamentals of Crystallography; Symmetry elements: Plane, axis, center; Crystal systems and their classification; Crystal classes and 32 point groups; Miller indices and their significance; Crystal lattices and Bravais lattices; Forms, zones, and twinning in crystals

UNIT II: Advanced Crystallography & X-ray Crystallography; Space groups and symmetry operations; Concept of unit cell and crystal structures; Introduction to X-ray crystallography; Bragg's Law and its applications; Powder and single-crystal diffraction methods; Interpretation of X-ray diffraction (XRD) patterns; Applications of crystallographic techniques in mineral identification

Unit III: A detailed study of the important silicate mineral groups (listed below) with reference to general and structural formulae, classification atomic structure, polymorphs/structural states, chemistry including substitution of elements/solid solution and experimental work on pressure-temperature stability of the minerals, modes of occurrence and alterations.

a) Nesosilicates: Olivine Group, Garnet Group, Aluminosilicate Group (Kyanite, Andalusite and Sillimanite).

b) Cyclosilicates: Beryl

c) Inosilicates; Pyroxene Group; Amphibole Group.

d) Phyllosilicates: Kaolinite Group, Serpentine Group, Pyrophyllite, Talc, Mica Group, Chlorite.

e) Tectosilicate: Feldspar Group, Cordierite.

Unit IV: Optical Mineralogy and Techniques; Principles of optical mineralogy; Properties of minerals in plane-polarized light and crossed polars; Interference figures and optical classification: Uniaxial, biaxial minerals; Determination of extinction angles, birefringence, pleochroism; Use of polarizing microscope; Introduction to advanced techniques: SEM, EPMA.

Unit V: Thermodynamics of Geological Processes; Introduction to thermodynamics: Systems, states, and processes; First, second, and third laws of thermodynamics; Gibbs free energy and its significance in geological systems; Phase rule and phase diagrams: One-component and binary systems; Activity-composition relationships in minerals; Mineral stability, metamorphic reactions, and P-T diagrams; Application of thermodynamics in petrology and geochemistry

Recommended Readings:

- Berry, L.G., Mason, B. and Dietrich, R.V. (1985) Mineralogy: Concepts, Descriptions and determinations. CBS Publishers
- Dana, E.S. and Ford, W.E. (2002) A text book of Mineralogy (Reprint)
- Deer, W.A., Howie, R.A. & Zussman, J. (2013): An Introduction to the rock forming minerals, ELBS and Longman
- Gribble C.D. (2005) Rutley's elements of Mineralogy, Springer.
- Kerr, P.F (1977) : Optical Mineralogy McGrew Hill • Nesse, D.W (1986) : Optical Mineralogy, McGraw Hill
- Perkins, D. (2013) Mineralogy, Prentice Hall • Phillips, F.C (1971) . Introduction to Crystallography. Longman Group Publication.
- Reed, S.J. B. (1996) Electron Microprobe Analysis and Scanning electron Microscopy in Geology, Cambridge University press.
- Sharma, R.S. and Sharma, A. (2013): Crystallography and Mineralogy- concepts and methods. Geological Society of India
- Winchell, E.N (1951) .: Elements of Optical Mineralogy, Wiley Eastern.

GEO 403: Structural Geology and Tectonics

Credits:2

Course Objective: The objective of this course is to provide students with a detailed understanding of the principles and processes of structural geology, including the formation and analysis of geological structures such as folds, faults, joints, and foliations. The course emphasizes the mechanics of rock deformation, techniques for structural mapping, and interpretation of structural data in both two and three dimensions. It aims to develop the skills necessary to analyze and solve geological problems related to tectonics, basin development, and crustal evolution using maps, cross-sections, and stereographic projections.

Course outcomes: By the end of this course, students will be able to:

- Describe the fundamental concepts of stress, strain, and rock deformation.
- Identify and classify primary and secondary geological structures in the field and in hand samples.
- Interpret the geometry and kinematics of folds, faults, joints, and foliations.
- Construct and analyze geological maps and cross-sections to infer subsurface structures.
- Apply stereographic projection techniques for analyzing planar and linear structural data.
- Analyze deformation histories through geometric and kinematic analysis.
- Evaluate the tectonic implications of structural features in various geological settings.
- Use field data, maps, and software tools to solve structural geology problems.
- Demonstrate competence in structural analysis through lab work, field exercises, and report writing.

