P. G. DEPARTMENT OF GEOLOGY
UNIVERSUTY OF LADAKH, LEH CAMPUS
LEH, U T OF LADAKH -194 101

Course structure, Marks Scheme

&

Syllabi

for

M. Sc. – Geology

2-year course
(Semester System)

Effective from

Academic Session-2022 onwards

SYLLABI AND COURSES OFFERING IN M.Sc. GEOLOGY

Effective from academic session 2022 onwards

Course structure of M. Sc. Programme as per NEP, 2020 Guidelines

The post-graduate level course of the Department of Geology consists of 2-year course (NEP, 2020 Guidelines) with semester system 4 semesters, with two semesters in a year. Total marks of **2000** (1000 per year and 500 per semester). A student is required to complete **80** credits for the completion of course and the award of degree.

(COURSES, CODES, MARKS, AND CREDITS FOR PG GEOLOGY PROGRAM
PROGRAM CODE: PGGL; C core; L lab; F field work; D dissertation; MD Multidisciplinary)

Semester-I **(Marks:500)**

Paper	Title	Max. Marks	Con. Hours	Total Credits
PGGL-C 101	Structural Geology& Geo Tectonics	100	60	4
PGGL-C 102	Mineralogy& Geochemistry	100	60	4
PGGL-C 103	Paleobiology & Stratigraphy	100	60	4
PGGL-MD 104	Earth Surface Processes	50	30	2
Practical courses (Skill Based)				
PGGL-L 105	Laboratory courses	100	60	4
PGGL-F 106	Skill based minor field Project work Field Geology-I (One-week local geological fieldwork within UT of Ladakh)	50	7 days	2
	Total credits	**500**		***20***

Students can opt for either Multidisciplinary (MD) or Massive Open Online Courses (MOOCs) from Study Webs of Active Learning for Young Aspiring Minds (SWAYAM: www.swayam.gov.in) of 2 credits.

Semester-II **(Marks:500)**

Paper	Title	Max. Marks	Con. Hours	Total Credits
PGGL-C 201	Sedimentology& Sedimentary petrology	100	60	4
PGGL-C 202	Igneous and Metamorphic Petrology	100	60	4
PGGL-C 203	Ore and Fuel Geology	100	60	4
PGGL-MD 204	Isotope Geology	50	30	2
Practical courses (Skill Based)				
PGGL-L 205	Laboratory courses	100	60	4
PGGL-F 206	Skill based Project work on Geological Field Training (Three weeks geological fieldwork outside UT of Ladakh)	50	21 days	2
	Total credits	500		***20***

Students can opt for either Multidisciplinary (MD) or Massive Open Online Courses (MOOCs) from Study Webs of Active Learning for Young Aspiring Minds (SWAYAM: www.swayam.gov.in) of 2 credits.

Semester-III **(Marks:500)**

Paper	Title	Max. Marks	Con. Hours	Total Credits
PGGL-C 301	Hydrogeology &Environmental Geology	100	60	4
PGGL-C 302	Engineering &Himalayan Geology	100	60	4
PGGL-C 303	Remote Sensing & GIS	100	60	4
PGGL-MD 304	Geophysics	50	30	2
PGGL-MD 305	Rocks and minerals of Ladakh	50	30	2
PGGL-MD 306	Stratigraphy and fossils	50	30	2
Practical courses (Skill Based)				
PGGL-L 307	Laboratory courses	100	60	04
PGGL-P 308	Skill based Project (Dissertation project work)	50	30	02
	Total credits	**500**		***20***

In 3rd semester, the students have to choose one MD of 2 credits from sister departments or Massive Open Online Courses (MOOCs) from Study Webs of Active of 2 credits Learning for Young Aspiring Minds (SWAYAM: www.swayam.gov.in) or from the within department.

Semester-IV **(Marks:500)**

Paper	Title	Max. Marks	Con. Hours	Total Credits
PGGL-C 401	Quaternary Geology & Paleoclimate	100	60	4
PGGL-C 402	Mining & Exploration Geology	100	60	4
PGGL-C403	Oceanography& Marine Geology	100	60	4
PGGL-D 404	Dissertation Project Work	200	3 months	8
	Total credits	**500**		**20**

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FIRST SEMESTER

Paper-Structural Geology & Geotectonics Course code: PGGL-C 101 Credits: 4 M. Marks: 100 (External=70, Internal = 30) 60 Hrs. (6 Hrs./week)

OBJECTIVE OF THE COURSE

1 To teach students the basic concepts of stress, strain and how they are measured in deformed rocks.
2 To teach students the structural geometries developed in extensional, compressional, and strike slip settings and the concept of brittle and ductile shear zones.
3 To teach students the mechanisms of folding, faulting and other structures and stereographic projection techniques to recognize deformation mechanisms in rocks.
4 To teach about the earths tectonic plates and how their movement shapes the earth's surface and its processes.

Unit I:

Dynamic analysis: Concept and methods of structural analysis. Stress and different methods of stress analyses. Stress on a surface and at a point. Stress ellipse and ellipsoid. Mohr circle and its interpretation.

Kinematic analysis: Concept of strain. Computing strain from lines and angles. Shear strain. Strain ellipsoid, its calculation and application.

Unit II:

Analysis of Structures: Geometry and types of folds. Ramsay's classification of folds. Mechanics of single layer and multilayer folds and associated structures.

Fractures and joints: classification, origin, significance, and analysis. Faults: classification and mechanism of development. Thrust systems and decollement. Petro-fabric analysis and its significance.

Unit III:

Introduction to geotectonics, continental drift, seafloor spreading and convection current hypotheses. Palaeomagnetism, polar wandering, and reversal of earth's magnetic field. Geomagnetic time scale and magnetostratigraphic. Geotectonic features of the ocean, continent and continental margins.

Unit IV:

Plates and Earth's critical zone plate boundaries. Principles of plate tectonics. Euler's theorem. Mantle plume models of plate movements. Orogeny and Epeirogeny. Anatomy of major orogenic belts of earth. Introduction to neotectonics and active tectonics.

Suggested Books on Structural Geology

Essential

Davis GR, 1984. Structural Geology of Rocks and Region. John Wiley.
Hobbs BE, Means WD & Williams PF, 1976. An Outline of Structural Geology.
Pollard DD and Fletcher RC, 2005. Fundamentals of structural geology, Cambridge University Press.
Ramsay JG, 1967. Folding and Fracturing of Rocks. McGraw Hill.
Ramsay JG and Huber MI. Modem Structural Geology, Vol. I, II, III. Academic Press.
Lisle RJ, 2004. Geological Structures and Maps: A Practical Guide, Third edition. Elsevier.

Further Reading

Bayly B, 1992. Mechanics in Structural Geology, Springer.
Davis GH and Reynolds SJ, 1996. Structural Geology of rocks and regions, John Wiley and Sons.
Ghosh SK, 1995. Structural Geology Fundamentals of modem Developments. P. Press.

Lisle RJ and Leyshon PR, 2004. Stereographic Projection Techniques for Geologists and Civil Engineers, 2 edition, Cambridge University Press.
Price NJ and Cosgrove JW, 1990. Analysis of Geological Structure. CU press.
Ragan DM, 2009. Structural Geology: An Introduction to Geometrical Techniques (Fourth Edition).
Rowland SM, Duebendorfer EM and Schiefelbein IM, 2007. Structural Analysis and Synthesis: A Laboratory Course in Structural Geology 3 edition, Wiley-Blackwell.

Suggested Books on Geotectonics

Essential

Davies GF, 1999. Dynamic Earth: Plates, Plumes and Mantle Convection. Cambridge University Press.
Kearey P and Vine, 2000. Global Tectonics. Black Well.
Kearey P, Klepeis, K. A. and Vine, F. J., 2009. Global Tectonics 3rd Edition. Wiley-Blackwell.
Cox A, 1996. Plate Tectonics. Blackwell.
Condie KC, 1989. Plate Tectonics and Crustal Evolution. 3rd Edition. Butterworth-Heinemann Ltd.

Further Reading

Keller EA and Pinter N, 2001. Active Tectonics. 2nd Edition. Pearson Publications.
Windlley B, 1995. The Evolving Continents. 3rd Edition Wiley-Blackwell.
Leyson PR and Lisle RJ, 1996. Stereographic projection techniques in structural geology, Cambridge University Press.

