Department of Geology

Cotton University, Guwahati

B.Sc. FIFTH SEMESTER SYLLABUS

PAPER: GLY24C501	**Igneous Petrology**	**L+T+P=3+0+1= 4 credits**
PAPER: GLY24C502	**Sedimentary Petrology**	**L+T+P=3+0+1= 4 credits**
PAPER: GLY24C503	**Metamorphic Petrology**	**L+T+P=3+0+1= 4 credits**
PAPER: GLY24C504	**Structural Geology**	**L+T+P=3+0+1= 4 credits**
PAPER: GLY24M501	**Petrology**	**L+T+P=3+0+1= 4 credits**

DETAILED SYLLABUS (CORE/MAJOR)

PAPER: GLY24C501 Igneous Petrology L+T+P=3+0+1= 4 credits

Total Number of Theory Classes: 45 (45 hours)
Total Number of Practical Classes: 15 (30 hours)

(i) Course learning outcome

On completion of the course the students will have gained an understanding of the processes involved in the formation of igneous rocks and their textures. They will be familiarized with the processes that lead to the generation of magmas in different tectonic settings. They will also get to know about phase diagrams and their importance in petrology. The students will be introduced to a wide variety of igneous rocks, which will help them to understand a wide range of magmatic processes.

(ii) Broad contents of the course

Igneous petrology is the study of magmatic rocks. The course will help the students to exhibit an improved understanding of fundamental magmatic processes. They will be given an overall idea about the nature and origin of magmatic rocks in different tectonic settings including their geochemical characteristics.

(iii) Skills to be learned

Students learn to identify, describe and classify igneous rocks using hand specimens. The students will also acquire skills to identify minerals and textures under the microscope and classify igneous rocks on the basis of microscopic observations. Further, they will also acquire skills to classify igneous rocks from geochemical data.

(iv) The detail contents of this course

THEORY

Nucleation and growth; Interpretation of common igneous textures with respect to nucleation and crystal growth; Role of partial melting in igneous petrogenesis. (5)

Concepts of system, phase and component; Mineralogical Phase rule; Phase equilibria in igneous rocks: Experimental observation of the following one, two & three component systems and their significance- (10)

(i) Silica (SiO_2) system
(ii) Diopside ($CaMgSi_2O_6$) - Anorthite ($CaAl_2Si_2O_8$) system
(iii) Forsterite (Mg_2SiO_4) - Silica (SiO_2) system
(iv) Albite ($NaAlSi_3O_8$) - Anorthite ($CaAl_2Si_2O_8$) system
(v) Potash feldspar ($KAlSi_3O_8$) - Albite ($NaAlSi_3O_8$) - Silica (SiO_2) system

Plate tectonics and generation of magmas in different tectonic settings; Igneous rocks in different tectonic settings: mid-oceanic ridge, oceanic intraplate, subduction and continental rift related settings; Geochemical characteristics of igneous rocks: major, trace and isotopic composition of igneous rocks in the context of petrogenesis; Compatible and incompatible trace elements; Application of trace elements in petrogenesis and source characterization; Geochemical criteria for identification of palaeotectonic settings; Mobility of elements during post-crystallization processes. (10)

Rock series and rock associations; Descriptive petrography & origin of the following rock families: (10)

(i) Granite - Rhyolite family
(ii) Syenite - Trachyte family
(iii) Gabbro - Basalt family
(iv) Ultrabasic - Ultramafic rocks

Petrogenesis of the following igneous rocks: Anorthosites, Ophiolites, Boninites, Layered complexes, Alkaline rocks, Carbonatites, Kimberlites and lamprophyres, Adakites and sanukitoids. (10)

PRACTICAL

(i) Study of hand specimen of various igneous rocks (3)
(ii) Microscopic study of mineralogical and textural characteristics of igneous rocks (10)
(iii) CIPW Norm calculation (2)

Recommended Books:

1. Best, M.G., 2002. Igneous Petrology, 2nd Edition, *Blackwell Publishers*.
2. Bose, M.K., 1997. Igneous Petrology, *World Press, Kolkata*.
3. Phillpotts, A.R., 1994. Principles of Igneous and Metamorphic Petrology, *Prentice Hall of India*.
4. Winter, J.D., 2010. Principles of Igneous and Metamorphic Petrology, *Pearson Prentice Hall*.
5. Frost, B.R., Frost, C.D., 2014. Essentials of Igneous and Metamorphic Petrology. *Cambridge University Press*.