Course Content:

Unit I: Introduction to Structural Geology; Scope, significance, and applications of structural geology; Concept of rock deformation: Elastic, brittle, ductile behavior; Stress and strain in geological materials; Outcrop patterns and attitude of beds: Strike, dip, apparent dip; Use of compass-clinometer in structural measurements

Unit II: Primary and Secondary Structures; Primary sedimentary structures: Bedding, ripple marks, cross-bedding; Secondary planar structures: Foliation, cleavage, schistosity; Secondary linear structures: Lineation, mineral lineation, intersection lineation; Relation between foliation, lineation, and folds

Unit III: Folds; Geometry and classification of folds**;** Fold terminology: Hinge, limb, axial plane, plunge**;** Types of folds: Symmetrical, asymmetrical, overturned, recumbent, isoclinal, chevron**;** Mechanics and causes of folding**;** Recognition of folds in the field and on geological maps.

Unit IV: Faults and Joints**;** Faults: Types (normal, reverse, thrust, strike-slip), classification and recognition criteria**;** Fault plane features: Slickensides, fault breccia, drag folds**;** Joints and fractures: Classification and geological significance**;** Distinguishing between faults and unconformities in the field

Unit V: Tectonics and Plate Movements; Plate tectonics: Lithospheric plates, boundaries, and types of plate margins**;** Continental drift and sea-floor spreading**;** Orogeny and mountain-

building processes**;** Concept of isostasy and geosynclines**;** Tectonics of Indian subcontinent: Himalayan orogeny, Indian plate evolution

Recommended Readings:

- Davis, G.H. and Reynolds, S. J. Structural geology of rocks and regions. 2011
- Fossen, H. Structural Geology. Cambridge University Press. London. 2010
- Ragan, D. M. Structural Geology. Cambridge University Press. London. 2009
- Ramsay, J.G. and Lisle, R. The Techniques of Modern Structural Geology, Vol. 3.Application of Continuum Mechanics in Structural Geology, Academic Press, London. 2000
- Marshak S. and Mitra S. Basic methods in structural geology. 1988
- Ramsay, J. G. and Huber, M. I. The Techniques of Modern Structural Geology, Vol. 1. Strain Analysis, Academic Press, London. 1983
- Jaeger, J. C. and Cook, N. G .W. Fundamentals of rock mechanics. Methuen, London, 593p 1979
- Ramsay, J. G. Folds and fractures. Mc-Graw Hills, NY 1967

GEO 404: Igneous, Metamorphic and Sedimentary Petrology

Credits:4

Course Objectives: The objective of this course is to provide students with a comprehensive understanding of the origin, classification, and evolution of igneous, metamorphic, and sedimentary rocks. The course aims to develop the ability to identify rock types in hand sample and thin section, understand the physical and chemical processes involved in their formation, and interpret their geological significance in the context of Earth's history and tectonic settings. Emphasis is placed on mineralogical composition, textures, classification schemes, and field relations, as well as laboratory techniques used in petrographic analysis.

Course outcomes: By the end of this course, students will be able to:

- Classify igneous, metamorphic, and sedimentary rocks based on their mineralogical composition, texture, and origin.
- Identify common rock-forming minerals and textures in hand samples and under a petrographic microscope.
- Explain the physical and chemical processes that lead to the formation of igneous, metamorphic, and sedimentary rocks.
- Interpret rock associations and assemblages in terms of their tectonic and geologic settings.
- Analyze the phase relationships and crystallization behavior of magmas using phase diagrams and Bowen’s Reaction Series.
- Evaluate metamorphic grade, facies, and reactions to determine pressure-temperature conditions of metamorphism.

- Describe sedimentary processes, including weathering, transportation, deposition, and diagenesis, and their role in basin evolution.
- Apply petrographic and geochemical techniques to solve geological problems related to rock origin and history.
- Demonstrate skills in rock sample preparation, microscopic analysis, and interpretation of thin sections.

