NEP Course Structure and Syllabi of B.Sc., (Honors) in Applied Geology (Revised)

For the academic year 2024-2025 onwards
February 2025

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 appeared for Physics, Chemistry and Mathematics as domain subjects in CUET-UG examination.

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	**BSAG 111** **Understanding Earth (4 Cr)**	Physics/ Chemistry (4 Cr)	1. **BSAG 112** **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)	**BSAG 113** **Introduction to Field Practices in Earth Sciences (3 Cr)** *(Local fieldwork within & around the university campus)*	**VAC 1** Understanding India (2 Cr) **VAC 2** Environmental Science (2 Cr)	**21 Cr**
II	**BSAG 121** **Stratigraphy and Indian Geology (4 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)	**BSAG 122** **Sample Preparation Techniques in Geology (3 Cr)** *(Rocks/ Minerals/ Ores/ Soil/ Core sampling; Water sampling: groundwater, lakes, streams, sea, etc.)*	**VAC 3** Health & wellness/ Yoga/ Sports/ Fitness (2 Cr) **VAC 4** Digital Technologies, AI, Big data Analysis, & related areas (2 Cr)	**21 Cr**
LEVEL – 5 Exit 1: **A certificate will be awarded when a student exits at the end of year 1 (Level 5). The first year of the undergraduate programme builds on the secondary education and requires 42 credits during the first year of the undergraduate programme for qualifying for an undergraduate certificate.**							**42 Cr**

Semester	Major Discipline (4 Credits)	Minor Discipline (4 Credits)	Multi-disciplinary Courses (MD) 1.(3 Credits)	Ability Enhancement Courses (AEC) (3 Credits)	Skill Enhancement Courses (SEC) (3 Credits)	Value-Added Courses (VAC) (2 Credits)	Total Credits
III	**BSAG 211** **Crystallography & Mineralogy (4 Cr)** **BSAG 212** **Palaeontology and Quaternary Geology (4 Cr)**	Physics /Chemistry/ Maths (4 Cr) **BSAG 213** **Oceanography & Climatology (4 Cr)**	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 2** (3 Cr)	**BSAG 214** **Geology Lab I (3 Cr) (Crystallography & Mineralogy, Palaeontology)**	--	**21 Cr**
IV	**BSAG 221** **Igneous & Metamorphic Petrology (4 Cr)** **BSAG 222** **Sedimentology & Structural Geology (4 Cr)**	Physics/ Chemistry (4 Cr) **BSAG 223** **Marine Geology (4 Cr)**	--	**MIL 2** (3 Cr) (Multi-Indian Languages)	**BSAG 224** **Geology Lab II (3 Cr) (Igneous & Metamorphic Petrology)** **BSAG 225** **Geology Lab III (3 Cr) (Sedimentology & Structural Geology)**	Community Engagement and Service (2 Cr) Offered by NSS/NCC Co-ordinators	**21 Cr**
LEVEL – 6 Exit 2: **If a student exits at the end of the 2nd year, a diploma shall be awarded (Level 6). A diploma requires 84 credits from levels 5 to 6, with 42 credits at level 6.**							**84 Cr**

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
V	**BSAG 311** **Geomorphology (4 Cr)** **BSAG 312** **Geohydrology & Environmental Geology (4 Cr)** **BSAG 313** **Solid Earth & Exploration Geophysics (4 Cr)**	Physics/ Chemistry (4 Cr) **BSAG 314 (4 Cr)** **Statistical and Computer Applications in Geosciences**	--	--	**BSAG 315** **Internship (3 Cr)** **BSAG 316** **Geology Lab IV (3 Cr) (Geohydrology, Solid Earth & Exploration Geophysics)**	--	**22 Cr**
VI	**BSAG 321** **Geochemistry (4 Cr)** **BSAG 322** **Economic Geology (4 Cr)** **BSAG 323** **Remote Sensing & GIS (4 Cr)**	Physics/ Chemistry (4 Cr) **BSAG 324** **Coal & Petroleum Geology (4 Cr)**	--	--	**BSAG 325** **Training/ Fieldwork (3 Cr)** **BSAG 326** **Geology Lab V (3 Cr) (Geochemistry, Economic Geology, Remote Sensing & GIS)**	--	**22 Cr**
LEVEL – 7 Exit 3: **On successful completion of three years, the relevant degree shall be awarded (Level 7). A Bachelor's degree requires 128 credits from levels 5 to 7, 42 credits at level 5, 42 credits at level 6, and 44 credits at level 7.**							**128 Cr**

