

**GEOLOGY – PAPER I : 200 Marks**

**Section A : Geomorphology and Remote Sensing.**

Introduction : Development, Scope, Geomorphic concepts, Types and Tools; Landforms: Role of Lithology, peneplaination, endogenous and exogenous forces responsible, climatic and Tectonic factors and rejuvenation of landforms; Denudational processes : Weathering , erosion, transportation, weathering products and soils – profiles, types, duricrusts; Hillslopes : Their characteristics and development, fluvial processes on hillslopes; River and drainage basin: Drainage pattern, network characteristics, Valleys and their development, processes of river erosion, transportation and deposition; Landforms produced by geomorphic agents: Fluvial, Coastal , Glacial and Aeolian landforms; Geomorphic indicators of neotectonic movements : Stream channel morphology changes , drainage modifications, fault reactivation, Uplift – subsidence pattern in coastal areas; Applied Geomorphology : Application in various fields of earth sciences viz. Mineral prospecting, Geohydrology, Civil Engineering and Environmental studies; Geomorphology of India: Geomorphical features and zones

Electromagnetic radiation – characteristics, remote sensing regions and bands; General orbital and sensor characteristics of remote sensing satellites; Spectra of common natural objects – soil, rock, water and vegetation. Aerial photos – types, scale, resolution, properties of aerial photos, stereoscopic parallax, relief displacement; Principles of photogrammetry; Digital image processing - characteristics of remote sensing data, preprocessing, enhancements, classification; Elements of photo and imagery pattern and interpretation, application in Geology; Remote sensing applications in interpreting structure and tectonics, Lithological mapping, mineral resources, natural hazards and disaster mitigation, groundwater potentials and environmental monitoring. Landsat, Skylab, Seasat and other foreign systems of satellites and their interpretation for geological and other studies; Space research in India – Bhaskara and IRS systems and their applications, Thermal IR remote sensing and its applications, Microwave remote sensing and its applications. Principles and components of Geographic Information System (GIS), remote sensing data integration with GIS, applications of GIS in various geological studies.

**Section B: Structural Geology**

Principle of geological mapping and map reading, projection diagrams. Stress-strain relationships for elastic, plastic and viscous materials. Measurement of strain in deformed rocks. Behaviour of minerals and rocks under deformation conditions. Structural analysis of folds, cleavages, lineations, joints and faults. Superposed deformation. Mechanism of folding, faulting and progressive deformation. Shear Zones: Brittle and ductile shear zones, geometry and products of shear zones; Mylonites and cataclasites, their origin and significance. Time relationship between crystallization and deformation. Unconformities and basement-cover relations. Structural behaviour of igneous plutons, diapirs and salt domes. Introduction to petrofabric analysis.

**Section C: Geodynamics**

Earth and its internal structure. Continental drift – geological and geophysical evidence and objections. An overview of plate tectonics including elementary concepts of plates, lithosphere, asthenosphere, types of plate boundaries and associated important geological features like oceanic trenches, volcanic arcs, accretionary wedges, topography of mid-ocean ridges, magnetic anomaly stripes and transform faults. Gravity anomalies at mid-ocean ridges, deep sea trenches, continental shield areas and mountain chains. Palaeomagnetism and its application for determining palaeoposition of continents. Isostasy, Orogeny and Epeirogeny. Seismic belts of the earth. Seismicity at plate boundaries. Principles of Geodesy, Global Positioning System (GPS) and its application in crustal motion monitoring including neotectonics. Palaeoposition of India and Geodynamics of the Indian plate.

