U. P. Education Service Selection Commission, Prayagraj

Syllabus

GEOLOGY /EARTH SCIENCES

(Subject Code-78)

Unit-1 : The Earth and the Solar System

Milky Way and the solar system. Modern theories on the origin of the earth and other planetary bodies. Earth's orbital parameters, Kelper's laws of planetary motion, Geological Time Scale; Space and time scales of processes in the solid earth, atmosphere and oceans. Age of the Earth. Radioactive isotopes and their applications in earth sciences. Theories about the origin of life and the nature of fossil record. Earth's gravity and magnetic fields and its thermal structure: Geoid spheroid, Isostasy.

Earth Materials, Surface Features and Processes

Gross composition and physical properties of important minerals and rocks; properties and processes responsible for mineral concentrations; nature and distribution of rocks and minerals in different units of the earth and different parts of India. Physiography of the Earth; weathering, erosion, transportation and deposition of Earth's material; formation of soil, sediments and sedimentary rocks; energy balance of the Earth's surface processes; physiographic features and river basins in India

Interior of the Earth, Deformation and Tectonics

Basic concepts of seismology and internal structure of the Earth. Physico-chemical and seismic properties of Earth's interior. Concepts of stress and strain. Behaviour of rocks under stress; Folds, joints and faults. Earthquakes – their causes and measurement. Interplate and intraplate seismicity.

Unit-2 : Structural Geology

Mechanical principles, properties of rocks and their controlling factors. Theory of rock failure. Concept of stress and strain; Two-dimensional strain and stress analyses; Types of strain ellipses and their properties and geological significance. Methods of strain measurements in naturally deformed rocks. Mechanics of folding and buckling. Fold development and distribution of strains in folds. Brittle and ductile shear zones, Geometry and products of shear zones, Mylonites and Cataclasites; Casuses and dynamics of faulting : Strike-slip Faults, Normal Faults, Thrust Faults; Thin-skinned deformation; Decollement. Planar and linear fabrics deformed rocks, their origin and significance. Basic idea about petrofabrics and use of Universal stage. Stereographic and equal area projections for representing various types of fabrics, π and βdiagram. Geometrical analysis of simple and complex structures on macroscopic scale. Basic idea on the structure and tectoincs of Himalaya.

Geomorphology

Basic concepts and significance of geomorphology; Typical landforms and their evolution; An elementary idea about morphogenesis and morphograph; Morphometric analysis; Morphochronology, Geomagnetism, Brief study of terrain evaluation for strategic purposes. Geomorphology of India - Peninsular, extra -peninsular and Indo-Gangetic Plains. Application of geomorphology in Mineral Prospecting, Civil Engineering, Hydrogeology and Environmental studies.

Geotectonics

Fundamental concept of geotectonics, its practical and theoretical importance. Organic and Epeirogenic Phases ; Concept and theories of Isostasy; Origin and significance of Mid-

Oceanic Ridges and Trenches ; Island arcs and mountain chains, their global distribution and evolution. Paleomagnetism, Concept of Sea floor spreading; Evidence of continental drift, Concept of Plate Tectonics, Nature and types of Plate Margins, Geometry and Mechanism of Plate Motion. Tectonic and Economic significance of Plate Tectonics. Polar Wandering and reversal of earth's magnetic field. Geomagnetic time scale. Tectonics of Pre-cambrian Organic Belts of India.

Unit-3 : Igneous Petrology

Magma : its physics, nature, factors affecting magma and its evolution. Petrology and melting of mantle. Generation of magmas in different tectonic environments. The phase equilibrium of binary and ternary systems and its relation to genesis of magma and crystallization in the light of modern experimental works. Interpretation of igneous textures in terms of rate nucleation and crystal growth. IUGS classification of the Igneous rocks. CIPW Norm. Petrology and petrogenesis of important igneous rock types giving Indian examples of Ultramafic, Basaltic, Granitic, Alkaline, Ophiolite, Carbonatite, Nephelinite -Ijolite, Lammproits, and Layered igneous rocks. Plume magmatism and hot spots. Mantle metasomatism. Mantle heterogeneities. Partial melting (batch and fractional melting), Crystal fractionation (equilibrium and fractional (Rayleigh) crystallization), contamination (AFCprocess) and dynamic melting.

