UNIVERSITY OF CALCUTTA

Notification No. CSR/138/2026

It is notified for information of all concerned that in terms of the provisions of Section 54 of the Calcutta University Act, 1979, (as amended), and, in the exercise of his powers under 9(6) of the said Act, the Vice-Chancellor has, by an order dated 28.10.2026, approved the documents for the **2-year in Applied Geology** programme under the National Education Policy (NEP) 2020.

1. **Syllabus Structure (**Semester-wise distribution of courses and credits)
2. **Detailed Syllabus for Semester I to IV**

The above shall take effect from the academic session 2026-2027.

03/11/2026

SENATE HOUSE
Kolkata-700073
03.11.2026

Prof.(Dr.) Debasis Das
Registrar

M.Sc. Applied Geology Course Structure & Syllabus Semester System Following NEP2020

(Effective from Academic Session 2026-27)

Course Code	Paper Name	Credit	Marks	Credit	Marks	Total Credit	Total Marks
	SEMESTER I	Th		Pr/IA			
AGE411	Advanced Igneous and Metamorphic Petrology	2	50	2	50	4	100
AGE412	Advanced Sedimentology and Palaeontology	2	50	2	50	4	100
AGE413	Field Geology			2	50	2	50
	Total	4	100	6	150	10	250
	SEMESTER II						
AGE421	Advanced Structural Geology and Tectonics	2	50			2	50
AGE422	Ore Geology and Mineral Exploration	2	50	2	50	4	100
AGE423	Energy and Environment	2	50	2	50	4	100
	Total	6	150	4	100	10	250
	SEMESTER III						
AGE511	Fundamental of Research in Applied Geology (Geophysics and Geodynamics)	2	50			2	50
AGE512	Advanced Methods of Research and Research Techniques and Tools (RS-GIS and Geostatistics)	2	50	2	50	4	100
AGE513	Review of Existing Research, Project Submission & Seminar Presentation	2	50	2	50	4	100
	Total	6	150	4	100	10	250
	SEMESTER IV						
AGE521	Internship			2	50	2	50
AGE522	Dissertation	6	150	2	50	8	200
	Total					10	250
	Grand total					**40**	**1000**

Internal assessment is mandatory for every theory and practical course within the syllabus. It accounts for up to 20% of the total marks for each subject and is evaluated through continuous assessments and multiple mid-term tests.

SEMESTER I

AGE411 Advanced Igneous and Metamorphic Petrology

Theory:

Part A: Igneous Petrology

Concept of Solidus, Liquidus, Geotherm and Adiabat. Understanding isothermal and adiabatic geological processes using CARNOT CYCLE.

Principles of magmatism in various geodynamic settings. Mantle potential temperature and its significance.

Various modes of mantle melting, melt migration through mantle and magma emplacement. Melt extraction mechanisms, melt-mantle interaction and magmatic evolution.

Magma chamber processes, understanding igneous textures and their origin using phase equilibria.

Mid Ocean Ridge Basalt (MORB) and its global correlation. Role of lithospheric thickness in mantle melting and its control on basalt compositions.

Ophiolites: Origin. Evolution and Emplacement. Secular variation in ophiolite rock record

Part B: Metamorphic Petrology

Phase rule and phase equilibria in metamorphic rocks. Metamorphic phase equilibria calculation: geothermometry and geobarometry. Phase diagrams, Schreinemakers bundle and petrogenetic grid for metamorphic assemblages in various grades of metamorphism.

Graphical representation of various mineral assemblages in different P-T conditions.

Application of metamorphic textures: Deformation texture, Reaction texture. Textural Geochronology.

Heat flow and metamorphism

Time-scale of metamorphism and implications on thermal history. Temperature-time histories in metamorphic rocks. Metamorphic P-T-t paths and tectonic evolution.

Thermal modeling and metamorphic facies series. Different types of metamorphic facies and their tectonic setting.

Ocean floor metamorphism.

Impact metamorphism.

Metamorphic conditions in HT and HP metamorphism. UHT and UHP metamorphism

Migmatite and granite Petrogenesis

Practical:

Part A: Igneous Petrology

Study of thin sections of different plutonic, volcanic and shallow mantle rocks with emphasis to understand relevant petrogenesis.

Calculation of CIPW norms of silica-oversaturated and undersaturated igneous rocks, use of those normative data to interpret crystallization/melting history.

Use of biaxial variation diagram to quantify magmatic crystallization.

Part B: Metamorphic Petrology

Description metamorphic rocks under microscope and their identification. Identification of equilibrium mineral assemblages.

Interpretation of metamorphic textures. Identification of reaction texture. Textural identification to establish time relations between deformation and recrystallization of minerals such as chloritoid, garnet, staurolite, kyanite and magnetite.

Estimation of Pressure and Temperature from important models of Geothermobarometry.

