Course Credits for B.Sc. Sem 3 and B.Sc. Sem 4 (Geology) (NEP 2020)

	Major (Credits)	**Minor (Credits)**	**MDC (Credits)**	**SEC (Credits)**	**AEC (Credits)**	**IKS (Credits)**	**VAC (Credits)**
Semester 3	12	–	4	2	2	2	–
Semester 4	12	4	–	2	2	–	2

Proposed Course Titles for B.Sc. Semester III and IV (Geology)				
1 FS B.Sc. II (Semester-III)	Major (12 Credits)	Paper I	(4 Credits) (3 Theory + 1 Lab)	**Crystallography GLM2003C**
		Paper II	(4 Credits) (3 Theory + 1 Lab)	**Mineralogy GLM2013C**
		Paper III	(4 Credits) (3 Theory + 1 Lab)	**Geomorphology GLM2023C**
	MDC (4 Credits)		(4 Credits) (3 Theory + 1 Lab)	**Earth Surface Processes MDC2533C**
	SEC (2 Credits)		(2 Credits) (Lab)	**Interpretation of Satellite Data and its Applications SEC2443C**
	IKS (2 Credits)		(2 Credits – Theory)	**Geological making of India: A Rigvedic Perspective IKS2343C**
SS B.Sc. II (Semester-IV)	Major (12 Credits)	Paper I	(4 Credits) (3 Theory + 1 Lab)	**Igneous Petrology GLM2004C**
		Paper II	(4 Credits) (3 Theory + 1 Lab)	**Sedimentary Petrology GLM2014C**
		Paper III	(4 Credits) (3 Theory + 1 Lab)	**Metamorphic Petrology GLM2024C**
	Minor (4 Credits)		(4 Credits) (3 Theory + 1 Lab)	**Evolution of Life Through Time GLE2004C**
	SEC (2 Credits)		(2 Credits) (Lab)	**GPS and Geocaching SEC2434C**
	VAC (2 Credits)		(2 Credits – Theory)	**Medical Geology VAC2374C**

FSBSC-II (B.Sc. Semester-III)

Major Paper-I GLM2003C Crystallography (3 Credits +1 Credit)

Unit I: Crystal morphology (symmetry, axis, forms, zones and habit), Measurement of crystal angles, Crystallographic laws (law of constancy of interfacial angles, the law of rationality of indices, the law of symmetry), Symmetry elements and operations, Crystallographic projections, 32-point groups of six crystal systems.

Unit-II: Iso-structuralism, Polymorphism, Polytypism, Metamict Minerals, Mineraloids, Pseudomorphism, Crystal defects, Intergrowths of crystals-parallel growth, epitaxies, twinning and common twin laws.

Unit-III: Introduction to crystal chemistry- Ionic and atomic radii, packing, radius ratio and coordination number, chemical bonds, Pauling's rules. Introduction to X-ray crystallography-X-ray spectra, diffraction effects and Bragg's equation.

Unit-IV (Lab): Crystal models of 32-point groups, stereographic projections, numerical problems related to radius ratio and coordination number.

Reference Books:

1. Cornelius K, and Cornelius S. H. (1895) Manual of Mineralogy John Wiley & Sons.
2. Read, H. H. (1966) Rutley's Elements of Mineralogy 26th Edition, S. K. Jain and CBS Publishers and distributors. P.560.
3. Sands, D.E. 1975. An Introduction to Crystallography, WA.Benjamine Inc., New York.

Major Paper-II GLM2013C Mineralogy (3 Credits +1 Credit)

Unit-I: Compositional variations in minerals-solid solution, exsolution, Systematic Study of Neso-, Soro-, Cyclo-, Ino-silicate minerals with reference to their chemical formula, structure, classification and occurrences.

Unit-II: Systematic Study of Phyllo- and Tecto-silicate minerals with reference to their chemical formula, structure, classification and occurrences. Carbonates, Oxides, Halides, Sulphates, Sulphides and Phosphates Groups, Goldschmidt classification of elements.

Unit-III: Elements of optics – ordinary and polarized light, Petrological microscope, isotropic and anisotropic substances, Snell's law, critical angle and total internal reflection, refractive index and Becke's line, dichroism and pleochroism, interference of light, Michel-Levy chart, optical accessories, extinction and birefringence.

