Kazi Nazrul University

National Curriculum Course Framework (NCCF)

For

Eight Semester Course Under

Choice Based Credit System (CBCS)

Syllabus for B.Sc. in Geology

3-Year UG Degree /4-Year UG Degree (Honours) / 4-Year UG Degree (Honours with Research)

2023

KAZI NAZRUL UNIVERSITY				FACULTY OF SCIENCE, TECHNOLOGY & VOCATIONAL STUDIES	3-Year UG Degree /4-Year UG Degree (Honours) / 4-Year UG Degree (Honours with Research)			WITH EFFECT FROM THE ACADEMIC SESSION: 2023-24									
Abbreviated Degree	**Discipline**	**Degree Programme**	**Semester**	**Course Name**	**Course Type**	**Course Code**	**Course Details**	**L - T - P**	**Course Credit**	**Sem Credit**	**CA Marks**		**ESE Marks**		**Total Marks**	**Sem Marks**
											Practical	**Theoretical**	**Practical**	**Theoretical**		
BSC	Geology	3-year UG Degree	I	Earth System Science	MAJOR	BSCGELMJ101	MJC-1	3 - 0 - 4	5	20	30	15	20	35	100	350
				Choose from the Pool of Minor Courses offered in 1st Semester by other Disciplines within the faculty	MINOR	See Pool	MNC-1	See Pool	5		See Pool				100	
				Choose from the Pool of Multidisciplinary Courses offered in 1st Semester across the faculties	MD	See Pool	MDC-1	2 - 1 - 0	3			15		35	50	
				English/MIL Communication	AE	See Pool	AEC-1	4 - 0 - 0	4			15		35	50	
				Field Geology - I	SE	BSCGELSE101	SEC-1	0 - 0 - 3	3		30		20		50	
			II	Mineral Science	MAJOR	BSCGELMJ201	MJC-2	3 - 0 - 4	5	20	30	15	20	35	100	350
				Choose from the Pool of Minor Courses offered in 2nd Semester by other Disciplines within the faculty	MINOR	Corresponding Course Code of Minor opted in 1st Semester	MNC-2	See Pool	5		See Pool				100	
				Choose from the Pool of Multidisciplinary Courses offered in 2nd Semester across the faculties	MD	See Pool	MDC-2	2 - 1 - 0	3			15		35	50	
				Environment Studies	VA	VA201	VAC-1	4 - 0 - 0	4			15		35	50	
				Field Geology - II	SE	BSCGELSE201	SEC-2	0 - 0 - 3	3		30		20	35	50	
			Student exiting the programmes after securing 40 credits will be awarded UG Certificate in the relevant Discipline/Subject provided they secure following 4 credits in work based vocational courses / summer internship during 1st year													
			II	Vocational Course / Summer Internship	Any One	VC / SI	VC201 / SI201	VCC-1 / SIC-1	0 - 0 - 8	4	24	30		20		50	400
			III	Elements of Geochemistry & Geophysics	MAJOR	BSCGELMJ301	MJC-3	3 - 0 - 4	5	22	30	15	20	35	100	400
				Structural Geology	MAJOR	BSCGELMJ302	MJC-4	3 - 0 - 4	5		30	15	20	35	100	
				Choose from the Pool of Minor Courses offered in 3rd Semester by other Disciplines within the faculty	MINOR	See Pool	MNC-3	See Pool	5		See Pool				100	
				Choose from the Pool of Multidisciplinary Courses offered in 3rd Semester across the faculties	MD	See Pool	MD-3	2 - 1 - 0	3			15		35	50	
				English Communication	AE	AEC301	AEC-2	4 - 0 - 0	4			15		35	50	
			IV	Igneous Petrology	MAJOR	BSCGELMJ401	MJC-5	3 - 0 - 4	5	22	30	15	20	35	100	400
				Metamorphic Petrology	MAJOR	BSCGELMJ402	MJC-6	3 - 0 - 4	5		30	15	20	35	100	
				Choose from the Pool of Minor Courses offered in 4th Semester by other Disciplines within the faculty	MINOR	See Pool	MNC-4	See Pool	5		See Pool				100	
				Field Geology - III	SE	BSCGELSE401	SEC-3	3 - 0 - 0	3		30		20		50	

