Geology Honours

SYLLABUS FOR THREE-YEAR HONOURS DEGREE COURSE IN GEOLOGY (C.U.)

Total Marks - 800

	Marks	Lectures / Periods
Theory		
Paper - I		
A. Introduction to Earth System Sciences	60	60
B. Structural Geology	40	40
Paper - II		
A. Crystallography and Optical Mineralogy	30 (10+20)	35
B. Mineralogy	45	35
C. Palaeontology I	25	25
Paper - III		
A. Igneous Petrology	45	50
B. Sedimentary Petrology	25	25
C. Metamorphic Petrology	30	25
Practical		
Paper - IV		
A		
1. Crystallography	10	16
2. Structural Geology	25	40
B		
1. Hand Specimens of Minerals and Rocks	25 (15+10)	60
2. Optical Mineralogy	15	50
3. Palaeontology	10	18
3. General Viva-Vocé	15	
Theory		
Paper - V		
A. Principles of Stratigraphy and Sedimentation	30	30
B. Palaeontology II	40	40
C. Geodynamics	30	30
Paper - VI		

A. Indian Stratigraphy	50	60
B. Economic Geology	50	50
Practical		
Paper - VII		
A. Petrography of Igneous Rocks	35	40
B		
1. Petrography of Sedimentary Rocks	15	14
2. Petrography of Metamorphic Rocks	30	30
C. General Viva-Vocé	20	
Paper - VII		
A. Structural Geology	50	50
B. Palaeontology	50	50

Detailed Syllabus (Honours)

PART - I

Theoretical

Paper-I:

Group A: Introduction to Earth System Sciences (Full Marks - 60, Periods 60)

Elementary information on solar system and lunar geology. Origin of the Earth; clues to the origin, accretionary models. Formation of crust, mantle, core, hydrosphere and atmosphere.

Earth System Science: atmosphere, hydrosphere, biosphere, solid earth. Historical development of Geology: Neptunism, Plutonism, Uniformitarianism, Law of superposition, Law of faunal succession; Contributions of Hutton, Werner, Smith and Lyell.

Surface processes: weathering; regolith, bed rock, soils and soil profile; erosion; mass wasting; transportation and deposition by wind, river, glacier, groundwater and ocean; landforms in relation to lithology, strucutre and exogenic processes. Evidence of global glaciation, ice ages.

Lithospheric plates, present day configuration and relative motion of plates.

Internal processes: volcanoes and volcanism, distribution of volcanoes. Earthquakes: causes of earthquakes and their effects, intensity and magnitude, earthquake belts, factors controlling their distribution; seismic zones of India; seismic waves, travel-time curve for seismic waves, seismic discontinuities. Geothermal gradient, heat flow.

Internal constitution of the earth - evidence from seismic waves, meteorites and rocks.

Gravity measurement and gravity anomaly; concept of isostasy, hypotheses of Pratt and Airy.

Relative ages of geological bodies; absolute ages of rocks and minerals; fundamental principles of radiometric dating. The Earth's age. The geological time scale up to the level of eras and periods.

Geological hazards and their mitigation: Earthquakes, Volcanoes, Landslides, Floods. Elementary idea of remote sensing.

Oceanic and atmosphere circulations.

Books:

Gilluly, J., Waters, A.C. and Woodford, A.G.: *Principles of Geology*.

Duff, P. and McL., D. (ed.): *Holmes' Principles of Physical Geology*.

Press, F. and Siever, R.: *Earth*.

Read, H. H. and Watson, J.: *Introduction to Geology, V. I*.

Strahler, A.: *Principles of Physical Geology*.

Emiliani: *Planet Earth*.

Paper - I

Group B: Structural Geology (Full Marks - 40, Periods - 40)

Deformation of rocks: concept of stress, normal stress, shear stress, principal axes of stress, planes of maximum shear stress; concept of strain, longitudinal and shear strain, principal axes of strain, homogeneous and inhomogeneous strain, rotational and irrotational strain, pure shear and simple shear, strain ellipse and strain ellipsoid, representation of strain ellipsoid in Flinn's diagram; factors controlling deformation behaviour of rocks - confining pressure, temperature, time, solution; creep of rocks, elastic, viscous and plastic behaviour.

Penetrative and non-penetrative structural elements: primary and secondary planar and linear structural elements, strike and dip, pitch and plunge, representation of planes and lines in stereographic and equal area projection diagrams. Outcrops of planes on horizontal and uneven surfaces: outlier and inliear. Scales of observation of structures.

Deformation of layered rocks: folds, parts of a fold, antiform, synform, neutral fold, anticline, syncline, nomenclature of folds based on fold shape and orientation of axis and axial plane. Ramsay's classification of folds, variation of thickness of folded layers, isogons. Outcrops of folded planes on horizontal and sloping surfaces. Relation between major folds and minor folds. Concept of buckle (flexure), flexure slip, bonding and slip (shear) folds, geometrical characteristics of folds formed by buckling and inhomogeneous simple shear.

Fracturing of rocks: tension and shear fractures: Joint sets and joint systems, relation to joints. Faults: translational and rotational movements, slip and separation, nomenclature of faults based on geometrical relation of faults to beds, slip and separation. Effects of faults on outcrop of strata, horst and graben, autochthon, allochthon, nappe, window and klippe, criteria for

recognition of faults.

Foliation: morphological features of cleavage and schistosity, relation of cleavage and schistosity to major folds, Powell's classification of rock cleavage.

Lineation: Different types of secondary linear structures in rocks, mineral lineation, intersection lineation, striping, stretching (elongation) lineation, mullion, rodding, boudinage, relation of lineation to folds.

Unconformity: types of unconformity, criteria for distinguishing unconformity from faults and intrusive contacts.

Books:

Davis, G.H. and Reynolds, S. J.: *Structural Geology of Rocks and Regions*.

Ghosh, S.: *Structural Geology*.

Marshak, S. and Van-der-Pluijm: *Structural Geology*.

Hatcher, R. D., Jr.: *Structural Geology*.