Metamorphic Petrology

Mineralogical Phase Rule for Closed and Open Systems. Nature of Metamorphic Reactions, Concept and Classification of Metamorphic Facies and Facies Series, Introduction to Ultrahigh Temperature and Ultrahigh Pressure Metamorphism, Description of each Facies of Low - Pressure, Medium to High - Pressure and very High Pressure with special reference to characteristic Minerals, Subdivision into Zones

/Subfacies, Mineral Assemblages, Metamorphic Reactions and Pressure - Temperature Conditions of Metamorphism. Isograds and Reaction Isograds, Schrienemakers Rule and Construction of Petrogenetic Grids, Metamorphic Differentiation, Anatexis and Origin of Migmatites in the light of experimental studies, Regional Metamorphism and Paired Metamorphic Belts with reference to the theory of plate Tectonics, Pressure - temperature - time paths. Laws of Thermodynamics, Gibb's Free - Energy, Entropy, Entropy, Δ G of Metamorphic Reactions (solid -Soild and Dehydration Reactions). Clausius - Clapeyron Equation, Geothermobarometry.

Sedimentology

Origin of terrigenous clastic and non-clastic grains; Weathering and its products; Chemical weathering of granite and basalt, Submarine weathering. Major carbonate minerals; Carbonate grains of biological origin. Simple fluid flow, Concepts and sediment transport; Sediment gravity flows and their deposits. Important bed forms and sedimentary structures-their genesis and stratigraphic significance. Palaeocurrent analysis; Classification of sedimentary basins. Grain size, textural parameters and their significance. Textural and compositional maturity. Petrography and origin of sandstones, limestones and mudrocks. Sedimentary facies, methods of their analysis and interpretation of depositional environments. Processes and characteristics of eolian, fluvial, barrier beach, tidalflats, deltaic and deeps environments. Diagenesis of clastic and non- clastic rocks, Stages and processes of diagenesis, Compaction and cementation by silica, carbonate and iron-oxide, dolomitization. Heavy minerals and their importance in determination of provenance.

Unit-4 : Geochemistry

Introduction of Geochemistry and Cosmochemistry. Chemical composition and properties of Earth's layers. Atmosphere; its layers, chemical composition and evolution of

Atmosphere. Meteorites, classification. mineralogy, origin, significance and phenomena of fall. Stable isotope geochemistry of Carbon and Oxygen and its application in Geology. Radiogenic isotopes. Decay scheme of K-Ar, U-Pb abd Rb-Sr. Geochemistry of Uranium and Lithium. Geochemical cycle; Minor cycle and major cycle. Geochemical classification of elements. Periodic table with special refernence to rare earth elements and transition elements.

Crystallography and mineralogy

Elementary ideas about crystal morphology in relation to internal structures. Crystal parameters and indices. Crystal symmetry and classification of crystals into six systems and 32 point groups. Stereographic projections of symmetry elements and forms. Introduction to XRD, DTA, SEM techniques.

Chemical bonding and introduction to solid state chemistry as applicable to structure to minerals. Minerals : definition and classification, physical properties and chemical composition of common rock-forming minerals. Principles of optical mineralogy. Introduction to the petrological microscope. Study of important optical properties such as refractive index, twinkling, birefringence, pleochroism, interference colour, extinction angle, and twinning of common rock forming minerals.

Systematic mineralogy (atomic structure, mineral chemistry and their P-T -stability and mode of occurrence) of silicates, native elements, sulphides, sulfosalts, oxides, hydroxides and carbonates. Mineral assesmblages. Gem and semi -precious minerals.

