

2021

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Syllabus for Ph.D. Entrance ExaminationInstructions to question paper setter

1. The questions from all branches must be necessarily set as specified in the syllabus.
2. The medium of instructions is in English.

Part-A Research Methodology

- Objective of research processes and steps in research methodology used in Mineralogy and Petrology, Structural Geology and Geotectonics, Applied Micropaleontology, Sedimentology and Stratigraphy, Geochemistry, Economic Geology, Engineering Geology and Geotechnology, Environmental Geology, Remote Sensing, Geoinformatics and Groundwater Geology.
- Field methods used in geological mapping.
- Format for writing thesis, reports and research papers.
- Statistical methods used in Earth Science/Geology.
- Research proposal and concept.
- Basic preparation of Major and Minor research project.
- Principles and Techniques of Research Methodology.
- Basic Knowledge about instruments used for geological studies.

Part-B Concerned Subject - Geology**1. MINERALOGY AND PETROLOGY:**

Concept of point group, space group, reciprocal lattice, diffraction and imaging. Concepts of crystal field theory and mineralogical spectroscopy. TEM and SEM applications. Lattice defects (point, line and planar). Study of the following mineral group including amphiboles, mica, garnet, olivine, feldspar, pyroxene. Electrical, magnetic and optical properties of minerals. Bonding and crystal structures of common oxides, sulphides, and silicates. Transformation of minerals - polymorphism, polytypism, and polysomatism. Solid solution and exsolution, Co-ordination number, Radius ratio: Bonding: Pauling's principles, Structure of silicate minerals, Bearing of structure on certain properties of minerals.

Steady-state geotherms. Genesis, properties, emplacement and crystallization of magmas. Phase equilibrium studies of simple systems, effect of volatiles on melt equilibrium. Magma-mixing, mingling and immiscibility. Scope of igneous Petrology; Composition of the crust and upper mantle, their emplacement and relation with the plate tectonics;

Origin of Magma: Magma, their nature, composition, origin and evolution.

Structure and textures: Definition, description, rock examples and genetic implication of common structure and textures of igneous rocks. Classification of igneous rock: Mode, CIPW norms, IUGS, Chemical, mineralogical and other standard classification. Bowen's reaction principle: Reactions series and their applications to petrogenesis. Magmatic evolution and differentiation: Fractional crystallization, gravitational differentiation, gas streaming, liquid immiscibility and assimilation. Mantle, onset and process of partial melting in mantle, mantle-magmas in relation to degree and depth level of partial melting. Phase equilibrium in igneous system: Binary and ternary system.

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Magmatism and tectonics: Inter-relationship between tectonic settings and igneous rock suites. Igneous rock suites: Form, structures, texture, model mineralogy, petrogenesis and distribution of ultramafic rocks: Dunite-peridotite-pyroxenite suite; Kimberlites, lamprophyres, lamproites, komatiites. Basic rocks: Gabbro-norite-anorthosite-troctolite suite, Dolerites; Basalt and related rocks. Intermediate rocks: Diorite-monzonite-syenite suite, Andesites and related rocks; Acidic rocks: Granites-syenite-granodiorite-tonalite suite; Rhyolites and related rocks.

Alkaline rocks: Shonkinite, ijolite, urtite, melignite, alkali gabbros, alkali basalt, alkali granite, alkali syenite, nepheline syenite and phonolite; Carbonatites, Ophiolite suite. Petrogenetic provinces: Continental areas: Volcanic flood basalts-tholeiites (Deccan Traps, Columbia River basalts). Layered gabbroic intrusions: The Bushveld complex, Shaergaard intrusion, Still water complex. Plutonic: Carbonatites and alkaline rock complex of India. Oceanic Rift valleys, MORB-Tholeiites-Ophiolites.

Metamorphic structures and textures; isograds and facies. Mineral reactions with condensed phases, solid solutions, mixed volatile equilibrium and thermobarometry. Metamorphism of pelites, mafic-ultra mafic rocks and siliceous dolomites. Material transport during metamorphism. P-T-t path in regional metamorphic terrains, plate tectonics and metamorphism. Petrogenetic aspects of important rock suites of India, such as the Deccan Traps, layered intrusive complexes, anorthosites, carbonatites, Charnockites, Khondalites and Gondites.

