

SEMESTER – II

Paper Code	Paper Title	Max mark
4621	Mineralogy and Geochemistry	75
4622	Economic Geology	55
4623	Stratigraphy	55
4624	Palaeontology	55
4625	Sequence Stratigraphy and Basin Analysis (Elective paper)	55
4626	Advance techniques in Structural Geology (Elective paper)	55
	Internal Assessment Theory (4621+ 4622+ 4623+ 4624+ 4625/4626)	105
4627	Practical - A-Mineralogy and Geochemistry & Economic Geology	100
4628	Practical – B- Stratigraphy & Palaeontology	100
4629	Practical-C- Elective Paper (Sequence Stratigraphy and Basin Analysis)	50
4630	Practical-C- Elective Paper (Advance techniques in Structural Geology)	50
Total marks : Theory 400 + Practical 250 = 650		

SEMESTER – II

Mineralogy and Geochemistry

Theory

Unit-I: Structural classification of silicates; Study of following group of minerals with reference to chemical and structural formula, classification, atomic structure, chemistry, physical and optical properties, occurrences: Olivine, Garnet, Pyroxene, Amphibole, Mica, Feldspars, Feldspathoids, Silica and Al silicates.

Unit-II: Formation of Uniaxial and Bi-axial interference figures, Interference colors, Pleochroism and determination of pleochroic scheme, Interference figures and determination of optic sign; Extinction; Uniaxial and Biaxial indicatrix and dispersion in minerals. Petrographical microscope; Mica, Gypsum and Quartz plates; Universal stage and their uses in the determination of optical properties of minerals.

Unit-III: Composition of Earth and its constituents (Crust, mantle and core); Ionic and co-ordination number; Rules of ionic substitution, coupled substitution; Distribution coefficient: Capture admission and camouflage, Geochemical classification of elements; Behaviour of major and trace including rare earth elements during magmatic crystallization.

Unit-IV: Near-surface geochemical environment: Eh-pH diagram; Principle of chemical mass balance and rock- cycle; Chemical weathering of minerals and rocks. Radiogenic isotopes in geochronology and petrogenesis: Rb-Sr, Sm-Nd, U-Pb isotopic system.

Books Recommended

- Battey, M.H. (1981) Mineralogy for students 2nd Edn. Longmans. Berry, L.G. and Mason, B. and
- Deer, W.A., Howie, R.A., and Zussman, J. (1992) An Introduction to the rock forming minerals, Longman.
- Sharma, R. S. and Sharma, A. (2014) Crystallography and mineralogy. Graduate Text Book Series, Geological Society of India, Bangalore.
- Klein, C. and Hurlbut, Jr., C.S. (1993) Manual of Mineralogy, John Wiley.
- Kerr, P.F. (1977) Optical Mineralogy 4th Edn., McGraw-Hill
- Putnis, Andrew (1992) Introduction to Mineral Sciences, Cambridge University Press.
- Winchell, A.N. (1962) Elements of Optical Mineralogy, John Wiley.
- Allegre, C.J. and Michard, G. (1974) Introduction to Geochemistry, Reidel, Holland.
- Evans, R.C. (1964) Introduction to Crystal Chemistry, Cambridge Univ. Press.
- Faure, G. (1998) Principles and applications of geochemistry, 2nd Edn., Prentice Hall, New Jersey, 593p.
- Faure, G. (1986) Principles of Isotope Geology, 2nd Edn., John Wiley.
- 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, Interpretation, Longman, U.K.

Economic Geology

Theory

Unit-I: Geological setting, characteristics and genesis of ferrous, base and noble metals.

Unit-II: Methods of mineral deposit studies including ore microscopy, fluid inclusions and isotopic systematic.

Unit-III: Origin, migration and entrapment of petroleum. Properties of source and reservoir rocks. Structural, stratigraphic and combination traps. Petroliferous basins of India.

Unit-IV: Origin of coal deposits. Classification, rank and grading of coal. Coal resources of India. Gas hydrates, coal bed methane and nuclear resources. Occurrence of mineral resources in the Himalaya.