Unit-IV (Lab): Study of various rock forming minerals in thin sections.

Reference Books:

1. Hurlbut, C. S., & Klein, C. (1977). Manual of mineralogy (after James D. Dana). Wiley.
2. Perkins, D. (1998). Mineralogy. Begin, 17, 17-38.
3. Rutley, F. (2012). Rutley's elements of mineralogy. Springer Science & Business Media.

Major Paper-III GLM2023C Geomorphology (3 Credits +1 Credit)

Unit-I: Concept of morphogenetic landforms, geomorphic features in areas comprising horizontal, dipping, folded and faulted rocks, Types of drainage patterns and their geological significance, Davisian model of cycle of erosion and fluvial cycle, Valley profiles, Base level and classification of valleys, Concept of graded stream.

Unit-II: Geomorphic processes involved in development of erosional and depositional landforms of fluvial, coastal and aeolian systems.

Unit-III: Karst topography – essential conditions to development of karst, important karst regions, features characteristics of karst region and karst geomorphic cycle. Glaciers-formation of ice, their classification, modern day distribution, nourishment and wastage, movement, erosional and depositional landforms (stratified and unstratified drifts). Introduction to planetary geomorphology.

Unit-IV (Lab): Topographic map- interpretation, preparation of a cross profile, extraction of landforms of fluvial, coastal, aeolian and glacial origin.

Reference Books:

1. Bloom A. L. Geomorphology: A Systematic analysis of late Cenozoic landforms. (3rd Ed.)
2. Thornbury, W.D. Principles of geomorphology. CBS Pub. Delhi
3. Leet, L.D. & Judson, S. (1969) Physical Geology

MDC- MDC2533C Earth Surface Processes (3 Credits +1 Credit)

Unit-I: Concepts of geomorphology, introduction to earth surface processes- endogenous, exogenous and extra-terrestrial processes; Weathering-Mechanical, chemical and biological; development of soil, soil profile.

Unit-II: Drainage patterns; processes and landforms associated with fluvial and aeolian systems and glacial systems; volcanic landforms.

Unit-III: Processes and landforms associated with oceans. Karst Topography-Conditions for the development of karst features, sinkhole and associated features. Introduction to applied geomorphology.

Unit-IV (Lab): Topographic maps, concept of scale, preparation of a topographic profile, study of various landforms on SOI toposheets.

Reference Books:

1. Bloom A. L. Geomorphology: A Systematic analysis of late Cenozoic landforms. (3rd Ed.)
2. Thornbury, W.D. Principles of geomorphology. CBS Pub. Delhi
3. Leet, L.D. & Judson, S. (1969) Physical Geology

SEC – SEC2443C Interpretation of Satellite Data and its Applications (Lab) (2 Credits)

Remote Sensing Platforms, Satellites and orbits, types of sensors. Resolutions: spatial, spectral, radiometric, temporal resolutions. Types of data products. Exercises on satellite image interpretation for identification of common geomorphic and structural features, land cover types and other relevant information. Temporal analysis of satellite images for analyzing and interpreting changes in land cover, vegetation and other relevant parameters.

Reference Books:

1. Conway, E. D. (1997). An introduction to satellite image interpretation. JHU Press.
2. A. A. Misra (Editor), S. Mukherjee (Editor) - Atlas of Structural Geological and Geomorphological Interpretation of Remote Sensing Images, John-Wiley.

IKS –IKS2343C Geological Making of India: A Rigvedic Perspective (2 Credits)

Unit-I: Brief introduction to Rigvedic period, Introduction to Sapta-sindhu, Geological evidences of Sapta-sindhu, Rigvedic evidences supporting geological evidences of Sapta-sindhu. Brief introduction to Rigvedic period, Introduction to Sapta-sindhu

Unit-II: Description of land and rivers of Sapta-sindhu and its minerals from Rigveda. Overview of deccan or southern India in Rigvedic times.

Reference Books:

1. Das, A. C. (1927). *Ṛigvedic India* (Vol. 1). R. Cambray.
2. Y.S. Sahasrabuddhe (2006) Geology in ancient Vedic literature.

