

Syllabus of Geology (SCPH13)

Note:

- i. There will be one Question Paper which will have 100 questions.
- ii. All questions will be compulsory.
- iii. The Question Paper will have two Parts i.e. Part A and Part B
- iv. Part A will have 50 questions based on Research Methodology
- v. Part B will have 50 questions based on Subject-Specific Knowledge.

- ❖ **Introduction to earth surface processes:** and historical development in concepts, terrestrial relief, scales in geomorphology, energy flow and relative energy of surface processes. Weathering and formation of soils, karst and speleology, slope and catchment erosion processes, fluvial, eolian, glacial, periglacial and coastal processes and resultant land forms, Water and sediment flux in river systems, Morphometric analysis of drainage basin and geomorphology-hydrology relationship.
- ❖ **Rates and changes in surface processes:** Techniques for process measurement-sediment budgeting, rock magnetism, isotope geochemical tracers, cosmogenic nuclides, OSL & C-14 dating. Controlling factors (tectonics, climate, sea level changes and anthropogenic) and surface processes; Climate change and geomorphic response of fluvial systems of arid and humid regions; Geomorphic response to tectonics, sea level/base level change, anthropogenic affects, Introduction to Anthropocene.
- ❖ **Geomorphic concepts in cause-effect relationship:** Spatial & temporal scales, geomorphic system, connectivity, buffering, magnitude-frequency concept, time lag, sensitivity, equilibrium, threshold, non-linearity & complexities. Mega geomorphology and process interrelationship, Surface processes and natural hazards; Applied aspects of geomorphology; Introduction to planetary geomorphology.
- ❖ **Structural Geology and Tectonics**
- ❖ **Introduction to Rock Mechanics:** Concept of Stress and Strain: 2-D stress and strain analysis; Strain ellipses: *types* and their geological significance; Mohr diagrams and their use; concept of stress-strain compatibility. Behaviour of rocks under stress: elastic, plastic, viscous and viscos-elastic responses and their geological significance. Concept of continuous and discontinuous media; deformation mechanism at grain scale: dislocation and diffusion creep, strain hardening and softening mechanisms, lattice preferred orientation, super plasticity. Mechanics of rock fracturing: fracture initiation and propagation; Coulomb's criterion and Griffith's theory; Crack linkage and their importance

❖ **Folds:**

- ❖ Mechanical aspects of folding: buckling, bending, flexural slip and flow folding,ptygmatic folds etc. Fold interference and superposed folds. Strain distribution n a folded layer and its significance. Evolution of axialplanar and transacted cleavages with folds; Lineation.

❖ **Faults:**

- ❖ Mechanics of faulting: Anderson's theory and its limitations. Complex geometry normal, strike slip and thrust faults with natural examples. Concept of fault tone weakening fault reactivation and its significance. Palaeostress analysis using fault-slip data. Geometric analyses of joints - mesofracture analyses and fractography. Shear zones: geometry and kinematics; their significance in continental crustal evolution; Mylonites, Pseudotachylytes.

❖ **Crustal deformation:**

- ❖ Brittle-plastic transition and seismic behaviour of the upper crust. Plate convergence and continental deformation: transpressional and trans tensional tectonics: Indian and overseas examples.

❖ **Global Tectonics:**

- ❖ Concept of subduction and orogeny
- ❖ Major global orogenic events in the geological past and their correlation with Indian examples; Himalayan Geology.

❖ **Igneous Petrology**

- ❖ **Earth as a heat engine.** Melting and crystallization. Magma and magmatic processes. Forms and types of igneousbodies: extrusive bodies- Flood basalts, Volcanoes and types of volcanoes pyroclastic deposits. Forms and structures of intrusive bodies: concept of concordant and discordant intrusion. Forms and structures of hypabasal rocks. Well studied Indian examples for the above rocks. Genetic aspects of structures and textures of igneous rocks. Classification of igneous rocks- concept of mode and norm. Phase rule and concept of phase diagrams and their application. General principles of the thermodynamics. Mineralogical and chemical description and significance of important igneous rocks of continental and oceanic association. Relationship of magma types and tectonic settings.