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
VII	**BSAG 411** **Advanced Mineral Sciences & Rock Deformation (4 Cr)** **BSAG 412** **Advanced Igneous & Metamorphic Petrology (4 Cr)** **BSAG 413** **Micropaleontology & Basin Analysis (4 Cr)**	**BSAG 414** **Isotope Geology (4 Cr)**	--	--	**BSAG 415** **Field Training II (3 Cr)** **BSAG 416** **Geology Lab VI (3 Cr) (Mineral Science and Rock Deformation, Basin Analysis)** **BSAG 417** **Geology Lab VII (3 Cr) (Igneous, Metamorphic, Micropaleontology)**	--	**25 Cr**
VIII	**BSAG 421** **Ore Geology & Geo-Exploration (4 Cr)** **BSAG 422** **Advanced Geohydrology & Engineering Geology (4 Cr)**	**BSAG 423** **Global Tectonics (4 Cr)**	--	--	**BSAG 424** **Geology Lab VIII (3 Cr) (Ore Geology & Geo-Exploration, Geohydrology & Engineering Geology)** **BSAG 425** **Research Project/Dissertation (12 Cr)**	--	**27 Cr**
LEVEL – 8 Exit 4: **On the successful completion of the fourth year, a student shall be awarded a degree (Honours/Research). A Bachelor's degree (Honours/Research) requires a total of 180 credits from levels 5 to 8, with 42 credits at level 5, 42 credits at level 6, and 44 credits at level 7, and 52 credits at level 8.**							**180 Cr**

Syllabi

BSAG 111 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. Spares

BSAG 112 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.

BSAG 113 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.

BSAG 121 Stratigraphy and 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

BSAG 122 Sample Preparation Techniques in Geology Credits: 3

Unit I

Standard practices of sample preparation for routine petrography, mineral analysis and fluid/melt inclusion studies. Types of section (thin, polished, and wafer) and their uses. Conventional rock cutting/grinding/polishing instruments (manual mode) and materials (steel/diamond blades, slab-cutter, chip-grinder, grinding and polishing powders, etc.).

Unit II

Standard practices of chipping, grinding, and powdering of geological materials (rocks, minerals, ores, fossils, etc.) for geochemical analysis (XRF, ICP AES, XRD, etc.) Types of crushers, pulverisers and grinding mills (jaw crusher, ball mill, cup mill, etc.).

Unit III

Techniques for water Sample Collection and Analysis, Preventing sample contamination, sampling equipment, sampling in wells, site inventory and documentation

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.

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

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).

BSAG 211 Crystallography and Mineralogy Credits: 4

Unit I

Basic ideas about crystal morphology in relation to internal structures. Crystal symmetry and classification of crystals into six systems and 32-point groups. Crystal parameters and indices.

Unit II

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 X-ray diffraction and secondary electron microscopy.

Unit III

Physical properties of crystals. Cohesive and elastic properties. Thermal, 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.

Unit IV

Minerals: definition and classification. Physical properties, chemical composition, crystal structure, and identification of common rock forming minerals. Genesis 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.
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.

BSAG 212 Palaeontology and Quaternary Geology Credits: 4

Palaeontology

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.

Quaternary Geology

Unit I
Definition of Quaternary. Quaternary Stratigraphy, climates – glacial-interglacial cycles, eustatic changes; Proxy indicators of paleoenvironmental/ paleoclimatic changes.

Unit-II
Responses of geomorphic systems to climate, sea level and tectonics on variable time scales in the Quaternary.

Unit III
Quaternary dating methods

Unit IV
Evolution of Man and Stone Age cultures.

Text books:

Elias, S.A., 2007. Encyclopedia of Quaternary Science Vol 1, 2nd Edition, Elsevier.
Quaternary Geology: Indian Perspective byU B Mathur. Memor No 63, Geological Society of India, Bangalore.

Reference books:

Quaternary Geology: Proceedings of the 30th International Geological Congress, Volume 21,Quaternary Geology 1997 Edition.
D.P. Agrawal, P. Sharma and S.K. Gupta, 1988. Palaeoclimatic and Paleoenvironmental Changes in Asia during the last 4 million years. Proceedings of Indian National Sci. Acad. 54.
Jean Riser, Quaternary Geology and the Environment. Springer, 2002.