PAPER: GLY24C502 Sedimentary Petrology L+T+P=3+0+1= 4 credits

Total Number of Theory Classes: 45 (45 hours)
Total Number of Practical Classes: 15 (30 hours)

(i) **Course learning outcome**

After studying this course, the student will be able to:

CO1 Learn different kinds of sedimentary rocks, their structures, textures and variability.
CO2 Understand of sedimentation process from deposition to diagenesis.
CO3 Understand the different types of sedimentary environments and facies.
CO4 Understand the different types of sedimentary basin and their importance.

(ii) **Broad contents of the course**

Sedimentary petrology is that branch of study concerned especially with the composition, characteristics and origins of sediments and sedimentary rocks. It focuses on the physical, chemical and biological characteristics of the principal kinds of sedimentary rocks; however, it is concerned also with the relationship of these properties to depositional conditions, provenance and sedimentary basins.

(iii) **Skills to be learned**

The student will learn how to use precise geological terms in describing and discussing sedimentary structures, textures and processes and identify the main types of sedimentary rocks such as mudstones, sandstones, conglomerates, limestones and evaporites interpret sedimentary processes based on the composition of the rock and sedimentary structures identify the depositional environments.

(iv) **The detail contents of this course**

THEORY

Weathering (5)

Weathering: Subaerial and submarine weathering processes and products, Fundamentals of fluid flow; Particle transport by fluids; Sediment gravity flow.

Sedimentary Texture (10)

Textures of sedimentary rocks: concepts of size, grade scale, sphericity, roundness, fabric, packing, porosity and permeability**;** Techniques of grain size analysis; Graphical presentation of grain size data.

Sedimentary Structure (5)
Genesis and significance of sedimentary structures: Inorganic and organic; Principles and statistical treatment of palaeocurrent analysis.
Siliciclastic Sedimentary Rocks (5)
Sandstones: Framework mineralogy, classification, maturity and general characteristics of major classes of sandstones; Conglomerates: Composition, classification, origin and occurrence; Mudrocks: Composition, classification, origin and occurrence; Diagenesis of clastic sedimentary rocks; Provenance of clastic sedimentary rocks.
Carbonate Sedimentary Rocks (5)
Carbonate deposition and origin; Carbonate petrography and classification; Dolomite and dolomitisation; Diagenesis of carbonates; Carbonate Environments.
Chemical/Biochemical and Carbonaceous Sedimentary Rocks (5)
Fundamentals of Evaporates; Siliceous sedimentary rocks (cherts); Iron-bearing sedimentary rocks; Sedimentary phosphorites; Carbonaceous sedimentary rocks.
Sedimentary Environments and Sedimentary Facies (5)
Basic ideas of depositional environments and their classification; Processes and Characteristics of aeolian, glacial, fluvial, lacustrine, deltaic and marine environments; Concepts of facies and facies association.
Sedimentary Basins (5)
Sedimentary basins; Geosyncline and plate tectonic concept; Plate movements and basin formation, basin classification.

PRACTICAL
Identification and study of the clastic and nonclastic rocks in hand specimens. (2) 37

Particle size distribution and statistical treatment. (2)
Identification and exercises on sedimentary structures. (3)
Identification & study of quartz types, sandstones, limestone and heavy minerals in thin sections. (8)

Recommended Books:

1. Sedimentary Petrology by F. J. Pettijohn; *CBS Publishers and Distributors*.
2. Introduction to Sedimentology by S. M. Sengupta; *CBS Publisher & Distributors*.
3. Principles of Sedimentology and Stratigraphy by Sam Boggs, 5th Ed., *Pearson Education Limited*.
4. Sedimentology and Stratigraphy by G. Nichols; Wiley and Blackwell.
5. Depositional Sedimentary Environments by H. E. Reineck & I. B. Singh; *Springer*.
6. Sedimentary Rocks in the Field by M. E. Tucker; *John Wiley & Sons Ltd*.
7. A Practical Approach to Sedimentology by R.C. Lindholm; *CBS Publishers and Distributors*

PAPER: GLY24C503 Metamorphic Petrology L+T+P=3+0+1= 4 credits

Total Number of Theory classes: 45 (45 hours)
Total Number of Practical classes:15 (30 hours)

(i) Course learning outcome

After the completion of this course students will be able to:

CO1 Understand metamorphic rocks, metamorphism and metamorphic processes.

CO2 Understand the aspects of metamorphic transformation and the role of P, T and chemically active fluid in controlling the changes in different types of metamorphism.

CO3 Understand nature of metamorphic rocks in contrast to igneous and sedimentary rocks.

CO4 Apply phase rule as a basic tool in study of these rocks.

CO5 Have an idea about metamorphic textures and textural geochronology.

CO6 Understand reactions involved in metamorphism.

CO7 Understand metamorphism of pelitic and mafic rocks.

