NEP Course Structure and Syllabi of UG (Honours) Program in Applied Geology

November 2023

Department of Earth Sciences
School of Physical, Chemical and Applied Sciences
Pondicherry University
Pondicherry – 605 014

Admission

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

Pass in +2 with 50% of marks and should have studied Physics, Chemistry, and Mathematics.

Department of Earth Sciences Curriculum and Credit Framework for Undergraduate Program under NEP							
Semester	**Major Discipline** (4 Credits)	**Minor Discipline** (4 Credits)	**Multi-disciplinary Courses (MD)** (3 Credits)	**Ability Enhancement Courses (AEC)** (3 Credits)	**Skill Enhancement Courses (SEC)** (3 Credits)	**Value-Added Courses (VAC)** (2 Credits)	**Total Credits**
I	**ESGL 1101** Understanding Earth (4 Cr)	Physics/ Chemistry (4 Cr)	1. **ESGL 1102 (MD)** Earth & Environment 2. Natural/Physical Sciences 3. Maths/Statistics/Computer Applications 4. Library Information and Media. Sciences 5. Commerce & Management 6. Humanities & Social Sciences (3 Cr)	**English 1** (3 Cr)	**ESGL 1103** Introduction to Field Practices in Earth Sciences (3 Cr)	**VAC 1** Understanding India (2 Cr) **VAC 2** Environmental Science (2 Cr)	**21 Cr**
II	**ESGL 1201-T** Geomorphology & Remote Sensing (2 Cr) **ESGL 1201-L** Remote Sensing Lab (2 Cr)	Maths/ Physics/ Chemistry (4 Cr)	1. Natural/Physical Sciences 2. Maths/Statistics/Computer Applications 3. Library Information and Media Sciences 4. Commerce & Management 5. Humanities & Social Sciences (3 Cr)	**MIL 1** (3 Cr) (Multi-Indian Languages)	**ESGL 1202** Sampling Techniques in Earth Sciences (3 Cr)	**VAC 3** Health & wellness/ Yoga/ Sports/ Fitness (2 Cr) **VAC 4** Digital Technologies, AI, Big data Analysis, & related areas (2 Cr)	**21 Cr**
Students Exiting the program will be awarded a UG certificate in the Subject (After securing 40 credits with 4 credits of Internship/ Apprenticeship and 6 credits from skill-based courses.							**42 Cr**

III	**ESGL 2101-T** Crystallography & Mineralogy Theory (2 Cr) **ESGL 2101-L** Crystallography & Mineralogy Lab (2 Cr) **ESGL 2102-T** Palaeontology Theory (2 Cr) **ESGL 2102-L** Palaeontology Lab (2 Cr)	Physics /Chemistry/ Maths (4 Cr) **ESGL 2103** Oceanography & Climatology (4 Cr)	1. Natural/Physical Sciences 2. Maths/Statistics/Computer Applications 3. Library Information and Media Sciences 4. Commerce & Management 5. Humanities & Social Sciences (3 Cr)	**English 2** (3 Cr)	**ESGL 2104** Sample Preparation Techniques in Geology - I (3 Cr)		**21 Cr**
IV	**ESGL 2201-T** Igneous & Metamorphic Petrology Theory (2 Cr) **ESGL 2201-L** Igneous & Metamorphic Petrology Lab (2 Cr) **ESGL 2202-T** Sedimentology & Structural Geology Theory (2 Cr) **ESGL 2202-L** Sedimentology & Structural Geology Lab (2 Cr) **ESGL 2203** Stratigraphy & Indian Geology (4 Cr)	Physics/ Chemistry (4 Cr) **ESGL 2204** Marine Geology (4 Cr)		**MIL 2** (3 Cr) (Multi-Indian Languages)	**ESGL 2205** Sample Preparation Techniques in Geology - II (3 Cr)	-	**22 Cr**
Students Exiting the program will be awarded a UG Diploma in the Subject (After securing 80 credits with 4 credits of internship/ Apprenticeship)							**85 Cr**

V	**ESGL 3101-T** Solid Earth & Exploration Geophysics Theory (2 Cr) **ESGL 3101-L** Solid Earth & Exploration Geophysics Lab (2 Cr) **ESGL 3102-T** Advanced Remote Sensing & GIS Theory (2 Cr) **ESGL 3102-L** Advanced Remote Sensing & GIS Lab (2 Cr) **ESGL 3103-T** Geohydrology Theory (2 Cr) **ESGL 3103-L** Geohydrology Lab (2 Cr)	Physics/ Chemistry (4 Cr) **ESGL 3104-T** Engineering Geology (4 Cr) **ESGL 3105** Quaternary Geology (4 Cr)	-	-	**ESGL 3106** Internship (4 Cr)		**24 Cr**
VI	**ESGL 3201** Advanced Geomorphology (4 Cr) **ESGL 3202-T** Geochemistry Theory (2 Cr) **ESGL 3202-L** Geochemistry Lab (2 Cr) **ESGL 3203-T** Economic Geology Theory (2 Cr) **ESGL 3203-L** Economic Geology Lab (2 Cr) **ESGL 3204-T** Micropaleontology Theory (2 Cr) **ESGL 3204-L** Micropaleontology Lab (2 Cr)	Physics/ Chemistry (4 Cr) **ESGL 3205** Isotope Geology (4 Cr) **ESGL 3206** Environmental Geology (4 Cr)	-	-	**ESGL 3207** Training/ Fieldwork (4 Cr)		**28 Cr**
Students exiting the program will be awarded a UG Degree in the Subject (After securing 122 credits with 4 credits of internship/ Apprenticeship)							**137 Cr**

VII	**ESGL 4101-T** Advanced Mineral Sciences Theory (2 Cr) **ESGL 4101-L** Advanced Mineral Sciences Lab (2 Cr) **ESGL 4102-T** Deformation & Rock Structures Theory (2 Cr) **ESGL 4102-L** Deformation & Rock Structures Lab (2 Cr) **ESGL 4103-T** Advanced Igneous Petrology Theory (2 Cr) **ESGL 4103-L** Advanced Igneous Petrology Lab (2 Cr) **ESGL 4104-T** Advanced Metamorphic Petrology Theory (2 Cr) **ESGL 4104-L** Advanced Metamorphic Petrology Lab (2 Cr) **ESGL 4105-T** Sedimentology & Basin Analysis Theory (2 Cr) **ESGL 4105-L** Sedimentology & Basin Analysis Lab (2 Cr)	**ESGL 4106** Coal & Petroleum Geology (4 Cr) **ESGL 4107** Global Tectonics (4 Cr)	**ESGL 4108** Field Training II (4 Cr)	**32 Cr**
VIII	**ESGL 4201-T** Ore Geology & Geo-Exploration Theory (2 Cr) **ESGL 4201-L** Ore Geology & Geo-Exploration Lab (2 Cr) **ESGL 4202-T** Advanced Geohydrology Theory (2 Cr) **ESGL 4202-L** Advanced Geohydrology Lab (2 Cr)		**ESGL 4203** Research Project/Dissertation (12 Cr)	**20 Cr**
Students will be awarded a UG Degree (Honours) with research in the relevant Discipline/subject (After securing 164 credits). Students without research must do 3 courses for 12 credits to compensate for the research project/Dissertation.				**189 Cr**

Major Highlights

- Regulations are applicable from the Academic Year 2023 – 24
- All Schools/ Departments are mandated to launch Integrated UG (Honours/Honours with Research) with entry – exit facility.

ESGL 1101 Understanding Earth **Credits: 4**

Introduction

Methods of studying the Earth – Observations, terminology, making and testing hypotheses. Historical development of the subject. Origin of the solar system and the Earth – Origin of the planets. Early Earth and the formation of a layered planet. Earth as a system of interacting components. Earth through geologic time. Plate Tectonics – The discovery of Plate Tectonics. The mosaic of tectonic plates, consequences and effects of plate movements. The Grand Reconstruction and the Engine of Plate Tectonics.

Earth Materials

Minerals – The atomic structure of minerals. Rock-forming Minerals and properties. Rocks – Igneous, sedimentary, and metamorphic Rocks. The rock cycle. Rocks and fossil records and the Geological Timescale.

Earth Processes

Dynamic processes of the Solid Earth – Folds, faults, and other types of rock deformation. Seismicity and volcanism. Evolution of the continents. Tectonics of the Indian Plate. Origin and evolution of the Himalayas. Weathering and Erosion – Physical weathering. Chemical weathering. Natural Hazards – Earthquakes, tsunamis, volcanoes, mass-wasting. Issues relating to prediction, protection, and mitigation. Landscapes, tectonics, and climate interaction.

Hydrosphere & Atmosphere

The hydrologic cycle and groundwater. Streams, stream loads, and sediment movement. Deltas. Oceans and physical and chemical sedimentation in the oceans. Waves and tides, shorelines. Winds and deserts. Atmospheric circulation. Wind erosion.

Earth resources, Environment, Landscape and Global Change

Energy Resources – Petroleum, Natural Gas and Coal. Alternatives to fossil fuels. Environment, global change and human impacts. The climate system. Natural climate variability. The carbon cycle. Human activity and global change.

Text Books:

F. Press and R. Siever, 2001. Understanding Earth (3rd edition). W. H. Freeman & Co Ltd, New York.

B. J. Skinner and S. C. Porter, 1995. The Dynamic Earth – An Introduction to Physical Geology (3rd edition). John Wiley & Sons, New York.