Course Content:

Unit I: Some fundamental concepts; Classification and Nomenclature of Igneous Rocks; Textures of Igneous rocks; Introduction to metamorphism; Classification of Metamorphic rocks; Igneous structures and field relationships Structures and textures of Metamorphic rocks; Subaerial weathering processes; submarine weathering processes; soil forming processes; Sedimentary textures and structures; Composition, Classification and Diagenesis of sedimentary rocks

Unit II: Introduction to thermodynamics, Phase rule; one and two component systems; systems with more than two components; Stable mineral assemblages in metamorphic rocks; Metamorphic facies; Siliclastic sedimentary rocks; Carbonate sedimentary rocks

Unit III: Major and trace elements; using trace element data for petrogenesis of Igneous rocks; Diversification of magmas; metamorphosed mafic rocks; Metamorphic reactions; Metamorphism of pelitic sediments; Chemical/Biochemical and carbonaceous sedimentary rocks; Depositional environments: Continental Environments;

Unit IV: Layered mafic intrusions; continental flood basalts; granitoid rocks; Alkaline rocks; metamorphism of calcareous and ultramafic rocks; Marginal Marine environments; Siliclastic marine environments;

Unit V: Anorthosites; Gabbroic rocks; Ultramafic and ultra basic rocks; andesite, dacite rhyolite; pyroclastic products; metamorphic fluids, mass transport and metasomatism; carbonate and Evaporite environments

Recommended Readings:

- Philpotts, A.R. and Ague, J.J., "Principles of Igneous and Metamorphic Petrology" Cambridge University Press 2010
- Winter, J., "An Introduction to Igneous and Metamorphic Petrology", Prentice-Hall 2001
- Hall, A., "Igneous Petrology", John Wiley & Sons 1995
- Rollinson, H., "Using geochemical data: evolution, presentation, interpretation" Pearson Education Limited 1993
- Willson, M., "Igneous Petrogenesis: A Global Tectonic Approach", UnwinHyman 1989
- Cox, K.G., Bell., J.D. and Pankhurst, R.J., "The Interpretation of Igneous Rocks" George Allen and Unwin Publishers Ltd. 1979

- Spear, F.S., “Metamorphic Phase Equilibria and Pressure-Temperature-Time Paths”, Mineralogical Society of America Monograph 1993
- Kornprobst, J., “Metamorphic Rocks and their Geodynamic Significance: A Petrological Handbook”, Springer 2002
- Vernon, R.H and Clarke, G., “Principles of Metamorphic Petrology”, Cambridge University Press 2008 4. Winter, J.D., “Principles of Igneous and Metamorphic Petrology”, Prentice Hall 2009
- Bucher, K. and Grapes, R., “Petrogenesis of Metamorphic Rocks”, Springer 2011
- Nichols, G.: Sedimentology and stratigraphy, 2nd Ed. WileyBlacwell 2009
- Boggs, Sam (Jr.): Principles of Sedimentology and Stratigraphy, 4th Ed. Pearson/Prentice Hall. 2006
- Allen, P.A. and Allen, J.R.: Basin Analysis: Principles and applications. Blackwell publishing 2005
- Van Loon A.J.: Cyclic development of sedimentary basins. Elsevier. 2005
- Reading, H.G.: Sedimentary Environments and Facies. 6th Ed., Blackwell Scientific Publ., Oxford. 1996.

GEO 405: Paleontology and Stratigraphy

Credits:2

Course Objectives: The objective of this course is to provide students with a comprehensive understanding of the principles and applications of stratigraphy and paleontology. The course aims to introduce the concepts of rock layering, correlation, geological time scale, and depositional environments, as well as the study of fossils and their significance in interpreting Earth's history. Emphasis is placed on biostratigraphy, lithostratigraphy, chronostratigraphy, and the evolutionary history of life through the fossil record.