Unit-5 : Palaeontology and its applications

Concepts of origin of life, Theories of organic evolution – punctuated equilibrium and phyletic gradualism models. Mass extinctions and their causes. Application of fossils in age determination and correlation of strata. Paleoecology, Life habitats and various ecosystems, Paleobiogeography. Modes of preservation of fossils and requisites of fossilization. Types of microfossils. Environmental significance of body and trace fossils. Use of microfossils in interpretation of sea floor tectonism. Application of micropaleontology in hydrocarbon exploration. Oxygen and Carbon isotope studies of microfossils and their use in paleoceanographic and paleoclimatic interpretation. Important invertebrate fossils, vertebrate fossils, plant fossils and microfossils in Indian stratigraphy. Fossil record and its utility in recognition of palaeoenvironment and system tracts of a depositional sequences.

General and Invertebrate Palaeontology

Modern systematics, Identification of fossils, Type specimens, Describing a fossil specimen, Ontogenic variation. Macro and micro-evolution, Trans-specific evolution, Radiation, Species and speciation, Heterochronic evolution, types of heterochrony and its significance in development of high resolution biostratigraphy. Distribution, migration and dispersal of organisms: implications to palaeobiogeography and plate-tectonics. Precambrian life. Concepts, classification and practices in palaeoecological investigations, Taphonomy : definition, processes and applications, Shell beds and its utility in taphonomic interpretations. Trace fossils: kinds and classification; their significance in palaeoenvironmental reconstruction. Evolutionary trends and Geological history of Brachiopoda, Bivalvia, Gastropoda, Ammonoidea, Trilobita, Echinoidea and Cnidaria (corals). Functional Morphology of Bivalvia.

Vertebrate Palaeontology

General characteristics of vertebrae. Vertebrate skeleton: Teeth and their modifications. Kinds of vertebrate fossils, nature of their record, Collection and preparation of vertebrate fossil remains. Main classificatory characters and divisions of the vertebrates. An outline classification of Agnathans, Pisces, Amphibia, Reptilia, Aves and Mammalia.

Origin of vertebrate animals. Vertebrate life through ages, and Landmarks in Evolution. General Account of the Gondwana Vertebrates, and Siwalik Mammals and the possible causes of their extinction. Dinosaurs and their extinction.

Evolutionary trends in Equidae, Probooscidae and Hominidae. Factors of Human Evolution: Evolution of Man, Tool culture.

Study of some important genera of Fossil vertebrate with particular reference to Indian Subcontinent.

Palaeobotany

Introduction and approaches to Palaeobotany. Preservation and kinds of fossil plants. Occurrence of plant fossils, their collection and preparation.

Techniques of palaeobotanical studies. Difficulties of identification. Concept of genera and species. 'Form' genera. Nature of palaeobotanical record. Palynology and its applications. Classification of fossil plants and broad characters of major plant groups. Brief morphology of different plant parts. Taxonomy, systematic position and distribution of common representative Indian plant genera.

Distribution and composition of pre-Gondwana, Gondwana, Inter-trappean and Tertiary Floras of India with observations on their origin, and relationship with other contemporaneous fossil floras of the world.

Evolution of Flowering plants. Dendrochronology. Applications of Palaeobotany with particular reference to stratigraphic correlation and palaeoclimates.

Unit-6 : Stratigraphy

Geological time scale, Basic principles of stratigraphy, Fundamentals of sequence stratigraphy, its concept, evolution; application and significance. Depositional sequence, boundaries and its types, System tracts. brief ideas of quantitative, magneto-, seismic, chemo- and event stratigraphy. Ocean Anoxia, Oceanic Anoxic events (OAEs), causes, consequences and implications. Stratigraphic classification and correlations.

Percambrian stratigraphy: Precambrian geochronology. Chronostratigraphy of the Precanbrian of Dharwar Craton, Eastern Ghats Belt, Southern Granulite Belt and Singhbhum- Chhotanagpur- Orissa Belt. Proterozoic stratigraphy of Son Valley, Cuddapah-Kurnool and Chatisgarh basins. Precambrian- Cambrian boundary.