P. McL. Duff and A. Holmes, 1993. Holmes' Principles of Physical Geology (4th edition). Chapman & Hall, London.

Reference Books:

A. Cox and R. B. Hart, 1986. Plate Tectonics: How It Works. Wiley-Blackwell, New Jersey.

P. A. Allen, 1997. Earth Surface Processes. Wiley-Blackwell, Oxford.

B. W. Murck, B. J. Skinner and S. C. Porter, 1996. Dangerous Earth – An Introduction to Geologic Hazards. John Wiley & Sons, New York.

B. W. Murck, B. J. Skinner and S. C. Porter, 1996. Environmental Geology. John Wiley & Sons, New York.

ESGL 1102 Earth and Environment **Credits: 3**

Introduction

Minerals – The atomic structure of minerals. Rock-forming Minerals and properties. Rocks – Igneous, sedimentary, and metamorphic Rocks. The rock cycle. Rocks and fossil records and the Geological Timescale. Plate Tectonics – The discovery of Plate Tectonics. The mosaic of tectonic plates, consequences and effects of plate movements. The Grand Reconstruction and the Engine of Plate Tectonics. Methods of studying the Earth – Observations, terminology, making and testing hypotheses. Historical development of the subject. Origin of the solar system and the Earth – Origin of the planets. Early Earth and the formation of a layered planet. Earth as a system of interacting components. Earth through geologic time.

Dynamics of Earth, Atmosphere & Hydrosphere

Processes of the Solid Earth – Folds, faults, and other types of rock deformation. Seismicity and volcanism. Evolution of the continents. Tectonics of the Indian Plate. Origin and evolution of the Himalayas. Weathering and Erosion – Physical weathering. Chemical weathering. Natural Hazards – Earthquakes, tsunamis, volcanoes, mass-wasting. Issues relating to prediction, protection, and mitigation. Landscapes, tectonics and climate interaction. Atmospheric circulation. Winds and deserts. Wind erosion. The hydrologic cycle and groundwater. Streams, stream loads, and sediment movement. Deltas. Oceans and physical and chemical sedimentation in the oceans. Waves and tides, shorelines.

Environment, Landscapes, Earth Resources, and Global Change

The climate system. Natural climate variability. The carbon cycle. Human activity and global change. Energy Resources – Petroleum, Natural Gas, and Coal. Alternatives to fossil fuels. Environment, global change, and human impacts.

Text Books:

F. Press and R. Siever, 2001. Understanding Earth (3rd edition). W. H. Freeman & Co Ltd, New York.

B. J. Skinner and S. C. Porter, 1995. The Dynamic Earth – An Introduction to Physical Geology (3rd edition). John Wiley & Sons, New York.

P. McL. Duff and A. Holmes, 1993. Holmes' Principles of Physical Geology (4th edition). Chapman & Hall, London.

Reference Books:

A. Cox and R. B. Hart, 1986. Plate Tectonics: How It Works. Wiley-Blackwell, New Jersey.

P. A. Allen, 1997. Earth Surface Processes. Wiley-Blackwell, Oxford.

B. W. Murck, B. J. Skinner and S. C. Porter, 1996. Dangerous Earth – An Introduction to Geologic Hazards. John Wiley & Sons, New York.

B. W. Murck, B. J. Skinner and S. C. Porter, 1996. Environmental Geology. John Wiley & Sons, New York.

ESGL 1103 Introduction to Field Practices in Earth Sciences Credits: 3

Unit I

Objectives of geological investigations. Introduction to geomorphic landforms, and concepts of outcrops and exposures and their features. Preliminary idea on primary and secondary structures and outcrop studies in igneous, sedimentary, and metamorphic terrains. Surveying and mapping methods in geological terrains.

Unit II

Elementary idea of topographic and geological base maps, aerial photographs, and satellite imageries. Field equipment and tools. Modern technological aids for surveying and mapping (e.g., GPS, computer software, and mobile applications). Types of field data and measurement techniques.

Unit III

Processing of field data, interpretation, and preparation of geological/thematic maps. Scientific writing and geological reports. Necessary discipline, essential decorum, and basic etiquettes during geological fieldwork.

Reference Books:

Montgomery, D.R., & Bierman, P.R. (2019). Key Concepts in Geomorphology, 2nd Edition. WH Freeman.

Lisle, R.J., Brabham, P., and Barnes, J.W. (2011). Basic Geological Mapping. Wiley-Blackwell.

Assaad, F.A., LaMoreaux, P.E. (2004). Field Methods for Geologists and Hydrogeologists. Springer Berlin, Heidelberg.

Lahee, F. H. (2002). Field Geology, 6th Edition. CBS Publishers & Distributors Pvt Ltd.

Genge, M.J. (2020). Geological Field Sketches and Illustrations: A Practical Guide. Oxford University Press.

Compton, R.R. (1985). Geology in the Field. John Wiley & Sons.

Coe, A.L. (2010). Geological Field Techniques. Wiley-Blackwell.

Jerram, D., Petford, N. (201). The Field Description of Igneous Rocks (Geological Field Guide), 2nd Edition. Wiley–Blackwell.

ESGL 1201-T Geomorphology, Remote Sensing and GIS Theory Credits: 2

Geomorphology

Unit I

Fundamental concepts of geomorphology, Endogenic- Exogenic interactions: upliftment and denudation, weathering and mass wasting.

Unit II

Endogenic processes and landforms: Tectonic and volcanic activities, their distributions and landforms.

Unit III

Exogenic processes and their erosional and depositional landforms: Fluvial, Coastal, Deep marine, Glacial, Aeolian, and Karst landforms and their distribution in India.

Remote Sensing and GIS

Unit I

Fundamental concepts of remote sensing.

Unit II

Aerial photography, photogrammetry concepts, and Satellite remote sensing.

Unit III

Visual interpretation of aerial photo/satellite images: Photo-recognition elements.

Unit IV

Fundamentals of Geographical Information System (GIS).

Text Books:

Geomorphology

Grotzinger, J. Jordan, T.H., Press, F., Siever, R., 2007. Understanding Earth, 5th Edition, W. H. Freeman and Company, New York.

Huggett, R.J., 2007. Fundamentals of Geomorphology, 3rd Edition, Routledge Publishers

Summerfield, M.A., 1991, Global Geomorphology, Pearson Education Ltd.

Sharma, H.S., 1990. Indian Geomorphology. Concept Pub. Co., New Delhi.

Thornbury, W.D., 1969. Principles of Geomorphology. Willey Eastern Ltd. New Delhi.

Remote sensing and GIS

Lillesand, T.M. and Kiefer, R.W. 1987. Remote sensing and Image Interpretation, John Wiley.

Avery, T.E. and Berlin, G.L. 1992. Fundamentals of remote sensing and Airphoto interpretation. McMillion Publishing Co., New York.

Miller, V.C. & Miller, C.F. 1961. Photogeology. McGraw Hill, New York.

Ray, R.G., 1969. Aerial photographs in geologic interpretation. USGS Profess. Paper 373.

Pandey, S.N., 1987. Principles and applications of photogeology. Wiley Eastern, Delhi.

Reference Books:

Gupta, R.P., 1991. Remote Sensing Geology. Springer-Verlag.

Drury, S.A. 1987. Image interpretation in Geology. Chapman and Hall.

ESGL 1201-L Remote Sensing and GIS Lab **Credits: 2**

Reading peripheral information on aerial photos. Determination of photo scale. Stereoscopic view; Height measurement using relief displacement; parallax methods; Visual interpretation of Aerial photographs and satellite images for geological and geomorphological applications.

Reference Books:

Lillesand, T.M. and Kiefer, R.W. (1987). Remote sensing and Image Interpretation, John Wiley.

Miller, V.C. & Miller, C.F. (1961). Photogeology. McGraw Hill, New York.

Ray, R.G. (1969) Aerial photographs in geologic interpretation. USGS Profess. Paper 373.

Pandey, S.N. (1987). Principles and applications of photogeology. Wiley Eastern, Delhi.

ESGL 1202 Sampling Techniques in Earth Sciences Credits: 3

Unit I

Geological methods of rocks and sediment sampling.

Unit II

Geological methods of ore minerals and coal sampling.

Unit III

Geological methods of water sampling.

Reference Books:

Ehrlich, R. (1986). Geological Sampling. Wiley.

Marjoribanks, R. (2010). Geological Methods in Mineral Exploration and Mining. Springer.

Reddy, A.G.S. (2020). A Textbook on Water Chemistry: Sampling, Data Analysis and Interpretation. Nova Science Publishers Inc.

Carter, M.R. and Gregorich, E.G. (Eds.) (2007). Soil Sampling and Methods of Analysis. CRC Press.

Brassington, R. (2023). Field Hydrogeology. John Wiley & Sons.

ESGL 2101-T Crystallography and Mineralogy Theory **Credits: 2**

Crystallography

Basic ideas about crystal morphology in relation to internal structures. Crystal parameters and indices. Crystal symmetry and classification of crystals into six systems and 32-point groups. Miller-Bravais indices, Stereographic projections of symmetry elements and forms. Crystal lattice and internal symmetry, Bravais lattices, Screw axis, glide planes Points, directions, and planes in crystal lattices and 230 Space Groups. Defects in Crystals. Introduction to analytical techniques like XRD (X-ray diffraction), and SEM (secondary electron microscopy).