Course Outcomes: By the end of this course, students will be able to:

- **Explain** the basic principles of stratigraphy, including superposition, original horizontality, and lateral continuity.
- **Classify** and correlate stratigraphic units using lithologic, fossil, and chronologic data.
- **Interpret** depositional environments and geologic history from stratigraphic sequences.
- **Describe** the geological time scale and the major events in Earth’s history.
- **Identify** major fossil groups and understand their morphological characteristics and evolutionary significance.
- **Use** fossils for biostratigraphic correlation and age dating of rock layers.
- **Analyze** paleoecological and paleogeographic information from fossil assemblages.
- **Evaluate** the stratigraphic significance of unconformities, facies changes, and transgressive-regressive sequences.
- **Apply** stratigraphic and paleontological data to solve geological problems related to basin analysis, resource exploration, and Earth history.

Course Content:

Stratigraphy

Unit I: Approaches to measurement of geological time; Stratigraphic Principles and concept of Litho-, Bio- and Chrono-Stratigraphy, brief idea about sequence, magneto- seismic- chemo- and event stratigraphy; Stratigraphic correlations; Development of Time Scale.
Application of fossils; Applications of fossils, Species concept, Darwin, Species and natural Selection, taphonomy, Events in taphonomic history, functional morphology, Ichnology; graphic correlation

Unit II: Precambrian chronostratigraphy of Aravalli craton, Dharwar craton, Eastern Ghats mobile belt, Bastar craton, Southern Granulite belt and Singhbhum craton.
Theory and rate of evolution and extinction, the species and Natural selection; mode of preservation of fossils; nature of fossil record and mode of evolution, microevolution, macroevolution; paleoecology; food chain in marine ecosystem

Unit III: Stratigraphy of Cuddapah, Vindhyan, Godavari Supergroup and their equivalents; Precambrian/Cambrian boundary.
Brief morphology and evolutionary trends in Bivalves, Gastropods, Cephalopods, Brachiopods, their modes of preservation and significance.

Unit IV: Concept, classification, fauna, flora and age limits of Gondwana Supergroup and related paleogeography, paleoclimate, depositional characteristics and igneous activities; Classification, depositional characteristics, fauna, and flora of Triassic, Jurassic and Cretaceous systems in major basins of India
Brief morphology and evolutionary trends in Echinoids, Graptoloides and Trilobites; Ichnofossils, their modes of preservation and significance. Gondwana flora; Ediacara fauna; microfossils-foraminifera

Unit V: Stratigraphy of Deccan Trap, Permian/Triassic boundary. Classification, depositional characteristics, fauna, and flora of the Palaeogene, Neogene and Quaternary systems and their equivalents in India; Epoch boundaries of the Cenozoic in India. Cretaceous/Tertiary boundary. Paleogene/ Neogene boundary.
Vertebrate sequence through time; Evolutionary changes in Equidae; Proboscidae; Evolution of Man;

Recommended Readings:

- Walton, J., “An Introduction to the Study of Fossil Plants”, Adam & Charles Black 1953
- Woods, H., “Paleontology Invertebrate”, CBS Publications 1963
- Haq B. U. and Boersma, A., “Introduction to Marine Micropaleontology”, Elsevier. 1978
- Braiser, M.D., Microfossils, Geogrge Alien and Unwin Publisher. 1980
- Benton, M.J., “Vertebrate Paleontology”, Chapman & Hall 1997
- Jones, R. W., 1996. Micropaleontology in Petroleum exploration, Clarendon Press Oxford. 1998
- Colbert, R.L., “Paleontology”, John Willey & Sons 1987
- Milsom, C., and Rigby, S., “Fossils at a Glance”, Blackwell 2004 9 McGowran, B.,

"Biostratigraphy: Microfossils & Geological Time", Cambridge University Press 2005
- Michel F. and Arnold I. Miller, David M. Raup, Steven M. Stanley "Principales of Paleontology", W. H. Freeman, 2007
- Nichols, G.: Sedimentology and stratigraphy, 2nd Ed. WileyBlacwell 2009
- Boggs, Sam (Jr.): Principles of Sedimentology and Stratigraphy, 4th Ed. Pearson/Prentice Hall. 2006
- Catuneanu, O.: Principles of Sequence Stratigraphy. Elsevier. 2006
- Allen, P.A. and Allen, J.R.: Basin Analysis: Principles and applications. Blackwell publishing 2005
- Van Loon A.J.: Cyclic development of sedimentary basins. Elsevier. 2005
- Brookefield, M.E.: Principles of Stratigraphy. Blackwell Publishing. 2004
- Reading, H.G.: Sedimentary Environments and Facies. 6th Ed., Blackwell Scientific Publ., Oxford. 1996.
- Raup, D. M and Stanley S. M. Principle of Paleontology, 2nd edition. CBS publishers
- Clarkson E.N.K. Invertibrate paleontology and Evolution.
- Ramakrishnan, M. and Vaidyanadhan, R., 2008. *Geology of India* (Vol. 1, pp. 261-333). Bangalore: Geological Society of India.
- Vaidyanadhan, R. and Ramakrishnan, M., 2010. *Geology of India* (Vol. 2, pp. 557-994). Bangalore: Geological Society of India.