Suggested Readings:

- 1.Craig, J.M. & Vaughan, D.J., 1981: Ore Petrography and Mineralogy-John wiley
- 2.Evans, A.M., 1993: Ore Geology and Industrial Minerals-Blackwell
- 3.Sawkins, F.J., 1984: Metal deposits in relation to plate tectonics-Springer Verlag
- 4.Stanton, R.L., 1972: Ore Petrography-McGraw Hill
- 5.Torling, D.H., 1981: Economic Geology and Geotectonics-blackwell Sci publ.
- 6.Barnes, H.L., 1979: Geochemistry of Hydrothermal Ore Deposits-John Wiley
- 7.Klemm, D.D. and Schneider, H.J., 1977: Time and Strata Bound Ore Deposits-

- Springer Verlag
8. Guibert, J.M. and Park, Jr. C.F., 1986: The Geology of Ore Deposits-Freeman
9. Mookherjee, A., 2000: Ore genesis-a Holistic Approach-Allied Publisher

Stratigraphy

Theory

Unit I

Recent development in stratigraphic classification, Code of stratigraphic nomenclature. Concept of sequence stratigraphy. Modern methods of stratigraphic correlation. Steps in stratigraphic studies. Approaches of paleogeography. Earth's climatic history.

Unit II

Brief ideas of quantitative, magneto, seismic, chemo and event stratigraphy. Evolution and biostratigraphy – controlling factor, zonation, time significance, quantitative stratigraphy, cyclostratigraphy, pedostratigraphy.

Unit III

Evolution of the early crust, lithological, geochemical and stratigraphic characteristics of granite-greenstone and granulite belts of India and global correlation. Proterozoic formations of Peninsular – Extrapeninsular India.

Unit IV

Precambrian life, stratigraphic records India. Boundary problems: Archaean-Proterozoic, Precambrian-Cambrian, Permo-Triassic, Cretaceous – Tertiary, Neogene-Quaternary. In Brief: Paleozoic-Mesozoic and Cenozoic stratigraphy, fossils, Paleogeography, Paleoclimate, Tectonism and economic deposits. Concept status scheme of classification.

Suggested Books

1. Stratigraphic Principles & Practice, J. Marvin Weller
2. Principles of stratigraphy V-2, Amadeus W. Grabau
3. Principles of Stratigraphy, Carl O. Dunbar and John Rodgers
4. Stratigraphy, D.N. Wadia
5. Geology of India & Burma, M.S. Krishnan
6. Fundamentals of historical geology and stratigraphy of India, Ravindra Kumar
7. A Guide to Stratigraphic Classification, Terminology and Procedure, Hollis Hedberg, John Wiley and Sons

Palaeontology

Theory

Unit 1: Theories of origin of life. Organic evolution-Punctuated equilibrium and phyletic gradualism models. Mass extinctions and their causes. Ichnology, classification and use.

Unit-2: Palaeobiology (palaeoecology, communities, modern environments, functional morphology and taphonomy).

Unit 3: Brief morphology, evolution and classification of Brachiopoda, Mollusca (Cephalopoda, Gastropoda, Bivalvia), Trilobita.

Unit 4: Evolution of vertebrates, dinosaurs and its extinction.

Selected Readings:

1. Raup and Stanley, Principles of Palaeontology,
2. Bilal U. Haq and A. Boersome , Introduction to Marine Micropalaeontology,
3. G.Bignot , Elements of Micropalaeontology,
4. Clarkson, E.N.K. (1986). Invertebrate Palaeontology and Evolution. ELBS, London.
5. Cushman, J.A. (1940). The Foraminifera, their classification and use. Harvard Univ. Press.
6. Moore, R.C. Lalliker, C.G. and Fischer, A.G. (1952). Text book of Invertebrate Palaeontology.
7. David Raup and Stanley (1985). Principles of Palaeontology., CBS Pub., Delhi
8. Glaessner, M.F. (1945). Principles of Micropaleontology. Melbourne Univ. Press.
9. Schrock, Twenhofel and Williams (1953). Principles of Invertebrate Palaeontology. CBS, Delhi

Sequence Stratigraphy and Basin Analysis (Elective paper)

Theory

Unit- 1 : Concept of sequence Stratigraphy. Evolution, order and duration of sequences. Applications and significance of sequence Stratigraphy

Unit-2 : Concept of facies and basin analysis. Walther's law and sedimentary environments. Sedimentary cycles, rhythms and cyclothem. Modern and ancient sedimentary environments. Continental clastic depositional sedimentary models-alluvial, fluvial, lacustrine, aeolian and glacial deposits.

Unit-3: Transitional and marine sedimentary facies models – deltaic, tidal flats, barrier islands , terrigenous shelves and shallow seas. Carbonate platforms and reefs and sabakhas, Continental rise and ocean basins

Unit-4: Sedimentation pattern and depositional environments of selected undeformed sedimentary basins of India. Himalayan sedimentary basins, Tectonic classification of sedimentary basins.

