ALIGARH MUSLIM UNIVERSITY, ALIGARH

FACULTY OF SCIENCE

SYLLABUS FOR

M.Sc. (Applied Geology) / M.Sc. Applied Geology (Hydrogeology)

Earth in the solar system. Formation of core, mantle, crust, hydrosphere, atmosphere and biosphere along with elemental abundance in each constituent. Radioactivity and age of the Earth. Internal structure of the Earth. Heat flow patterns, Causes of internal heat of the Earth and Heat budget. Mantle convection. Continental drift theory, Seafloor spreading and plate tectonics. Geotectonic features. Wilson cycle. Paleomagnetism. Apparent polar wander paths. Supercontinent cycle. Oceanic plateaus and aseismic ridges. Ophiolites. Accretionary orogens. Neotectonics. Principle of uniformitarianism. Principles of geodesy. Concept and theories of isostasy. Island arcs and trenches. Cycles in Earth system: biogeochemical cycle, rock cycle, geochemical cycles. Oceanic circulation. Concept of natural ecosystem and its components.

Volcanoes: Origin, structure, types and distribution. Volcanic materials and deposits. Major paleovolcanic events: causes and consequences. Earthquakes: origin, distribution, magnitude and intensity. Pre- and post-seismic event indicators. Paleoseismicity.

Geohazards – Floods, Earthquakes, Volcanic Eruptions, Tsunami, Landslides and Land Subsidence: causes, types, impacts, assessment and mitigation.

Weathering and erosion: Types, controlling factors and products of weathering. Soil formation, soil profile and soil types. Erosional and depositional landforms formed by running water, wind and glaciers. Physiographic subdivisions of the Indian subcontinent – their physical, structural and geological features. Stream patterns.

Elementary Ideas about Crystal Structure, symmetries and notations. Silicate structure and its classification. Physical and optical properties of minerals. Indicatrix. Interference figures. Polymorphism, Polytypism, Pseudomorphism. P-T stability diagrams of minerals. Chemical composition, crystal structure and mode of occurrence of Native elements, Sulfides, Oxides, Sulfates, Halides and Silicates.

Physical properties and chemical characteristics of magma. Bowen's reaction series. Magmatic differentiation processes: Fractional crystallization, magma mixing, crystal settling, liquid immiscibility, assimilation-fractional crystallization (AFC). Basic principles and application of thermodynamics in igneous petrology. Binary systems: Albite-Anorthite; Diopside-Anorthite; Nepheline-Silica. Ternary systems: Albite-Anorthite-Diopside; Nepheline-Kalsilite-Silica. Forms and structures of igneous rocks. Igneous textures. Classification of igneous rocks. General characteristics of

Precambrian igneous rock suites: Komatiites, Anorthosites, Tonalite-Trondhjemite-Granodiorite. Mineralogical characteristics and origin of (I) Granite, granodiorite, diorite, rhyolite; (II) Basalt, dolerite, gabbro; (III) Syenite, nepheline-syenite, trachyte; and (IV) Peridotites.

Introduction to metamorphic rocks and their significance. Basic principles and applications of thermodynamics in metamorphic petrology. Classification of metamorphic rocks. Concepts of isograds and zones and metamorphism. Metamorphic processes, agents and their role in metamorphism. Types of metamorphism: Contact, regional, cataclastic and metasomatism. Textures and structures of metamorphic rocks and their significance. Concept of metamorphic facies and facies series. Cataclastic metamorphism and its products. Contact metamorphism of mafic, pelitic and carbonate rocks. Regional metamorphism of mafic, pelitic rocks. Petrology, origin and distribution (in India) of charnockites, khondalites, granulites and eclogites. Anatexis and origin of migmatites. Chemographic projections: ACF, AKF diagrams. P-T-t paths and their significance.