- ❖ **Introduction to Geochemistry**, isotope geology and its application in igneous petrology. Mobility of elements during post crystallization processes. Trace element partitioning, factors governing values of partition coefficient. Application of trace elements in petrogenesis and source characterization.

❖ **Sedimentary Geology**

❖ **Sedimentary Processes and Products:**

- ❖ **Introduction to basic concepts:** Developments in sedimentology, description and classification of sedimentary rocks, sedimentary environments and facies, earth's sedimentary shell,
- ❖ **Weathering and sedimentary flux:** Physical and chemical weathering, submarine weathering, soils and paleo sols'

- ❖ **Fluid flow, sediment transport and sedimentary structures:** Types of fluids, Laminar vs. turbulent flow, Reynolds number, Froude Number, Boundary layer effect, Particle entrainment, transport and deposition, sediment gravity flows, Concept of flow regimes and bedforms
- ❖ **Siliciclastic sediments and environments:**
- ❖ **Sedimentary texture:** Grain size scale, particle size distribution, statistical treatment of particle size data, particle shape and fabric
- ❖ Sedimentary structures: Primary and secondary sedimentary structures, Paleocurrent analysis.
- ❖ Siliciclastic rocks: Conglomerates, sandstones, mudrocks (texture, composition, classification and origin and occurrence), diagenetic processes and histories, terrestrial, coastal and marine sedimentary environments; lithification and diagenesis of siliciclastic rocks.
- ❖ **Non-siliciclastic rocks and environments:**
- ❖ Carbonate rocks, controls of carbonate deposition, components and classification of limestone, dolomite and dolomitization, carbonate sedimentary environments, Chert and siliceous sediments, phosphorites, carbonaceous sediments, iron rich sediments and evaporates; lithification and diagenesis of carbonate rocks, chert and siliceous sediments.
- ❖ **Paleo environment analysis:**
- ❖ Application of radioactive and stable isotopes in reconstruction of paleo environments
- ❖ **Basin Analysis:**
- ❖ Sedimentary basins and their classification, basin analysis (maps, cross sections, petrofacies, geological history, applications)
- ❖ **Tectonics and Sedimentation:**
- ❖ Sedimentation in orogenic belts and cratons, plate tectonics and sedimentation (sedimentation-divergent margins, convergent margins, transform margins) secular changes in sedimentary record.
- ❖ **Metamorphic Petrology**
- ❖ **Closed and Open Systems,** Nature of Metamorphic Reactions, Isograds and Reaction Isograds, Schriener's Rule and Construction of Petrogenetic Grids. Application of mineral chemistry and isotope geology in metamorphic petrology.
- ❖ **Quantitative Geothermobarometry:** P-T evolution paths of metamorphic rocks.
- ❖ **Overview of different types of metamorphism:** Concept and Classification of Metamorphic Facies and Facies Series; Textures and structures in relation to deformation and metamorphism in regional terrains; Dynamic metamorphism Processes and kinetics of thrust and fault rocks; Metamorphism of pelites, mafic, ultramafic and calcareous rocks; High P/T ratio metamorphism, Metasomatism.
- ❖ Metamorphic Differentiation, Anatexis and Origin of Migmatites in the light of experimental studies
- ❖ Exhumation and Uplift rates, Erosion, Geodynamics and the Geomorphology of Metamorphic Terrains
- ❖ Geochronology/Dating methods (Fission-Track) and isotope studies in metamorphism, Diffusion and Kinetics of metamorphic reactions.
- ❖ **Stratigraphy**
- ❖ **International Stratigraphic Code** Development of a standardized stratigraphic nomenclature. Concepts of Stratotypes, Global Stratotype Section and Point (GSSP).

Principles of stratigraphy, Facies Concept in Stratigraphy: Walther's Law of Facies. Concepts of Sequence stratigraphy; Application of Sequence.

