

Ph.D. Entrance Exam Syllabus 2024-25 (Geology)

STRUCTURAL GEOLOGY

Rock deformation: Theory of stress & strain, their relationship; Factors controlling rock deformation, Properties of elastic, plastic and brittle materials; Progressive deformation, Strain analysis: types of strain; strain ellipse; strain ellipsoid; Geological application of strain theory. Rheology., Stress analysis: compressive and shear stress; biaxial and triaxial stress. Mohr's Circle and envelope, Fold: Definition, Geometrical and Genetic Classification of Fold. Fleutys Classification, Ramsay Classification and Dip Isogon Classification, Mechanism of Fold formation and types of fold, Superimposed fold; Outcrop pattern of superimposed structure comprising of two fold system, Joints, and its types; their analysis and relation with major structures, Fault: Types and mechanism of faulting, Principal stress orientation for the main fault types; Relationship between stress and strain ellipsoid, Analyses of brittle-ductile and ductile shear zones, Petrofabric Analysis: Field and laboratory techniques. Preparation of petrofabric diagrams and their interpretation, Cleavage & Schistosity: definition and types, Mechanism of formation of Cleavage & Schistosity; its relationship with major deformation structures, Lineation: definition and its types; their mode of development and relation to major structures, Plutons: Definition & description; its role in progressive deformation, Tectonites: definition and its types, Stereographic Projection: Principles and application, Tectonics and structural characteristics of Plate Boundaries; associated structures in extensional, compressional and strike-slip terrains, Geodynamic evolution of the Himalayas

MINERALOGY

Composition of minerals and Mineraloids, Physical Properties of Minerals depending on Crystal Growth, Crystal Structure, Chemical Composition and Interaction with light, Electrical Magnetic, Luminescence, Thermal and Radioactive Properties of Mineral, Structure of Silicates, Ionic Radius, Coordination Principles, Close Packing, Pauling's Rules, Unit Cell, Bonding Forces in crystals Ionic Bond, Covalent Bond, Van Der Waal's Bond, Metallic Bond, Solid solution - Substitution, Interstitial and Omission solid solution. Ex-solution, Polymorphism, polytypism, pseudomorphism, Classification of Minerals. Systematic mineralogy of Olivine Group Garnet Group Al_2SiO_5 Group Zircon, Topaz, Staurolite, Sphene. Epidote, Cordierite, Tourmaline Beryl, Pyroxene Group, Amphibole Group Serpentine Group, Mica Group, Chlorite Group, Clay Mineral Group – Kaolin and Talc, SiO_2 Group, Zeolite Group Feldspar Group Feldspathoid Group Carbonates and Phosphates, Gem and Semi precious minerals.

GEOCHEMISTRY

Introduction to Geochemistry. Cosmic Abundance of the Elements and Nucleosynthesis. Geochemical classification of elements. Formation of Solar System

and Planets, Composition and Classification of Meteorites, Chondrules, Chondrites and Achondrites. Geology and Chemistry of Moon, Trace, Volatile, Semi volatile, Alkali and Alkaline earth elements its behaviour in Fractional Crystallization and Partial melting, REE and Y, HFSE elements, Transition & Noble elements-its importance and concentrations in various igneous rocks and its behaviour in various magmatic processes, Partition coefficient, Factors governing partition co-efficient, Compatible and incompatible elements, behaviour of these elements in Fractional Crystallization and partial melting, Fundamental Laws of Thermodynamics. Free energy. Phase equilibrium and Gibb's Phase Rule, Thermodynamics of magmatic Crystallization, Geochemistry of island arcs, Geochemistry of Crust, Composition of Mantle, mineralogy of lower mantle, Phase transition in the Mantle, mineral-phase transition in lower mantle, Stable isotope geochemistry. Oxygen isotope studies. Isotope fractionation, application, use of oxygen isotope together with radiogenic isotope in correlation diagrams, Carbon isotope. Carbon isotope studies in association with Oxygen isotope for Carbonate rocks, Radiogenic isotopes. Decay scheme, Laws of decay, half-life period. Decay scheme of K-Ar, Sm-Nd and Rb-Sr. Radiogenic isotopes in petrogenesis, Isotopic reservoirs, Depleted mantle (DM), HIMU Mantle, Enriched Mantle, PREMA, Bulk Silicate Earth (BSE), Continental crustal source, Aquatic Chemistry- Acid Base reactions, Dissolution and Precipitation of CaCO_3 . Solubility of Mg, SiO_2 and $\text{Al}(\text{OH})_3$, Geochemical properties of clays - Kaolinite, Pyrophyllite and Chlorite Groups. Ion exchange properties of clays, Redox in Natural Waters. Eutrophication. Factors controlling Weathering. Soil profile. Chemical and biogeochemical cycling in the soil, Composition of Rivers. Composition of Seawater- Temperature variation. Density structure and deep circulation, Distribution of CO_2 in Ocean. Carbonate dissolution and precipitation. Sources and sinks of Dissolved matter in seawater.