Paper-Core: Mineralogy and Geochemistry Course code: PGGL-C 102 Credits: 4 M. Marks: 100 (External=70, Internal = 30) 60 Hrs. (6 Hrs./week)

OBJECTIVE OF THE COURSE

1. To impart comprehensive knowledge formation, classification, association and occurrence of rock forming minerals.
2. To impart in-depth knowledge about the identification of minerals based on physical, chemical and optical properties of mineral
3. To understand distribution and applications of various groups of elements in Geology.
4. To understand concept of radioactive elements and radioactive dating methods.

UNIT-I

Atomic structure, ionic size, radius ratio, coordination number, types of chemical bonding. Pauling's rules, Polymorphism, Pseudomorphism, Isomorphism, Polytypism, and Polysomatism solid solution, types of solid solution, Exsolution, Zoning. Physical, electrical and magnetic properties of minerals. Physical properties, mode of occurrence and p-t stability of following common rock forming mineral groups: a) Nesosilicates: b) Aluminosilicate Group: c) Cyclosilicates: d) Inosilicates: e) Phyllosilicates: f) Tectosilicate: g) Oxides: h) Carbonates: i) Phosphates: j) Sulphides:

UNIT-II

Concept of polarizing microscope and accessory plates. Concept of Orthoscopic and conoscopic study of minerals. Application of optical indicatrix. Interference phenomenon and chart. Optic figure, Optic sign, Dispersion, Pleochroism and absorption, Double refraction, and Refractive index. Determinative methods for Refractive index (Colored Backeline variation method).Pleochroism scheme and 2V Microscopic methods. Optical properties of essential rock forming minerals.

UNIT-III

Origin of elements, Nucleosynthesis. Geochemical cycle; Meteorites types and composition; Goldschmidt's

classification of elements; Fractionation of elements in minerals / rocks; Nernst's
partition coefficient (compatible and incompatible elements), Nernst-Berthelot partition coefficient and bulk partition coefficient; Laws of substitution of trace elements. Application of trace elements in petrogenesis of rocks. Concept and applications of REEs, PGEs and Eh and pH diagrams.

UNIT-IV

Radioactivity, Half-life and decay equation; dating of minerals and rocks with potassium-argon, rubidium-strontium, uranium-lead and samarium-neodymium isotopes; petrogenetic implications of samarium-neodymium and rubidium-strontium systems; Stable isotope geochemistry of carbon, oxygen and Sulphur and their applications in geology; monazite chemical dating

Suggested Books

Essential

Dana, E.S. and Ford, W.E., 2002. A text book of Mineralogy (Reprint)
Berry, L.G., Mason, B. and Dietrich, R.V., 1985. Mineralogy: Concepts, Descriptions and determinations. CBS Publishers.
Kerr, P.F., 1977. Optical Mineralogy McGrew Hill.
Nesse, D.W., 1986. Optical Mineralogy, McGraw Hill
Deer, W.A., Howie, R.A. & Zussman, J., 2013.An Introduction to the rock forming minerals, ELBS and Longman.
K. B. Krauskopf : 1979, Introduction to Geochemistry. McGraw Hill.
Albarede, F., 2003.An introduction to geochemistry. Cambridge University Press.
Faure, G., 1986.Principle of Isotope Geology, J. Wiley & Sons.
Walther, J, V., 2008. Essentials of geochemistry, student edition. Jones and Bartlett Publishers.
Hoefs, J., 1980. Stable isotope Geochemistry-Springer Verlag.
Brian Mason 1982, Principles of Geochemistry. J. Wiley & Sons.

Further readings

Gribble, C.D., 2005.Rutley's elements of Mineralogy, Springer.
Perkins, D., 2013. Mineralogy, Prentice Hall
Winchell, E.N., 1951.Elements of Optical Mineralogy, Wiley Eastern.
Dickin, A. P., 2005. Radiogenic Isotope Geology 2nd Edition, Cambridge University Press
Faure, G. and Mensing, T. M., 2005. Isotopes-Principles and Application, 3rd Edition, John Wiley and Sons Ltd, New York.
Henderson, P., 1982.Inorganic Geochemistry, Pergamon Press, Oxford.
Krauskopf, K. B., 1979. Introduction to Geochemistry. McGraw Hill.
Mason, B. and Moore, C.B., 1991. Introduction to Geochemistry-Wiley Eastern
Rollinson, H., 2007. Using geochemical data-evaluation. Presentation and interpretation. 2nd Edition. Publisher Longman Scientific & Technical.

Paper-Paleobiology & Stratigraphy Course code: PGGL-C 103 Credits: 4 M. Marks: 100 (External=70, Internal = 30) 60 Hrs. (6 Hrs./week)

OBJECTIVE OF THE COURSE

1. To impart the knowledge about the concept of Paleobiology and Origin of life.
2. To understand the basic knowledge of paleontology and fossil record through geological time.

3. To impart basic knowledge about principles of stratigraphy and to understand correlation of Indian Stratigraphy.
4. To study the different Indian stratigraphic sections related to stratigraphic boundary problems.

Paleobiology

Unit I: Modern concepts of origin of life; Precambrian fossil record and Origin of Metazoans; Concept of Taphonomy and Fossil communities; Mmorphology, classification and evolutionary geological history of Phylum Brachiopoda, Lamellibranchia and Gastropoda. Siwalik vertebrates & their geological significance. Gondwana plant fossils: classification and distribution in India.

Unit II: Introduction to various groups of microfossils, their importance in geology; Morphology, classification, ecology and geological significance of Foraminifera, Ostracods and Conodonts; Application of microfossils hydrocarbon exploration. Morphology of pollens and spores and their geological significance.

Stratigraphy

Unit I: Introduction and scope of stratigraphy; Principles & laws of stratigraphy; Code of stratigraphic nomenclature, Archaean cratonic nuclei of Peninsular India with particular reference to Dharwar, Singbhum & Aravalli; Proterozoic mobile belts of eastern Ghats and Satpura. Purana Sedimentary basins with special reference to Cuddapah and Vindhyan basins;

Unit II: Palaeozoic stratigraphy of India with particular reference to Jammu and Kashmir, Himachal Pradesh, Uttaranchal and Peninsular India. Classification, lithology and biostratigraphy of Gondwana Super Group; Classification, lithology and biostratigraphy of Siwalik Super Group. Boundary problem in stratigraphy: Precambrian-Cambrian Boundary; Permian -Triassic Boundary and Cretaceous – Tertiary Boundary with special to Indian stratigraphic Horizons

Suggested Books

Bignot, G., Grahm and Trottman (1985): Elements of Micropaleontology, London.
Clarksons, E.N.K. (1998): Invertebrate Paleontology and Evolution, Allen and Unwin,
Benton, M.J. (1990): Vertebrate Paleontology. Unwin Hyman, Lindon.
Raup, D.M. and Stanley, S.M. (1985): Principles of Paleontology ,CBS Publ..
Strean, C.W. and Carroll, R.L. (1989): Paleontology the record of life, John Wiley.
Swnnerton, H.H. (1950): An outline of paleontology, Edward Arnold and Co.
Alfred R. Loeblich, Jr. and Helen Tappan (1998): Foraminiferal Genera and their classification: VanNostrand Reinhold Company, New York
Arnold (2002): Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett), Oxford university Press, New York.
B.K. Sengupta: Modern Foraminifera
Boardman, R.S., Cheethan, A.M. and Rowell, A.J. (1988): Fossil Invertebrates, Blackwell.
London.
Colbert, E.H. (1984): Evolution of Vertebrates. Willey Eeastern Ltd.
Glaessner. N. (1944): Principles of Micropaleontology, Melbourne
Haynes,J.R; 1981: Foraminifera, John Wiley
Jones, D..J. Introduction to Microfossils: Cambridge University press
Jones, Robert Wynn. (1996): Micropaleontology in Petroleum Exploration, Clarendon Press
M. Brasier: Micropaleontology, Blackwell
Prothero, D.R. (2004): Bringing Fossil to Life An Introduction to Paleontology (2nd Ed.), McGraw Hill.
Raup, D.M. and Stanley, S.M (2008): Earth System History, Blackwell Publ.