Marine Palaeozoic stratigraphy: Igenous activities and palaeogeography during the Palaeozoic Era. Stratigraphy, facies, and fossil contents of the Palaeozoic rock formations of India. Permian-Triassic boundary.

Gondawana stratigraphy: Concepts, classification, fauna, flora and age limits of Gondwana Supergroup and related palaeogeography, palaeoclimate, depositional characteristics and igneous activity.

Mesozoic stratigraphy: Classification, depositional characteristics, fauna and flora of Triassic, Jurassic and Cretaceous systems in principal basins of India. Cretaceous - Tertiary boundary. Cenozoic stratigraphy: Classification, depositional characteristics, fauna and flora of the Palaeogene and Neogene systems in their type localities and their equivalents in India. Deccan Trap. Epoch boundaries of the Cenozoic in India.

Unit-7 : Ore Geology

Concept of ore bearing fluids, their origin and migration. Wall-rock alteration. Structural, physicochemical and stratigraphic controls of ore localization. Paragenesis, paragenetic sequence and zoning in metallic ore deposits. Ore deposits in relation to plate tectonics, Fluid inclusions in ore : principles, assumptions, limitations and applications. Geothermometry, geobarometry and isotope studies in ore geology.

Mineralogy, classification and genesis of petrological ore associations: Orthomagmatic ores of ultramafic-mafic association, ores of felsic -silicic igneous rocks : ores related to submarine volcanism, biochemical, chemical and clastic sedimentation ; placers and residual concentration deposits. Ores of metamorphic affiliations.

A detailed study of ore minerals related to the following metals with special reference to their mineralogy, genesis, specification if any, uses and distribution in India: Fe, Mn, Cr, Cu, Pb, Zn, Al, Mg, Au, Sn and W.

Study of important industrial minerals of India with particular reference to the following : Iron and Steel industry, refractory industry, fertilizer industry, cement industry, chemical industry and abrasives.

Coal Geology

Definition and origin of coal. Sedimentology of coal bearing strata, tyopes of seam discontinuities and structures associated with coal seams. Chemical analysis of coal (proximate and ultimate analysis).

Coal Petrology - concept of 'Lithotype', 'Maceral' and 'Microlithotype'. Classification and optical properties of macerals and microlithotypes. Techniques and methods of coal microscopy. Elementary knowledge of the application of reflectance and fluorescence microscopy. Application of coal petrology. Classification of coal in terms of Rank, Grade and Type. Indian classification for coking and non-coking coals. International classifications (I.S.O. and Alpern's classification). Origin of coal seams. Elementary Idea about coal preparation, coal carbonisation, coal gasification, coal hydrogenation, coal combustion and fertilizer from coal. Coal as a source rock in petroleum generation.

Coalbed methane - a new energy resource. Elementary idea about generation of methane in coal beds, coal as a reservoir and coalbed methane exploration.

Geological and geographical distribution of coal and lignite deposits in India. Coal exploration and estimation of coal reserves. Indian coal reserves and production of coal in India.

Petroleum Geology

Petroleum - its composition. Origin (Formation of source rocks -kerogen, organic maturation and thermal cracking of kerogen) and migration of petroleum. Reservoir rocks-porosity and permeability. Reservoir traps - structural, stratigraphic and combination traps. Oilfield fluids -water, oil and gas. Methods of prospecting for oil and gas (geological modelling). Elementary knowledge of drilling and logging procedures. Oil shale. An outline of oil belts of the world. Onshore and offshore petroliferous basins of India. Geology of productive oilfields of India.

Atomic Fuel

Concept of atomic energy. Mode of occurrence and association of atomic minerals in nature. Methods of exploration for atomic minerals. Productive geological horizons of atomic minerals in India.

Mineral Exploration

Classification of mineral deposits for exploration. Host rocks of mineral deposits. Remote sensing in mineral exploration. Geological exploration: Geological criteria and guides for exploration of mineral deposits. Gossan and capping.

