511. GEOPHYSICS

UNIT-I

Mathematics:

TENSORS: Introduction, Definition, Contraction, Direct product, Quotient rule, Pseudo tensors, Dual Tensors, Studies of some Geophysical examples.

ANALYTIC FUNCTIONS: Functions of a complex variable. Mappings Limits. Theorems on Limits, Continuity Derivatives. Differentiation Formulas. The Cauchy Riemann Equations, Sufficient conditions. The Cauchy – Riemann Equations in polar Form. Analytic Functions Harmonic Functions. Some Geophysical examples.

Numerical analysis and inversion: Numerical differentiation and integration, finite element, and finite difference techniques; Simpson's rules; Gauss' quad rature formula; initial value problems; pattern recognition in Geophysics. Well posed and ill-posed problems; method of least squares; direct search and gradient methods; generalized inversion techniques; singular value decomposition; global optimization.

Signal Processing: Continuous and discrete signals; Fourier series; linear time invariant systems with deterministic and random inputs; band limited signal and sampling theorem; discrete and Fast Fourier transform; Z-transform; convolution; Filters: discrete and continuous, recursive, non-recursive, optimal and inverse filters; deconvolution, relation between Z and Fourier transforms, Hilbert transform, analytic signal, Amplitude, phase, instantaneous frequency and envelope of time series. Radon, Walsh and Mellin transforms, their discrete transforms and properties.

UNIT-II

Geology:

Fundamentals of Mineralogy: Basic concepts of Minerology, Types of minerals, Chemical Physical and optical properties.

Classification into plutonic, hypabyssal and volcanic rocks. Forms of igneous rocks: Lava flows, sill, lacolith, lopolith, dyke, Phacolith, Botholith, structures: vesicular, amygdaloidal, block and ropy lava.

Textures: Definition of texture, microstructure, allotromorphic, hypidiomorphic, Panidiomorphic, ophitic, porphyritic, poikilitic, intersectral and intergranular, graphic, Classification of igneous Rocks: Classifications of C.I.P.W. shand, Johannsen Rosenbuch and Terrell's tabular classification.

Origin of Igneous Rocks: Bowen's reaction principle, differentiation and assimilationn

Descriptive study of following igneous rocks: Granite, granodiorite, syenite, porphiritic granite, Pegmatite gabbro, dunite, peridotite, dolerite, rhyolite, obsidian, basalt and laterite.

Sedimentary Petrology: Introduction, mode of formation source, Transportation and deposition, classification of Sedimentary rocks, Structures and textures of sedimentary rocks, lithification and diagnosis.

Brief description of the following sedimentary rocks: Conglomerate, breccia, sandstone, greywacke, shale, limestone, dolomite, Shelly limestone and diatomaceous earth.

Metamorphic Petrology: Introduction: Definition, Types and agents of metamorphism; structure and textures of metamorphic rocks – grades and zones of metamorphism. Short notes on retrograde metamorphism. Metasomatism, Palingenesis, petrological cycle.

Brief description of the following metamorphic rocks: Quartzite, marble, slate, phyllite, schist, gneiss, charnockite and Khondalite.

Definition of Structural Geology: Objectives of structural geology-primary and secondary structures; bed, bedding planes, outcrop, attitude of beds, strike, dip and apparent dip.

Folds: parts of a folds, nomenclature of folds: Anticline, syncline, symmetrical fold, asymmetrical fold, overturned fold, recumbent fold, isoclinal fold, chevron fold, box fold, fan fold, kink bands, monocline, homocline, closed and open folds, drag folds, plunge of folds, doubly plunging fold, dome, basins,

RECOGNITION OF FOLDS IN THE FIELD: Direct observation, inferred folds, plotting attitude of beds on a map, aerial map pattern, drilling, mining and Geophysical methods, Determination of top of beds by