				Choose from the Pool of Value-Added Course offered in 4th Semester		VA	See Pool	VAC-2	See Pool	4			15		35	50	
			Student exiting the programmes after securing 84 credits will be awarded UG Diploma in the relevant Discipline/Subject provided they secure following 4 credits in work based vocational courses / summer internship during 2nd year														
			IV	Vocational Course	Any One	VC	VC401	VCD-1	0 - 0 - 8	4	26	30		20		50	450
				Summer Internship		SI	SI401	SID-1									
			V	Sedimentology		MAJOR	BSCGELMJ501	MJC-7	3 - 0 - 4	5	20	30	15	20	35	100	400
				Palaeontology		MAJOR	BSCGELMJ502	MJC-8	3 - 0 - 4	5		30	15	20	35	100	
				Hydrogeology		MAJOR	BSCGELMJ503	MJC-9	3 - 0 - 4	5		30	15	20	35	100	
				Choose from the Pool of Minor Courses offered in 5th Semester by other Disciplines within the faculty		MINOR	See Pool	MNC-5	See Pool	5		See Pool				100	
			VI	Remote Sensing and GIS		MAJOR	BSCGELMJ601	MJC-10	3 - 0 - 4	5	22	30	15	20	35	100	450
				Economic Geology & Fuel Geology		MAJOR	BSCGELMJ602	MJC-11	3 - 0 - 4	5		30	15	20	35	100	
				Stratigraphy		MAJOR	BSCGELMJ603	MJC-12	3 - 0 - 4	5		30	15	20	35	100	
				Geotectonics		MAJOR	BSCGELMJ604	MJC-13	3 - 0 - 4	5		30	15	20	35	100	
				Summer Internship		SI	SI601	SIMC-1	0 - 0 - 4	2		30		20		50	
				Total Credit and Marks		**TOTAL CREDIT**					**126**	**TOTAL MARKS**				**2350**	
			Students who want to undertake 3-year UG programme will be awarded UG Degree in the relevant Discipline / Subject upon securing 126 credits														
		4 - Year UG Degree (Honours)	**VII**	Mineral Exploration & Mining		MAJOR	BSCGELMJ701	MJC-14	3 - 0 - 4	5	25	30	15	20	35	100	500
				Engineering Geology		MAJOR	BSCGELMJ702	MJC-15	3 - 0 - 4	5		30	15	20	35	100	
				Environmental Geology		MAJOR	BSCGELMJ703	MJC-16	3 - 0 - 4	5		30	15	20	35	100	
				Statistical Analysis and Computer Application in Geology		MAJOR	BSCGELMJ704	MJC-17	3 - 0 - 4	5		30	15	20	35	100	
				Choose from the Pool of Minor Courses offered in 7th Semester by other Disciplines within the faculty		MINOR	See Pool	MNC-6	See Pool	5		See Pool				100	
			VIII	Oceanography & Climatology		MAJOR	BSCGELMJ801	MJC-18	3 - 0 - 4	5	22	30	15	20	35	100	500
				Colloquium		MAJOR	BSCGELMJ802	MJC-19	2 - 0 - 4	4		30	15	20	35	100	
				Mineral Beneficiation & Mineral Economics		MAJOR	BSCGELMJ803	MJC-20	2 - 0 - 4	4		30	15	20	35	100	
				Industrial Training		MAJOR	BSCGELMJ804	MJC-21	2 - 0 - 4	4		30	15	20	35	100	
				Choose from the Pool of Minor Courses offered in 8th Semester by other Disciplines within the faculty		MINOR	See Pool	MNC-7	See Pool	5		See Pool				100	
				Total Credit and Marks		**TOTAL CREDIT**					**173**	**TOTAL MARKS**				**3350**	
			Students who want to undertake 4-year UG Honours program will be awarded UG Degree (Honours) in the relevant Discipline / Subject provided they secure 173 credits														
		4 - Year UG Degree (Honours with Research)	**VII**	Mineral Exploration & Mining		MAJOR	BSCGELMJ701	MJC-14	3 - 0 - 4	5	25	30	15	20	35	100	500
				Engineering Geology		MAJOR	BSCGELMJ702	MJC-15	3 - 0 - 4	5		30	15	20	35	100	
				Environmental Geology		MAJOR	BSCGELMJ703	MJC-16	3 - 0 - 4	5		30	15	20	35	100	
				Statistical Analysis and Computer Application in Geology		MAJOR	BSCGELMJ704	MJC-17	3 - 0 - 4	5		30	15	20	35	100	
				Choose from the Pool of Minor Courses offered in 7th Semester by other Disciplines within the faculty		MINOR	See Pool	MNC-6	See Pool	5		See Pool				100	
			VIII	Oceanography & Climatology		MAJOR	BSCGELMJ801	MJC-18	3 - 0 - 4	5	22	30	15	20	35	100	500

				Research Methodology	RP	BSCGELRP801	RPC-1	4 - 0 - 0	4			30		70	100	
				Dissertation	RP	BSCGELRP802	RPC-2	0 - 0 - 16	8		120		80		200	
				choose from the Pool of Minor Courses offered in 8th Semester by other Disciplines within the faculty	MINOR	See Pool	MNC-7	See Pool	5		See Pool				100	
				Total Credit and Marks	**TOTAL CREDIT**					**173**	**TOTAL MARKS**				**3350**	
		Students who want to undertake 4-year UG Honours with Research program will be awarded UG Degree (Honours with Research) in the relevant Discipline / Subject provided they secure 173 credits														

Abbreviations: MJ-= Major;MJC-= Major Course;MN= Minor;MNC= Minor Course; AE= Ability Enhancement; AEC= Ability Enhancement Course; SE= Skill Enhancement; SEC= Skill Enhancement Course; MD= Multidisciplinary ; MDC= Multidisciplinary Course; SI - Summer Internship;SIC - Summer Internship for Certificate; SID:Summer Internship for Diploma; SIMC - Summer Internship Mandatory Course; RP= Research Project ;RPC= Research Project Course; VA= Value Added;VAC= Value Added Course; VC= Vocational Course; VCC= Vocational Course for Certificate; VCD= Vocational Course for Diploma; CA= Continuous Assessment, ESE= End Semester Examination, L= Lecture Hour; T= Tutorial Hour and P= Practical Hour/ Field Work and NA= Not Applicable

Note: Minor Courses (MNC) : Students of a particular UG Course will choose from the Pool of Minor Courses offered by disciplines other than the major discipline opted by the student within the faculty. The student is required to opt the same Minor Discipline in the 2nd semester which he had opted in 1st semester. Explanation: If a student of Physics Major, opts for a Minor Course offered by Chemistry in 1st semester then that student is required to continue with the Minor Course offered by Chemistry for 2nd semester as Minor Course in the 2nd semester.

Semester wise Pool of Minor Courses offered by Geology for other Disciplines within the Faculty

Discipline	Semester	Course Name	Course Type	Course Code	Course Details	L - T - P	Course Credit	Sem Credit	CA Marks		ESE Marks		Total Marks	Sem Marks
									Practical	Theoretical	Practical	Theoretical		
Geology	I	Earth System Science	MINOR	BSCGELMN101	MNC-1	3 - 0 - 4	5	NA	30	15	20	35	100	NA
	II	Mineral Science		BSCGELMN201	MNC-2	3 - 0 - 4	5		30	15	20	35	100	
	III	Essentials of Petrology		BSCGELMN301	MNC-3	3 - 0 - 4	5		30	15	20	35	100	
	IV	Structural Geology & Geodynamics		BSCGELMN401	MNC-4	3 - 0 - 4	5		30	15	20	35	100	
	V	Essentials of Palaeontology		BSCGELMN501	MNC-5	3 - 0 - 4	5		30	15	20	35	100	
	VI	**NA**		**NA**					**NA**					
	VII	Geology of India		BSCGELMN701	MNC-6	3 - 0 - 4	5		30	15	20	35	100	
	VIII	Economic and Fuel Geology		BSCGELMN801	MNC-7	3 - 0 - 4	5		30	15	20	35	100	