BSAG 213 Oceanography and Climatology Credits: 4

Unit I

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.

Unit II

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.

Unit III

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.

Unit IV

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.

Unit V

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.

Unit VI

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.

BSAG 214 **Geology Lab-1** **Credits: 3**

Crystallography, Mineralogy and Palaeontology

Crystallography

Study of symmetry and forms in crystal models. Study of color, streak, luster, cleavage, fracture, hardness (Moh's scale), magnetism, and forms of the minerals. Study of common rock-forming minerals under a petrological polarizing microscope.

Mineralogy

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.

Palaeontology

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

BSAG 221 Igneous and Metamorphic Petrology Credits: 4

Unit I

Introduction to petrology and rock cycle. Internal structure of the earth and mechanisms of heat flow. Concept of geothermal gradient. Magma generation, differentiation, assimilation, mixing and mingling. Bowen's reaction series and its applications in igneous petrology.

Unit II

Modes of occurrence and forms of igneous bodies. Structure, textures and classification of igneous rocks. Gibb's phase rule and phase diagrams in igneous systems. Petrography and petrogenesis of common plutonic and volcanic igneous rocks. Igneous rocks in the context of plate tectonics.

Unit III

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

Unit IV

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

A.R. Philpotts, 1990. Principles of Igneous and Metamorphic petrology. Prentice Hall.

M.G. Best, 2002. Igneous and Metamorphic Petrology (2nd edition). Blackwell Publishers.

J.D. Winter, 2007. An Introduction to Igneous and Metamorphic Petrology. Prentice Hall.

BSAG 222 Sedimentology and Structural Geology Credits: 4

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.

Text Books:
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.

Reference Books:
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

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:

Ghosh, S.K. (1993). Structural Geology: Fundamentals and modern developments. Pergamon Press.

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:

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.

BSAG 223 Marine and Medical 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, gaps; mid-oceanic rise; mid-oceanic ridges. Tectonic history of oceans; Submarine volcanism, Tsunamis.

Unit II

Ocean circulation: surface circulation, concepts of mixed layer, thermocline and pychnocline; Water-masses; Deep-sea circulation; Thermohaline circulation and earth's climate; Turbidity current, submarine and sedimentation processes. Marine stratigraphy.

Unit III

Oceanic sediments: Terrigenous, biogenous, cosmogenous and hydrogenous deposits; Mineral resources of the ocean; Deposits of the continental margin: Placer-formations, mode of occurrence, mineral composition and distribution; Deposits of the continental shelf; Deposits of the deep-sea floor: Physical and chemical aspects of polymetallic nodules and their formation, distribution and concentration; Hydrocarbons beneath the sea floor- Marine gas hydrates.

Unit IV

Marine and coastal environment; Classification of marine environment and marine organism; Coral reefs; Marine microfossils; Major oceanographic events in the Cenozoic.

List of Reference Books:

Introductory oceanography (5th ed),1988 Thurman, H.V., Mercill Publ. Co, Ohio.
Oceanography (5th ed), 1990 –Grant Gross, M., Prentice Hall.
Coastal and estuarine sediment dynamics, 1986 – Dyer, K.R., John Wiley & Sons.
Beach processes and sedimentation, 1976 – Komar, P.D., Prentice Hall
The mineral sources of the sea, 1965 – Mcro, J.L., Elsevier, Amsterdam.
Marine minerals: advances in research and resource assessment, 1987 – Teleki, P.G. et al. D. Reidel Dordrechart.
Marine geology and oceanography of the Arabian Sea and coastal Pakistan 1984 – Haq. B.U. and Milliman, J.D., Van Norstrand Reinhold Co.
Marine Geology, 1982 – James P. Kennet. Prentice Hall INC Englewood, Cliffs, N.J. 07632.
Guides to the identification on marine and estuarine invertebrates, 1971-Grossner, K.L.
Quantitative ecology and marine biology, 1990 Bakus, G.J.

BSAG 224 Geology Lab-II Credits: 3

Igneous and Metamorphic Petrology

Study of megascopic specimens of various igneous and metamorphic rocks. Microscopic study of mineralogical and textural characteristics of igneous and metamorphic rocks.

BSAG 225 Geology Lab - III Credits: 3

Sedimentology and Structural Geology

Sedimentology
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
Measurement of attitude. Interpretation of geological maps - concept of topographic and structure contours, determining attitudes from outcrop pattern, determining stratigraphic succession, construction of geologic cross-section, interpretation of deformation structures. Geometric and steoreographic methods for attitude caculations.

