

TRIBHUVAN UNIVERSITY
INSTITUTE OF SCIENCE AND TECHNOLOGY
MASTER OF SCIENCE IN GEOLOGY
(MSc Geology)

COURSE STRUCTURE
and
CURRICULUM
(REVISED)
2080

Submitted by
Central Department of Geology
Tribhuvan University
Kirtipur, Kathmandu
Nepal



Introduction

The Central Department of Geology (CDG) was established in the Tribhuvan University in 1976. CDG has been offering international standard academic syllabus for the Master of Science in Geology since its establishment in 1976. CDG offers not only theoretical and laboratory based teaching but also extensive field work techniques, in order to build students capacity to work in various fields, such as tunnels, roads, bridges, dams, mining industries, and groundwater. CDG has been known for producer of competitive geoscientists with outstanding academic results, Courses offered by CDG are designed to maximize employment prospects through acquisition of subject knowledge and practical skills. The Geology Subject Committee regularly revises its courses to meet the new requirements in a changed context,

The CDG has decided to introduce Semester System from academic year (2013) to meet the contemporary needs of the country as well as to make the level of education at par with the international standards. Accordingly, the Geology Subject Committee prepared course structure and curriculum for four semesters. The course was revised in 2015 and 2017. Tribhuvan University started Master of Science in Engineering Geology at the CDG and Tri Chandra College from 2016. The Geology Subject Committee has decided to make appropriate revisions in the MSc Geology course and implement it from the 2080 batch.

Aims and Objectives

The main aim of the Course is to create professionals having in depth knowledge and skills in the field of geology. Apart from it, the course also aims at producing specialists able to follow integrated and multi disciplinary approaches in their profession. After the completion of the course in geology the students will be able to carry out the professional work, research and /or advance studies independently.

Eligibility for Admission

The candidates who have passed the B.Sc. course in Geology from the Tribhuvan University or the B.Sc. course in Geology from any other equivalent universities or institutions shall be considered eligible for admission to the M.Sc. course in Geology. They should have also attended the prescribed geological field training at the B.Sc. level.

Admission Criteria

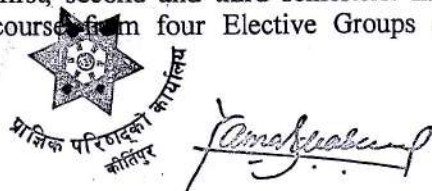
The applicants will have to appear in an entrance examination conducted by the Institute of Science and Technology, Tribhuvan University. An applicant who fails to appear in the Entrance Examination or fails to obtain a minimum qualifying score will not be allowed admission. A merit list of the qualified applicants will be prepared based on the marks obtained by them in the Entrance Examination. Admission of the students will be based strictly on the merit list and the enrolment capacity of the Central Department of Geology.

Medium of Instruction

English

Duration of the program

Four semesters completed in two academic years (4 academic semesters). There will be common courses for all students in the first, second and third semesters. In the fourth semester, the students will be assigned one special course from four Elective Groups designed according to their proposal for



dissertation topic in the third semester. A student should complete the course within 5 years (10 academic semesters).

Hours of Instruction and credit calculation

Working days: 90 days per semester

Semesters: 4

Total credits: 69

Full Marks: 1725

Theory

One credit = 15 hours and 25 marks

One theory paper of 1 credit will have one hour of lecture per week

Practical

One credit 45 lab work hours and 25 marks.

One practical paper of 1 credit will have 3 hours of practical per week

Field work

One credit 70 field work hours/week (10 hours/day) and 25 marks,

A fieldwork for a period of 8 weeks will be given to each student of the M.Sc. course in Geology. There will be two fieldworks each of four weeks duration (one in the First Semester and the other in the Third Semester) and each of them will carry 4 credits.

Dissertation

The dissertation carries 4 credits. The student shall have to prepare a dissertation in the 4th semester. The dissertation will ordinarily include from 4 to 6 weeks of fieldwork

Evaluation

Theory paper

Forty percent (40%) marks as Internal Assessment is assessed by concerned teacher on the basis of seminar, term-paper or internal examination. 60% mark is allocated for Final examination. Without passing internal exam students will not be qualified to appear in the semester exam.

Practical

The Practical work is evaluated separately (100%)

Dissertation

The dissertation will be submitted to the Central Department of Geology. The dissertation will be forwarded to the Institute of Science and Technology (IOST), Tribhuvan University for examination. The external examiner will be assigned by the IOST and internal examiner will be assigned by the CDG. A committee of head of department of CDG, external examiner, internal examiner and dissertation supervisor will examine the dissertation. The student should compulsorily attend the viva voce examination of the dissertation.

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Grading

Student must pass all compulsory papers separately. The pass marks for both theory and practical is 50% the performance of student shall be made on a four point scale ranging from 0 to 4 grades. A student must secure a minimum Grade Point Average (GPA) of 2.7 or Grade B minus (B⁻) in each course. The absolute grading scale will be as follows:

Grade	CGPA	Percentage Equivalent	Performance Remarks
A	4.0	90 and above	Distinction
A ⁻	3.7	80-89.9	Very Good
B ⁺	3.3	70-79.9	First Division
B	3.0	60-69.9	Second Division
B ⁻	2.7	50-59.9	Pass in individual Subject
F	0	Below 50	Fail

Certificate

The successful candidates, who have passed all the examinations in theoretical and practical subjects, fieldwork, and dissertation work, will obtain a certificate of Master of Science in Geology from Tribhuvan University.

MSc Geology Course Structure

I SEMESTER

Semesters	SN	Course code	Course name	Credits	Marks
First	1	GEO.511	Mineralogy	2	50
	2	GEO.512	Sedimentology	2	50
	3	GEO.513	Igneous Petrology	2	50
	4	GEO.514	Metamorphic Petrology	2	50
	5	GEO.515	Structural Geology	2	50
	6	GEO.516	Stratigraphy and Microplaeontology	2	50
	7	GEO.517	Practical of GEO.511 and GEO.512	2	50
	8	GEO.518	Practical of GEO.513 and GEO.514	2	50
	9	GEO.519	Practical of GEO.515 and GEO.516	2	50
	10	GEO.520	Field work	4	100
		Total	22	550	

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GEO.511: MINERALOGY

Semester	I
Course Title	Mineralogy
Course Code	GEO.511
Full Marks	50
Pass Marks	25
Nature of the course	Theory
Credit	2 (30 hrs.)