CO8 Have a basic idea on Thermodynamics and Geothermobarometry.

(ii) Broad content of the course

The course imparts ideas on the aspects of metamorphic transformation and the role of P, T and chemically active fluid in controlling the changes in different types of metamorphism, metamorphic facies, formation of different mineral assemblages, metamorphic textures and structures, textural geochronology, Phase rule and its application in metamorphic rocks, Chemographic diagrams, Metamorphic reactions and its types, Metamorphism of pelitic rocks and mafic rocks, thermodynamics and geothermobarometry.

(iii) Skills to be learned

Students learn to identify, describe and classify rocks using hand specimens. The students will also acquire skills to determine and interpret petrogenetic history of the metamorphic rock.

(iv) The detail contents of this course

THEORY

Concept of metamorphism: Limits of metamorphism (2), Agents of metamorphism (2), Types of metamorphism (3), Types of Protoliths (2), A preliminary classification of metamorphic rocks (2), concept of zones (2), grades and facies (2), Metamorphic textures and structures (3), Textural geochronology (2), The phase rule and its application in metamorphic rocks (2), Common chemographic diagrams-ACF and AKF diagrams (3), Metamorphic reactions and its types: Polymorphic transformation, exsolution reactions, Solid - solid net transfer reactions, devolatilization reactions, Continuous reactions, oxidation/reduction reactions, reactions involving dissolved species (2). Metamorphism of pelitic sediments: Diagenesis and low- grade metamorphism of pelites, medium P/T metamorphism of Pelites – The Burrovian sequence, Low P/T of metamorphism of Pelites (3), Partial melting of Pelites and migmatites (2). Me metamorphism of mafic rocks (3) PT-t paths (2). An introduction to thermodynamics: Gibbs Free Energy, Gibbs Free Energy for a phase, Gibb's Free Energy for a reaction (5). An introduction to geothermobarometry: Geothermobarometry, Geothermometers and Geobarometers (3).

PRACTICAL

Identification of the various kinds of metamorphic rocks and identification of their textures and structures in hand specimen. Slate, phyllite, various types of schists, gneiss, amphibolite, quartzite, hornfels, augen gneiss, marble, migmatite (5). Study of the textures and assemblages of metamorphic rocks in thin section to know the petrogenetic history of the rock and nomenclature of the rocks: Chlorite schist, biotite schist, garnet schist, sillimanite schist, hornblende schist, amphibolites, granulites, eclogites and quartzites. (10).

Recommended Books:

1. Metamorphic Petrology – B.W.D. Yardley; *ELBS/Longman*.
2. Petrology of Igneous and Metamorphic Rocks – D.W Hyndman (2nd Edition); *McGraw-Hill Book Company*.
3. Igneous and Metamorphic Petrology – M.G. Best; *CBS Publishers and Distributors*.
4. An introduction to igneous and metamorphic petrology - John, D Winter; *Prentice Hall*.
5. Petrology – W.T Huang; *McGraw-Hill book Company*.
6. Metamorphism and Metamorphic Belts – A Miyashiro; *George Allen & Unwin Ltd*.
7. The Study of Rocks in Thin Section – W.W. Moorhouse; *CBS Publishers & Distributors*.
8. Principles of Igneous and Metamorphic Petrology – A.R. Phillpotts; *Prentice-Hall of India Pvt. Ltd*.
9. Igneous and Metamorphic Petrology – F.J. Turner and & J. Verhoogen; *McGraw -Hill book Company*.
10. Metamorphic Petrology – F.J. Turner; *McGraw-Hill book Company*.
11. Petrogenesis of Metamorphic Petrology – H.G.F. Winkler; *Springer Verlag, New York Inc*.

PAPER: GLY24C504 Structural Geology L+T+P=3+0+1= 4 credits

Total Number of Theory Classes: 45 (45 hours)
Total Number of Practical Classes: 15 (30 hours)

(i) Course learning outcome

After studying this course, the student will be able to:

CO1 Deal with geological structures resulting from the action of forces on rocks.
CO2 Gain knowledge about the deformation mechanism of the rocks.
CO3 Gain knowledge of the geometry of the rock structures
CO4 Understand the mechanism of the evolution of rock structures and its application in the field.

(ii) Broad contents of the course

The course is designed for the students to understand the geometry and mechanics of the various geological structures that result through the deformative processes operative within the earth.

(iii) Skills to be learned

The students learn the skills of identifying different structure and measurements using Clinometer and Brunton compass. This is fundamental to geological mapping. This course also helps to know how to use structures and help students appreciate the dynamic nature of the Earth lithosphere. Learn how to read geologic maps and solve map problems using strike and preparations of cross sections, stereographic projection of geological structures and some other structural problems.