GEO 406: Practical I- Physical Geology and Geomorphology, Crystallography, Mineralogy and Thermodynamics , Structural Geology and Tectonics

Credits:2

Course Objectives: The main objective of this course is to introduce the students to different landform features and their analysis to interpret the genesis and tectonic evolution. This course will also introduce the students to different laboratory techniques pertaining to the crystals, mineral hand specimens and mineral thin sections. Furthermore, this course will acquaint the students about different field and laboratory techniques related to structural geology. It is also aimed to familiarize the students to different techniques related to geological mapping.

Course Outcomes: After completion of the course the students will be able to:

- study and analyse different geomorphic features from topographic maps and elevation models
- study and analyse different minerals based on their physical, chemical and optical characteristics.
- analyse and interpret various structural features from maps, sections, photographs and field data.

Practicals- Physical Geology and Geomorphology:

Study of geomorphic models and topographic maps; Drainage basin morphometry; Songitudinal profile of rivers and SL index; Study of active tectonics from geomorphic indices; Geomorphological mapping using Remote Sensing and GIS

Practicals- Crystallography, Mineralogy and Thermodynamics:
Study of rock forming minerals in hand specimen and thin sections: Physical and optical properties of common rock forming minerals; Study of Becke line; Determination of refractive indices and birefringence; Pleochroism and Dichroism: Pleochroic scheme of tourmaline, biotite, hornblende, actinolite, glaucophane, hypersthene, aegirine, andalusite and other silicate minerals; Study of Interference figures of uniaxial and biaxial minerals and determination of optic sign; Conversions of oxide and element weight percentages; Calculation of mineral formulae.

Practicals- Structural Geology and Tectonics:
Interpretation of structure from hand specimen, photographs; Preparation and interpretation of geological maps and cross sections; Structure contour maps, isopach maps and other facies maps, balanced cross-section, their importance in unraveling the geological history; Structural problems concerning economic deposit based on orthographic and stereographic projections; Recording and plotting of the field data.

Recommended Readings:

- A Key for Identification of Rock-forming Minerals in Thin Section - Andrew J. Barker, *CRC Press*
- A Practical Introduction to Optical Mineralogy - C. D. Gribble and A. J. Hall, Springer
- Atlas of Rock-Forming Minerals in Thin Section - W. S. MacKenzie and C. Guilford, *Routledge*
- Laboratory Manual of Geology - A. K. Sen, *Modern Book Agency, Kolkata*
- Practical approach to Crystallography and Mineralogy - R. N. Hota, *CBS Publishers*
- Rock-forming Minerals in Thin Section - H. Pichler, C. Schmitt-Riegraf and L. Hoke, *Chapman &. Hall*
- Rocks and Minerals in Thin Section - W. S. MacKenzie, A. E. Adams andK.H. Brodie , *CRC Press*
- A Manual of Problems in Structural Geology - N. W. Gokhale, *CBS Publishers*
- Atlas of Structural Geology - Soumyajit Mukherjee, Elsevier
- Basic Methods of Structural Geology - S. Marshak and G. Mitra, *Prentice Hall*
- Tools in Fluvial Geomorphology - G. Mathias Kondolf and Hervé Piégay, W*iley Blackwell*

GEO 407: Practical II- Igneous, Metamorphic and Sedimentary Petrology, Paleontology and Stratigraphy

Credits:2

Course Objectivess: The main objective of this course is to introduce the students to different types of rocks in hand specimen, thin section as well as in the field and also to introduce them to analyse various types of petrological data and interpret them. This is also

aimed to introduce the students to study morphological characters of different invertebrate and micro fossils and plant fossils and correlation of different sections.

