Annexure 7

Revised Course Structure and Syllabi

M.Sc. (Applied Geology)

(Including 4th and 5th year of Integrated M.Sc. (Applied Geology))

Effective from 2022-2023

DEPARTMENT OF EARTH SCIENCES
SCHOOL OF PHYSICAL, CHEMICAL & APPLIED SCIENCES
PONDICHERRY UNIVERSITY
PONDICHERRY – 605 014

July 2022

Admission

Total number of seats for 2-year M.Sc. (Applied Geology) will continue to be 25 till the NEP compliant Integrated Program replaces it. The admission will be based on the merit in the nationwide test conducted by NTA. A student fulfilling the following criteria is eligible to apply.

Eligibility

Bachelor's degree in Geology as the major subject and any two out of Mathematics/ Statistics, Physics, Chemistry, Biology as ancillary subjects with a minimum of 55% of marks.

M.Sc. (Applied Geology)

Minimum of 72 credits need to be earned for compilation of the M.Sc. (Applied Geology) course of 2 years duration.

Semester 1(Semester 7 for Integrated M.Sc. students): Required Credits - 18

S. No.	Course	Hard/Soft Core	Credits
1.	EASC 411 Crystallography and Crystal Chemistry	Hard Core	2
2.	EASC 412 Rock Forming Minerals	Hard Core	2
3.	EASC 413 Deformation and Rock Structures	Hard Core	3
4.	EASC 414 Geochemistry	Hard Core	3
5.	EASC 415 Advanced Geomorphology	Hard Core	2
6.	EASC416 Advanced Geology Lab-I (Crystallography, Mineralogy, Structural geology, Geochemistry)	Hard Core	4
TOTAL			16

Suggested Soft Core Course:

Sl. No	Course	Hard/Soft	Credits
1.	EASC 417 Summer Internship II	Soft Core	3
2.	EASC 418 Stable Isotope Geochemistry	Soft Core	2
3.	EASC 419 Statistics in Geosciences	Soft Core	3
4.	EASC 420 Computer Applications in Earth Sciences	Soft Core	3

Semester 2(Semester 8 for Integrated M.Sc. students): Required Credits – 18

S. No	Course	Hard/Soft Core	Credits
1 .	EASC 421 Igneous Petrology	Hard Core	2
2.	EASC 422 Stratigraphy	Hard Core	2
3.	EASC 423 Metamorphic Petrology	Hard Core	2
4.	EASC 424 Vertebrate and Invertebrate Paleontology	Hard Core	2
5.	EASC 425 Advanced Geology Lab-II (Igneous, Metamorphic Petrology, Paleontology)	Hard Core	3
6.	EASC 426 Advanced Field Training-I	Hard Core	3
TOTAL			14

Suggested Soft Core Course:

Sl. No.	Course	Hard/Soft	Credits
1.	EASC427 Isotope Geology	Soft Core	2
2.	EASC 428 Radiogenic Isotope Geology	Soft Core	2
3.	EASC 429 Marine Geology	Soft Core	2
4.	EASC 430 Quaternary Geology	Soft Core	2

Semester 3 (Semester 9th for Integrated M.Sc. students): Required Credits - 18

S. No	Course	Hard/Soft	Credits
1.	EASC 511 Geology of Mineral Deposits	Hard Core	4
2.	EASC 512 Sedimentology	Hard Core	2
3.	EASC 513 Solid Earth Geophysics	Hard Core	2
4.	EASC 514 Micropaleontology	Hard Core	2
5.	EASC 515 Advanced Remote Sensing & GIS	Hard Core	3
6.	EASC 516 Advanced Geology Lab-III	Hard Core	4
TOTAL			17

Suggested Soft Core Courses:

Sl. No	Course	Hard/Soft	Credits
1.	EASC 517 Term Paper	Soft Core	2
2.	EASC 518 Professional Training	Soft Core	3
3.	EASC 519 Coal and Petroleum Geology	Soft Core	2
4.	EASC 520 Mineral Economics	Soft Core	2

Semester 4(Semester 10th for Integrated M.Sc. students): Required Credits - 18

S. No	Course	Hard/Soft	Credits
1.	EASC 521 Geoexploration	Hard Core	4
2.	EASC 522 Advanced Geohydrology	Hard Core	2
3.	EASC 523 Advanced Geology Lab-IV	Hard Core	3
4.	EASC 524 Advanced Field Training-II	Hard Core	3
TOTAL			12

Suggested Soft Core Courses:

Sl. No	Course	Hard/Soft	Credits
1	EASC 525 Project	Soft Core	4
2.	EASC 526 Global Tectonics	Soft Core	2
3.	EASC 527 Mining Geology	Soft Core	2
4.	EASC528 Paleoclimatology	Soft Core	3
5.	EASC 529 Planetary Geosciences	Soft Core	2
6.	EASC 530 Well Logging	Soft Core	2
7.	EASC 531 Indian Mineral Deposits	Soft Core	2

EASC-411- CRYSTALLOGRAPHY AND CRYSTAL CHEMISTRY
(Hard Core Course)

Credits: 2

UNIT 1

Geometric and algebric approaches to crystallography, Derivation and determination of point groups. Crystal forms. Space lattice and unit cell. Concept of space group. Stereographic projections.

UNIT 2

X-ray crystallography. Laue's and Braggs equations. X-ray diffractometer and powder method of mineral identification. Reciprocal lattice.

UNIT 3

Types of bonding in minerals. Chemical composition and unit cell content. Crystal structures and defects. Twinning.

UNIT 4

Solid solution and polymorphism. Crystallization process in different environments. Chemical classification of minerals.

UNIT 5

Crystal structures of silicates and other rock forming minerals. Chemical analyses of minerals.

Text books:

1. F. D. Bloss, (1971), Crystallogrphy and Crystal Chemistry, Holt, Rinehart, Winston, New York.
2. W. D. Nesse, (2000), Introduction to Mineralogy, Oxford University Press, ISBN 0-19-510691-1
3. Crystallography: An Introduction for Earth Science and other solid state students. Published by Pergamon Press, 1981.
4. Fundamentals of Crystallography (International Union of Crystallography Book Series, No. 2). Edited by C. Giacovazzo. Published by Oxford University Press.
5. The Basics of Crystallography and Diffraction (International Union of Crystallography Book Series). by Christopher Hammond Published by Oxford University Press. 3rd Edition 2009.

EASC-412 ROCK FORMING MINERALS (Hard Core Course)

Credits: 2

(Pre requisite: EASC 211 – Crystallography and Mineralogy or Teacher's consent.)

Unit I
Introduction. Structural and crystal chemical classification of minerals. Classification of silicate minerals. Chemical analyses of minerals and analytical techniques.

Unit II
Ortho and Chain Silicates

Unit III
Sheet Silicates and Framework silicates

Unit IV
Oxides. Carbonates

Unit V
Phosphates, Sulphates, Sulfides and other mineral groups.

Text book:

1. Deer, W. A. , Howie, R. A. and Zussman, J., An introduction to the rock forming minerals, ELBS publication, 2nd Ed. 2005, 696 pp.

Reference books:

1. Deer, W. A., Howie, R. A. and Zussman, J., Rock forming minerals, volumes I to VII.
2. Mineralogical Society of America volumes on individual mineral groups

EASC-413 DEFORMATION AND ROCK STRUCTURES (Hard Core Course)

Credits:3

Unit I: Structural elements in rocks, Concept of stress, State of stress, Mohr circle and failure criterion, Concept of Strain, Homogeneous deformation and concept of strain ellipsoid (ellipse), Types of strain ellipsoids, Stress-strain relation and rheological equations; Rheological equations and deformation behaviors, Factors controlling rock deformation.

Unit II: Joint: Concept and structural elements of Joint, Joint propagation, Joint surface feature, Joint associated with other structures, Age relations, Origin of joints. **Fault:** Concept and structural element of fault, Classification and recognition criteria of fault, Anderson's theory of faulting, Characteristic features of normal, strike-slip and thrust fault, thrust system and thrust propagation. **Boudinage:** Concept and structural elements of boudinage, Classification of boudinage, Characteristic boudin shape, Origin of boudinage

UNIT II: Foliation: Concept and types of foliations, Foliation and strain, Foliation in relation to fold, Origin of foliation. **Lineation:** Concept and types of lineation, Usefulness of lineation in structural analyses. **Fold:** Concept and structural elements of fold, Qualitative fold classification, Ramsay's fold, Mechanism of folding, Concept of fold interference, Types Superposed folds and characteristic outcrop patterns, Kinematics of superposed folding.