Romer, A.S. (1966): Vertebrate Paleontology (3rd Edn.) Chicago University Press.
Vladimir Pokorny(1963):Principles of Zoological Micropaleontology, Vol.1, Pergamon press, Oxford, London, New York,pp.91
Dunbar, C.O. and Rodgers, J. (1957): Principles of Stratigraphy. John Wiley & Sons.
Schoch, Robert, M. (1989): Stratigraphy: Principles and Methods, Van Nostrand Reinhold, New York.
Naqvi, S.M. and Rogers, J.J.W. 1987: Precambrian Geology of India. Oxford University Press.
Brenner, R.E. and Mc Hargue, T.R. 1988: Integrative Stratigraphy: Concepts and Applications. Prentice Hall.
Goodwin, A.M. 1991: Precambrian Geology: The Dynamic Evolution of Continental Crust. Academic Press.
Pomerol, C. 1982: The Cenozoic Era: Tertiary and Quaternary. Ellis Harwood Ltd.
Krishnan, M.S. (1982): Geology of India and Burma. C.B.S. Publishers & Distributors, Delhi
Pascoe, E.H. (1968): A Manual of the Geology of India & Burma (Vols.I-IV) Govt. of India Press, Delhi
Doyle, P. & Bennett. M.R. (1996): Unlocking the Stratigraphic Record (John Willey).
Pascoe, E.H. 1968. A manual of the Geology of India and Burma (Vol.IIV), Govt. of India Press, Delhi.
Ramakrishnan, M. &Vaidyanathan, R. 2008.Geology of India Volumes 1 & 2, geological society of India, Bangalore.
Valdiya, K.S. 2010. The making of lndia, Macmillan India Pvt. Ltd.

Paper-MD: Earth Surface Processes Course code: PGGL-MD 104
Credits: 2M. Marks: 50 (External=35, Internal = 15) 30 Hrs. (3 Hrs./week)

OBJECTIVE OF THE COURSE

1. To impart knowledge of basic concepts of Earth Processes
2. To build concepts of Earth surface processes and its applications in geological studies.
3. To understand landforms and their evolution

Unit I:

Introduction to earth surface processes and historical development in concepts, terrestrial relief, scales in geomorphology, energy flow and relative energy of surface processes

Unit II:

Weathering and formation of soils, karst and speleology, slope and catchment erosion processes, fluvial, eolian, glacial, periglacial and coastal processes and resultant landforms, physiographic features and river basins in India

Suggested Books

Essential

Allen, P. A., 2009. Earth Surface Processes. Wiley.
Bloom, A.L., 1998. Geomorphology: A Systematic Analysis of Late Cenozoic Landforms, Pearson Education.
Davies, G.F. 1999, Dynamic Earth: Plates, Plumes and Mantle Convection. Cambridge University Press.
Kearey, P., Klepeis, K. A. and Vine, F. J., 2009. Global Tectonics 3rd Edition. Wiley-Blackwell.
Cox, A., 1996, Plate Tectonics. Blackwell.

Further Reading

Burbank, DW and Anderson, R S 2016. Tectonic Geomorphology. Wiley India.
Condie, K. C., 1989. Plate Tectonics and Crustal Evolution. 3rd Edition. Butterworth-Heinemann Ltd.
Gass I G., et al. 1982. Understanding the Earth. Artemis Press (Pvt) Ltd. U.K.
John Bridge and Robert Demicco: Earth Surface Processes and Landforms and Sediment Deposit.

Jon D. Pelletier. 2008. Quantitative Modeling of Earth Surface Processes. Cambridge University Press
Keller, E. A. and Pinter, N., 2001. Active Tectonics. 2nd Edition. Pearson Publications.
Summerfield, M. A., 1991. Global Geomorphology, Prentice Hall.
Windlley, B., 1995. The Evolving Continents. 3rd Edition Wiley-Blackwell.

Paper: Laboratory courses Course code: PGGL-L 105
Credits: 4 M. Marks: 100 (External=70, Internal = 30) 60 Hrs. (3 Hrs./week)

Structural Geology &Geotectonics

Preparation and interpretation of geological maps and sections. Exercises on stress and strain analysis. Structural problems related to borehole data used in mineral exploration. Stereographic projections, π and β diagrams, and analyses of structural data. Study of tectonic features of the Earth.

Paleobiology & Stratigraphy

Identification, Morphology, classification of given invertebrate fossils, microfossils & plant fossils. Identification and description of given stratigraphic rocks from various stratigraphic horizons of India and preparation of stratigraphic column.

Mineralogy and Geochemistry

Megascopic and microscopic identification of important rock forming minerals. Preparation of thin section and polished sections. Etching and staining. Open and closed acid digestion methods. Preparation of classificatory and variation diagrams and their interpretation; plotting of REE data and their interpretation.

Paper-Skill based minor Project work Course code: PGGL-F 106 Credits: 2
M. Marks: 50 (External=35, Internal = 15) 30 Hrs. (3 Hrs./week)

The course is intended to familiarize the students with exposure of rocks, basic techniques of field work, introduction to concepts of geological mapping, hand-on training of mapping. Geological Field Training shall be conducted on every alternate week in the Ladakh region.

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SECOND SEMESTER

Paper-Core 1: Sedimentology & sedimentary Petrology Course code: PGGL-C 201 Credits: 4M. Marks: 100 (External=70, Internal = 30) 60 Hrs. (6 Hrs./week)

OBJECTIVE OF THE COURSE

1 To teach students the knowledge of hydrodynamic conditions, mode of transport and depositional conditions for the clastic sediments.
2 To teach the students the processes of formation of sedimentary rocks and classification of depositional environments.
3 To make understand the students the origin, classification and distribution of sedimentary rocks.
4 To teach the processes of generation of sedimentary structures and understand the lithofacies analysis in depositional environments.

Unit I:

Introduction to earth surface system and sedimentation; Liberation of flux of sediments; Fluid flow mechanics and formation of sedimentary bed forms; Concept of Flow Regime; Physical and chemical parameters of depositional environments; Concept of sedimentary facies and facies association; Walter's Law of facies and application; Sedimentary cycles and cyclothems; Facies models and environmental reconstruction.

Unit II:

Introduction to sedimentary processes; Lithification & Diagenesis; Classification of sediments; Particle morphology of clastic and non-clastic sediments; Properties of sedimentary particles as size, shape, roundness, sphericity, fabric, form and surface textures; Types of sedimentary structures and their genesis and significance,

Unit III:

Introduction to petrogenesis of sedimentary rocks; Classification of sandstones and limestones; Diagenesis of sandstones and carbonate rocks; Dolomitization; Heavy minerals and their uses in provenance studies. Clay minerals and their significance.

UNIT V:

Introduction and classification of sedimentary environments; Lithologies, structures and vertical sequences formed in alluvial, deltaic, coastal, and deep sea, and glacial and aeolian environments; Use of sedimentary structures in reconstruction of paleogeography, paleocurrent and basin analysis; Sedimentation and tectonic control on sedimentation; Basin evolution in relation to plate tectonics.

Suggested Books

Sam Boggs, 1995. Principles of Sedimentology and Stratigraphy, Prentice Hall, New Jersey.
Pettijohn, F. J., 1975. Sedimentary Rocks, Harper and Row Publ. New Delhi.
Blatt, H., Middleton, G. V., Murray, R. C., 1980.Origin of Sedimentary Rocks, Prentice-Hall Inc.
Collinson, J. D., Thompson, D. B., 1988. Sedimentary Structures, Unwin-Hyman, London.
Hsu, K.J., 2004. Physics of Sedimentology, Springer Verlag, Berlin.
James, N. P and Jones, B., 2016. Origin of carbonate sedimentary rocks. Wiley.
Leeder, M. R., 1982. Sedimentology: Process and Product. George Alien &Unwin, London.
Nichols, G., 1999.Sedimentology and Stratigraphy, Blackwell publishing.
Allen, J.R.L. 1985: Principles of Physical Sedimentation. George Allen & Unwin.
Allen, P. 1997: Earth Surface Processes. Blackwell.
Bhattacharya, A. and Chakrabarti, C. 2000: Analyses of Sedimentary Successions. Oxford -IBH.
Blatt, H., Murray, G.V., and Middleton, R.C. 1980: Origin of Sedimentary Rocks.