SSBSC-II (B.Sc. Semester-IV)

Major Paper-I GLM2004C Igneous Petrology (3 Credits +1 Credit)

Unit-I: Origin and types; Physical properties of magma (temperature, viscosity, density and volatile content) and chemical composition; Intrusive and extrusive forms; structure and textures of igneous rocks and its petrogenetic significance; Classification of igneous rocks- based on mode of occurrence, chemical and mineralogical composition, IUGS classification (QAPF, mafic and ultramafic triangles); chemical classification schemes (TAS diagram).

Unit-II: Phase equilibria in igneous systems- Introduction (The phase rule and lever rule), phase equilibrium in one-component (SiO_2), two components (diopside-anorthite, forsterite-silica, albite-anorthite and albite-orthoclase), three component (diopside – albite – anorthite, forsterite – diopside – silica) silicate systems and their petrogenetic significance. Introduction to chemical petrology (Major and minor elements, Goldschmidt's classification, variation diagrams based on major elements in igneous rocks).

Unit-III: Magmatic processes- Differentiation (gravity settling, filter pressing, flow segregation), mixing, assimilation and magma diversity; Tectono-magmatic environments and magma series- Intraplate and interplate volcanism and associated magmatism; Petrogenesis of common felsic and mafic igneous rocks.

Unit-IV(Lab): Microscopic studies of important igneous rocks. Outdoor practical exercise in igneous terrain.

Reference Books

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. Bose M.K. (1997). Igneous Petrology.
4. White, W. M. (2020). Geochemistry. John Wiley & Sons.

Major Paper II: GLM2014C Sedimentary Petrology (3 Credits +1 Credit)

Unit I: Role of weathering in sedimentation: a) Surface processes of rock weathering b) Chemistry of the weathering processes and mobility of oxides; Fluid dynamics: laminar and turbulent flow, Reynold's number, Froude number, boundary layers, particle entrainment, liquefied flow, grain flow, debris and mud flow, turbidity current; Introduction and types of duricrust: Calcrete, Silcrete, Ferricrete.

Unit II: Concept of grain size and texture of sediments; Primary sedimentary structures: Stratification and bedforms, bedding plane markings; Secondary sedimentary structures: erosional structures; chemical and organic sedimentary structures; Introduction to soft-

sediment deformation structures and seismites; Siliciclastics: Classification and detailed petrographic study of conglomerate, sandstone, shale, and mud rocks. An introduction to provenance analysis.

Unit III: Carbonate rocks: Constituents of carbonate rocks: skeletal, non-skeletal, allochemical and orthochemical components. Major controls on carbonate sedimentation and classification of limestones. Dolomitization and dedolimitization. Introduction to other chemical, biochemical and carbonaceous sedimentary rocks (Evaporites, cherts, ironstones, phosphorites and coal). Basic concepts and stages of diagenesis. Concept of sedimentary facies and Walther's law. Introduction to continental and marine depositional environments.

Unit IV (Lab): Microscopic studies of clastic and non-clastic sedimentary rocks. Outdoor practical exercise in sedimentary terrain.

Reference Books:

1. Nichols, G., 2009. *Sedimentology and stratigraphy*. John Wiley & Sons.
2. Boggs, S., 2009. *Petrology of sedimentary rocks*. Cambridge university press.
3. Sengupta, S. M., 2007. *Introduction to sedimentology. Second edition.* CBS Publishers and Distributors Pvt. Ltd.
4. Tucker, M.E. and Wright, V.P., 2009. *Carbonate sedimentology*. John Wiley & Sons.

Major Paper-III GLM2024C Metamorphic Petrology (3 Credits +1 Credit)

Unit-I: Metamorphism; limits of metamorphism; factors controlling metamorphism, types of metamorphism-contact, regional, hydrothermal, fault-zone and impact metamorphism; genesis of micro-scale and mesoscale structures; relationship between metamorphism and deformation; metamorphic mineral reactions; classification of metamorphic rocks.

Unit-II: Regional and contact metamorphism of argillaceous, calcareous, quartzo-feldspathic and basic igneous rocks; concept and classification of metamorphic facies; metamorphic facies series; Barrovian zones and isograds.

Unit-III: Metasomatism and role of fluids in metamorphism; origin and structure of migmatites and amphibolites; metamorphism and its relation to plate tectonics; paired metamorphic belts; petrogenesis of common occurring metamorphic rocks.