UNIT IV: Heterogeneous deformation and concept of shear zone, Types of shear zone, Shear zone rocks, Characteristic feature of ductile shear zone and shear sense indicators.

UNIT V: Mineral deformation behaviour and microstructure. Application of grain-scale deformation behaviours in structural analyses.

Text books:

1. Ghosh, S.K. 1993. Structural Geology: Fundamentals and modern developments.
2. Van der Pluijm and Stephen Marshak 2004. Earth Structure: an introduction to structural Geology and Tectonics, 2nd Edition. WW Norton & Company
3. Paschier C.W & Toruw, R.A.J. Micro-tectonics, Springer
4. Marshak, S and Mitra, G. Basic Methods of Structural Geology

Reference books:

1. Ramsay, J.G. & Huber, M.I. 1983. The Techniques of modern structural geology. V.1 & V2
2. Park, R.G. Foundations of structural geology.
3. Price, N.J. & Cosgrove, J.W. 1990. Analysis of Geological structures. Cambridge University Press.
4. Davis, G.H. 1984. Structural Geology of Rocks and Regions.

5. Suppe, J. 1985 Principles of structural geology. Printice-Hall.

EASC-414 GEOCHEMISTRY (Hard Core Course)

Credits: 3

Unit I Stellar evolution and origin of elements. Different processes of nucleosynthesis. Abundances of elements, Oddo-Harkin Law. Meteorites. Geochemical and Cosmochemical classification of elements and their basis. Differentiation of the Earth and resultant elements distribution in core, mantle, crust.

Unit-II Nuclides and atoms. Electronic configuration of atoms, arrangement of atoms in the Periodic Table. Periodic changes of elemental properties in the Periodic Table. Chemical bonding. Properties of elements (volatiles, semi-volatiles, alkalis, alkaline earths, REE, HFS). Silicate structures: Silicate polymers, cation sites in silicates, calculation of site occupancy, cation substitution, concept of distribution coefficients.

Unit III Laws of thermodynamics. Equations of State. Standard states. Enthalpy, entropy, heat capacity, changes in enthalpy and entropy with P and T, Gibbs free energy and equilibrium. Clapeyron equation. Simple thermodynamic calculations.

Unit IV Chemical weathering, soil formation, geochemistry of clays. Fundamentals of low-temperature aqueous geochemistry: ionic concentration, Molarity and molality, solubility and solubility product, acids and bases, dissociation constant. pH and oxidation and reduction processes: Eh-pH diagrams. Carbonate Equilibria**:** CO_2-H_2O interaction to form carbonic acid, dissolution of calcite. Introduction to chemical evolution of hydrosphere.

Unit-V **Isotopes:** Stability of nuclides. Radioactive decay schemes. Decay constant, half life, parent-daughter relations. Principles of geochronology. Radiogenic isotopes and their use in geochemistry. Stable isotopes: processes of isotope fractionation, δ-notation. C and O isotopes.

Text books:

1. H. Y. McSween, S. M. Richardson and M. E. Uhle : Geochemistry: Pathways and Processes. Second ed., 2004, Columbia University Press.
2. Robin Gill : 1988, Chemical Fundamentals of Geology. Chapman and Hall.
3. Brian Mason : 1982, Principles of Geochemistry. J. Wiley & Sons.
4. K. B. Krauskopf : 1979, Introduction to Geochemistry. McGraw Hill.

Reference books:

W. M. White : Geochemistry. Retrievable from http://www.geo.cornell.edu/geology/classes/geo455.

D. K. Nordstrom and J. L. Munoz : 2006, Geochemical Thermodynamics. Blackwell Scientific Publications. Gunter Faure: (1986, 2004)

EASC-415 – ADVANCED GEOMORPHOLOGY (Hard Core Course)

Credits:2

Geomorphic principles. Theory of Uniformaitarianism. Influence of structure, process, time, and climate on landforms. Energy flow in geomorphic systems.

Tectonic and Volcanic processes and landforms. Cenozoic diastrophism - orogeny and epierogeny. Landforms made by folding and faulting (tectonic scarps, fault valley and block mountains). Volcanic activity – distribution and landforms.

Fluvial Geomorphology. Rock weathering and soil formation. Soil types and soil profile. Karst processes and landforms. Mass wasting and hillslope evolution. Hydrological cycle. Drainage basins and networks. River and channel geometry. Sediment erosion and transportation mechanisms.
Concept of grade and base level of erosion. Fluvial deposition and landforms (alluvia fans, floodplains, and deltas). River terraces. Lakes – types and origins. Structural control on fluvial erosion. Landform evolution by fluvial processes.

Climatic Morphogenesis. Geomorphic processes in dry climates. Wind erosion and deposition. Landforms of arid, semi-arid, and savanna regions.
Perigacial and glacial morphogenesis. Mechanisms of erosion and transportation by moving ice. Continental and alpine glaciation. Glacial landforms. Permafrost and periglacial landforms.

Coastal and Marine Geomorphology. Shore zone processes and landforms. Classification of coasts. Sea level fluctuations. Submarine processes and landforms.

Applied Geomorphology. Application of geomorphogical knowledge in groundwater investigations, mineral exploration (placer deposits, residual deposits, oxidized zones), and engineering (construction materials, highway and railway routes)
Geomorphic provinces of India - Himalayas, Indo-Gangetic Plains, Peninsular region.

Text Books:

R.J. Huggest (2007) Fundamentals of Geomorphology. Routledge Publishers
A.S. Goudie (2004), Encyclopedia of Geomorphology (Vol. 1&2). Routledge Publishers.
D.W. Burbank & R.S. Anderson (2001), Tectonic Geomorphology, Blackwell Science Publishers.
A.L. Bloom (1992) Geomorphology – A systematic analysis of ate Cenozoic landforms. PHI, New Delhi.
M.A. Summerfield (1991), Global Geomorphology, Pearson Education Ltd.
W.D. Thornbury (1969) Principles of Geomorphology. Willey Eastern Ltd. New Delhi.
H.S. Sharma (1990) Indian Geomorphology. Concept Pub. Co., New Delhi.

EASC-416 ADVANCED GEOLOGY LAB – I (Hard Core course)

Credits: 4

Part 1: Crystallography (1 credit)

Crystallography and Mineralogy (1 credit)

Study of symmetry in models. Stereographic projections. XRD: identification of mineral from powder XRD data. Peak indexing of a cubic system mineral.

Part 1: Mineralogy (1 credit)

Identification of minerals in hand specimen. Study of optical properties of minerals in transmitted light and their identification in thin section. Calculation of chemical formula of minerals from analytical data.

Part 2: Structural Geology (1 credit)

Interpretation of geological maps and drawing sections. Fold analysis by dip isogon method. Strain analysis from deformed objects. Structural problems concerning mineral deposits. Elementary structural analysis by stereographic methods.

Part 3: Geochemistry (1 credit)

Introduction to methods of sampling in field, and sample preparation. Lab protocols and safety. Understanding of basic principles of geochemical methods for the analysis of rocks, soils, and aqueous fluids. Hands on training of solution preparation for analysis. Introduction to key aspects of data presentation, analysis and interpretation. Principles and hands-on application of the major analytical tools necessary to characterize the geochemistry of natural systems including: Spectrophotometer, Flame photometer, AAS and ICP-AES.

Reference books:

Ehlers E.G. (1987) **Optical Mineralogy: Theory and Techniques,** Blackwell Scientific Publications, 158 p. New York, John Wiley & Sons, Inc., 192p.

Klein, C, Hurlbut, C.S., and Dana, J.D. 1998, **Manual of Mineralogy (after James D. Dana), 21st Edition,** John Wiley & Sons Inc.

Mackenzie, W.S. & Adams, 1994, A.E. **Color Atlas of Rock and Minerals in Thin Section,** John Wiley & Sons

EASC-417 SUMMER INTERNSHIP-II (Soft Core course)

Credits: 3

Intensive training in advanced field or laboratory technique relevant to geological studies under the supervision of a faculty member of the Department or Scientist in a reputed national laboratory / academic institution, for 4 to 8 weeks. A report on summer internship must be submitted for evaluation.

EASC-418 STABLE ISOTOPE GEOCHEMISTRY (Soft core Course)
Credits:2

Unit I: Introduction and scope of stable isotope geochemistry. Terminology used in stable isotope studies. Principles of stable isotope mass spectrometry and various standards used in the mass spectrometric measurements.

Unit II: Theory of isotopic fractionation. Modes of isotopic fractionation: Equilibrium, kinetic and mass-independent.