Boggs, Sam Jr. 1995: Principles of Sedimentology and Stratigraphy. Prentice Hall.
Davis, R.A. Jr. 1992: Depositional Systems. Prentice Hall.
Einsele, G. 1992: Sedimentary Basins. Springer Verlag.
Lindholm, R.C. (1987) A Practical Approach to Sedimentology, Allen and Unwin, London.
Miall, A.D. 2000: Principles of Sedimentary Basin Analysis. Springer Verlag.
Nichols, G. 1999: Sedimentology and Stratigraphy. Blackwell.
Pettijohn, F.J., Potter, P.E., and Siever, R. 1990: Sand and Sandstone. Springer Verlag.
Prothero, D.R. and Schwab, F. 1996: Sedimentary Geology. Freeman.
Reading, H.G. 1996: Sedimentary Environments. Blackwell.
Reineck, H.E. and Singh, I.B. 1980: Depositional Sedimentary Environments. Springer Verlag.
Selley, R. C. (2000) Applied Sedimentology, Academic Press.
Sengupta, S. 1997: Introduction to Sedimentology. Oxford - IBH.
Tucker, M.E. (1981): Sedimentary Petrology: An Introduction, Wiley and Sons, New York.
Tucker, M.E. (1990): Carbonate Sedimentology, Blackwell Scientific Publication.

Paper-Core: Igneous and Metamorphic Petrology Course code: PGGL-C 202 Credits: 4 M. Marks: 100 (External=70, Internal = 30) 60 Hrs. (6 Hrs./week)

OBJECTIVE OF THE COURSE

1. To impart knowledge about the magmatic systems
2. To understand characteristics and genesis of Igneous rocks
3. Application of the silicate phase equilibrium to understand magma genesis and crystallization.
4. To understand characteristics of various facies and belts of metamorphism.
5. To understand characteristics of various metamorphic rocks.

UNIT-I

Magma: types, components, chemistry, physical properties. Processes involved in Evolution of primary magma: Fractional crystallization, Assimilation and crustal contamination, magma mixing and mingling, and immiscibility. Nucleation and growth of minerals in magmatic rocks. Types of mantle melting (batch, fractional and dynamic). Mantle components. Chemical classification of Igneous rocks. IUGS classification of plutonic and volcanic rocks. Magmatism in relation to plate tectonics. Mantle plumes and associated magmatism. Genesis and petrogenetic significance of following textures: porphyritic, spinifex, rapakivi and intergrowths.

UNIT-II

Concept of system, component and phase. Binary (albite-anorthite, forsterite-silica and diopside-anorthite) and ternary (diopside-forsterite-silica and diopside-forsterite-anorthite) magmatic crystallization systems. Tectonic setting and petrogenesis of the following: Basalts, Andesites, Granites, Boninites, Anorthosites, Kimberlites and Lamprophyres. Petrogenesis of Decan traps and Panjal traps. Formation and types of Ophiolites.

UNIT-III

Introduction to metamorphic petrology: Metamorphism and metamorphic processes; factors controlling metamorphism; role of fluids in metamorphism; types of metamorphism; Index minerals; Mineral assemblages; metamorphic differentiation. Metamorphic structures and textures. Progressive and retrogressive metamorphism of pelitic, calcareous and basic rocks. Metamorphic facies: detailed description of each facies of low pressure, medium to high pressures and very high pressure.

UNIT-IV

Basic characteristics of metamorphic reactions, solid-solid reactions, dehydration reactions, decarbonization and

oxidation-reduction reactions. Mineralogical geothermo-barometry (applications and pitfalls). Roles of bulk rock and fluid compositions on the dispositions of isograds. Schrienemakers rule and construction of petrogenetic grids; their application to petrological problems. Regional metamorphism and paired metamorphic belts. Metamorphic facies series. P-T-t paths and their implications. Ultra-high temperature, ultra-high pressure and ocean-floor metamorphism.

Suggested Books

Essential

Best, M. G., 1986.Igneous and Metamorphic Petrology, CBS Pub.
Bose, M. K., 1997.Igneous Petrology. World Press.
Hall, A., 1988.Igneous petrology. ELBSI Longman.
Winter, J.D., 2010. Igneous and Metamorphic Petrology.

Further Readings

Gill, R., 2010. Igneous Rocks and Processes: a practical guide. John Wiley & Sons.
McBirney, A. R., 1993.Igneous Petrology. John Wiley.
Phillpotts, A., 1992.Igneous and Metamorphic Petrology. Prentice Hall.
Sen, G., 2014. Petrology: Principles and Practice, Springer
Shelley, D., 1995.Descriptive Petrology of the Igneous Rocks. Chapman & Hall.
Turner & Verhoogen, 1999.Igneous and Metamorphic Petrology. CBS Pub.
Wilson, M., 1989. Igneous Petrogenesis: A Global Tectonic Approach. Chapman and Hall publishing.
Yardley, B.W.D., 1997. An Introduction to Metamorphic Petrology, Longman Earth Science Series.

Further Readings

Bucher, K. and Grapes, R., 2010. Petrogenesis of Metamorphic Rocks, Springer.
Fry, N., 1985. Field Description of Metamorphic Rocks, New York, Geological Society of London Handbook Series.
Vernon, R. H., and Clarke G.L. 2008. Principles of Metamorphic Petrology, Cambridge University Press.

Paper-Core: Ore and Fuel Geology Course code: PGGL-C 203
Credits: 4 M. Marks: 100 (External=70, Internal = 30) 60 Hrs. (6 Hrs./week)

OBJECTIVE OF THE COURSE

The objectives of this course are to: (a) to introduce economic and policy issues related to minerals and their national importance, (b) make students understand fundamentals of ore, hydrocarbon and coal, various environments and processes of their formation, (c) familiarize with common ore minerals and their identifying criteria at various scales of study (d) to understand the genetic controls exerted by physical and chemical processes on ore formation in various geologic settings, and (e) to familiarize and understand the genetic controls exerted by physical and chemical processes on hydrocarbon and coal deposits in various geologic settings.

Unit I: 15 hours.

Mineral economics and its significance. Different types of ore reserves. National Mineral Policy. UNFC classification. Processes of formation of different ore deposits. General characteristics and genesis of magmatic ore deposits - chromite deposits, base-metal Ni-Cu sulphide deposits, PGE sulphide deposits, rare-metal pegmatites and diamond deposits associated with kimberlites and lamproites. Chemical and clastic deposits. Weathering and Placer deposits. Ore deposits formed by supergene processes. Fluid inclusions in ore mineral assemblage.

Unit II: 15 hours

Basic concepts related to hydrothermal ore formation. Chemical nature of hydrothermal ore fluid in magmatic, metamorphic and sedimentary basin environments. General characteristics and genesis of hydrothermal ore deposits

- Porphyry deposits; greisen and related ore deposits; skarn and carbonate-replacement deposits; epithermal deposits; volcanic-hosted massive sulfide deposits; orogenic gold deposits; carlin-type deposits; iron oxide-copper-gold (IOCG) deposits; Mississippi Valley-type (MVT) Pb-Zn deposits; SEDEX Pb-Zn-Ag deposits. Red-bed copper deposits and various type of uranium deposits.

Unit III: 15 hours

Origin of Hydrocarbons (Petroleum and Gas). (Inorganic and Organic theories). Formation of source rocks- Kerogen, organic maturation and thermal cracking of Kerogen. Properties of reservoir rocks. Classification of reservoir rocks, clastic and non-clastic reservoir rocks. Migration of oil and gas, geologic framework of migration; primary and secondary migration.

Definition and classification of hydrocarbon traps, structural, stratigraphic and combination. Cap rocks- definition and general properties. Plate tectonics and global distribution of hydrocarbon reserves. Petroliferous basins of India: Petroleum geology of Assam-Arakan, Cauvery basin, Krishna-Godavari, Cambay and Bombay offshore basins.

Unit IV: 15 hours

Definition and origin of coal, process of coalification. Classification of coal in terms of type, grade and rank. Classification of coal (cocking coal, non- coking coal, international classification). Composition of coal, lithotype and micro-lithotype classification. Concept of maceral and its classification: their physical chemical and optical properties.

Concept of Coal Bed Methane (CBM) an unconventional source of energy. Coal forming epochs in geological past. Concept of Gondwanaland and plate tectonics and its effect on distribution of coal on earth. Geological and geographical distribution of coal and lignite in India.