## **Section D: Stratigraphy**

Principles of Stratigraphy : History and Development of Stratigraphy; Stratigraphic procedures (Surface and Subsurface); Concept of Lithofacies and Biofacies; Stratigraphic Correlation (Litho, Bio- and Chronostratigraphic Correlation); Study of standard stratigraphic code (Lithostratigraphic, Biostratigraphic and Chronostratigraphic); Concepts of Magnetostratigraphy, Chemostratigraphy, Event stratigraphy, and Sequence stratigraphy; Nomenclature and the modern stratigraphic code. Radioisotopes and measuring geological time. Geological time-scale. Stratigraphic procedures of correlation of unfossiliferous rocks. Precambrian stratigraphy of India : Achaean stratigraphy - tectonic frame-work, geological history and evolution of Dharwar, and their equivalents; Easterghats mobile belt; Proterozoic stratigraphy -tectonic framework, geological history and evolution of Cuddapahs and their equivalents. *Palaeozoic stratigraphy*: Palaeozoic formations of India with special reference to type localities, history of sedimentation, fossil content. *Mesozoic stratigraphy*: Mesozoic formations of India with special reference to type localities, history of sedimentation, fossil content. *Cenozoic stratigraphy*: Cenozoic formations of India, Rise of the Himalayas and evolution of Siwalik basin. *Stratigraphic boundaries*: Stratigraphic boundary problems in Indian geology. Gondwana Supergroup and Gondwanaland. Deccan Volcanics. Quaternary stratigraphy. Rocks record, palaeoclimates and palaeogeography.

## **Section E : Palaeontology**

Evolution of the fossil record and the geological time scale. Basic and functional morphology of major fossil groups. Species concept; Major evolutionary theories ; Techniques in Palaeontology mega fossils- microfossils – nannofossils , ichnofossils – collection, identification and illustration – binomial Nomenclature; Invertebrate Palaeontology – A brief study of morphology, classification, evolutionary trends and distribution of Bivalves, cephalopoda and Gastropods, Echinoids, Corals and Brachiopods. Vertebrate Palaeontology – Brief study of vertebrate life through ages. Evolution of reptiles and mammals; Siwalik vertebrate fauna; Biodiversity and mass extinction events; evidence of life in Precambrian times; Palaeontological perspective : Use of palaeontological data in a) Stratigraphy b) Palaeoecology and evolution; Introduction to Micropalaeontology; Types of Microfossils; Plant fossils: Gondwana flora and their significance. Different microfossil groups and their distribution in India; Application of palynology. Basic idea about statistical application in palaeontology. Fundamentals of isotopic studies of fossils.

## GEOLOGY – PAPER II : 200 Marks

### Section A : Mineralogy and Geochemistry & Isotope Geology

*External symmetry of crystals:* Symmetry Elements, methods of projection, derivation of 32 classes, Hermaun Muguin notation. *Internal symmetry of crystals:* Derivation of 230 space groups, diffraction of crystals by X-rays, Braggs' law. *Principles of optical mineralogy :* Optical mineralogy, polarized light, behaviour of isotropic and anisotropic minerals in polarized light, refractive index, double refraction, birefringence, sign of elongation, interference figures, 2V, dispersion in minerals. Optic sign, pleochroic scheme and determination of fast and slow vibrations and accessory plates. *Introduction to mineralogy:* Definition and classification of minerals. Structural and chemical principles of crystals / minerals, chemical bonds, ionic radii, coordination number (CN) and polyhedron. *Structure, chemistry, physical and optical characters and paragenesis of mineral groups:* Olivine, pyroxene, amphibole, mica and spinel groups; Feldspar, quartz, feldspathoid, aluminum silicate, epidote and garnet groups. *Accessory minerals:* Apatite, calcite, corundum, scapolite, sphene and zircon. *Earth mineralogy:* Average mineralogical composition of crust and mantle, mineral transformations in the mantle with depth.

Earth in relation to the solar system and universe, cosmic abundance of elements. Composition of the planets and meteorites. Structure and composition of earth and distribution of elements. Trace elements and REE and their importance in fractional crystallization during magmatic / partial melting. Elementary crystal chemistry and thermodynamics. Introduction to isotope geochemistry. Geochronology and age of the Earth: Law of Radioactivity; Principles of isotopic dating, Decay schemes and Derivation of equation of age. Rb/Sr, U- Th –Pb methods of dating the rocks. Age of the Earth. Geochemistry and principles of evolution of hydrosphere, biosphere and atmosphere. Geochemical cycle and principles of geochemical prospecting.