Books Recommended

- (1) Reading H. G. 1996 : Sedimentary Environments and Facies, Balckwell
- (2) Reading H.E. and Singh , I.B. 1980 : Depositional Sedimentary Environments, Springer Verlag
- (3) Boggs Sam Jr, 1995 . Principles of Sedimentary and Stratigraphy , Prentice Hall
- (4) Selley R.C.,1998. Applied Sedimentology, Academic Press
- (5) Miall, A.D. 2000 : Principles of Sedimentary Basin Analysis, Springer Verlag
- (6) Eirsele , G . 1992 : Sedimentary Basins , Springers Verlag .
- (7) Bhattacharya A and Chakraborti , C .2000 . Analysis of Sedimentary Successions, Oxford and IBH .

Practical-

Preparation of lithologs , Interpretation and reading depositional environments from the given idealized lithologs and data, Heavy mineral identification and provenance interpretation . Petrography of selected sedimentary rock types. Staining and Mineral identification in Carbonate rocks.

Advance techniques in Structural Geology (Elective paper)

Theory

Unit-1: Principles of geological mapping and map reading, projection diagrams. Strain markers in naturally deformed rocks and graphical representation of strain. Strain pattern and folding. Measurement of strain in deformed rocks.

Unit-2: Structural analysis of folds, cleavages, lineations, joints and faults. Tectonites and their type. Concept of petrofabric and symmetry- field and laboratory techniques and graphical solutions.

Unit-3: Types of fabric, fabric elements and interpretation on macroscopic to microscopic scale. Use of Crystallographic Preferred Orientation (CPO) and Anisotropy of Magnetic Susceptibility (AMS) in petrofabric.

Unit-4: Time-relationship between crystallization and deformation. Unconformities and basement-cover relations. structural behaviour of igneous rocks, diapirs and salt domes.

Suggested Readings:

1. Turner F.J. and Weiss, L.E., 1963. Structural Analysis of Metamorphic Tectonites. McGraw Hill.
2. Davis G. R., 1984. Structural Geology of Rocks and Region. John Wiley.
3. Ramsay J.G. and Huber, M.I., 1987. Modern Structural Geology, Vol. I & II. Academic Press.
4. Stephen Marshak and Gautum Mitra. 1988. Basic Methods of Structural Geology.
5. Price N. J. and Cosgrove, J. W., 1990. Analysis of Geological Structures. Cambridge Univ. Press.
6. Bayle B., 1992. Mechanics in Structural Geology. Springer Verlag.
7. Tarling D. H. and Hrouda F, 1993: The Magnetic Anisotropy of Rocks. Chapman and Hall, London.
8. Valdiya K.S., 1998. Dynamic Himalaya. University Press.
9. Passchier C. w. and Treuw R. a. J., 2005: Microtectonics, Springr.

10. Richard H. Groshong (Jul 24, 2008). 3-D Structural Geology: A Practical Guide to Quantitative Surface and Subsurface Map Interpretation. Springer
11. Donal M. Rangan, 2009. Structural Geology: An introduction to Geometrical Techniques. Cambridge, University Press.
12. Davis G. R., Stephen J. Reynolds and Charles F. Kluth. 2011. Structural Geology of Rocks and Region. Amazon Press

Marine Geology (Elective paper)

Theory

Unit-1: Definition and Scope of the subject. History of development of Oceanography, Ocean Drilling Programme (ODP), and its major accomplishments.

Unit-2: Ocean Circulation, Surface Circulation, Concept of mixed layers, Thermocline and pycnocline, Concept of upwelling, El Nino, Deep ocean circulation, Formations of Bottom waters, Water masses of the world oceans and sea sediments (oozes etc.).

Unit-3: Paleooceanography: Approaches to palaeoceanographic reconstructions. Reconstruction of monsoon variability by using marine proxy records. Eustatic Changes.

Unit-4: Global climate pattern and energy budget, Climate controlling factors. Plate tectonics and climate change Milankovitch cycles, Atmosphere and Ocean interaction and its effect on climate. An overview of Paleoclimatic reconstruction; Pleistocene Glacial-Interglacial cycles; Future climate: Anthropogenic activity and its effect on Global climate.

Practical- 205 (c)

Study of modern surface water mass assemblages of various microfossils from different oceans. Depth biotopes and estimation of paleodepth of the ocean using microfossils group. Thermocline and deep surface waters of the modern oceans.