primary features. Ripple marks, cross bedding, graded bedding, sole markings, local unconformities and related features, pillow structures and drag folds.
JOINTS: Definition, geometric and genetic classification.
FAULTS: Terminology of fault plane; nature of movement along faults: Translational and rotational movements, relative movements, Effects of disturbed strata. Throw and heave; Classification: Geometrical classification, Genetic classification. Classification based on absolute movements.
UNCONFORMITIES:
Types of unconformities, Local unconformity, Angular unconformity, Nonunconformity and Disconformity.
Introduction to the theory of plate Tectonics.
Introduction and Principles of Stratigraphy: Standard Geological time scale, Principles of correlation:
Physiographical sub-divisions of India.
A brief study of area, distribution Lithology and economic importance of the following geological groups of India. Dharwar, Cuddapah, Vindhyans, Kurnool, Gondwana, Deccan Traps.
Economic Geology: Introduction: Ore minerals, gangue, ore and ore deposits. Syngenetic and epigenetic mineral deposits, concepts of magmatic, hydrothermal, sedimentary deposits, residual and Mechanical concentration and respective types of ore mineral occurrence.
Petroleum Geology: Chemical composition and physical properties of petroleum crude, origin of petroleum, migration of oil and gas, gas hydrates. Reservoir rocks – classification, hydrocarbon traps. Petroliferous basins of India.

Remote Sensing and GIS: Elements of photogrammetry, elements of photo-interpretation, electromagnetic spectrum, emission range, film and imagery, sensors, geological interpretations of air photos and imageries. Global positioning systems. GIS- data structure, attribute data, thematic layers and query analysis.

Hydrogeology: Groundwater, Darcy's law, hydrological characteristics of aquifers, hydrological cycle. Precipitation, evapotranspiration and infiltration processes. Hydrological classification of water-bearing formations. Fresh and salt-water relationships in coastal and inland areas. Groundwater exploration and water pollution. Groundwater regimes in India.

UNIT-III
General Geophysics:
Introduction to Geophysics: Geophysics and its importance among earth Sciences.
Paleomagnetism: Natural Remanent Magnetisation, Measurement of direction and intensity of NRM. Continental drift and polar wonder curves.
Geothermics: Heat sources, Geothermal flux distribution over continents and oceans.
Geochronology: Rock dating methods, U-Th, K-Ar, Rb-Sr, C-14, Fission-Track and magnetic dating.
Petrophysics: Different physical and Engineering properties of rocks Laboratory measurements of the physical properties of rocks namely Density, Seismic wave velocities, magnetic susceptibility, Electrical resistivity, thermal conductivity, porosity and permeability.
Seismology: Natural and Artificial seismology and its relation to other Earth System sciences. Classification of Earth quakes, Causes and propagation of Different seismic wave and fundamental laws. Various methods for determination of focal depth and epicentral location. Interior of the Earth and Earth quake prediction. Concepts of Geodynamics.
Basic concepts of Instrumentation: A descriptive treatment of instrument as a part of system. Linear systems, Static and Dynamic characteristics. Error and uncertainty in measurements.

Seismic Methods:
Historical Development and Background of Refraction and Reflection Methods, Difference between Refraction and Reflection Surveys, Propagation of Seismic Waves in Linear and Nonlinear medium. Common Depth Point technique, 2D, 3D and 4D Seismics, Vertical Seismic Profiling, Deep Seismic

Sounding, Sequence of Digital Seismic data Processing, Analysis of Multiples and Ghost Reflections, Time and Depth
Sections, Seismic Inversion, Migration Techniques, Processing and interpretation of Refraction Seismic data.
Petroleum system analysis, Acquisition and processing of multi-component seismic data
Application of Seismic methods in Hydrocarbon, Mining , Groundwater and Engineering studies.

Gravity and Magnetic Methods:
Principles of gravity prospecting, the gravitational field of the earth and its variation in space and time. Geoid, spheroid and Ellipsoid of the earth. Shape and size of the earth. Concept of gravity potential, Poission's & Laplace's.equations International Gravity Formula Factors contributing to the variation of gravity on the surface of the earth. Concept of anomaly & Definition of micro gravity anomaly. Density of rocks and minerals and their variations.
Basic principles of Astatic Gravimeters and survey procedures on land, at sea and in satellite gravity. Scales of survey. Reduction of land gravity data. Determination of surface rock densities using Netelton and other empirical methods. Various corrections, Reduction of marine and airborne gravity data, concept of absolute & relative Bouguer anomalies, preparation of Bouguer anomaly maps.
Principles of Magnetic prospecting Magnetic field of the earth & its variation in space and time. Concept of Magnetic potential and field Poission's relation. Magnetic elements., factors contributing to the main Magnetic fields of the earth. Magnetic properties of rocks and minerals.
Brief introduction to the working principles and operational procedures of modern magnetometers. Magnetic survey procedures on land marine and air borne. Accuracy corrections to magnetic data. Qualitative Analysis of gravity and magnetic data –Regional – Residual separation, various techniques. Green's Equivalent layer, Gravity and magnetic anomalies over common geological features. Continuation techniques,
calculation of second vertical gradients. Qualitative analysis of magnetic data. Derivatives and Continuation techniques, calculation of second derivatives, Reduction to pole
Application of gravity and magnetic methods in
(i) Regional geological and structural problems.
(ii) Mineral Exploration and Hydro carbons Exploration, application of micro gravity techniques.
(iii) Groundwater and Engineering problems