(iv) The detail contents of this course

THEORY

Introduction

Geometric, kinematic and dynamic analysis of rock structures; Penetrative and non-penetrative structural elements; Scales of observation: time & length; Structural Elements and their attitudes; Concept of non-diastrophic and diastrophic structures. (5)

Primary structures

Primary structures in sedimentary rocks: bedding & stratification, primary structures as markers and facing/younging direction, recognition of bedding in deformed terrains; Penecontemporaneous structures; Primary structures in igneous rocks; Unconformities. (5)

Physics of deformation

Analysis of Stress: Concept of Force, Traction & Stress, Stress components, Stress at a point, Principal axes of stress & principal stresses, Stress ellipsoid; Elementary concept of Mohr's stress circle, Terminology of states of stress: Hydrostatic stress, Uniaxial compression & -tension, Axial compression & -extension, Triaxial stress, Pure shear & Simple shear, Deviatoric stress, Differential stress, Effective stress.

Analysis of strain: Strain & Strain ellipsoid; Measure of strain- longitudinal and shear strain; Homogeneous & Inhomogeneous Strain; Finite & Infinitesimal strain; Special type of Homogeneous (finite) strain: Plane strain, constriction, & flattening; Pure shear & simple shear.

Deformational behaviour of rocks: Elementary concept of rheology, Basic rheological models: Viscous, Elastic, Plastic; Controls of time, temperature and pressure on deformation. (10)

Rock Fabrics in deformed rocks

Concept of pervasive (material) and non-pervasive (non-material) fabrics; Tectonites.

*Lineation***:** Morphological types of lineation: Discrete structural lineation, Constructed structural lineation, Mineral lineations, slickenlines & slickensides, Rods, Mullions.

Foliation: Cleavage; Morphological types of foliations: Axial planar foliation, Compositional foliation, Disjunctive foliation, Crenulation foliation, Continuous foliation, Transected foliation.

Role of fabric elements in structural interpretations of deformed rocks. (5)

Brittle Deformation in Rocks

Fractures & Joints: Types of fractures: Extension, Shear fracture; Modes of fracture; Feature of fracture surfaces; Classification of joints; Origin of joints.

Faults: Terminology of faults; Rocks associated with faults; Structural elements of faults; Classification & Types of faults; Characteristics & Structural Associations: Normal fault, Reverse (Thrust) fault, and Strike-slip fault; Anderson's classification of faults; Recognition of faults in field.

Boudinage: Types of boudins; Geometrical parts of boudin; Pinch-and-swell Structure. (10)

Ductile Deformation in Rocks

Folds: Geometrical parts of single folded layer & multilayer folded surface; Structural elements of folds; Morphological classification of folds (after Ramsay, 1967); Types of folds. (10)

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PRACTICAL

1. Introduction to structural elements: Structural lines & Structural planes. (1)
2. Graphical method for structural solution. (1)
3. Analysis of bore hole data: Thickness and depth of planes; Solution of three-point problems. (1)

4. Geological Maps: Completion of outcrops of beds from surface and borehole data; Drawing of cross-section & Interpretation of structures from geological maps. (3)
5. Stereographic projection: Plotting of i) lines, ii) planes, iii) poles to the planes; Determination of i) attitude of the line of intersection between two planes, ii) angle between two planes, iii) apparent dip(s) in different directions in a plane, iii) strike & true dip from apparent dip(s); Stereo-plot of some different folds. (5)
6. Determination of fault displacement. (1)
7. Exercise on Mohr's Stress Circle: Determination of (i) principal stresses from normal and shear stresses & ii) the normal and shear stresses from the principal stresses and their directions. (1)
8. Plot of different stress types on Mohr's circle. (1)
9. Calculation of Finite Strain from deformed fossils, grains and pebbles. (1)

Recommended Books:

1. Foundation of Structural Geology (1997) – R.G. Park; *Routledge*.
2. Structural Geology- Fundamentals & Modern Developments (1993) – S.K. Ghosh; *Pergamon Press*.
3. Folding and fracturing of rocks (1967) – J.G. Ramsay; *McGraw-Hill*.
4. Structural Geology (2007) – R.J. Twiss and E.M. Moores; *W.H. Freeman and Company*.
5. An outline of Structural Geology (1976) – B.E. Hobbs, W.D. Means & P.F. Williams; *John Wiley*.
6. Structural Geology of Rocks and Regions (2011) – G.H. Davis; *John Wiley*.
7. Structural Geology (2010) - Haakon Fossen; *Cambridge University Press*.
8. Structural Geology (1973) – M.P. Billings; *Pearson College*

DETAILED SYLLABUS (MINOR)

PAPER: GLY24M501 Petrology L+T+P=3+0+1= 4 credits

Total Number of Theory Classes: 45 (45 hours)
Total Number of Practical Classes: 15 (30 hours)

(i) Course learning outcome

CO1 The course is typically designed to help students understand the origins, classification, and processes of rock formation.
CO2 Learning about the processes that form rocks, including igneous, metamorphic, and sedimentary processes, and the geological conditions under which they occur.
CO3 Developing an understanding of the relationship between the composition, structure, and properties of rocks and their geological history.