Twiss, R. J. and Moores, E. M.: *Structural Geology*.

Paper - II

Group A: Crystallography & Optical Mineralogy (Full Marks - 30, Periods 35)

Crystallography (Full Marks - 10):

Essential characteristics of crystalline and non-crystalline states of matter.

Crystal measurements: interfacial angle, zone, law of constancy of interfacial angles, principles of stereographic projection, notation of crystal faces, edges and comers, crystallographic axes, Miller indices, law of rational indices, general zonal relations of faces.

Crystal symmetry: periodic repetition, elements of symmetry, HermannMauguin symmetry notation, crystal forms - classification and nomenclature.

Classification of crystals into 7 systems and 32 classes; their Hermann Mauguin notation and representation of symmetry elements.

Crystal habit, types of crystal aggregates, twinning in crystals.

Space lattice, unit cell.

Diffraction of X-ray by crystal lattice, Bragg's law.

Optical Mineralogy (Full Marks - 20)

Optical behaviour of crystals: isotropic and anisotropic media, double refraction, use. of clacite to illustrate double refraction, polarization of light; methods of production of plane polarized light, different types of polaroids (construction of Nicol Prism not necessary), anatomy of a polarizing microscope. Pleochroism, optical indicatrix of uniaxial and biaxial crystals. Outline method of estimation of refractive index by liquid immersion.

Inteference phenomena in crystals, order of interference colour, birefringence,

extinction phenomenon.

Outline of methods of determination of refractive indices.

Interference phenomena in convergent light, interference figures, methods of determination of optic sign.

Paper - II

Group B: Mineralogy (Full Marks - 45, Periods - 35)

Physical properties of minerals: form and structure, colour and transparency, lustre, streak, specific gravity, hardness, cleavage, fracture, para-, dia- and ferro-magnetic properties, radioactivity.

Crystal chemistry: different types of chemical bonding, co-ordination principle, Pauling's rule. Polymorphism: displacive and reconstructive transformation, order-disorder transformation as displayed by K-feldspars, enantiotropy and monotropy, polymorphs of carbon, SiO_2, $CaCO_3$, Al_2SiO_5. Diadochy vis-à-vis solid solution, exsolution principle (example from alkali feldspar), pseudomorphism.

Classification of minerals: native elements, sulphides, oxides, carbonates, silicates, sulphates and phosphates.

Classification of silicates on the basis of linking of SiO4 tetrahedra, examples of minerals in each class, outline of atomic structures of pyroxene, amphibole and mica group of minerals.

Descriptive Mineralogy:

(a). Chemical compositions and diagnostic physical properties of the following minerals: Haematite, magnetite, goethite, ilmenite, chromite, pyrolusite, psilomelane, bauxite; Pyrite, chalcopyrite, pyrrhotite, sphalerite, galena; Calcite, aragonite, dolomite, magnesite, siderite, malachite; Fluorite, gypsum, barite, wolframite, apatite, graphite; Quartz, feldspars, muscovite, biotite, beryl, tourmaline, garnet, serpentine (including asbestos variety), talc, chlorite, kyanite, sillimanite, staurolite.

(b) Classification of the following groups of rock-forming minerals: Silica minerals, feldspars, olivines, pyroxenes, amphiboles, micas, garnets. Diagnostic optical properties: Quartz, feldspars, feldspathoids (nepheline, leucite), olivines, pyroxenes (pyroxene quadrilateral), amphiboles (tremolite, actinolite, hornblende, anthophyllite), micas (muscovite, biotite), chlorite, cordierite, staurolite, epidote-zoisite-clinozoisite.

Books:

Berry, L. G. and Mason, B.: *Mineralogy*.

Deer, W. A., Howie, R. A. and Zussman, J.: *An Introduction to Rock forming Minerals (Condensed Volume)*.

Klein, C. and Hurlbut, C. S. (Jr.): *Manual of Mineralogy*.

Nesse, D.: *Introduction to Optical Mineralogy*.

Wahlstrom, E. E.: *Optical Crystallography*.

Winchell, A. N.: *Elements of Optical Mineralogy*.

Paper - II

Group C: Palaeontology I (Full Marks - 25, Periods - 25)

Introduction: Fossils: definition, kinds and uses, scope and subdivisions of palaeontology.

Fossilization: definition, condition (physico-chemical) and modes of preservation of ancient life forms, taphonomy; imperfections of fossil record; uses of fossils.

Elementary ideas about taxonomy: classification of organic kingdom upto the level of phyla. Concept of species and types: typomorphic, evolutionary and phylogenetic systematics. Binominal system of nomenclature, rules and procedure for naming a new species.

Stratigraphic palaeontology: fossils as constituent of rocks, law of faunal succession; outline of time distribution. Brief idea on earliest metazoa and Precambrian fossils. Appearance and extinction of taxon; index fossil, zone fossil, facies fossil, trace fossil.

Palaeoecology: principles of palaeoecologic study: examples from corals, bivalves and brachiopods.

Principles of palaeogeographic and palaeoclimatic reconstruction on the basis of fossils: examples from corals and plants.

Hard part morphology of brachiopods, bivalves, and corals.

Books:

Babin, C.: *Elements of Palaeontology*.

Baksi, S.: *Purajibabidya*.

Black, R. M.: *The Elements of Palaeontology*.

Clarkson, E. N. K.: *Invertebrate Palaeontology and Evolution*.

Moore, R. C., Lalicker, C. G. and Fischer, A. G.: *Invertebrate fossils*.

Nield, E. W. and Tucker, V. C. T.: *Paleontology: An Introduction*.

Raup, D. M. and Stanley, S. M.: *Principles of Palaeontology*.

Shrock, R. R. and Twenhofel, W. H.: *Principles of Invertebrate Palaeontology*.

Paper - III

Group A: Igneous Petrology (Full Marks - 45, Periods - 50)

Igneous rocks and magma; pressure and temperature domains of igneous processes; sources of magma; intrusion and extrusion of magmas.

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Distinctiveness of igneous, metamorphic and sedimentary processes; rock cycle.