Course Description: This course provides the students with the concepts of mineralogy dealing with crystal chemistry, optical mineralogy and systematic mineralogy.

General Objective: To give in-depth knowledge and understanding of mineral structure, chemistry, physical and optical properties and classification.

Specific Objectives: To provide the students with in-depth knowledge and practical skills of Mineral identification and classification

(Total credit=2, FM=50, Teaching hours= 30)

Title	Content	Teaching hours
Mineral Chemistry		
Coordination of ions	Importance of mineral chemistry, atomic radius, ionic radius, Elements and minerals, Modern Periodic Table, Radius ratio. Coordination principles. Bonding forces in crystal, Crystal structures: Packing of Spheres. Isostructuralism. Some common structure types. Polymorphism. Pseudomorphism.	4
Compositional Variation in Minerals	Substitutional solid solution: Simple and coupled substitutions, Interstitial solid solution, Omission solid solution, Variation diagrams. Exsolution.	2
Optical Mineralogy		
Nature of light	Polarized light. Isotropic and Anisotropic Crystals.	4
Uniaxial and biaxial crystals under plain polarized light	Uniaxial and biaxial crystals and indicatrices. vibration directions. Pleochroism. Relative Relief.	
Uniaxial and biaxial crystals between crossed polars	Extinction, Interference colour, Accessory plates. Birefringence, and Sign of elongation.	2
Uniaxial crystals under convergent light	Uniaxial interference figures; determination of optic sign of uniaxial crystals.	2
Biaxial crystals under convergent light	Biaxial interference figures; Determination of optic sign of biaxial crystals using various interference figures. Optic axial angle, Apparent optic axial angle and Dispersion in biaxial crystals.	2

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Systematic Mineralogy		
Chemical formulae, structures, diagnostic properties and occurrences of following minerals	Nesosilicates (Olivine and Garnet groups). Inosilicates (Pyroxene group)	2
	Inosilicates (Amphibole group). Sorosilicates (Epidote groups). Cyclosilicates (Beryl and Tourmaline groups)	2
	Phyllosilicates (Clay mineral and Mica groups)	2
	Tectosilicates (SiO ₂ and Feldspar groups)	2
	Calcite and Dolomite groups, Anhydrite and Gypsum groups.	2
	Spinel and Hematite groups. Gem minerals	2
Advanced Analytical methods	Atomic Absorption Spectrometry (AAS), X-Ray Fluorescence Analysis (XRFA), Laser Ablation Coupling Techniques (LA-ICP-AES, LA-ICP-MS) Electron Microprobe Analysis (EMPA), X-ray Diffraction (XRD)	2

Text Books

1. Nesse, W. (2014). *Introduction to optical mineralogy*, Oxford University Press, 384p.
2. Blackburn, W H. and William, H.D. (1999). *Principles of Mineralogy*, Wm. C. Brown Publishers, 413p.
3. Klein, C. and Hurlbut, Jr. (1985). *Manual of Mineralogy*, John Wiley and Sons, 596p.
4. Tamrakar, N.K. (2011). *Practical Mineralogy*, CDGTU, Kirtipur, 184p.
5. Shelley, D. (1985). *Optical Mineralogy*, Elsevier Science Ltd, 2nd edition. 352p.

Reference Books

6. Phillips, W.R. and Griffen, D.T. (1986). *Optical Mineralogy, The no-opaque minerals*, CBS Publisher and Distributaries, Delhi, 677p.
7. Zussam, J. (1977). *Physical Methods in Determinative Mineralogy*, Academic Press, 720 p.
8. Sands, D.E. (1975). *Introduction to Crystallography*, Dover Publication Inc., New York, 165p.
9. Hutchison (1974). *Laboratory Methods in Petrography*, John Willey and Sons Inc. New York.
10. Kerr, P.F. (1971). *Optical Mineralogy*, McGraw-Hill, New York. 492p.

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Geo.512: SEDIMENTOLOGY

Semester	I
Course Title	Sedimentology
Course Code	GEO.512
Full Marks	50
Pass Marks	25
Nature of the course	Theory
Credit	2 (30 hrs.)

Course Description: This course provides the students with sedimentology dealing with origin of sediments, transportation and deposition of sediment, and transformation of sediments to sedimentary rocks.

General Objective: To give in-depth knowledge and understanding of genesis, processes, applied aspects of sediments and sedimentary rocks.

Specific Objectives: To provide the students with in-depth knowledge and practical skills of

- Identifying sediments and sedimentary rocks with their description, classification, nomenclature, and origin
- Analysing composition, texture, structure and provenance of sediments

(Total credit=2, FM=50, Teaching hours= 30)

Title	Content	hours
	Origin of Sediments	
Origin of Terrigenous Clastic Grains	Weathering and soil formation. Clastic sediments as chemical and physical weathering products: Rock forming minerals during weathering, Factors controlling rates of weathering, Goldich's Stability of sequence of rock forming minerals, Stability of common minerals under weathering, Geochemical differentiation of elements from weathering of rocks. Provenance: Siliciclastic sediment sourcing. Solid Breakdown products of older deposits.	3
Origin of Calcium Carbonate, Evaporites, Silica, Iron-rich and Phosphate Sediments	Particles that are not solid breakdown products of older deposits: <i>Authigenic Particles</i> : Carbonates as precipitates, biological origin, and non-skeletal carbonate grains. Evaporite salts. Silica sediments. Iron-rich sediments. Phosphates. Primary and microbial-induced sediments. <i>Pyroclastic particles</i> .	3
Properties of sedimentary particles, Pores and Permeability	Grain size, Distribution and characteristics of grain population. Graphic measures of size distribution. Grain shape and form. Mass properties. Pore morphology and origin of primary pores. Sedimentary fabrics: Sorting, packing, orientation of particles. Mass density of solid particles, Volumetric sediment concentration, specific weight of mixture, dynamic and kinematic viscosities of Newtonian mixtures.	3