Mineralogy

Physical properties of crystals. Cohesive and elastic properties, Thermal properties, Electrical and magnetic properties, piezo- and pyro-electricity, Nature of light, and basic principles of interaction of light with crystals. Elements of crystal chemistry and aspects of crystal structures. Minerals: definition and classification, physical and chemical composition of common rock-forming minerals. Physical properties, crystal structure, and identification of common rock-forming minerals. Origin and association of rock-forming minerals in various geological environments.

Text Books:

Nesse, W.D. (2000). Introduction to Mineralogy. Oxford University Press.
Tareen, J.A.K. and Kutty, T.R.N. (2001). A basic course in crystallography. Uni. Press.
Nesse, W. D. (2008). Introduction to Optical Mineralogy. Oxford University Press.

Reference Books:

Bloss, F.D. (1971). Crystallography and Crystal Chemistry. Holt, Reinhart & Winston.
Klein, C. and Dutrow, B. (2007). The Manual of Mineral Science. John Wiley & Sons.
Verma, P.K. (2009). Optical mineralogy. Ane Books Pvt. Ltd.
Deer, W.A., Howie, R.A. and Zussman, J. (1992). An Introduction to the Rock-Forming Minerals (2nd edition). Longman, UK.

ESGL 2101-L Crystallography and Mineralogy Lab **Credits: 2**

Study of symmetry in models (quartz, tourmaline, barite, gypsum, augite, hornblende). Study of symmetry and forms in the models (Fluorite, garnet, pyrite, tetrahedrite, galena, zircon, beryl, calcite, olivine, orthoclase, albite). Study of color, streak, luster, cleavage, fracture, hardness (Moh's scale), magnetism, and forms of the minerals. Determination of specific gravity of minerals. Study of isotropic, uniaxial, and biaxial common rock-forming minerals under a petrological polarizing microscope and determination of relative refractive indices (RI), pleochroism, extinction angle, interference color, and order.

Reference Books:

Ehlers, E.G. (1987). Optical Mineralogy: Theory and Techniques. Blackwell Scientific Publications, New York.
Klein, C., Hurlbut, C.S. and Dana, J.D. (1998). Manual of Mineralogy (after James D. Dana, 21st edition). John Wiley & Sons.
Mackenzie, W.S. and Adams, A.E. (1994). Color Atlas of Rock and Minerals in Thin Section. John Wiley & Sons.

ESGL 2102-T Palaeontology Theory **Credits: 2**

Unit I

Definition and scope of Paleontology; Fossils - types, their modes of preservation and uses; Elementary idea of organic evolution, extinction, and classification; Geological Time Scale.

Unit II

A brief study of morphology, evolutionary trends, and geological history of Coelenterata, Graptolodiea, Brachiopoda, Bivalvia, Cephalopoda, Gastropoda, Echinoidea, and Trilobita.

Unit III

Brief introduction, evolution, and broad classification of vertebrates.

Unit IV

Brief introduction of Microfossils, Plant fossils, and Gondwana flora.

Text Books:

Shrock, R.R. and Twenhofel, W.H. (1987). Principles of Invertebrate Paleontology. McGraw Hill, New York.
Moore, R.C., Lalicker C.G., and Fisher, A.G. (1997). Invertebrate Fossils (1st Indian edition). CBS Publishers & Distributors, New Delhi.
Benton, M.J. (1997). Vertebrate Paleontology. Chapman & Hall.
Walton, J., (1953). An Introduction to the Study of Fossil Plants, Adam & Charles Black.
Woods, H., (1963). Paleontology Invertebrate. CBS Publications.
Clarkson, E.N. (1993). Invertebrate Paleontology and Evolution. Chapman Hall India, Chennai.
Raup, D. M. and Stanley, S. M. (1985). Principles of Paleontology. CBS Publishers, New Delhi.
Kathal, P.K. (2012): Application of Microfossils. CBS Publishers & Distributors.

ESGL 2102-L Paleontology Lab **Credits: 2**

Megascopic study of major invertebrate fossils. Study of some important microfossils under a binocular microscope.

Reference Books:

Woods, H. (1982). Invertebrate Paleontology. CBS Publishers & Distributors.

ESGL 2103 Oceanography and Climatology Credits: 4

Importance and relevance of climatology in today's world. Climate Vs. weather. Atmosphere: Composition, vertical structure, air pressure, air density, temperature, and heat transfer. Atmospheric greenhouse effect. Greenhouse gases and global warming. Atmospheric pollution, ozone depletion.

Earth's radiation balance; latitudinal and seasonal variation of insolation, temperature, pressure, wind belts, humidity, cloud formation. Cloud classification. Atmospheric stability. Cloud development, condensation nuclei, growth of cloud drops, and ice crystals. Precipitation mechanisms: Bergeron, collision-coalescence process. Type of Precipitation, artificial precipitation, hail suppression.

Atmospheric circulation- Single-cell and three cell model. Air masses- Classification; Fronts- Stationary, cold, Warm, and occluded fronts. Monsoon system, cyclone, and jet stream. Western disturbances and severe local convective systems. Distribution of precipitation over India. Koppen's classification of climate., General weather systems of India.

Ocean basins- Distribution of land and water, Hypsography of the continents and ocean floor –continental shelf, slope, rise, and abyssal plains, Physiography of the Ocean floor. Physical and chemical properties of seawater and their spatial variations- Chlorinity, salinity, thermal properties, density, pressure, optical properties, the transmission of sound. Residence times of elements in seawater.

Ocean currents, causes of ocean currents, and important current systems. surface circulation, thermohaline circulation, Ekman theory, Water masses- their formation and characteristics; T-S diagram, Upwelling and sinking of ocean waters. Formation of subtropical gyres; western boundary currents; equatorial current systems; El Nino Southern Oscillation (ENSO), monsoonal winds and currents over the North Indian Ocean; Somali current; Upwelling process in the Arabian Sea.

Waves and Tides-Wave celerity, group velocity, theory of surface gravity waves, short and long waves, transformation of waves in shallow water; effects of stratification; effect of bottom friction, breakers, and surf; littoral currents; Tide generating forces, principal harmonic components, theories of tides, description and types of tides, prediction of tides, tidal gauges, seiches; tsunami, Sea level changes.

Reference Books:

Agnado, E. and Burt, J. E. (2007). Understanding Weather and Climate. Pearson Prentice Hall.
Lal, D.S. (2003). Climatology. Sharda Pustak Bhavan.
Oliver, J.E. & Hidore, J.H. (2002). Climatology: An Atmospheric Science. Prentice Hall.
Ahrens, C.D. (2008.) Essentials of Meteorology: An Introduction to Atmosphere. Cengage Learning.
Trujillo, A.P. and Thurman, H.V. (2011). Essentials of Oceanography, Prentice Hall.
Pinet, P.R. (2009). Invitation to Oceanography. Jones and Barlett Publishers.
Pickard, G.L. and Emery, W.J. (1990). Descriptive Physical Oceanography: An Introduction. Elsevier.
Gross, M.G. (1987). Oceanography: A View of the Earth. Prentice Hall.
Gross, M.G. (1995). Principles of Oceanography. Prentice Hall.

ESGL 2104 Sample Preparation Techniques in Geology – I Credits: 3

Unit I

Introduction to geological materials (rocks, minerals, ores including coal and petroleum, fossils, etc.) and their physical properties. Introduction to transmitted and reflected light microscopy and its application in geology.

Unit II

Types of thin, polished, and wafer sections, and their uses. Standard practices for sample preparation for routine petrographic analysis and mineral analysis (polished thin/wafer sections). Sample preparation techniques for task-specific, user-intended samples (e.g., microtextural analysis, EPMA/LA-ICPMS, etc.).

Unit III

Conventional rock cutting/grinding/polishing instruments (manual mode) and materials (steel/diamond blades, slab-cutter, chip-grinder, grinding and polishing powders, etc.). Principles and conditions of operation of the instruments. Modern/sophisticated rock-cutting-grinding-polishing machines (automatic/semi-automatic mode, e.g., Petrothin).

Unit IV

Material and machine suppliers, operating budget, and feasibility. Business model, potential clients, and commercial scope.

Reference Books:

Humphries, D.W. (1992). The Preparation of Thin Sections of Rocks, Minerals, and Ceramics. Oxford University Press.

Perlman, P. (1971). Basic Microscope Techniques. Chemical Publishing Company.

Craig, J.R. and Vaughan D.J. (1995). Ore Microscopy and Ore Petrography, 2nd Edition. John Willey &Sons.

Ineson, P.R. (1989). Introduction to Practical Ore Microscopy. Routledge.

ESGL 2201-T Igneous and Metamorphic Petrology Theory Credits: 2

Igneous Petrology

Introduction to petrology and rock cycle. Internal structure of Earth and heat flow mechanisms. Concept of geothermal gradient. Fundamentals of plate tectonics. Mechanisms of melting and magma generation in the Earth.

Physical properties and composition of magma. Magmatic differentiation. Bowen's reaction series and its applications. Modes of occurrence and forms of igneous bodies. Intrusive (batholith, lopolith, laccolith, stocks, dykes, and sills) and Extrusive (volcanoes and their types, lava flows, and pyroclastic deposits) bodies. Structure and textures of igneous rocks.

IUGS recommended the classification of igneous rocks. CIPW norm. Gibb's phase rule and binary phase diagrams (Di-An, Ab-An, and Fo-SiO_2). Igneous rocks in the context of plate tectonics. Petrology of some common plutonic and volcanic igneous rocks.