AGE412 Advanced Sedimentology and Palaeontology

Theory:

Part A: Sedimentology

Fluid mechanics basic concepts and its relation to sedimentary bed forms and structures.

Principles of sediment entrainment and transportation.

Seismic and sequence stratigraphy.

Subsidence analysis, fill character and modelling techniques of sedimentary basins.

Fundamental concepts and methods of depositional environment reconstruction.

Clastic and non-clastic sediments- petrology and depositional systems.

Part B: Palaeontology

Fossil collection from field: Spot and channel sample; Representation of palaeontological samples in litholog and geological maps

Morphodynamics - Growth and function; functional morphology; methods of morphodynamic Analysis.

Mass extinction – Definition and patterns; major mass extinction episodes.

Study of major micro-invertebrate groups – Biostratigraphic significance, morphology and evolution of foraminifera; Introduction to Ostracoda, Pteropoda, Calcareous Algae, Radiolaria, Conodonts, Bryozoa and Cocolithophores.

Vertebrate paleontology - Terrestrial diversity; major evolutionary events; patterns and processes of evolution of horses, elephants, and hominids.

Ichnofossils – Types, utilities, classifications and limitations.

Practical:

Part A: Sedimentology

Description and interpretation of sedimentary structures in hand specimens. Palaeocurrent analysis, granulometric analysis of sediments and interpretation.

Granulometric analysis and interpretation of siliciclastic and carbonate rocks under microscope.

Geochemical data interpretation.

Facies correlation from lithologs.

Part B: Palaeontology

Elementary exercise on Cladistics

Elementary exercise on Biostratigraphy

Determination of relative age and depth of deposition from larger and smaller foraminiferal assemblages respectively.

Study of morphological characteristics of vertebrate teeth

AGE413 Field Geology

Field training to students in different geological terrains including mine-visits.

SEMESTER II

AGE421 Advanced Structural Geology and Tectonics

Theory:

Stress: Stress as tensor, principal stresses, Mohr circle for stress

Strain and deformation: Infinitesimal strain; Finite Strain, Mohr circle for strain and analysis of strain;

Progressive deformation; different strain ellipsoids, role of fluid in deformation

Rheology: Macrorheology: Elastic, plastic, and viscous deformation, non-Newtonian rheology, viscoelasticity and viscoplasticity, poro-elasticity. Microrheology: Grain scale deformation: Mechanisms and its manifestation in rock microstructure, diffusion and dislocation creep, recrystallization, crystallographic preferred orientation.

Basic Fluid Dynamics: Conservation of mass, momentum and energy; continuity equation; Navier–Stokes and Stokes equations; Boussinesq approximation; Stream function.

Brittle Deformation: Fracture mechanics; dynamics of faulting and jointing. Problems on Mohr envelope and frictional sliding envelope, Fault-slip data, paleostress determination,

Ductile Deformation: Mechanism of folding; Interference and Superposition of folding: theory, mechanism, outcrop pattern, stereonet pattern, relationship with other linear and planar structures;

Interpretations of ductile structures: foliation, lineation, boudinage; Shear Zones

Structural analysis of polydeformed terrain using Map, structural data and advanced stereonet techniques

Topic on Regional tectonics: Orogens and thrush tectonics with special reference to Himalaya, extensional tectonics, transpressional and transtensional systems.

AGE422 Ore Geology and Mineral Exploration

Theory:

Processes of formation of mineral deposits, changing perception of ore genesis. Modern sea floor deposits, their genetic implications and ancient analogies. Important metallic, non-metallic and atomic mineral deposits of India and of neighbouring countries. Ore texture, sequence of temperature of formation, ore solutions, complexing and ore deposition

Mineral resources- time, space, and dynamic controls, resource management concept, mineral economics, present status of resources, resource development and future sources.

National mineral policy; classification of mineral deposits, discovery types, stages of exploration: reconnaissance permits, large area prospecting, prospecting license, mining lease, mineral deposits and host rocks.

Geological exploration: surface signatures like stratigraphy, weathering (gossan), structures (fold, fault, lineament, shear, breccia), old mining activities (India) Geochemical exploration: soil, rock, stream sediments, hydrogeochemical, biogeochemical, geobotanical, atmogeochemical, and electrogeochemical.

Drilling technology: percussion, diamond, reverse circulation, air core, wireline, BH deviation survey. Sampling: pitting, trenching, channel, chip, drill core/ non-core, bulk/muck/grab/car/stack sampling; reduction, accuracy and challenges; QCR, QA analysis. Reserve estimation: cut-off, ROM, cross section, long section, level plan and inverse distance; classification of reserves/resources (conventional, USGS, UNFC, and JORC). Mining terminologies: surface and underground (soft and hard rock). Beneficiation: general beneficiation techniques of Pb, Zn, and Cu sulfides, Fe ores Exploration rick management and parameters for success. Hazards of mineral industries. Exploration case studies.

