# Department of Geology
# IGNTU, Amarkantak

# SYLLABUS
# M.Sc. Geology

| SEMESTER I | |
|---|---|
| **GEOT 101** | Mineralogy and Crystallography |
| **GEOT 102** | Sedimentology |
| **GEOT 103** | Igneous Petrology |
| **GEOT 104** | Metamorphic Petrology |
| **GEOP 101** | Mineralogy Practical |
| **GEOP 102** | Sedimentology Practical |
| **GEOP 103** | Igneous Petrology Practical |
| **GEOP 104** | Metamorphic Petrology Practical |
| **SEMESTER II** | |
| **GEOT 201** | Geomorphology and Remote Sensing |
| **GEOT 202** | Structural Geology and Tectonics |
| **GEOT 203** | Invertebrate Paleontology |
| **GEOT 204** | Stratigraphy and Geology of India |
| **GEOT 205** | Geological Field Training |
| **GEOP 201** | Remote Sensing Practical |
| **GEOP 202** | Structural Geology Practical |
| **GEOP 201** | Invertebrate Paleontology Practical |
| **GEOP 202** | Stratigraphy Practical |
| **SEMESTER III** | |
| **GEOT 301** | Fuel Geology |
| **GEOT 302** | Geological Oceanography and Micropaleontology |
| **GEOT 303** | Hydrogeology and Engineering Geology |
| **GEOT 304** | Ore Geology |
| **GEOT 305** | Geological Field Training |
| **GEOP 301** | Fuel Geology Practical |
| **GEOP 302** | Micropaleontology Practical |
| **GEOP 303** | Hydrogeology Practical |
| **GEOP 304** | Ore Geology Practical |
| **DSEGEO 301** | Thermodynamics and Geothermobarometry |
| **DSEGEO 302** | Basics of Geographical Information System |
| **SEMESTER IV** | |
| **GEOT 401** | Geochemistry and Isotope Geology |
| **GEOT 402** | Dissertation |
| **GEOP 401** | Geochemistry Practical |
| **DSEGEO 401** | Geology of the Central India- A Geochemical Approach |
| **DSEGEO 402** | Deformation Kinematics and Geodynamic Modelling |
| **DSEGEO 403** | Watershed Management |

## FIRST SEMESTER EXAMINATION

| Nomenclature of Paper | Credits | Contact Hrs./ Week | Maximum Marks | Internal Assessment (40 marks) | End Semester Examination Marks | Min. Pass Marks in End Sem. Exam. |
|---|---|---|---|---|---|---|
| | | | | 20x2 tests | | |
| **GEOT 101**: Mineralogy and Crystallography | 4 | 4 hrs. | 100 | 40 | 60 | 24 |
| **GEOT 102**: Sedimentology | 4 | 4 hrs. | 100 | 40 | 60 | 24 |
| **GEOT 103**: Igneous Petrology | 4 | 4 hrs. | 100 | 40 | 60 | 24 |
| **GEOT 104**: Metamorphic Petrology | 4 | 4 hrs. | 100 | 40 | 60 | 24 |
| **GEOP 101:** Mineralogy Practical | 2 | 3 hrs. | 50 | | 50 | 20 |
| **GEOP 102:** Sedimentology Practical | 2 | 3 hrs. | 50 | | 50 | 20 |
| **GEOP 103:** Igneous Petrology Practical | 2 | 3 hrs. | 50 | | 50 | 20 |
| **GEOP 104:** Metamorphic Petrology Practical | 2 | 3 hrs. | 50 | | 50 | 20 |
| **Total** | 24 | | 600 | 160 | 440 | |

**Detailed Syllabus**

**M.Sc. GEOLOGY**

**SEMESTER-I**

## GEOT 101: Mineralogy and Crystallography

### Unit-I

Polymorphic Reactions: Reconstructive, Displacive, Order-disorder polymorphism. Polytypism, Solid Solution and Exsolution Processes. Mineralogy: stability of the minerals, modes of occurrence and alterations.

### Unit-II

Classification of silicates; detailed study of important silicates groups (Nesosilicates/Orthosilicates, Sorosilicates, Cyclosilicates, Inosilicates, Phyllosilicates and Tectosilicates) with reference to general and structural formulae, atomic structure, structural states/polymorphs,Structure, relation of chemical composition. Optical, physical properties, alteration, and paragenesis of following group of minerals: Olivine, Pyroxene, Amphiboles, Garnet, Mica, Epidote etc.; Introduction to Gemmology

### Unit-III

Crystallography: 32 classes of symmetry; concept of Space Group- Symmorphic and Asymomorphic space group; Concept of Miller Indices, Hermann-Mauguin notation; Types of crystal projection and their uses-Spherical and stereographic; X-ray Diffraction methods in mineralogical investigations-Bragg's Law, Ewald's sphere;

### Unit-IV

Principles of optical mineralogy: polarized light; optical mineralogy; behavior of isotropic and anisotropic minerals in polarized light: Birefringence, refractive index, double refraction, sign of elongation, Pleochroism, extinction angle, 2V, dispersion in minerals and pleochroic scheme.

### Unit-V

Uniaxial and Biaxial minerals. Concept of optical Indicatrix-Uniaxial Indicatrix and Biaxial Indicatrix. Use of Indicatrix, relation between crystallographic axes and the Indicatrix axes, Interference figures, Determination of 2V from Interference figures.

**List of Books Recommended:**


- Azaraoff: Elements of X-ray Crystallography.
- Buerger: Elementary Crystallography
- Cornelis Klein and Barbara Dutrow, The manual of Mineral Science, Wiley Publication 2007.
- Dana, E.S. and Ford, W.E.: A textbook of Mineralogy. Wiley Eastern Limited.
- Deer, W. A. , Howie, R. A. and Zussman, J., An introduction to the rock forming
- Kerr,P.F. Optical Mineralogy. McGraw Hill Book Company
- Minerals, ELBS publication,1962-1963.
- Nesse W.D., Introduction to Optical mineralogy, 2008
- P. K. Verma , Optical mineralogy, CRC press 200
- Putnis, Andrew. 1992: Introduction to Mineral Sciences. Cambridge Univ. Press
- Spear, F. S. (1993): Mineralogical phase equilibria and Pressure- Temperature-Time paths
- Winchell: Elements of Optical Mineralogy part I and II

## GEOT 102: Sedimentology

### Unit-I

Sediment types and generation; Sediment transport and deposition, fundamentals of fluid dynamics; Sedimentary textures; Sedimentary structures: lamination, ripples, cross-bedding etc.; Methods of textural analysis, textural parameters and their significance

### Unit-II

Siliciclastic sedimentary rocks, classifications; Siliciclastic diagenesis; Siliciclastic marine environments; Petrogenesis of sandstones, Graywacke and graywacke problem; plate tectonics and sandstones composition; Argillaceous rocks, their classification and genesis

### Unit-III

Carbonate sedimentary rocks, classification and diagenesis; Limestones, their modes of formation, petrography and classification; Dolomites, their petrographic characteristics and models of dolomitization; Study of evaporites such as gypsum, anhydrite and halite; Diagenesis - physical and chemical, processes and evidences of diagenesis in sandstones, mud rocks and carbonate rocks

### Unit-IV

Eolian and lacustrine environments; Glacial environment; Deltaic and beach barrier island environments; Estuarine, lagoonal and tidal environments

### Unit-V

Implication of facies in environmental interpretation and basin analysis; Introduction to Sequence Stratigraphy and its applications.

**List of recommended books:**


- Blatt, H., Middleton, G.V. and Murray, R.C. (1980): Origin of Sedimentary Rocks, Prentice-Hall Inc.
- Catuneanu, O. (2006): Principles of Sequence Stratigraphy, Elsevier.
- Collins, J.D., and Thompson, D.B. (1982): Sedimentary Structures, George Allen and Unwin, London.
- Miall, A.D. (2000): Principles of Basin Analysis, Springer-Verlag.
- Nichols Gary (2009): Sedimentology and Stratigraphy, Wiley India.
- Pettijohn, F.J. (1975): Sedimentary Rocks (3rd Ed.), Harper and Row Publ., New Delhi.
- Reading, H.G. (1997): Sedimentary Environments and facies, Blackwell Scientific Publication.
- Reineck, H.E. and Singh, I.B. (1973): Depositional Sedimentary Environments, Springer Verlag.
- Selley, R. C. (2000) Applied Sedimentology, Academic Press.
- Tucker, M.E. (1990): Carbonate Sedimentolgy, Blackwell Scientific Publication.
- Tucker, M.E. (2001): Sedimentary Petrology: An Introduction, Wiley and Sons, New York.