Suggested Books

Essential

1. Barker, C., Thermal Modelling of Petroleum Generation, Pubs: Elsevier Science (1996).
2. Barnes, H.L., Geochemistry of Hydrothermal Ore Deposits, Pubs: John Wiley (1979).
3. Chandra, D., Singh, R.M., Singh M.P., Text book of coal (Indian context), Pubs: Tara Book Agency, Varanasi (2000).
4. Craig, J. R., and Vaughn, D.J., Ore microscopy and ore mineralogy (1994).
5. Evans, A. M., Ore Geology and Industrial Minerals, Pubs: Blackwell (1993).
6. Jahn, F., Cook, M. and Graham, M., Hydrocarbon Exploration and Production, Pubs; Elsevier Science (1998).
7. Mukherjee, A., Ore Genesis - A Holistic Approach, Pubs: Allied Publisher (2000).
8. Ridley, J., Ore deposit geology, Pubs: Cambridge University Press (2013).
9. Sawkins, F. J., Metal deposits in relation to plate tectonics, Pubs: Springer Science & Business Media (2013).
10. Larry, T., Coal Geology, Pubs: John Wiley and Sons. Ltd. England (2002).
11. Selley, R.C., Elements of petroleum geology, Pubs: Academic Press (1998).

Further Reading

1. Bateman, Alan Mara, and Mead L. Jensen. Economic mineral deposits. Vol. 259, Pubs: Wiley (1950).
2. Makhous, M., The Formation of Hydrocarbon Deposits in North African Basins, Geological and Geochemical Conditions, Pubs: Springer-Verlag (2000).
3. McDonald, I., Boyce, A. J., Butler, I.B., Herrington, R. J. and Polys, D. A. (Eds), Mineral Deposits and Earth Evolution, Pubs: The Geological Society of London (2005).
4. Nicholas, A. and Ganino, C., Metals and Society – An Introduction to Economic Geology, Pubs: Springer, Heidelberg (2012).
5. North, F.K., Petroleum Geology, Pubs: Allen Unwin (1985).
6. Pracejus, B., The ore minerals under the microscope: an optical guide. Vol. 3. Pubs: Elsevier (2015).

7. Stach, E., Mackowsky, M-Th., Tylor, G.H., Chandra, D., Teichumullelr, L. and Teichumuller, R., Text book on coal petrology, Pubs: Gebruder Borntreager Stuttgart (1982).
8. Taylor, G. H., Teichmuller, M., Davis, A., Diesel, C. F. K., Littke, R and Robert, P., Organic Petrology, Pubs: Gebruder Borntreager Stuttgart (1998).
9. Scott, A.C., Coal and coal bearing strata: Recent Advances, Pubs: Blackwell Scientifics Publications (1987).
10. Tissot, B. P. and Welte, D. H., Petroleum formation and occurrence, Pubs: Springer–Verlag (1984).
11. Van Krevelen, D. W., Coal: Typology-Physics-Chemistry-Constitution, Pubs: Elsevier Science, Netherlands (1993).

Paper-MD: Isotope Geology Course code: PGGL-MD 204 Credits: 2
M. Marks: 50 (External=35, Internal = 15) 30 Hrs. (2 Hrs./week)

OBJECTIVE OF THE COURSE

1. To impart basic knowledge about Radiogenic & Stable Isotopes.

UNIT I

Introduction, nuclear stability, atomic mass and binding energy. Half-life and decay equation; dating of minerals and rocks with potassium-argon, rubidium-strontium, uranium-lead and samarium-neodymium isotopes; petrogenetic implications of samarium-neodymium and rubidium-strontium systems;

UNIT II

Stable isotope geochemistry of carbon, oxygen and Sulphur and their applications in geology; monazite chemical dating

Suggested Books

Essential

1. Dickin, A.P., 1997: Radiogenic Isotope Geology. Cambridge University Press.
2. Faure, G. (1986). Principles of Isotope Geology, John Wiley & Sons, New York.
3. Heofs, J. (1987). Stable Isotope geochemistry, Springer– Verlag, Berlin.
4. Rollinson, H. (1993). Using Geochemical Data: Evaluation, Presentation Interpretation. Longman, Essex.

Further Readings

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

Paper: Laboratory courses Course code: PGGL-L 205 Credits: 2 M. Marks: 50 (External=35, Internal= 15) 30 Hrs. (3 Hrs./week)

Sedimentology & Sedimentary petrology

Megascopic & microscopic study of clastic and non-clastic rocks. Exercises related to paleocurrent analysis and interpretation of depositional sedimentary environments. Heavy mineral separation and microscopic examination. Grain-size analysis by sieving method; Plotting of size-distribution data as frequency and cumulative curves, computation of statistical parameters and interpretation.

Igneous & Metamorphic Petrology

Megascopic and microscopic study of various igneous rocks. Calculation of CIPW Norm, Normalized plots of trace elements and rare earth elements and their interpretations. Chemographic diagrams (ACF & AFM ternary diagrams). Megascopic and microscopic study of metamorphic rocks representing different metamorphic facies. Calculation of ACF, AKF and AFM values from chemical and structural formulation of minerals and their graphical representation.

Ore and Fuel Geology

Megascopic study of metallic and industrial minerals in hand specimens; Study of ore structures in hand specimens; Study of optical properties and identification of important ore minerals under ore-microscope; Preparation of maps showing distribution of metallic and industrial minerals in India and also classical world mineral deposits. Spatial distribution of various metallogenic provinces in India and associated ore deposits.

Paper: Skill based Project work Course code: PGGL-F 206 Credits: 4

M. Marks: 100 (External=70, Internal = 30) 60 Hrs. (6 Hrs./week)

The course is intended to familiarize the students with exposure of rocks, basic techniques of field work, introduction to concepts of geological mapping, hand-on training of mapping. Geological Field Training will be imparted for three weeks outside UT of Ladakh. Project report has to be submitted after the completion of the training.

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THIRD SEMESTER

Paper-Hydrogeology and Environmental Geology Course code: PGGL-C 301 Credits: 4
M. Marks: 100 (External=70, Internal = 30) 60 Hrs. (6 Hrs./week)

OBJECTIVE OF THE COURSE

1. To teach about groundwater, fundamentals of aquifers, groundwater flow, and various processes of groundwater.
2. To teach the students natural and anthropogenic controls on water chemistry and quality, and the concepts of groundwater modelling and management in different aquifers.
3. To impart the knowledge about basics of environmental geology, natural hazards and their effects, and critical thinking about the environment.

Unit I:

Groundwater in the hydrologic cycle. Groundwater & Groundwater table. Groundwater flow processes. Types of aquifers. Hydrogeological properties, definition and methods of determination. Darcy's law. Differential equation of groundwater flow. Theory of groundwater flow in confined and unconfined aquifers.

Well hydraulics. Well & well designs. Specific capacity and its determination. Radial flow into wells. Pumping tests aquifer characteristics in confined, unconfined and leaky aquifers.

Unit II:

Groundwater chemistry: Physical, chemical, and biological parameters. Quality criteria for different uses. Geogenic and anthropogenic contamination. Graphical presentation of water quality data. Coastal aquifers and their development. Study of Groundwater in India.

Groundwater exploration: Geomorphic, lithological, lineament mapping, fracture trace analysis & Remote sensing in groundwater. Surface geophysical methods. Geophysical logging. Introduction to groundwater modeling and management. Introduction to MODFLOW software.

Unit III:

Concepts of environmental geology. Anthropocene. Local and global changes in the environment. Global warming: causes and impacts. Carbon sequestration. Change of atmosphere and ocean circulation and their impact on climate and environment.

Environmental impact assessment from exploitation of mineral, water, and energy resources and construction and urbanization with some examples from India.

Unit IV:

Geohazards: Exogenic and Endogenic hazards. Earthquakes and their impacts on environment. Landslide, flood, volcanic, and coastal hazards, their causes and controls.

Waste management and geological environment. Solid and liquid waste. Waste disposal. Waste gases and the atmosphere. Radioactive waste and management. Environmental legislation.

Suggested Books on Hydrogeology

Essential

Fetter, C. W., 1990. Applied Hydrogeology. Merill Publishing.
Freeze RA, Cherry JA, 1979. Groundwater, Englewood Cliffs, New Jersey: Prentice Hall.
Todd, D.K., 2004. Ground Water Hydrology, John Wiley & Sons, New York.
Raghunath, H.M., 1987. Ground Water, Wiley Eastern Ltd., Calcutta.

Further readings

Chow, V. T., 1988. Advances in Hydrosciences, McGraw Hill.
Fitts, C.R., 2006. Groundwater Science, Academic Press.
Karanth KR, 1987. Groundwater: Assessment, Development and Management, Tata McGraw Hill Pub. Co. Ltd.
Schward and Zhang, 2003. Fundamentals of Groundwater, John Willey and Sons.