Composition of major crustal components and upper mantle. Distribution of igneous rocks in the continental and oceanic crusts with emphasis on the major differences among them.

Forms of igneous rock bodies: description of the major forms of extrusives and intrusives and a general idea of their mode of emplacement: central eruptions, fissure eruptions, pyroclastic deposit, volcanic neck, sill, dyke, ring dyke, cone sheet, laccolith, lopolith, phacolith, stock, batholith. Salient factors controlling the ascent of magma.

Description and origin of the following structures of igneous rocks: vesicular structure, pillow structure, flow banding, flow lines, schlieren, ropy lava, block lava, joints. Concept of lava stratigraphy (identifiction of flows in a trap hill).

(a) Physical properties of magmas: temperature, volatile content, viscosity, density.

(b) Concept of equilibrium and fractional crystallization, system, phase component, basic thermodynamic principle and phase rule, systems involving eutectic, peritectic and solid solution relations; bivariant field, univariant curve and invariant point.

(c) Studies on crystallization of melts in the following systems with particular reference to phase rule: diopside-anorthite, forsterite-silica, albite-anorthite, albite-orthoclase, diopside-albite-anorthite, diopside-forsterite-silica; nepheline-kaliophyllite-silica; petrogeneic applications of these systems. Bowen's reaction series and its use in petrogenesis. Role of volatiles in magmatic crystallization.

Description of textures and microstructures of common igneous rocks. General idea of the origin of the following textures and micro-structures: porphyritic, poikilitic, ophitic, perthitic, corona, spherulitic, spinifex.

General knowledge of the basis of classification of igneous rocks mineralogical, textural, chemical and associational. Concept of CIPW norm and its significance (CIPW classification not necessary); concept of Niggli values; Hatch & Wells classification of igneous rocks; IUGS classification of plutonic rocks; TAS diagram for volcanic rocks. Important mineralogical and textural features of the following rocks: alkali feldspar granite, alkali granite, granite, granodiorite, tonalite, trondhjemite, pegmatite, aplite; rhyolite; syenite; foid syenite, diorite; trachyte, phonolite, andesite; dolerite, gabbro, norite, anorthosite; basalt, spilite, oceanite, ankaramite; pyroxenite, peridotite, kimberlite; lamprophyre, carbonatite, pyroclastic rocks including agglomerate, volcanic breccia, ignimbrite, welded tuff, tuff and ash.

Processes of diversification of igneous rocks: differentiation, assimilation, and partial melting. Chemical variation during differentiation - silica variation diagram, Fe-Mg-(Na+K) and Ca-Na-K diagrams. Trend of variation in calc-alkaline and tholeiitic series in AFM diagrams.

General knowledge on the petrogenesis of the following rocks (with a broad idea only on their distribution in India):

Granitic rocks, basalts, anorthosites, peridotites, alkaline rocks.

Books:

Best, M. G.: *Igneous and Metamorphic Petrology*.

Bose, M. K.: *Igneous Petrology*.

Hall, A.: *Igneous Petrology*.

Hyndman, D. W.: *Petrology of Igneous and Metamorphic Rocks*.

Middlemost, E. A. K.: *Magmas and Magmatic Rocks*.

Philpotts, A. R.: *Principles of Igneous and Metamorphic Petrology*.

Paper-III

Group B: Sedimentary Petrology (Full Marks - 25, Periods - 25)

Introduction; brief idea about the processes of sedimentation: breakdown of rocks, mineral stability, transportation and deposition of sediments. General classification of sedimentary rocks - schemes proposed by Grabau, Pettijohn, and Folk.

Texture of sedimentary rocks: definition of clastic and non-clastic textures: components, framework, matrix, cement, allochemical and orthochemical components. Textural parameters: grain size, sphericity, roundness, concept of textural inversion. Computation of grain size statistics (mean, median, mode, sorting index, skewness, kurtosis) - purpose and limitations. Types of non-clastic textures. Concept of maturity, mineralogical and textural indicators of maturity.

Siliciclastic rocks: definitions of conglomerate, sandstone and shale. Conglomerate: composition, classification (Pettijohn's classification). Sandstone: composition, maturity, diagenesis, matrix classification, classification of sandstone (Dott's and McBrides's classification and their comparative study). Shale: classification, composition and clay mineralogy. Carbonate rocks: definition, components and their origin, diagenesis, classification (Folk's and Dunham's classification). Petrography and origin of banded iron formation.

Sedimentary structures: Types and origin with special emphasis on bedding and lamination, ripple marks, cross-lamination, graded bedding, sole marks, mud cracks, penecontemporaneous deformation structures.

Books:

Blatt, H., Middleton, G. and Murray, R.: *Origin of Sedimentary Rocks*.

Folk, R. L.: *Introduction to Sedimentary Rocks*.

Leeder, M. R.: *Sedimentology - processes and products*.

Allen, J. R. L.: *Principles of physical sedimentology*.

Collinson, J. D. and Thompson, D. B.: *Sedimentary structures*.

Pettijohn, E. J.: *Sedimentary Rocks*.

Sengupta, S.: *Introduction to Sedimentology*.

Tucker, M. E.: *Sedimentary Petrology - An Introduction*.

Paper-III

Group C: Metamorphic Petrology (Full Marks - 30, Periods - 25).

Concept of metamorphism, types of metamorphic changes: mineralogical, textural, chemical. P- T limits of metamorphism. Elementary ideas on processes of solid state transformation - recrystallization, neocrystallization.

Controlling factors of metamorphism: pressure, temperature, fluids. Types of metamorphism: burial, regional, contact, cataclastic, hydrothermal.

Textures and structures of metamorphic rocks; naming of metamorphic rocks; mineral assemblages and textures of the following rocks: slate, phyllite, schist, gneiss, mylonite, phyllonite, granulite, hornfels, quartzite, marble, clacsilicate rock, serpentinite, greenschist, blueschist, amphibolite, eclogite, mafic granulite, khondalite, charnockite; brief idea about Indian occurrences of charnockites and khondalites. Protoliths of common metamorphic rocks. Growth of porphyroblast in relation to deformation.