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	Sediment Sedimented	
Sedimentological Fluid Dynamics, Transport of Sediment Grains, Sedimentation and Depositional Systems	<p>Fluid basics: Fluid properties, Boundary layer. Channel roughness and resistance to flow: State of flow. Effect of fluid viscosity: laminar and turbulent flow, Reynolds number, Effect of gravity: Froude Number,</p> <p>Flow resistance equations: Chézy Equation, Manning Equation, Darcy-Weisbach Equation, Hydraulic flow-resistance factors; Estimating total roughness using Cowan's method. Flow path of grain motion. Grains in stationary fluid. Fall velocity. Flocculation.</p>	3
	<p>Erosion. Sediment Yield. Annandale's Erodibility Index.</p> <p>Sediment load: Modes of transport, Incipient motion and sediment transport. Bed shear stress.</p> <p>Bed load transport: deterministic, probabilistic and stream power approaches. Suspended load transport. Total sediment load. Sediment Transport Capacity: stream power.</p> <p>Sediment Deposition and Sediment characteristics: Aqueous processes: Lake or reservoir: settling velocity of mud and coarse grains. Flocculation. Subaqueous gravity displacement sedimentation. Sedimentation from traction. Eolian Processes: Sedimentation; traction and suspension.</p>	3
	<p>Glacial Processes: Glacial transport and sedimentation, Glacio-lacustrine and glacio-marine sedimentation. Gravitational Processes: Debris flows, Grain flows, Fluidized flows. Sedimentary Structures: Syn- and Post-depositional Sedimentary Structures. Paleocurrent Analysis. Sedimentary Environment: Definition, Classification, Facies, Facies Assemblage and Environmental models.</p>	3
	Sediment to Rock	
Allochthonous Sediments	<p>Conglomerates and Breccias: Classification and genesis. Mudrocks: Classification and genesis. Mudrock diagenesis.</p>	3
	<p>Sandstones: Classification, origin of sandstones: quartz arenites, arkoses, litharenites, and greywackes. Sandstone diagenesis and porosity evolution.</p>	3
Autochthonous Sediments	<p>Carbonate Sedimentary rocks: Components, Classification, Limestone diagenesis, and porosity evolution. Dolomite diagenesis.</p>	3
	<p>Authigenic Sedimentary rocks: Evaporites: Geological characteristics, carbonate-anhydrite cycle. Sedimentary Iron Ores: Dispersal of iron and formation of minerals, Oolitic iron ores, Precambrian banded Iron Formations.</p> <p>Sedimentary phosphate deposits: Nodular and Bedded phosphorites. Cherts and siliceous sediments: Bedded and nodular cherts, Non-marine cherts. Carbonaceous Rocks: Coals and coal series: Humic and Sapropelic coals, Coal formation and rank, Environment of coal deposition.</p>	3

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Textbooks

1. Selley, R.C. (2000). *Applied Sedimentology*, Second Edition, Academic Press, 543p.
2. Leeder, M.R. (1982). *Sedimentology: process and product*, Georg Allen and Unwin, London, 344p.
3. Boggs Jr. S. (2009). *Petrology of Sedimentary Rocks*, Second Edition. Cambridge University Press, 600p.
4. Freidman, G.M. and Sanders, J.E. (1978). *Principles of Sedimentology*, John Wiley and Sons, New York, 792p.
5. Collinson, J.D. and Thompson, D.M. (1994). *Sedimentary structures*, CBS, Delhi, 207p.
6. Tucker, M.E. (1981). *Sedimentary petrology: an Introduction*, Geoscience Texts, Vol. 3. Blackwell Sci. publications, 252p.
7. Pettihohn, F.J. (1975). *Sedimentary Rocks*, Harper and Row, New York, 628p.
8. Pettijohn F. J. (1984). *Sedimentary Rocks*, 3rd edition, CBS Delhi, 628 p
9. Tamrakar, N.K. (2011). *Practical Sedimentology*, Bhrikuti Academic Publication, Kathmandu, 232p.
10. Tamrakar, N. K. (2011). *Practical Mineralogy*, CDGTU, Kirtipur, 184p
11. Morris, G. L. and Fan, J., (2010). *Reservoir Sedimentation Handbook*, McGraw-Hill, 805p.
12. Blatt, H. (1992). *Sedimentary Petrology*, second edition, W.H. Freeman and company, New York, 514p.

Reference Books

1. Folk, R.L. (1980). *Petrology of Sedimentary rocks*, Hemphill Publishing Company. Austin, Texas, 184p.
2. Pettijohn, F.J. Potter, P.E. Siever. R. (1987). *Sand and sandstones*, 2nd ed., Springer-Verlag; New York, Berlin, Heidelberg, London, Paris, Tokyo, 355p.
3. Lindholm, R. (1991). *A practical approach to sedimentology*, CBS Publishers and Distributors, Delhi, 176p.
4. Greensmith, J.T. (1978). *Petrology of the sedimentary rocks*, (sixth Edition). George Allen and UNWIN/Thomos Murby, London, Boston, Sydney.
5. Tamrakar, N.K. (2013). *Handbook of field geology with reference to the Siwaliks*, CDGTU, Kirtipur, Kathmandu, Nepal. 162p.
6. Reineck H.E. and Singh I.B. (1980). *Depositional Sedimentary Environments*, 2nd edition, Springer Verlag, 549p.

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GEO.513: IGNEOUS PETROLOGY

Semester	I
Course Title	Igneous Petrology
Course Code	GEO.513
Full Marks	50
Pass Marks	25
Nature of the course	Theory
Credit	2 (30 hrs.)

Course Description: This course provides the students with the concepts of igneous Petrology and petrogenesis. It deals with the igneous rocks, their origin, classification, occurrence, and distribution in space and time.

General Objective: To provide an in-depth understanding of igneous rocks and their processes of formation and evolution.

Specific Objective: To provide the students with in-depth knowledge and practical skills of

-Magmatism

-Geodynamic relations of formation of different types of rocks

-Modern methods of study and analysis of igneous rocks.