Semester wise Pool of Multidisciplinary Courses offered by Geology for other Disciplines across the Faculties

Discipline	Semester	Course Name	Course Type	Course Code	Course Details	L - T - P	Course Credit	Sem Credit	CA Marks		ESE Marks		Total Marks	Sem Marks
									Practical	Theoretical	Practical	Theoretical		
Geology	I	A B C D of Geology	MD	MDC121	MDC-2	2 - 1 - 0	3	NA		15		35	50	NA
	II	The Past Life on Earth	MD	MDC222	MDC-2	2 - 1 - 0	3	NA		15		35	50	NA
	III	Remote Sensing and GIS	MD	MDC309	MDC-3	2 - 1 - 0	3	NA		15		35	50	NA

Semester- I

Discipline Specific Major (and Minor) Course

Course Name: EARTH SYSTEM SCIENCE

Course Code: BSCGELMJ101

Course Type: **MAJOR**	Course Details: **MJC-1**			L-T-P: **3 - 0 - 4**	
Credit: **5** Theory 4, Practical 1	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

OR

Course Code: BSCGELMN101

Course Type: **MINOR**	Course Details: **MNC-1**			L-T-P: **3 - 0 - 4**	
Credit: **5** Theory 4, Practical 1	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

THEORY

Unit 1: Introduction (Credit Hours – 10)
Earth System Science – Definition, history of evolution of Earth Sciences, and its different branches; Brief idea about the origin of the Universe, Solar System and its planets; the Terrestrial and Jovian planets; Meteorites and Asteroids; Earth: origin, size, shape, mass, density, rotational and revolution parameters.

Unit 2: Solid Earth and its fluid cover (Credit Hours – 10)
Internal constitution - its recognition vis-à-vis solid earth geophysics: crust, mantle, core, evidence from seismic waves and rocks, lithosphere and asthenosphere; Elementary idea about the hydrosphere, atmosphere and biosphere: Nature of Earth's magnetic field.

Unit 3: Crust and the supracrustal materials (Credit Hours – 10)
Major constituents of the crust; Minerals - definition and classification; Rocks – Types, rock cycle, brief idea about their origin, general classification; Fossil: Definition, broad idea about different types.

Unit 4: Tectonics (Credit Hours – 10)
Brief idea about the Continental Drift Theory, Sea-floor Spreading and Plate Tectonics.

Unit 5: Earth surface processes (Credit Hours – 10)
Rock weathering; Formation of soil, soil profile and soil types; Erosion; mass wasting; Geological work of wind, river and glacier; coastal processes, oceanic current system and effect of Coriolis force; Concepts of eustasy

Unit 6: Introduction to the concept of deep time in geological studies (Credit Hours – 10)
Stratigraphy: definition and scope, Brief history of development of stratigraphic principles; concepts of Neptunism, Plutonism and Uniformitarianism
Geological Time Table, introduction to geochronological methods and their application in geological studies
Fundamental laws of stratigraphy: Superposition, Faunal succession and correlation

PRACTICAL

Study of major geomorphic features and their relationships with outcrops through physiographic maps; Principles of Topographic Sheet indexing; Detailed study of topographic sheets and preparation of physiographic description of an area, Preparation of topographic profile.

SUGGESTED READINGS:

1. Duff, P. M. D., & Duff, D (Eds.),1993. *Holmes' principles of physical geology*. Taylor & Francis.
2. Emiliani, C.,1992. *Planet earth: cosmology, geology, and the evolution of life and environment*. Cambridge University Press.
3. Gross, M. G. ,1977. *Oceanography: A view of the earth*.
4. Robert S. Anderson and Suzzane P. Anderson, 2010. *Geomorphology - The Mechanics and Chemistry of Landscapes.* Cambridge University Press.
5. Faure, Gunter. 1986. "Principles of isotope geology". Wiley International.

Skill Enhancement Course

Course Name: FIELD GEOLOGY - I

Course Code: BSCGELSE101

Course Type: **Skill Enhancement Course**	Course Details: **SEC-1**			L-T-P: **0 - 0 - 3**	
Credit: **3** (Practical)	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**….**	**20**	**…..**

Unit 1: Basic idea about field geology (10 Credit Hours)
Field work ethics: dos and don'ts in field; Determination of topographic sheet number; Study of topographic sheets; Comparison of topographic sheet of a specific area with satellite imagery (Google Earth); Basic principles of clinometer compass and Brunton compass

Unit 2: Field work (At least of five days duration; 35 Credit Hours)
Field reconnaissance and identification of reference unit; Basic techniques of fixation of location on the reference toposheet or satellite imagery; study of different types of outcrops, rock types and their disposition; acquisition of basic field data; collection of samples (including oriented samples); basic principles of field photography.

Multi-Disciplinary Course

Course Name: A B C D OF GEOLOGY

Course Code: MDC-121

Course Type: **MD**	Course Details: **MDC-1**			L-T-P: 2 **- 1 - 0**	
Credit: **3**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		-	**15**	**-**	**35**

THEORY

Unit 1: Introduction

General idea about Earth and solar system; The concept of lithosphere, hydrosphere, biosphere and atmosphere.

Unit 2: Geology and its branches

Definition; The basic units of studying geology; Branches of geology and what do these different units tell us.

Unit 3: Natural resources and their use

The definition of natural resources; Mineral resources, their use and distribution of mineral resources found in India.
Energy resources: Non-renewable and renewable energy resources; Coal, Petroleum, Nuclear fuel: their occurrence and use; The scope of renewable energy resource in India

Unit 4: Natural disaster and their effects

Earthquake, landslide, flood, Tsunami, and volcanism and their effects on human life.

SUGGESTED READINGS:

1. Mukherjee, P.K. Introduction to Geology
2. Duff, P. M. D., & Duff, D (Eds.),1993. *Holmes' principles of physical geology*. Taylor & Francis.
3. Coch, N.K. (1994): Geohazards: Natural and Human, Pearson College.
4. Valdiya K.S. 2013 Environmental Geology : Ecology, Resource and Hazard Management. McGraw Hill Education (India)Private Limited.