Zingg's and Folk's shape classes. Textural attributes of sedimentary rocks. Fluid flow dynamics in sedimentary environments. Concept of sedimentary facies and depositional environments. Sedimentary structures and their significance. Biogenic structures and significance of ichnofossils. Mineralogy, classification and origin of sedimentary rocks. Heavy Minerals and their significance in sedimentological studies. Diagenesis of terrigenous and chemical sedimentary rocks. Formation of sedimentary basins in relation to plate tectonics.

Concept of dip, strike, trend and plunge. Definition of force, stress and strain. Stages of rock deformation, Stress-strain diagram. Unconformities, their types and recognition in the field and on geological maps. Geometric and genetic classification of folds. Synforms and antiforms. Mechanics and causes of folding. Description and classification of faults. Planar structures, their identification and description. Type of cleavage and schistosity and their origin. Types of lineations, their origin and their relation to major structures. Joints, their classification and significance. Representation of planar and linear features using stereographic projection.

Renewable and non-renewable energy resources. Metallogenic Epochs and Provinces of India. Geological setting, mineralogical characteristics and Indian distribution of mineral deposits: Iron, Manganese, Copper, Lead-Zinc, Chromite, Bauxite, Gold. Classification of ore deposits: classification based on ore-forming process and plate tectonics. Mineral zoning, paragenesis and paragenetic sequence. Ore guides. Mining methods. Basics of mineral economics. Industrial Minerals and Gemstones.

Geochemical Data: Major elements; trace elements; radiogenic and stable isotopes. Classification and Behavior of Trace Elements: LILE and HFSE; Raoult's law; Henry's law; mineral-melt partition coefficients. Controls on Trace-Element Distribution: Geological controls; element mobility; effects of partial melting and fractional crystallization. REE chemistry; LREE-HREE behavior; Oddo-Harkins rule, geochemical data normalization; Eu anomaly; interpretation of REE patterns.

Igneous Rock Classification Using Geochemical Data: Alkaline vs subalkaline magmas; subdivision of subalkaline series (tholeiitic and calc-alkaline). Norm-Based Classification: Normative basalt and granite classifications.

Fundamentals of Isotopes: Importance of isotopes; classes of isotopes; radioactive decay law, equation, decay schemes, decay constant and half-life; non-traditional isotopes. Radiogenic Isotope Systems and Geochronology: U-Th-Pb systematics; U-Pb concordia; zircon dating methods; Re-Os and Lu-Hf systems; K-Ar and Ar-Ar dating; Rb-Sr systematics; Sm-Nd systematics. Isochron, errorchron, initial ratio, CHUR, epsilon notation, model ages; Radiocarbon generation and ^{14}C dating; chemical dating. Stable Isotopes: Stable isotope systems (C, O, H, N, S); clumped isotopes; applications in paleoclimate, environmental studies and petrogenesis.

Major and Trace-Element Analytical Techniques: Spectrophotometry; Atomic Absorption Spectroscopy (AAS); X-ray Fluorescence (XRF: WD and ED); ICP-AES/OES; ICP-MS. Mineralogical Techniques: Powder X-ray Diffraction (XRD); X-ray spectrometry. Electron and Ion Microbeam Techniques: Electron Probe Microanalysis (EPMA); Scanning Electron Microscopy (SEM); Transmission Electron Microscopy (TEM); Secondary Ion Mass Spectrometry (SIMS); Thermal Ionization Mass Spectrometry (TIMS); cathodoluminescence and thermoluminescence. Staining Techniques: K-feldspar, plagioclase, quartz and carbonates.

Geological Time Scale. Elements and Principles of Stratigraphy. Stratigraphic correlation and classification. Various geological divisions of Peninsular Shield-Cratons: Dharwar, Bastar, Singhbhum, Bundelkhand and Aravalli. Mobile belts: Eastern Ghats, Southern Granulite Terrain, Satpura. Supergroups: Delhi Supergroup, Vindhyan Supergroup, Cuddapah Supergroup. Aravalli Supergroup, Gondwana Supergroup. Deccan Traps. Lithotectonic divisions and evolution of the Himalaya.