CRYSTALLOGRAPHY & CRYSTAL OPTICS

Crystal growth. Development of ideas of internal structure of crystals, Space lattices and point systems. X-ray analysis of crystal structure, SEM, TEM, Morphology of crystals. Fundamental Laws of Crystal Zones and Zonal Symbols, Symmetry elements, operations. Classification of Crystals in 32 Classes, Symmetry and forms of crystals of isometric, tetragonal and hexagonal systems, Symmetry and forms of crystals of orthorhombic, monoclinic and triclinic systems, Goniometry of Crystals. Crystal Projections – Spherical, Gnomonic and Stereographic, Crystal Aggregates, Twinning, Irregularities & Imperfections in Crystals, Principles of transmission and reflection of light from crystals. Classification of minerals according to interaction of light, Interference colour, Refraction and Refractometry. Methods of determination of R.I., Birefringence in Crystals. Significance and use of plates, wedge and Berek Compensator, Pleochroism in Crystals, Classification of Crystals into isotropic, Uniaxial and Biaxial minerals, Isotropic, uniaxial and biaxial indicatrix, Optical characters of Isotropic and uniaxial minerals, Optical characters of biaxial minerals, Optical Orientation – Extinction angle, Universal stage. Construction & Use, Dispersion in mineral optic axial angle, Optical anomalies, Systematic determination of optical properties of minerals.

IGNEOUS PETROLOGY

Factors affecting magma and its evolution. Composition of primary magma; mantle mineralogy, Partial melting of mantle – different models. Trace element behavior during partial melting, Magmatic differentiation processes, Behavior of major and trace elements during fractional crystallization, Concurrent assimilation and fractional crystallization. Magma mixing, Various criterion for classification of Igneous rocks, Petrographic Province. Different variation diagrams and their applications, Crystallization of basaltic magmas. Generation of magma with reference to plate tectonics, Study the petrogenetic significance of following silicate systems: Albite-Anorthite, Forsterite – Silica, Diopside-Albite-Anorthite, Diopside-Forsterite- Silica, Nepheline-kalsilite-silica Petrogenetic study of Basalt and Ophiolite, Peridotite and other Ultramafic rocks, Granite, Anorthosite Komatite, Kimberlite and Lamproite, Carbonatite, Lamprophyre, and their distribution in India, Mid-ocean ridge volcanism and oceanic intra-plate volcanism., Magmatism associated with subduction related igneous activity- continental and island arcs. Magmatism in Large Igneous Plutons and continental alkaline magmatism.

METAMORPHIC PETROLOGY

Definition of metamorphism, significance of metamorphic rocks, Agents and kinds of metamorphism, Phase rule and its application in metamorphism, Structure and texture of metamorphic rocks and their significance. Classification of metamorphic rocks, Fabric of metamorphic rocks, Evolution of the concept of depth zones. Systematic study of Barrovian and Abukuma zones of metamorphism, Grade of metamorphism, Isograd & reaction Isograd and construction of petrogenetic grids, Study of ACF, AKF and AFM diagrams, Concept of Facies and Facies series, Polymetamorphism and Paired metamorphic belts, Metamorphic differentiation, Retrograde Metamorphism and Crystalloblastic series, General Characters of thermal and regional metamorphism of Calcareous, Pelitic and Basic igneous rocks. Migmatites, Tectonics and Metamorphism, Metasomatism-Principles and types of metasomatism, Anataxis, Palingenesis, Kinetics of metamorphic mineral reaction. Pressure – Temperature – time paths, Ultra-high temperature metamorphism, Ultra-high pressure metamorphism, Petrogenetic significance of following rocks with special reference to Indian occurrences: Charnockite, Amphibolite, Khondalite, Gondite, Eclogite.