(Total credit=2, FM=50, Teaching hours=30)

Title	Content	Teaching hours
Igneous Petrogenesis		
Concepts of Thermodynamics and Kinetics	Heat flow in the Earth, Importance of thermodynamics in petrology, elementary concepts of thermodynamics, First and Second Laws of thermodynamics, Gibb's Free Energy for closed and open systems, chemical potential, Clausius-Clapeyron equation, thermodynamics of solutions (some basic concepts), application of thermodynamics to solutions, Limitations of classical thermodynamics, Activation energy, overstepping and metastable persistence	6
Silicate melts and volatile fluids in the magmatic system	Nature of magma, volatile fluids in melts, consequences of fluid exsolution from melts	2
Crystal-melt equilibria in magmatic system	Phase rule, stability (phase) diagram, melting of a pure mineral and polymorphism, phase relations in binary systems, phase relations in ternary system, sub solidus reaction in magmatic rocks	4
Chemical Dynamics of melts and crystals	The viscosity of melts, chemical diffusion, Interfacial energy and Crystallization, secondary overstepping processes, vesiculation, and fragmentation of magma	2
Fabric of magmatic rocks	Crystallinity and grain size, grain shape, inhomogeneous grains, fabrics related to secondary grain-boundary modification, exsolution, fragmentation of magma, consolidation of volcano-clastic rocks,	2



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Igneous Structures and Field Relationships	Extrusive, or volcanic processes, products, and landforms, pyroclastic deposits. Intrusive or plutonic processes and bodies, contact relationships of plutons, the process of magma rise and emplacement. Hydrothermal systems.	2
Chemical Petrology	Major and minor elements, analytical methods, Pearce Element Ratios (PERs). Graphical and mathematical models of magmatic evolution. Trace elements and isotopes. Models for solid melt processes: Batch melting, Rayleigh fractionation, spider diagrams, application of trace elements to igneous systems. Isotopes: Stable isotopes. Radioactive and Radiogenic isotopes,	2
Magma ascent	Movement of magma in the earth, sheet intrusions (dikes), diapirs, magma-emplacement in the crust (space problem)	2
Magma extrusion	Controlling factors for extrusion, effusion of basaltic lava, effusion of silicic lava, explosive eruptions, and other volcanoclastic deposits	2
Generation of magma	Melting of solid rocks, generation of basaltic magma, generation of granitic magma	2
Diversification of magma	Major and minor elements in the crust, variation diagrams, using variation diagrams to model magmatic evolution, Pearce Element Ratios (PER), closed-system magmatic differentiation, open-system diversification, differentiation in basaltic intrusions, origin of calc-alkaline differentiation trend	2
Magmatic Associations	Mid-Ocean Ridge Basalt (MORB), Ocean Island Basalt (OIB), Continental Flood Basalt, Ophiolites, Calc-alkaline rocks, A-type granites, S-type granites, I-type granites, Alkaline orphans (lamprophyres, kimberlites)	2

Textbooks

1. Philpott, A.R. and Ague, J.J. (2022). *Principles of Igneous and Metamorphic Petrology*, Cambridge University Press, 752p. <https://doi.org/10.1017/9781108631419>
2. Best, M. G. (2003). *Igneous and Metamorphic Petrology*, Second Edition, Blackwell Publishing, 729p.

Reference Books

1. Forst and Forst (2014). *Essentials of Igneous and Metamorphic Petrology*, First Edition, Cambridge University Press, 303p.
2. Winter, J.D. (2012). *Principles of Igneous and Metamorphic Petrology (second edition)*, PHI Learning Private Limited, New Delhi-110001, 702p.
3. Hyndman D.W. (1985). *Petrology of Igneous and Metamorphic Rocks*, McGraw Hill Inc., 786p.

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4. Thorpe, R.S. and Brown, G.C. (1995). *The Field Description of Igneous Rocks*, John Wiley and Sons, 154p.
5. McBirney A.R. (1993). *Igneous Petrology*, Jones and Bartlett Publishers, Inc., 508p.
6. Hall, A. (1988). *Igneous Petrology*, ELBS, 573p.
7. Carmichael, I.S.E., Turner, F J., and Verhoogen, J. (1974). *Igneous Petrology*, McGraw Hill Inc., 739p.

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GEO.514: METAMORPHIC PETROLOGY

Semester	I
Course Title	Metamorphic Petrology
Course Code	GEO.514
Full Marks	50
Pass Marks	25
Nature of the course	Theory
Credit	2 (30 hrs.)

Course Description: This course provides the students with the concepts of Metamorphic petrology and petrogenesis. It deals with the metamorphic rocks, mode of origin, classification, occurrence, and distribution in space and time.

General Objective: To provide an in-depth understanding of metamorphic rocks and their processes of formation and evolution.

Specific Objective: To provide the students with in-depth knowledge and practical skills.

of
-Metamorphism

-Geodynamic relations of formation and transformation of different types of rocks

-Modern methods of study and analysis of metamorphic rocks.

(Total credit=2, FM=50, Teaching hours=30)

Title	Content	Teaching hours
Igneous Petrogenesis		
Introduction to Metamorphism	Limits of metamorphism, metamorphic agents and changes, types of metamorphism, progressive nature of metamorphism, types of protolith, P-T-t paths, grades, and zones. Some case studies of different types of metamorphisms.	4
Classification of Metamorphic Rocks	Foliated and lineated rocks, non-foliated and non-lineated rocks and high-strained rocks. Petrography and composition of metamorphic bodies.	2
Petrogenesis and Petro-fabrics of Metamorphic Rocks	Processes of deformation, recovery and recrystallization, textures, shear sense indicators, mechanism of tectonite development, gneissose structures, and layers, mineral growth, analysis of poly-deformed and poly-metamorphosed rocks. Crystallographically controlled inclusions, replacement textures, and reaction rims. Textural geo-chronology. Structural petrology.	4
Stable Mineral Assemblages	Equilibrium mineral assemblages. Phase rule in metamorphic system and common Chemographic diagrams. Chemical principles of metamorphism.	2
Metamorphic Facies and Facies Series	Metamorphic facies and facies series. Classification of three types of metamorphism based on P/T ratio. Facies of contact and regional metamorphism.	2

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Metamorphic Reactions	Mineralogical and chemical aspects of metamorphic systems. Petrogenetic grids. Isograds. Reaction mechanisms. Principles of geothermo-barometry.	2
Metamorphism of Different Rocks	Metamorphism of ultramafic and mafic rocks, metamorphism of pelitic and calcareous rocks.	4
Metamorphic Fluids, Mass Transport, and Metasomatism	Metamorphic fluids. Role of fluids in metamorphism, Metasomatism, Changes associated with metasomatism. Metamorphic differentiation.	2
Field Relations of Metamorphic Bodies	Mylonite zones. Contact metamorphism and metasomatism. Burial metamorphic bodies. Regional metamorphism in orogenic belts. Paired metamorphic belts and plate tectonics. Serpentinites. Development of veins.	4
Methods of Study and Analysis of Metamorphic Rocks	Field observations and geological mapping. Mineral identification techniques. Chemical analysis. Thermobarometry. Isotopic dating. Fluid inclusion studies. Geochronology. Computer works.	4

Textbooks

1. Winter, J.D. (2012). *Principles of Igneous and Metamorphic Petrology (second edition)*, PHI Learning Private Limited, New Delhi-110001, 702p (original U.S. edition).
2. Best, M.G. (2003). *Igneous and Metamorphic Petrology*, Second Edition, Blackwell Publishing, 729p.