Fossils: Types and fossilization processes. Microfossils: definition, significance and important groups. Morphology and geological distribution of Brachiopoda, Echinoidea, Trilobita, Pelecypoda, Gastropoda. Cephalopoda. Evolutionary History of Equidae. Morphology, Classification and Geological range of important Gondwana flora.

Coal: Origin, petrology, types, classification and ranks. Major Gondwana and Tertiary coalfields of India. Hydrocarbons: Origin, migration and entrapment. Structural, stratigraphic and mixed oil traps. Hydrocarbon exploration techniques – geological and geophysical methods. Onshore and offshore distribution of petroliferous basins in India. Gas hydrates: Origin, distribution and economic potential. Radioactive minerals: Mineralogy, geochemistry and origin. Distribution of uranium and thorium deposits in India. Detection and measurement of radioactivity. Surface and subsurface methods of mineral exploration. Geophysical methods of mineral exploration: Gravity, electrical, magnetic and seismic methods. Methods of drilling, assaying and reserve estimation. Geobotanical and Geochemical methods of mineral exploration. Strategic and critical minerals. Mineral resources of the sea and law of sea.

Basics of remote sensing, EMR, platforms, sensors. Types of aerial photographs. Scale determination on aerial photographs. Framing and Scanning Systems. Types of Satellites and images. IRS, LANDSAT and SPOT Satellites. EMR interaction with atmosphere and earth surface spectral signatures of soil, water and vegetation. Basic drainage pattern and their recognition on images / aerial photos. Identification and characteristics of common rock types on aerial; photographs / satellite images. Concept of datum and coordinate system. Map projections: Conical, cylindrical and azimuthal. Basic concepts and applications of GIS in geosciences, functions of GIS, data structure, data input and analysis in GIS. Global positioning system (GPS): components, operating principle, application and limitations. Morphometric analysis. Digital Image Processing Techniques. Supervised and unsupervised classification. Band ratioing, filtering and PCA classification. Concept of georeferencing. Radiometric and atmospheric corrections in satellite data. Concept of ellipsoid and spheroid. Digital Elevation Model and its applications. Microwave remote sensing missions. Identification of fluvial, eolian and glacial landforms on satellite data.

Hydrologic cycle and its components. Vertical distribution of sub-surface water. Classification of aquifers. Darcy's Law and its validity permeability. Concept of watershed management, chemical quality of groundwater. Groundwater pollution. Hydrologic properties of aquifers: porosity, permeability, specific yield, specific retention, hydraulic conductivity, transmissivity, storage coefficient and methods of their measurements. Hydrographs, Springs and their types. Concept of drainage basins and groundwater basins. Hydraulic properties of aquifer and aquitard and their controlling factors. Well Hydraulics. Determination of permeability in the lab and field. Groundwater flow equations. Techniques of Artificial recharge of groundwater. Geophysical methods in groundwater exploration: Electrical resistivity, Seismic, Gravity. Geophysical well logging, electrical and radiation logging.

Structure, composition and evolution of atmosphere. Atmospheric circulation. Atmospheric thermal inversion, suspended particulate matter, heavy metals, carbon monoxide, sulfur dioxide, nitrogen oxide, volatile organic compounds, ground-level ozone, smog and tropospheric ozone. Climate Change. Paleoclimatic records from glaciers. Glaciation in Earth's history.

Urban geology: scope and dimensions, geohydrogeological constraints in urban planning. Impact of urban waste disposal, liquid waste disposal, their management and control. Trace elements and human health. Water pollution and water-borne diseases: cause and remedies. Aquifer vulnerability.

Engineering properties of soil and rock. Intact rock and rock mass. Discontinuities in rock mass: Geotechnical classification and its significance. Schmidt hammer rebound test. Core recovery and Rock Quality Designation. Rock mass classification methods. Structurally controlled failures. Soil: Grain size distribution, Atterberg limits & related indices, Mass-Volume relationships. Soil classification systems. Building stones and aggregates. Mass movements with emphasis on landslides and rockfalls. Slope stabilization and protection measures. Geological and geotechnical considerations for the evaluation of dams, reservoirs, tunnels, coastlines and

bridges.