Concept of metamorphic grade, isograds, isoreactiongrads, metamorphic zones, index minerals, concept of metamorphic facies, facies classfication, P- T fields of different metamorphic facies, concept of facies series. Interrelation between facies, grade and metamorphic zones, baric divisions of metamorphic grade.

Concept of chemical equilibrium in metamorphic rocks, criteria for equilibrium and disequilibrium, phase rule, mineralogical phase rule and its application. ACF, AKF and AFM diagrams and their use.

Metamorphic phase diagrams, divariant field, univariant curve, invariant point. Discontinuous, continuous and exchange reactions. Stability fields of Al_2SiO_5 polymorphs, muscovite breakdown reaction, wollastonite forming reaction, concept of petrogenetic grid, role of fluids in these reactions.

Regional metamorphism of pelitic and mafic rocks and contact metamorphism of impure limestones.

Brief idea of retrograde metamorphism, metasomatism and metamorphic differentiation.

Migmatites: Definition and types.

Books:

Mason, R.: *Petrology of Metamorphic Rocks*.

Miyashiro, A.: *Metamorphic Petrology*.

Winkler, H. G. E.: *Petrogenesis of Metamorphic Rocks*.

Yardley, B.: *Introduction to Metamorphic Petrology*.

Paper - IV

Group A: Practical (Full Marks - 35, Periods - 56)

Crystallography (Full Marks - 10, Periods - 16):

Study of crystal models: symmetry elements and forms.

Stereograms (with and without stereonets) from given crystallographic data.

Structural Geology (Full Marks - 25, Periods - 40):

Reading and interpretation of topographic contour maps.

Use of Clinometer and Brunton compass, measurement of attitude of planar and linear structural elements.

Graphical solution of true dip-apparent dip problems, three-point problems.

Stereographic projection of structural elements; solution of simple structural problems using a net, e.g., true dip-apparent dip relations, determination of axis of cylindrical folds, vertical and inclined fault problems.

Construction of block diagrams of homoclinal beds, folded beds (plunging, non-plunging, upright, inclined, overturned, recumbent and reclined folds), faulted beds (normal and reverse faults on homoclinal and folded beds).

Interpretation of maps showing outcrops of horizontal and homoclinal beds, unconformity, fault, normal and reverse faults, igneous intrusives and extrusives on flat surface and uneven topography.

Paper-IV

Group B: (Full Marks - 50, Periods - 128)

Hand specimens of Minerals and Rocks (Periods - 60)

Minerals (Full Marks - 15):

Systematic study in hand specimen of the minerals listed below on the following points: form and structure, colour, transparency, lustre, streak, cleavage, parting, fractures, hardness, specific gravity, magnetism, and treatment with dilute HCl.

Haematite, magnetite, geothite, ilmenite, chromite, pyrolusite, psilomelane, bauxite;

Pyrite, chalcopyrite, pyrrhotite, sphalerite, galena;

Calcite, aragonite, dolomite, magnesite, malachite; Fluorite, gypsum, barite, wolframite, apatite, graphite; Quartz, feldspar, pyroxene, amphibole, muscovite, biotite, beryl, tourmaline, garnet, serpentine (including asbestos variety), talc, chlorite, kyanite, sillimanite, staurolite.

Rocks (Full Marks - 10):

Study and identification of the following rocks in hand specimen:

Granite, granite porphyry, pegmatite, syenite, nepheline syenite, diorite, gabbro, dolerite, anorthosite, basalt, rhyolite, peridotite, lamprophyre, tuff. Conglomerate, breccia, sandstone (arkose, quartz-arenite, greywacke), mudstone, shale, limestone, banded haematite jasper, banded ferruginous quartzite, laterite. Slate, phyllite, varieties of mica schists, gneiss, marble, quartzite, amphibolite, hornblende schist, calc-silicate rock, khondalite, charnockite.

Optical Mineralogy (Full Marks - 15, Periods - 50)

a. Study of the following minerals in transmitted polarised light: Quartz, orthoclase, microcline, plagioclase, perthite, nepheline, olivine, enstatite, hypersthene, augite, hornblende, tremolite, kyanite, sillimanite, andalusite, cordierite, staurolite, epidote, zoisite, garnet, tourmaline, zircon, sphene, muscovite, biotite, chlorite, apatite, carbonate, scapolite.

b. Becke test, determination of order of interference colour, use of accessory plates like gypsum; quartz and mica; extinction angle, scheme of pleochroism of minerals, determination of optic sign of uniaxial mineral from interference figure.

Palaeontology (Full Marks - 10, Periods - 18)

Morphology, systematic position and geologic age of the following:

(i) Brachiopoda: Terebratula, Rhynconella, Atrypa, Athyris, Spirifer, Productus.

(ii) Bivalvia: Area, Unio, Ostrea, Pecten, Venus, Hippurites, Gryphea.

(iii) Anthozoa: Halysites, Favosites, Calceola, Zaphrentis, Montlivaltia.

Paper-IV

Group C: General Viva-voce (Full Marks - 15)

N.B. Compulsory field work in each academic year.

First year (field work of approximately 10 days): Reconnaissance study of areas with sedimentary, igneous and metamorphic rocks in the field. Collection of samples and field data and preparation of field report.

Second year (field work of approximately 17 days):

a. Geological mapping of a small area, collection and study of samples and preparation of field report.

b. Tape and compass surveying and use of Brunton compass.

PART - II

Honours Theoretical

Paper - V

Group A: Principles of Stratigraphy and Sedimentation (Full Marks - 30, Period-30)

Introduction, concept of strata and sequence of strata formation; laws of superposition and faunal succession, correlation; principle of uniformitarianism.

Stratigraphic units: lithostratigraphic, biostratigraphic and chronostratigraphic units. Geologic time scale.

Facies: definition, lithofacies, biofacies; lateral facies variation, vertical facies variation, Walther's law.

Sedimentary environment: concept, classification. Principles of reconstruction of ancient sedimentary environment from rock record (examples from Shelf, Glacial, Fluvial, Delta).