Unit-IV (Lab): Microscopic studies of important metamorphic rocks. Outdoor practical exercise in metamorphic terrain.

Reference books:

1. Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson
2. Barker, A. J. (2013). Introduction to metamorphic textures and microstructures. Routledge.
3. Turner, F. J., & Verhoogen, J. (1960). Igneous and metamorphic petrology

4. Yardley, B., & Warren, C. (2021). An introduction to metamorphic petrology. Cambridge University Press.
5. Miyashiro Akiho. Metamorphism and metamorphic belts. George Allen & Unwin

Minor – GLE2004C Evolution of life through time (3 Credits +1 Credit)

Unit –I: Theories of Origin and Evolution of life, Evidences of evolution of life, Five kingdoms classification of life, Types of fossils and modes of preservation, Patterns of evolution, Major biological events through geologic time, Mass extinctions and turnover of entire ecosystems.

Unit-II: Environment of the early Earth, the Great Oxygenation Event, the Rise of Algae, Evolution of different life forms- Bacteria, Ediacara biota and others, The Cambrian explosion, Life in various time periods of the Palaeozoic era, Rise of fishes, amphibians tetrapods and invasion of land. End Palaeozoic environmental crisis and mass extinction.

Unit-III: Life forms of the Mesozoic era, The rise of the reptiles, Dinosaurs and birds, End Mesozoic meterorite impact and mass extinction, Life during the Tertiary and Quaternary periods, Cenozoic land bridges, sea level changes and dispersal of life, Evolutionary history of horse, camel, elephant, Primates and Hominids, Cultural evolution of man.

Unit-IV (Lab): Study of modes of fossil preservation; Study of Phanerozoic fossils from India; Exercises related to major evolutionary trends in important groups of animals.

References Books:

1. Stanley, S.M. & Luczaj, J.A. (2014). Earth System History (4th Edition).
2. Cowen, R. (2000). History of Life. Wiley-Blackwell.
3. Benton, M.J. & Harper, D.A.T. (2016). Introduction to Paleobiology and the fossil record. Wiley.
4. Lumine, J. I. & Freeman, W.H. (1999). Earth-Evolution of a Habitable World, Cambridge University Press.
5. Canfield, D.E. & Konhauser, K.O., (2012). Fundamentals of Geobiology, Blackwell.

VAC – VAC2374C Medical Geology (2 Credits)

Unit-I: History of medical geology; Principles, branches, prospects and development of medical geology; The relation between medical geology and public health; Effects of natural disasters on human health. Medical geology of fluoride, arsenic, uranium.

Unit-II: Anthropogenic sources of contaminating elements: mining, mineral processing and metal refining, contaminants in urban areas. Mining geology problems: Silicosis, Black Lung Disease, Asbestosis, Heavy Metal Toxicity. Mitigations of health hazards using geological knowledge.

Reference Books:

1. Dissanayake, C. B., and Chandrajith, R. (2009). *Introduction to medical geology*. Springer science & business media.
2. Selinus, O. (2007). Medical geology: An opportunity for the future. *AMBIO: A Journal of the Human Environment*, *36*(1), 114-116.
3. Davies, B. E., Bowman, C., Davies, T. C., and Selinus, O. (2012). Medical geology: Perspectives and prospects. *Essentials of medical geology: Revised edition*, 1-13.
4. Gomes, C.D.S.F. and Silva, J.B.P., 2007. Minerals and clay minerals in medical geology. *Applied Clay Science*, *36*(1-3), pp.4-21.

SEC – SEC2434C GPS and Geocaching (Lab) (2 Credits)

Overview of Global Positioning System, Geocaching and Geotagging, GPS Receivers, Satellite Constellations, Segments, Antennas, Signal Codes and errors; Accuracy of GPS measurements; Application of GPS, Hands on training, field training and individual projects using GPS.

Reference Books:

1. Rahman Atiqur, Fazal Shahab Global Positioning System: Concept, Technique and Application, New Age International(P) ltd.,Publishers
2. Satheesh Gopi, Global Positioning System: Principles and Applications, Tata Mcgraw-Hill Publishing Company Limited, 2005