Course Outcomes: After completion of the course the students will be able to:

- Study and analyse different rocks based on their physical, chemical and optical characteristics.
- handle, analyse and interpret chemical data, textural data and structural data of different rock types.
- analyse and interpret and evaluate environment of deposition
- classify and to identify different types of fossils.

Practicals- Igneous, Metamorphic and Sedimentary Petrology:
Megascopic and microscopic study of different igneous (syenite, pitchstone granite, diorite, pegmatite, rhyolite, basalt, andesite, trachyte, norite, diorite, pyroxenite, lamprophyre) sedimentary (shale, Brecia, limestone, conglomerate, sandstone, mudstone) and metamorphic rocks (gneiss, schist, slate, phyllite, marble, quartzite, amphibolite; Calculation of CIPW norms; Ternary diagrams, Presenting major and trace element data for Igneous and sedimentary rocks; Provenance estimate using geochemical data; Identification of heavy minerals under microscope; Grain-size analysis by sieving method; Plotting of size-distribution data as frequency and cumulative curves; sedimentary structures.

Practicals-Paleontology:
Study of modes of preservation of fossils; Study of morphological characters of important invertebrate fossils belonging to Brachiopoda, Bivalvia, Cephalopods, Arthropoda, Gastropoda, Echinoidea, Foraminifera; Study of important trace fossils and microfossils; Study of important Indian Gondwana and Paleogene flora; Paleogeographic maps.

Practicals Stratigraphy:
Pre-Cambrian sedimentary basins of India, Phaneozoic sedimentary basins of India, tectonic divisions of India; Gondwana Provinces in India; Exercises on stratigraphic classification and correlation, sequence, magneto and seismic stratigraphic interpretations.

Recommended Readings:

- A Practical Guide to Rock Microstructure - Ron H. Vernon, *Cambridge University Press*
- Atlas of Metamorphic Rocks and Their Textures - B. W. D. Yardley, W.S. MacKenzie and C. Guilford, *Prentice Hall*
- BGS Rock Classification Scheme Volume 1 Classification of igneous rocks -M. R. Gillespie and M. T. Styles, *British Geological Survey*
- Introduction to Metamorphic Textures and Microstructures - A. J. Barker, *Routledge*
- Laboratory Manual of Geology - A. K. Sen, *Modern Book Agency, Kolkata*
- Microtextures of Igneous and Metamorphic Rocks - J. P. Bard, *Springer*
- Petrography of Igneous and Metamorphic Rocks-Anthony R. Philpotts, *CBS Publishers*
- Practical Approach to Petrology - R. N. Hota, *CBS Publishers*

- Quantitative Textural Measurements in Igneous and Metamorphic Petrology - Michael D. Higgins, *Cambridge University Press*
- Rocks and Minerals in Thin Section - W. S. MacKenzie, A. E. Adams andK.H. Brodie , *CRC Press*
- A Practical Approach to Sedimentology - Roy C. Lindholm, Springer
- Historical Geological Lab Manual - Pamela J. W. Gore, Wiley
- Interpreting Earth History: A Manual in Historical Geology - Scott Ritter and Morris Petersen, Waveland Press
- Practical Approach to Petrology - R. N. Hota, CBS Publishers
- Rocks and Minerals in Thin Section - W. S. MacKenzie, A. E. Adams and K. H. Brodie, CRC Press
- Paleontology: A Practical Manual - L. Mahesh Bilwa, Studera Press
- Practical Manual in Palaeontology - V. Manivannan and K. Subramani, Vishal Publishing Co