Principles of stratigraphic correlation.

Books:

Boggs, S. (Jr.): *Principles of Sedimentology and Stratigraphy*.

Shelley, R. C.: *Ancient Sedimentary Environment*.

Sengupta, S.: *Introduction to Sedimentology*.

Davis, R. A.: *Depositional systems*.

Paper - V

Group B: Palaeontology II (Full Marks - 40, Periods - 40)

Hard part morphology of Gastropoda, Cephalopda, Trilobita, Echinoidea.

Brief account of Indian vertebrates with reference to Gondwana and Siwalik vertebrates: Composition, distribution and importance.

Organic evolution: Theory: (a) speciation, broad patterns, mechanism. (b) examples: evolution of equidae, hominidae and ammonoidea.

Brief account of Indian flora with special reference to Gondwana flora under the following heads: definition, composition, geographic distribution, botanical affinity, climatic implication, stratigraphic distribution.

Books:

Babin, C.: *Elements of Palaeontology*.

Bakshi, S.: *Purajibabidya*.

Black, R. M.: *The Elements of Palaeontology*.

Clarkson, E. N. K.: *Invertebrate Palaeontology and Evolution*.

Colbert, E. H.: *Evolution of the Vertebrates*.

Nield, E. W. and Tucker, V. C. T.: *Palaeontology: An Introduction*.

Shukla, A. C. and Misra, S. P.: *Essentials of Palaeobotany*.

Shrock, R. R. and Twenhofel, W. H.: *Principles of Invertebrate Palaeontology*.

Paper - V

Group C: Geodynamics (Full Marks - 30, Periods - 30)

Continents and oceans, active and passive continental margins, shield, continental rift systems, island arc and trench, marginal basin, oceanic ridges.

Orogeny and epirogeny. Neotectonics: active faults, geomorphological indicators and recurrent seismicity.

Eugeosyncline and miogeosyncline.

Continental drift - geological, palaeoclimatological and palaeontological evidences. Palaeomagnetism - apparent polar wandering curve and continental reconstruction. Gondwanaland and its break-up.

Seafloor spreading, marine magnetic anomlies and their interpretation.

Plate tectonics: concept of lithosphere and asthenosphere, plate boundaries. Relative movement of the plates on a spherical Earth, pole of rotation.

Plate tectonic models for the evolution of ocean basins and mountain belts, Wilson cycle.

Books:

Condie, K. C.: *Plate Tectonics and Crustal Evolution*.

Keary, P. and Vine, E. J.: *Global Tectonics*.

Moores, E. M. and Twiss, R. J.: *Tectonics*.

Mussett, A. E. and Khan, M. A.: *Looking into the Earth*.

Paper - VI

Group A: Indian Stratigraphy (Full Marks - 50, Periods - 60)

Physiographic divisions of India: peninsula, extrapenirisula, Indo-gangetic alluvial plain. Rock record in peninsular and extrapeninsular India.

Subdivision of Precambrian eon-Archaean and Proterozoic. Distribution of Precambrian rocks in India. Outline of Precambrian geology of Bihar-Orissa, Rajasthan, Central India, Karnataka and Eastern Ghats on the following points: stratigraphic sequence, structures and geochronology.

Brief account of stratigraphy of the Cuddapah and Vindhyan Supergroups in their type areas.

Outline of Phanerozoic stratigraphy (classification, correlation, succession, biostratigraphy and conditions of deposition) of the following:

a. Extrapeninsular basins (Kashmir, Spiti, Assam-Arakan)

b. Peninsular basins (Kutch, Kaveri-Coromandal coast, Bengal)

c. Gondwana basins: general characters and classification of the Indian

Gondawanas, stratigraphy of the Damodar Valley and Godavari basins.

d. Siwalik basin.

A brief outline of the age of the Deccan Traps, stratigraphy of intertrappean and infratrappean beds.

Books:

Krishnan, M. S.: *Geology of India and Burma*.

Naqvi, S. M. and Rogers, J. J. W.: *Precambrian Geology of India*.

Pascoe, E. H.: *A Manual of the Geology of India and Burma (3 Volumes)*.

Sarbadhikary, T.: *Bharater Shilastar O Bhutatiyo Itihash*.

Paper-VI

Group B: Economic Geology (Full Marks - 50, Periods - 50)

Scope of the subject. Useful earth materials: rocks, minerals, water, fossil fuels. Metallic and non-metallic deposits. Concept of conventional and non-conventional resources.

Definition of the following terms: ore, protore, gangue, tenor, beneficiation, hypogene and supergene deposits, epigenetic and syngenetic mineral deposits, hyrothermal solution. Forms and structures of ore deposits.

Processes of formation of mineral deposits: igneous, sedimentary and metamorphic.

Igneous: Magmatic crystallization, segregation, immiscibility and differentiation. Mineral deposits as related to different stages of magmatic crystallization - early and late magmatic deposits, hydrothermal deposits, hypothermal, mesothermal, epithermal, telethermal and xenothermal. Cavity filling and replacement deposits.

Sedimentary: Mechnical, chemical and biochemical processes. A brief introduction to modem seafloor resources.

Metamorphic: Metamorphosed and metamorphic mineral deposits, metasomatic deposits. Oxidation and supergene enrichment.

Classification of mineral deposits (Lindgren and Bateman); metallogenic epochs and provinces.

Geologic and geographic distribution and resource position of the following important economic mineral deposits of India. Metallic: Fe, Mn, Cr, Ni, Cu, Pb-Zn-Ag, Au, U, Th, Ti, Sn, W. Non-metallic: Bauxite, mica, phosphate, fluorite, limestone, barite, refractories, asbestos, diamond, graphite, monazite.

Mode of occurrence, geological set-up, mineralogy, geographic distribution and probable genesis of gold (Kolar, Hutti), copper (Singhbhum, Malanchkhand), iron (Bihar, Orissa), manganese (Central India), Pb-Zn-Ag (Zawar), Uranium (Singhbhum).

Desirable specifications of the minerals used as essential raw materials in the

following industries: iron and steel, cement, refractories, fertilizer.