Metamorphic Petrology

Introduction to metamorphism: Concept, agents, and types of metamorphism. Classification of metamorphic rocks. Texture and structure of metamorphic rocks.

Concept of metamorphic grade, facies, and facies series. Concept of index minerals, metamorphic zones, and isograds. metamorphic system, Introduction to thermodynamics and metamorphic reactions. Progressive metamorphism of pelitic and mafic rocks.

Text Books:

Philpotts, A.R. (1990). Principles of Igneous and Metamorphic petrology. Prentice Hall.
Best, M.G. (2002). Igneous and Metamorphic Petrology (2nd edition). Blackwell Publishers.
Winter, J.D. (2007). An Introduction to Igneous and Metamorphic Petrology. Prentice Hall.
Gill, R. (2010). Igneous Rocks and Processes: A practical guide. Wiley-Blackwell.

ESGL 2201-L Igneous and Metamorphic Petrology Lab Credits: 2

Study of hand specimens of various igneous and metamorphic rocks. Preparation of thin sections for microscopic study. Microscopic study of mineralogical and textural characteristics of igneous and metamorphic rocks.

ESGL 2202-T Sedimentology and Structural Geology Theory Credits: 2

Sedimentology

Unit I

Introduction to the process of formation of sedimentary rocks (Weathering, soil formation, erosion, transportation, and their deposition.

Unit II

Texture and fabric of Clastic rocks (Rudaceous, arenaceous, and argillaceous rocks). Classification of sedimentary rocks (Siliciclastic, Carbonate, and Chemical deposits) and a brief introduction to their origin.

Unit III

Petrography of important clastic and carbonate rocks.

Unit IV

Introduction to flow mechanics and genesis of sedimentary structures. Basic ideas about the depositional environment and facies concept.

Unit V

Post depositional changes and introduction to provenance interpretation.

Structural Geology

Unit I

Characteristics and classification of rock structures. Direction conventions and Concept of attitude. Parameters and conventions of attitude for planar and linear structures. 2-D and 3-D state of stress. Mohr circle of stress and condition of failure. Measurement of strain. Concept of homogeneous deformation. Shape-change and strain ellipsoid.

Unit II

Structures related to brittle deformation – Joint: Definition and structural elements of joints, Joint surface features. Joint developments related to fold, fault, and tectonic cycle. Fault: Definition and structural elements of fault, Fault classifications, Recognition criteria of faults, Anderson's theory of faulting, Features associated with normal, strike-slip, and reverse faults.

Unit III

Structures related to plastic deformation – a) Foliation: Concept, classification of foliation and its usefulness in structural analysis. Lineation: Concept, classification of lineation, and its usefulness in structural analysis. Folds: Concept and structural elements of fold, Qualitative fold classifications, Ramsay's fold classification, Mechanism of folding, Type of strain in buckle folded layer, Nature and recognition criteria of buckle folds, Nature and type of Superposed folds, Characteristic outcrop pattern of superposed fold.

Text Books:

Sedimentology

Sengupta, S.M. (1994). Introduction to Sedimentology, Oxford & IBH.
Collinson, J.D. and Thompson, D.B. (1982). Sedimentary Structures. George Allen & Unwin, London.

Tucker, M.E. (1981). Sedimentary Petrology: an introduction. John Willey & Sons, New York.
Tucker, M.E. and Wright, V.P. (1990). Carbonate Sedimentology. Blackwell, Oxford.

Structural Geology

Ghosh, S.K. (1993). Structural Geology: Fundamentals and modern developments.
Davis, G.H., Reynolds, S.J., (1996). Structural geology of rocks and regions, 2nd Edition, John Wiley & sons.
Park, R. G., (1983). Foundations of Structural Geology, Blackie Academic and Professional
Billings, M. P. Structural Geology, Prentice Hall.

Reference Books:

Sedimentology

Blatt, M., and Murray (1980). Origin of sedimentary rocks. Printice Hall Inc.
Pettijohn, F.J. (1975). Sedimentary rocks. Harper and Row Publ., New Delhi.
Prothero, D.R., Schwab, F., (2003). Sedimentary Geology. W. H. Freeman; 2nd Edition
Allen, J.R.L (2001). Principles of Physical Sedimentology by Blackburn Press; 1st, corrected reprint edition (February 1, 2001).

Structural Geology

Pollard, D.D. & Fletcher, R.C. (2005). Fundamentals of Structural Geology, Cambridge University Press
Ramsay, J.G. & Huber, M.I. (1987). The Techniques of Modern Structural Geology, Vol. 2: Folds and Fractures, Academic Press.
Moores, E.M., Twiss, R.J. (1995). Tectonics, W.H. Freeman
Hamblin, W.K., Christiansen, E.H. (2003). Earth's Dynamic Systems, 10th Edition, Prentice Hall
Turcotte, D.L., & Schubert, G., (2001). Geodynamics 2nd Edition, Cambridge University Press.

ESGL 2202-L Sedimentology and Structural Geology Lab **Credits: 2**

Sedimentary Petrology

Study of clastic and non-clastic rocks in hand specimen. Petrographic study of sedimentary rocks in thin-sections using microscope. Plotting of size distribution data.

Structural Geology

Drawing exercises for Attitude of planes and lines: True and Apparent dip, strike, pitch, plunge, trend. Concept of structure contours and determining outcrop pattern. Interpretation of geological maps- determining exact attitudes from outcrop. Determining stratigraphic thickness. Constructing stratigraphic columns. Construction of a geological cross-section.

Reference Books:

Sedimentary Petrology

Folk, R. L. Petrology of Sedimentary rocks. Hemphil Publishing Company.
Adams, A. E., MacKenzie, W.S., and Guilford, C., (1984). Atlas of Sedimentary rocks under the microscope. Longman Group UK Ltd.

Tucker, M.E. (1981). Sedimentary Petrology: an introduction. John Willey & Sons, New York.
Tucker, M.E. and Wright, V.P. (1990). Carbonate Sedimentology. Blackwell, Oxford.

Structural Geology

Rowland, S. Duebendorfer, E. & Schiefelbein, I. (2006). Structural Analysis and Synthesis, A Laboratory Course in Structural Geology, 3rd Edition Blackwell Publishers.

ESGL 2203 Stratigraphy & Indian Geology Credits: 4

Unit I

Scope of the subject and its relationship with other disciplines. Principles of stratigraphy. An outline of Stratigraphical classification. Correlation, facies, and stratigraphic contacts, Geological Time Scale - purpose, scope, and development.

Unit II

Physiographic divisions of India. Major Precambrian stratigraphic sequences of India: a brief account of distribution, succession, structures, economic importance, and fossil content.

Unit III

Palaeozoic and Mesozoic stratigraphic sequences of India, Gondwana Supergroup of India: nomenclature, classification, distribution, structures, fossils, age, paleogeography, and paleoclimate.

Unit IV

Deccan Volcanism, Inter-trappeans, and associated sedimentary formations and their fossils. Cenozoic stratigraphic sequences of India.

Text Books:

Lemon, R.L. (1990). Principles of Stratigraphy. Meril Publishing
Boggs, S., Jr. (1987). Principles of Sedimentology and Stratigraphy. Meril Publishing
Kumar, R. (1985). Fundamentals of Historical Geology and Stratigraphy of India. Wiley
Krishnan, M.S. (1985). Geology of India and Burma. CBS Publications
Ramakrishnan, M. and Vaidyanathan, R. (2008). Geology of India, Vol. I. Geological Society of India
Vaidyanathan, R. and Ramakrishnan, M. (2008). Geology of India, Vol. II. Geological Society of India

ESGL 2204 Marine Geology **Credits: 4**

Unit I

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.

Unit II

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.

Unit III

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

Text Books:

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

ESGL 2205 Sample Preparation Techniques in Geology – II Credits: 3

Unit I

Introduction to chemical analysis of geological materials, analytical techniques, instruments, and operating mechanisms. Machines and methods of chipping, griding, and powdering of rocks, minerals, ores, fossils, etc.

Unit II

Mineral separation techniques. Types of shaking tables, shaking sieves, and separating funnels. Heavy liquids and their use in mineral separation. Techniques of grain mounting, grinding and polishing, etc.

Unit III

Material and machine suppliers, operating budget, and feasibility. Business model, potential clients, and commercial scope.

Reference Books:

Gill, R. (1997). Modern Analytical Geochemistry: An Introduction to Quantitative Chemical Analysis Techniques for Earth, Environmental and Materials Scientists. Routledge: Taylor and Francis Group, London, and New York.

Balaram, V. and Subramanyam, K.V.S. (2018). Sample preparation for geochemical analysis: Strategies and significance. Advances in Sample Preparation, Vol. I. Elsevier.

Jain, S.K. (2019). Mineral Processing, 2nd Edition. CBS Publishers.

Rao, V., Patel, S. and Lele, A. (2020). Mineral Processing. Dreamtech Press.

Subba Rao, D.V. (2017). Textbook of Mineral Processing. Scientific Publishers (India).

Chisholm, E.K., Sircombe, K., DiBugnara, D. (2014). Handbook of Geochronology Mineral Separation Laboratory Techniques. Record 2014/46. Geoscience Australia.