SEDIMENTOLOGY AND CRUSTAL EVOLUTION

Earth surface system – liberation and flux of sediments, Processes of transport and generation of sedimentary structures. Flow regimes and related bed forms, Stromatolites and their significance, Textural analysis of sediments, Graphical representation, statistical treatment and geological significance, Classification of sandstone and carbonate rocks. Dolomite and dolomitization, Volcaniclastics. Sedimentary environments and facies, Continental: alluvial-fluvial facies, Lacustrine, Desert – Aeolian and glacial sedimentary environments, Shallow coastal clastics and shallow water carbonates, Evaporites. Deep-sea basins, Paleocurrents and basin analysis, Clastic Petrofacies. Plaeoclimates and paleoenvironment analysis, Diagenesis of sandstone and carbonate rocks – changes in mineralogy, fabric, and chemistry, Petrogenesis of arkoses, greywacke and quartz arenites, Evolution of lithosphere, hydrosphere, atmosphere and biosphere, Application of Trace, REE and stable isotopes

geochemistry to sedimentological problems, Surface features of earth – island arcs, mid-oceanic ridges, Young mountain belts and their distribution. Evolution of continental and oceanic crust, Lithological, geochemical, stratigraphic characteristics of granite-greenstone belts, Evolution of Proterozoic sedimentary basins of India, Anatomy of Orogenic belts and formation of mountain roots, Life in Pre Cambrians, PreCambrian Cambrian boundary with special reference to India

STRATIGRAPHIC PRINCIPLES AND INDIAN GEOLOGY

Principles of stratigraphic scales and its divisions, dual classification, Stratigraphic units – lithostratigraphic, biostratigraphic and chronostratigraphic, Rules of stratigraphic nomenclature, Stratigraphic correlation, Concept of sequence stratigraphy, Chief divisions of Indian sub continent and their physiographic characters, Archaean Era. Distribution and classification in Peninsula (Mysore, Bihar, M. P. and Rajasthan) and extrapeninsular regions. Their correlation and economic importance, Dharwar Supergroup (Classification, Distribution, Economic importance), Cuddapah Supergroup its distribution, classification & equivalent in extra peninsula, Vindhyan Supergroup – its distribution classification age economic importance and correlation, Chhattisgarh Group, Indravati Group and Khairagarh Group, their classification, age correlation and economic importance, Palaeozoic formations of extra peninsular regions with special reference to their classification distribution and correlation, Distribution, geological succession, classification and climate of Gondwana Supergroup. Age and correlation of Gondwana formations, Jurassic system of rocks – in extrapeninsular region, Distribution, Classification & correlation of cretaceous formations of Peninsula and extra peninsular regions of India, Distribution, structural features and age of the Deccan Traps. Inter trappeans and infra trappeans of India, Problems of Permo-triassic and Cretaceous – Palaeocene boundaries, Distribution, succession, correlation and life of Siwalik formations, Distribution, lithology, correlation & life of the Cenozoics of Assam & Western India and Pleistocene (Quaternary) deposits, Karewa Beds, Indogangetic Alluvium, Quaternary climate, glacial and interglacial cycle, Eustatic changes

PALAEONTOLOGY

Definition of fossil and modes of fossilization their application in age determination, paleoclimatology, palaeogeography and evolution, Modes and theories of organic evolution, concept of bathymetric distribution of animals, migration and extinction of species, Outline classification of organisms, Study of morphology, classification, evolutionary trends and geologic and geographic distribution of Brachiopod, Study of morphology, Classification, Evolutionary geologic history of the following Pelecypoda (Lamellibranches), Gastropoda, Cephalopoda, Trilobites, Echinoids. Graptolites and Rugose Corals. An elementary idea about the origin of major groups of vertebrates., Study of evolutionary history of Horse and Elephant Man. General study of Siwalik mammalian fauna. Plant life through geologic ages. Study of fossil flora of Gondwana Group and Tertiary Formations of India. Definition and scope of micropaleontology. Techniques in micropaleontology. Application of microfossils in stratigraphic correlation, age determination and palaeoenvironmental interpretations. Study of morphology of foraminifers. Classification, evolution and geological distribution of foraminifers.