Coal: classification (peat, lignite, bituminous, anthracite), constitutents of coal, viz., vitrain, durain, clarain, fusain. Origin and Indian distribution of coal.

Petroleum: indication, migration, accumulation and origin. Distribution of productive oil-bearing horizons in India.

Groundwater: Definition, aquifer, aquitard, aquiclude, water table, porosity, premeability, Darcy's law, zone of saturation, zone of aeration. Importance of groundwater.

Books:

Banerjee, D. K.: *Mineral Resources of India.*

Brown, J. C. and Dey A. K.: *Coal and Nuclear Fuel*.

Chandra, D.: *Petroleum*.

Deb, S.: *Industrial Minerals and Rocks of India*.

Edwards, R. and Atkinson, K.: *Ore Deposit Geology and its Influence on Mineral Exploration*.

Evans, M.: *An Introduction to Ore Geology*.

Gokhale, K. V. G. K. and Rao, T. E.: *Ore Deposits of India*.

Jensen, M. L. and Bateman, A. M.: *Economic Mineral Deposits*.

Todd, D. K.: *Groundwater Hydrology*.

PART - II

Honours Practical

Paper - VII

Group A: Igneous Rocks (Full Marks - 35, Periods - 40)

Study under microscope of the following textures of igneous rocks: Porphyritic, poikilitic, ophitic, intergranular, intersertal, graphic, perthitic, myrmekitic, hypidiomorphic, allotriomorphic, corona, flowage.

Description and identification by microscopic characters of the following rocks:

Granite, granodiorite, tonalite, syenite, nepheline syenite, aplite, granophyre, diorite, gabbro, anorthosite, pyroxenite, peridotite, mica-lamprophyre, dolerite, basalt, andesite.

Plotting of mineralogical and chemical data in triangular diagram.

C.I.P.W. norm calculation of granitic and basic rock (without foid).

Paper - VII

Group B: Sedimentary and Metamorphic Rocks (Full Marks - 45, Periods - 44)

Sedimentary Rocks: (Full Marks - 15, Periods - 14)

Microscope study and recognition of the following rocks: sandstone (arkose, quartz arenite, and greywacke), limestone, calc-arenite, chert, tuffaceous sediments.

Metamorphic Rocks: (Full Marks - 30, Periods - 30)

(a) Description and identification by microscopic characters of the following rocks: quartzite, marble, schists (including biotite -, muscovite-, chlorite-, gamet-, staurolite-, actionlite-, hornblende-, kyanite-, sillimanite schists), amphibolite, granitoid gneiss, chamockite, khondalite, calc-silicate rock, mafic granulite.

(b) Construction of ACF & AKF diagrams and finding out the mineral assemblages of pelitic rock in greenschist and amphibolite facies.

Paper - VII

Group C: General Viva-voce (Full Marks - 20)

N.B. Compulsory field work (duration approximately 8 days)

Study in the field of two economic mineral deposits and study of surface geology of these two deposits.

Paper-VIII

Group A: Structural Geology (Full Marks - 50, Periods - 50)

Interpretation of maps showing outcrops of unconformity, intrusive bodies, folds, faults, folded faults and nappes on uneven and flat surfaces.

Completion of outcrops of homoclinal beds, unconformity and fault on uneven topography from partial outcrops or other clues.

Paper-VIII

Group B: Palaeontology (Full Marks - 50, Periods - 50)

Study of fossil specimens exemplifying various modes of preservation: body fossil, internal mould, external mould, impression, petrifaction.

Morphology, systematic position and geologic age of the following:

(a) Plants: Glossopteris, Gangamopteris, Vertebraria, Ptilophyllum, Schizoneura, Pterophyllum, Cladophlebis, Dadoxylon.

(b) Vertebrates (molar teeth) : Equus, Hipparion, Rhinoceros, Stegodon.

(c) Invertebrates:

(i) Trilobita: Calymene, Phacops.

(ii) Gastropoda: Turritella, Cerithium, Nerita, Natica, Conus, Murex, Cyprea,

Physa, Bellerophon.

(iii) Cephalopoda: Nautilus, Ceratites, Perisphinctes, Macrocephalites, Belemnites, Acanthoceras.

(iv) Echinoidea: Hemiaster, Breynia, Schizaster, Echinolampas, Stygmatopygus, Clypeaster. 3. Determination of the age of an assemblage of fossils.

General Geology

SYLLABUS FOR THREE-YEAR GENERL COURSE IN GEOLOGY (C.U.)

Distribution of papers, marks and lectures / periods

	Marks	Lectures / Periods
Theory		
Paper - I		
A. Physical Geology	40	45
B. Mineralogy	30	30
C. Petrology	30	40
Paper - II		
A. Structural Geology	25	20
B. Palaeontology	25	30
C. Stratigraphy	25	30
D. Economic Geology	25	30
Practical		
Paper - III		
Minerals, Rocks, Structural Problems and Maps, Fossils	80	160
Field Note and Field Report	10	
Viva-voce	10	
Paper - IV (Theory)		
A. Petrology & Tectonics	25	25
B. Applied Geology	45	45
Paper - V (Practical)		
Minerals, Rocks, Field work of one week duration	30	60 (Excluding field work)

General Course Theoretical

Paper - I, Group A (Physical Geology) Full Marks - 40, Periods - 45

Science of the earth. Men's natural environments. The domains of earth science and geology. Principle of Uniformitarianism. Relation of Geology to other sciences. Major Branches of Geology.

Important facts and figures of the Earth rotation, revolution, size, shape, mass, density and gravity. Elementary ideas of the nature of the atmosphere, crust, mantle and core.

Major surface features of the Earth continents, ocean, continental margin, geomorphic features of continents and oceans, mountain ranges, plateaus, valleys, plains, basins, continental shelf, continental slope, island arch, trenches, ocean basins, mid-oceanic ridges.

Sculpturing of the land surface: weathering, erosion and sedimentation - geological action of river, glacier, wind and ocean. Regolith and bedrock; soils, concept of soil profile.