Unit III: Natural examples of equilibrium, kinetic and mass-independent isotopic fractionation. Isotope fractionation in biological and chemical systems.

Unit IV: Temperature dependence of equilibrium isotope fractionation. Introduction to geothermometry. Application of stable isotope thermometry on low temperature and high temperature systems. Carbonate geothermometry.

Unit V: Uses of isotopes of hydrogen, oxygen, carbon, sulfur and 'Non-traditional' isotopes in earth system processes. Applications of stable isotopes in climatic, hydrological and biogeochemical studies. Application of stable isotope as geological tracers and in chemostratigraphy.

Unit VI: Application of stable isotopes in hydrothermal, igneous and metamorphic systems. Stable isotopes in deciphering physico-chemical environment of ore and petroleum formation.

Text Books

Sharp, Z., 2017. Principles of stable isotope geochemistry. Online text book.
Allegre, C. J. , 2008. Isotope Geology. Cambridge University Press. 512 p.
Clark, I., and Fritz, P., 1997. Environmental Isotopes in Hydrogeology, Lewis Publishers, Boca Raton, 328 p.
Hoefs, J., 1997. Stable Isotope Geochemistry, 4th edition, Springer-Verlag, Berlin, 285 p.
Faure, G., and Mensing, T., M., 2004. Isotopes: Principles and Applications, 3rd edition, J. Wiley & Sons, 928 p.
White, W., M.,. Geochemistry, an On-line Textbook, available at http://www.geo.cornell.edu/geology/classes/geo455/Chapters.HTML, 15 Chapters.

Reference Books

Valley, J., W., Taylor, Jr. H., P., and O'Neil, J., R., Ed., 1986. Stable Isotopes in High Temperature Geological Processes, Volume 16, Reviews in Mineralogy, Mineralogical Society of America and The Geochemical Society, 570 p.
Valley, J., W., and Cole, D., Ed., 2001. Stable Isotope Geochemistry, Volume 43, Reviews in Mineralogy and Geochemistry, Mineralogical Society of America and The Geochemical Society, 531 p.
Turekian, K., K., and Holland, H., D., Ed., 2003. Treatise of geochemistry: Chapters 4.06 to 4.09 (p.159-260) in Volume 4, The Atmosphere; Chapter 5.11 (p.320-364) in Volume 5, Surface and Ground water, Weathering and Soils; Chapter 6.11 (p.366-390) in Volume 6, The Oceans and Marine Geochemistry.

Johnson, C., M., Beard, B., L., and Albarede, F., Ed., 2004. Geochemistry of Non-Traditional Stable Isotopes, Volume 55, Reviews in Mineralogy and Geochemistry, Mineralogical Society of America and The Geochemical Society, 454 p.

EASC-419 STATISTICS IN GEOSCIENCES (Soft core Course)

Credits: 3

Introduction to organization and description of data: mean, median, mode, variance, standard deviation, quartile, percentile and covariance of data. Introduction to probability, discrete and continuous probability distributions. Introduction to statistical inference sampling distributions, point and interval estimation, hypothesis testing involving one and two univariate populations. Linear models for analysis of variance. Regression. Error propagation. Introduction to multivariate techniques.

Text Books

Harry Frank and Steven C. Althoen "Statistics concepts and applications" Cambridge University Press (1994)
Pitman, J. Probability, Springer-Verlag, (also Narosa Publ.), 1993. Creighton, J.H.C. First Course in Probability Models and Statistical Inference, Springer- Verlag, Berlin, 1994. Davis, J.C. Statistics and Data Analysis in Geology, John Wiley & Sons, New York, 1986.
Walpole, R.E. and Myers, R.H. Probability and Statistics for Engineers and Scientists, Macmillan, 1989.
Johnson, R.A. and Wichern, D.W. Applied Multivariate Statistical Analysis, Prentice Hall, New Jersey, 1982.
Cooley, W.W. and Lohnes, P.R. Multivariate Data Analysis, John Wiley & Sons, New York, 1971.
Morrison, D.F. Multivariate Statistical Methods, McGraw-Hill, New York,1967. Spiegel, M.R. Probability and Statistics, Schaums Outline Series, McGraw-Hill Intl., Singapore.

EASC-420 COMPUTER APPLICATIONS IN EARTH SCIENCES (Soft Core Course)
Credits: 3

Introduction: Quantitative analyses and need of computer-aided computations in Earth Sciences. Modeling different Earth processes.

Plotting and drawing tools. Statistical data analysis tools. Mapping and GIS tools.

Programming. Applications of Matlab and Python in Earth Sciences.

References:

1. Daniel F. Merriam (Editor), Computer Applications in the Earth Sciences, Springer New York, NY.
2. Srivastava, A. N., Nemani, R., Steinhaeuser, K. (2020) Large-Scale Machine Learning in the Earth Sciences, Chapman and Hall.

EASC-421 IGNEOUS PETROLOGY (Hard Core Course)

Credits: 2

Unit 1

Generation of magma, their nature, cooling behaviour and properties. Magmatism and volcanism on Earth, major volcanic eruptions and magmatic provinces.

Unit 2

Laws of thermodynamics. Gibbs free energy. Concept of activity, fugacity, ideal and non-ideal solutions. Phase rule.

Unit 3

Classification of igneous rocks. Petrography and interpretation of igneous textures in terms of nucleation and crystal growth. Definition, geochemistry, phase equilibria studies and paragenesis of important magmatic systems.

Unit 4

Tectonic settings and igneous rock associations. Major, trace elements and isotopes in igneous systems. Geochemical and thermodynamical modeling of partial melting and magmatic processes.

Text books:

1. Philpots A.R., Principles of Igneous and metamorphic petrology**,** Prentice Hall.
2. McBirney, A.R. Igneous Petrology, CBS Publishers and Distributors.
3. C ox, K.G. Bell, J.D. and Pankhurst, R.J. Interpretation of igneous rocks. George Allen Unwin.
4. W inter, J. D. An introduction to igneous and metamorphic petrology. Printice Hall.
5. M arjorie Wilson. Igneous petrogenesis: A global tectonic approach. Published by Chapman & Hall
6. D avis A. Young. Mind over Magma: The story of Igneous Petrology. Princeton University Press.

EASC-422 STRATIGRAPHY (Hard Core Course)

Credits: 2

Stratigraphic principles and practices. Classification and codeof stratigraphic nomenclatures. Sratification and sratigraphic column.

Lateral variation and facies. Graphic representation of sratigraphic data.

World stratigraphy: Brief description of the principal, stratigraphic units of the world in type areas. Paleogeographic reconstruction.

Indian stratigraphy: Physiographic subdivisions, structures and tectonic history of the Indian subcontinent. Study of the various geological formations of Precambrian, Paleozoic, Mesozoic, Tertiary and Quaternary Eras: distribution, geological succession, classification, correlation, paleogeography and life of each periods.

Gondwana Super Group - Distribution, succession, classification, flora and fauna, lower and upper age limit, structure of Gondwana basin, climate and paleogeography. Deccan Traps and associated sedimentary formations. Age of Deccan traps. Himalayan orogeny. Glacial and interglacial deposits.

Boundary problem of Precambrian - Cambrian; Permo-Triassic; Mesozoic - Tertiary.

Text books:

M.S.Krishnan 1982. Geology of India and Burma. CBS Publ. & Distributors, New Delhi.
C.O. Dunbar & J. Rodgers 1957 Principles of stratigraphy. John Wiley and Sons, New York.
Ramakrishnan, M. and Vaidyanathan, R. 2000. Geology of India. Geological Society of India, Bangalore.
Ravindra Kumar 1978. Historical Geology and Stratigraphy of India.

EASC-423 METAMORPHIC PETROLOGY (Hard Core Course)

Credits: 2

Unit 1
Introduction to metamorphism: Concept, agents, degree, facies, grade, and types of metamorphism. Classification of metamorphic rocks. Texture and structure of metamorphic rocks.

Unit 2
Application of thermodynamics: mineral equilibria and phase rule. Schreinemaker's analysis. Concept of thermodynamic modelling (pseudosection analysis). Metamorphic P-T estimation (Geothermobarometers). Diffusion kinematics (geospeedometry)

Unit 3
Proxies to decode metamorphism: Linking metamorphism with deformation and time. Fundamentals of geochronology. Application of geochronology in metamorphic petrology (P-T-t path). Evolution of plate tectonics and metamorphism with geological time.

Unit 4
Role of fluid in metamorphism: insight from fluid inclusion study and texture.