Semester- II

Discipline Specific Major (and Minor) Course

Course Name: MINERAL SCIENCE

Course Code: BSCGELMJ201

Course Type: **MAJOR**	Course Details: **MJC-2**			L-T-P: **3 - 0 - 4**	
Credit: **5** Theory 4, Practical 1	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

OR

Course Code: BSCGELMN201

Course Type: **MINOR**	Course Details: **MNC-2**			L-T-P: **3 - 0 - 4**	
Credit: **5** Theory 4, Practical 1	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

THEORY

Unit 1: Crystallography (20 Credit Hours)
Elementary ideas about crystal morphology in relation to internal structures; Crystal parameters and indices; Crystal symmetry and classification of crystals into point groups, space groups; Stereographic projections of symmetry elements and forms; Characteristics of crystal systems; Crystal defects; X-ray crystallography.

Unit 2: Rock forming minerals (20 Credit Hours)
Physical and chemical properties; Substitution principles – Goldschmidt's rule of substitution of elements; partitioning of elements between coexisting phases; Brief idea about Isomorphism, Solid solution, Pseudomorphism and Polymorphism: elementary concept on principle types – common polymorphic forms of C, SiO_2 and Al_2SiO_5; Crystal structure and its controls: bonding and coordination principles.
Classification of silicate groups based on structure and derivation of structural formulae based on composition with example of common rock-forming minerals from each group, Non-silicate structures; CCP and HCP structures

Unit 3: Optical mineralogy (20 Credit Hours)
Optical behaviour of crystals – Isotropic and anisotropic minerals; Nicol prism and its principle of construction; Polaroid; Refractive index of minerals; Uniaxial & Biaxial minerals; Optical indicatrix of uniaxial and biaxial minerals; Birefringence, Interference colour and use of interference colour chart; Relation between crystallographic and optical axes of crystals;

Pleochroism and pleochroic scheme; Extinction; Study of interference figures; Optic sign of uniaxial and biaxial minerals

PRACTICAL

Unit 1: Study of physical properties of common rock-forming minerals in hand specimen
Unit 2: Study of the symmetry of crystals in hand specimen; Solution of crystallographic problems through stereographic projection
Unit 3: Study of optical properties of common rock-forming minerals: quartz, orthoclase, microcline, plagioclase, perthite, nepheline, olivine, orthopyroxene, clinopyroxene, hornblende, staurolite, garnet, muscovite, biotite, calcite
Unit 4: Determination of extinction angle and pleochroic scheme; Determination of optic sign from interference figures

SUGGESTED READINGS:

1. Klein, C., Dutrow, B., Dwight, J., & Klein, C., 2007. *The 23rd Edition of the Manual of Mineral Science (after James D. Dana)*. J. Wiley & Sons.
2. Kerr, P. F., 1959. *Optical Mineralogy*. McGraw-Hill.
3. Verma, P. K., 2010. *Optical Mineralogy (Four Colour)*. Ane Books Pvt Ltd.
4. Deer, W. A., Howie, R. A., and Zussman, J., 1992. *An introduction to the rock-forming minerals*. London, Longman.

Skill Enhancement Course

Course Name: FIELD GEOLOGY - II

Course Code: BSCGELSE201

Course Type: **Skill Enhancement Course**	Course Details: **SEC-2**			L-T-P: **0 - 0 - 3**	
Credit: **3** (Practical)	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**….**	**20**	**…..**

Unit 1: Field work (At least of five days duration; 35 Credit Hours)
Usage of topographic sheet and satellite imagery in the field; Usage of GPS
Study of different types of rock outcrop; study of different rock types (Igneous, Metamorphic and Sedimentary) in the field; Acquisition of different field data and collection of samples including oriented ones; field photography.

Unit 3: Sample processing (10 Credit Hours)
Preparation of thin sections of collected samples and study under microscope; Sampling protocol, recovery and restoration of fossil samples.

Multi-Disciplinary Course

Course Name: THE PAST LIFE ON EARTH

Course Code: MDC-221

Course Type: **MD**	Course Details: **MDC-2**			L-T-P: 2 **- 1 - 0**	
Credit: **3**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		-	**15**	**-**	**35**

THEORY

Unit 1. Introduction

Scope and purpose of Palaeontology; Geological time, dating methods

Unit 2. Origin and Evolution of Life

Early Earth conditions and origin of life; Evolution of prokaryotes, eukaryotes, and multicellular organisms

Unit 3. Paleozoic Era

Key events and fossil groups (trilobites, brachiopods, early fishes); - Paleozoic extinction events

Unit 4. Mesozoic Era

Major events and fossil groups (ammonites, dinosaurs, early mammals, birds); Impact of Mesozoic extinction events

Unit 5. Cenozoic Era and Modern Life

Diversification of mammals and birds; Development of modern ecosystems and Cenozoic extinction events

Unit 6. Human Evolution

Fossil evidence of early human ancestors; Key discoveries in paleoanthropology

SUGGESTED READINGS:

1. "Invertebrate Paleontology and Evolution" by E. N. K. Clarkson
2. "Vertebrate Paleontology" by Michael J. Benton
3. "Principles of Paleontology" by M. Foote and A. Miller, Freeman, NYC, (2008)

Semester- III

Discipline Specific Major Course

Course Name: ELEMENTS OF GEOCHEMISTRY & GEOPHYSICS

Course Code: BSCGELMJ301

Course Type: **MAJOR**	Course Details: **MJC-3**			L-T-P: **3 - 0 - 4**	
Credit: **5** Theory 4, Practical 1	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

THEORY

Geophysics:

Unit 1: **Introduction to Geophysics (1 Credit Hour)**
General introduction; Different branches of Geophysics. Relationship between Geology and Geophysics.

Unit 2: Gravity Method (4 Credit Hours)
Gravity and its variation over the surface of the Earth. Principle of Gravimeters; Gravity field surveys. Gravity reduction, Gravity anomaly, Isogal maps and their interpretation.