Major internal processes: igneous activity, volcanism and volcanoes, earthquake - causes and effects, intensity and magnitude, earthquake belts.

Internal constitution of the earth: use of seismic waves in the study of the earth.

Age of the Earth: use of radioactivity in dating rocks and minerals with example of Rb-Sr method of dating.

Isostasy and its use in explaining the relief of the earth's surface.

Elementary concepts of continental drift, sea-floor spreading and plate tectonics - different types of plate boundaries and related major earth features.

Paper - I, Group B (Mineralogy) Full Marks - 30, Periods - 30

Definitions of minerals and crystals: crystalline and noncrystalline states of matter; crystal forms, habit, zone, elements of symmetry. Law of constancy of interfacial angles in crystals; parameters and Miller indices. Axial elements and diagnostic symmetry elements of seven crystal systems: symmetry of normal classes; crystal aggregates: parallel growth and twins; twine plane and composition plane; common twin laws in feldspars.

Polarization of light; principles of construction of polars; parts of polarized microscope. Isotropic and anisotropic media; double refraction; birefringence; pleochroism. Interference phenomena in crystals; extinction in crystals.

Important physical characters of minerals - methods of their determination. Classification of minerals into broad divisions on the basis of chemical composition. Structural framework of silicates and their broad classification.

Elementary knowledge of the physical properties and general chemical composition of the following rock-forming minerals; Quartz, Feldspar group, Pyroxene group, Amphibole group, Mica group, Calcite-Dolomite.

Paper - I, Group C (Petrology) Full Marks - 30, Periods - 40

Average major element composition of the crust. Broad sub-division of rocks: igneous, sedimentary and metamorphic rocks.

Forms of igneous rock bodies: extrusive (lava flows and pyroclastic) and intrusive (sill, dyke, lacolith, batholith) types, classification of igneous rocks ??

Textures and microstructures of igneous rocks in terms of the following: crystallinity, granularity, shape of grains and mutual relation of grains. Description of the following textures/structures: equigranular, inequigranular, porphyritic poikilitic, ophitic, perthitic, graphic, flow structures.

Petrography of the following rocks: granite, granodiorite, pegmatite, rhyolite, syenite, trachyte, diorite, gabbro, anorthosite, basalt, dolerite, peridotite.

Clastic and non-clastic sedimentary rocks, Textural characteristics of the sedimentary rocks, introduction of the concept of size, sphericity and roundness. Petrography of shale, sandstones, limestones, sandstones.

Concept of metamorphism, factors and kinds of metamorphism, concept of grade of metamorphism with the help of Barrovian index minerals. Textures and structures of metamorphic rocks , granoblastic, porphiroblastic, hornfelsic, schistose, gneissose, cataclastic.

Petrography of common metamorphic rocks produced from shale (slates, phyllite, mica-schists), sandstone (quartzites), limestones (marbles), mafic igneous rocks (amphibolites).

Distribution, association and brief petrography of charnockite, khondalite, Deccan basalt.

Paper - II, Group A (Structural Geology) Full Marks - 25, Periods - 20

Scope of structural geology

Primary and secondary structural elements: planer and linear; strike and dip; pitch and plunge.

Primary structures: stratification, current bedding, graded bedding, ripple marks, pillow structures and vesicular structure. Use of primary structures in determination of top-bottom of a stratified sequence.

Fold: definition, parts of a fold: hinge, fold axis, limb, inflexion line, axial surface, interlimb angle. Types of folds: antiform, synform and natural; anticline and syscline, symmetrical and asymmetrical. Classification of fold on the basis of dip of axial plane and plunge of fold axis.

Faults and joints: definition; net slip and separation, threw and heave of a fault. Types of faults: dip fault, strike fault, oblique fault, strike-slip fault, dip-slip fault and oblique-slip faults, normal and reverse faults; thrust. Recognition of fault in the field.

Foliation: axial plane foliation; brief morphological features of cleavage, schistosity, gneissocity.

Unconformity: definition, types of unconformity and their recognition.

Paper - II, Group B (Palaeontology) Full Marks - 25, Periods - 35

Fossil and fossilization: definition, condition and modes of preservation; principal uses of fossils. Kinds of fossils: macro and micro fossils.

Systematic palaeontology: broad outline of the scheme to classify the organic world upto the level of species. Binomial system of classification. Broad subdivisions (down to the level of phylum) of the organic kingdom. Main characteristics of the following phyla and their geologic range:

Fossil as tools of correlation: law of faunal succession; index fossil, zone fossil.

Geological time scale and life through ages.

Gondwana flora: composition, distribution in India and geologic range.

Invertebrates: morphology of the following - Brachiopoda, Pelecypoda, Gastropoda, Cephalopoda, Echinoidea.

An outline of evolution of Ammonoidea and Equidae.

Paper - II, Group C (Strigraphy) Full Marks - 25, Periods - 35

Stratigraphy - definition and scope. Fundamental laws of stratigraphy: superposition, faunal succession and correlation. Principle of Uniformitarianism.

Stratigraphic units. Lithostratigraphic, Chronostratigraphic and Biostratigraphic. Definition of Terms: Group, Formation, Bed, System, Series, Stage.

Physiographic divisions of India - peninsula, extra-peninsula and Ganga-Brahmaputra alluvial plane.

Distribution of Precambrian (Archaean, Proterozoic), Palaeozoic, Mesozoic and Cenozoic rocks in peninsular and in extra-peninsular India.

Brief stratigraphic account of succession and lithology of Precambrian rocks of Bihar-Orissa, Vindhyan basins (Sone valley).

Brief stratigraphic account succession, lithology and fossil) of Spiti Basin (Palaeozoic and Mesozoic), Cauvery basin (Mesozoic), Assam basin (Cenozoic).

Gondwana stratigraphy: geographic distribution, general characteristics, general stratigraphic succession. Stratigraphy of Damodor valley basin (succession, lithology and fossil).

Deccan traps: distribution and age (palaeontological and radiometric data).