Unit 5
Extremities of metamorphism: Introduction and challenges of UHT and UHP metamorphism. Crustal anatexis and migmatization.

Text books:

1. Winter, J.D. (2001/7): An introduction to Igneous and Metamorphic Petrology, Prentice Hall.
2. Bucher, K. and Martin, F. (2002): Petrogenesis of Metamorphic Rocks (7Rev. Ed.), Springer–Verlag
3. Yardley, B.W.D. 1989. An introduction of Metamorphic Petrology, Longman Scientific and Technical, NewYork.

Reference books:

1. Spear, F. S. (1993): Mineralogical Phase Equilibria and pressure – temperature – time Paths, MineralogicalSociety of America.
2. Philpotts, A.R. 1990. Principles of Igneous and Metamorphic Petrology. Prentice Hall.
3. Yardley, B.W.D., Mackenzie, W.S. and Guilford, C. (1995): Atlas of Metamorphic Rocks and their textures, Longman Scientific and Technical, England.

Journal Reference:

1. Journal of Metamorphic Geology, Elsevier.
1. Journal of Petrology, Springer-Verlag

EASC-424 VERTEBRATE AND INVERTEBRATE PALEONTOLOGY
(Hard Core Course)

Credits: 2

Invertebrate Paleontology:

An overview. Morphology, classification, evolutionary trend, composition and structure of shells of selected groups of organisms - A brief study of morphology, geological history and geographical distribution of Brachiopoda, Pelecypoda, Cephalopoda, Gastropoda, Echinoidea, Trilobita, Coelenterata and Graptoloidea.

Vertebrate Palaeontology:

Introduction, Brief study of vertebrate life through ages. General evolution of reptiles and mammals. Indian pre-Tertiary vertebrate - their distribution and paleogeographic implication; extinction of dinosaurs. Indian Tertiary vertebrate - Siwalik mammals; phylogeny - Equidae & Proboscidae. Indian fossil Hominoides and modern theories regarding human evolution.

References books:

Benton, M.J., "Vertebrate Paleontology", Chapman & Hall 1997

Moore, R.C., Lalicker, C.G. and Fisher, A.G.: Invertebrate Fossils. McGraw Hill

Shrock,R.R and Twenhofel,W.H. 1987. Principles of Invertebrate Paleontology. McGraw Hill, New York.

Walton, J., "An Introduction to the Study of Fossil Plants", Adam & Charles Black 1953

Clarkson,E.N.1993.Invertebrate Paleontology and Evolution, Chapman Hall India,Madras

Woods, H., "Paleontology Invertebrate", CBS Publications 1963

EASC-425 ADVANCED GEOLOGY LAB II (Hard Core course)

Credits: 3

Part 1: Igneous & Metamorphic Petrology (2 credits)

Study of igneous rocks and metamorphic rocks of different facies mineral assemblage, texture and structure) in hand specimen and in thin sections. Calculations of CIPW norms of igneous rocks. Plotting chemical data in various diagrams and trace element modeling to infer petrogenetic conditions. Petrogenetic grid. Thermodynamic modelling. Identification of reaction and stages of metamorphism under an optical microscope. Petro-chronological plots and software

Part 2: Paleontology (1 credit)

Megascopic study of major invertebrate fossils:Gastropoda, Pelecypoda, Cephalopoda, Brachipoda, Echinoids, Corals, Trilobita, Plant fossils etc.
Methods of Separation of fossils from sediments/sedimentary rocks.
Study of some important microfossils under binocular microscope.

EASC-426 ADVANCED FIELD TRAINING –I (Hard Core Course)

Credits: 3

Geological field training in lithological and structural mapping in sedimentary, igneous and metamorphic terrains. Study of igneous, metamorphic and sedimentary rocks and fossil occurrences in the field. Total duration of the training will be about three weeks in the field.

EASC-427 ISOTOPE GEOLOGY (Soft Core Course)

Credits: **2**

Nuclear structure, atomic weights, nuclear stability and abundance. Discovery of radioactivity, stable and radiogenic isotopes. Decay Mechanisms.

Mass spectrometer: Instrumentation, chemical separation, isotope dilution and ratio analysis.

Principles of geochronology. Methods of dating: Isochron method, model ages.
Isotope systematics of K-Ar, Rb-Sr, Sm-Nd, U-Th-Pb in igneous, metamorphic and sedimentary rocks and in evolution of ocean, crust and mantle.
Fission track, 40Ar-39Ar, U and Th disequilibrium isotopes and their applications. Cosmogenic isotopes: 14C, Be and Al, etc. and their applications.

Fractionation of stable isotopes in lithosphere, hydrosphere and atmosphere. Stable isotopes of oxygen and hydrogen, carbon, nitrogen and sulphur. Stable isotope geothrermometry and geobarometry.

Isotopes in mineral exploration, paleo-climate studies, health and environmental aspects.

Text books:

Faure, G. (1986). Principles of Isotope Geology. John Wiley, 589p.
Doe, B.R. (1970) Lead isotopes. Springer Verlag, 137p.
Faure, G. and Powell, J.L. (1972) Strontium Isotope Geology. Springer Verlag, 188p.

EASC-428 RADIOGENIC ISOTOPE GEOLOGY (Soft Core Course)
Credits: 2

UNIT 1

Scope of radiogenic isotope geology. Discovery of radioactivity and historical development of the subject. Nuclear structure, atomic weights, nuclear stability and abundance.

UNIT 2

Theory and mechanism of decay, particles emitted, growth and retention of daughter isotopes in earth systems. Mass spectrometery and laboratory methods.

UNIT 3

Geochronology. Methods of dating. Radio Isotope systematic- K-Ar, ^{40}Ar-^{39}Ar, Rb-Sr, Sm-Nd, Lu-Hf, Re-Os, U-Th-Pb and others.

UNIT 4

Cosmogenic radio-nuclides. Short-lived and extinct radio-nuclides.

UNIT 5

Radioactive and radiogenic elements as major , minor and trace elements and their geochemical behaviour. Applications of radio-isotope systematic in geochemistry and petrogenesis of Igneous, Metamorphic and Seimentary Rocks and applications in surface-processes.

Text books:

Dickins, Radiogenic Isotope Geology
Allegre (2008), Isotope Geology
Faure, G. (1986). Principles of Isotope Geology. John Wiley, 589p.
Doe, B.R. (1970) Lead isotopes. Springer Verlag, 137p.
Faure, G. and Powell, J.L. (1972) Strontium Isotope Geology.Springer Verlag, 188p.

EASC-429 MARINE GEOLOGY (Soft Core Course)

Credits: 2

Origin of seas and oceans. Ocean morphology, oceanic crust and ocean margin; sea bottom topography - continental margin, shelf, slope, submarine canyon; ocean basin floor; abyssal hills, plains and gaps; mid-oceanic rise; mid-oceanic ridges-origin, crust and flank province.

Ocean circulation: turbidity current, submarine and sedimentation processes. Oceanic sediments and microfossils. marine stratigraphy, correlation and chronology. Tectonic history of oceans. Mineral resources of the oceans.

Historical development of oceanography. Methods of measuring the properties of sea. Deep sea record. Sea level processes and sea level changes. Major oceanographic events in the Cenozic.

Text books:

J.P.Kennet (1982) Marine geology. Printice Hall Inc., New Jersy, 813p.
E. Seibold & W.H.Berger (1982) The sea floor. Springer-Verlag, Berlin.
J.Weisberg & H. Parish (1974). Introductory Oceanograpghy. McGraw Hill.
B.W.Pipkin, D.S.Gorslin, R.E.Casey & D.E. Hammord (1972). Laboratory exercises in oceanography. W.H.Freeman & Co., San Francisco, 255p.

EASC-430 QUATERNARY GEOLOGY (Soft core course)

Credits: 2

Quaternary Geology - an overview. Quaternary environments.
Quaternary stratigraphy – Oxygen Isotope stratigraphy, biostratigraphy and magnetostratigraphy. Quaternary climates – glacial-interglacial cycles, eustatic changes, proxy indicators of paleoenvironmental/ paleoclimatic changes, – land, ocean and cryosphere (ice core studies). Atmospheric composition, ocean circulation and biological processes during Quaternary.
Genesis of quaternary deposits, fauna and flora, paleogeography and economic importance of Quaternary resources.

Responses of geomorphic systems to climate, sea level and tectonics on variable time scales in the Quaternary, Quaternary dating methods – radiocarbon, Uranium series, Luminescence, Amino – acid.