Reference Books:
Sedimentology
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.
G.M. Beninson (1990). An Introduction to Geological Structures and Maps. 5th Edition, Edward Arnold.
Bose N. & Mukherjee, S (2017). Map Interpretation for Structural Geologists. Elsevier.

BSAG 311 Geomorphology Credits: 4

Unit I

Fundamental concepts of geomorphology; Endogenic- Exogenic interactions; Cycle of erosion, base level control. Role of structure, process, time, and climate in landform evolution.

Unit II

Endogenic landforms: Landforms made by folding and faulting (tectonic scarps, fault valleys, and block mountains). Volcanic activity– distribution and landforms.

Unit III

Exogenic process; Weathering and soil formation: Physical and chemical weathering. Soil profile and Soil types.

Unit VI

Mass wasting and hillslope stability. Classification of mass wasting processes.

Unit V

Exogenic landforms: Fluvial, Karst, Aeolian, Glacial and periglacial, Coastal and submarine processes and landforms – their distribution in India.

Unit VI

Applied Geomorphology: Application of geomorphological knowledge in groundwater investigations, mineral exploration, and engineering.

Text Books:

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

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

R.J. Huggest (2007) Fundamentals of Geomorphology. Routledge Publishers

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

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

Reference books:

Burbank, R and Anderson, S (2011) Tectonic Geomorphology.John Wiley & Sons

Goudie A (2013) Encyclopedia of Geomorphology, Routledge

BSAG 312 Geohydrology and Environmental Geology Credits: 4

Geohydrology

Unit I

Watershed and water budget equation, - Global water balance- Freshwater resources. Forms and characteristics of precipitation - Measurement techniques-- Rain gauge stations, mean precipitation-- Depth-area-duration, frequency, point rainfall- Monsoon studies in India

Unit II

Evaporation process and empirical equations- Estimation techniques- Potential and actual evapotranspiration - Infiltration: capacity, measurement, modeling techniques, classification

Unit III

Streamflow and Hydrometry, velocity measurement, dilution technique - Stage-discharge relations, hydrometry - Rating curve extrapolation

Unit IV

Runoff and catchment characteristics - Volume calculation, SCS-CN method - Flow duration, droughts, surface water resources - Hydrographs: components, base flow separation - Floods: frequency analysis, flood routing

Unit V

Geologic formations and aquifers - Aquifer types and properties - Groundwater flow: Darcy's Law - Water chemistry: sampling, quality, analysis - Saline intrusion, recharge, groundwater resources- Groundwater monitoring in India. Recharge, demand, and control – Desalination - Water management case studies in 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.

Environmental Geology

Unit I

Environmental geoscience and fundamental concepts. Basic environmental problems. Geoscience factors in environmental planning.

Unit II

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

Unit III

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.

Unit IV

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.

Unit V

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

BSAG 313 Solid Earth and Exploration Geophysics Credits: 4

Unit I

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.

Unit II

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.

Unit III

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.

Unit IV

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.

Unit V

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.

BSAG 314 Statistics and Computer Applications in Geosciences Credits: 4

Statistics

Unit I

Introduction to organization and description of data: mean, median, mode, variance, standard deviation, quartile, percentile, and covariance of data.

Unit II

Introduction to probability, discrete and continuous probability distributions.

Unit III

Introduction to statistical inference sampling distributions, point and interval estimation, hypothesis testing involving one and two univariate populations.

Unit IV

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.

Reference Books:

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.

Computer Applications

Unit I

Introduction to computers: PC configuration, CPU, I/O, memory, networking and peripheral devices. Operating system, BIOS, drivers and application software.

Unit II

DOS platform: Boot sequence, system files, internal and external commands, file structure and commands. Brief exposure to DOS programs and utilities for geoscience applications.

Unit III

Windows platform: Sharing of memory, time, program and data, features of graphical user interface, configuring desktop environment, installing and running applications. Working with spread sheet, presentation graphics, database and imaging software for geoscience applications. Image formats and compression techniques. Data compression and anti-virus programs. Network environment, LAN and internet protocols, internet resources in geosciences. Brief exposure to HTML and web publishing.

Unit IV

Linux platform: Common Linux features, file structure and commands, security features. Working with Red Hat Linux, text mode and desk top environments, installing and running geoscience applications.