## GEOT 103: IGNEOUS PETROLOGY

### Unit-I

Nature and evolution of magma; Mantle petrology and mantle heterogeneities; Magmatism in relation to plate tectonics; Partial melting (batch and fractional melting); Crystal fractionation (equilibrium and fractional (Rayleigh) crystallization)

### Unit-II

Phase equilibrium - binary systems (Ab-An, Ab-Or, Di-An, Fo-Si) and their relations to magma genesis; Ternary systems (Di-Ab-An, Di-Fo-Si, Di-Fo-An, Fo-An-Si) and their relations to magma genesis; Interpretation of igneous textures in terms of rate of nucleation and crystal growth.

### Unit-III

IUGS classification of the igneous rocks; CIPW norm; Petrology and petrogenesis of major igneous rock types with Indian examples of ultramafics, komatiite, basalt, granite, alkaline rocks, ophiolite, bornite, carbonatite, lamprophyre, lamproite, and kimberlite.

### Unit-IV

Application of major, trace and Rare Earth elements in petrogenesis. Classification of Trace element. Geological controls of trace elements distributions. Understanding of trace element partition coefficient (kds). Magma generation in different tectonic scenario: minor elements finger printing (through spider-diagram and rare earth elements patterns) for source characterization and magma tectonics.

### Unit-V

Chemical characteristics of igneous rocks in the following tectonic setting: Mid Oceanic Ridge, Island Arcs, Oceanic plateaus, Continental Margins, Continental Rifts and Continental intraplates; Plume magmatism and hot spots; Large igneous provinces, mafic dyke swarms.

**List of recommended books:**


- Marjorie Wilson, 1989. Igneous petrogenesis
- Cox, KG, Bell, JD and Pankhurst, RJ, 1993. The Interpretation of Igneous Rocks. Chapman & Hall, London
- Rollinson, HR 2007. Using geochemical data-evaluation, presentation and interpretation. 2nd edition. Longman Scientific & Technical
- Blatt H., Tracy R.J. and Owens B.E. (2006): Petrology – Igneous, sedimentary and Metamorphic (3rd Edition), W.H. Freeman and Company, New York.
- Bose M.K. (1997): Igneous Petrology. The World Press Pvt. Ltd.
- Bowen N.L. (1928): The evolution of Igneous Rocks. Princeton Univ. Press. N. J.
- Ehlers, E.G. and H. Blatt (1982): Petrology, Igneous, Sedimentary and Metamorphic, Freeman and company.
- Hatch F.H., Wells A.K and Wells M.K. (1984): Petrology of the igneous rocks, CBS.
- Philpotts A.R. (1994): Principles of igneous and metamorphic Petrology, Prentice Hall of India.

- Philpotts, A and Ague, J (2009): Principles of igneous and metamorphic petrology, Cambridge University Press Publishers,
- Turner F.J & Verhoogen J. (1951): Igneous and Metamorphic Rocks, McGraw Hill.
- Williams H, Turner F.J & Gilbert C.M. (1955): Petrography, W.H. Freeman and company. San Francisco.
- Winkler Helmut G.F. (1987): Petrogenesis of Metamorphic Rocks (Fifth Edition), Narosa Publishing House, New Delhi.
- Winter J. D. (2001): An Introduction to Igneous and Metamorphic Petrology, Prentice
- Winter, John D. (2010): Principles of igneous and metamorphic petrology, PHI learning Pvt. Ltd.


## GEOT 104: Metamorphic Petrology

### Unit-I

Definition and Conditions of Metamorphism: Low and High-Temperature Limit of Metamorphism and Low and High-Pressure Limit of Metamorphism; Metamorphic Agents and Changes: Role of Temperature, Pressure, Stress and Fluids; Types of Metamorphism; Types of Protolith; Classification of Metamorphic Rocks; Structures and Textures of Metamorphic Rocks.

### Unit-II

Mineralogical phase rule for closed and open systems; Nature of Metamorphic Reactions; Concept and Classification of Metamorphic Facies and Facies Series; Introduction to Ultra-High-Temperature (UHT) and Ultra-High-Pressure (UHP) Metamorphism.

### Unit-III

Phase Rule and Phase diagram; ACF, AKF and AFM Diagrams: Basic Concepts and Common Diagrams in Metamorphic Petrology; Isograds and Reaction Isograds; Construction of Phase Diagrams for Multicomponent Systems after the Method of Schreinemakers.

### Unit-IV

Facies of Contact and Regional Metamorphism: Sanidinite, Pyroxenite-Hornfels, Hornblende-Hornfels and Albite-Epidote-Hornfels Facies; Facies of Medium-High Pressure Metamorphism: Zeolite, Greenschist, Amphibolite and Granulite Facies.

### Unit-V

Facies of High Pressure metamorphism: Eclogite Facies; Blueschist Facies; Regional Metamorphism and Plate Tectonics; Paired Metamorphic Belts; Migmatites and their Origin; Pressure–Temperature–Time Paths and Reaction History; Charnockites; Shock Metamorphism

**List of recommended books**


- Mason Roger (1984): Petrology of the Metamorphic Rocks, CBS Publishers and Distributors, New Delhi.
- Miyashiro A. (1998): Metamorphism and Metamorphic Belts, George Allen & Unwin, New York.
- Philpotts, A.R. 1994 Principles of Igneous and Metamorphic Petrology, Prentice Hall
- Passicher C.W, Myers J.S and Kroner A. (1990): Field geology of high grade gneiss terraines; Narosa Publishing house, Springer Verlag and IUGS.
- Yardley Bruce W.D. (1989): An Introduction to Metamorphic Petrology, Longman Singapore Publishers (Pvt.) Ltd.
- Frost, B.R. and Frost, C.D. 2014, Essentials of Igneous and Metamorphic Petrology, Cambridge University Press.
- Winter, John D. (2010): Principles of igneous and metamorphic petrology, Prentice Hall.
- Spry, A. 1976 Metamorphic Textures, Pergamon Press.
- Sharma, Ram. S., 2016. Metamorphic Petrology: Concepts and Methods, Geological Society of India
- Turner, F.J., 1980: Metamorphic Petrology, Mc Graw Hill.
- Spear, F. S. 1993: Mineralogical Phase equilibria and pressure-temperature-time paths, Mineralogical Society of America.
- Spry, A. 1976: Metamorphic Textures, Pergamon Press.


## GEOP 101: Mineralogy Practical

- Stereographic projection of face poles of crystals. Study of elements of symmetry of normal classes of six crystal systems.
- Study of physical properties of minerals in hand specimen - Silicates: Olivine, Garnet, Andalusite, Sillimanite, Kyanite, Staurolite, Beryl, Tourmaline, Augite, Actinolite, Tremolite, Hornblende, Serpentine, Asbestos, Kaolinite, Talc, Muscovite, Biotite, Phlogopite, Quartz, Orthoclase, Plagioclase, Microcline, Nepheline, Sodalite, Zeolite. Quartz varieties: Chert, Flint, Chalcedony, Agate, Jasper, Amethyst, Rose quartz, Smoky quartz, Rock crystal. Native Metals/non-metals, Sulphides, Oxides: Copper, Sulphur, Graphite, Pyrite, Corundum, Magnetite. Hydroxides, Halides, Carbonates, Sulphates, Phosphates: Psilomelane, Fluorite, Calcite, Malachite, Gypsum, Apatite.
- Study of optical properties of rock forming minerals: Quartz, Plagioclase, Microcline, Muscovite, Biotite, Fluorite, Olivine, Garnet, Tourmaline, Staurolite, Andalusite, Kyanite, Sillimanite, Cordierite. Hypersthene, Augite, Diopside, Hornblende, Tremolite-Actinolite, Corundum, Beryl, Calcite, Barite.
- Pleochroic scheme determination
- Optical sign determination of minerals
- Extinction angle measurement.