Quaternary fluvial, eolian and glacial systems. Paleoenvironments of Quaternary period in India. Evolution of Quaternary land forms in India. Study of lake deposits and laterites of India.

Quaternary stratigraphy of India – continental records (fluvial, glacial, aeolian, palaeosols and duricrust); marine records; continental – marine correlation of Quaternary record.

Evolution of man and Stone Age cultures. Plant and animal life in relation to glacial and interglacial cycles during Quaternary.

Tectonic geomorphology, neotectonics, active tectonics and their applications to natural hazard assessment.

Text books:

Holmes, A. : Principles of Physical Geology, ELBS, U.K.
Bird, E.C.F: Coastline changes. John Wiley & Sons, New York.
Stowe, K. : Exploring Ocean Science: John Wiley, New York.
Bloom, A.L.: Geomorphology - A Systematic Analysis of Late Cenozoic Landforms. Prentice-Hall, New Delhi.
Wadia et al : Quaternary environments and geoarchaeology of India. Geol. Soc. India, Bangalore.
Thornbury, W.D. :Principles of Geomorphology, Wiley Eastern, New Delhi.
Vaidyanathan, R. (ed) : Quaternary Deltas of India: Geol. Soc. India, Bangalore.
Davis R.A. (ed) Coastal sedimentary environments. Springer Verlag, New York.
Ahmad, E. : Coastal Geomorphology of India. Orient Longman, New Delhi.
Leeder, M.R. : Sedimentary process and product: George Allen & Unwin, London.

EASC-511 GEOLOGY OF MINERAL DEPOSITS (Hard Core Course)

Credits: 4

Mineral deposits, morphology of ore bodies. Lithological and geochemical characteristics of mineral deposits. Spatial and temporal distribution of mineral deposits. Metallogenetic epochs and provinces. Role of plate tectonics in ore formation.

Ore forming processes. Source of ore constituents and ore fluids. Magmatic, metamorphic, hydrothermal, sedimentary and related processes. Deposits types and classification of mineral deposits.

Understanding ore genesis. Structure and texture of ores, ore mineral paragenesis. Fluid inclusion studies of ore mineral assemblages. Stable isotope geochemistry of ore mineral assemblages.

Geology of mineral deposits associated with (i) Ultramafic-mafic-intermediate-acidic igneous rocks, (ii) Low grade and high grade metamorphic rocks, (iii) Sedimentary and volcano-sedimentary sequences, (iv) Weathering surfaces, (v) Placers.

Geological characteristics and genesis of important metallic and non-metallic deposits in India, occurring in Aravalli, Dharwar, Singhbhum, Bastar cratons; southern granulite terrain, eastern ghats granulite terrain; Proterozoic and Phanerozoic sedimentary basins; and in Himalaya.

Text books:

Barnes, H.L. (Ed.). 1997. Geochemistry of hydrothermal ore deposits. John Wiley & Sons.
Craig, J.R. & Vaughan, 1994. Ore microscopy and ore petrography. John Wiley & Sons.
Evans, A.M. 1992. Ore geology and industrial minerals. 3rd edition. Blackwell Science.
Jensen, M.L. & Bateman, A.M. 1981. Economic mineral deposits. John Wiley & Sons.
Misra, K.C. 1999. Understanding mineral deposits. Kluwer Academic Publishers.
Mookherjee, A. 1998. Ore genesis – a holistic approach. Allied Publishers.
Sarkar, S.C. and Gupta, A. 2011. Crustal evolution and metallogeny in India. Cambrisdge University Press, Delhi.
Stanton, R.L. 1981. Ore Petrology. McGraw Hill.

EASC-512 SEDIMENTOLOGY (Hard Core Course)

Credits: 2

Sedimentary processes: weathering, sediment transport by fluids. Simple fluid flow concept.

Textures of clastic and non-clastic rocks. Sedimentary structures: classification, genesis and significance. Use of structures and textures in basin studies.

Sedimentary environment: physical and chemical properties of depositional environment and its classification. Lithologies, structures and vertical sequences formed in fluvial, deltaic, coastal, deep sea, glacial, aeolian and carbonate depositional environments.

Provinance: light minerals, heavy minerals and insoluble residue in provinance studies and correlation of sedimentary rocks.

Diagenesis: compaction, cementation, chemical alteration and recrystalisation.Sedimentation and Tectonics: tectonic control of sedimentation. Geosynclines and their lithological associations. Plate tectonics in relation to type and evolution of basins.

Clay Minerals: classification, techniques of identification, diagenesis and use in environmental inerpretation.

Introduction to sequence stratigraphy, Sea level changes; parasequence, sequence and system tracts

Text books:

F.J. Pettijohn (1975) Sedimentary rocks. Harper and Row Publ., New Delhi.
Blatt, Middleton & Murray (1980) Origin of sedimentary rocks. Printice Hall Inc.
J.D. Collins and D.B. Thompson (1982) Sedimentary Structures. George Allen & Unwin, London.
M.E. Tucker (1981) Sedimentary Petrology: an introduction. John Willey & Sons, New York.

EASC-513 SOLID EARTH GEOPHYSICS (Hard Core Course)

Credits: 2

Introduction

Introduction to Geophysics, Various Geophysical methods-dependant physical properties, applications, Planning of Geophysical Survey.

Seismology

Earthquakes. Observational seismology, Seismic waves. Seismological instruments and observatories. Travel time curves. Crust, mantle and Core. Phase transition inside the Earth. Internal distribution of density and other physical parameters. magnitude and intensity scales, Energy of earthquakes. World-wide distribution of earthquakes. Earthquake prediction.

Gravity Method

Gravitational field of the Earth; Spheroid and Geoid; Densities of rocks; Gravity units; Measurement of Gravity, Corrections to gravity Observations ; Anomalies of Gravity field- Free air , Bouguer and Isostatic anomaly; Models of Isostasy, Isostatic compensation and vertical crustal movements.

Magnetic Method

Principles of magnetic method, The Earth's magnetic Field; Geomagnetic elements; Magnetic properties of rocks- Induced and remnant, Magnetic surveying, Data reduction procedure- diurnal correction, IGRF; Paleomagnetism and Geomagnetic polarity transitions.

Geothermics

Thermal history of the earth. Temperature inside the earth. Heat transfer-conduction, convection, radiation; Thermal structures of the continental and oceanic lithosphere. Heat flow measurements. Regions of anomalous heat flow. Hot spots. Relationship of heat flow to radioactivity of the Earth.

Reference books:

1. Fowler, C.M.R. (1990) The solid earth: An introduction to Global Geophysics.
2. William Lowrie (1997). Fundamentals of Geophysics
3. John. M. Reynolds (1997). An Introduction to Applied and Environmental Geophysics
4. Alan E. Mussett and M. Aftab Khan (2000). Looking into the Earth
5. Robert J. Lillie (1999). Whole earth Geophysics
6. Philip Kearey, Michael Brooks, Ian Hill (2003). An introduction to Geophyical exploration
7. Bullen and Bolt. Introduction to the theory of Seismology.
8. Bath, M. Introduction to Seismology.
9. McElhiry. Paleomagnetism and Plate Tectonics.
10. Verma, R.K. Gravity field, Siesmicity and Tectonics of Indian Peninsula and the Himalayas.

EASC-514 MICROPALEONTOLOGY (Hard core course)

Credits: 2

Definition and Scope : Fossils and their preservation. Principles of taxonomic classification and nomenclature. Organic evolution and fossil record. Principles of paleoecology, biostratigraphy and paleogeography.

Micropaleontology : Sampling methods and sample processing techniques. Types of microfossils. Calcareous Microfossils - Foraminifera - major morphologic groups; Benthic Foraminifera; depth biotopes, value in paleobathymetric determination. Larger foraminifera - their utility in Indian stratigraphy. Planktonic foraminifera and calcareous nannofossils. Ostracoda - outline morphology, paleoecology & geological history. Brief knowledge about pteropods, calpionellids and calcareous algae.

Siliceous Microfossils : Radiolaria-outline morphology, classification. Brief knowledge of marine diatoms and silicoflagellates.

Phosphatic Microfossils : Conodont - outline morphology, paleoecology and geologic significance.

Organic Walled Microfossils : Brief account of dinoflagellates and acritarchs.

Palynology : General morphology of spores and pollen, their geological significance.

Applications : Micropaleontology in petroleum exploration. Environmental significance of microfossils - correlation of paleofacies, and paleobathymetry estimation of paleontemperature. The role of micropaleontology in marine geology and oceanography.