Text books:

Crumlish (2000) The internet. 2nd Edition. BPB Publishers, New Delhi.

David Nash (2001) Linux in easy steps. IDG Books, New Delhi.

Nathan Wallace (2000) Windows 2000 in easy steps. IDG Books, New Delhi.

PC complete. 2nd Edition. BPB Publishers, New Delhi. (2000).

Peter Ingram (2000) Networking in easy steps. Dreamtech Press, New Delhi. Stultz (1996) Illustrated MS-DOS 6.22. BPB Publishers, New Delhi.

Reference books:

P.K. Sinha and Priti Sinha (2004). Computer Fundamentals, BCP publishers, New Delhi.
Kris Jamsa (1987), MS-DOS: The Complete Reference, MCGraw-Hill.
David Pogue (2015) Windows 10: The Missing Manual,O'Reilly Media, USA
Joan Lambert and Curtis Frye (2019) Microsoft Office 2019 Step by Step, Microsoft, USA
William E. Shotts Jr. (2012) The Linux Command Line: A Complete Introduction, USA.
James F. Kurose and Keith W. Ross (2017) Computer Networking: A Top-Down Approach" by, Addison-Wesley, USA.

BSAG 315 Internship Credits: 3

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.

BSAG 316 Geology Lab IV Credits: 3

Geohydrology, Solid Earth and Exploration Geophysics

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

Solid Earth and Exploration Geophysics
Geophysical Surveying, corrections to gravity and magnetic data, gravity and magnetic anomalies, qualitative and quantitative interpretation of geophysical anomalies. Determination of Seismic wave velocities and geometry of Earth's sub-surface layer, travel time curves and interpretation. Estimating the properties of reservoir rocks, and borehole log interpretations.

BSAG 321 Geochemistry Credits: 4

Unit I

Stellar evolution, origin of elements and processes of nucleosynthesis. Origin of the solar system and distribution of elements with respect to distance from the Sun. Abundances of elements. Oddo-Harkin Rule. Meteorites. Geochemical and Cosmochemical classification of elements. Differentiation of the Earth and resultant elements distribution in core, mantle, and crust. Atoms and their arrangement and classification in periodic table. Electronegativity and Ionization potential. Chemical bonding. Concept of partition coefficient. Elemental substitutions and calculation of site occupancy in minerals.

Unit II

Nuclear properties of the elements. Isotopes, isobars and isotones. Table of nuclides and valley of stability. 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.

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 involving phase changes and equilibrium reactions.

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: CO2-H2O interaction to form carbonic acid, dissolution of calcite. Introduction to chemical evolution of hydrosphere.

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.

Reference Books

W. M. White, 2013. Geochemistry. Wiley-Blackwell.

D. K. Nordstrom and J. L. Munoz, 2006. Geochemical Thermodynamics. Blackwell Scientific Publications.

BSAG 322 Economic Geology Credits:4

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 (synsedimentary, 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).

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.

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.

BSAG 323 Remote Sensing and GIS Credits: 4

Unit I

Fundamentals of remote sensing: Remote sensing system; Electromagnetic spectrum; Interaction of EMR with atmosphere & target; Concept of Spectral signatures- spectral signatures of vegetation, water, minerals (rocks); Platforms and Sensors; remote sensing Satellites - orbits – polar, Sunsysnchonous, geosynchronous; Scanners, Earth observation and meteorological satellites, sensor characteristics – resolutions (spatial, spectral, radiometric and temporal); types of satellite data – panchromatic; multispectral, and hyperspectral data.

Unit II

Aerial remote sensing: History of remote sensing; aerial camera- films and filters, products; types of aerial photo; photogrammetry concepts, marginal information, Photo scale, relief displacement, stereovision- stereoscopes, Image parallax.

Unit III

Photo-recognition elements. Visual interpretation of Aerial photographs and satellite images for geological and geomorphological applications.

Unit IV

Digital Image Processing: digital data format; Image rectification and restoration techniques; Image Enhancement techniques; Image transformation; Image Classification; Landuse/Landcover change detection

Unit V

GIS: Definition, Elements of GIS, representation of geographic data, spatial data models - vector and raster data structure, Attribute data, geodatabase; coordinate systems & map projection; spatial data input and editing; Query &Spatial Analysis; Map preparation in GIS; current trends in GIS.