- ❖ Stratigraphy in hydrocarbon exploration, Basic concepts of magneto-, seismic and chemo- stratigraphy. Methods of measurements of Geological time. Recent advances in refinement of Geological time Scale. Stratigraphic Correlation. Paleogeographic reconstructions and its application in oil exploration.
- ❖ **Precambrian stratigraphy**
- ❖ Precambrian and its subdivisions. Plate tectonics during Precambrian. Precambrian / Cambrian boundary with special reference to India. Sequence of major Precambrian events in terms of rock record in Indian Stratigraphy. Precambrian biota and their application in stratigraphy. Potential Precambrian petroliferous basins of India and their brief stratigraphic framework.
- ❖ **Phanerozoic Stratigraphy**
- ❖ Major plate movements during Phanerozoic. Subdivisions of Phanerozoic up to Stage level. Stratigraphic framework of Marine Paleozoic and Mesozoic rocks of Himalaya with special reference to Kashmir and Spite, marine Mesozoic Rocks of Peninsular India and their
- ❖ Correlation with those of Himalaya. Depositional history and economic potential of Gondwana Super group. Stratigraphic framework of marine Cenozoic rocks of India with special emphasis on Petroliferous horizons. Stratigraphy of Siwalik Super group and correlation with its marine equivalents. Recognizing criteria for major stratigraphic boundaries of Phanerozoic and their GSSPs. Permian Triassic boundary, Cretaceous Tertiary boundary in Indian sections. Continental Quaternary deposits and their significance.
- ❖ **Micropaleontology and Oceanography**
- ❖ **Oceanography**
- ❖ (Physical Oceanography) History of development of Marine Geology and Oceanography,; Components of thermohaline circulation and its role in controlling world's climate, concept of mixed layer, thermocline and pycnocline, Coriolis Force and Ekman Spiral, Upwelling, El Nino-Southern Oscillation, Global warming and the role of oceans, The great oceanic conveyor belt and its role in global climate change.
- ❖ **Chemical Oceanography:** General introduction to chemical oceanography. Properties of water and seawater. Techniques for measurement of various properties Major ions of seawater. Origin and implications of Oxygen Minimum Zone and denitrification. Carbon dioxide and carbonate cycle; Calcite and Aragonite Compensation depth and its significance, Chemical Equilibrium. Mass balance, residence time, chemical inflow from the rivers. Ocean's biological productivity, proxies to measure paleoproductivities of the oceans.
- ❖ **Geological Oceanography:** Ocean floor morphology Deep-sea sediments in time and space as related to tectonic models and their relation to oceanic processes Deep Sea hiatuses and their causes, Tsunamis Paleoceanographic changes in relation to earth system history including impact of the oceans on climate change, Marine Stratigraphy, correlation and chronology.
- ❖ Evolution of Oceans in the Cenozoic. Ocean Gateways of the Cenozoic and their role in controlling global climates. Sea level changes during Quaternary with special reference to India. Marine pollution emphasizing geochemical aspects of the sources, transport, and fate of pollutants in the coastal marine environment.

- ❖ Exclusive economic zone, law of the sea, mineral resources of the sea.

❖ **Micropaleontology**

- ❖ Definition and scope of Micro pale ontology. Relationship of Micro paleontology with Ocean Science
- ❖ Surface and Subsurface sampling methods including deep sea drilling (ODP, DSDP, IODP); Sampling Modern Ocean Biogenic Flux including Joint Global Ocean Flux Studies (JGOFS). Sample processing techniques. Equipments for micropaleontological studies.
- ❖ Study of following groups of microfossils with reference to their outline of morphology, modern biogeography, application in paleoceanographic and paleoclimatic reconstruction and oceanic biostratigraphy with special reference to India.
- ❖ Calcareous microfossils including Foraminifera, Calcareous nannofossils. Ostracoda, pteropods, calpionellids and calcareous algae. Siliceous microfossils including Radiolaria, Diatoms, Silicoflagellates. Phosphatic microfossils including Conodonts. Organic Walled Microfossils including Acritarchs and Dinoflagellates, Pollens and Spores.
- ❖ Applications of stable isotopic and elemental composition of various microfossils in paleoclimatic/paleoceanographic reconstruction.
- ❖ Organo-geochemical proxies for paleoclimatic /paleoceanographic studies Application of Micro
- ❖ Pale ontology in Hydrocarbon Exploration.