Text books:

1. B.U. Hag and A. Boersma (1978). Introduction to marine micropaleontology. Elsevier, Netherlands, 376p.
2. J.P. Kennet & M.S. Srinivasan (1983). Neogene-Planktonic Foraminifera. Hutchison Ross Publ. Co., U.S.A., 263p.
3. M.D. Brasier (1980). Microfossils. George Allen & Unwin, London, 193p.
4. G. Bignot (1985). Elements of Micropaleontology. Graham & Trotman, London, 212p.
5. E.N.K. Clarkson (1986). Invertebrate paleontology and evolution. George Allen & Unwin.
6. R.C. Moore, Lalicker & Fisher (1952). Invertebrate fossil. McGraw Hill Book Co., San Francisco.

EASC-515 ADVANCED REMOTE SENSING & GIS (Hard Core Course)

Credits: 3

Unit1: Basic concepts of remote sensing, Concept of Spectral signatures; spectral signatures of minerals and rocks; Satellite remote sensing – orbits, scanners (Along track/Across track scanners), earth observation and meteorological satellites, sensor characteristics – resolutions (spatial, spectral, radiometric and temporal); types of satellite data – panchromatic; multispectral, and hyperspectral data.

Unit2: Digital Image Processing: digital data format; Image rectification and restoration techniques–radiometric and geometric corrections; Image Enhancement techniques – image histogram, contrast manipulation, spatial filtering, and edge enhancement; Multi-image analysis – band Ratio; vegetation indices; Principal Component Analysis; Image Classification – supervised & unsupervised classification.

Unit3: GIS: Definition, Elements of GIS, representation of geographic data, spatial data models - vector and raster data structure, Attribute data, geodatabase; coordinate systems, Scale, resolution, map projection; spatial data input and editing - data input devices, digitization, external databases; storage and manipulation of GIS databases, Data quality; spatial data transformations; Spatial Analysis and query – proximity analysis (buffer), network analysis, overlay analysis (raster and vector overlay); applications with case studies; DEM analysis – slope and aspect; Map preparation in GIS; current trends in GIS.

Unit 4: Geological Application of Remote sensed data & GIS – geological, geomorphological, and land use/landcover mapping; natural resources management; natural hazards, and environmental studies.

Textbooks:

6. Benhardsen, T. (2002) Geographic Information Systems: an Introduction, John Wiley & Sons, New York
7. Campbell, J., (2002), Introduction to Remote Sensing, Taylor & Francis, London.
8. Chang, K T., (2006), Introduction to Geographic Information Systems, Tata McGraw- Hill
9. Jensen, J.R. (2017) Introductory Digital Image Processing: a Remote Sensing Perspective, 4th edition, Prentice Hall, New Jersey.
10. Joseph,G., (2005) Fundamentals of Remote Sensing, University Press.
11. Lillesand,T., Kiefer, R.W., and Chipman, J (2015) Remote Sensing and Image Interpretation, 7th Edition, John Wiley & Sons, New Delhi
12. Sabins, Floyd F. Jr., (1997), Remote Sensing: Principles and Interpretation, W.H.Freeman, New York.

Reference Books:

- Burrough, P.A. & McDonnell, R.A., (1998), Principles of Geographic Information systems, Oxford University Press, Oxford.
- Environmental Systems Research Institute (ESRI), (1997), Getting to know Arc View GIS, Cambridge: Geoinformation International
- Gupta, R.P. (1991) Remote Sensing Geology. Springer-Verlag.
- Longley, P.A., Goodchild, M.F., Maguire, D.J. & Rhind, D.W., (2001), Geographic
- Information Systems and Science, Wiley, Chichester

EASC-516 ADVANCED GEOLOGY LAB-III (Hard Core course)

Credits: 4

Part 1: Ore Microscopy (1 Credit)

Identification of economic minerals in hand specimen. Study of optical properties of opaque minerals in reflected light and their identification in polished section. Study of ore textures and interpretation of paragenesis.

Part 2: Sedimentology (1 Credit)

Study of clastic and non-clastic rocks in hand specimen. Microscopic examination of important rock types. Separation of heavy minerals and study of their microscopic charcteristics. Grain size analysis by sieving, plotting of size distribution data. Determination of roundness and sphericity of grains.

Part 3: Micropaleontology (1 credit)

Techniques of separation of microfossils. Study of important benthic and planktonic foraminifera useful in bottom and surface water oceanography. Study of larger foraminifera important to the Indian stratigraphy.

Part 3: Remote Sensing & GIS (1 Credit)

Visual interpretation of remotely sensed datasets for lithology, structures, and geomorphology

Digital Image Processing of satellite data – Importing satellite data; Preprocessing the digital data (geometric and radiometric correction); Image enhancement and transformations, identification of different earth objects based on their spectral signatures;Image Classification (land use/Landcover analysis).

GIS – Georeferencing of toposheet/satellite imagery; creation of Vector data (Point, line Polygon), adding an attribute, spatial analysis, Map generaion.

EASC-517 TERM PAPER (Soft core course)

Credits: 2

Individual literature survey and preparation of a term paper on a specialized topic in earth sciences, under the supervision of a faculty member of the Department, followed by a seminar presentation.

EASC-518 PROFESSIONAL TRAINING (Soft Core Course)

Credits:3

Intensive field and/or laboratory training on any applied aspect of geology including exploration and mining practices, petroleum well logging and related well site operations, geotechnical and geo-environmental investigations etc. Training will be conducted through professional organisations engaged in above activities. Total duration of the training will be about three weeks.

EASC-519 COAL AND PETROLEUM GEOLOGY (Soft Core Course)

Credits: 2

Unit-1

Introduction: Origin of life, evolution of marine and terrestrial life. Nature of petroleum: chemical composition and physical properties of organic matters and hydrocarbon. Origin of petroleum: organic and inorganic theories. Productivity and preservation of organic matter. Long-term fate of organic matter.

Unit-2

Transformation of organic matter into Kerogen. Classification of kerogen, maturation and thermal cracking. Diagenesis, ketagenesis and metagenesis stage of maturation. Formation of petroleum in relation to geological processes: temperature, time, and pressure. Timing of oil and gas generation.

Unit-3

Migration of oil and gas: evidence of migration, primary and secondary migration. reservoirs – porosity, permeability and capillary pressure, porosity types in clastic and carbonate reservoirs, reservoir heterogeneity, drive mechanisms. Trapping mechanism for oil and gas, characteristic of structural, stratigraphic and combination traps.

Unit-4

Petroleum exploration- surface indication of oil and gas, sequence of exploratory steps. Formation evaluation: well-logging, types of well logs, interpretation of lithology, quality and quantity of formation fluids from well logs. Geology of productive oil and gas fields of India.

Unit-5

Origin of coal. Geo-environment of peat forming mires. Evolution of flora. Rank and coal series. Classification of coal: Indian and International. Physical and petrographic characters: concept of lithotypes, microlithotypes, and macerals. Chemical characterization: proximate and ultimate analyses.

Unit-6

Sedimentology of coal bearing strata. Coal forming epochs in geological past, relation to paleogeography of Pangea. Coal deposits of India and their distribution. Application of coal petrology in solving geological problems and in hydrocarbon exploration. Methods of Coal prospecting and estimation of its reserves. Coal bed Methane: generation and exploration of coal as reservoir of methane.

Texts/References

Holson, G.D. and Tiratsoo, E.N., 1985: Introduction to Petroleum Geology-Gulf Publ. Houston, Texas

1. Tissot, B.P. and Welte, D.H., 1984: Petroleum Formation and Occurrence-Springer Verlag

2. Leverson, A.L. 1970. Geology of Petroleum. Freeman and co.,

3. Selley, R. C. 1998. Elements of Petroleum Geology, II Edition. Academic Press,

4. North, F.K. Petroleum Geology, Allen & Unwin, London, 1985.

5. Hunt, J.M. Petroleum Geochemistry and Geology, 2nd Edition, W.H. Freeman, San Fransisco, 1996.

6. Sahay, B., Rai, A. and Ghosh, M. Wellsite Geological Techniques for Petroleum Exploration, Oxford & IBH, New Delhi, 1984.