Suggested Reading:

1. Paleoclimatology by J.J. Bhatt
2. Oceanography by Savander Singh
3. Paleoclimatology: climate through ages by C.E. Brooks
4. Climate Change in Pre history by W.J. Burrough
5. Introduction to Physical Oceanography by R.h. Stewart
6. Gross, M.G, 1977. *Oceanography: A view of the Earth*, Prentice Hall.
7. Haq and Boersma, 1978. *Introduction to Marine Micropaleontology*, Elsevier.
8. Haslett, S.K., 2002. *Quaternary Environmental Micropaleontology*, Oxford University Press, New York.
9. Tolmazin, D_1985. *Elements of Dynamic Oceanography*, Allen and Unwin.
10. Bigg, G., 1999 Ocean and Climate. Springer- Verlag
11. Bradley, F., 2000. Paleoclimatology: Reconstructing Climates of the Quaternary. Springer-Verlag
12. Maher and Thompson, 2000. Quaternary Climates, Environments and Magnetism. Cambridge University Press.
13. Williams, Durnkerley, Decker, Kershaw and Chhappell, 1998. Quaternary Environments. Wiley and Sons.

Advanced Mineralogy and Thermodynamics (Elective paper)

Theory

Unit-1: Fundamental concepts: Equilibrium, disequilibrium, steady state; exact/inexact Differentials; first and second laws of thermodynamics; combined first and second laws; enthalpy; free energy functions; criteria for spontaneity and equilibrium; the third law of thermodynamics and finite entropies.

Unit-II: Phase equilibria in simple systems: Derivation of Gibbs phase rule; chemography; free energy surfaces; Clapeyron equation; Morey-Schreinemakers rules; calculation of univariant lines in simple systems

Unit-III: Thermodynamics of solutions: Partial molal properties, chemical potential; Gibbs-Duhem equation and phase rule; ideal solutions; non-ideal solutions, fugacity, activity, standard states, activity coefficients, and excess functions; solution modeling and equation of state; calculation of activities in gas mixtures, ideal and non-ideal crystalline solutions; electrolyte theory.

Unit-IV: Phase equilibria: The equilibrium constant; temperature, pressure and compositional dependence of equilibrium constant; chemical potential diagrams; oxidation-reduction diagrams; calculation of one-, two- and three-component phase diagrams. Thermodynamic data: Measurements and estimations; sources of data; computerized Phase diagram constructions; TWQ and THERMOCALC software.

Suggested Readings

1. Chemical Thermodynamics: Basic Theory and Methods. By I. M. Klotz and R. M. Rosenberg. The Benjamin/Cummings Publishing Company.
2. Thermodynamics of Solids. By R. A. Swalin. John Willey & Sons.
3. Geochemical Thermodynamics. By D. K. Nordstrom and J. A. Munoz. The Benjamin/Cummings Publishing Company.
4. Short Course on Application of Thermodynamics to Petrology and ore Deposits. By H. J. Greenwood (Editor). Mineralogical Association of Canada.
5. Elementary Thermodynamics for Geologists. By B. J. Wood and D. G. Fraser. Oxford University Press.
6. Anderson, G.M. Thermodynamics of Natural Systems, Cambridge University Press, 2005.
7. Winter, J. D. Introduction to Igneous and Metamorphic Petrology. Prentice-Hall, 2001.
8. Drever, J.I. The Geochemistry of Natural Waters, 3rd Edn., Prentice Hall, 1997.
9. Faure, G. Principles of Isotope Geology, 2nd Edn., John Wiley, 1986.
10. Mason, B. and Moore, C. B. Principles of Geochemistry, 4th Edn., John Wiley, 1982.

Practical- A

Practical : Mineralogy and Geochemistry

Study of physical and optical properties of important rock forming minerals; Determination of An content of plagioclase feldspars; Determination of elongation and optic sign of minerals; Determination of Pleochroism and absorption schemes.

Construction of geochemical variation diagrams (Spidergrams; Harker's variation diagrams; addition-substraction diagrams); Calculation of stoichiometric formula from chemical analysis of minerals.

Practical : Economic Geology

Study of ores in hand specimen. Geographical distribution of classic ore deposits of India and world. Study of metallic minerals under the reflecting microscope.

Practical- B

Practical: Stratigraphy

Study of characteristics stratigraphic rocks of India and their distribution. Chronostratigraphic/Lithostratigraphic placement of important stratigraphic rocks of India.

Practical: Palaeontology

Systematic description of Brachiopoda, Bivalvia, Cephalopoda and Gastropoda; vertebrates

Practical-C- (Elective Paper)

Practical:- Sequence Stratigraphy and Basin Analysis

Preparation of lithologs , Interpretation and reading depositional environments from the given idealized lithologs and data, Heavy mineral identification and provenance interpretation . Petrography of selected sedimentary rock types. Staining and Mineral identification in Carbonate rocks.

Or

Practical:- Advanced Techniques in Structural Geology

Preparation and interpretation of balanced cross sections. Uses of stereographic techniques in solving structural problems. Plotting and interpretation of petrofabric data and diagrams. Measurement of strain in naturally deformed rocks.