❖ **Hydrogeology**

- ❖ **Origin of water: meteoric**, juvenile, magmatic and sea waters. Hydrologic cycle: clouds, type of clouds; precipitation, measurement of precipitation, rainfall-runoff analysis, stream discharge parameters and its measurement, infiltration and evapotranspiration. Hydrographs; Stage-discharge relationship and rating curves;
- ❖ Flood frequency Analysis, flood routing, Surface water and groundwater interaction.
- ❖ **Subsurface movement and vertical distribution of groundwater.** Springs. Classification of aquifers. Flow nets. Concepts of drainage basin and groundwater basin. Hydrological properties of rocks - specific yield, specific retention, porosity, hydraulic conductivity, transmissivity, storage coefficient. Water table fluctuations - causative factors, concept of barometric and tidal efficiencies. Water table contour maps. Classification of rocks with respect to. Their water bearing characteristics. Hydro stratigraphic units. Groundwater
- ❖ Provinces of India. Hydrogeology of arid zones of India.
- ❖ **Well hydraulics and well design**
- ❖ Theory of groundwater flow, Darcy's Law and its applications, Types of wells, drilling methods, construction, design, development and maintenance of wells, specific capacity and its determination. Unconfined, confined, steady, unsteady and radial flow conditions.
- ❖ **Pumping tests** - methods, data analysis and interpretation for hydrogeologic boundaries. Evaluation of aquifer parameters using Thiem, Theis, Jacob and Walton methods. Groundwater modelling -numerical and electrical models.

❖ **Groundwater chemistry**

- ❖ Groundwater quality - physical and chemical properties of water, quality criteria for different uses, graphical presentation of water quality data, ground water quality in different provinces of India - problems of arsenic and fluoride. Saline water intrusion in coastal and other aquifers and its prevention. Radioisotopes in hydrogeological studies. Groundwater contamination. Application of isotopes as tracer and budgeting tool.

❖ **Groundwater exploration**

- ❖ Geological - lithological and structural mapping, fracture trace analysis. Hydrogeological-lithological classification with respect to hydrologic properties. Hydraulic continuity in relation to geologic structures. Location of springs.

- ❖ **Remote sensing** - Hydro geomorphic mapping of the terrain using different images of different satellite missions. Lineament mapping. Shallow groundwater potential zone mapping using satellite images. Surface geophysical methods - seismic, gravity, geo-electrical and magnetic. Subsurface geophysical methods- well logging for delineation of aquifers and estimation of water quality.

❖ **Groundwater problems and management**

- ❖ Groundwater problems related to foundation work, mining, canals, dams, reservoirs and tunnels. Problems of overexploitation and groundwater mining. Groundwater development in urban areas and rain water harvesting. Artificial recharge methods. Groundwater problems in arid regions and remediation. Groundwater balance and methods of estimation. Groundwater legislation. Sustainability criteria and managing renewable and nonrenewable ground water resources.

❖ **Ore Geology and Mineral Economics**

Historical background to the development of Ore Geology. Field and laboratory studies of ores: Brief Survey of Geological, Geochemical, Geophysical Exploration, Remote Sensing, Sampling methods. Distribution, morphology and disposition of Ore bodies. Physical characteristics, optical properties, ore microscopy, Structure of ore minerals, Experimental ore petrology, fluid inclusion, and trace element and isotope studies in ore.

- ❖ Ore Minerals, Their texture and structure, development in open space and polycrystalline aggregates. Process of formation and transformation of ores. Endogenous: magmatic, pegmatitic, contact metasomatic (skarn, greisen, and hydrothermal ore generation- emphasis on critical aspects and physicochemical conditions. Exogenous: residual, chemical weathering and mechanical weathering accumulation; sedimentary including bacteriogenic and submarine exhalative, emphasis on chemical and biochemical factor. Transformation:

- ❖ Metamorphic and Metamorphosed.