Geochemical exploration: mobility and geochemical associations of elements. Primary and secondary geochemical dispersion patterns. Geochemical prospecting methods. Use of geostatistical techniques for exploration of mineral deposits. Samples and sampling mthods. Drilling, its methods and advantages. Ore reserves, methods of ore reserves calculations. Geological modelling for mineral exploration.

Unit-8 : Hydrogeology

Ground water : Origin, types, importance, occurrence, reservoirs and movement. Renewable and non-renewable groundwater resources; Hydrologic cycle; Hydrological properties of rocks : porosity, permeability, specific yield, specific retention, hydraulic conductivity, transmitivity, storage coefficients. Hydrographs. Water level contour maps, hydrostratigraphic units, hydrogeology of arid zones and wetlands.

Groundwater quality, estimation and methods of treatment for various uses, Groundwater quality map of India. Water contaminants and pollutants: problem of arsenic and fluride and remedial measures for their treatment. Groundwater quality problems in India.

Geological formations as aquifers, types of aquifers, geological classification of aquifers, springs . Darcy's law and its validity. Reynold's Number, Groundwater provinces of India.

Well Hydraulics : theory of ground water flow under steady and unsteady conditions in confined, unconfined conditions, radial flow. Water level fluctuations: causative factors and their measurements. Method of pumping test and analysis of test data, evaluation of aquifer parameters.

Artificial recharge of water: Recharging by surface water and rain water harvesting. Consumptive and conjunctive use of surface and ground water, problem of overexploitation, ground water legislation.

Water well Technology: Well types, drilling methods, construction design, development and maintenance of wells. Water management in rural and urban areas.

Coastal water and its management. Arid zone Ground water, Ground water in hard rocks and non-indurated sediments; their management.

Surface and subsurface geophysical and geological methods of ground water exploration, hydrogeomorphic mapping using various remote sensing techniques. Radio isotopes in hydrogeological studies.

Unit-9 : Environmental Geology and Natural Hazards

Time scales of global changes in the ecosystems and climate. Impact of circulations in atmosphere and oceans on climate, rainfall and agriculture.

Carbon di-oxide in atmosphere, limestone deposits in the geological sequences, records of palaeotemperatures in ice cores of glaciers. Global warming caused by CO_2 increase in present atmosphere due to indiscrete exploitation of fossil fuels, volcanic eruptions and deforestation.

Cenozoic climate extremes, evolution of life, especially the impact on human evolution. Impact assessment of degradation and contamination of surface water and ground water quality due to industrialization and urbanizations. Water logging problems due to the indiscrete construction of canals, reservoirs and dams. Soil profiles and soil quality degradation due to irrigation, use of fertilizers and pesticides.

Influence of neotectonics in seismic hazard assessment. Preparation of seismic hazards maps. Distribution, magnitude and intensity of earthquakes. Landslide hazards: causes and investigations ; floods, their causes and control.

Remote Sensing and GIS in Geology

Electromagnetic Radiation - Characteristics and Remote Sensing Regions and bands; Aerial photos - types, scale, resolution; properties of aerial photos, stereoscopic parallax, Relief displacement; General Orbital characteristics of remote sensing satellites; General sensor characteristics of remote sensing satellites; Spectra of common natural objects -

soil, rock, water and vegetation. Data Processing and Interpretation (Digital Image Processing - DIP)

Characteristics of remote sensing data; preprocessing; Enhancements, Classification, Elements of photo and imagery pattern and interpretation - drainage, erosion, details, gray tones.

Application in Geology : Remote sensing applications in geological structures and tectonics; Systematic mapping, Mineral resources, Groundwater potentials, Environmental monitoring and mapping.

Remote Sensing and GIS: Principles and components of GIS. Remote sensing data integration with GIS; Applications of GIS in various geological aspects. Remote sensing in minerals exploration.