## GEOP 102: Sedimentology Practical

- Petrography of clastic and non-clastic rocks through hand specimens and thin sections.
- Plotting of size-distribution data as Frequency and Cumulative curves.
- Exercises on sedimentary structures.
- Granulometric analysis. Particle size distribution and statistical treatment Paleocurrent analysis.
- Petrography of sedimentary rocks - texture and mineralogy.

## GEOP 103: Igneous Petrology Practical

- Study of igneous rocks in hand specimens and under the petrological microscope
- Whole rock analysis of igneous rocks using XRF
- Norm calculations and application of GEOSOFTWARE.
- Study of Multi-elements and REEs pattern
- Calculations of model melting
- Model age calculations

## GEOP 104: Metamorphic Petrology Practical

- Study of metamorphic rocks of different metamorphic facies in Hand Specimens
- Calculation of ACF, AKF and AFM values from chemical and structural formulation of minerals and their graphical representation
- Study of Metamorphic Rocks in thin sections belonging to different facies with emphasis on texture/structure, mineral composition, parent rock, metamorphic facies / subfacies / zone to which the rock can be assigned and graphical representation of the assemblage in ACF, AKF and AFM diagrams
- Estimation of Pressure and Temperature from important models of Geothermobarometry

## SECOND SEMESTER EXAMINATION

| Nomenclature of Paper | Credits | Contact Hrs./ Week | Maximum Marks | Internal Assessment 40 Marks<br>20x2 tests | End Semester Examination Marks | Min. Pass Marks in End Sem. Exam. |
|---|---|---|---|---|---|---|
| **GEOT 201**: Geomorphology and Remote Sensing | 4 | 4 hrs. | 100 | 40 | 60 | 24 |
| **GEOT 202**: Structural Geology and Tectonics | 4 | 4 hrs. | 100 | 40 | 60 | 24 |
| **GEOT 203**: Invertebrate Paleontology | 4 | 4 hrs. | 100 | 40 | 60 | 24 |
| **GEOT 204**: Stratigraphy and Geology of India | 4 | 4 hrs. | 100 | 40 | 60 | 24 |
| **GEOT 205**: Geological Field Training | 4 | 5-7 days | 100 | | 100 | 40 |
| **GEOP 201:** Remote Sensing Practical | 2 | 3 hrs. | 50 | | 50 | 20 |
| **GEOP 202:** Structural Geology Practical | 2 | 3 hrs. | 50 | | 50 | 20 |
| **GEOP 203:** Invertebrate Paleontology Practical | 2 | 3 hrs. | 50 | | 50 | 20 |
| **GEOP 204:** Stratigraphy Practical | 2 | 6 hrs. | 50 | | 50 | 20 |
| **Total** | 28 | | 700 | 160 | 540 | |

**Detailed Syllabus**

**M.Sc. GEOLOGY**

**II SEMESTER**

## GEOT 201: Geomorphology and Remote Sensing

### Unit – I

Historical background of geomorphology –Fundamentals of geomorphic concepts – Geomorphic significance of weathering; soils and its profile, formation of soils – Mass wasting and its geomorphic significance; creep, solifluction, patterned ground, earth flows, mud flows, debris avalanches, landslides, subsidence forms

### Unit - II

Evolution of landforms; endogenous and exogenous forces, role of lithology, peneplanation, rejuvenation of landforms – Fluvial geomorphic cycle; streams and valleys, valley development, classification of valleys – Drainage patterns and their significance; types of drainage patterns – Morphometric analysis of the drainage basin. Depositional and erosional landforms; Fluvial, Aeolian, Glacial, and Coastal – Karst topography - Topography of Ocean floors,

### Unit – III

Basic concepts and fundamentals of aerial photography - Scale of photography, Aerial cameras, factors influencing image quality, side lap and overlap, mosaicking of Aerial photographs, stereoscopy, estimation of dip and slope - Aerial photo interpretation for Geology; Techniques of interpretation; Recognition elements, Convergence of evidence for interpretation of Geology.

### Unit – IV

Basic concepts and fundamentals of Remote sensing - Electromagnetic energy and its sources - Interaction of EM radiation with atmosphere - Interaction of EM radiation with earth's surface - Atmospheric windows different spectral regions useful for Remote sensing. Sensors – platforms, Multispectral Remote sensing in Micro wave regions, Remote sensing in Thermal infrared regions, remote sensing satellites and their pay load characteristics - Application of remote sensing for identifications of mineral resources, lithological mapping and groundwater exploration.

### Unit- V

GIS: Hardware and software in GIS – spatial and non-spatial data, Raster and vector data structures – Data conversions Elements of GIS: Data capture, Verification and processing, data storage - Data base management systems: Types, merits and demerits - Data manipulation analysis and spatial modeling. Applications of GIS in various geological studies

**Textbooks/Reference Books:**


- Thornbury. W.D, (2004): Principles of Geomorphology, 2 Edition, CBS Publishers and Distributors Pvt. Ltd., New Delhi
- Huggett Richard John (2007): Fundamentals of Geomorphology. 2nd Edn, Taylor & Francis.
- Bloom. A.L., (1992): Surface of the Earth. Prentice Hall India, New Delhi.
- Savindra Singh, (1998): Geomorphology, CBS Publishers and Distributors Pvt. Ltd., New Delhi

- Holmes A. (1993): Principles of Physical Geology., ed by David Duff, Nelson Thornes Ltd.
- Holmes, A.(1992): Holmes Principles of Physical Geology, Edited by P. McL. D. Sabbins, F. F., 2007: Remote sensing – Principles and application; Waveland Print, INC.
- Richard, G. Ray, 1960: Aerial photographs in Geologic interpretations, Report, USGS,U.S. Govt. Print. Off.
- Victor, C. Miller. 1961: Photogeology; McGraw – Hill, New York.
- Siegal, B.S & Gillespie, A. R. (eds), 1980: Remote sensing in Geology; John Wiley.
- Burrough, P.A., 1986: Principles of Geographic Information System for Land resource assessment, Oxford University Press, New York
- Lillesand, T.M. and Kiefer, R.W. (1987): Remote Sensing and Image Interpretation, John Wiley.


## GEOT 202: Structural Geology and Tectonics

### Unit-I

Mechanical principles related to structural deformations, properties of rocks and their controlling factors; Concept of stress; Two-dimensional stress analyses; Faulting: Causes and dynamics; Types of faults: normal faults, reverse faults, thrust faults, strike-slip faults; Decollement; Thrust sheet and Nappe- propagation and mechanism.

### Unit-II

Concept of strain, two and three dimensional strain analysis; Types of strain ellipses and ellipsoids, their properties and geological significance; Strain measurements in naturally deformed rocks; Mechanics of folding and buckling, superposed folding patterns, fold development and distribution of strains in folds.

### Unit-III

Shear Zones: Brittle and ductile; Geometry and products of shear zones; Mylonites and cataclasites; Planar and linear fabrics in deformed rocks, their origin and significance.

Axial plane foliation- fracture cleavage, crenulation cleavage, slaty cleavage and schistosity; Origin of axial plane foliations; Transposed foliation; Cleavage bedding relationship; Structural association of gently dipping schistosity; Recognition of shear zones; Kinematic classification of shear zones; Fabric distribution in shear zones

### Unit-IV

Basic idea about petrofabrics; Stereographic and equal area projections for representing different types of fabrics, $\pi$ and $\beta$ diagrams; Geometrical analysis of simple and complex structures on macroscopic scale.

### Unit-V

Paleomagnetism, polar wandering and reversal of earth's magnetic field; Geomagnetic time scale; Concept of plate tectonics, nature and types of plate margins, geometry and mechanism of plate motion; Island arcs and mountain chains, their global distribution and evolution; Orogenic and epeirogenic phases; Plate tectonic evolution of India.

**List of recommended books:**


- Condie, Kent. C. (1982): Plate Tectonics and Crustal Evolution, Pergamon Press Inc.
- Ghosh, S.K. (1993): Structural Geology: Fundamental and Modern Development. Pergamon Press.
- Grohong, R.H (2006): 3-D Structural Geology, Springer-Berlin-Hydelberg-New York Fossen, H. (2010): Structural Geology, Cambridge University Press
- Hatcher Jr. R.D. (1990): Structural Geology, Merrill Publishing Company.
- Leyshon, P. R. And Lisle, R.J (2004): Stereographic projection techniques for geologists and civil engineers, Cambridge University Press
- Ramsay J.G. and Huber M.I. (2002): The Techniques of modern structural geology, 2nd ed., Vol. 2, Elsevier Science Ltd.
- Ramsay, J.G. (1967): Folding and fracturing of rocks, McGraw Hill.
- Ramsay, J.G. and Huber, M.I. (2000): Techniques of Modern Structural Geology, Vol. III (Application of continuum mechanics), Academic Press.
- Turner, F.J. and Weiss, L.E. (1963): Structural analysis of Metamorphic Tectonites, McGraw Hill.
- Windley B. (1973): The Evolving continents, John Wiley and Sons, New York.