Suggested books on Environmental Geology

Essential

Keller, E. A., 1978. Environmental Geology, Bell and Howell, USA.
Valdiya, K. S., 1987. Environmental Geology-Indian Context. Tata McGraw Hill.
Subramaniam V, 2001.Textbook in Environmental Science, Narosa International.
Bell, F. G., 1999. Geological Hazards, Routledge, London.

Further readings

Bennett, M. R. and Doyle, P. 1997. Environmental Geology: Geology and the Human Environment. Wiley Publications, UK.
Botkin, D. B. and Keller, E. A., 1999. Environmental Science. Wiley Publications.
Bryant, E., 1985.Natural Hazards, Cambridge University Press.
Patwardhan, A. M., 1999. The Dynamic Earth System. Prentice Hall.
Reichard, J., 2018. Environmental Geology, 3rd Edition. McGraw Hill.
Smith, K., 1992. Environmental Hazards. Routledge, London.

Paper-Core: Engineering & Himalayan Geology Course code: PGGL-C 302 Credits: 4 M. Marks: 100 (External=50, Internal = 50) 60 Hrs. (4 Hrs./week)

OBJECTIVE OF THE COURSE

1. To develop concept and applied aspect of geology in various geotechnical Engineering projects.
2. To teach the students the Origin, Evolution & tectonics of Himalaya.

Engineering Geology

Unit I:

Introduction & scope of Engineering Geology; Engineering properties and classification of rocks; Factors affecting engineering services of rocks; Engineering properties of soils; Soil liquefaction and creep; Stress distribution in soil and foundation failure.

Unit II:

Geological considering for evaluation of Dams and Reservoir sites. Dam foundation rock problems; Geological considering for evaluation of Dam sites; Methods of tunneling and classification of ground for tunneling purposes; Various types of tunneling supports; Geological considering for evaluation of foundation and design of buildings; Aseismic designs of buildings and retrofitting.

Himalayan Geology

Unit I:

Major litho-tectonic divisions of India; Formation of Tethys and its paleogeography;Origin and evolution of Himalaya; Phases of upheaval of Himalaya; Geotechnical division of Himalaya; Tectonic framework and geological features of Sub-Himalaya, Lesser Himalaya, Higher Himalaya Crystalline and Zanskar Tethyan Zone& Trans-Himalaya with special reference to NW Himalaya.

Unit II:

Tectonic framework and geological features of different litho-tectonic units of Indus Suture Zone (ISZ) with special reference to NW Himalaya: Flysch & Molasse sediments of Indus Suture Zone, Indus Ophiolite and Omphalic melange, Drass Volcanics and Ladakh Batholith. Brief idea about the tectonic framework and geological features of Shyok Suture Zine and adjoining Eastern Karakoram terrain.

Suggested Books

Engineering Geology

Krynine, D.H. & Judd, W.R. (1998) Principles of Engineering Geology, CBS Edition.
Schultz, J.R. & Cleaves, A.B. (1951) Geology in Engineering, John Willey & Sons, New York.
Waltham, T., 2009. Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.
Johnson, R.B. and DeGraf, J.Y. 1988. Principles of Engineering Geology, John Wiley & Sons, N.Y.
Krynin, D.P. and Judd W.R. 1957. Principles of Engineering Geology and Geotechnique, McGraw-Hill (CBS Publ).
Roy Chowdhary, K.P. (1987): Surveying (Plane and Geodetic) Oxford &IBH Pub. Co., New Delhi.
Shahani, P.B. (1978): Text Book of Surveying, vol. I. Oxford &IBH Pub. Co., New Delhi.
Goodman, R.E., 1993. Engineering Geology: Rock in Engineering constructions. Jonh Wiley & Sons, N.Y.

Himalayan Geology

Books recommended

Condie, Kent. C., 1982. Plate Tectonics and Crystal Evolution Pergamon Press Inc.
Cox, A. D. (Ed)1973. Plate Tectonics and Geomagnetic reversals, W. H. Freeman, San Francisco.
Gansser A. 1964. The Geology of the Himalaya. Wiley Interscience, Chichester
Heim A. & Gansser A. 1939. Central Himalaya Geological Observations of the Swiss Expedition,
1936. Mémoires de la Société Helvétique des Sciences Natuelles, Zürich.
Sharma, K. K., 1991. Geology and Geodynamic evolution of the Himalayan Collision Zone. Pergamon Press.
Sinha, A.K., 1989. Geology of the Higher Central Himalaya. John Wiley and Sons, Chichester.
Sinha, A.K. (Ed), 1992. Himalayan Orogen and Global Tectonics. Oxford &IBH Publ. Co. New Delhi.
Thakur, V. C., 1992. Geology of Western Himalaya (Vol 19).Pergamon Press
Windley B. 1973.The Evolving continents. John Wiley & Sons, New York.

Paper-Core: Remote Sensing & GIS Course code: PGGL-C 303 Credits: 4
M. Marks: 100 (External=50, Internal = 50) 60 Hrs. (6 Hrs./week)

OBJECTIVE OF THE COURSE

1. To impart knowledge and applications of remote sensing and GIS in Geology.
2. To provide information on latest techniques in RS and GIS.
3. To teach the basics of latest software's and imageries and their analysis.

Unit I:

Remote sensing and its components. Electromagnetic radiations, sensors and platforms. Spectral reflectance of soil, water and vegetation. Characteristics (orbits, swaths, data formats and resolution) of remote sensing satellites: IRS, Landsat, SPOT, ASTER, Quick bird, Ikanos, Senital. Introduction to Microwave Remote Sensing. Classification of aerial photographs and aerial mosaics. Errors in aerial photographs and their correction, swing, tilt, pitch, yaw. Scale of aerial photographs.

Unit II:

Digital Image Processing. Image rectification and restoration. Image enhancement: contrast stretching, filtering,

FCC's, Image rationing. Image classification: supervised & unsupervised classification, error estimation. Introduction to RS Software's (ERDAS, ARC View).

Unit III:

Geographic Information System. Coordinate systems and datum Projection systems. Principles of GIS: functions, data structure and formats. Spatial data models and data structures. Attribute data input and management. Digital elevation and terrain models. Applications of RS and GIS in geosciences (some examples).

Unit IV:

Global Navigation Satellite System. Concepts of GPS and component. GPS accuracy and error sources, DGPS.GPS and GIS applications in earth system sciences (some examples).

Suggested Books

Essential

Gupta, RP., 2003. Remote Sensing Geology 2nd Edition- Springer

Lilles TM., Kiefer, R. W. and Chipman, J., 2008. Remote Sensing and Image Interpretation. 6th Edition, John Wiley and Sons

Sabins, FF., 2007. Remote Sensing Principles and Interpretations 3rd Edition, Waveland Pr Inc.

Sabins, FF., 2012. Remote Sensing Principles and Practice 3rd Edition, Levant Books

Bhatia, SC., 2008. Fundamentals of Remote Sensing. Atlantic Publications

Drury, SA., 1987. Image Interpretation in Geology. Springer

Further readings

Pandey, SN., 1987. Principles and Applications of Photogeology, Wiley Eastern limited.

George Joseph, 2005. Fundamentals of Remote Sensing 2nd edition: Universities Press

Gopi, S., Sathikumar, R and Madhu, N., 2006. Advanced Surveying total station GIS and Remote Sensing Pearson Education

Bhatta B., 2011. Remote Sensing and GIS 2nd Edition, Oxford University Press

Jensen, JR., 2013. Remote Sensing of the Environment: An Earth Resource Perspective 2nd Edition, Pearson India

Paper-Geophysics Course code: PGGL-MD 304 Credits: 2

M. Marks: 50 (External=35, Internal= 15) 30 Hrs. (3 Hrs./week)

OBJECTIVE OF THE COURSE

The main objectives of this course are to provide the students with principles of geophysics and their use to unravel the hidden structure of the solid Earth and natural geological processes that occur within the Earth.

Unit-I

Introduction to Geophysics and its branches.Solar System: Origin, formation and characteristics of planets, Earth: Shape and rotation. Basics of geomagnetism; Gravitation: Law of Universal Gravitation; gravitational acceleration; Equipotential Surface; centripetal and centrifugal acceleration; origin and form of seismic waves; earthquakes: Focus epicenter and depth of earthquakes, locating earthquakes; elements of Earth Magnetic Field geoelectric and electromagnetic (GPR) Methods. Gravity anomalies. Figure of the earth

Unit-II

Marine magnetic anomalies, sea floor spreading; mid- oceanic ridges and geodynamics; plate tectonics hypothesis; plate boundaries and seismicity. Paleomagnetism, Reconstruction of paleopole position, Apparent Polar wandering curves and continental drift. Introduction to geophysical exploration techniques. Concept of logging, Open and cased hole log, Borehole Environment (Pressure and Temperature).