Reference Books

1. Turner and Verhoogen (1987). *Igneous and Metamorphic Petrology (second edition)*, CBS Publishers and Distributors, Delhi, 694p.
2. Forst and Forst (2014). *Essentials of Igneous and Metamorphic Petrology*, First Edition, Cambridge University Press, 303p.
3. Hyndman D.W. (1985). *Petrology of Igneous and Metamorphic Rocks*, McGraw Hill Inc., 786p.

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GEO.515: STRUCTURAL GEOLOGY

Semester	I
Course Title	Structural Geology
Course Code	GEO.515
Full Marks	50
Pass Marks	25
Nature of the course	Theory
Credit	2 (30 hrs.)

Course Description: Structural geology deals with the architecture of the earth's crust and its componential parts.

General Objective: To give in-depth knowledge and understanding of the structure of the earth's crust and its various components.

Specific Objective: To provide the students with in-depth knowledge and practical skills for the study, analysis, and interpretation and geological significance of

- folds,
- faults and shear zones
- joints.
- foliation, and
- lineation.

The structural geology course also provides the concepts of stress and strain and concepts of microtectonics and structural analysis

Total credit=2, FM=50, Teaching hours=30)

Title	Content	Teaching hours
Introduction	Introduction of structural geology and structural analysis, scope of structural geology, descriptive and kinematic analysis, concepts of structural analysis, limitations of structural analysis, homogeneous and inhomogeneous deformation.	4
Primary structures	Primary sedimentary structures and their significance in structural geology.	2
Secondary structures	Morphology, geometry, classification and mechanism, field identification criteria and geological and engineering geological significances of fold, faults, shear zones and joints. Concept of shear zone and mylonite.	10
Superimposed folding	Concept, environment and mechanism	2
Foliation and Lineation	Types, mechanism and structural geological significance of different types of foliation and lineation. Relationship between bedding and foliation.	2
Stress	Stress at a point. Stress on a plane. Principal planes of stress. Mohr	4



	circle. Types of stresses and Mohr circle configurations for them. Stress in two dimensions.	
Strain	Definitions. Displacement vector, Displacement field, Displacement gradient. Homogeneous and inhomogeneous deformations. Simple shear and pure shear, finite and infinitesimal strain. Homogeneous deformation of straight line. Circle and ellipse. Changes in lengths and orientation of lines in different zones with strain ellipse and corresponding geological structures.	2
Microtectonics	Concept of microtectonics and its use in structural geology and other branches of geology.	2
Thin skin tectonics	: Introduction, Ramp and flat, Piggy back and overlap sequence, Imbricate fault, duplex, Nappe and Klippe, roof thrust and floor thrust, back thrust and its types, blind thrust, out of sequence thrust	2

Textbooks

1. Hobbs, B.E., Means, W.D., and Williams, P.F. (1976). *An Outline of Structural Geology*, John Wiley and Sons, 571p.
2. Ramsay, J.G. (1967). *Folding and Fracturing of Rocks*, McGraw Hill Inc., 568p.
3. Passchier, C.W. and Trouw R.A.J. (2003). *Micro-tectonics*, Springer, 253p.
4. Ramsay, J.G. and Huber, M.I. (1983). *The Techniques of Modern Structural Geology, Volume 1: Strain Analysis*, Academic Press, 307 p.

Reference Books

1. Bayly, B. (1991). *Mechanics in Structural Geology*, Springer-Verlag, 253 p
2. Johnson, A.M. (1977). *Styles of Folding*, Elsevier Scientific Publishing Company, 406p.
3. McClay, K.R. (1987). *The Mapping of Geological Structures*, John Wiley and Sons Inc., 161p.
4. Ragan, D.M. (1985). *Structural Geology, An Introduction to Geometrical Techniques*, 3rd edition, John Wiley and Sons Inc., 393p.
5. Means, W.D. (1985). *Stress and Strain Basic concepts of continuum mechanics for geologists*, Springer-Verlag New York, 339p.
6. Davis, G.H. and Reynolds S.J. (1996). *Structural Geology of rocks and regions*, John Wiley and Sons Inc., 776p.

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GEO.516: STRATIGRAPHY AND MICROPALAEONTOLOGY

Semester	I
Course Title	Stratigraphy and Micropalaeontology
Course Code	GEO.516
Full Marks	50
Pass Marks	25
Nature of the course	Theory
Credit	2 (30 hrs.)

Course Description: This course is designed to acquire the knowledge about the basic principles of stratigraphy and microfossils contained in stratigraphic successions.

General Objectives: To provide the students knowledge of identification of rock successions and microfossils in solving geological problems.

Specific Objectives: To provide the students with in-depth knowledge and practical skills of Stratigraphy, microfossil identification and interpretation

(Total credit=2, FM=50, Teaching hours= 30)

Title	Content	Teaching hours
Principles of Stratigraphy	Principles of stratigraphy; Laws of superposition and faunal succession; Geological time scale, Classification and nomenclature of stratigraphic units: lithostratigraphic, biostratigraphy and chronostratigraphic units; Sequence stratigraphy, International Stratigraphic Guide; Unconformity, Stratigraphic correlation, Index fossils.	6
Techniques of microfossil analysis	Types of fossils, Process of fossilization, Micropalaeontology: Importance and application of microfossils; Extraction methods in micropalaeontology; Microfossil in stratigraphy; Microfossils, stable isotopes and ocean atmosphere history; Microfossils as thermal metamorphic indicators, Palaobiogeography, paleoecology and palaeoclimate; Co-existence theory, NLRs, Microfossil data analysis and representation.	4
Inorganic walled microfossils	Foraminifera, Radiolaria, Ostracods, Conodonts, Diatoms, Calcareous nannoplankton, Silicoflagellates and Chrysophytes.	8
Organic walled microfossils	Acritarchs, Dinoflagellates, Chitinozoa, Scolecodonts, Cladocera, Pollen and Spores	6
Microfossils in the Nepal Himalaya	Microfossils from the Nepal Himalaya, Palynological records from Tertiary and Quaternary succession in the Nepal Himalaya	4
Climatic events	Mass extinctions: Process and Events, Extinction in the Ice ages.	2

Text Books

1. Armstrong, H.A. and Brasier, M.D. (2005). *Microfossils*, London: Allen and Unwin, 305p.
2. Paudyal, K.N. (2017). *Study of Pollen and Spores*, CDGTU, Kirtipur, 196 p.
3. Paudyal, K.N. (2017). *Vegetation History of Nepal Himalaya*, CDGTU, Kirtipur, 108 p.
4. Boggs, S. (2006). *Principles of Sedimentology and Stratigraphy*, Pearson-Prentice Hall, 676p.