Practical:

Ore microscopy- mineral identification, mineral association and paragenesis, broad textural features.

Problems on ore reserve estimation from surface and sub-surface sampling data.

AGE423 Energy and Environment

Theory:

Part A: Energy Resources

Overview of global and Indian energy resources, Formation of fossil fuels (coal, petroleum, gas) in geological time.

Properties of coal, Classification of coal – ASTM, Mott, Seyler, and Indian, Petrology and Palynology of coal; Conditions of formation of coal and coal seams; Estimation and categorization of resources; Industrial utilization of coal; Coal resources of India.

Elements of petroleum systems: source, reservoir, seal (conceptual), Basin evolution and hydrocarbon accumulation, Basics of hydrocarbon traps (structural and stratigraphic), application of logging and seismic techniques in petroleum exploration.

Uranium and thorium: occurrence and geochemistry, Types of nuclear fuel deposits.

CBM, shale gas, oil shale, gas hydrates (overview), Geological controls and occurrence

Part B: Environmental Geology

Introduction to earth processes and natural hazards Geotechnical properties of soils and rocks. Slope stability and mass wasting; landslides and related hazards Earthquake; hazard assessment and mitigation

Engineering structures: dam, tunnels, roads, bridges; selection of sites for construction

Earth's processes affecting engineering structures

Environmental impact assessment: air, soil, groundwater, flora-fauna, and ecosystem; waste management of energy resources; pollution of environmental and its mitigation. The environmental impact of mining, beneficiation, and smelting Climate change and global warming

Role of man in environment (Anthropocene and Neo-mass extinction)

Practical:

Part A: Energy Resources

Macroscopic study of coal; Proximate analysis of coal; Caking and swelling properties of coal. Maceral analysis; Microlithotype analysis; Reflectance study of coal of different rank. Drawing and demarcation of area on the basis of physico-chemical characters; Estimation and categorization of reserve in an area.

Interpretation of seismic section; Interpretation of well-logs and VSP data; Calculation of formation-pressures; Estimation of oil and gas reserves.

Part B: Environmental Geology

Determination of void ratio, degree of saturation, amount of consolidation, compaction in soil. Analysis of discontinuities in rocks for estimating stability of surface. Stability of mass, RQD calculation. Determination of pore water pressure, seepage pressure, drainage capacity.

Preparation and interpretation of engineering geologic maps including face maps, subsurface maps and diagrams, hazard zonation maps, etc.

Analysis of soil stability. Testing and description of aggregate samples. Sampling and analysis of water and soil. Preparation of project report on environmental impacts of any one of the following: mining, river valley projects, thermal power plants, industrial projects.

SEMESTER III

AGE511 Fundamentals of Research in Applied Geology (Geophysics and Geodynamics)

Theory

Part A: Geophysics

Basic principles of Geophysics. Detailed knowledge of different branches of geophysics.

Exploration Geophysics: Gravity methods: introduction, gravity corrections, Bouguer and free-air gravity anomalies, Gravity potential and anomaly due to different simple bodies and structures. Field procedure, interpretations & amp; field-cases. Magnetic methods: introduction, magnetic properties of rocks, geomagnetic field, fieldprocedure, measurement of magnetic anomalies, interpretation. Electrical and electromagnetic method: Introduction, Self-potential, earth resistivity, different arrays, profiling & amp; sounding techniques, interpretation & field cases. Induced polarization. Telluric & amp; electromagnetic methods. Seismic method: introduction, refraction methods, layered earth refraction studies, hiddenlayer problem, correction, instruments, field procedures, interpretation.Various well-logging techniques.

Topics on solid earth geophysics: Gravity: Earth's figure and gravity, concepts of geopotential, geoid and reference spheroid; gravity anomalies over oceans and continents; Airy and Pratt isostasy; Isostatic gravity anomaly; dynamic topography

Seismology: Types of seismic waves: elastic wave theory, seismic wave velocities andpropagation mechanisms; Earthquake seismology; tomography and internal structure of the Earth.

Part B: Geodynamics

Heat transfer: Heat transfer within Earth: Conductive geotherms, oceanic lithosphere andhalf space cooling, adiabatic gradients, importance of internal heat production, Advection-diffusion equation of heat.

Theory of Instability: Mechanical instability: folding and lithospheric flexure, Elastic plate theory,foreland basins and seamount loading; Thermal instability: Rayleigh–Bénard convection; Thermo-mechanical instability: Mantle plumes and theory of Rayleigh–Taylor instabilities, types ofmantle plumes; diapirism; subduction dynamics: toroidal and poloidal motion on Earth, trenchmigration, lithospheric delamination.