Paper - II, Group D (Economic Geology) Full Marks - 25, Periods - 30

Scope: Rocks and minerals of economic importance. Usefulness of water and fossil fuels.

Definition of the following terms: ore, potore, gangue, tenor, host rock, hypogene and supergene deposits, syngenetic and epigenetic deposits, hydrothermal deposit and wall rock alteration.

Forms and structures of ore deposits.

Brief outline of the process of formation of mineral deposits: igneous, metamorphic and sedimentary.

Bateman's scheme of classification of mineral deposits.

Geographic distribution of the following deposits in India: Iron ore, Manganese ore, Gold, Copper, Lead-Zinc, Chromium, Uranium, Diamond and Sapphire, Coal and Petroleum, Limestone.

Indian mineral deposits: Iron (Bihar-Orissa), Manganese, (M.P and Maharastra), Gold (Hutti), Copper (Singhbhum) and Lead-Zinc (Zawar) under the following heads - mode of occurrence, mineralogy and genesis.

General Course Practical

Paper - III Full Marks - 100, Periods - 160

Minerals

Symmetry elements of crystal models - normal classes of isomeric, tetragonal and orthorhombic systems.

Systematic study of the following minerals in hand specimen on the following points - mineral form and structure, colour and transperancy, lusture, streak, cleavage, fracture, hardness, specific gravity, magnetism (with addition of HCl, if needed):

Graphite; Chalcopyrite, pyrite, sphalerite, galena; Haematite, magnetite, chromite, pyrolusite, psilomelane, bauxite; Calcite, dolomite; Quartz, feldspar, garnet beryl, asbestos, muscovite, biotite, talc, keoline, kyanite; Tourmaline; Gypsum; Apatite.

Study under petrographic microscope of the following minerals: Quartz, orthoclase, microcline, plagioclase, orthopyroxene, clinopyroxene, hornblende, muscovite, biotite, garnet, tourmaline, kyanite, sillimanite, calcite.

Rocks

Recognition of the following rocks in hand specimen:

Granite, pegmatite, gabbro, anorthosite, rhyolite, basalt, dolerite; shale sandstone, conglomerate, limestone, coal, laterite; gneiss, schist, slate, phyllite, marble quartzite.

Study and identification under microscope of those in italics in the above list.

Structural problems and maps

Clinometer compass and its uses. Reading of topographic maps.

Solutions of simple problems of dip, strike and outcrop.

Interpretation of geologic maps containing horizontal beds, homoclines, monoclines, simple folds, faults, unconformities, large intrusives, dykes and sills.

Fossils

Identification of the following genera of fossils by their morphological features:

(a) Cidaris, Hemiaster, Stygmatopygus; (b) Atrypa, Spirifer, Productus, Terebratula; (c) Unio, Cyrena, Pecten, Ostrea; (d) Physa, Natica, Cypraca, Tyrretella; (e) Ceratites, Nautilus; (f) Hipparion, Stegodon; (g) Gangamopteris, Glossopteris, Vertebraria, Schizoneura, Ptilophyllum.

Field Work

Reconnaissance study in the field of igneous, sedimentary and metamorphic rocks. Use of clinometer compass and toposheets; collection of samples and preparation of field report.

General Course Theoritical

Paper IV. Group A (Petrology and Tectonics) Full Marks - 25, Periods - 25

IUGS Classification of igneous rocks

Processes of diversification of igneous rocks: differentiation, assimilation, partial melting.

General knowledge of magma genesis with special reference to granite and basalt.

Common sedimentary structures: bedding and lamination, cross bedding, graded bedding, penecontemporenous deformation structures.

Barroian zone of metamorphism. Concept of metamorphic facies. Facies classification of metamorphic rocks. P-T fields of metamorphic facies.

Orogeny, epirogeny and mountain building.

Paper IV. Group B (Applied Geology) Full Marks - 45, Periods - 45

Desirable specification of the minerals uses as essential raw material in the following industries: iron and steel, cement, refractories, fertilizers.

Coal: classification - peat, lignite, bituminous, anthracie. Consistuents of coal viz. vitrain, durain, clarain, fusain. Origin of coal. Industrial uses of coal.

Petroleum: indication, migration, accumulation and origin. Use of microfossils in oil exploration.

An outline of India's reserve position with regard to supply of fuels (coal, petroleum), iron, alluminium, manganese, uranium, thoium, mica, gold and diamond.

Rocks as building materials - Indian occurrence.

An elementary idea on the application of Engineering Geology for construction of reservoir dam, tunnel and control of sea beach erosion.

Geological Hazards and their management mitigation: Earthquake, Landslides, Land subsidence.

Groundwater: definition, water table, aquifer types and different rocks as acquifer

- (a) Gravels, sand, sandstone, limestone and glacial deposits. (b) Igneous rocks, (c) Metamorphic rocks. - recharge and discharge of ground water. Quality of ground water, pollution of ground water.

Remote sensing: principles and application in geology.

General Course Practical

Paper V Full Marks - 30, Periods - 60 (Excluding field work)

Rocks (Full Marks - 6)

Recognition of the following rocks in hand specimen:

Granite, pegmatite, gabbro, anorthosite, rhyolite, basalt, dolerite shale, sandstone, conglomerate, limestone, coal, laterite, gneiss, schist, slate, phyllite, marble, quartzite, breccia, banded haematite quartzite, amphibolite, augen gneiss, charnockite, khondalite, calc-gneiss (the underline rocks are also included in the syllabus for B. Sc Part - I General Course Practical)

Studies under microscope (Full Marks - 14)

(a) Study under petrographic microscope of the following minerals:

Quartz, orthoclase, microcline, plagioclase, orthopyroxene, clinopyroxene, hornblende, muscovite, biotite, garnet, tourmaline, kyanite, sillimanite, calcite, staurolite, epidote. (the underline rocks are also included in the syllabus for B. Sc Part - I General Course Practical)

(b) Estimation of relative refractive indices by Backe test.

(c) Determination of extinction angle

Field work (Full Marks - 5)

Field investigation of an Economic mineral deposit and preparation of field report.

Laboratory Note Books (Full Marks - 5)