Reference Books

5. Brookfield, M.E. (2008). *Principles of Stratigraphy*, Blackwell Publishing Ltd, 340p.
6. Adolf, S., (2007). *Trace Fossil Analysis*, Springer Verlag, 238p.
7. Moore, P.D., Webb, J.A. and Collinson, M.E., (1994). *Pollen Analysis*, Oxford, 216p.

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Amal Kumar

GEO.517: PRACTICAL OF GEO.511 and GEO.512

Semester	I
Course Title	Practical of Geo.511 and Geo.512
Course Code	GEO.517
Full Marks	50
Pass Marks	25
Nature of the course	Practical
Credit	2 (90 hrs.)

PART A: MINERALOGY

(1 credit, 45 hours)

Course Contents:

- Lab 1: Classification of minerals
- Lab 2: Study of physical properties of minerals
- Lab 3: Identification of important silicate minerals in hand specimens.
- Lab 4: Identification of important non-silicate minerals in hand specimens.
- Lab 5: Polarising microscope set up and its handling.
- Lab 6: Study of optical properties of minerals under plane polarized light.
- Lab 7: Study of optical properties of minerals under crossed-nicols.
- Lab 8: Study of optical properties of minerals under conoscopic setting.
- Lab 9: Identification of essential rock-forming minerals under microscope (Quartz, alkali feldspar).
- Lab 10: Identification of essential rock-forming minerals under microscope (perthite, plagioclase, microcline).
- Lab 11: Identification of essential rock-forming minerals under microscope (Olivine and pyroxene)..
- Lab 11: Identification of essential rock-forming minerals under microscope (Hornblende, biotite, muscovite, sericite).
- Lab 12: Identification of essential rock-forming minerals under microscope (Garnet, kyanite, Sillimanite) .
- Lab 13: Identification of essential rock-forming minerals under microscope (Chlorite, calcite).
- Lab 14: Zoning and twinning in minerals under microscope.
- Lab 15: Recalculation analysis of mineral formula.

Text and Reference Books:

1. Blackburn, W.H. and William, H.D. (1999). *Principles of Mineralogy*, Brown Publishers, 413p.
2. Shelley, D. (1985). *Optical Mineralogy*, Elsevier Science Ltd; 2nd edition, 352p.
3. Phillips, W.R. and Griffen, D.T. (1986). *Optical Mineralogy, The no-opaque minerals*, CBS Publisher and Distributaries, Delhi, 677p.
4. Tamrakar, N.K. (2011). *Practical Mineralogy*, CDGTU, Kirtipur, 184p.
5. Moorehouse, W.W. (1959). *The study of rocks in thin sections*, CBS Publishers and Distributors, 514 p.
6. Klein, C. and Hurlbut, Jr. (1985). *Manual of Mineralogy*, John Wiley and Sons, 596 p.
7. Paudel, L.P. (2011). *Study of Minerals and Rocks in Thin Sections*, GEOS, 102p.
8. Hutchison (1974). *Laboratory Methods in Petrography*, John Willey and Sons Inc. New York.
9. Zussam, J. (editor) (1977). *Physical Methods in Determinative Mineralogy*, Academic Press, 720 p.

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PART B: SEDIMENTOLOGY

(1 credit, 45 hours)

Course Contents:

- Lab 1: Grain size analysis of sediment sample
Lab 2: Representation, classification, statistical treatment and interpretation of grain size data.
Lab 3: Analysis of forms, sphericity and roundness of sediment, representation and interpretation.
Lab 4: Stereographic projection of fabric and structures, treatment of primary data.
Lab 5: Graphical representation of fabric and structure, analysis of vector data, treatment of data using statistical tool, and preparation of dispersal and palaeocurrent maps.
Lab 6: Study of hand specimens of Siliciclastic and autochthonous rocks: Description and nomenclature.
Lab 7: Study of thin sections of clastic rocks: description of textures, and textural classification.
Lab 8: Study of thin sections of clastic rocks: composition, classification, and using clastic petrographic data for provenance discrimination.
Lab 9: Study of thin-sections of carbonate rocks: description of textures, and textural classification
Lab 10: Study of thin-sections of carbonate rocks: composition, classification and nomenclature.

Text and Reference Books:

1. Boggs, Jr. S. (2009). *Petrology of Sedimentary Rocks*, Second Edition. Cambridge University Press. 600p.
2. Tamrakar, N.K. (2011). *Practical Sedimentology*, Bhrikuti Academic Publication, Kathmandu, 232p.
3. Tamrakar, N.K. (2011). *Practical Mineralogy*, CDGTU, Kirtipur, 184p
4. Collinson, J.D. and Thompson, D.B. (1994). *Sedimentary Structures*, CBS Delhi, 207p.
5. Adam, A.E., Mackenzie, W.S. and Guilford, C. (1988) *Atlas of Sedimentary Rocks under the Microscope*, ELSB, Longman Group, UK. 104p
6. Lindholm, R.C. (1991). *A Practical Approach to Sedimentology*, CBS Publishers and Distributors Delhi, 276 p.
7. Folk, R.L. (1980). *Petrology of Sedimentary Rock*, Hemphil Publishing Company, Austin Texas, 184p.
8. Freidman, G.M. and Sanders, J.E. (1978). *Introduction to Sedimentology*, Wiley, New York. 28
9. Pettijohn, F.J. (1984). *Sedimentary Rocks*, 3rd edition, CBS Delhi, 628p.

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GEO.518: PRACTICAL OF GEO.513 and GEO.514

Semester	I
Course Title	Practical of Geo.513 and Geo.514
Course Code	GEO.518
Full Marks	50
Pass Marks	25
Nature of the course	Practical
Credit	2 (90 hrs.)