## GEOT 203: Invertebrate Paleontology

### Unit-I

Fossils: definition, characteristics, types; Taphonomy; Modern systematics; Concept and kind of type specimens; Distribution, migration and dispersal of organisms applied to paleobiogeography and plate-tectonics.

### Unit-II

Chief characteristics, Evolutionary trends and functional morphology and geological history of invertebrate fossil groups: Trilobites; Brachiopoda; Echinoidea;

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### Unit-III

Chief characteristics, Evolutionary trends and functional morphology and geological history of invertebrate fossils: Mollusca- Bivalvia, Gastropoda, Cephalopoda.

### Unit-IV

Chief characteristics, Evolutionary trends and functional morphology and geological history of invertebrate fossils: Corals; Graptoloidea.
Ichnofossils, their modes of preservation, behavioral classification and ichnofacies.

### Unit-V

Approaches to paleoenvironmental studies; Micro and macro-evolution; Paleoceology and paleoclimates; Mass extinctions and biodiversity loss; Fossils form and functions; Introduction to Genomic studies to establish the affinities of fossil groups.

**List of recommended books:**


- Benton, Michael J. and Harper, David A.T. (2009): Introduction to Paleobiology and fossil record, John-Wiley & Sons.
- Clarksons, E.N.K. (1998): Invertebrate Paleontology and Evolution, Allen and Unwin, London.
- Mayr, E. (1971): Population, Species and Evolution, Harvard.
- Prothero, D.R. (2004): Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.), McGraw Hill.
- Raup, D.M. and Stanley, S.M. (1985): Principles of Paleontology, CBS Publ
- Shrock, Robert R. and Twenhofel, William H. (2002): Principles of Invertebrate Paleontology, (McGraw Hill) Dist. CBS Publishers.
- Smith, A.B. (1994): Systematics and Fossil Record – Documenting Evolutionary Patterns, Blackwell.
- Woods, Henry (1926): Invertebrate Paleontology
- Armstrong, H.A. and Brasier, M. (2005): Microfossils, Blackwell Publishing, Australia. Arnold (2002): Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett), Oxford University Press, New York.
- Bignot, G., Grahm and Trottman (1985): Elements of Micropaleontology, Micropaleontology Press, London.
- Garrison, T. (2007): Oceanography: An invitation to marine sciences, Cengage Learning.
- Haq, Bilal and Boersma, Anne (Ed.) (1998): Introduction to Marine Micropaleontology, Jones, T.P. and Rowe, T.P. (1999): Fossil plants and spores, Modern Techniques, Geological Soc. of London.
- Kennett, J.P. and Srinivasan, M.S. (1983): Neogene Planktonic Foraminifera- a phylogenetic atlas, Hutchinson Ross Publishing Company.
- Pinet, Paul R. (2006): Invitation to Oceanography, Jones & Bartlett Learning.


## GEOT 204: Stratigraphy and Geology of India

### Unit-I

Development of stratigraphic concepts; Stratigraphic classification & nomenclature, study of stratigraphic elements; Lithostratigraphy and its units; Stratification: processes controlling stratification- physical, chemical and biological; Vertical succession, lithological uniformity, heterogeneity, patterned succession, alternations, varves, cycles (symmetrical and asymmetrical); Lateral variations and facies concept; Unconformity; Chronostratigraphy and its units; Biostratigraphy and its units; inter-relationship between lithostratigraphic, chronostratigraphic and biostratigraphic units; Brief ideas of magneto-seismo- chemo-stratigraphy; Geological Time Scale.

### Unit-II

Precambrian Stratigraphy; Precambrian geochronology; Archean Geology of India: (i) Dharwar Craton, (ii) Singhbhum Craton; Proterozoic Geology of India: (i) Central Indian Tectonic Zone, (ii) Vindhyan Supergroup, (iii) Cuddapah Supergroup; Precambrian-Cambrian boundary.

**Unit-III**

Paleozoic Stratigraphy; Igneous activities and paleogeography during the Paleozoic Era; Paleozoic of Kashmir; Permian-Triassic Boundary Concept, classification, fauna, flora and age limits of Gondwana Supergroup and related paleogeography, paleoclimate, and depositional characteristics.

**Unit-IV**

Mesozoic Stratigraphy; Classification, depositional characteristics, fauna, and flora of: Triassic of Spiti, Jurassic of Kutch, Cretaceous of Trichinapalli; Deccan Volcanic Province; Cretaceous- Tertiary Boundary. Cenozoic Stratigraphy; Paleogene Systems of India

**Unit-V**

Neogene Systems of India; Siwalik Supergroup; Pleistocene-Holocene Boundary; Concept of Meghalayan.
Himalayan Stratigraphy.

**List of recommended books:**


- Boggs, S. (2001): Principles of Sedimentology and Stratigraphy, Prentice Hall.
- Danbar, C.O. and Rodgers, J. (1957): Principles of Stratigraphy, John Wiley and Sons.
- Doyle, P. and Bennett. M.R. (1996): Unlocking the Stratigraphic Record, John Wiley and Sons.
- Harold L. Lewis (1987): Earth through Time; 3rd Edition. Saunders College Publishing, New York
- K. S. Valdiya (2010): The Making of India-Geodynamic Evolution; Macmillan Publishers India Ltd.
- Krishnan, M.S. (1982): Geology of India and Burma, C.B.S. Publ. and Distributors, Delhi.
- M. Ramakrishnan and R. Vaidyanadhan (2008): Geology of India (Vol. I and II); Geological Society of India, Bangalore.
- M. S. Krishnan (1982), Geology of India and Burma; 6th Ed. CBS Publishers and Distributors (India).
- Naqvi, S.M. and Rogers, J.J.W. (1987): Precambrian Geology of India, Oxford University Press.
- Pascoe, E.H. (1968): A Manual of the Geology of India and Burma (Vols. I-IV), GSI, Govt. of India Press, Delhi.
- Pomerol, C. (1982): The Cenozoic Era? Tertiary and Quaternary, Ellis Harwood Ltd., Halsted Press. Schoch,
- Robert, M. (1989): Stratigraphy: Principles and Methods, Van Nostrand Reinhold, New York.
- Roy, R. Lemon (1990): Principles of Stratigraphy; Merrill Publishing Company, Ohio
- Wadia, D.N. (1984), Geology of India; 4th edition. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.


## GEOT 205: Geological Field Training

Compulsory field work in geologically significant terrains, viva-voce and field report.

## GEOP 201: Remote Sensing Practical

- Modular and salient features of ARC GIS
- Displaying the data
- Creation of shape file and adding features to shape file
- Define and project geographic and projected co-ordinate system
- Co-ordinate system using import option
- Map creation

## GEOP 202: Structural Geology Practical

- Exercises of stereographic projections of mesoscopic structural data (planar, linear, folded etc.), contour diagrams and orientation analyses of foliation and lineation data for regional structural geometry.
- Geometric and stereographic techniques related to true dip- apparent dip problems.
- Geometric technique for ascertaining unground structure from borehole data.
- Techniques for characterization of geological faults and folds from geometric relationship between geological field data (e.g., orientation and spatial disposition of the disrupted beds)
- Drawing profile sections and interpretation of geological maps of different complexities.
- Problems related to practical strain measurement (Rf-φ method, Fry method etc.)