ESGL 3101-T Solid Earth and Exploration Geophysics Theory Credits: 2

Gravity and Magnetic Methods

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. Principles of the magnetic method, The Earth's magnetic field; Geomagnetic elements; Magnetic properties of rocks- Induced and remnant, Magnetic surveying, Data reduction procedure- diurnal correction, IGRF; Palaeomagnetism and Geomagnetic polarity transitions; Working principle of gravimeters and magnetometers; geological interpretation and modeling for simple geometrical shapes.

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.

Electrical and Electromagnetic methods

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

Seismic Method

Theory and geometry of seismic waves, types of seismic waves, seismic velocity of rocks, nature of seismic sources-passive and active; Passive source 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. Worldwide distribution of earthquakes. Earthquake prediction; Active source- Reflection and refraction methods, Data Acquisition, CMP gather, Data processing- velocity analysis, Moveout corrections, stacking and migration. Interpretation of Seismic reflection profiles.

Well Logging

Introduction and objective of well logging, formation evaluation, reservoir rock types and their properties- porosity, permeability, and fluid saturation, Borehole environment and Invasion effect, different logging methods- Resistivity logging and its interpretation, SP logging, SP curve and interpretation, calculation of formation water resistivity from SP curve, estimation of permeability, Porosity estimation from sonic log, temperature log, Density log-principle of gamma-gamma ray and neutron logs and their interpretation.

Text Books:

Fowler, C.M.R. (1990) The solid earth: An introduction to Global Geophysics.
William Lowrie (1997). Fundamentals of Geophysics
John. M. Reynolds (1997). An Introduction to Applied and Environmental Geophysics
Alan E. Mussett and M. Aftab Khan (2000). Looking into the Earth
Robert J. Lillie, Whole Earth Geophysics, 1999. An introductory textbook for geologists and Geophysicists, Prentice Hall.

Philip Kearey, Michael Brooks, Ian Hill (2003). An introduction to Geophyical exploration 7. Bullen and Bolt. Introduction to the theory of Seismology.
Bath, M. Introduction to Seismology.
McElhiry. Paleomagnetism and Plate Tectonics.
Verma, R.K. Gravity field, Siesmicity and Tectonics of Indian Peninsula and the Himalayas.
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.
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.

ESGL 3101-L Solid Earth and Exploration Geophysics Lab **Credits: 2**

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 and interpretation.

ESGL 3102-T Advanced Remote Sensing and GIS Theory Credits: 2

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.

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 and unsupervised classification.

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.

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

Text Books:

T. Benhardsen, 2002. Geographic Information Systems: An Introduction. John Wiley & Sons, New York.
J. B. Campbell, 1996. Introduction to Remote Sensing. Guilford Press.
K. T. Chang, 2006. Introduction to Geographic Information Systems. Tata McGraw-Hill.
J. R. Jensen, 1996. Introductory Digital Image Processing: A Remote Sensing Perspective. Prentice Hall, New Jersey.
G. Joseph, 2005. Fundamentals of Remote Sensing. University Press.
T. M. Lillesand and R. W. Kiefer, 1987. Remote sensing and Image Interpretation. John Wiley & Sons.
F. F. Sabins, 1997. Remote Sensing: Principles & Interpretation, W.H. Freeman, New York.

Reference Books:

P. A. Burrough and R. A. McDonnell, 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
R. P. Gupta, 1991. Remote Sensing Geology. Springer-Verlag.
P. A. Longley, M. F. Goodchild, D. J. Maguire, D. W. Rhind, 2001. Geographic Information Systems and Science, Wiley, Chichester.

ESGL 3102-L Advanced Remote Sensing and GIS Lab **Credits: 2**

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 generation.

ESGL 3103-T Geohydrology Theory **Credits: 2**

Hydrology, Distribution of water, Hydrological cycle, watershed, water budget equation, global water balance, freshwater resources. Precipitation, forms, precipitation characteristics in India, measurement, rain gauge stations, mean precipitation, depth area duration, frequency, point rainfall, and monsoon studies in India.

Evaporation process, empirical equations, estimation techniques, evapotranspiration, Potential, actual evapotranspiration, infiltration, capacity, measurement, modelling techniques, classification of infiltration capacities. Streamflow, stage, velocity measurement, dilution technique, stage-discharge relations, hydrometry, rating curve extrapolation.

Runoff, hydrograph, runoff, catchment characteristics, volume calculation, SCS-CN method of runoff estimation, flow duration, droughts, surface water resources of India. Hydrographs, runoff hydrographs, components, base flow separation, floods, frequency analysis, flood routing.

Groundwater, geologic formation as aquifers, aquifer types, aquifer properties, Groundwater flow: Darcy's Law; Water Chemistry: Water sampling; water quality, major, minor, and trace elements, water analysis, saline intrusion, recharge, groundwater resources, groundwater monitoring in India.

Water resources management, recharge, demand and control, desalination, water management case studies with reference to India.

Text Books:

Dingman, L. (2014) Physical Hydrology (3rd Edition). Waveland Press, Inc.
H.M. Raghunath, 4th Edition, Hydrology Principles, Analysis, Design, New Age International Publishers.
Tim Davie, Fundamentals of Hydrology (Routledge Fundamentals of Physical Geography) 3rd Edition.

Reference Books:

Hornberger et.al. (2014) Elements of Physical Hydrology (2nd Edition).
Shaw, E.M., Beven, K.J., Chappell, N.A., & Lamb, R. (2011). Hydrology in Practice (4th ed.). CRC Press. https://doi.org/10.1201/9781315274904
Raghunath, H.M. (1987) Groundwater. New Age International.
Chow, V.T. (1964) Handbook of Applied Hydrology. McGraw-Hill.
Meinzer, O. E. (1949) Hydrology. Dover Publications.
Wisler, C.O. & Brater, E.F. (1959) Hydrology. John Wiley & Sons Inc.

ESGL 3103-L Geohydrology Lab **Credits: 2**

Rainfall analysis, Evapotranspiration calculation, Runoff estimation, infiltration calculation, Morphometric analysis, Hydrologic analysis, Problems with groundwater flow, Graphical representation of Groundwater Quality.

ESGL 3104 Engineering Geology **Credits: 4**

Description, Properties, and Behaviour of Soils and Rocks, soil classification, description of rocks and rock masses, Engineering Aspects of Igneous and Metamorphic Rocks, Engineering Behaviour of Sedimentary Rocks.

Geological Materials Used in Construction, Building or Dimension Stones, Roofing and Facing Materials, Armour stone, Crushed Rock: Concrete Aggregate, Road Aggregate, Gravels and Sands, Lime, Cement and Plaster, Clays and Clay Products.

Site Investigation, Desk Study and Preliminary Reconnaissance, Site Exploration – Direct Methods, In Situ Testing, Field Instrumentation, Geophysical Methods: Indirect Site Exploration, Maps for Engineering Purposes, Geographical Information Systems

Geology, Planning and Development, Geological Hazards, Risk Assessment and Planning, Hazard Maps, Natural Geological Hazards and Planning, Geological-Related Hazards Induced by Man, Derelict and Contaminated Land.

Geology and Construction, Open Excavation, Tunnels and Tunnelling, Underground Caverns, Shafts and Raises, Reservoirs, Dams and Dam Sites, Highways, Railroads, Bridges, Foundations for Buildings.

Text Books:

F. G. Bell, 1983. Fundamentals of Engineering Geology. Elsevier.

Reference Books:

F. C. Beavis, 1985. Engineering Geology. John Wiley & Sons.
S. N. Davis and R. J. N. De Wiest, 1966. Hydrogeology. John Wiley & Sons, New York.
D. P. Krynine and W. R. Judd, 1957. Principles of Engineering Geology and Geotechnique. McGraw Hill, New York.
R. E. Goodman, 1980. Introduction to Rock Mechanics. John Wiley & Sons.
R. L. Schuster and R. J. Krizek, 1978. Landslide analysis and control. National Academy of Science, Washington DC.

ESGL 3105 Quaternary Geology **Credits: 4**

Quaternary Geology: an overview. Quaternary environments. Quaternary stratigraphy, lithology, genesis of quaternary deposits, fauna and flora, paleogeography, and economic importance of Quaternary resources.

Major climatic changes during the Quaternary period - Ice Age, Pleistocene climate. Quaternary sea level changes and coastal geomorphology. Atmospheric composition, ocean circulation, and biological processes during Quaternary.

Quaternary fluvial, Aeolian and glacial systems. Paleoenvironments of the Quaternary period in India. Evolution of Quaternary landforms in India. Study of lake deposits and laterites of India.

Text Books:

A. Holmes, 1958. Principles of Physical Geology. ELBS, U.K.
E. C. F. Bird, 1985. Coastline changes. John Wiley & Sons, New York.
K. Stowe, 1995. Exploring Ocean Science. John Wiley, New York.
A. L. Bloom, 2004. Geomorphology - A Systematic Analysis of Late Cenozoic Landforms. Prentice-Hall, New Delhi.
D. N. Wadia, 1995. Quaternary environments and geoarchaeology of India. Geological Society of India, Bangalore.
W. D. Thornbury, 1969. Principles of Geomorphology. John Wiley & Sons.
R. Vaidyanathan, 1991. Quaternary Deltas of India. Geological Society of India, Bangalore.
R. A. Davis, 1978. Coastal sedimentary environments. Springer Verlag, New York.
E. Ahmad, 1972. Coastal Geomorphology of India. Orient Longman, New Delhi.