GEO 408: Indian Knowledge System

Credits:2

Course Objectivess: Bhārata has a very rich and versatile knowledge system and cultural heritage. The Bhāratīya knowledge system was developed during the Vedic period, the Saraswatī-Sindhu Civilization, the Middle ages and is being practiced till the conditions of modern times. In this basic course, a special attention is given to the historical prospective of ideas occurrence in the ancient society, and implication to the concept of material world, and religious, social, and cultural beliefs. On the closer examination religion, culture and science have appeared epistemological very rigidly connected in the Bhāratīya knowledge system. As such, this land has provided invaluable knowledge stuff to the society and the world in all the spheres of life; e.g. aeronautics, astronomy, mathematics, life science, medical science, architecture, polity, trade, art, music, dance, literature, and drama. Over the period, most of the works were either lost or confined to the libraries or personal possessions. However, some of the activities are still in practice of the masses unknowing the scientific and practical values. Given the nature of course and diversity of the learners' fields, the course is designed to provide a broad spectrum of the Bhāratīya knowledge system. The main objectives of this course are as follows:

- Creating awareness amongst the youths about the true history and rich culture of the country;
- Understanding the scientific value of the traditional knowledge of Bhārata;
- Promoting the youths to do research in the various fields of Bhāratīya knowledge system;
- Converting the Bhāratīya wisdom into the applied aspect of the modern scientific paradigm;
- Adding career, professional and business opportunities to the youths. It is also believed that after completion of this course the students will get a holistic insight into the understanding the working of nature and life.

Course Outcome: Upon successful completion of this course, students will be able to:

- **Demonstrate a comprehensive understanding of Bhāratīya knowledge systems**, including their historical evolution from the Vedic period through to the modern era, and their interconnectedness with religion, culture, and science.
- **Critically analyze the scientific foundations and epistemological principles** embedded in traditional Bhāratīya disciplines such as astronomy, mathematics, medicine, architecture, arts, and polity.
- **Recognize and articulate the practical relevance of traditional knowledge** in contemporary contexts, thereby bridging ancient wisdom with modern scientific paradigms.
- **Develop research aptitude and curiosity** towards exploring, preserving, and revitalizing various aspects of the Bhāratīya knowledge system through interdisciplinary approaches.
- **Identify and explore career, professional, and entrepreneurial opportunities** rooted in indigenous knowledge systems, contributing to self-reliance and innovation.
- **Gain a holistic perspective on nature, life, and the universe,** inspired by the integrated worldview presented in the Bhāratīya intellectual and cultural heritage.

Course Content:

Unit-I: Genesis of the land, Antiquity of civilization, On the Trail of the Lost River, Discovery of the Saraswatī River, the Saraswatī-Sindhu Civilization, Traditional Knowledge System, The Vedas, Main Schools of Philosophy (6+3), Ancient Education System, the Takṣaśilā University, the Nālandā University, Alumni, Knowledge Export from Bhārata.

Unit-II: Arts, Literature, and Scholars (4 hours) Art, Music, and Dance, Naṭarāja– A Masterpiece of Bhāratīya Art, Literature, Life and works of Agastya, Lopāmudrā, Ghoṣā, Vālmīki, Patañjali, Vedavyāsa, Yājňavalkya, Gārgī, Maitreyī, Bodhāyana, Caraka, Suśruta, Jīvaka, Nāgārjuna, Kaṇāda, Patañjali, Kauṭīlya, Pāṇini, Thiruvalluvar, Āryabhaṭa, Varāhamihira, Ādi Śaṅkarācārya, Bhāskarācārya, Mādhavācārya.

Unit-III: Science, Astronomy, and Mathematics (4 hours) Concept of Matter, Life and Universe, Gravity, Sage Agastya's Model of Battery, Velocity of Light, Vimāna: Aeronautics, Vedic Cosmology and Modern Concepts, Bhāratīya Kāla-gaṇanā, Kerala School for Mathematics and Astronomy, History and Culture of Astronomy, Sun, Earth, Moon, and Eclipses, Earth is Spherical and Rotation of Earth, Archaeostronomy; Concepts of Zero and Pi, Number System, Pythagoras Theorem, and Vedic Mathematics.

Unit-IV: Engineering, Technology, and Architecture (4 hours) Pre-Harappan and Sindhu Valley Civilization, Laboratory and Apparatus, Juices, Dyes, Paints and Cements, Glass and Pottery, Metallurgy, Engineering Science and Technology in the Vedic Age and Post-Vedic Records, Iron Pillar of Delhi, Rakhigarhi, Mehrgarh, Sindhu Valley Civilization, Marine Technology, and Bet–Dwārkā.