2) STRUCTURAL GEOLOGY AND GEOTECTONICS:

Theory of stress and strain, Behaviour of rocks under stress, Mohr circle. Various states of stress and their representation by Mohr circles. Different types of failure and sliding criteria. Geometry and mechanics of fracturing and conditions for reactivation of pre-existing discontinuities. Paleostress analyses. Common types of finite strain ellipsoids. L-, L-S-, and S-tectonic fabrics. Techniques of strain analysis. Particle paths and flow patterns. Progressive strain history and methods for its determination. Deformation mechanisms. Role of fluids in deformation processes. Geometry and analyses of brittle-ductile and ductile shear zones. Sheath folds. Geometry and mechanics of development of folds, boudins, foliations and lineations. Interference patterns and structural analyses in areas of superposed folding. Fault-related folding. Gravity induced structures. Major tectonic features and associated structures in extensional-, compressional-, and strike-slip-terrains. Geological and geophysical characteristics of plate boundaries. Geodynamic evolution of Himalaya.

3) APPLIED MICROPALAEONTOLOGY:

General Palaeontology: Theories on origin of life. Application of fossils in age determination and correlation. Paleogeology, Life habitats and various ecosystems, Paleobiogeography. Modes of preservation of fossils and taphonomic considerations. Types of microfossils. Environmental significance of fossils and trace fossils. Use of microfossils in dating, biozonation, biostratigraphic correlation; Biozones and their types.

Micropalaeontology: Application of micropaleontology in hydrocarbon exploration. Oxygen and Carbon isotope studies of microfossils and their use in paleoceanographic and paleoclimatic interpretation. Foraminifera: Living animal, habit, life cycle; dimorphism; test shape, Wall composition, wall structure, lamellar character of wall in foraminifera; Formation and arrangement of chambers and ornamentation in foraminifera; Test openings, apertures, perforations, pore plates and taxonomic importance in foraminifera. Classification of Foraminifera. Elementary idea of

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Conodonts, Ostracodes, Nannoplanktons, Diatoms and Palynology. Important invertebrate fossils, vertebrate fossils, plant fossils and microfossils in Indian stratigraphy.

4) SEDIMENTOLOGY AND STRATIGRAPHY:

Precambrian Geology: Evolution of lithosphere, hydrosphere, atmosphere, biosphere, and cryosphere; lithological, geochemical and stratigraphic characteristics of granite – greenstone and granulite belts. Stratigraphy and geochronology of the cratonic nuclei, mobile belts and Proterozoic sedimentary basins of India. Life in Precambrian. Precambrian – Cambrian boundary with special reference to India.

Basic Sedimentology: Clastic sediments- gravel, sand and mud; biogenic, chemical and volcanogenic sediments. Classification of conglomerates, sandstones and mudstones, and carbonate rocks. Flow regimes and processes of sediment transport. Sedimentary textures and structures. Sedimentary facies and environments, reconstruction of paleoenvironments. Formation and evolution of sedimentary basins. Diagenesis of siliciclastic and carbonate rocks.

General and Phanerozoic Stratigraphy: Recent developments in stratigraphic classification. Code of stratigraphic nomenclature – Stratotypes, Global Boundary Stratotype Sections and Points (GSSP). Lithostratigraphic, chronostratigraphic and biostratigraphic subdivisions. Methods of stratigraphic correlation including Shaw's Graphic correlation. Surface and subsurface procedures of correlation, physical and palaeontological methods. Major geological events during the different periods of the earth's history. Concept of sequence stratigraphy. Rates of sediment accumulation, unconformities. Facies concept in Stratigraphy – Walther's law. Methods for paleogeographic reconstruction. Earth's Climatic History. Phanerozoic stratigraphy of India with reference to the type areas- their correlation with equivalent formations in other regions. Boundary problems in Indian Phanerozoic stratigraphy. Distribution of Paleozoic rocks in India: Salt range, Spiti, Kashmir and Penninsular India. Mesozoic Stratigraphy, Depositional Environment, distribution-life, classification and economic importance of Gondwana formations of India, Coastal Gondwana of India, Triassic of Spiti, Jurassic of Kutch, Cretaceous of Tiruchirapalli – Pondicherry – Bagh Beds, Deccan traps: distribution, structure, Lameta beds Infratrapean and Intertrapean beds, age of the Deccan Traps.