7. Stach, E., Mackowsky, M.T.H., Taylor, G.H., Chandra, D., Teichmuller, M. and Teichmuller, R., 1982: 7.Stach's Text Book of Coal Petrology- Gebruder Borntraeger, Stuttgart

8. Thomas, L ., 2002. Coal Geology. John Willey & Sons Ltd., England

9. Chandra, D., Singh, R.M. and Singh, M.P., 2000: Textbook of Coal (Indian Context)-Tara Book Agency, Varanasi.

10. Singh, M.P., (Ed.), 1998: Coal and Organic Petrology-Hindustan Publ. Corp., New Delhi

11. K illops, V.J. and Killops, S.D., 2013. Introduction to organic geochemistry. John Wiley & Sons.

EASC-520 MINERAL ECONOMICS (Soft Core Course)

Credits: 2

Concept of mineral economics and its importance in national development. International mineral trade; peculiarities inherent in mineral industry. Mineral supply as a stock: assessment of world mineral supplies, reserves and resources, technology and price.

Mineral legislation; national mineral policy; mineral taxation, preservation of environment, mineral conservation. The mines and minerals (regulation and development) act. Structure and organization of mineral industry; valuation of mineral property.

Future mineral consumption and world economy; energy demand and supply in future; marine mineral resources; developments in mineral exploration and exploitation.

Text books:

Chatterjee, K.C. 2012. An introduction to mineral economics. New Age International Publishers, New Delhi.
Govett, G.J.S. & Govett, M.H. 1976. World mineral supplies. Elsevier, Amsterdam.
Sinha, R.K. & Sharma, N.L. Mineral economics. Oxford & IBH.

EASC-521 GEOEXPLORATION (Hard Core Course)

Credits: 4

Part 1: Geological and Geochemical Exploration

Unit -1
Introduction to past and present exploration practices. Prospecting criteria of various mineral deposits. Ore guides, regional and local parameters for exploration. Different stages and practices of geological prospecting, regional and detailed exploration.

Unit-2
Principles and methods of geochemical prospecting, pathfinders and indicator elements in rocks and soils. Mobility of elements. Primary and secondary dispersion patterns, geochemical anomalies and their interpretation.

Unit-3
Ore deposit evaluation techniques. Concept of cut-off grade and cu-off thickness. Objectives of drilling, types of drilling for exploration and their advantages. Selection of sites, angle and direction of bore holes, logging, borehole drift and deviation. Ore reserve estimation. Mineral resources and their classification.

Part 2: Geophysical Exploration

Unit-4
Introduction to geophysical methods of exploration and their applications. physical properties of rocks and minerals, types and scales of survey. Principles of gravity and magnetic methods, Working principle of gravimeters and magnetometers, gravity and magnetic surveys, data reduction, anomalies, geological interpretation and modeling for simple geometrical shapes.

Unit-5
Electrical properties of rocks. Fundamentals of resistivity and electromagnetic methods of prospecting, origin of self potential and induced polarization, surveys, instruments, application.

Unit-6
Theory and geometry of seismic wave propagation, Reflection and refraction methods, Data Acquisition, CMP gather, Data processing- velocity analysis, Moveout corrections, stacking and migration. Interpretation of Seismic reflection profiles. Introduction to well logging, formation evaluation, logging methods- Resistivity, induction, SP, radiometric, sonic, temperature.

Text/Reference books:

Peters, W.C. 1987. Exploration and mining geology. John Wiley & Sons, New York.
Annels, A.E. 1991 Mineral Deposit Evaluation. A practical approach. Chapman and Hall, London
Banerjee, P.K and Ghosh, S . 1997. Element of prospecting for non-fuel mineral deposits. Allied Publisher Ltd, New Delhi

Rose, A.W., Hawkes, H.E. & Webb, J.S. 1979. Geochemistry in mineral exploration. Academic
Press, London.
Moon, C.J., Whateley, M.K.G. and Evans, A.M. 2006. Introduction to mineral exploration, 2nd edition. Blackwell Publishing Ltd. Oxford.
Robert J. Lillie, Whole Earth Geophysics, 1999. An introductory textbook for geologists and Geophysicists, Prentice Hall,
Alan E. Mussett and M. Aftab Khan, 2000. Looking into the earth, An introduction to geological geophysics, Cambridge Univ. Press.
Telford, W.M. Geldart, L.P. and Sheriff, R.E.,1990. Applied Geophysics,Cambridge University Press.
Robinson, E.S. and Coruh, C. 1988. Basic Exploration Geophysics, John Wiley & Sons,
Reynolds, J M.1997 An introduction to applied and environmental Geophysics, John Wiley & Sons Ltd .

Text books:

Indian Bureau of Mines, 1979. Mineral exploration. IBM, Nagpur.
Peters, W.C. 1978. Exploration and mining geology. John Wiley & Sons, New York.
Rose, A.W., Hawkes, H.E. & Webb, J.S. 1979. Geochemistry in mineral exploration. Academic Press, London.
Levinson, A.A. 1974. Introduction to exploration geochemistry. Applied Publication Co., Calgary.
Dorbin, M.B. Introduction to geophysical prospecting.
Parasnis, D.S. Principles of applied geophysics.
Ramachandra Rao. Geophysical prospecting for geologists.

EASC-522 ADVANCED GEOHYDROLOGY (Hard Core Course)

Credits: 2

Hydrologic Cycle, Water Balance, Atmospheric Circulation, Hydrologic Elements, Peak Runoff Computation, Geological Influences on Groundwater Occurrence and Movement, Principles and Regional Equations of Groundwater Flow, Groundwater in regions of Climatic Extremes, Hydrological Divisions of India

Methods of Aquifer Delineation and Well Location, Pumping Test and Data Interpretation, Methods of Well Drilling, Development and Design, Sea Water Intrusion in Coastal Aquifers

Stable Isotopes, Radioactive Isotopes used in dating, contamination, and recharge studies

Water quality, standards, presentation of results of chemical analysis, carbonate equilibrium, thermodynamic relationship, groundwater contamination and restoration

Groundwater models, finite difference and element, steady and transient state, basics of VMODFLOW

Groundwater Development and management, water budget, water law, artificial recharge, Indian groundwater scenario, Remote Sensing and GIS applications for groundwater exploration

Text books:

Fetter, C.W. 2001. Applied Hydrogeology (4th edition). Prentice Hall
Todd, D.K. 1988. Groundwater Hydrology. John Willey & Sons
Davis, S.N. & De Wiest, R.J.N. 1966. Hydrogeology. John Wiley & Sons, New York
Raghunath, H.M. 1983. Groundwater. Wiley Eastern, Calcutta.
Clark, I. & Fritz. 1997. Environmental Isotopes in Hydrogeology. Lewis Publishers, Boca Raton.
Herman Bower, 1978. Groundwater Hydrology. Mc Graw Hill Book Co.
Pathak, B.D. 1988. Hydrogeology of India, Central Board for Irrigation and Power, Mecha Marg, Chanakyapuri, New Delhi.

EASC-523 ADVANCED GEOLOGY LAB IV (Hard Core Course)

Credits: 3

Part 1: Geological & Geochemical Exploration (1 credit)

Map exercises on use of geological and geochemical prospecting criteria. Selection of suitable sampling method. Recognition of anomalies. Preparation of level plans and sections. Various methods of ore reserve estimation.

Part 2: Geophysical Exploration (1 credit)

Geophysical Surveying, corrections to gravity and magnetic data, gravity and magnetic anomalies, qualitative and quantitative interpretation of geophysical anomalies, computations based on seismic reflection and refraction & interpretation.

Part 3: Geohydrology (1 credit)

Water balance calculation, groundwater budgeting, groundwater flow nets, Artificial recharge methods and analysis, Electrical resistivity for groundwater investigations – 1D, 2 D methods and interpretation, geo-logging - neutron, SP and resistivity log analysis and interpretation, Hydrochemical analysis of water samples, charge balance, ion exchange calculations, rock water interaction analysis, piper, Collins bar graph, USSL salinity plot and calculation of water suitability for agricultural, industrial and domestic utilities, thermodynamics and saturation index calculations, calculation of rainfall and runoff analysis.

EASC-524 ADVANCED FIELD TRAINING-II (Hard Core Course)

Credits: 3

Study of various geological features of mineral deposits in prospects and working mines. Methods of mining. Underground mine mapping, quality control operations. Geological operations at exploration sites. Field work related to petroleum exploration, engineering and environmental geological studies. Total duration of the training will be about three weeks in the field.

EASC–525 PROJECT (Soft Core Course)

Credits: 4

Individual project work on applied aspects of current interest in geosciences. One faculty member of the Department will be assigned as the Supervisor. In case of inter-disciplinary project, one more faculty member from related discipline can be co-opted as the second Supervisor.

EASC-526 GLOBAL TECTONICS (Soft Core Course)

Credits: 2

Introduction

Earth and its early history. Differentiation of earth into crust, mantle and core, Internal structure of the Earth.