PART A: IGNEOUS PETROLOGY

(1 credit, 45 hours)

Course Contents:

- Lab 1: Review of igneous rock classification, textures and structures.
Lab 2: Calculation of Normative Minerals (NORM) from given chemical composition of rocks.
Lab 3: Study of crystallization of magma in two and three component systems.
Lab 4: Preparation of chemical variation diagram and their interpretations.
Lab 5: Study of igneous rocks in hand specimens with emphasis on rock forming minerals, texture, structure, genesis and classification.
Lab 6: Study of igneous rocks in thin sections with emphasis on rock forming minerals, texture, structure, genesis and classification (Acidic/granitoid rocks).
Lab 7: Study of igneous rocks in thin sections with emphasis on rock forming minerals, texture, structure, genesis and classification (Basic and ultrabasic rocks).
Lab 8: Study of igneous rocks in thin sections with emphasis on rock forming minerals, texture, structure, genesis and classification (Basic and ultrabasic rocks).

Text and Reference Books:

- 1 Winter, J.D., (2012). *Learning Principles of Igneous and Metamorphic Petrology*, PHI Learning Private Limited, New Delhi, 702p.
- 2 Best, M.G., *Igneous and Metamorphic Petrology*, CBS Publisher and Distributors, Delhi, 630p.
- 3 Moorhouse, W.W, *The study of rocks in thin sections*, CBS Publisher and Distributors, Delhi, 514p.
- 4 Williams, H., Francis, J. Turner and Charles M. Gilbert. *Petrography: An introduction to the study of rocks in thin sections*, CBS Publishers and Distributors. Shahdara, Delhi-32, 514p.
- 5 Paudel, L.P., *Study of minerals and rocks in thin sections*, Geo-Science Innovations (P) Ltd., Kirtipur, Kathmandu, Nepal, 102p.

PART B: METAMORPHIC PETROLOGY

(1 credit, 45 hours)

Course Contents:

- Lab 1: Study of metamorphic rocks in hand specimens with emphasis on mineral Assemblages, texture, structure, genesis, and metamorphic history.
Lab 2: Study of metamorphic rocks in hand specimens with emphasis on mineral assemblages, texture, structure, genesis, and metamorphic history.
Lab 3: Study of metamorphic rocks in thin sections with emphasis on mineral assemblages, texture, structure, genesis, and metamorphic history.
Lab 4: Study of metamorphic rocks in thin sections with emphasis on mineral assemblages, texture, structure, genesis, and metamorphic history.



- Lab 5: Study of microstructures developed in metamorphic rocks under thin sections.
Lab. 6: Study of pressure-temperature diagrams and interpretation of metamorphic facies.
Lab. 7: Classification of metamorphic rocks using chemographic diagrams.

Text and Reference Books

- 1 Winter, J.D., (2012). *Learning Principles of Igneous and Metamorphic Petrology*, PHI Learning Private Limited, New Delhi, 702p.
2. Best, M.G., *Igneous and Metamorphic Petrology*, CBS Publisher and Distributors, Delhi, 630p.
3. Moorhouse, W.W, *The study of rocks in thin sections*, CBS Publisher and Distributors, Delhi, 514p.
4. Williams, H., Francis, J. Turner and Charles M. Gilbert. *Petrography: An introduction to the study of rocks in thin sections*, CBS Publishers and Distributors. Delhi, 514p.
5. Paudel, L.P., *Study of minerals and rocks in thin sections*, Geo-Science Innovations (P) Ltd., Kirtipur, Kathmandu, Nepal, 102p.



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GEO.519: STRUCTURAL GEOLOGY

Semester	I
Course Title	Practical of Geo.515 and Geo.516
Course Code	GEO.519
Full Marks	50
Pass Marks	25
Nature of the course	Practical
Credit	2 (90 hrs.)

PART A: STRUCTURAL GEOLOGY

(1 credit, 45 hours)

Course Contents:

- Lab 1: Contours and topography. Relationship between contours and contacts. Description of geomorphological and man-made features from topographic maps, construction of profiles.
- Lab 2: Understanding the rule of V's, recognition of inliers, outliers, windows, klippe.
- Lab 3: Study of structural features and stratigraphic sequence of the given geological maps.
- Lab 4: Study of geological maps and preparation of geological cross-sections of horizontal, inclined, vertical and folded beds.
- Lab 5: Study of geological maps with unconformity, faults and dykes.
- Lab 6: Determination of apparent and true thickness of beds.
- Lab 7: Determination of through of faults.
- Lab 8: Stereographic projection techniques
- Lab 9: Three point problems
- Lab 10: Geometrical and stereographic techniques for the determination of net slip, dip slip and strike slip along the fault planes
- Lab 11: Busk construction of parallel folds

Text and reference books

1. Hobbs, B.E., Means, W.D., and Williams, P.F. (1976). *An Outline of Structural Geology*, John Wiley and Sons, 571 p.
2. Ramsay, J.G. (1967). *Folding and Fracturing of Rocks*, McGraw Hill Inc., 568 p.
3. Passchier, C.W. and Trouw R.A.J. (2003). *Micro-tectonics*, Springer, 253 p.
4. Ramsay, J.G. and Huber, M.I. (1983). *The Techniques of Modern Structural Geology*, Volume 1: Strain Analysis, Academic Press, 307 p.
5. Bayly, B. (1991). *Mechanics in Structural Geology*, Springer-Verlag, 253 p
6. Johnson A.M. (1977). *Styles of Folding*, Elsevier Scientific Publishing Company, 406 p.
7. McClay, K.R. (1987). *The Mapping of Geological Structures*, John Wiley and Sons Inc., 161 p.
8. Ragan D.M. (1985). *Structural Geology, An Introduction to Geometrical Techniques*, 3rd edition, John Wiley and Sons Inc., 393 p.
9. Means W.D. (1985). *Stress and Strain Basic concepts of continuum mechanics for geologists*, Springer-Verlag New York, 339 p.
10. Davis G.H. and Reynolds S.J. (1996). *Structural Geology of rocks and regions*, John Wiley and Sons Inc., 776 p.