Suggested Books

Essential

1. Dobrin, M. B and Savit, C. H., 1988. Introduction to Geophysical Prospecting, McGraw-Hill.
2. Grant, F. S. and West, G. F., 1965. Interpretation Theory in Applied Geophysics McGraw Hill, New York.
3. Musset A. E. and Khan M. A., 2000. Looking Into The Earth : An introduction to geological geophysics Cambridge University Press.

Further Reading

4. Fowler, C. M. R. (2004) The Solid Earth: An Introduction to Global Geophysics, 2nd Edition, Cambridge University Press, McGraw-Hill, 686p.
5. Murthy, L. Y. R. And Mishra, D. C., 1989. Interpretation of Gravity and Magnetic Anomalies in Space and Frequency Domain, AEG publication, Hyderabad, India
6. Telford W. M.,Geldart L. P., Sheriff, R. E. and Keys, D. A., 1976. Applied Geophysics, Oxford and IBH Publishing Co. Pvt., Ltd. New Delhi.

Paper MD*: Rocks & Minerals of Ladakh Course code: PGGL-L 305 Credits: 2
M. Marks: 50 (External=35, Internal= 15) 30 Hrs. (2 Hrs./week)

OBJECTIVE OF THE COURSE

1. To introduce the students with different types of minerals and rocks of Ladakh.

Unit-I

Introduction and scope of mineralogy; definition of mineralogy and crystals; Crystal lattice. Classification of minerals; Physical and chemical properties of fundamental rock forming minerals and minerals of economic importance.

Unit-II

Introduction and scope of petrology; Definition and major types of rocks; Texture and structure in igneous, sedimentary and metamorphic rocks; Petrological description of igneous, sedimentary and metamorphic rocks of Ladakh.

Suggested Books:

Bose, M. K., 1997: Igneous Petrology. World Press.
Hall, A., 1988: Igneous petrology. ELBSI Longman.
Hatch & Wells, Text Book of Petrology. CBS Pub.
Blatt H.& Tracy R.J. 1995. Petrology: Igneous, Sedimentary & Metamorphic. WHF& Co, New York.

Paper MD*: Stratigraphy and fossils Course code: PGGL-L 306 Credits: 2. M. Marks: 50 (External=35, Internal= 15) 30 Hrs. (2 Hrs./week)

OBJECTIVE OF THE COURSE

1. To introduce the students of other department about the basic principles and laws of stratigraphy and geological time scale.
2. To teach the students of about fossils and process of fossilization.

Unit-I

Introduction and scope of stratigraphy; Definition, principles and laws of stratigraphy; Litho-stratigraphy, bio-stratigraphy and chrono-stratigraphy; Geological Time Scale. Stratigraphic correlation.

Unit-II

Introduction and definition of fossils; Necessary conditions for fossilization; Types of preservation and occurrences of fossils. Types of fossils: Index fossils & living fossils; Significance of fossils of fossils.

Suggested Books:

Arnold, C. A., 1947: An introduction to Paleobotany. McGraw - Hill Book Co.
Clerkson, E. N. K., 1998: Invertebrate Paleontology and evolution. Black Well
Dunbar, C. O, Rodger, J., 1957: Principles of stratigraphy. Wiley International.
Krishnan, M. S., 1968: Geology of India and Burma. Higginbotham's Pvt. Ltd., Madras.
Kumar, R, 1998: Fundamentals of Historical Geology and Stratigraphy. Wiley Eastern Limited.

Paper: Laboratory course Course code: PGGL-L 307 Credits: 4
M. Marks: 100 (External=70, Internal = 30) 60 Hrs. (3 Hrs./week)

Hydrogeology and Environmental Geology

Presentation of rainfall data. Water table maps and delineation of hydrological boundaries. Interpretation of water table contour maps, hydraulic gradient, three-point problem for groundwater movement. Groundwater balance; some Indian examples. Analysis of pumping test data: Thiem's, Theis's and Jacob's method. Analysis of hydrographs (some examples).Exercises on chemical analyses of groundwater. Interpretation of geophysical logs for groundwater exploration (some examples).Some exercises on environmental impact assessment of Ladakh.

Engineering & Himalayan Geology

To study the engineering properties of rocks in hand specimens. Preparation of log chart for drill core logging. Study of maps and models of important engineering structures as dam sites and tunnels. Petrological study of common rocks of Indus Suture Zone & Trans-Himalaya

Remote Sensing & GIS in Geology

Introduction to RS Software's. Practical exercises for digitization and image classification. Hands on exercises on Digital Image Processing techniques and GIS. Scene identification of IRS and Landsat data using NRSA website. Calculating image statistics. Interpretation and mapping related to landuse, geomorphology, lithology, structure, hydrogeology and engineering geology with the help of aerial photographs and satellite imageries.

Paper: Skill based Project Course code: PGGL-P 308 Credits: 2
M. Marks: 50 (External=35, Internal= 15) 30 Hrs. (1 Hrs./week)

The course is intended to familiarize the students with the project and dissertations work. It will help students how to review the literatures, identify research problems, identifying the methodology that is required, writing of synopsis, projects reports. It will also help students to get knowledge on the techniques used in research projects and some basic software.

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Fourth Semester

Paper-Core: Quaternary Geology and Paleoclimate Course code: PGGL-C 401 Credits: 4
M. Marks: 100 (External=70, Internal = 30) 60 Hrs. (6 Hrs./week)

OBJECTIVE OF THE COURSE

1. To provide comprehensive knowledge about the geological activities during Quaternary period.
2. Significance of Quaternary period in the evolutionary history of the Earth and an overview of Quaternary events.
3. Methods employed for dating Quaternary events.

Unit I:

Definition of Quaternary. Quaternary Stratigraphy – Oxygen Isotope stratigraphy, biostratigraphy and magnetostratigraphy. Quaternary climates – glacial-interglacial cycles, eustatic changes, proxy indicators of paleoenvironmental/ paleoclimatic changes, - land, ocean and cryosphere (ice core studies). Responses of geomorphic systems to climate, sea level and tectonics on variable time scales in the Quaternary

Unit II:

Quaternary dating methods, –radiocarbon, Uranium series, Luminescence, Amino- acid. Quaternary stratigraphy of India– continental records (fluvial, glacial, aeolian, palaeosols and duricrust); marine records; continental-marine correlation of Quaternary record. Evolution of man and Stone Age cultures. Plant and animal life in relation to glacial and interglacial cycles during Quaternary

UNIT III

Paleoclimatology, Paleoclimatic reconstruction. Reconstructing the climates of the quaternary, Paleoclimatic reconstruction from clay, ice, pollens and spores, diatoms, radiolarian, foraminifera, organo-geochemical proxies, corals, speleothems, loess-paleosols.

UNIT IV

Weather, Climate, Components of climate, Climate change Instruments used for paleoclimatic studies. Modeling climate change Aerosols: Definition, origin, role in climate change Plate tectonics and climate change, Variations of the earth's orbital parameters, **(**Milankovitch cycles)

Suggested Books

Essential

Bigg, G., 1999 Ocean and Climate. Springer - Verlag
Bradley, R. S., 1999. Paleoclimatology- reconstructing climates of the Quaternary. Academic Press.
Ruddiman, W. F., 2008. Earth's climate-past and future. Freeman.
Cronin, T.M., 1999. Principles *of Paleoclimatology,* Columbia University Press.
Alastair G. Dawson- Ice Age Earth: Late Quaternary Geology and Climate.

Further Readings

Alverson, K. D., Bradley, R. S. and Pedersen, T. F., 2003. Paleoclimate, global change and the future. Springer Verlag Berlin Heidelberg.
Lowe, J.J. and Walker, M.J., 2014. Reconstructing Quaternary environments. Routledge.
Maher and Thompson, 2000. Quaternary Climates, Environments and Magnetism. Cambridge University Press.
North, G.R. and Crowley, T.J., 1995. *Paleoclimatology*, Oxford University Press.
Pomerol, C. The Cenozoic Era: Tertiary and Quaternary
Bradley, R.S., *Paleoclimatology: Reconstructing Climates of the Quaternary,* Academic. *Press.*
Brasier, M.D. 1980 Microfossils, George Allen and Unwin.