Unit 3: **Magnetic Method (3 Credit Hours)**
Geomagnetic field, Principle of Magnetometers. Magnetic field survey, preparation of magnetic anomaly maps and their interpretation.

Unit 4: Electrical Methods (3 Credit Hours)
Electrical properties of rocks. Resistivity method, Induced Polarisation Method and Self potential method. Field procedure, interpretation of electrical profile.

Unit 5: **Seismic Method (3 Credit Hours)**
Refraction and Reflection seismic surveys. Seismic data acquisition and interpretation.

Unit 6: Well logging (7 Credit Hours)
Principle of electrical logging. Types of logging: Open hole, cased hole logging; Caliper, Induction, Spontaneous Potential, Sonic, Neutron; Gamma Ray log.

Unit 7: Application of Geophysics **(9 Credit Hours)**
Groundwater prospecting, Mineral exploration, Engineering Geology, Petroleum exploration, Archeological studies, Environmental studies.

Geochemistry:

Unit 5: Concepts of geochemistry (6 Credit Hours)

Nucleosynthesis, Cosmic abundance of elements: Distribution of elements in solar system and in Earth; Introduction to chemical differentiation and composition of the Earth, Composition of the bulk silicate Earth, Atomic environment of elements. Geochemical classification of elements. Uses of major, minor trace and REE in magmatic evolution, concept of Kd and D.

Unit 6: Isotope Geology (11 Credit Hours)

Internal structure of atoms, nuclear systematics, atomic weights, and isotopes (Stable and radioactive isotopes), nuclear stability and abundance. Decaying mechanism-Beta decay, positron decay, electron capture decay, alpha decay, nuclear fission. Decay laws and half-life. Geochronology-K-Ar, Rb-Sr, Sm-Nd, and U-Pb dating and their application in Geology.

Unit 7: Aqueous geochemistry (3 Credit Hours)

Role of ionic potential; hydrogen ion concentration and oxidation-Reduction potential in sedimentation; Eh- pH diagrams of Mn- H_2O systems and Fe-H_2O systems with and without CO_2.

Unit 8: General concepts about geochemical cycles (10 Credit Hours)
The atmosphere: Structure and composition of atmosphere; geochemical cycle of nitrogen. The evolution of atmosphere Formation and destruction of ozone layer, Ozone hole. The Hydrosphere: Distribution of water on the earth; average compositions of sea water, river water and ground water; origin and evolution of sea water, chemical evolution of ground water, The Biosphere: Concept of biosphere, Geochemical cycle of carbon.

PRACTICAL

Geophysics
Anomaly and background- Graphical method
Study and interpretation of seismic reflector geometry
Problems on gravity anomaly
Geochemistry
Interpretation of geochemical data: Bivariate and trivariate plots to delineate the control of different compositional variables : Harker variation diagram, AFM diagram, MgO diagram,compatible and incompatible element variation.
Simple examples of determining radiometric age from given data on appropriate mother & daughter isotopes.

SUGGESTED READINGS:

1. Lowrie, W. (2007). Fundamentals of geophysics. Cambridge University Press.
2. Telford, W. M., Geldart, L. P., & Sheriff, R. E. (1990). Applied geophysics (Vol. 1). Cambridge University Press.
3. Haldar, S.K., 2013. Mineral Exploration: Principles and Applications. Elsevier.
4. Exploration Geophysics - An Outline by Bhimasarikaram V.L.S., Association of Exploration Geophysicists, Osmania University, Hyderabad, 1990.
5. Mason, B. (1986) Principles of Geochemistry. 3rd Edition, Wiley New York.
6. Rollinson, H. (2007) Using geochemical data – evaluation, presentation and interpretation. 2nd Edition. ROUTLEDGE.

7. Walther, J. V. (2009). Essentials of geochemistry. Jones and Bartlett Publishers, Inc
Albarède, F. (2003). Geochemistry: an introduction. Cambridge University Press.
8. Faure, Gunter and Teresa M. Mensing (2004). Isotopes: Principles and Applications, Wiley India Pvt. Ltd

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Discipline Specific Major Course

Course Name: STRUCTURAL GEOLOGY

Course Code: BSCGELMJ302

Course Type: **MAJOR**	Course Details: **MJC-4**			L-T-P: **3 - 0 - 4**	
Credit: **5** Theory 4, Practical 1	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

THEORY

Unit 1: Introduction to structural geology (5 Credit Hours)

Different schemes of classifying geological structures. Attitudes of planar and linear structures; concepts of dip, strike, plunge, pitch (or rake), trend etc. Basic principles of stereographic and equal area projection.

Unit 2: Unconformity (1 Credit hour)

Definition, types, and significance of each type

Unit 2: Rock deformation and Rheology (10 Credit Hours)

Concept of Stress: normal stress, shear stress, concept of stress ellipsoid, principal axes of stress, planes of maximum shear stress, Mohr circle of stress.

Concept of strain: Longitudinal and shear strain, principal axes of strain, concept of strain ellipsoid, Mohr circle for strain

Homogenous and inhomogeneous strain, Rotational and irrotational strain in rocks. Strain ellipsoids of different types and their geological significance. Flinn and Ramsay's diagram. Basic methods of strain analysis.

Rheological properties of rocks, Concept of rock deformation- brittle and ductile deformation, Factors controlling deformation behaviour of rocks.

Unit 3: Folds (15 Credit Hours)

Fold morphology and structural elements; Morphological classification of folds

Outcrop patterns of folds, Geometric classification of folds

Mechanics of folding- buckling, bending. Kinematics of folding- flexural folding, flexural slip and flow folding, shear folding and passive folding

Superposed folding, morphological types, classification and basic geometric analysis in polydeformed terranes

Unit 4: Foliation and lineation (10 Credit Hours)

Morphological features of foliations and lineations; Tectonic significance of foliation and lineation, Relation of foliation and lineation with folds; Brief idea of origin of foliation, Deformation mechanism, microstructure and fabric development

Unit 5: Fractures, Joints and Faults (10 Credit Hours)

Classification of fractures- Faults and Joints; Joint- common terminology, characteristics and classification; Relation of Joints to Folds, exhumation and igneous bodies; Fault zone terminology, Geometric classification of faults; Effects of faulting on the outcrops, Criteria for recognition of faults, Fault zone rocks; Anderson dynamic analysis of faulting, Characteristics of Normal, Reverse and Strike slip fault systems; Thrust and thrust related deformation; Mechanics of fracturing and faulting.