Engineering Geology

Role of engineering geology in civil construction and mining industry. Various stages of engineering geological investigations for civil engineering projects. Engineering, geotechnical and Mechanical properties of rocks; rock discontinuities, physical characters of building stones, concrete and other aggregates. Geological considering for evaluation of dams and reservoir sites. Dam foundation, Rock problems, Geotechnical evaluations of tunnel alignments and transportation routes. Methods of tunneling; Classification of ground for tunneling purposes; Various types of support.

Mass Movements with special emphasis on landslide and causes of hill slope instability. Aseismic designs of buildings; influence of geological condition on foundation and design buildings.

Mining Geology

Application of rock mechanics in mining. Planning, exploration and exploratory mining of surface and underground mineral deposits involving diamond drilling, shaft sinking, drifting, cross cutting, winzing, stopping, room and pillaring, top-slicing, sublevel caving and block caving. Cycles of surface and underground mining operations. Exploration and placer deposits. Open pit mining. Ocean -bottom mining. Types of drilling methods. Mining hazards: min inundation, fire and rock burst.

Geophysical Exploration

Variation of gravity over the surface of the earth. Principle of gravimeters. Gravity field surveys. Various types of corrections applied to gravity data. Preparation of gravity anomaly maps and their interpretation in terms of shape, size and depth.

Geomagnetic field of the earth. Magnetic properties of rocks and minerals. Working principle of magnetometers. Field surveys and reductions of data. Preparation of magnetic anomaly maps and their quantitative interpretation. Magnetic anomalies due to single pole and dipole. Introduction to Aeromagnetic survey. Three dimensional current flow, potential due to a point current source.

Resistivity method : Electrical Properties of rocks and minerals. Basic principles, various types of electrode configurations, Field procedure : profiling and sounding. Application of electrical methods in ground water prospecting and civil engineering problems.

Seismic method : fundamental principles of wave propagation, refraction and reflection surveys for single interface, horizontal and dipping cases. Concept of seismic channel and multi-channel recording of seismic data. End -on and split spread shooting techniques. CDP method of data acquisition, sorting, gather, stacking and record section. Seismic velocity and interpretation of seismic data.

Application in mineral and petroleum exploration. Description of borehole environment. Well- logging; Brief outline of various well-logging techniques. Principles of electric

logging and its application in petroleum, groundwater and mineral exploration.

Unit-10: Oceanography

Physical Oceanography : Methods of measuring properties of sea water. Molecular structure of water. Temperature and salinity distribution in surface of the ocean. Salt composition and residence time. Dissolved gases in seawater. Carbon dioxide and carbonate cycle.

Ocean circulation: The Ocean Conveyor belt and its role in controlling world's climate. Surface circulation; concept of mixed layer, thermocline and pycnocline, Carioles Force and Ekman Spiral, Upwelling; EI nino. Processes affecting biological productivity of ocean margin waters. Deep Ocean Circulation, concept of thermohaline circulation, formation of bottom waters; water masses of the world oceans. Oxygen minimum layer in the ocean. Major currents of the world's ocean.

Deep-Sea Sediments and Processes : Deep -sea sediments and their relation to oceanic processes such as solution, productivity, and dilution. Sediment distributions in time and space as related to tectonic models. Deep Sea hiatuses and their causes. Calcite and Aragonite Compensation depth and significance.

Ocean Resources : Mineral resources of the ocean including polymetalic nodules. Marine Gas Hydrates and their economic potential.

Marine Pollution : Marine Pollution emphasizing geochemical aspects of the sources, transport, and fate of pollutants in the coastal marine environment. Interpreting marine pollution with the help of microfossils during Quaternary.

Paleoceanography : Ocean Floor Morphology, Oceanic Crust and Ocean Margins. Approaches to Paleoceanographic reconstructions. Paleoceanographic changes in relation to earth system history including impact of the oceans on climate change. 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.
Application of stable isotopes (Oxygen and Carbon) in Paleoceanography and Paleoclimatology. Paleoclimatic reconstructions from ice cores.
Marine Stratigraphy, correlation and chronology.