## GEOP 203: Invertebrate Paleontology Practical

- Taxonomic identification, morphology and functional morphology of Invertebrate fossil groups: Trilobita, Brachiopoda, Mollusca- Bivalvia, Gastropoda, Cephalopoda, Echinoidea, Coral
- Suture Patterns in Cephalopoda and its applications in paleobathymetric studies
- Shell morphology of Bivalvia and Brachiopoda and its application in deciphering the modes of living of fauna

## GEOP 204: Stratigraphy Practical

- Construction of profiles from contour maps and identifying stratigraphic contacts
- Study of rocks in hand specimens from known Indian stratigraphic horizons and type localities
- Stratigraphic classification and correlation, sequence, and magneto stratigraphic interpretations.
- Shaw's Graphic Correlation method
- Biozonation and Biochronology based on micropaleontological data

## THIRD SEMESTER EXAMINATION

| **Nomenclature of Paper** | **Credits** | **Contact Hrs./ Week** | **Maximum Marks** | **Internal Assessment 40 marks** | **End Semester Examination Marks** | **Min. Pass Marks in End Sem. Exam.** |
|---|---|---|---|---|---|---|
| | | | | 20x2 tests | | |
| **GEOT 301**: Fuel Geology | 4 | 4 hrs. | 100 | 20x2 | 60 | 24 |
| **GEOT 302:** Geological Oceanography & Micropaleontology | 4 | 4 hrs. | 100 | 20x2 | 60 | 24 |
| **GEOT 303**: Hydrogeology and Engineering Geology | 4 | 4 hrs. | 100 | 20x2 | 60 | 24 |
| **GEOT 304**: Ore Geology | 4 | 4 hrs. | 100 | 20x2 | 60 | 24 |
| **GEOT 305**: Geological Field Training | 4 | 5-7 days | 100 | | 100 | 60 |
| **GEOP 301**: Fuel Geology Practical | 2 | 3 hrs. | 50 | | 50 | 20 |
| **GEOP 302**: Micropaleontology Practical | 2 | 3 hrs. | 50 | | 50 | 20 |
| **GEOP 303**: Hydrogeology Practical | 2 | 3 hrs. | 50 | | 50 | 20 |
| **GEOP 304**: Ore Geology Practical | 2 | 3 hrs. | 50 | | 50 | 20 |
| **DSEGEO 301**: Thermodynamics and Geothermobarometry<br>**DSEGEO 302**: Basics of GIS | 3 | 2 hrs. | 100 | 20x2 | 60 | 24 |
| **Total** | **31** | | **800** | 200 | 600 | |

**Detailed Syllabus**
**M.Sc. GEOLOGY**

**SEMESTER-III**

## GEOT 301: Fuel Geology

### Unit-I

Definition and origin of coal; Sedimentology of coal bearing strata; Types of seam discontinuities and structures associated with coal seams; Chemical analysis of coal (proximate and ultimate analysis). Classification of coal in terms of rank, grade and type; Indian classification for coking and non-coking coals.

### Unit-II

Coal Petrology– concept of 'lithotype', 'maceral' and 'microlithotype; Techniques and methods of coal microscopy; Applications of coal petrology

### Unit-III

Petroleum– its composition, origin (formation of source rocks- kerogen, organic maturation and thermal cracking of kerogen); Migration of petroleum; Reservoir rocks-petrology of reservoir rocks, porosity and permeability; Reservoir traps – structural, stratigraphic and combination traps.

### Unit-IV

An outline of the oil belts of the world; Onshore and offshore petroliferous basins of India; Geology of productive oilfields of India; Elements of unconventional petroleum systems.

### Unit-V

Gas Hydrates; Coal Bed Methane (CBM)– An unconventional petroleum system; Elementary idea about generation of methane in coal beds; coal as a reservoir and coal bed methane exploration; Coal as a source rock for oil and gas; Geological and geographical distribution of coal and lignite deposits in India; Coal exploration and estimation of coal reserves; Indian coal reserves and production of coal in India. Petroleum exploration; Identification and characterization (petrographic and geochemical) of petroleum source rocks; Amount, type and maturation of organic matter; Oil and source rock correlation. Well logging techniques.

**List of recommended books:**


- Chandra, D., Singh, R.M. and Singh, M.P. (2000): Textbook of Coal (Indian context), Tara Book Agency, Varanasi.
- Holson, G.D. and Tiratso, E.N. (1985): Introduction of Petroleum Geology, Fulf Publishing, Houston, Texas.
- Hunt, J.M. (1996): Petroleum Geochemistry and Geology (2nd Ed.), Freeman, San Francisco.
- Jahn, F., Cook, M. and Graham, M. (1998): Hydrocarbon exploration and production, Eslevier Science.
- Leverson, A.I (2006): Geology of Petroleum, CBS publications. enton,

- North, F.K. (1985): Petroleum Geology, Allen Unwin.
- Selley, R.C. (1998): Elements of Petroleum Geology, Academic Press.
- Singh, M.P. (1998): Coal and organic Petrology, Hindustan Publishing Corporation, New Delhi.
- Stach, E., Mackowsky, M-Th., Taylor, G.H., Chandra, D., Teichumullelr, M. and Teichmuller R. (1982): Stach's Texbook of Coal petrology, Gebruder Borntraeger, Stuttgart.
- Thomas, Larry (2002): Coal Geology, John Wiley and Sons Ltd., England.
- Tissot, B.P. and Welte, D.H. (1984): Petroleum Formation and Occurrence, Springer–Verlag.
- Van Krevelen, D. W. (1993): Coal: Typology-Physics-Chemistry-Constitution, Elsevier Science, Netherlands.


## GEOT 302: Geological Oceanography and Micropaleontology

### Unit I

Oceans of the Earth; Sampling of modern ocean; Scientific Ocean floor drilling and its major accomplishments. Coriolis force and Ekman spiral, upwelling, El Niño and La Nina; Atmospheric Circulation: concept of wind belts of the Earth; Introduction to Stable Isotopes.

### Unit II

Definition and scope of micropaleontology and its relation with ocean sciences; Modern field and laboratory techniques in the study of microfossils. Role of micropaleontology in marine geology and oceanography; Types of Microfossils- Calcareous Microfossils: (i) Foraminifera, (ii) Coccolithophores, (iii) Pteropoda, (iv) Ostracoda; Siliceous Microfossils- (i) Radiolaria and (ii) Diatoms; Phosphatic Microfossils- Conodonts; Organic Walled Microfossils: (i) Spores and Pollens

### Unit III

Temperature and salinity distribution (horizontal and vertical) in ocean waters; Dissolved gases in sea water; Biological - chemical - physical interactions in the oceans; Oxygen minimum layer in the ocean. Concept of mixed layer, thermocline, halocline, and pycnocline.

### Unit IV

Ocean circulation- surface circulation; deep ocean circulation; Waves and Tides. Ocean-Atmosphere interaction; Inter- Ocean exchange.

### Unit V

Applications of Micropaleontology in petroleum exploration; Environmental significance of microfossils; Geochemical study of microfossil tests and its application in paleoceanography and paleoclimatology; Application of palynology in identifying ancient coast lines.

**List of recommended books:**


- Armstrong, H.A. and Brasier, M. (2005): Microfossils, Blackwell Publishing, Australia. Arnold (2002): Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett), Oxford University Press, New York.

- Bignot, G., Grahm and Trottman (1985): Elements of Micropaleontology, Micropaleontology Press, London.
- Garrison, T. (2007): Oceanography: An invitation to marine sciences, Cengage Learning.
- Haq, Bilal and Boersma, Anne (Ed.) (1998): Introduction to Marine Micropaleontology, Jones, T.P. and Rowe, T.P. (1999): Fossil plants and spores, Modern Techniques, Geological Soc. of London.
- Kennett, J.P. and Srinivasan, M.S. (1983): Neogene Planktonic Foraminifera- a phylogenetic atlas, Hutchinson Ross Publishing Company.
- Pinet, Paul R. (2006): Invitation to Oceanography, Jones & Bartlett Learning.


## GEOT 303: Hydrogeology and Engineering Geology

### Unit I

Origin of water- Meteoric Juvenile, magmatic and sea waters; Hydrologic Cycle; Precipitation, Runoff, Infiltration, Evaporation, Transpiration. Occurrence and Subsurface movement and Vertical Distribution of Groundwater – Classification of aquifers - Geological Formations as Aquifers, springs. Darcy's Law, Hydrological properties of rocks – Specific Yield, Specific Retention, Porosity, Permeability, Hydraulic Conductivity, storage coefficient and specific capacity. Groundwater distribution of India; Groundwater provinces of India.

### Unit II

Groundwater Exploration: Surface and Subsurface Geological and Geophysical Methods-Electrical Resistivity Methods, Seismic Methods, Gravity Methods, Magnetic Method and Electromagnetic method.