- ❖ Petrological ore association-consideration with reference to distinct ore types, classical occurrences and details of Indian Ore Deposits.

Ore associated with ultramafic and related mafic plutonic rocks. Sudbury -type Fe - Ni -Cu sulphides, apatite rich and Ti -v bearing magnetites. Fe-Ti oxides and anorthites.

- ❖ Ores associated with felsic plutonic rock: porphyry deposit of Cu, Mo Greisen and skarn deposit of W and Sn Various Pegmatoid deposit.
- ❖ Ores associated with acid mafic volcanic rocks, including those in greenstone belts: Kabalda type, Kurokotype, Cyprus Types of ore.
- ❖ Stratabound ore deposit associated with nonvolcanic, Meta Sedimentary rocks, Kupferschiefer, Rhodesia - Katanga, Broken Hill
- ❖ McArthur, Mississippi valley type, Witwatersrand type, Bog iron manganese ores ironstone, Banded iron formation manganese ores orthoquartzite-clay association, Jaspilite and volcanic association, metamorphosed manganese ores. Colorado Plateau type U-V ores, surficial deposits: Lateritoid and Karst deposit of Fe, Mn, Al, and Ni: Placer deposit of Gold, Tin, Tungsten, and monazite. Oxidation and supergene enrichment sulphide enrichment. Ocean floor deposit of Mn, Ni-Cu-Co
- ❖ Crustal evolution and metallogenesis. Discussion on Various environment of Ore formation.

❖ **Mineral Economics**

- ❖ Importance of Minerals in National Economy. Basic pattern of Mineral economy and changing mineral requirements, Concepts of strategic Minerals and their supplies in time of peace and war material in various important industries, problem relating to their marketing. developing substitute to cover internal shortage, production cost & its relation to mineral in short supply. internal controls (monopolies and cartel), trade restriction and production incentives. Concession rules, world resources and production of important mineral. Importance of steel & Fuels in Modern Economy. Impact of atomic Energy over conventional fuels.
- ❖ Conservation of non renewable & associated Renewable resources.

Oil and Coal Geology

❖ **Petroleum**

- ❖ Introduction to Petroleum geology, Physical and chemical properties of petroleum, subsurface environment, generation and migration of petroleum, traps and seals, sedimentary basins, assessment of basin reserves and global reserves, reservoir characteristics, identification and demarcation of flow units, relationship between porosity, permeability and texture, Correlation of well log parameters with seismic properties, bulk properties and pore fluid conditions. Oil and gas fields of India.

❖ **Coal**

Definition, origin of coal. Stratigraphy of coal measures. Fundamentals of coal petrology, peat, lignite, bituminous and anthracite coal. Microscopic constituents of coal. Industrial application of coal petrology. Indian coal deposit.

Geo-Exploration

❖ **Exploration**

- ❖ Methods of prospecting and exploration, airborne and subsurface survey including geophysical methods such as seismic gravity, magnetic and electrical, geochemical and geobotanical prospecting, types of drilling-core and non-core, parts of drilling machine, drill hole deviation, surveys and method. Bore hole logging and preparation of drill hole section and plans. Various sampling methods. Ore reserve estimation techniques.

❖ **Mining**

- ❖ Mining parameters for selecting mining methods, open cast or underground mining. Various underground mining methods like sub level open scooping method, cut and fill and high productive VCR method. Mine safety and ventilation.