ESGL 3106 Internship **Credits: 4**

Intensive training for a minimum of two weeks in any 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. A report on the summer internship must be submitted for evaluation.

ESGL 3201 Advanced Geomorphology Credits: 4

Unit I

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

Unit II

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.

Unit III

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.

Unit IV

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.

Unit V

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.

Unit VI

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

Unit VII

Applied Geomorphology: Dating methods of the Quaternary deposits, Application of geomorphological knowledge in groundwater investigations, mineral exploration (placer deposits, residual deposits, oxidized zones), and engineering (construction materials, highway and railway routes); tectonic geomorphology. 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.

ESGL 3202-T Geochemistry Theory **Credits: 2**

Unit I

Stellar evolution and origin of elements. Different processes of nucleosynthesis. Origin of the solar system and distribution of elements with respect to distance from the Sun. 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, and crust.

Unit II

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 involving phase changes and equilibrium reactions.

Unit III

Nuclides and atoms. Electronic configuration of atoms, arrangement of atoms in the periodic table, electronegativity, ionization potential, chemical bonding. Properties of elements (volatiles, semi-volatiles, alkalis, alkaline earth, REE, HFS), Transition metals and noble metals. Silicate structures: Silicate polymers, cation sites in silicates, calculation of site occupancy, cation substitution, concept of distribution coefficients.

Unit IV

Chemical weathering, soil formation, geochemistry of clays. Fundamentals of low- 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. Rb-Sr and Sm-Nd systematics and their use in geochemistry. Stable isotopes: processes of isotope fractionation, δ-notation for C and O isotopes. O isotopes: fractionation in the hydrologic cycle.

Text Books:

H. Y. McSween, S. M. Richardson and M. E. Uhle, 2004. Geochemistry: Pathways and Processes (2nd edition). Columbia University Press.
R. Gill, 1988. Chemical Fundamentals of Geology. Chapman & Hall.
B. Mason and M. Moore, 1982. Principles of Geochemistry. John Wiley & Sons.
K. B. Krauskopf, 1979. Introduction to Geochemistry. McGraw Hill.

Reference Books:

W. M. White, 2013. Geochemistry. Wiley-Blackwell.
D. K. Nordstrom and J. L. Munoz, 2006. Geochemical Thermodynamics. Blackwell Scientific Publications.
G. Faure, 1986. Principles of Isotope Geology. John Wiley & Sons.

ESGL 3202-L Geochemistry Lab **Credits: 2**

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 in 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.

ESGL 3203-T **Economic Geology Theory** **Credits: 2**

Unit I

Economic minerals: chemical and industrial classification. Concept of ore minerals and gangue minerals; tenor and cut-off grade. Physical properties, chemical composition, and mode of occurrence of important ore minerals, industrial minerals, fossil fuels, and building stones.

Unit II

Mineral deposits – types, morphology and forms of ore bodies. Spatial distribution of mineral deposits and their distribution through geological time. Genetic classifications of mineral deposits. Ore forming processes and physical-chemical environment of ore deposition. Magmatic (early magmatic, late magmatic, volcanic), sedimentary (syn-sedimentary, diagenetic), metamorphic, hydrothermal, and weathering-surface processes of ore formation.

Unit III

Geological characteristics and Indian occurrences of important types of magmatic deposits (chromite, titaniferous magnetite, Cu-Ni sulphide), pegmatitic deposits (muscovite and rare metals), skarn deposits and hydrothermal deposits (base metals, gold, tin, tungsten, molybdenum), and metamorphic deposits (gondite-type manganese, graphite).

Unit IV

Geological characteristics and Indian occurrences of sedimentary deposits (Banded iron formation, manganese), lateritic deposits (aluminum). Various types of coal deposits, and oil and natural gas occurrences. Petroleum reservoirs and various types of oil and gas traps. On-shore and off-shore petroliferous basins of India. Other important hydrocarbon resources (coal bed methane, gas hydrate).

Unit V

Basic concepts of prospecting and exploration of mineral and fossil fuel resources. Geological, geochemical, and geophysical methods of exploration. Elementary ideas on methods of mining – open cast and underground methods. Principles of mineral economics – strategic, critical, and essential minerals; conservation of minerals. National mineral policy of India.

Text Books:

A. M. Evans, 1993. Ore geology and industrial minerals - an introduction. Blackwell Science, New Delhi.

R. K. Sinha and N. L. Sharma, 1988. Mineral Economics. Oxford-IBH, New Delhi.

D. Chandra, R. M. Singh and M. P. Singh, 2000. Textbook of coal (Indian context). Tara Book Agency, Varanasi.

A. I. Levorsen, 1985. Geology of Petroleum (2nd edition). CBS Publishers, New Delhi.

Reference books:

M. L. Jensen and A. M. Bateman, 1981. Economic mineral deposits. John Wiley & Sons, New York.

L. Robb, 2004. Introduction to Ore-forming Processes. Blackwell Science, UK.

P. K. Banerjee and S. Ghosh, 1997. Fundamental principles of prospecting. Allied Publishers.

S. Krishnaswami, 1988. Mineral resources of India. Oxford-IBH, New Delhi.

ESGL 3203-L **Economic Geology Lab** **Credits: 2**

Study of physical properties of ore minerals, industrial minerals, and fossil fuels in hand specimens, and their identification. Study of textures and structures of economic minores in hand specimen. Preparation of maps of major mining districts of India. Preparation of maps showing the occurrence of various mineral deposits in India.

ESGL 3204-T Micropaleontology Theory **Credits: 2**

Unit I

Introduction to Micropalaeontology, Sampling methods and sample processing techniques. Collection, preparation, and preservation of fossils. Types of Microfossils.

Unit II

Foraminifera and Ostracoda - Morphology, paleoecology & geological history. Brief account of Pteropods and Calcareous Nannofossils.

Unit III

Radiolaria, Marine Diatoms and Silicoflagellates - morphology, classification and geological distribution. Conodont - Classification, Morphology, and geological significance. Classification of palynomorphs; study of major groups of palynomophs - Spores, Pollen, Blue-green algae, Dinoflagellate.

Unit IV

Applications of microfossils in biostratigraphy and palaeoenvironmental interpretation. Microfossils as a tool in petroleum exploration.

Text Books:

Armstrong, H.A. and Brasier, M.D. 2005: Microfossils, II Edition, Blackwell Publishing.
Bignot, G., 1985: Elements of Micropalaeontology. Graham and Trotman
Glaessner, M.F, 1972: Principals of Micropalaeontology. Hafner publishing Company.
Haq, B. V. and Boersma, A., 1988: Introduction to Marine Micropalaeontology. Elsevier
Kathal, P.K. 2012: Application of Microfossils. C B S Publishers & Distributors.

ESGL 3204-L Micropaleontology Lab **Credits: 2**

Sample preparation, separation techniques of microfossils. Identification and description of major microfossils under a microscope.

ESGL 3205 Isotope Geology **Credits: 4**

Unit I

Discovery of radioactivity, stable and radiogenic isotopes. Literature on isotope geology. Nuclear structure, atomic weights, nuclear stability, and abundance. Theory and mechanism of decay, particles emitted, positron, negatron, and alpha decay, effect of mineral/crystal structures, growth, and retention of daughter isotope in earth systems.

Unit II

Abundances of unstable nuclides in earth, core, mantle, crust, oceans, and different rock types; their decay schemes; radioactive elements as major elements, minor elements and trace elements and their geochemical behavior.

Unit III

Mass spectrometer: Instrumentation, chemical separation, isotope dilution, and ratio analysis. Methods of dating: Isochron method, model/mineral ages, Fission track, 40Ar-39Ar, U and Th disequilibrium, concordia method, 14C, Be and Al. Interpretation and geological significance of ages.

Unit IV

Isotope systematics of K-Ar, Rb-Sr, Sm-Nd, U-Th-Pb in igneous, metamorphic, and sedimentary rocks and in the evolution of ocean, crust, and mantle.

Unit V

Stable isotopes of oxygen and hydrogen, carbon, nitrogen, and sulphur. Fractionation of stable isotopes in lithosphere, hydrosphere, and atmosphere. Stable isotope geothermometry and geobarometry. Isotopes in mineral exploration, petroleum exploration, paleo-climate evaluation, health and environmental aspects.

Text Books:

G. Faure, 1986. Principles of Isotope Geology. John Wiley & Sons.
B. R. Doe, 1970. Lead isotopes. Springer Verlag.
G. Faure and J. L. Powell, 1972. Strontium Isotope Geology. Springer Verlag.

ESGL 3206 Environmental Geology **Credits: 4**

Introduction

Earth, man, and environment. Environmental geoscience and fundamental concepts. Basic environmental problems. Geoscience factors in environmental planning.

The Earth Systems and Biosphere

Conservation of matter in various geospheres: lithosphere, hydrosphere, atmosphere, and biosphere. Concepts of ecology/Ecosystems. Biogeographical zonation of earth. The earth's major ecosystems terrestrial and aquatic.

Earth's Processes and Geological Hazards

Earth's processes; Concept of residence time and rates of natural cycles. Catastrophic geological hazards. Study of floods, landslides, earthquakes, volcanism, and avalanches, with a view to assessing the magnitude of the problem, prediction, and perception of the hazards.

Mineral and Energy Resources and Environment

Resource and Reserves. Environmental impact of exploitation, processing, and smelting of minerals. Environmental effects associated with each type of energy resource, viz., petroleum, natural gas, hydropower, nuclear, coal, solar, and wind energy.