Unit-V: Life, Environment, and Health (4 hours) Ethnic Studies, Life Science in Plants, Anatomy, Physiology, Agriculture, Ecology and Environment, Āyurveda, Integrated Approach to Healthcare, Medicine, Microbiology, Medicine, Surgery, and Yoga, etc.

Recommended Readings:

- Textbook on The Knowledge System of Bhārata by Bhag Chand Chauhan,
- Histrory of Science in India Volume-1, Part-I, Part-II, Volume VIII, by Sibaji Raha, et al. National Academy of Sciences, India and The Ramkrishan Mission Institute of Culture, Kolkata (2014).
- Pride of India- A Glimpse of India's Scientific Heritage edited by Pradeep Kohle et al. Samskrit Bharati (2006).
- Vedic Physics by Keshav Dev Verma, Motilal Banarsidass Publishers (2012). 3. India's Glorious Scientific Tradition by Suresh Soni, Ocean Books Pvt. Ltd. (2010). Text books

GEO 409a: IDC (Natural Hazards)

Credits:2

Course Objectives: To develop an in-depth understanding of natural hazards—such as earthquakes, floods, landslides, volcanoes, and climate-induced events—and equip students with skills for disaster risk assessment, mitigation strategies, and management frameworks, with a focus on geological processes and spatial analysis.

Course Outcomes: After completing this course, students will be able to:

- Identify and classify various types of natural hazards from a geoscientific perspective.
- Analyze the causes, impacts, and geospatial patterns of natural disasters.
- Apply geological and remote sensing tools for hazard zonation and risk mapping.
- Understand disaster management policies, frameworks (NDMA, UNDRR), and mitigation strategies.
- Propose sustainable solutions for community resilience and disaster preparedness.

Course Content:

Unit-I: **Introduction to Natural Hazards;** Definition, classification, and concepts of hazard, vulnerability, risk, and disaster; Geological and geomorphological controls on natural hazards.

Unit-II*:* **Earthquake Hazards-** Seismotectonics, fault systems, seismic waves, ground motion; Earthquake hazard zoning, liquefaction, structural damage assessment.

Unit-III: Landslides and Slope Failures-Types, causes, and mechanics of landslides; Landslide hazard zonation using GIS and remote sensing; ***Floods and River Hazards;*** Causes of floods: meteorological, hydrological, and anthropogenic; Flood plain mapping and hydrological modeling

Unit-IV: Volcanic and Coastal Hazards, Types of volcanoes, lava flow, ash fall, and associated risks, Tsunamis, cyclones, sea-level rise, and coastal erosion; ***Disaster Risk Reduction and Management;*** Early warning systems, mitigation planning, emergency response; National Disaster Management Authority (NDMA) guidelines; Community-based disaster risk reduction (CBDRR).

Unit-V: Case Studies and Practical Applications- Indian and global disaster case studies (e.g., Uttarakhand floods, Bhuj earthquake); Use of GIS/remote sensing in hazard mapping; Field-based disaster risk assessment (if applicable)

Recommended Readings:

- **Keller, E. A. & DeVecchio, D. E.** – *Natural Hazards: Earth's Processes as Hazards, Disasters, and Catastrophes,* Routledge, 5th Edition, *2021 (Comprehensive foundation for all natural hazards)*
- **Smith, K.** – *Environmental Hazards: Assessing Risk and Reducing Disaster, Routledge, 8th Edition, 2021 (Focuses on risk assessment and mitigation strategies)*
- **Bryant, E.** – *Natural Hazards*, Cambridge University Press, 2nd Edition, 2005 *(Fundamentals of hazard science with emphasis on climate and tectonics)*
- **Singh, R. B. (Ed.)** – *Natural Hazards and Disaster Management: Vulnerability and Mitigation*, Rawat Publications, 2006 *(Indian perspective and vulnerability mapping)*
- **NDMA Publications** – *Disaster Management Guidelines*, National Disaster Management Authority, Government of India, *(Available online; regularly updated for official policy framework)*

Sarkar, S. – *Disaster Management*, APH Publishing Corporation, 2007, *(Indian context of disasters with case studies and mitigation)*