ORE AND FUEL GEOLOGY

Modern concepts of ore genesis. Spatial and temporal distribution of ore deposits- Global perspective, Concept of ore bearing fluids, their origin and migration. Fluid inclusion in ores – limitations and applications, Texture, paragenesis and zoning in ores, Wall rock alteration. Structural, physico-chemical and stratigraphic controls of ore localization, Orthomagmatic ores of mafic-ultramafic association – Diamonds in Kimberlites, REE in Carbonatite, Ti -V Ores, Chromite and PGE, Ni Ores, Cyprus type Cu-Zn Ores, Ores of Silicic igneous rocks- Kiruna type Fe-P. Pegmatoids, Greisen and Skarn deposits, Porphyry associations – Kuroko type Zn-Pb-Cu, Malanjkhand Type Cu-Mo deposits, Ores of Sedimentary affiliations- Chemical and Clastic sediments. Stratiform and Stratabound ore deposits. (Fe, Mn, non ferrous). Placers and paleoplacers, Ores of Metamorphic affiliations. Metamorphism of ores and metamorphogenic ores, Ores related to weathered surfaces – Bauxite, Ni and Au laterite, Mineralogy, genesis, distribution in India and uses of Cu, Pb, Zn, Iron and manganese, Gold and Silver, Aluminum and chromium, National Mineral Policy and mineral concession rules, Definition and origin of Kerogene and coal. Rank, Grade and type of coal. Microscopic constituents of coal, Chemical characterization of coal Proximate and Ultimate analysis. Coal bed methane, Distribution of Coal in India. Origin, nature and migration of oil and gas. Characteristics of reservoir rocks, Oil bearing basins of India. Geology of productive oil fields of India. Mode of Occurrence and association of atomic minerals in nature. Productive geological horizons.

GEMORPHOLOGY AND REMOTE SENSING

Geomorphic concepts and geomorphic cycle, Geomorphic processes – Weathering, soil formation, Mass-Wasting, Valley development, cycle of erosion, rejuvenation, Drainage patterns and their significance, Fluvial landforms and Glacial landforms, Karst topography, Arid and Eolian landforms, Coastal and volcanic landforms, Terrain evaluation and concept of morphometric analysis, Geomorphological mapping based on genesis of landforms, Geomorphic regions of India. Principles of terrain analysis, Concept and physical basis of remote sensing. Platforms: Terrestrial, Aerial and Space platforms. Advantages and limitations, Electromagnetic spectrum and principles of remote sensing, Interaction of EMR with atmosphere and earth surface features, Remote sensing sensors, data acquisition, visual interpretation and digital processing techniques. Interpretation of topographic and tectonic features, Aerial photography, photographs and their geometry. Photogrammetry, Satellite remote sensing. Global and Indian space missions. Satellite exploration Programs and their characteristics, Application of remote sensing in geology, Application in Geomorphology, Application in groundwater evaluation, terrain evaluation and strategic purposes.

MINERAL EXPLORATION

Prospecting & Exploration: Definition and characteristic features. Stages of prospecting, regional and detailed exploration; objectives and practices of these stages, Guides to ore search: global, regional and local guides, Detailed study of Regional, Physiographic, Stratigraphic, Lithological, Mineralogical and Structural guides, Drilling: Type of drills,

Diamond drilling, Drilling records and logs, Duty of geologists during drilling, Sampling: General principles, various methods and procedures. Salting. Precautions during Sampling, Calculating grade and tonnage of ore: Average grade, volume, specific gravity, tonnage factor, UNFC classification, Gravity Method of prospecting: Principle and Instrumentation. Gravity field surveys. Gravity corrections: Free-air correction, Bouguer correction, Latitude correction, Terrain correction. Magnetic method of prospecting: Magnetic properties. Magnetic anomaly. Magnetometer. Field survey. Preparation of magnetic anomaly maps. Aeromagnetic surveys, Seismic prospecting: Fundamentals of seismic wave propagation. Methods of seismic prospecting: Refraction and reflection seismic methods. Seismic Stratigraphy, Detection of hydrocarbons, Electrical methods of prospecting: Basic principles of resistivity method. Electrical properties of rocks, Flow of current through ground surface, Apparent resistivity, Electrode arrangements, Resistivity survey. Application and interpretation of resistivity data, Electromagnetic methods of prospecting: Electromagnetic spectrum and induction, EM frequency and depth of penetration, EM response of conductors, Classification of EM methods and their description: Telluric current method, Magnetotelluric method, CSMT/CSAMT, Tilt angle method, Turam method, VLF method, Transient EM methods, Ground Penetrating Radar, Radiometric prospecting and Borehole Logging. Radiometric survey, Application and interpretation of data, Borehole logging: Different geophysical logs, Equipment; measurements and interpretation, Geochemical mobility and association of elements. Forms of primary and surficial dispersion patterns., Secondary dispersion processes and anomalies. Factors affecting dispersion patterns, Geochemical surveys: Litho-geochemical and Pedo-geochemical surveys, Geochemical surveys: Hydro-geochemical, Atmo-geochemical and Bio-geochemical surveys, Case studies of regional exploration for deposits of plutonic associations; vein and replacement types; magmatic sulphides and chromite; pegmatitic deposits of Sn and rare metals, Case studies of regional exploration for deposits of hydrothermal deposits of Au-Ag, base metals, W-Mo, U; skarn deposits; sedimentary and supergene deposits, Instrumental analytical techniques, Statistical analysis and interpretation of geochemical prospecting data.