### Section B : Igneous Petrology

*Origin of magmas:* Mantle, onset of partial melting of mantle, processes of partial melting in mantle, mantle-magmas in relation to degree and depth-level of partial melting. *Phase equilibrium in igneous systems:* Binary and ternary systems. *Bowen's reaction principle:* Reaction series and its application to petrogenesis. *Magmatic evolution and differentiation:* Fractional crystallization, gravitational differentiation, gas streaming, liquid immiscibility and assimilation. *Structures and textures:* Definition, description, rock examples and genetic implications of common structures and textures of igneous rocks. *Classification of igneous rocks:* Mode, CIPW norm, IUGS and other standard classifications; *Magmatism and tectonics:* Inter-relationship between tectonic settings and igneous rock suites. *Igneous rock suites:* Form, structure, texture, modal mineralogy, petrogenesis and distribution of *Ultramafic rocks:* Dunite-peridotite-pyroxenite suite; kimberlites, lamprophyres, lamproites, komatiites; *Basic rocks:* Gabbro-norite-anorthosite-troctolite suite, Dolerites; Basalts and related rocks; *Intermediate rocks:* Diorite-monzonite-syenite suite; Andesites and related rocks; *Acidic rocks:* Granite-syenite-granodiorite-tonalite suite; Rhyolites and related rocks; *Alkaline rocks:* Shonkinite, ijolite, urtite, melteigite, malignite, alkali gabbros, alkali basalt, alkali granite, alkali syenite, nepheline syenite and phonolite; *Carbonatites; Ophiolite suite.*  
Petrogenetic provinces : Continental areas: Volcanic-Flood basalts-Tholeiites (Deccan Trap, Columbia River basalts); Layered gabbroic intrusions: The Bushveld complex, Skaergaard intrusion, Still water complex. Plutonic: Carbonatites and alkaline rock complexes of India; Oceanic Rift valleys: MORB- Tholeiites-Ophiolites

### Section C : Metamorphic Petrology & Processes

Concepts and Theory: Types of Metamorphism and their controlling factors; Common minerals of metamorphic rocks; Field observations, petrographic classification of common metamorphic rocks; Metamorphic facies and facies series. Effects of Metamorphism : Phase diagrams and graphic representation of mineral assemblages; Prograde and retrograde metamorphism, Matasomatism; Deformation textures and textures related to recrystallization; Metamorphic reactions, elemental exchange and Pressure – Temperature conditions of Isograds; Mineral assemblages equilibrium/

reaction textures and geo-thermo barometry. Experimental and thermodynamic appraisal of metamorphic reactions; Role of fluids in metamorphic reactions. Metamorphism types and products: Regional and thermal metamorphism of pelitic rocks. Regional and thermal metamorphism of basic and ultrabasic rocks; Regional and thermal metamorphism of impure, silicious carbonate rocks; Metamorphism of Granitoides, Charnockites and Migmatites. Metamorphism in space and time: Plate tectonics and metamorphic processes; Paired metamorphic belts, Archaean and Proterozoic terrains; Extraterrestrial Metamorphism (Impact and Shock Metamorphism); polymetamorphism

#### **Section D : Sedimentology**

Provenance and diagenesis of sediments. Sedimentary textures. Framework, matrix and cement of terrigenous sediments. Definition, measurement and interpretation of grain size. Elements of hydraulics. Primary structures, palaeocurrent analysis. Biogenic and chemical sedimentary structures. Sedimentary environment and facies. Facies modeling for marine, non-marine and mixed sediments. Tectonics and sedimentation. Classification and definition of sedimentary basins. Sedimentary basins of India. Cyclic sediments. Seismic and sequence stratigraphy. Purpose and scope of basin analysis. Stratum contours and isopach maps.

#### **Section E : Environmental Geology and Natural Hazards**

Fundamental concepts of Environmental Geology - it's scope, objectives, and aims. Earth's thermal environment and Climates. Global warming. Green house effect. Ozone depletion–Ice sheets and fluctuation in sea levels. Concepts of ecosystem. Earth's major ecosystems terrestrial and aquatic. Meteorology as environmental science. Air Pollution, sources of pollution, pollution due to dust and waste disposal. National and International standards. Environmental health hazards. Mining, opencast, underground, disposal of industrial and radio-active waste, dumping stacking, rehandling, management, mineral processing, tailing ponds, acid mine drainage, siltation, case studies. Mining below water table, mine water discharges, regional effects on water regime. Noise levels- national standards, mining machinery, ill effects. Air sampling techniques – respirable dust samplers, high volume air samplers, personal sampling pumps, weather monitoring equipments, automatic recorders. Elements of Environmental Impact Assessment – impacts, primary, secondary, prediction, assessment, base-line data generation, physical, biological, cultural, socioeconomic aspects. Carrying capacity based developmental planning – Assimilative capacity – supportive capacity – Resource based planning – Institutional strategies. Sustainable Developmental Planning - Applications of GIS in Environmental Management. Environmental Legislations in India.