Unit 6: Ductile shear zones (DSZ) (10 Credit Hours)

Types of Shear zones and their kinematics, Shear zone rocks, classification of mylonitic rocks; shear sense indicators.

PRACTICAL

Topographic maps. General idea about the outcrop patterns of different structures.

Stereographic projections of planes and lines

3-point problems, fold-fault problems and their solutions through graphical methods and stereographic projection methods.

Interpretation of geological maps with unconformity, fault, fold and igneous bodies. Construction of structural cross section.

Completion of outcrop.

Application of Borehole and Rotational Problems in Structural analyses

Simple strain analysis problems.

Recognition of fold interference from outcrop patterns.

SUGGESTED READINGS:

1. Billings M.P. (1987). Structural Geology, 4th edition Prentice-Hall.
2. Davis, G.H., Reynolds, S.J., and Kluth, C.F. (2012). Structural Geology of Rocks and Region. 3rd edition. John Wiley and Sons, lnc.
3. Fossen,H. (2016). Structural Geology. Second Edition. Cambridge University Press.
4. Ghosh, S.K (1993). Structural Geology Fundamentals and Modern Development. Pergamon Press.
5. Twiss R. J. and Moores E.M. (2007). Structural Geology, Second Edition, W.H. Freeman and Company.
6. Ramsay, J.G., 1967. Folding and fracturing of rocks. McGraw-Hill.
7. Ramsay, J.G. and Huber, M.I., 1984 & 1987. The Techniques of Modern Structural Geology – Volumes 1 & 2, respectively. Academic Press.
8. Ragan, D. M., 2009. Structural Geology: an introduction to geometrical techniques. 4th Edition, Cambridge University Press (For Practical)
9. Park, R.G. (2005). Foundation of Structural Geology, 3rd Edition, Routledge.
10. Marshak, S and Mitra G. (1988) Basic Methods in Structural Geology, Prentice Hall.

11. Ben A. van der Pluijm and Stephen Marshak (2004) Earth Structure: An Introduction to Structural Geology and Tectonics (Second Edition) 2nd Edition
12. Passhier, C. and Trouw, RAJ, 2005. Microtectonics. Springer, Berlin.
13. Pollard, D.D. and Fletcher, R.C., 2005. Fundamentals of structural geology, Cambridge University Press.
14. Rowland, S.M., Duebendorfer, E. and Schiefelbein, I.M., 2007. Structural analysis and synthesis: a laboratory course in structural geology, Blackwell Pub.

Discipline Specific Minor Course

Course Name: ESSENTIALS OF PETROLOGY

Course Code: BSCGELMN301

Course Type: **MINOR**	Course Details: **MNC-1**			L-T-P: **3 - 0 - 4**	
Credit: **5** Theory 4, Practical 1	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

THEORY

Unit 1 Introduction
Rocks: Definition, the major rock types, Distinction between three types of rocks; Crustal abundance of rocks

Unit 2 Igneous rocks
Field observations of igneous rocks; Large scale features: Extrusive vs Intrusive structures; Small scale features; Classification of igneous rocks; Textures and structures in igneous rocks

Unit 3 Petrogenesis of igneous rocks
Origin of common igneous rocks like granite, basalt, anorthosite; Plate tectonics and emplacement of igneous rocks

Unit 4 Sedimentary rocks
Sediments: Types of terrigenous and chemical sediments; origin of sediments, deposition and lithification; Depositional environment of sedimentary rocks

Unit 5 Metamorphic rocks and metamorphism
What is metamorphism and metamorphic rock; Classification of metamorphic rocks; Factors of metamorphism.

Unit 6 Structure and texture in metamorphic rocks
Foliated and non-foliated metamorphic rocks and structure and texture found therein; Interpretation of temporal relation between metamorphism and deformation from textures.

Unit 7 Genetic classification of metamorphism
Grade, zone, Barrovian Zonal Scheme and Facies concept in metamorphism; Different facies types and facies series.

Unit 8 Progressive metamorphism
Progressive metamorphism of basic, pelitic rocks. Relationship between tectonism and metamorphism.

PRACTICAL

Study of common igneous and metamorphic rocks in hand specimens.
Study of hand specimens of sedimentary rocks and primary structure therein
Petrographic study of common igneous, metamorphic and sedimentary rocks.

SUGGESTED READINGS:

1. Frost, B. R. and Frost, C. D. (2019). Essentials of Igneous and Metamorphic Petrology, 2nd ed. Cambridge University Press
2. Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
3. Yardley, B. W., & Yardley, B. W. D. (1989). An introduction to metamorphic petrology. Longman Earth Science Series.
4. Myron G. Best (2001). Igneous and Metamorphic Petrology, 2nd ed. Wiley-Blackwell
5. Ehlers, E.G. & Blatt, H. (1987) Petrology Igneous, Sedimentary and Metamorphic W. H. Freeman and Company (USA), Indian Edition CBS Publishers and Distributors, New Delhi

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Multi-Disciplinary Course

Course Name: REMOTE SENSING AND GIS

Course Code: MDC-309

Course Type: **MD**	Course Details: **MDC-3**			L-T-P: 2 **- 1 - 0**	
Credit: **3**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		-	**15**	**-**	**35**

THEORY

Unit 1: What is remote sensing

Remote Sensing Process, Electromagnetic Spectrum; Electromagnetic Interactions, Interactions with the Atmosphere, Interactions with the Target, Spectral response (Spectral Signatures). Remote Sensing Platforms Systems, Ground based platforms, Airborne platforms, Satellite; Remote Sensing Sensors, Passive Remote Sensing, Active Remote Sensing, Sensors' resolution, Examples of Remote sensing satellites.