### Unit III

Geological and Geotechnical investigations for Civil Engineering Projects: Tunnels: Terminology, Types of tunnels, methods of investigation, Geology for bridge sites, problems of constructing civil engineering structures in areas prone to landslides, faulting, earthquake and coastal erosion. Geological conditions for tunnel sites, Tunnels in folded rocks and bedded rocks.

### Unit IV

Dams and Reservoirs: Definition and parts of the dam, Terminology associated with dams. Types of dams: Masonry Dams (Gravity Buttress and Arch types), earthen dams. Geological conditions for the selection of dam and reservoir sites. Locations of all the important dams and hydroelectric projects in India. Dam failures-causes and case studies, remedial measures for the failure of dams and reservoirs.

### Unit V

Applications of geological investigations: Role of geologist in the engineering projects – Remote sensing for engineering applications: Site selection for dams and tunnels and road cuttings. Hydrogeological investigations and mining, investigation of landslides causes and mitigation. Engineering properties of rocks -physical characteristics of building stones, Rock as a Construction material. Case histories of some major dams: Nagarjuna Sagar, Srisailam and Bhakranangal.

**List of recommended books:**


- Schward and Zhang, 2003: Fundamentals of Groundwater, John Willey and Sons.
- Davies, S.N. and De-West, R.J.N., 1966: *Hydrogeology*, John Wiley & Sons, New York.
- Raghunath, H.M., 1987: *Ground Water*, Wiley Eastern Ltd., Calcutta.
- Fetter, C.W., 1984: *Applied Hydrogeology*, McGraw-Hill Book Co., New York.
- Fitts, C.R., 2013: *Groundwater Science*, Academic Press.
- Freeze, R.A. and Cherry, J.A., 1979: *Groundwater*, Englewood Cliffs, NewJersey: Prentice-Hall.
- Karanth, K.R., 1987: *Groundwater: Assessment, Development and Management*, Tata McGraw - Hill Pub. Co. Ltd.
- Parbin Singh., Engineering and General Geology
- Fitts, C.R., 2013: *Groundwater Science*, Academic Press.
- K. R. Karanth (1989): Hydrogeology, Tata McGraw Hill Publ.
- K.V.G.K.Gokhele., Principles of Engineering Geology.
- Karanth, K.R.,Groundwater Assessment and Development and Management.
- N.Chennakesavulu., Text Book of Engineering Geology .
- Ragunath, H.M., (1992): Groundwater Wiley Eastern Ltd. New Delhi.
- Schward and Zhang, 2003: Fundamentals of Groundwater, John Willey and Sons.
- Todd, D.K., 2004: Ground Water Hydrology, John Wiley & Sons, New York


## GEOT 304: Ore Geology

### Unit-I

Introduction to ore microscopy, techniques, methods, textures and microstructures of ores, interpretation of ore texture and optical properties of common sulphide, oxide ore minerals; Concept of ore bearing fluids, their origin and migration; Wall rock alteration; Structural, physicochemical and stratigraphic controls of ore localization; Ore deposits in relation to plate tectonics; Organic matters in ores and their significance; Fluid inclusions in ore - principles, assumptions, limitations and applications.

### Unit-II

Mineralogy, classification and genesis of ore deposits associated with orthomagmatic ores of ultramafic-mafic rocks; Ores of felsic-silicic igneous rocks; Ores of sedimentary affiliation - biochemical, chemical and clastic sedimentation, placers and residual concentration deposits; Ores of metamorphic affiliations; Ore mineral provinces of India.

### Unit-III

Study of ore minerals related to the following metals with special reference to their mineralogy, genesis, specification, uses and distribution in India: Iron, Manganese, Base Metals, Chromium, Gold, Tin and Tungsten. Study of important Indian ore deposits with reference to their geology, stratigraphy and reserves.

### Unit IV

Mineral Exploration: surface and subsurface exploration methods; sampling and assaying. Assessment of grade; Reserve estimation; Basic pattern of Mineral economy

and changing mineral requirements; Concepts of strategic; Minerals and their supplies in time of peace and war material in various important industries, problem relating to their marketing.

**Unit V**

Concession rules, world resources and production of important mineral. Importance of steel & Fuels in Modern Economy. Impact of atomic Energy over conventional fuels. Conservation of non-renewable & associated Renewable resources.

**List of recommended books:**


- Branes, H.L. (1979): Geochemistry of Hydrothermal Ore Deposits, John Wiley.
- Craig, J.R. and Vaughan, D.J. (1994): Ore Microscopy and Petrography.
- Cuilbert, J.M. (1986): The Geology of Ore Deposits, Freidman.
- Evans, A.M. (1993): Ore Geology and Industrial Minerals, Blackwell.
- Jensen M.R. and Bateman A.M. (1981), Economic mineral deposits, John Wiley & Sons.
- Klemm, D.D. and Schnieder, H.J. (1977): Time and Strata Bound Ore Deposits, Springer-Verlag.
- Mookherjee, A. (1999): Ore Genesis- A Holistic Approach, Allied Publishers.
- Wolf, K.H. (1976-1981): Handbook of Stratabound and Stratiform Ore deposits, Elsevier.
- Arogyaswami, R.P.N. (1996): Courses in Mining Geology, IV Ed. Oxford IBH.
- Bateman, A.M. (1952): Economic Mineral Deposits, The University of Chicago Press.


## GEOT 304: GEOLOGICAL FIELD TRAINING

Compulsory field work in geologically significant terrains, Viva-voce and Report

## GEOP 301: Fuel Geology Practical

- Study of hand specimen of coal and identification of lithotypes.
- Microscopic examination of polished coal pellets (identification of macerals in coal.
- Megascopic characterization of banded coals.
- Proximate analysis of coals.
- Study of geological maps and sections of important oilfields of India;

## GEOP 302: Micropaleontology Practical

- Microscopic identification of types of microfossils
- Taxonomic identification of planktic foraminifera according to watermass preference and latitudinal provincialism: tropical, subtropical, transitional, subpolar and polar
- Paleoceanographic and paleoclimatic reconstructions using the census count data of planktic foraminifera
- Taxonomic identification of benthic foraminifera
- Taxonomic identification of larger foraminifera

## GEOP 303: Hydrogeology Practical

- Physico-chemical parameters of waters: Determination pH, sodium, Ca, Mg, Carbonate, Bi carbonates, total alkalinity, estimation of total hardness, electrical conductivity Cl.
- Preparation of drainage and hydro-geological maps using GIS
- Identification of the lithology of the area based on the electrical resistivity methods.

## GEOP 304: Ore Geology Practical

- Study of ore minerals in hand specimens
- Study of ore minerals under the microscope
- Analysis and interpretations of ore geological maps (India and World)
- Numerical based interpretations of Ore reserve estimations

## DEPARTMENT SPECIFIC ELECTIVES

The students of M.Sc. Semester III have to choose one of the two DSE papers.

## DSEGEO 301: Thermodynamics and Geothermobarometry

### Unit I

Introduction of Thermodynamics; The First Law of Thermodynamics; The Second Law of Thermodynamics; The Third Law of Thermodynamics; The fundamental equation: the first and second laws combined

### Unit II

Introduction of the Geothermobarometry, Geothermometry and Geobarometry; Computation of simple P–T phase diagrams; The Clapeyron equation; Geothermobarometric Investigations on a Metapelitic Rock

### Unit III

Thermodynamics Properties; Volume; Entropy; Enthalpy; Gibbs Energy; Heat Capacity; Thermodynamics of Solids; Thermodynamics of Fluids: Aqueous Fluids and Silicate Liquids.

### Unit IV

Tools for Geothermobarometry; Selection of Reactions for Thermobarometry; Dependence of Equilibrium Constant on Temperature and Pressure; Univariant Reactions and Displaced
Equilibria; $Al_2SiO_5$ Polymorphs; Garnet–Rutile–$Al_2SiO_5$ Polymorph–Ilmenite–Quartz (GRAIL) Barometry; Garnet–Plagioclase–Pyroxene–Quartz (GAPES and GADS) Barometry.

### Unit V

Exchange Reactions; Garnet–Clinopyroxene Thermometry; Garnet–Biotite (GABI) Thermometry; Magnetite–Ilmenite Thermometry and Oxygen Barometry; Solvus Equilibria; Uncertainties in Thermobarometric Estimates; Fluid Inclusion Thermobarometry.