Concepts and principles: Natural hazards – preventive/ precautionary measures – floods, landslides, earthquakes, river and coastal erosion. Distribution, magnitude and intensity of earthquakes. Neotectonics and seismic hazard assessment. preparation of seismic hazard maps. Impact of seismic hazards on long and short term environmental conditions. Mechanism of landslides, causes of major floods, cyclones and storms. Deforestation and land degradation. Coastal erosion, its causes and control of Geological hazards and crisis management.

## **GEOLOGY – PAPER III : 200 MARKS**

### **Section A: Indian mineral deposits and mineral economics**

Occurrence and distribution in India of metalliferous deposits - base metals, iron, manganese, aluminium, chromium, nickel, gold, silver, molybdenum. Indian deposits of non-metals – Diamond, mica, asbestos, barytes, gypsum, graphite, apatite and beryl. Gemstones, refractory minerals, abrasives and minerals used in glass, fertilizer, paint, ceramic and cement industries. Building stones. Phosphorite deposits. Placer deposits, rare earth minerals. Strategic, critical and essential minerals. India's status in mineral production vis a vis world scenario, Changing patterns of mineral consumption. UNFC classification, National Mineral Policy. Mineral Concession Rules. Marine mineral resources and Laws of Sea.

### **Section B: Ore genesis and Geophysics**

Ore deposits and ore minerals. Magmatic processes of mineralization. Porphyry, skarn and hydrothermal mineralization. Fluid inclusion studies. Mineralisation associated with – (i) ultramafic, mafic and acidic rocks (ii) greenstone belts (iii) komatiites, anorthosites and kimberlites and (iv) submarine volcanism. Magma related mineralization through geological time. Stratiform and stratabound ores. Ores and metamorphism – cause and effect relations. Metallogeny and mineral belts.

Interrelationship between geology and geophysics - Role of geological and geophysical data in explaining geodynamical features of the earth. General and Exploration geophysics - Different types of geophysical methods; Gravity, magnetic, Electrical, Seismic - their principles and applications. Geophysical field operations - Different types of surveys, grid and route surveys, profiling and sounding techniques, scales of survey, presentation of geophysical data. Application of Geophysical methods - Regional geophysics, ore geophysics, engineering geophysics. Geophysical anomalies : correction to measured quantities, geophysical, anomaly, regional and residual (local) anomalies, factors controlling anomaly, depth of exploration. Integrated geophysical methods - Ambiguities in geophysical interpretation, Planning and execution of geophysical surveys.

### **Section C: Mineral exploration**

Resource, reserve definitions; mineral resource in industries - historical perspective and present. A brief overview of classification of mineral deposits with respect to processes of formation in relation to exploration strategies. Principles of mineral prospecting and exploration - conceptualization, methodology and stages; sampling, subsurface sampling including pitting, trenching and drilling, core and non-core drilling, planning of bore holes and location of bore holes on ground. Core logging, geochemical exploration- nature of samples anomaly, strength of anomaly and controlling factors, coefficient of aqueous migration. Principles of reserve estimation, density and bulk density, factors affecting reliability of reserve estimation, reserve estimation based on geometrical models (square, rectangular, triangular and polygon blocks ) regular and irregular grid patterns, statistics and error estimation. Application of Geophysical techniques, Geomorphological and remote sensing techniques and Geobotanical and geochemical methods. Application of geostatistical techniques in Mineral Exploration.