Cenozoic Stratigraphy: Comprehensive account of the geological events took place during Cenozoic Era in India, rise of Himalaya, Stratigraphy of Siwalik system, fauna and flora, Tertiary rocks of Assam, Karewa Formation. Tertiary rocks of the East and West coast of India, Pleistocene Glaciation – Cenozoic oil bearing formations of India.

5) GEOCHEMISTRY:

Structure and atomic properties of elements, the Periodic Table; ionic substitution in minerals; Phase rule and its applications in petrology, thermodynamics of reactions involving pure phases, ideal and non-ideal solutions, and fluids; equilibrium and distribution coefficients. Nucleation and diffusion processes in igneous, metamorphic and sedimentary environments, redox reactions and Eh-pH diagrams and their applications. Mineral/mineral assemblages as 'sensors' of ambient environments. Geochemical studies of aerosols, surface-, marine-, and ground waters. Radioactive decay schemes and their application to geochronology and petrogenesis. Stable isotopes and their application to earth system processes.

Composition and structure of the earth and principles of distribution of elements in the cosmos; Distribution of elements in the earth, Minor and trace elements during magmatic crystallization. Significance of REEs in igneous petrology and their importance in fractional crystallization during

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magmatic/partial melting. Fate of minor and trace elements during Metamorphism. The geochemical cycle. A brief survey geochemical cycle of the following elements, Si, Al, Fe, U-Th & Au. Law of radioactivity; Principles of isotopic dating; Decay schemes & derivation of equation of age. Isotope Geochemistry; Significance of strontium isotopes in igneous petrology. Basic concepts of Geochemical exploration; Geochemical environment, mobility, dispersion & dispersion patterns. Geochemical background, threshold and anomaly. Geochemical association and pathfinder elements. Interpretation of geochemical anomaly; false anomalies.

6) ECONOMIC GEOLOGY:

Magmatic, hydrothermal and surface processes of ore formation. Classification of ore deposits. Metallogeny and its relation to crustal evolution; Active ore-forming systems, methods of mineral deposit studies including ore microscopy, fluid inclusions and isotopic systematics; ores and metamorphism- cause and effect relationships. Geological setting, characteristics, and genesis of ferrous, base and noble metals. The stratigraphic position, occurrence, ore and gangue mineralogy, genetic aspects and distribution of the following ore deposits in India and important examples from other countries and world resources and reserves: (1) Chromium, nickel, gold, silver, Molybdenum; (2). Tin Tungsten, Uranium (3) Iron and Manganese (4) Copper, Lead and Zinc and (5) Aluminum. Origin, migration and entrapment of petroleum; properties of source and reservoir rocks; structural, stratigraphic and combination traps. Methods of petroleum exploration. Petroliferous basins of India. Origin of peat, lignite, bitumen and anthracite. Classification, rank and grading of coal; coal petrography, coal resources of India. Gas hydrates and coal bed methane. Nuclear and non-conventional energy resources. History and significance of mineral exploration. Surface and subsurface indicators, Index to mineral deposit, Field parameters of mineral exploration; Mining terminology. Planning of field work; mine examination; Surface and underground mapping. Basic factors of ore estimation; classification of ore reserves & resources, methods of estimation of different types of deposits. Developing & Mining: introduction to development a prospects; prospecting different features (shaft drift and tunnels, ventilation, illumination, transports, drainage). Samples: Introduction, principles, methods, types, applications, subsurface sampling, sampling reduction and related aspects. Mining Methods: Surface, subsurface and underground for various minerals, building stones, ores and fuels Explosive, their grades, uses and precaution. Elementary principles and methods of mining, open-pit alluvial, underground duties of geologist in mining organization, Mine machineries.