Water Resources and Environment

Global Water Balance. Ice Sheets and fluctuations of sea levels. Origin and composition of seawater. Resources of oceans. Ocean pollution by toxic wastes. Human Use of Surface and Ground Waters. Ground Water Pollution.

Waste Disposal

Solid waste disposal – application of geology in planning and location of landfills. Radioactive waste management.

Environmental Health and Law

Biogeochemical factors in environmental health. Human use, trace elements and health. Possible effects of imbalance of some trace elements. Diseases induced by human use of land. Environmental legislations in India.

Text Books:

Keller, E.A., 2010. Environmental Geology. CBS Publisher, New Delhi.
K. S. Valdiya, 2005. Geology Environment and Society. Universities Press.
E. Bryant, 2008. Natural Hazard. Cambridge University Press.

ESGL 3207 Training / Fieldwork **Credits: 4**

Introduction to Topographic maps, identifying various topographic features like peaks, hills, valleys, etc., and relating them to topographic maps / aerial photographs/ satellite imageries. Basics of Global Positioning System (GPS). Identification of various igneous, metamorphic, and sedimentary rocks in the field and Identification of minerals and characterizing the rocks based on mineralogy and texture. Location of contacts between different rock units, lithological mapping on topographic maps / aerial photographs /satellite imageries. Identifying planar and linear structures in the field: - folds, faults, joints, unconformity, lineations, and foliations. Use of clinometer compass to measure various structural elements: Measurement of the attitude of planar and linear structure: dip, strike, pitch, plunge, and trend. Collection and plotting of structural elements. Field training on reconstruction of surface and subsurface geological units from available exposures. The total duration of the training will be about three weeks in the field.

ESGL 4101-T Advanced Mineral Sciences Theory **Credits: 2**

Unit I

Geometric and algebraic approaches to crystallography. Unit cells and Bravais lattices. Stacking sequences and close-packed structures. Voids and interstitial sites. Symmetry operations and 32 crystal classes. Introduction to space groups. Stereographic and spherical projection in Crystallography. Crystal forms.

Unit II

Axial ratios, Weiss parameters, and Miller Indices. Derivation and application of Bragg's Law. X-ray diffractometry and methods of mineral identification. Optical crystallography of uniaxial and biaxial minerals. Indicatrix.

Unit III

Crystal defects and imperfections. Types of bonding in minerals. Pauling's rules and its applications. Structural classification of silicates. Solid solution, Polymorphism, Isomorphism, Isostructuralism and Isotypism. Twinning. Application of Electron Microprobe Analysis (EPMA) and Scanning Electron Microscopy (SEM) in mineral sciences.

Unit IV

Chemical classification of minerals. Detailed study of the structure, composition, physical, and optical properties, and occurrence of common rock-forming minerals belonging to silicate mineral groups: Nesosilicates, Sorosilicates, Cyclosilicates, Inosilicates, Phyllosilicates, and Tectosilicates.

Text Books:

W. D. Nesse, 2000. Introduction to Mineralogy. Oxford University Press.
W. D. Nesse, 2008. Introduction to Optical Mineralogy. Oxford University Press.
F. D. Bloss, 1971. Crystallography and Crystal Chemistry. Holt, Reinhart & Winston. New York.
C. Klein and B. Dutrow, 2007. The Manual of Mineral Science. John Wiley & Sons.
P. K. Verma, 2009. Optical Mineralogy. Ane Books Pvt. Ltd.
W. A. Deer, R. A. Howie, and J. Zussman, 1992. An Introduction to the Rock-Forming Minerals (2nd edition). Longman, UK.

ESGL 4101-L Advanced Mineral Sciences Lab **Credits: 2**

Study of symmetry and identification of crystal classes in crystal models. Stereographic projections. XRD: identification of minerals from powder XRD data. Peak indexing of a cubic system mineral. Identification of minerals in hand specimens and thin sections. Calculation of cations and chemical formula of minerals from analytical data. Thermodynamic calculation for estimating mineral stability fields.

ESGL 4102-T Deformation and Rock Structures Theory Credits: 2

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, Origin, and propagation of Joint, Joint surface feature, Joint associated with other structures, Age relations. 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 III

Foliation: Concept and types of foliations and their usefulness in structural analyses. Lineation: Concept and types of lineations and their usefulness in structural analyses. Fold: Concept and structural elements of the fold, Qualitative fold classification. Fold classifications based on morphology Mechanism of folding. Concept of fold interference. Types Superposed folds and characteristic outcrop patterns.

Unit IV

Heterogeneous deformation and concept of shear zone. Types of shear zone. Shear zone rocks. Characteristic features of ductile shear zone and shear sense indicators.

Text books:

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

Reference books:

Ramsay, J.G. & Huber, M.I. 1983. The Techniques of Modern Structural Geology. V.1 & V2
Park, R.G. Foundations of structural geology.
Price, N.J. & Cosgrove, J.W. 1990. Analysis of Geological Structures. Cambridge University Press.
Davis, G.H. 1984. Structural Geology of Rocks and Regions.
Suppe, J. 1985 Principles of structural geology. Printice-Hall.

ESGL 4102-L Deformation and Rock Structures Lab Credits: 2

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.

ESGL 4103-T Advanced Igneous Petrology Theory **Credits: 2**

Unit I

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

Unit II

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

Unit III

Classification of igneous rocks. Petrography and interpretation of igneous textures in terms of nucleation and crystal growth. Phase equilibria studies and petrogenesis of important magmatic systems.

Unit IV

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

Text Books:

A. R. Philpotts, 1990. Principles of Igneous and Metamorphic Petrology. Prentice Hall.
A. R. McBirney, 1993. Igneous Petrology. Jones & Bartlett Learning.
K. G. Cox, J. D. Bell and R. J. Pankhurst, 1979. Interpretation of Igneous Rocks. George Allen Unwin.
J. D. Winter, 2007. An Introduction to Igneous and Metamorphic Petrology. Prentice Hall.
M. Wilson, 1989. Igneous petrogenesis: A global tectonic approach. Chapman & Hall.
D. A. Young, 2003. Mind over Magma: The story of Igneous Petrology. Princeton University Press.

ESGL 4103-L Advanced Igneous Petrology Lab **Credits: 2**

Study of igneous rocks (structure, texture and mineral assemblage) 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 processes.

ESGL 4104-T Advanced Metamorphic Petrology Theory Credits: 2

Unit I

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

Unit II

Application of thermodynamics: mineral equilibria and phase rule. Concept of thermodynamic modeling. Metamorphic P-T estimation.

Unit III

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 IV

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

Text Book:

Principles of Igneous and Metamorphic Petrology by J.D. Winter

Principles of Igneous and Metamorphic Petrology by Anthony R. Philpotts & Jay J. Ague

An Introduction to Metamorphic Petrology by Bruce Yardley & Clare Warren

Reference Books:

Atlas of metamorphic rocks and their textures by B. W. D. Yardley

Petrogenesis of Metamorphic Rocks by Kurt Bucher & Rodney Grapes

Metamorphic Phase Equilibria and Pressure-Temperature-Time Paths by Frank S. Spear

ESGL 4104-L Advanced Metamorphic Petrology Lab Credits: 2

Identification of reaction and stages of metamorphism under an optical microscope. Thermodynamic modeling using Perple_X or GeoPS. Petro-chronological plots and software (optional).

ESGL 4105-T Sedimentology and Basin Analysis Theory Credits: 2

Unit I

Sediments, sedimentary rocks and Sedimentary structures

Texture and fabric of sediments and sedimentary rocks (clastic and non-clastic rocks), classification of sedimentary rocks. Fluid mechanics and sediment transportation. Erosional and deformational structures, depositional structures in mud/mudstones, sand/ sandstones, gravel/ conglomerates, Chemical and biogenic structures

Unit II

Facies analysis of siliciclastic depositional environment

Depositional system analysis from sedimentary succession: basic concepts, facies, facies associations and architectural elements, and cyclic sedimentation in alluvial, lacustrine, aeolian, glacial, shallow coastal and deep marine deposits

Unit III

Facies analysis of Carbonate depositional environment

Carbonate sedimentation and cycles, facies and facies association of Carbonate depositional systems: shallow coastal marine and lacustrine succession, deep water pelagic and limestone deposits, dolomites

Unit IV

Diagenesis

Concepts of diagenesis; Process and stages of diagenesis; Compaction and different types of cementations. Chemical Index of Alteration and its paleoclimatic implications Clay Minerals: classification, techniques of identification, and implication in environmental and paleoclimatic interpretation

Unit V

Provenance and Basin Analysis

Sedimentary basin and classification; Mechanics of basin formation; allogenic and autogenic factors controlling the sedimentation, Paleocurrent analysis for paleogeographic reconstruction. Study of light minerals, heavy minerals, and insoluble residue for provenance studies – climatic and tectonic implications. Sequence stratigraphy: interaction among sea level/base level changes, sedimentation rate and tectonism; concept of parasequence, sequence and systems tracts: Lowstand, Transgressive, Highstand, Falling stage; Hierarchy of sequences and bounding surfaces. Application of sequence stratigraphy on outcrop data and seismic data; well log analysis. Basin mapping methods and basin modelling techniques: Heat flow analysis for understanding maturity of the basin, Resource potential of sedimentary basins, use of basin modelling in hydrocarbon generation and exploration.