Unit 2: Aerial and Satellite Images

Types of Remotely sensed images, Aerial photography, Satellite imagery, Differences between Aerial photography and Satellite imagery. Colour Composites, Natural or True Colour Composites, False Colour Composites.

Unit 3: Remote Sensing Image Processing

Pre-processing: Radiometric correction, Atmospheric correction, Geometric corrections; Image Transformation, Image Classification.

Unit 4: What is Geographic Information System (GIS)

Basic concepts of GIS. GIS data, spatial and attribute data; Spatial data model: Raster & Vector; GIS components: Hardware for GIS, GIS Software, Data and GIS.

Unit 5: Applications of Remote Sensing and GIS techniques:

Watershed Studies, Flood Studies, Utility Studies, Security and Defence Studies, Urban and infrastructure Studies, Disaster Relief Management

SUGGESTED READINGS:

1. Paine, D.P., 1986. Aerial photography and image interpretation for resource management, Wiley and Sons, New York.
2. Ramasamy, SM., 1999. Trends in Geological Remote Sensing - Rawat Publishers, Jaipur
3. Rolf, A. de, 2001. Principles of Geographic Information Systems-An introductory textbook. ITC Educational Textbook Series. Enschede, The Netherlands.
4. Wilhelm Burger; Mark J. Burge, 2007. Digital Image Processing: An Algorithmic Approach Using Java. Springer.
5. Lo C.P. and Albert K. W. Yeung, 2002. Concepts and Techniques of Geographic Information System. Prentice –Hall, India.

Semester- IV

Discipline Specific Major Course

Course Name: IGNEOUS PETROLOGY

Course Code: BSCGELMJ401

Course Type: **MAJOR**	Course Details: **MJC-5**			L-T-P: **3 - 0 - 4**	
Credit: **5** Theory 4, Practical 1	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

THEORY

Unit 1: Introduction to Igneous Petrology (3 Credit Hours)

Modes of magma generation in the lower crust, upper mantle and core mantle boundary.
Definition of magma and lava, physical properties of magma, temperature , viscosity ,volatile content and density of the magma. Concept of plutonic, volcanic and hypabyssal igneous rock. Mode of emplacement of magma. Different types of lava.

Unit 2: Forms and Structures of Igneous Rock Bodies (5 Credit Hours)

Concordant and Discordant form of igneous body. Dykes and Sills, Cone sheet and Ring Dyke, Laccoliths, Lopoliths, Phacoliths, Bysmaliths, Batholiths,
Mode of occurrence of Extrusive rock
Lava Flows, Pahoehoe lava, Aa lava, Pillow lava, Buried lava flow, pyroclastic rocks

Unit3: Texture and Microstructure of Igneous Rock (8 Credit Hours)

Crystallinity, Granularity, Shape and mutual relations among the grains, nucleation and rate of growth of minerals.
Description of the following texture and microstructure with their occurrences in the different rocks – Panidiomorphic granular, hypidiomorphic granular, allotriomorphic granular, porphyritic, vitrophyric, poikilitic, ophitic, sub ophitic, intergranular, Intersertal, pilotaxitic, trachytic, graphic, granophyric, rapakivi, orbicular, corona and keliphitic rims, perthitic, myrmekitic, variolitic, spherulitic and spinifex, vesicular and amygdaloidal structures.

Unit 4: Classification of Igneous rocks and petrographic description (10 Credit Hours)

Bases of classification of Igneous rocks, mineralogical, textural, chemical, chemico-mineralogical, associational and tectonic, IUGS classification, TAS diagram
Description of following rocks in terms of mineralogy, texture and Indian occurrences. Granite, Granodiorite, Tonalite, Diorite, Monzonite, Pegmatite, Aplite, Norite, Gabbro, Dolerite, Syenite, Nepheline syenite, Anorthosite, Peridotite, Pyroxenite, Dunite, Lherzolite, Harzburgite, Wherlite, Lamprophyre, Carbonatite, Komatite, Basalt, Andesite, Rhyolite, Dacite, Phonolite, Carbonatite.

Unit 5: Phase Diagrams (14 Credit Hours)

Phase rules and its application in Eutectic, Peritectic and solid solution system. Phase equlibria in the following binary and ternary systems and their significance diopside-anorthite, forsterite-silica,

Nepheline-silica, albite-anorthite, albite-orthoclase, diopside-albite-anorthite, anorthite-forsterite-silica, quartz -albite- orthoclase, forsterite-diopside-silica, nepheline-kalsilite-silica.
Bowen's reaction series.

Unit 6: Petrogenesis of Igneous rocks (12 Credit Hours)
Magmatic processes, crystal settling by gravitational process, filter pressing, magma convection, flowage differentiation, mixing of magma, magmatic assimilation, magmatic differentiation and diversity of igneous rocks and fractional crystallization
Petrogenesis of felsic and mafic igneous rocks: granitoids (I-, S-, M-, and A-type), basalt, anorthosite, alkaline rocks, carbonatites.

Unit 7: **Magmatism in different tectonic setting (8 Credit Hours)**
Basic ideas on Mantle convection, Mantle melting, batch melting and partial melting
MORB and IAB. Large igneous province and mantle plume, Deccan Basalt.
General idea about layered complexes and Ophiolite complexes.

PRACTICAL

Study of important igneous rocks in hand specimens and thin sections - granite, granodiorite, diorite, syenite, nepheline syenite, gabbro, anorthosites, ultramafic rocks, basalts, andesites. Determination of normative composition and nomenclature of igneous rocks from given bulk rock chemical analyses.