UNIT-IV
Electrical and Electromagnetic Methods:
Basic Principles of electrical methods of prospecting. Classification of methods.
Electrical properties of rocks and minerals, Influence of (1) mineral composition (2) moisture and salinity (3) Temperature on resistivity.
Basics of Resistivity methods of prospecting: Concepts of True and Apparent resistivities. Two electrode, Three electrode Dipole, Schlumberger, Wenner arrays and their Geometric factors, Principle of reciprocity.
Electrical Profiling(EP): Basics of electrical resistivity profiling. Response of EP with, Two electrode , Three electrode, Dipole- Dipole, Schlumberger & Wenner arrays over a vertical contact. The unipole, combined and Schlumberger arrays and their use in different cases of prospecting. Field procedure and illustration of results and interpretation.
Vertical Electrical Sounding (VES): Apparent Resistivity over a layered earth. Master curves for Schlumberger arrays- Types of two, three and multiplayer VES curves. Principles of Equivalence and Principle of suppression. Field procedures and examples of applications.
Resistivity imaging: Some fundamental concepts. Methods in resistivity imaging, field survey & uses.
Electrochemical Methods: Origin and nature of electro-chemical processes (spontaneous polarization) in the earth. exploration of sulphide ore bodies. Induced Polarization (IP)Method: Introduction, origin , Time domain and Frequency domain measurement of IP, chargeability, percent frequency effect and metal factors, apparent chargeability, Applications of IP Methods.

Electromagnetic Methods: Principles of Electromagnetic Prospecting, Primary field, Secondary field, Total field, Anomaly field, amplitude, phase, real and imaginary components.
Classification of Electromagnetic methods: Based on type of source and (1) Harmonically varying field, (2) transient fields.
Basic principles, operations, field procedures, processing and interpretation of

1. Surface low frequency methods
a. Dipole induction profiling (Slingram and Turam methods)
b. Tilt Angle Techniques – VLF and AFMAG
c. Surface Transient Methods
d. Surface High Frequency Methods
a) Radiowave mapping
b) Radiowave absorption
c) Ground-penetrating radar
2. General Principles of Borehole EM Methods:
3. Methods using Natural Fields: Telluric Current and Magnetotelluric Methods including Remote Reference technique.
Applications of EM methods in geological mapping, mineral and groundwater exploration.

Well Logging:
Reservoirs characteristics and objectives of well logging. Reservoir Rocks : Clastic and carbonate rocks.
Reservoir Properties: Borehole environment- invasion process and various profiles. Classification of well logging methods
Basic principles, operations, field procedures, processing and interpretation of
1. Spontaneous Potential (SP) logging
2. Non focused resistivity logging
3. Focused current logs
4. Micro resistivity (Wall) logging
5. Induction logging
6. Radioactivity and Nuclear Logging Methods:
7. Acoustic (sonic) logging
Sub-surface correlation and mapping from log data. Production logging.
Application of Well logging for (a) Groundwater, (b) Ore Minerals, (c)Petroleum & Gas.

LIST OF RECOMMENDED BOOKS:
1) Murray R-SPIGEL, May 1981, Advanced Calculus, Mc Graw Hill, International Book Company, Singapore.
2) R.V. Churchill, 1963 Fourier series and boundary value problem, Mc Graw Hill Koga Kusha Ltd., Tokyo.
3) Murray R-SPIGEL, 1965, Laplace transforms, Schaum's out line series Mc. Graw Hill, International Book Company, New York.
4) L.A. Pipes, 1970, Applied Mathematics for Engineers & Physicists, Mc. Graw Hill, Koga Kusha Ltd., Tokyo.
5) B.S. Grewal, 1999, Higher Engineering Mathematics, Khanna Publishers Delhi.
6) M.K.Jain, Numerical solution of differential equations. Wiley Eastern Ltd., New Delhi.
7) Rutleys, 1991, Elementary of Mineralogy – Revised by Gribble, C.D. CBS, Publishers and Distributors.
8) Tyrrell, G.W. 1975, The Principles of Petrology B.I. Publications.
9) Billings, M.P.1974, Structural Geology, Printice Hall.
10) Krishnan, M.S. 1982 Geology of India and Burma CBS Publishers.
11) Jenson, M.L. and Bateman, A.M. 1981, Economic Mineral Deposits – John Wiley & Sons.
12) Krishnaswamy S., 1972, India's Mineral Resources – Oxford & IBII Publishing Co.,
13) P.V. Sarma, 1976, Geophysical Methods in Geology, Elsevier.
14) Howell, 1959, Introduction to Geophysics, Mc Graw Hill Book Co. New York.