Fischer, G. and Wefer, G 1999 *Use of Proxies in Palaeoceanography: Examples from the South Atlantic*, Springer. Dullers, GAT 2008 Luminescence Dating: Guidelines on using luminescence dating in archaeology. Swinder; English Heritage.

Paper-Core: Mining & Exploration Geology Course code: PGGL-C 402
Credits: 4 M. Marks: 100 (External=70, Internal = 30) 60 Hrs. (6 Hrs./week)

OBJECTIVE OF THE COURSE

The main objectives of this course are to comprehend the processes of mining and mineral exploration in various geologic environments. To introduce the concept of exploratory mining methods and also to familiarize students with issues related to mineral economic. It is intended to familiarize the students with the principles, methodology and application of important geophysical, geochemical and drilling methods adopted to investigate the surface and subsurface.

Unit I: 15 hours

Drilling: objectives of drilling, types of drilling for exploration and their advantages. Concept of Slice Plan/Bench Plan, role of stripping boundary, Geological and mineable ore reserves, mineable waste and their calculation. Geological modelling for mineral exploration.

Unit II: 15 hours

Mineral economics and its concepts. Tenor, grade and specification. Strategic, critical and essential minerals. National mineral policy. United Nations Framework Classification (UNFC).

Unit III: 15 hours

Selection of minerals for explorations. Use of GIS and remote sensing in mineral exploration. Criteria and guides for mineral search. Stages of mineral exploration in India. Field observations and field equipments. Geochemical exploration: mobility of elements and their primary & secondary dispersion. Geochemical approaches, mapping and sample material. Introduction to geobotanical and geophysical exploration methods.

Unit IV: 15 hours

Basic Exploration Geophysics: main techniques used in applied geophysics, including the seismic, electrical, magnetic, electromagnetic and gravity methods. The discussion incorporates basic theory, instrumentation, data processing and interpretation techniques.

Suggested Books

Essential

1. Arogyaswami, R. P. N., Courses in Mining Geology (1996).
2. Moon, C. J., Michael, K. G., Whateley and Evans A. M., Introduction to Mineral Exploration, Pubs: Blackwell Publishing House (2006).
3. Mussett A. E. and Khan M. A., Looking Into The Earth: An introduction to geological geophysics, Pubs: Cambridge University Press (2000).
4. Sinha, R. K. and Sharma, N. L., Mineral Economics (1976).

Further Reading

1. Bagchi, T. C., Sengupta, D. K., Rao, S. V. L. N., 1979. Elements of Prospecting and Exploration (1979).
2. Banerjee, P. K. and Ghosh, S., Elements of prospecting for non-fuel mineral deposits (1997).

Paper-Core: Oceanography & Marine Geology Course code: PGGL-C 403
Credits: 4 M. Marks: 100 (External=70, Internal = 30) 60 Hrs. (6 Hrs./week)

OBJECTIVE OF THE COURSE

1. To impart knowledge about the morphology and tectonics of ocean floors
2. To understand circulation of ocean water and distribution of oceanic sediments
3. To impart knowledge about the mineral resources of oceans.
4. To understand Paleoceanography reconstructions and Quaternary Sea level and climatic changes.

UNIT-I

Morphologic and tectonic domains of the ocean floor. Structure, composition and mechanism of the formation of oceanic crust. Hydrothermal vents-. Ocean margins and their significance. Ocean Circulation, Coriolis effect and Ekman spiral, convergence, divergence and upwelling, El Nino. Indian Ocean Dipole Thermohaline circulation and oceanic conveyor belt. Formation of Bottom waters; major water masses of the world oceans.

UNIT-II

Oceanic sediments: Factors controlling the deposition and distribution of oceanic sediments; geochronology of oceanic sediments, diagenetic changes in oxic and anoxic environments. Tectonic evolution of the ocean basins.Classification of coasts. Deep sea sediments and their relation to oceanic processes such as productivity, solution and dilution; sedimentation rates; Calcite and aragonite compensation depth.

UNIT-III

Mineral resources of oceans including polymetallic nodules; Hydrocarbons beneath the sea floor; Marine gas hydrates and their economic potential. Objectives and major accomplishments of Deep-Sea Drilling Project (DSDP), Ocean Drilling Program (ODP) and International Ocean Discovery Program (IODP). Law of the Sea Treaty: Introduction to UNCLOS(United Nations Convention on the Law of the Sea); Exclusive Economic Zone.

UNIT-IV

Paleoceanography – Approaches to palaeoceanographic reconstructions; various proxy indicators for palaeoceanographic interpretation. Reconstruction of monsoon variability by using marine proxy records; Opening and closing of ocean gateways and their effect on circulation and climate during the Cenozoic. Sea level processes and Sea level changes during Quaternary with special reference to India. Quaternary climatic and oceanographic history on shorter time scales using marine records.

Books recommended

Arnold. 2002. Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett), Oxford Univ. Press, New York.

Kennett, J.P.,1982. Laboratory Exercises in Oceanography Marine Geology, Prentice Hall,.

Seibold, E. and Berger, W.H., 1982.The Sea Floor, Springer-Verlag.

Shepard, F.P., 1963. Submarine Geology, Harper Row.

Komar, P.D., 1976. Beach processes and sedimentation, Prentice Hall.

Paper-Core: Dissertation Project Work Course code: PGGL-D 404

Credits: 8 M. Marks: 200 (External=140, Internal = 60) 120 Hrs. (12 Hrs./week)

Project/Dissertation work will begin in forth semester. The weightage will be of 200 marks. At the end of semester, students will submit project work in the form of a report. There will be a presentation before a panel of teachers from the department.

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NOTE

Internal examinations

There will be internal examinations (Assignments, Tests and Presentations) of 30%marksineachsemester. In case of papers having four (04) credits the Internal marks will be as (5 marks for assessment grade, 5 marks for attendance, 5 marks for presentations, 10 marks of two class tests, 5 marks for Assignment). However, in case of two (02) credit papers the internal marks will be divided into (2.5 marks for assessment grade, 2.5 marks for attendance, 2.5 marks for presentation, 05 marks of two class tests, 2.5 marks for Assignment). End-semester examination will be of the rest 70% marks (External) in each semester.

Geological Field Training

The Skill based minor field Project work (One week local) (PGGL-F 105) carried out during first semester is of fifty (50) marks is divided into Thirty-five (35) marks for external and fifteen (15) marks for internal. The internal marks will be based on field work attendance, attitude and performance of the student. The external marks will be divided into two components project report (25 marks) and presentation/Viva (10 marks).

The Skill based Project work on Geological Field Training (PGGL-F 206) carried out during second semester is of Fifty (50) marks is divided into Thirty-Five (35) marks for external and 15 marks for internal. The internal marks will be based on field work attendance, attitude and performance of the student. The external marks will be divided into two components project report (20 marks) and presentation/Viva (15 marks).

The Skill based Project (Dissertation project work) PGGL-P 308 carried out during third semester is of Fifty (50) marks is divided into Thirty-Five (35) marks for external and 15 marks for internal. The internal marks will be based on field work attendance, attitude and performance of the student. The external marks will be divided into two components project report (20 marks) and presentation/Viva (15 marks). The external component will include Literature review and presentation viva.

Project work

Project/Dissertation work will begin in forth semester. The weightage will be of 200 marks. At the end of semester, students will submit project work in the form of a report. There will be a presentation before a panel of teachers from the department. The Dissertation Project Work (PGGL-D 403) which students have to take in 4^{th} semester is of eight (08) credits and carries two hundred (200) marks divided into one hundred fifty (150) marks for external and fifty (50) marks for internal. The internal marks will be based on field work diary report and lab work (25 marks) and presentation (25 marks). The external marks will be divided into two components project report (100 marks) and presentation/Viva (50 marks).

Pattern of end-semester question paper

(i) There will be two sections A and B.

(ii) There will be 9 questions in all.

(iii) **Section A** will carry one compulsory question (question no 1) with four sub-parts (consisting of short answer type questions). Each sub-part (short answer type question) will be from each unit and a student will have to attempt all the four sub-parts.

(iv) **Section B** will comprise of four long answer type questions (question number 2 to 5); each question will have an option. Thus, there will be two questions from each unit. In total, there will be eight questions in the section; two from each unit and a candidate will be asked to attempt four questions.

(v) All short answer type questions will carry 2½ marks each. Thus, question No 1 will carry weightage of 10 marks. Whereas, each question from no 2 to 5 will carry equal marks of 10 marks.

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