### **Section D: Geology of fuels**

Coal and its properties: Different varieties and ranks of coal. Origin of coal. Coalification process and its causes. Lithotypes, microlithotypes and macerals: their physical, chemical and optical properties. Maceral analysis of coal: Mineral and organic matter in coal. Petrographical methods and tools of examination. Fundamentals of coal petrology, concept of coal maturity, peat, lignite, bituminous and anthracite coal. Application of coal geology in hydrocarbon exploration. Applications of coal petrography. Proximate and ultimate analyses. Indian coal & lignite deposits. Industrial evaluation of coal characteristics with reference to coal classification. Geology and coal petrography of different

coalfields of India. Uses of coal for various industries e.g. carbonization, liquefaction, power generation, gasification and coal-bed methane production.

Origin, migration and entrapment of natural hydrocarbons. Characters of source and reservoir rocks. Structural, stratigraphic and mixed traps. Techniques of exploration. Geographical and geological distributions of onshore and offshore petroliferous basins of India.

Mineralogy and geochemistry of radioactive minerals. Instrumental techniques of detection and measurement of radioactivity. Radioactive methods for prospecting and assaying of mineral deposits. Distribution of radioactive minerals in India. Radioactive methods in petroleum exploration – well logging techniques. Nuclear waste disposal – geological constraints.

### **Section E : Engineering Geology**

Geological studies and evaluation in planning, design and construction of major civil structures. Elementary concepts of rock mechanics and soil mechanics. Site investigation, characterization and problems related to civil engineering projects: geological and geotechnical investigations for dams, reservoirs and spillways, tunnels, underground caverns, bridges, highways, shorelines. Problems of groundwater in engineering projects. Coastal geotechniques. Environmental considerations related to civil engineering projects. Resource evaluation of construction materials. Geological hazards (landslides and earthquakes), their significance, causes, preparedness and mitigation. Recent trends in geotechnical engineering. Geotechnical case studies of major projects in India.

# COMBINED GEO-SCIENTIST AND GEOLOGIST EXAMINATION

(4) HYDROGEOLOGY: 200 Marks

Section A: Origin, occurrence and distribution of water.

Water on earth; Types of water — meteoric, juvenile, magmatic and sea water; Hydrological Cycle and its components; Water balance; Water-bearing properties of rocks — porosity, permeability, specific yield and specific retention; Vertical distribution of water; Zone of aeration and zone of saturation; Classification of rocks according to their waterbearing properties; Aquifers; Classification of aquifers; Concepts of drainage basins and groundwater basins; Aquifer parameters- transmissivity and storage coefficient; Water table and piezometric surface; Fluctuations of water table and piezometric surface; Barometric and tidal efficiencies; Water table contour maps; Hydrographs; Springs; Geologic and geomorphic controls on groundwater; Hydrostratigraphic units; Groundwater provinces of India. Hydrogeology of arid zones of India; Hydrogeology of wet lands.

Section B: Groundwater Hydraulics

Theory of groundwater flow; Darcy's law and its applications; Determination of permeability in laboratory and in field; Flow through aquifers; steady, unsteady and radial flow conditions; Evaluation of aquifer parameters of confined, semi-confined and unconfined aquifers -Thiem, Thies, Jacob and Walton's methods; Groundwater modelling.

Section C: Groundwater Exploration and Water Well Construction

Geologic and hydrogeologic methods of exploration; Role of remote sensing in groundwater exploration; Hydrogeomorphic and lineament mapping; Surface geophysical methods — seismic, gravity, geo-electrical and magnetic methods; Types of water wells and methods of construction; Design, development, maintenance and revitalization of wells; Sub-surface geophysical methods; Yield characteristics of wells; Pumping tests- methods, data analysis and interpretation;

Section 1): Groundwater Quality

Physical and chemical properties of water; Quality criteria for different uses; Graphical presentation of groundwater quality data; Groundwater quality in different provinces in India; Groundwater contamination; natural (geogenic) and anthropogenic contaminants; Saline water intrusion; Radio-isotopes in hydrogeological studies.

## Section E: Groundwater Management

Groundwater problems related to foundation work, mining, canals and tunnels; Over-exploitation of groundwater and groundwater mining; Groundwater problems in urban areas; Ground water management in arid and semi arid areas; Climate change impact on groundwater resources; Concept of sustainable development of groundwater resources; Groundwater management —supply side and demand side management; Rainwater harvesting and managed aquifer recharge; Conjunctive use of surface and groundwater; Groundwater legislation.