15) R.E. Sheriff, 1989, Geophysical Methods. Prentice Hall Engle Wood Cliffs. New Jerssy.
16) I.K. Kaul, S. Senugupta and A.K. Bhattacharya, 1990, General and Applied Geophysics, (An introduction), Associate of, Geophysics.
17) F.D. Stacey, 1977, Physics of the Earth, John Wiley and Sons, New York.
18) Rezhevisky and Novik, 1971, Physical properties of Rocks, Mir Publications.
19) Richter, C.F. 1969, Elementary Seismology, Eurasia Publishing house, Pvt. Ltd. New Delhi.
20) Dobrin M.B. Savit C.H. 1988 Introduction toGeophysical Prospecting. Mc. Graw Hill Book Company, Singapore.
21) Telford, W.M., Geldart, L.P. Sheriff, R.E. and Keys, D.A. 1981, Applied Geophysics, Cambridge University Press, Cambridge.
22) Sheriff, R.E. and Geldart, L.P. 1987 Exploration Seismology, Vol. I, CambridgeUniv. Press, Cambridge.
23) Sheriff, R.E.and Geldart, L.P. 1987 Exploration Seismology, Vol. II, Cambridge Univ. Press, Cambridge.
24) Sheriff R.E. 1989, Geophysical Methods, prentice Hall, Englewood cliffs,
25) Robinson, E.A., 1988, Migration of Seismic data SEG Publication.
26) B.S.R. Rao and IVR Murthy, 1978, Gravity and Magnetic Methods of Prospecting Arnold – Henniman Publishing Company, Delhi. 390 P.
27) D.S. Parasnis 1973, Mining Geophysics, Amsterdom, Elsevier Publishers,
28) The Netherlands, 354 P.
29) Grant F.S. and West G.F.,1964, Interpretation Theory in Applied Geophysics Mc Graw Hill Publication, New York.
30) L.L.Nettleton, 1967,. Gravity and Magnetics in oil Propoecting McGraw Hill Publication, New York. 464P.
31) E.I. Parkhomenko – 1967 Electrical Properties of Rocks – Plenum Press, New York.
32) Keller and Frischkeicht, 1966, Electrical methods in Geophysical Prospecting Pergaon.
33) Patra and Bhattacharya 1969, Direct Current Geoelectrical Sounding, Elsevier.
34) Marcus Bath, 1974, Spectral Analysis in Geophysics, Elsevier.
35) A Populis, 1962, The Fourier integral and its applications, MC Graw Hill Publishers.
36) J.F. Clarbout, 1976, Fundamentals of geophysical data processing. Mc. Graw Hill Publishers.
37) E.A. Robinson and S. Treitel, 1983, Digital Seismic inverse methods, D. Reidel Publishing Co.
38) Serra ,1986, fundamentals of well log interpretation-2.The acquisition of
39) Logging data.,Elsevier Science Publishers ,B.V
40) Itenberg,S.S. 1971, Study of oil and gas series from Well logs, Mir. Pub. Moscow
41) Schlumberger, 1972 , Essential of log interpretation Practice . Schlumberger France
42) Bhimasankaram, V.L.S., Savenko, E.I. and Venkat Rao, N., Centre of Exploration Geophysics,1973. Laboratory and Field Methods of Radiometry and Nuclear Geophysics.
43) Bhimasankaram, V.L.S., Venkat Rao, N. Sri Rama Murthy, K, and Savenko, E.I., 1985. Principles and Methods of Nuclear Geophysics, AEG.
44) Ward, Ed.S.H., 1990. Geotechnical and Environmental Geophysics, Vol. I, SEG. (pp. 219-286).
45) Stanislav Mares, D., 1984, Introduction to Applied Geophysics.(Chap-III), Reidel, Publishers.

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