Plate Tectonics

Development of theory of plate tectonics. Mechanism of plate-tectonics: Mantle convection, and the forces acting on plates.

Plate boundary processes

Constructive Plate Boundary: Physiography, structure, magmatism and metamorphism along mid-oceanic ridges. Sea-floor spreading. Continental rifting. Sedimentary basins. Conservative Plate Boundaries: Physiography, structure and types of transform faults. Their relation to slipping rates. Consuming Plate Boundaries: Geometry and structure of Benioff zones. Sedimentation, magmatism and metamorphism in subduction zones. Developments of Island arcs.

Origin and evolution of land

Origin and evolution of continental crust. Proterozoic orogenic belts. Pacific and Andean-type margins. Collision tectonics. Obduction and ophiolite emplacement. Supercontinent cycles. Initiation of plate tectonics on the Earth.

Indian plate vis-a-vis global tectonics

Configuration of Indian plate. Cratons and surrounding tectonic zones. Evolution of the Himalaya and Himalayan tectonics. Andaman subduction zone. Plume related magmatism in Indian plate.

Text Books

Kearey, P. and Vine, F.J. (1996) Global Tectonics. Blackwell Science.
Windley, B.F. (1995) The evolving continents. John Wiley & Sons, 526 pp.
Rogers, J.J.W. A history of the Earth. Cambridge University Press.
Fowler, C.M.R. (1990) The solid Earth: an introduction to Global Geophysics. Cambridge University Press.
Brown, G.C. and Mussett, A.E. The Inaccessible Earth: an integrated view of its structure and composition. Chapman and Hall.
Brown, G., Hawkesworth, C. and Wilson, C. (1992) Understanding the earth. Cambridge Univesity Press.
Condie, K.C. (1976) Plate Tectonics and Continental Evolution. Pergamom Press Inc.
Le Pichon, and J.Francheteau. Plate tectonics.

EASC-527 MINING GEOLOGY (Soft Core course)

Credits: 2

Orebody reevaluation. Appraisal of exploration data for exploratory mining. Exploratory development works for mineral deposits by open-cast and underground mining methods. Mine design, metallurgical design and planning.

Environmental baseline data needed for mine planning, its acquisation and documentation during different stages of mineral exploration. Nature and extent of environmental problems due to surface and underground mining.

Mine waste management.

Role of the geologist at operative mines. Grade control in open-pit and underground operations. Blending and stock-piling of ores.

Economic appraisal of mines.

Text books:

H.E.McKinstry (1980) Mining Geology. Printice Hall, New York.
R.N.P.Arogyswamy (1994) Courses in mining geology. Oxford-IBH, New Delhi.
Indian Bureau of Mines (1979) Mineral exploration. IBM, Nagpur.
A.E. Annels (1992) Mineral deposit evaluation. Chapman and Hall, London.
R.T.Deshmukh (1993) Elements of mining technology. Dhanbad Publishers, Dhanbad.
W.C.Peters (1987) Exploration and mining geology. John Wiley & Sons, New York.

EASC –528 PALEOCLIMATOLOGY (Soft Core course)

Credits 3

Unit I: Factors affecting climate and climate variations: variations in solar insolation, changes in ocean circulation, plate tectonics and volcanic activity, the evolution of vascular plants, and fossil fuel burning. Ocean and atmospheric circulation.

Unit II: Interactions between the atmosphere, ocean, and land components of the earth's climate system.

Unit III: Introduction to climate proxies, timescales involved in climate reconstruction
and interpretations of climate proxies. Methods used for dating climate proxies: isotopic and non-isotopic; and methodology of paleoclimatic reconstructions.

Unit IV: Marine and terrestrial proxies.

Unit V: Salient features of Precambrian, Phanerozoic climate. Anthropocene.

Text books:

Bradley R.S. 1999. Paleoclimatology, reconstructing the climate of the quaternary. Academic Press, Amsterdam.
Ruddiman W.F. 2007. Earth's Climate: Past and Future (2nd edition). W.H Freeman and Co., New York.

Reference books:

Hartmann D. L. 1994. Global Physical Climatology, Volume 56 (International Geophysics), Academic Press, p. 411.
Crowley T. J. and North G. R. 1999. Paleoclimatology. Oxford University Press, p. 360.
Wallace J. M. and Hobbs P. V. 2006. Atmospheric Science: An Introductory Survey, Second Edition, Academic Press, p. 483.

EASC-529 PLANETARY GEOLOGY (Soft Core Course)

Credits: 2

UNIT 1

Scientific methods, units of measurements and mathematical fundamentals used in planetary science and astronomy. Historical development of planetary explorations and planetary geology

UNIT 2

Stellar evolution. Nucleosynthesis. Observations and facts of solar system. Solar nebula and origin of Solar Sytem. Planets and other objects of Solar system

UNIT 4

Physical and Chemical properties of Inner planets. Physical properties, atmosphere and celestial mechanics of Outer planets. Natural satellites of planets.

UNIT 5

Comets, Asteroids and Meteorites. Impact craters. Evolution of Earth as a planet. Earth-moon system. Lunar geology.

UNIT 6.

Extra solar systems. Exploration and evolution of life. Missions to other planets. Indian space missions.

Text books:

1. Introduction to Planetary Sciences, The geological perspective. Authors: Gunter Faure and Teresa, M. Mensing. Published by Springer, The Netherlands. 2007.

2. Planetary Geology: An Introduction. Author- Claudio Vita-Finzi. Publisher: Terra Publishing, 2005.

3. Introduction to Planetary Geology. Author- Billy P. Glass, Publisher Cambridge University Press.

4. The New Solar System Edited by J. Kelly Beatty and C. C. Petersen. Published by Cambridge University Press.

EASC-530 WELL LOGGING (Soft Core course)

Credits: 2

Basic Concepts: Fundamentals of drilling, drilling mud, flushed zone, invaded zone and uncontaminated zone. Physical properties of reservoir rocks, porosity, formation factor, water saturation and hydrocarbon saturation.

Electrical Logging: SP log, cause of SP in bore hole, principles of measurement, factors affecting SP log and interpretation of SP log. Resistivity log, principles and interpretation of various resistivity logs and their specific uses. Induction log, theory, procedure and interpretation of shallow, medium and deep induction tools.

Radiation Logging: Nature and properties of Gamma rays. Gamma log, detection system, principle of measurement and interpretation. Gamma-Gamma log, physical principle, photo electric effect, Compton scattering and pair production, estimation of density and porosity of formations. Neutron log, Gamma-Neutron log and Neutron activation log, basic principles, the instruments and interpretation.

Temperature, Magnetic, Gravity and Sonic Logging: basic principles, logging devices and interpretation.

Applications: Various approaches for porosity estimations. Correlation of sub-surface structures and comprehensive interpretation from available logging data. Application of well logging for mineral and groundwater exploration. A few case histories.

Text books:

S.J.Pirson: Hand book of well log analysis.
E.J.Lynch: Formation evaluation. Harper & Row.
M.R.J.Wyllie: The fundamentals of well log interpretation.
Y.I.Gorbachev: Well logging. John Wiley & Sons.

EASC-531 INDIAN MINERAL DEPOSITS (Soft Core course)

Credits: 2

Overview of various types of mineral deposits and their distribution in the Indian shield and Himalaya. Geological characteristics, age and genesis of important industrial mineral and ore deposits in India; magmatic deposits – chromite, PGE, Ti-magnetite, diamond, REE, muscovite, Sn and rare metals; various types of hydrothermal deposits - porphyry Cu, greisen Sn-W, skarn wollastonite, SEDEX Zn-Pb and barite, carbonate-hosted Zn-Pb, unconformity related U, orogenic Au, other hydrothermal Cu and U deposits; sedimentary and other sediment hosted deposits – placer deposits, BIF and associated Mn, phosphorite, sandstone-type U, dolostone-hosted U; ore deposits formed by residual concentration and supergene enrichment – lateritic Al, Ni, BIF-hosted iron ore; metamorphic deposits – gondite-, kodurite-type Mn, graphite.

Text books:

Deb, S. 1980. Industrial minerals and rocks of India. Allied Publishers, New Delhi.

Krishnaswamy, S. and Sinha, R.K. 1988. India's mineral resources. Oxford & IBH, New Delhi.

Mookherjee, A. 1998. Ore genesis – a holistic approach. Allied Publishers, New Delhi.

Sarkar, S.C. and Gupta, A. 2012. Crustal evolution and metallogeny in India. Cambridge University Press, Delhi.