SUGGESTED READINGS:

1. Philpotts, A., and Ague, J., 2009. Principles of igneous and metamorphic petrology. Cambridge University Press.
2. Winter, J. D., 2014. Principles of igneous and metamorphic petrology. Pearson.
3. Rollinson, H. R., 2014. Using geochemical data: evaluation, presentation, interpretation. Routledge.
4. Raymond, L. A., 2002. Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
5. McBirney, A. R., 1984. Igneous Petrology. San Francisco (Freeman, Cooper & Company) and Oxford (Oxford Univ. Press),
6. Best, M. G., 2001. Igneous and Metamorphic Petrology.
7. K. G. Cox, J. D. Bell., 1979. The Interpretation of Igneous Rocks. Springer/Chapman & Hall.
8. Bose M.K., 1997. Igneous Petrology.
9. Tyrrell, G.W., 1926. Principles of Petrology. Springer

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Discipline Specific Major Course

Course Name: METAMORPHIC PETROLOGY

Course Code: BSCGELMJ402

Course Type: **MAJOR**	Course Details: **MJC-6**			L-T-P: **3 - 0 - 4**	
Credit: **5** Theory 4, Practical 1	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

THEORY

Unit 1: Introduction to Metamorphism (6 Credit Hours)
Definition of metamorphism; factors controlling metamorphism; limits of metamorphism. Types of metamorphism – on the basis of factors (dynamic, thermal, dynamothermal); on the basis of settings (contact, regional, fault zone metamorphism, impact metamorphism); Protoliths of metamorphic rocks; Progressive and Retrogressive metamorphism; Metamorphic mineral reactions.

Unit 2: Phase equilibria in metamorphism (12 Credit Hours)
Concept of equilibrium; Gibbs Phase Rule and Mineralogical phase rule of closed and open system, Graphical relations in metamorphic assemblages – Interpretation and representation of mineral assemblages; ACF, AKF and AFM diagrams; Schreinemakers' analysis for simple systems; Quantification of equilibrium in metamorphism Metamorphic rocks as geochemical systems; Application of chemical thermodynamics in homogeneous phase equilibria; Geothermobarometry

Unit 3: Genetic classification of metamorphism (6 Credit Hours)
Grade, Zone and metamorphic facies; metamorphic zones and isograds; Metamorphic Facies Series; Paired Metamorphic Belt.

Unit 4: Metamorphism vis-à-vis Deformation (8 Credit Hours)
Relationship between metamorphism and deformation; structure and textures of metamorphic rocks, Interpretation of porphyroblast – Si – Se relations.

Unit 5: Types of Metamorphism (10 Credit Hours)
Progressive metamorphism of pelitic and basic rocks; Contact metamorphism of impure limestone.

Unit 6: Granulites and Crustal anatexis (8 Credit Hours)
Introduction, mode of occurrence, lithology, structure, P-T estimation in granulite, origin; Role of fluids in granulite petrogenesis. Crustal anatexis, Partial melting in metamorphic rocks; Migmatites: Definition, types and their origin; .

Unit 7: Metasomatism (4 Credit Hours)
Role of fluids in metamorphism; Origin of skarn, fenite and spilite.

Unit 9: Metamorphic rock associations and plate tectonic settings (6 Credit Hours)
Heat flow and metamorphism. Role of plate tectonics in metamorphism; Pressure-Temperature-time paths and their interpretation; Types of metamorphism in plate boundaries (subduction zone, mid oceanic rift and continent-continent collision zone) and plate interior.

PRACTICAL

Megascopic and microscopic study (textural and mineralogical) of common metamorphic rocks : Slate, phyllite, chlorite schist, muscovite-biotite schist (+garnet, staurolite, andalusite), sillimanite-kyanite schist, amphibolites, marble, garnet-biotite gneiss, metagranitoid, orthopyroxene granulite, 2-pyroxene granulite, khondalite, calc granulite.
Laboratory exercises in graphic plots for composition paragenesis diagrams.
Determination of equilibrium P-T-fluid composition using thermodynamic expressions.

SUGGESTED READINGS:

1. Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
2. Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
3. Frost, B. R. and Frost, C. D. (2019). Essentials of Igneous and Metamorphic Petrology, 2nd ed. Cambridge University Press
4. Vernon, R. H. & Clarke, G.L. (2008) Principles of Metamorphic Petrology, Cambridge University Press.
5. Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
6. Yardley, B. W., & Yardley, B. W. D. (1989). An introduction to metamorphic petrology. Longman Earth Science Series.
7. Myron G. Best (2001). Igneous and Metamorphic Petrology, 2nd ed. Wiley-Blackwell

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Discipline Specific Minor Course

Course Name: STRUCTURAL GEOLOGY AND GEODYNAMICS

Course Code: BSCGELMN401

Course Type: **MINOR**	Course Details: **MNC-4**			L-T-P: **3 - 0 - 4**	
Credit: **5** Theory 4, Practical 1	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

THEORY

Unit 1: Introduction to Structural Geology

Definition and Classification of geological structures. Preliminary concept of dip, strike of planar structure and plunge and rake of linear structures. Methods of determination of stratigraphic right way up. Unconformity – types and origin.

Unit 2: Folds

Definition of fold. Different parts of fold. Geometric Classification of Folds.

Unit 3: Fault and Joint

Definition of fault and Joint. Different parts of fault. Geometrical classification of Fault and Joint. Columnar joint.

Unit 4: Introduction to Geodynamic

Definition of "Global tectonics ", Asthenosphere and Lithosphere. Brief ideas about the major, intermediate and minor plates on the globe.

Unit 5: Continental drift theory and formation of ocean

Wegner's concept of continental drift theory. Special example of drifting between South America and African continents. Brief idea of seafloor spreading with example of formation of Atlantic Ocean.

Unit 6: Plate tectonic theory

Plates and their margins, different types of plate boundaries. Plate motions and their driving forces. Brief ideas of formation of Himalayan Mountain belt, Andes Mountain belt, San Andreas Fault and Red Sea.

PRACTICAL

Three points drill holes problems for the determination of dip and strike of a plane. Bed thickness problem with drill hole. Simple homoclinal dipping beds map and section. Marking different plates on global map. Marking the position of Red Sea,Alpine Himalayan Belt, Mid Atlantic Ridge and San Andreas fault.

SUGGESTED READINGS:

1. Billings. M.P,1987. Structural Geology, 4th edition, Prentice-Hall.

2.Keary, P., Klepies, K.A and Vine, F.J., 2009. Global Tectonics 3rd Edition, Wiley Blackwell.