**List of recommended books**


- Kula C Misra (2012) Introduction to Geochemistry: Principles and Applications, Wiley-Blackwell.
- Winter, John D. (2010): Principles of igneous and metamorphic petrology, Prentice Hall.
- Spear, F. S. 1993: Mineralogical Phase equilibria and pressure-temperature-time paths, Mineralogical Society of America
- Andrew Putnis: Introduction to mineral sciences, Cambridge University Press.
- Roger Powell 1978: Equilibrium Thermodynamics in Petrology: An Introduction, Harper & Row, Publishers London.
- Rastogy, R.P. and Mishra, R.R. 1993: An Introduction to Chemical Thermodynamics, Vikash Publishing House.
- Wood, B.J. and Fraser, D.G. 1976: Elementary Thermodynamics for Geologists, Oxford University Press, London.
- Thomas M. Will 1998: Phase Equilibria in Metamorphic Rocks Thermodynamic Background and Petrological Applications, Springer.


## DSEGEO 302: Basics of Geographical Information System

Unit -I

GIS: Definition, Components of GIS, Hardware, Software and Organisational Context, GIS software; Maps: Definition, Types of Maps, Characteristics of Maps, Map Projections.

**Unit -II**

Data Types: Spatial and Non-Spatial; Spatial Data: Points, Lines and Polygons; Non-spatial data: Nominal, Ordinal, Interval and Ratio; Digitizer, Scanner, Editing and Cleaning; Georeferencing

**Unit -III**

Raster and Vector Data Structure: Raster data storage, Run length, Chain and Block Coding; Vector Data Storage, Topology, Topological Models, ArcNode Structure, Surface Data; DEM – Gridded DEM and TIN structure- Applications of DEM

**Unit -IV**

Reclassification, Measurement, Buffering, Overlaying SQL for Queries; Neighbourhood and zonal operations; Data Quality: Components of data quality, Sources of errors in GIS, Meta data

**Unit -V**

Output – Maps, Graphs, Charts, Plots, Reports; Printers, Plotters, Fields of application, Natural Resource Management, Parcel based; AM/FM applications examples – Case study: Urban growth studies using GIS

**List of recommended books:**


- Anji Reddy, Remote Sensing and Geographical Information Systems, BS Publications 2001
- M.G. Srinivas (Edited by), Remote Sensing Applications, Narosa Publishing House, 2001

- Star J. and Estes. J., GIS – An Introduction, Prentice Hall, USA.
- Robert Laurini and Derek Thompson, Fundamentals of Spatial Information Systems, Academic Press, 1996.
- Kang-tsung Chang (2007), 'Introduction to Geographic Information Systems' Tata MCGraw Hill, New Delhi.
- C.P.Lo and Albert K.W. Yeung (2006) "Concepts and Techniques of Geographic¬ information Systems" Prentice Hall of India, New Delhi
- Burrough, Peter A. and Rachael McDonnell, (1998), 'Principles of Geographical¬ Information Systems' Oxford University press, New York.
- Magwire, D.J. Goodchild, M.F. and Rhind, D.M., (2005), 'Geographical Information¬ Systems: Principles and Applications', Longman Group, U.K.
- Burrough, P.A., 1986, Geographical Information System for land Resources System,¬ Oxford Univ. Press, UK.
- Fotheringham, S.; Rogerson, P. (ed.), 1994. Spatial analysis and GIS. Taylor and Francis,¬ London, UK.
- Laurini, Robert and Dierk Thompson, 1992, Fundamentals of Spatial Information¬ Systems, Academics Press, ISBN 0-12-438380-7.
- Maguire,D.J.; Goodchild, M.F.; Rhind,D.W. 1991.Geographical information System,¬ Longman, London,UK
- Siddiqui, M.A.; 2006, Introduction to Geographical Information System, Sharda Pustak¬ Bhavan, Allahabad.
- Siddiqui, M.A.; 2011, Concepts and Techniques of Geoinformatics, Sharda Pustak¬ Bhavan, Allahabad.

## M.Sc. GEOLOGY
## FOURTH SEMESTER EXAMINATION

| Nomenclature of Paper | Credits | Contact Hrs./ Week | Maximum Marks | Internal Assessment 40 Marks | End Semester Examination Marks | Min. Pass Marks in End Sem. Exam. |
|---|---|---|---|---|---|---|
| | | | | **20x2** | | |
| **GEOT 401**: Geochemistry and Isotope Geology | 4 | 4 hrs. | 100 | 20x2 | 60 | 24 |
| **GEOT 402**: Dissertation | 6 | One full semester | 200 | | 200 | 80 |
| **GEOP 401:** Geochemistry Practical | 2 | 3 hrs. | 50 | | 50 | 20 |
| **DSEGEO 401:** Geology of the Central India- A Geochemical Approach<br>**DSEGEO 402:** Deformation Kinematics and Geodynamic Modelling<br>**DSEGEO 403:** Watershed Management | 3 | 2 hrs. | 100 | 20x2 | 60 | 24 |
| **Total** | **15** | | **450** | **80** | **370** | |

**Detailed Syllabus**
**M.Sc. GEOLOGY**
**SEMESTER-IV**

## GEOT 401: Geochemistry and Isotope Geology

### Unit I

Introduction and Principles of Geochemistry; Chemical Composition and Properties of Atmosphere, Hydrosphere, Lithosphere and Biosphere; Geochemical Cycles; Meteorites-Types and Composition; Geochemical Classification of Elements; Fractionation of Elements in Minerals/Rocks; Nernst's Partition Coefficient (Compatible and Incompatible Elements).

### Unit II

Principles of Ionic Substitution in Minerals; Crystal Structure of Some Simple Compounds – AX Structures (NaCl, CsCl, ZnS and NiAs) and $AX_2$ Structure (Fluorite, Rutile). A Brief Idea about Some other Compounds Such as $A_2X_3$ (Corundum), $ABX_3$ (Calcite and Ilmenite) and $AB_2X_4$ (Spinel).

### Unit III

Trace and Rare Earth Element (REEs) Geochemistry; Application of Spider/REE Patterns in Petrogenesis; Mineral Stability in Eh-pH Diagrams; A Brief Introduction to Geochemistry of Natural Waters and Sedimentary Rocks; Geochemical Processes Involved in Rock Weathering and Soil Formation.

### Unit IV

Stable Isotope Geochemistry of Carbon and Oxygen and their Application in Geological Studies; Monazite Chemical dating; Half-Life and Decay Equation; Dating of Minerals and Rocks with Rb-Sr, U-Pb and Sm-Nd Isotopes; Petrogenetic Implications of Sm-Nd and Rb-Sr Systems. Clumped isotopes.

### Unit V

Sampling Procedures and Introduction to Analytical Techniques Used in Geochemical Analysis (XRF; ICPMS; AMS and EPMA).

**List of recommended books:**


- Bloss, F.D. (1971): Crystallography and Crystal Chemistry, Holt, Rinehart, and Winston, New York.
- Brownlow, A. (1996): Geochemistry, 2nd edition, Prenctice Hall.
- Elderfield, H. (1985): The Oceans and the Marine Geochemistry, 1st Edition, Elsevier.
- Evans, R.C., (1964): Introduction to Crystal Chemistry, Cambridge Univ. Press.
- Faure, G. (1998): Principles and Application of Geochemistry, 2nd edition, Prentice Hall.
- Mason, B. and Moore, C.B. (1985): Principles of Geochemistry, 4th edition, Wiley Eastern Limited.
- Hoefs, J. (1980): Stable Isotope Geochemistry, Springer- Verlag.

- Klein, C. and Hurlbut, C.S. (1993): Manual of Mineralogy, John Viley and Sons, New York.
- Krauskopf, K.B. (1967): Introduction to Geochemistry, McGraw Hill.
- Mason, B. and Moore, C.B. (1991): Introduction to Geochemistry, Wiley Eastern.
- Rollinson, H. R. (1993): Using geochemical data: Evaluation, Presentation, and Interpretation. Longman U.K.
- Gopalan, K. (2017): Principles of Radiometric Dating, Cambridge University Press.
- Robin Gill (2015) Chemical Fundamentals of Geology and Environmental Geoscience, John Wiley & Sons Ltd.
- Alan P. Dickins (2005) Radiogenic Isotope Geology,. Cambridge University Press.
- Kula C Misra (2012) Introduction to Geochemistry: Principles and Applications, Wiley-Blackwell.