Text Books:

Collinson, J.D. Mountney, N. and Thompson, D.B., 2006 Sedimentary Structures, 3rd edition George Allen & Unwin, London.

Tucker, M.E. (1981) Sedimentary Petrology: an introduction. John Willey & Sons, New York.

Tucker, M.E. and Wright, V.P. (1990) Carbonate Sedimentology. Blackwell, Oxford.

Allen, P.A. and Allen, J.R., Basin Analysis: Principles and applications Blackwell publishing, 2005.

Miall, A.D. Principles of Sedimentary Basin Analysis, 3rd Edition, Springer-Verlag, Berlin, 2000.
Reading, H. Sedimentary Environments: Processes, Facies and Stratigraphy, Blackwell Science, Oxford, 1996.
Boggs, S., 2006. Principles of sedimentology and stratigraphy, 4th Edition, Pearson Prentice Hall.

ESGL 4105-L Sedimentology and Basin Analysis Lab Credits: 2

Unit I Sedimentology

Grain size analysis by sieving and measuring grains from thin sections. Determination of roundness and sphericity of grains. Study of clastic and non-clastic textures in hand specimens and thin sections. Separation of heavy minerals and study of their microscopic characteristics. Spherical distribution of flow directions and Palaeocurrent analysis. GPR data interpretation and reconstruction of paleo environment.

Unit II Basin Analysis

Interpretation of seismic profiles and reconstruction of sea level rise and fall in the basin. Markov chain analysis for stratigraphic sequence

Text books:

Folk, R. L. Petrology of Sedimentary rocks. Hemphil Publishing Company.
Adams, A. E., MacKenzie, W.S., and Guilford, C., 1984. Atlas of Sedimentary rocks under the microscope. Longman Group UK Ltd.
Tucker, M.E., 1981. Sedimentary Petrology: an introduction. John Willey & Sons, New York.
Tucker, M.E. and Wright, V.P., 1990. Carbonate Sedimentology. Blackwell, Oxford.
Weimer, P. and Posamentier, H.W., 1994. Siliciclastic sequence stratigraphy: Recent Development and Application. AAPG Memoir 58.

ESGL 4106 Coal and Petroleum Geology Credits: 4

Nature of petroleum: chemical composition and physical properties of organic matter and hydrocarbon. Origin of petroleum: organic and inorganic theories. Transformation of organic matter into Kerogen, organic maturation, thermal cracking of kerogen. Diagenesis, ketogenesis and metagenesis. Formation of petroleum in relation to geological processes: temperature, time, and pressure. Timing of oil and gas generation.

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.

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.

Definition, origin, rank, and types of coal. Classification: Indian and International. Physical and petrographic characters: concept of Lithotypes, microlithotypes, and macerals. Chemical characterization: proximate and ultimate analyses.

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

Text Books:

Leverson, A.L. 1970. Geology of Petroleum. Freeman and Co.,
Selley, R. C. 1998. Elements of Petroleum Geology, II Edition. Academic Press,
North, F.K. Petroleum Geology, Allen & Unwin, London, 1985.

Reference Books:

Holson, G.D. and Tiratsoo, E.N., 1985: Introduction to Petroleum Geology-Gulf Publ. Houston, Texas
Tissot, B.P. and Welte, D.H., 1984: Petroleum Formation and Occurrence-Springer Verlag
Hunt, J.M. Petroleum Geochemistry and Geology, 2nd Edition, W.H. Freeman, San Fransisco, 1996.
Sahay, B., Rai, A. and Ghosh, M. Wellsite Geological Techniques for Petroleum Exploration, Oxford & IBH, New Delhi, 1984.
Stach, E., Mackowsky, M.T.H., Taylor, G.H., Chandra, D., Teichmuller, M. and Teichmuller, R., 1982:
Stach's Text Book of Coal Petrology- Gebruder Borntraeger, Stuttgart
Thomas, L ., 2002. Coal Geology. John Willey & Sons Ltd., England
Chandra, D., Singh, R.M. and Singh, M.P., 2000: Textbook of Coal (Indian Context)-Tara Book Agency, Varanasi.
Singh, M.P., (Ed.), 1998: Coal and Organic Petrology-Hindustan Publ. Corp., New Delhi.

ESGL 4107 Global Tectonics **Credits: 4**

Introduction

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

Plate Tectonics

Development of the 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:

P. Kearey and F. J. Vine, 1996. Global Tectonics. Blackwell Science.
B. F. Windley, 1995. The evolving continents. John Wiley & Sons.
J. J. W. Rogers, 1987. A history of the Earth. Cambridge University Press.
C. M. R. Fowler, 1990. The Solid Earth: An Introduction to Global Geophysics. Cambridge University Press.
G. C. Brown and A. E. Mussett, 1993. The Inaccessible Earth: an integrated view of its structure and composition. Chapman and Hall.
G. Brown, C. Hawkesworth and C. Wilson, 1992. Understanding the earth. Cambridge University Press.
K. C. Condie, 1976. Plate Tectonics and Continental Evolution. Pergamon Press.

ESGL 4108 Field Training II **Credits: 4**

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.

ESGL 4201-T Ore Geology and Geo-Exploration Theory Credits: 2

Ore deposits, morphology of ore bodies. Lithological and geochemical characteristics of ore deposits. Spatial and temporal distribution of ore deposits. Metallogenetic epochs and provinces. Ore forming processes. Source of ore constituents and ore fluids. Magmatic, metamorphic, hydrothermal, sedimentary and supergene processes of ore formation. Ore 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.

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.

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. 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.

Text Books:

H. L. Barnes, 1997. Geochemistry of hydrothermal ore deposits. John Wiley & Sons.
J. R. Craig and Vaughan, 1994. Ore microscopy and ore petrography. John Wiley & Sons.
A. M. Evans, 1992. Ore geology and industrial minerals (3rd edition). Blackwell Science.
K. C. Misra, 1999. Understanding mineral deposits. Kluwer Academic Publishers.
A. Mookherjee, 1998. Ore genesis – a holistic approach. Allied Publishers.
S. C. Sarkar and A. Gupta, 2011. Crustal evolution and metallogeny in India. Cambridge University Press, Delhi.
W. C. Peters, 1987. Exploration and mining geology. John Wiley & Sons, New York.
A. Annels, 1991. Mineral Deposit Evaluation. A practical approach. Chapman & Hall.
P. K. Banerjee and S. Ghosh, 1997. Element of prospecting for non-fuel mineral deposits. Allied Publisher Ltd, New Delhi.
A. W. Rose, H. E. Hawkes and J. S. Webb, 1979. Geochemistry in mineral exploration. Academic Press, London.
C. J. Moon, M. K. G. Whateley and A. M. Evans, 2006. Introduction to mineral exploration (2nd edition). Blackwell Publishing Ltd. Oxford.
W. C. Peters, 1978. Exploration and mining geology. John Wiley & Sons, New York.

A. A. Levinson, 1974. Introduction to exploration geochemistry. Applied Publication Co., Calgary.

ESGL 4201-L Ore Geology and Geo-Exploration Lab **Credits: 2**

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. 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.

ESGL 4202-T Advanced Geohydrology Theory **Credits: 2**

Water cycle, budget, precipitation, evaporation, and transpiration; Soil moisture and infiltration; Groundwater; Snow hydrology, water balance; Runoff and hydrographs; Flooding; Basins, hill slopes, and erosion; Rivers and streams –hydraulics, sediments, geometries; hydrology and climate; Surface-groundwater interactions.

Aquifer properties; Darcy's law; aquifer types; Principles of groundwater flow; Groundwater flow equations; Flow nets; Steady-state flow in confined and unconfined aquifers; Vadose zone; Groundwater recharge; Principles of salt-water intrusion. Resistivity investigations for water studies.

Methods of well construction, casing, screens, development, Groundwater flow to Wells: Pump-Test, well efficiency; Well specific capacity, aquifer transmissivity; Effects of well interference and aquifer boundaries; Estimation of distance to a hidden source of recharge.

Water chemistry and quality, standards, results of chemical analysis, carbonate equilibrium, thermodynamic relationship, groundwater contamination and restoration, Transport of pollutants in groundwater; Advection and dispersion; Sorption and diffusive mass transfer; Aquifer remediation; Groundwater restoration. Stable Isotopes, Radioactive Isotopes used in dating, contamination, and recharge studies.

Groundwater models, finite difference and element, steady and transient state, basics of VMODFLOW, Groundwater Development and management, water law, artificial recharge, Indian groundwater scenario, Remote Sensing and GIS for water studies, Integrated water resource management, desalination, hydro politics, case studies.

Text Books:

Fetter, C.W. 2001. Applied Hydrogeology (4th edition). Prentice Hall
Todd, D.K. 1988. Groundwater Hydrology. John Willey & Sons

Reference Books:

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. McGraw Hill Book Co.
Pathak, B.D. 1988. Hydrogeology of India, Central Board for Irrigation and Power, Mecha Marg, Chanakyapuri, New Delhi.

ESGL 4202-L Advanced Geohydrology Lab **Credits: 2**

Water balance calculation, groundwater budgeting, groundwater flow nets, Electrical resistivity for groundwater investigations, geo-logging and interpretation, Hydrochemical analysis of water samples, charge balance, ion exchange, rock water interaction, Graphical representation of water plots, water suitability for agricultural, industrial and domestic utilities, thermodynamics and saturation index calculations.

ESGL 4203 Research Project/Dissertation Credits: 12

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