Early Earth geodynamics: segregation of core, mantle and crust, stagnant lid and drip tectonics,formation and evolution Mantle reservoirs; stagnant-lid to mobile-lid transition and initiation of platetectonics, Evolution of Earth's mantle through time.

AGE512 Advanced Methods of Research and Research Technique and Tools (RS-GIS and Geostatistics)

Theory

Part A: Remote Sensing and GIS

Concept of Electromagnetic Radiation (EMR). Principles of remote sensing, thermalinfrared remote sensing and microwave remote sensing (RADAR). Concept of Spectralsignatures- with special emphasis on spectral properties of minerals and rocks.

Digital Image Processing: Image rectification and restoration techniques–radiometric andgeometric corrections; Spectral Enhancement techniques – Histogram analysis and equalization,contrast enhancement, Spatial Enhancement techniques- Filtering techniques and edge detectionand enhancement; Multi image analysis – band Ratio; Geological indices; Image Classification – supervised & unsupervised and accuracy assessment.

Geological Mapping: Digitization of geological maps, extraction of geological featuresusing multi/hyperspectral imagery, LiDAR. Geological resource and Hazard Mapping (Mineralpotential zone mapping, Groundwater potential zone mapping, Landslide susceptibility andsubsidence mapping, Flood/drought hazard mapping, Shoreline change analysis and Glacialmonitoring).

Geospatial analysis of terrestrial and planetary surface: Concept of DEM (DSM andDTM), Landform characterization, Crater geometry analysis.Concept of Geodesy and GNSS (Real Time Kinematics). Concept of AIML and Google Earth Engine.

Part B: Geostatistics

Basic concept of statistics: Concept of population and sample; Central limit theorem; Classification and presentation of statistical data; Sampling and sample distributions, Probability. Univariate Statistics: Probability distributions- binomial, normal, log-normal, Poisson; Measures of central tendency and dispersion; Confidence Intervals; Characteristics of Normal distribution;

Concept and methodology of Hypotheses Testing and its application in geology – z- statistics, student's t test, F test, $\chi 2$ test, ANOVA; Statistical inferences- errors in judgment.

Bivariate Statistics: Correlation, Least square method and regression analysis.

Concept of regionalized variable: Semi variograms and Kriging

Multivariate Statistics: Multiple regression: Discriminant functions; Cluster analysis; R- and Q-mode factor analysis, Principal component Analysis.

Analysis of sequence of data: Markov chain and embedded Markov chain; Auto correlation; Cross correlation; Cross association.

Practical

Part A: Remote Sensing and GIS

Downloading satellite data from different internet sites and choice of datasets, Georeferencingtopographic and cadastral map, Image rectification and restoration (radiometric and geometriccorrections), Recognition of Spectral signatures, Image enhancement methods,Visual Interpretation of Aerial photographs and Satellite Imagery, Recognition and identificationof spectral indices using band ratios.

Multivariate Image Analysis, Unsupervised and Supervised Image Classification, AccuracyAssessment. Data Merging, GIS Integration and Spatial interpolation estimation methods.Generation of DEM and its derivatives, application of spatial analysis tool.Detection, identification and analysis of primary terrains. Spectral analysis of rocks andminerals.

Part B: Geostatistics

Introduction to Scientific Programming: Variables and array, Matrix operations, loops and logics, Functions and scripts, Data visualization, Scientific plotting in 2D and 3D, Concept of iteration.

Curve fitting: Data fitting using software

Solving linear equation: Direct and iterative methods; Eigenvalue, eigenvector andsolvability.

Numerical solution to boundary value problems: Numerical differentiation methods; concept of numerical Grid and mesh generation; solution to steady-state geotherm.

Numerical solution to initial boundary value problems: Explicit finite difference methods,Implicit finite difference methods, Stability analysis; solving time-dependent heat equation.

Numerical solution to basic Fluid dynamics conservation equation.

AGE513 Review of Existing Research, Project Submission & Seminar Presentation

To foster independent analytical thinking and academic rigour, students are required to conduct a thorough review of existing geological literature and carry out project-based research. The culmination of this work involves submitting a formal project report/dissertation, followed by a seminar presentation where students present their findings and defend their research before an evaluation committee.

SEMESTER IV

AGE521 Internship

Students are required to undergo an internship program, which may be undertaken in either an industrial organization (preferable), academic institution, or research laboratory related to Earth Sciences. This module aims to bridge theoretical knowledge with real-world application, offering hands-on exposure to practical geology, modern exploration/analytical techniques, or advanced geological research. Upon completion, students must submit a comprehensive internship report and present their work for evaluation.

AGE522 Dissertation

The dissertation is the core research project of the program, giving students a chance to tackle a geological question of their choice. Under the guidance of a faculty supervisor, students will formulate a research problem, collect and analyze field or laboratory data, and present their findings in a structured manuscript. The final evaluation will be based on the quality of the written dissertation and an oral defense during a viva-voce examination.