Unit VI

Geological Application of Remote sensed data & GIS

Text Books:

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

Joseph, G. (2005). Fundamentals of Remote Sensing. University Press.

Bhatta, B (2020). Remote Sensing and GIS. Oxford University Press

Campbell, J. B. (1996). Introduction to Remote Sensing. Guilford Press.

Sabins, F. F. (1997). Remote Sensing: Principles & Interpretation, W.H. Freeman, New York.

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.

Benhardsen,T. (2002). Geographic Information Systems: An Introduction. John Wiley & Sons, New York.

Chang,K. T. (2006). Introduction to Geographic Information Systems. Tata McGraw-Hill.

Reference Books:

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

Jensen, J. R. (1996). Introductory Digital Image Processing: A Remote Sensing Perspective. Prentice Hall, New Jersey

Burrough,P. A. and 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

BSAG 324 Coal and Petroleum Geology Credits: 4

Unit I

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.

Unit II

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 III

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 IV

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.

Unit V

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.

BSAG 325 Field Training I Credits: 3

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.

BSAG 326 Geology Lab V Credits: 3

Geochemistry, **Economic Geology, Remote Sensing and GIS**

Geochemistry

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.

Economic Geology

Study of physical properties of ore minerals, industrial minerals 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.

Remote Sensing and GIS

Reading peripheral information on aerial photos. Determination of photo scale. Stereoscopic viewing; Determination of length, width and Height of the object from aerial photograph; Visual interpretation of Aerial photographs and satellite images for geological and geomorphological applications.

Hands-on Digital Image Processing of Remote Sensing Data and GIS.

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.
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

BSAG 411 Advanced Mineral Sciences and Rock Deformation Credits: 4

Unit I

Geometric and algebraic approaches to crystallography. Unit cells and Bravais lattices. Derivation and determination of point groups. Crystal forms, Packing, and Twinning. Plane and Space lattice. Introduction to space group. Spherical and Stereographic projections.

Unit II

Axial ratios, Weiss parameters, and Miller Indices. Derivation and application of Bragg's Law. X-ray diffractometry. Crystal defects and imperfections. X-ray diffractometer and powder method of mineral identification.

Unit III

Types of bonding in minerals. Structural classification of silicates. Solid solution, Polymorphism, Isomorphism, Isostructuralism and Isotypism. Application of Electron Microprobe Analysis (EPMA) and Scanning Electron Microscopy (SEM) in mineral sciences.

Unit IV

Introduction to physical and optical properties of minerals. Structural and chemical classification of minerals. Classification of silicate minerals. Detailed study of the structure, composition, physical, and optical properties, use, and occurrence of common rock-forming minerals: Nesosilicates, Sorosilicates, Cyclosilicates, Inosilicates, Phyllosilicates, Tectosilicates, Oxides, Carbonates, Phosphates, Sulphates, Sulfides, and other mineral groups.

Unit V

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 VI

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 VII

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 VIII

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:

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, 2013. An Introduction to the Rock-Forming Minerals (3rd edition). Longman, UK.
Ghosh, S.K. 1993. Structural Geology: Fundamentals and modern developments. Pergamon Press
Van der Pluijm and Stephen Marshak 2004. Earth Structure: an introduction to structural Geology and Tectonics, 2nd Edition. WW Norton & Company.
Paschier C.W. & Trouw, R.A.J. Micro-tectonics, Springer.

Reference books:

W.S. Mackenzie, C. Guilford, 1980. Atlas of the Rock-Forming Minerals in Thin Section. Routledge. London
W.S. MacKenzie, A.E. Adams, K.H. Brodie, 2017. Rocks and Minerals in Thin Section. CRC Press, London.
Ramsay, J.G. & Huber, M.I. 1983. The Techniques of Modern Structural Geology. V.1 & V2. Academic Press
Park, R.G. 1982. Foundations of structural geology. Routledge (Taylor & Francis Group)
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.

BSAG 412 Advanced Igneous and Metamorphic Petrology Credits: 4

Unit I

Mechanisms of melting and magma generation. Nature, properties and cooling behaviour of magma. IUGS schemes for classification and nomenclature of igneous rocks. Major volcanic and magmatic provinces of the world. Petrography and interpretation of igneous textures in terms of diffusion, crystal nucleation and growth.