7) ENGINEERING GEOLOGY AND GEOTECHNOLOGY:

Geotechnical engineering and environmental geo-technology: Introduction and scope, recent trends & developments. Engineering properties of rocks, behaviour under loads, stress & strain, elasticity (elastic constants), residual stresses, rock discontinuity (RQD, Q & RMR), geotechnical logging charts, engineering classifications (NGI, ISRM & CSIR), physical characters of building stones, concrete and other aggregates. Engineering properties of soils- soil profile, grading, index properties, consistency limits, influence of clay minerals, liquefaction, behaviour under loads, effective, neutral and total stresses, lateral earth pressure and arching in soil, theories of failure, engineering classification, expansive pressure, consolidation and compressibility, geo-grids.

Dams and reservoirs: types and classification, forces acting on the dam body, reservoir induced seismicity, investigations for the construction of dams and reservoir, spillways etc., case studies.

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Foundation rock and abutment problems- abatement technology, reservoir area problems (such as assessment of mineral resources, agriculture, forest, silt survey, reservoir life and rehabilitation sites), bearing strength of foundation rocks/soils and their improvement, piles, case studies. Tunnels- types, problems due to underground water and fault-shear zones, tunneling in hard and soft grounds, investigations for tunnel alignment, tunnel support design, tunnel linings, TBM, case studies.

Bridges: Types, abutment and foundation problems across river and valley crossing, geological investigations for construction of bridges, Case studies. Canals-types, investigations for canals, drains and linings, problems and their control, river interlinking projects in India. Buildings- foundations and their selection, types of piles, foundation problems and their improvement, power plants and pumping station on fills. A seismic designing - earthquake mechanism, intensity, magnitude, seismicity and zoning, calculation of safety factor (seismic coefficient), earthquake resistance design, geo-raders, major earthquakes and their impact.

Landslides and types of mass movements: Types and classification, causes and mechanism, subsidence and settlements, investigations for soil and rock slope instability, prevention and mitigations, earthquake induced landslides, hazard zoning, case studies of Himalayas. Highways and embankments- types, investigations for the construction of highways and embankments in plain and sloping land, cut and fill excavation, classification of excavation materials, foundation problems and their control, case studies.

Shoreline engineering and coastal geotectonics: destruction of shorelines, planning and construction of littoral barriers; sedimentation and its control in harbours. River training and flood control- river improvement for navigation, principles of flood control, control of abutment erosion, case studies. Military geology- Applying engineering geology to military problems, organizing geological services for the army, Military Engineering-BRO. Environmental considerations related to civil engineering projects.

g.) GROUNDWATER HYDROLOGY

Sources of Groundwater. The hydrologic cycle. Occurrence, movements and origin of groundwater. Vertical distribution of groundwater, zones of aeration- perched water table, zone of saturation - free and confined groundwater, comparison of surface and sub-surface storage. Darcy's Law and its range of validity. Importance of meteorology in hydrologic investigations, rainfall-runoff estimation of seasonal and annual rainfall. Temperature, humidity and wind velocity. Measurement of stream flow measurement of evaporation and transpiration losses. Hydrological properties of water bearing material. - permeability, hydraulic conductivity, transmissivity, storativity, specific yield, specific retention, hydrostatic pressure, water table slope or hydraulic gradient.

The water table- definition, water table in granular formations, in fractures and solution opening, water table maps and pressure surface maps, fluctuation of water table, groundwater basin, mounds, trenches and cascades. Groundwater and well hydraulics- groundwater flow- Permeability methods. Laboratory methods - direct and indirect, variable head and constant head methods. Field Methods - Groundwater velocity methods- dye method, salt method, electrolyte method,

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discharging well method, drawdown method: Equilibrium method, Thiem method, Non-equilibrium methods - Theis Method, Cooper and Jacob Method, Chow Method; Recovery Method and Theis Recovery Method.

The construction of water wells- shallow well and deep wells. Types of wells - inverted wells, recharge wells, radial wells, drill wells, dug wells dug cum bore wells and open wells, infiltration galleries, collector wells. Development of wells - Different methods of development of wells, fundamental principles governing performance of wells, relation of drawdown to yield, relation of diameter to yields, specific capacity of wells and efficiency of wells step drawdown test. The completion of wells or design of wells - relation of slot openings to mesh sizes and gauge number. Corrosion of wells & encrustation of well screen. Gravel treatment of wells- basic principles of gravel treatment, hydraulics of gravel treated wells, development & pumping of gravel treated wells. Testing wells for yield, protection of wells.