(ii) **Broad contents of the course**

The course imparts ideas on the aspects of metamorphic transformation and the role of P, T and chemically active fluid in controlling the changes in different types of metamorphism, metamorphic facies, metamorphic textures and structures.
Sedimentary petrology is that particular branch of petrology which concerned with the basic principles including the classification, nomenclature and properties of sedimentary rocks. The

application of sedimentological concepts helps to interpret geological phenomena, such as the formation of sedimentary basins, the evolution of sedimentary sequences, and the reconstruction of paleoenvironments.

(iii) **Skills to be learned**

By the end of a petrology course, students should have a comprehensive understanding of the formation, properties and classification of rocks, as well as the practical applications of this knowledge in various fields of geology.

(iv) **The detail contents of this course**

THEORY

Igneous Petrology (15)

Nucleation and growth; Interpretation of common igneous textures with respect to nucleation and crystal growth. (3)

Concepts of system, phase and component; Mineralogical Phase rule; Phase equilibria in igneous rocks: Experimental observation of the following one, two & three component systems and their significance- (6)

(i) Silica (SiO_2) system

(ii) Diopside ($CaMgSi_2O_6$) - Anorthite ($CaAl_2Si_2O_8$) system

(iii) Potash feldspar ($KAlSi_3O_8$) - Albite ($NaAlSi_3O_8$) - Silica (SiO_2) system 43

Plate tectonics and generation of magmas in different tectonic settings; Igneous rocks in different tectonic settings: mid-oceanic ridge, oceanic intraplate, subduction and continental rift related settings

Rock series and rock associations; Descriptive petrography & origin of the following rock families: (6)

(i) Granite - Rhyolite family

(ii) Gabbro - Basalt family

(iii) Ultrabasic - Ultramafic rocks

Metamorphic Petrology (15)

Concept of metamorphism: Limits of metamorphism (1), Agents of metamorphism (1), Types of metamorphism (3), Types of Protoliths (2), A preliminary classification of metamorphic rocks (2), concept of zones (1), grades and facies (2). Metamorphic textures and structures (3).

Sedimentary Petrology (15)

Introduction; Scope and purpose; Processes of formation of sedimentary rocks: Weathering, erosion, transportation, deposition and diagenesis; Abundance of common sediments; Mineralogical composition of sedimentary rocks; Sedimentary cycle. (3)

Textures of sedimentary rocks: concepts of size, grade scale, sphericity, roundness, fabric, packing, porosity and permeability. (3)

Sedimentary structures: Mechanical, chemical and biological. (2)

General classification of sedimentary rocks; Descriptive petrography of sandstone and limestone. (3)

Basic ideas of depositional environments and their classification. (2)

Concepts of facies. (2)

PRACTICAL

Igneous Petrology (5)

(i) Study of hand specimen of various igneous rocks (2)

(ii) Microscopic study of mineralogical and textural characteristics of igneous rocks (3)

Metamorphic Petrology (5)

(i) Identification of the various kinds of metamorphic rocks and identification of their textures and structures in hand specimen. Slate, phyllite, various types of schists, gneiss, amphibolite, quartzite, augen gneiss, migmatite (2).

(ii) Study of the textures and assemblages of metamorphic rocks in thin section to know the petrogenetic history of the rocks and nomenclature of the rocks. *Chlorite schist, biotite schist, garnet schist, sillimanite schist, hornblende schist, amphibolites, quartzites* (3).

Sedimentary Petrology (5)

Identification of the clastic and nonclastic rocks in hand specimens. (1)

Identification of sedimentary structures. (1)

Identification & study of quartz types, limestone and heavy minerals in thin sections. (3)

Recommended Books:

1. An Introduction to Igneous and Metamorphic Petrology - John, D Winter; *Prentice Hall*.
2. Principles of Igneous and Metamorphic Petrology – A.R. Phillpotts; *Prentice-Hall of India Pvt. Ltd*.
3. Introduction to Sedimentology by S. M. Sengupta; *CBS Publisher & Distributors*.