Unit II

Thermodynamic laws, phase rule, free energy, activity, fugacity in the context of igneous petrology. Phase equilibria studies in igneous systems. Major, minor and trace elements and isotopes in igneous petrogenesis. Geochemical and thermodynamic modelling of magmatic processes. Tectonic settings and igneous rock associations.

Unit III

Metamorphic facies. Metamorphic texture and structure. Metamorphic reaction and P-T estimation. Mineral equilibria and phase rule. Thermodynamic modeling. Fundamentals of geochronology. Application of geochronology in metamorphic petrology (P-T-t path).

Unit IV

Metasomatism: fluid inclusion study and texture. Progressive metamorphism of calcareous, and ultramafic rocks. UHT and UHP metamorphism. Crustal anatexis and migmatization. Evolution of plate tectonics and metamorphism with geological time.

Text Books

A.R. Philpotts, 1990. Principles of Igneous and Metamorphic Petrology. Prentice Hall.
A.R. McBirney, 1993. Igneous Petrology. Jones & Bartlett Learning
B. Yardley & C. Warren, 2020. An Introduction to Metamorphic Petrology. Cambridge UP
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 UP

Reference Books

K.G. Cox, J. D. Bell & R. J. Pankhurst, 1979. Interpretation of Igneous Rocks. GAU.
B.W.D. Yardley, 1990. Atlas of metamorphic rocks and their textures. Longman
K. Bucher & R. Grapes, 2011. Petrogenesis of Metamorphic Rocks. Springer
F.S. Spear, 1993. Metamorphic Phase Equilibria and Pressure-Temperature-Time Paths.

BSAG 413 Micropaleontology and Basin Analysis Credits: 4

Micropaleontology

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.

Basin Analysis

Unit I

Classification and texture of sediments and sedimentary rocks; Fluid dynamics and sedimentary structures; Chemical and biogenic structures.

Unit II

Facies analysis of siliciclastic depositional environment: Facies, facies associations and architectural elements of alluvial, lacustrine, aeolian, glacial, shallow coastal and deep marine deposits.

Unit III

Carbonate sedimentation and cycles; Facies analysis of Carbonate depositional environment: shallow coastal marine and lacustrine succession, deep water pelagic and limestone deposits, dolomites

Unit IV

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 on environmental and paleoclimatic interpretation

Unit V

Study of light minerals, heavy minerals, and insoluble residue for provenance studies – climatic and tectonic implications.

Unit VI

Types of sedimentary basins and mechanism of basin formation; Paleocurrent analysis for paleogeographic reconstruction. Interaction among allogenic and autogenic factors (sea level/base level changes, climate, sedimentation rate and tectonism) Sequence Stratigraphy, Application of sequence stratigraphy on outcrop and seismic data; well log analysis. Basin mapping methods and basin modelling techniques: Heat flow analysis for understanding the maturity of the basin.

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.

BSAG 414 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.

BSAG 415 Field Training II 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.

BSAG 416 Geology Lab VI Credits: 3

Advanced Mineral Sciences, Rock Deformation, and Basin Analysis

Rock Deformation Lab

Interpretation of geological maps - determining attitude, stratigraphy, cross-section and deformation structures. Fold analysis by dip isogon method. Methods of strain analysis using natural strain markers. Stereographic projection techniques and applications in structural analyses.

Reference books:

Rowland, S. Duebendorfer, E. & Schiefelbein, I. (2006). Structural Analysis and Synthesis, A Laboratory Course in Structural Geology, 3rd Edition Blackwell Publishers.
Marshak, S and Mitra, G. Basic Methods of Structural Geology. Prentice Hall
G.M. Beninson (1990). An Introduction to Geological Structures and Maps. 5th Edition Edward Arnold.
Bose N. & Mukherjee, S (2017). Map Interpretation for Structural Geologists. Elsevier.

Advanced Mineral Sciences Lab

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.

Reference books:

D. E. Sands, 1993. Introduction to Crystallography. Courier Dover Publications.
Schwarzenbach, D. 1996. Crystallography. John Wiley and Sons.
J. Dana, 1854. A System of Mineralogy [Vols 1, 2]. George P. Putnam and Co.

Basin Analysis

Statistical Analysis of sediments and sedimentary rocks. Study of clastic and non-clastic textures in hand specimens and thin sections. Separation of heavy minerals and their microscopic characteristics. Spherical distribution of flow directions and Palaeocurrent analysis. GPR data interpretation and reconstruction of paleoenvironment. Interpretation of seismic profiles and reconstruction of sea level rise and fall in the basin.