Impurities and treatment of natural water- origin of impurities in natural water, quality of water- physical, chemical, biological and radiological characteristics. Importance of quality in ground water. Monitoring of ground water quality. Ground water suitability for drinking, irrigation and industrial purposes. Groundwater pollution their sources and causes, treatment of ground water- increasing and decreasing hardness removal of impurities chlorination, removal of dissolved material. Saline water intrusion in aquifers. Radio isotopes and hydro-geological studies. Basin wide groundwater development, conjunctive use of surface and ground water. Groundwater development assessment and management. Groundwater modelling. Artificial recharge of groundwaters, problems of over exploitation, groundwater legislation.

9.1) REMOTE SENSING AND GEOINFORMATICS

Introduction & scope of photogeology: types and acquisition of aerial photographs, their geometric characteristics, scale, factors affecting scale & aerial photography, mosaics, film and filter combination, aerial cameras & flying agencies. Stereoscopy: lens and mirror stereoscope, stereovision, pseudo stereovision, vertical exaggeration, image displacement. Parallax and various distortions, measurement & their removal, instrumentation for interpretation, plotting and measurement. Basic elements of photo interpretation: recognition and interpretation of aeolian, glacial, fluvial and marine landforms in igneous, sedimentary and metamorphic terrain.

Introduction & scope of remote sensing: Earth Resources Technology Satellites (ERTS), LANDSAT, SPOT & IRS mission, Meteorological and Ocean Monitoring Satellites. Indian and global missions. Remote Sensing- principles, electromagnetic spectrum and atmospheric windows, EMR quantities, radiation laws, interactions with atmosphere and terrain objects, Platforms and sensors- multispectral scanners (MSS) & scanning modes.

Types of remote sensing- thermal & microwave remote sensing, scale & resolutions, interpretation of panchromatic, black & white, false colour composites (FCC), coloured infrared, thermal infrared, radar, MSS and hyper spectral imageries, spectral signature.

Digital Elevation Model (DEM), Triangular Irregular Network model and other models & their applications; network analysis. Applications of GIS- in geological, geomorphological, hydrogeological, engineering geological surveying and mapping.

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Survey & mapping- of Soil, agriculture, forest, land use & land cover. Ecosystem analysis & biodiversity management, coastal zone management and oceanography, high resolution satellite images and human settlement analysis. GPS- components, positioning and corrections, navigation principles, differential GPS, other navigation systems, surveying methods & integration with GIS themes.

Concept of digital images and data formats: pre-processing, enhancement, classification algorithms and accuracy assessment, satellite data reception, product generation and ordering procedure. Geographic Information System- hardware and software requirements, GIS packages, recent trends and developments. Spatial data models- data qualities and sources of errors, inputting, editing and topology creation, coordinate system- datum and projections. Spatial analysis.

12.) ENVIRONMENTAL GEOLOGY

Silicosis, and other industrial maladies; mine dust. Phthisis and fluorosis; their causes remedies and prevention. Geological factors of environmental health. Environmental elements of medical geology. Anthropogenic activities and environment. Planning and management of land, soil erosion, conservation, urban. Geology and environmental laws.

Environmental pollution: sampling of soil, water, biological materials. An idea of dating of soils and waters. Radioactive minerals and their impact of the environment. Principles of sedimentation, sedimentary environments. Clay mineralogy and related health hazards. Reservoir petrography of sandstones and limestone; sedimentary petrology in relation to military geology.

River flooding, erosion and sedimentation, coastal subsidence. Cement petrography and its application to pollution. Man as geological agent. Geological consequences of industrialization; Waster; their disposal and management of environment. Physical system, biological system and the oceans. Surface and subsurface water Contamination.

Pollution of atmosphere: Types of energy resources, utilization and effects. Mining hazards, pollution. Geological factors affecting environmental purity. Classification of pathogenic bacteria and their utility in mineral beneficiation.

Definition, scope, concepts, forms of environment: Interaction between man and natural systems. Application of geomorphology in environment. An idea of environmental impact of landslides, earthquakes, volcanoes, large civil engineering structures. Physico-chemical properties of rocks and their engineering geological significance. Primary and Secondary dispersion patterns; biogeochemical anomalies. Distribution and significance of heavy elements in rocks, their weathering products.

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