MINING GEOLOGY, ENGINEERING GEOLOGY AND MINERAL DRESSING

Definition of mining terms: pitting, trenching, adits, tunnels, and shafts, Role of geologist in mining industry, Geological structures of ore deposits and choice of mining methods, Mine Subsidence and mine support. Rock bursts, Mine Ventilation. Mine Drainage, Geological and geomorphic control on mining methods. Alluvial mining, Open pit mining. Methods of opencast mining; its advantages and limitations, Underground mining methods – drifting; cross cutting; winzing; stoping; room and pillaring; top –slicing; sub-level caving and block caving, Coal mining methods: Long wall, Board and Pillar method, Engineering properties of rocks and soil. Physical characters of building stones. Aggregate, Geological considerations for evaluation of Dam and reservoir sites. Dam foundation problems. Dam failure, Geotechnical evaluation of tunnel alignment and transportation routes. Methods of tunneling, Role of geologist in engineering projects, General principles and scope of Mineral Dressing, Primary and secondary breaking, crushing and grinding, liberation by sizes, reduction, Principles and methods of screening, Principles and methods of classification, classification as a means of concentration, Concentration methods, hand sorting, washing, jigging, tabling heavy fluid, Magnetic and electrostatic methods of separation of minerals, Floatation methods-

Principles and techniques with examples, Application of ore microscopy in mineral dressing.

ENVIRONMENTAL GEOLOGY

Definition, Scope and Basic concepts of Environmental Geology, Environment, Ecology, Ecosystems and habitat, Renewable and non-renewable natural resources, Role of geology in natural resources management and environmental planning, Landforms as ecosystem units, Characteristics of various environmental regimes – fluvial, coastal, marine, Aeolian, desert, and glacial, Understanding their causes, types, Mitigation and Management. Geomorphic controls on biodiversity and its conservation, Conservation of soil and water resources, Geological hazards: Lands slides, Volcanic activity, Earthquake and Tsunami, Understanding their causes, types, Mitigation and Management, Draught and desertification, Measures of mitigation, Sea level changes. Measures of mitigation, Geological hazards -River flooding, erosion and sedimentation, coastal erosion, cyclones and tsunamis, Human modifications of nature on surface and subsurface by engineering, Human modifications of nature on surface and subsurface by mining activities, Human settlement and contamination of atmosphere, soil, surface water and groundwater by waste disposal and agro-industries, National Environmental Policy for air and water pollution, National Environmental Laws, Climate Change and global warming: Causes and Impact (Ozone layer depletion and ozone hole), Environment impact assessment report and preparation of environment Management plans.

HYDROGEOLOGY

Scope of hydrogeology and its relation with hydrology, meteorology and their uses in the Hydrogeological investigation, Hydrologic cycle. Role of groundwater in the hydrologic cycle, Hydrograph, data collection and analysis, Water table and piezometric surface. Water table fluctuation. Water table contour maps, interpretation and uses, Water bearing formation - aquifers, aquitard. aquiclude, aquifuse. Aquifer types: perched, unconfined, semi-confined and confined. Isotropic, anisotropic aquifers, Porosity, permeability. Ground water movement: Darcy's law and its applications, Specific yield and specific retention. Storativity and transmissivity, Steady and unsteady flow, leaky aquifers. Groundwater flow near aquifer boundaries, Bounded aquifers. Image wells, Water wells and their types. Construction of wells, Well Development and completion, Pumping test and Yield of wells, Geological and Hydrogeological methods of groundwater exploration, Geophysical methods – Electrical resistivity method for groundwater exploration, Application of remote sensing in groundwater exploration, Basin wise development of groundwater with special reference to Chhattisgarh region, Groundwater provinces of India, Sources of dissolved constituents in groundwater. Groundwater quality standards-drinking, domestic, agriculture and industry. Groundwater pollution, Groundwater management. Safe yield, overdraft and spacing of wells, Conservation of Groundwater; conjunctive use of water. Artificial recharge.