Reference 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.

BSAG 417 Geology Lab VII Credits: 3

Advanced Igneous and Metamorphic Petrology and Micropaleontology

Igneous Petrology

Study of igneous textures and mineral assemblages in megascopic specimens and thin sections. Modal analysis of igneous rocks and CIPW NORM calculation. Harker plots, REE patterns, spider diagrams and trace element modelling to infer magmatic processes.

Metamorphic Petrology

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

Micropaleontology

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

BSAG 421 Ore Geology and Geo-exploration Credits: 4

Unit I

Morphology of ore bodies. Lithological and geochemical characteristics of ore deposits. Global distribution of mineral deposits in time and space. Ore deposits types and classification of mineral deposits. Ore forming processes: Magmatic, metamorphic, hydrothermal, sedimentary and supergene processes of ore formation. Source of ore constituents and ore fluids. Wall rock alteration.

Unit II

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.

Unit III

Understanding ore genesis: structure and texture of ores, ore mineral paragenesis. Fluid inclusion studies and stable isotope geochemistry of ore mineral assemblages.

Unit IV

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. Mobility of elements. Primary and secondary dispersion patterns, geochemical anomalies and their interpretation. Ore deposit evaluation techniques. Concept of cut-off grade and cut-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:

Laurence Robb, 2020. Introduction to ore-forming processes. John Wiley & Sons
John Ridley, 2013. *Ore deposit geology*. Cambridge University Press
J.M. Guilbert and C.F.Park Jr, 2007. The geology of ore deposits. Waveland Press.
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.

BSAG 422 Advanced Geohydrology and Engineering Geology Credits: 4

Advanced Geohydrology

Unit I

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.

Unit II

Aquifer properties- Darcy's law - 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.

Unit III

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.

Unit IV

Water chemistry and quality, Carbonate equilibrium, thermodynamic relationships - Groundwater contamination and restoration – Contaminant transport, advection and dispersion - Sorption and diffusive mass transfer - Aquifer remediation; groundwater restoration- Stable isotopes, radioactive isotopes used in dating, contamination, and recharge studies.

Unit V

Groundwater models: finite difference and element methods - Steady and transient states - 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.

Textbooks:

Fetter, C.W. (2001). Applied Hydrogeology (4th edition). Prentice Hall.
Todd, D.K. (1988). Groundwater Hydrology. John Wiley & Sons.
Heath, R.C. (1983). Basic Ground-Water Hydrology. U.S. Geological Survey Water-Supply Paper 2220.
Driscoll, F.G. (1986). Groundwater and Wells (2nd edition). Johnson Division.

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, P. (1997). Environmental Isotopes in Hydrogeology. Lewis Publishers, Boca Raton.
Bower, H. (1978). Groundwater Hydrology. McGraw Hill Book Co.
Pathak, B.D. (1988). Hydrogeology of India. Central Board for Irrigation and Power, New Delhi.
Freeze, R.A. & Cherry, J.A. (1979). Groundwater. Prentice Hall.
Kresic, N. (2006). Hydrogeology and Groundwater Modeling (2nd edition). CRC Press.

Engineering Geology

Unit I

Role of Geology in civil constructions. Recent advancements.

Unit II

Stages of Geological site investigations for selection of site for engineering structures. Desk study. Analysis of Remote sensing data, Geological maps, cross sections and written reports. Subsurface site characterization.

Unit III

Emphasis on pre construction geological analysis to recognize potential hazards and problems. Weathering and its Impact on Engineering Constructions. Introduction to application of geophysical methods.

Unit IV

Physical and Mechanical properties of rocks: Concepts of stress and strain. Strength, deformation, and hydraulic aspects. Soil Formation and Description of Indian Soils.

Unit V

Engineering classification of Rocks. Construction materials. Geological investigations for construction of dams, reservoirs, tunnels, bridges, and highways.

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.

BSAG 423 Global Tectonics Credits: 4

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

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

Unit III
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.

Unit IV
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.

Unit V
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.

BSAG 424 Geology Lab VIII Credits: 3

Ore Geology and Geo- exploration, Advanced Geohydrology, Engineering Geology

Ore Geology and Geo-exploration

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.

Advanced Geohydrology and Engineering Geology

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 assessment, thermodynamics and saturation index calculations. Development and application of Groundwater models. Engineering properties of rocks and soils, geotechnical investigations

BSAG 425 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.