PART B: STRATIGRAPHY AND MICROPALAEONTOLOGY

(1 Credit, 45 hours)

Course Contents

- Lab 1: Geological time scale-major climatic and biotic events
- Lab 2: Paleogeography and Paleoclimate of the Earth
- Lab 3: Process of fossilization
- Lab 4: Index fossils through geological time
- Lab 5: Extraction of microfossils
- Lab 6: Study of Foraminifera and Raiolaria
- Lab 7: Study of Ostracodes and Conodonts
- Lab 8: Study of Pollen and Spores, Diatoms and Dinoflagellates
- Lab 9: Microfossils from the Nepal Himalaya
- Lab 10: Interpretation of microfossils data, climate reconstruction

Text and reference books

1. Armstrong, H.A. and Brasier, M.D. (2005). *Microfossils*, London: Allen and Unwin, 305p.
2. Paudyal, K.N. (2017). *Study of Pollen and Spores*, CDGTU, Kirtipur, 196 p.
3. Paudyal, K.N. (2017). *Vegetation History of Nepal Himalaya*, CDGTU, Kirtipur, 108 p.
4. Boggs, S. (2006). *Principles of Sedimentology and Stratigraphy*, Pearson-Prentice Hall, 676p.
5. Brookfield, M.E. (2008). *Principles of Stratigraphy*, Blackwell Publishing Ltd, 340p.
6. Adolf, S., (2007). *Trace Fossil Analysis*, Springer Verlag, 238p.
7. Moore, P.D., Webb, J.A. and Collinson, M.E., (1994). *Pollen Analysis*, Oxford, 216p.



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GEO.520: FIELD WORK

Semester:	I
Course Title	Field work
Course Code	GEO.520
Full Marks	100
Pass Marks	50
Nature of the course	Practical
Credit	4 (4 weeks)

Course description: Fieldwork is carried out to provide the field knowledge of rocks, their texture, structure and techniques and skills of observation, data recording, sampling, description, analysis, interpretation and mapping of rocks and their structures in the field.

General objective: To give the knowledge, techniques and skill of geological mapping in the field.

Specific objective: To provide the students with the techniques of

- Describing rock outcrop.
- Mapping of rock outcrop,
- Interpretation of rocks texture and structure palaeocurrent, sedimentary structure, folds and faults, and
- Preparation of geological maps, stratigraphic columns and geological cross-sections.
- Give the knowledge of different tectonic units of the Nepal Himalaya.

Field work duration: The field work will carry a total of 28 days. One credit of field work will have 70 hours of teaching per week. One teacher will be assigned per 10 students in the field.

Course Contents

Location: The fieldwork will be carried out for two weeks in the Sub-Himalaya and another two weeks in the Lesser Himalaya of Makawanpur, Bara, Tanahu, Gorkha and Dhading Districts. The location may vary depending upon the criteria set by the Department and situation in the field sites.

Fieldwork in the Sub-Himalaya (14 days; 2 credits)

Introduction:

Reading of topographical and geological maps of the area, identification of main lithological, stratigraphic and structural features of the area, learn techniques of stratigraphic and sedimentologic surface data acquisition, learn to measure various sedimentary structures and geological structures, and study of processes and origin of rocks, Identification, description and nomenclature of rocks, Graphical and statistical treatment of sedimentological scalar and vector data

Title	Contents
Preparatory works	Reading of topographical and geological maps of the area, Review of literatures, Field orientation and Regulations.
Mapping:	Geological traverse. Recording field data. Measuring sedimentary structures and bed structures. Preparation of graphic logs of large scale. Geological Route Mapping. Columnar sectioning from the route map. Introduction to modern fluvial environments and mapping of quarternary alluvial fan, Mapping of lithological boundaries, tectonic contacts and other structural features (folds, faults, joints,


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	foliation, bedding, etc.). Preparation of the geological maps and cross-sections in 1:25,000 scales.
Interpretation:	Interpretation of the data on the basis of measured attitudes of beds. Use of stereographic projection in palaeocurrent analysis and statistical analysis. Interpretation of sedimentary structures and processes of sedimentation. Use of various graphical plots to interpret composition and shape of sediment grains. Interpretation on sediment sourcing. Interpretation of environments of deposition of sedimentary rocks. Interpretation of geological structures.
Field report:	The students need to prepare sketches, maps, and field notebooks containing all the relevant information. The field report includes chapters on regional setting, literature review, lithostratigraphy, environment of deposition, and structural interpretation of the area on geological maps and cross-sections. Apart from the report, the students will collect relevant rocks and fossil samples.

Fieldwork in the Lesser Himalaya (14 days; 2 credits)

Introduction:
Study of topographical and geological maps of the area, identification of main lithological, stratigraphic and structural features of the area and study of contacts of various rock units.

Title	Contents
Preparatory works	Reading of topographical and geological maps of the area, Review of literatures, Field orientation and Regulations.
Mapping:	Preparation of route maps and columnar sections of the important units. Mapping of lithological boundaries, tectonic contacts and other structural features (folds, faults). Measurement and analysis of joints, foliation, lineation, bedding, etc. Preparation of the geological maps in 1:25,000 scales. Prepare a metamorphic zonation map of the area based on index minerals. Identify the possible mineral resources in the area.
Interpretation:	Preparation of geological cross-section, analysis of structural. Interpret the environment of deposition, tectonic history and finally establishment of the geological history of the area.
Field report:	The field report includes chapter on regional setting, previous works, lithology, stratigraphy and environment of deposition, structural interpretation of the area and geological maps and cross-sections. Apart from the report, the students will collect relevant rocks and fossil samples. The students prepare drawings, maps, and field notebooks containing all the relevant information. The content of the field report may vary depending upon the actual data gathered in the field and their interpretation.

Text and reference books

1. Thrope R.S. and Brown G.C. (1995). *The Field Description of Igneous Rocks*, John Wiley and Sons, 154 p.
2. Barnes J.W. (1981). *Basic Geological Mapping*, Geological Society of London Handbook Series, No. 1 Open University Press.



3. Tucker M. (1982). *The Field Description of Sedimentation Rocks*, Geological Society of London Handbook Series, No. 1 Open University Press.
4. Fry, N. (1984). *The Field Description of Metamorphic Rocks*, Geological Society of London Handbook Series, No. 3 Open University Press.
5. Paudel, L.P., (2012). *Handbook of Field Geology*, Geo-Science Innovations (P) Ltd., 134p.
6. Tamrakar, N.K. (2013). *Handbook of Field Geology with reference to the Siwaliks*, CDGTU, Kirtipur, 162p.
7. Tamrakar, N. K. (2011). *Practical Sedimentology*, Bhrikuti Academic Publication, Kathmandu, 232p.
8. McClay, K.R. (1987). *The Mapping of Geological Structures*, John Wiley and Sons Inc., 161 p
10. Gansser, A. (1964). *Geology of the Himalayas*, John Wiley and Sons Inc.
11. Journal of Nepal Geological Society (Various issues)
12. Bulletin of Department of Geology (Various issues)

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