## GEOT 402: Dissertation

A project-oriented dissertation in consultation with the faculty in-charge.

* Criteria for the allotment of Project Oriented Dissertation: The students will be allotted dissertation as per the following criteria:
a. Merit list of the M.Sc.-I (Semester I) examination
b. Available facilities and expertise in the department
c. The mode of project (field work, lab analysis, review work) shall be decided by the faculty and shall be abided by the students

## GEOP-401: Geochemistry Practical

- Mineral formula calculations;
- Plotting of REE data and their interpretation;
- Plotting of Spider Diagrams and their interpretation;
- Variation diagrams and their interpretation;
- Chemical classification and nomenclature of rocks based upon major oxides.

## DEPARTMENT SPECIFIC ELECTIVES

The students of M.Sc. Semester IV have to choose one of the three DSE papers.

## DSEGEO 401: Geology of the Central India- A Geochemical Approach

### Unit-I

The Archean geological record; Tectonic, petrological and geochemical evolution of different Archean Cratons situated in the Central India. Bastar Craton: Tectonic boundaries, deformation pattern, Sukma Group, Bengpal Group, Bailadila Group, Bhopalpatanam Granulite, Mafic dykes. Bundelkhand Craton: Evolution of the Craton, Boundaries of Craton, Banded Gneissic Complex, Sandmata Complex, Mafic dykes, Bundelkhand Granite.

**Unit-II**

Paleoproterozoic Mobile Belts in Central India; Chhotanagpur Gneiss Complex. Bhandara Group; Sakoli Basin: structural boundaries, tectonic setup, mineralization. Dongargarh Domain: tectonic boundaries and Bimodal Volcanism. Sausar Mobile Belt (SMB): tectonic setup, mineralization. Malanjkhand Granite: Geological setting, Copper deposit.

**Unit-III**

Geochemical and crustal evolution of the different tectonic Zones**:** Central Indian Tectonic Zone (CITZ) - Kotri-Dongargarh Belt. Gneissic Complex: Amgaon Gneiss, Bengpal Gneisses, Tirodi Gneisses.

**Unit-IV**

Supracrustal belts within the central Indian Tectonic Zone: Mahakoshal Supracrustal Belt, Betul Supracrustal Belt, Sausar Supracrustal Belt.

**Unit-V**

Major Shear Zones in central Indian tectonic zone: Son-Narmada North Fault (SNNF), Son-Narmada South Fault (SNSF), Tan Shear Zone, Balrampur fault. Granulite Terrain:Balaghat-Bhandara Granulite Belt (BBG), Ramakona-Katangi Granulite Belt (RKG), Makrohar Granulite Belt (MGB).

**List of recommended books:**


- J. Halla, M.J. Whitehouse, T. Ahmad , Z. Bagai (2017): Crust–Mantle Interactions and Granitoid Diversification: Insights from Archaean Craton. Geological Society of London.
- K. S Valdiya (2010): The making of India Geodynamic Evolution. Macmillan Publishers India Ltd.
- S.M. Naqvi (2005): Geology and Evolution of the Indian Plate (From Hadean to Holocene-4Ga to 4Ka). Capital Publishing Company.
- R. Vaidyanadhan and M. Ramakrishnan (2008): Geology of India. Geological Society of India Bangalore.


**DSEGEO 402: Deformation Kinematics and Geodynamic Modelling**

**Unit-I**

Stress Tensor: Homogeneous and Heterogenous stress functions. Deformation Tensor: Analysis of homogeneous deformation: strain ellipses of different types and their geological significance; concept of stress-strain compatibility. Mohr diagram: Mechanics of rock fracturing: fracture initiation and propagation; coulomb’s criterion and Griffith's theory.

**Unit-II**

Behaviour of rocks under stress: elastic, plastic, viscous and viscoelastic responses and their geological significance. Rheological Models for complex rheology. Flow law: Influence of time, presence of fluid, grain size. Deformation Mechanism: Cataclastic flow, Crystal Plasticity, Diffusion flow.

**Unit-III**

Recrystallisation mechanism: Grain Boundary Migration, sub-grain rotation, Bulging recrystallisation, Grain Boundary Area Reduction. Static Recrystallisation. Inter-crystalline deformation, Twining and Kinking. Introduction to Lattice-Preferred Orientation.

**Unit-IV**

Introduction to Experimental Structural Geology; High P-T experiments with rock samples: basic concepts and important examples. Analogue modelling of deformational structures and its geological importance: concept of experimental scaling. Published examples of sandbox/shear box experiments and their extrapolation to natural situations.

**Unit-V**

Numerical Modelling of deformational structure: Lagrangian and Eulerian frame of reference, Continuity equation, Momentum equation, Energy equation. Introduction to Finite Difference Method (FDE). Solution of the conservation equations using Finite Difference Method. Published examples of deformation modelling using FDE and their extrapolation to natural situations.

**List of recommended books:**


1. Gerya, T., 2019. Introduction to numerical geodynamic modelling. Cambridge University Press.
2. Beer, F.P., Johnston, E.R., DeWolf, J.T. and Mazurek, D.F., 2021. Statics and mechanics of materials. McGraw-Hill Education.
3. Passchier, Cees W., and Rudolph AJ Trouw. *Microtectonics*. Vol. 2. Berlin: Springer, 1996.
4. York Fossen, H. (2010): Structural Geology, Cambridge University Press
5. Ghosh, S.K. (1993): Structural Geology: Fundamental and Modern Development. Pergamon Press.
6. Bayly, B., 1992. *Mechanics in Structural Geology,* Springer
7. Rams ay, J.G. and Huber, M. l., 1983. Techniques of Modern Structural Geology: Vol. I & Il. AcadeJnic Press
8. Ramsay, J. G., 1967. Folding and Fracturing of Rocks, McGraw-Hill Book Company, New York


**DSEGEO403- Watershed Management**

**Unit-I**

**INTRODUCTION OF WATERSHED**

Watershed: Definition, scope, characteristics and classification, Objectives of watershed development - Principles of watershed – Effects of watershed on community –

Delineating the watershed – Basic data on watersheds –Need for watershed development – Watershed development programmes in India –Watershed Atlas

**Unit-II**

**EROSION, DEGRADATION and LAND MANAGEMENT**

Types and Factors affecting erosion - Effects and control methods of erosion - Estimation of soil loss due to erosion - Universal soil loss equation –Degradation agents – Impact of the degradation of watersheds– Land use and land capability studies - Management of Agricultural, Forest, Grassland and wild land - Reclamation of saline and alkaline soils. Soil and Water conservation

**Unit-III**

**WATER HARVESTING:** Concept of Rainwater harvesting - water harvesting structures - Guidelines for construction of harvesting structures – Success stories of water harvesting structures –Role of peoples participation in construction and management of harvesting structures– Rain water harvesting from roof top

**Unit-IV**

**PLANNING AND MANAGEMNT**

Elements of watershed management – Planning and Implementation of watershed Management activities – Multidisciplinary approach for watershed management – Socio-economic Impact of watershed Management.

**Unit-V**

**WATERSHED DEVELOPMENT PROGRAME**

River valley project (RVP)- Hill Area Development Programme (HADP)-National Watershed Development Programme for Rainfed Agriculture (NWDPRA)- other similar projects operated in India- Govt. of India guidelines on watershed development programme- Watershed based rural development-infrastructure development- use of Aerial photography and Remote sensing in watershed management- Role of NGO in watershed development.

**List of recommended books:**


- Rajora, R., (1998), Integrated Watershed Management, Rewat Publications, New Delhi.
- Tideman, E.M., (1996): Watershed Management: Guidelines for Indian Conditions, Omega Scientific Publishers, New Delhi.
- Lal. S., (2004), Watershed Development, Management and Technology, Mangal Deep Publications.
- Paranjape, S. et. al., (1998), Watershed Based Development: A Source Book, Bharat Gyan Vigyan Samathi, New Delhi.
- Suresh, R., (2002), Soil and Water Conservation Engineering, Standard Publishers and Distributers, Delhi.
- Kakade, B.K., (2002), Soil and Water Conservation Structures in Watershed Development Programs, BAIF Development Research Foundation, Pune.