Engineering Geology

- ❖ **Rock Mechanics and Rock Engineering:** Engineering properties of rocks and their determination; Rock mass Classification, Rating, Quality Determination and Characterization; In-situ and Induced Stresses; Factor of Safety and Probability of Failure; Strain and strength of rock; Various strength tests; Effect of discontinuities on Rock Mass Strength. Soil Mechanics: Soil Profile and Classification; Engineering properties of Soils and their determination; Consistency limits.
- ❖ **Site Investigation:** Study of maps & plans, Aerial Photographs and Images. Remote Sensing, Site reconnaissance. Site Investigation Report: Style and Content; Factual Reports and its interpretation:
- ❖ **Site Characterization:** Geotechnical treatments including Grouting and Rock Bolting; Foundation Treatment. Ground Investigation: Boreholes and Trial Pits; Drilling, Sampling and Logging etc.
- ❖ **Environmental Considerations:** Impact of civil engineering projects. On Environment, Nature's Equilibrium, Reservoir Induced Seismicity; Alternatives for environmental protection.

- ❖ **Geological & Geotechnical Investigation:** Dams (Dam-break Analysis), Reservoirs and Spillways; Tunnels; Powerhouse and other Caverns; Bridges; Highways; Geotechnical Treatment for the above mentioned structures. Structural analysis of engineering projects.
- ❖ **Natural Disasters:** Effect of natural disasters on engineering structures and its remedial/preventive measures. Earthquakes and landslides hazard zonation.
- ❖ **Case Histories:** Examples and Case histories from India and other important worldwide projects.

Remote Sensing and GIS

❖ **Remote Sensing**

- ❖ Concepts in Remote sensing; EM radiation and its interaction with atmosphere; Platform, sensors and scanners; Earth resources satellites; Data acquisition, Data formats- Raster, Vector Data, TIN, DEM; Introduction to Microwave remote sensing and its applications.

❖ **Digital Image Processing**

- ❖ Image rectification and restoration; Image enhancement - single image & multiimage: contrast stretching, filtering, PCA images, FCC, Image ratioing; Image classification and accuracy assessment - supervised & unsupervised classification, error estimation; Data merging and GIS integration; Case studies- Indian Examples.

❖ **GIS**

- ❖ Introduction, Coordinate systems and datum Projection systems; Spatial data models and data structures; Attributed data input and management; Data editing, exploration and analysis; Digital terrain analysis using DEM data, Path analysis, network applications and morphometry; Introduction to GIS models and modeling.

❖ **GPS**

- ❖ Concepts of GPS; GPS receivers; GPS positioning mode- point positioning & relative positioning (DGPS & RTKGPS); GPS accuracy and error sources, Integrating GPS data with GIS; Applications in earth system sciences

❖ **Geophysics**

- ❖ Gravity and Magnetic fields of the earth: Normal-gravity field; Shape of the earth;

Bouguer and isostatic anomalies, isostatic models for local regional compensation. Geomagnetic field, secular and transient variations and their Suggested Books: theories; palaeomagnetism, construction of polar wandering curves.

- ❖ Plate Tectonics and Geodynamics: Sea floor spreading and mid-oceanic ridges: Plate boundaries and seismicity.
- ❖ Seismology & Tomography: Elements of earthquake seismology; Seismometry; Seismic moment tensor, focal mechanism and fault plane solutions; seismic gaps; Seismotectonics and structure of the earth; Himalayan and stable continental region earthquakes, Reservoir induced seismicity; Seismic hazards.
- ❖ Gravity and Magnetic Methods: Gravimeters and magnetometers; Data acquisition and corrections; Regional and residual separation; Interpretation of anomalies of simple geometric bodies, e.g. single pole, sphere, horizontal cylinder, sheet, dyke and fault.
- ❖ Electrical and Electromagnetic Methods: Electrical profiling and sounding, resistivity transforms and direct interpretation; Electromagnetic field techniques and interpretation; Magnetotelluric method, geomagnetic depth sounding.
- ❖ Seismic Methods: Reflection, refraction, diffraction methods and data processing, seismic noises and noise profile analysis; seismic data recording and telemetry devices; Introduction to 3D seismics; seismic stratigraphy.
- ❖ Well logging and other methods: Electrical logs; sonic log; nuclear logging; cross plotting; determination of porosity; permeability, formation factor and density; principles of radioactive and geothermal.