Ph.D. COURSE WORK SYLLABUS

Centre for Applied Geology

Ph.D Course Work

Semester	Paper Code	Course Title	Credits	Total
Core Courses				
I	17GEOR0101	Advanced Mineralogy and Petrology	4	
	17GEOR0102	Structural Geology and Field Mapping	4	
	17GEOR0103	Applied Geomorphology	4	
	17GEOR0104	Research Methodology in Geological Studies	4	
II	17GEOR0205	Instrumentation, Analytical Methods and Quantitative Techniques	4	
	17GEOR02SX	Specific course to be prescribed by the Doctoral committee	4	24
	Seminar (3) Term paper/Topical Research			
III semester onwards	Research Credits a)Project planning including literature collection, finalization of objectives and methodology b) Field/ Lab Studies, Data collection, compilation of results, statistical analysis, results and final conclusion.		4 32	
End of Program	Synopsis and Thesis submission, final viva		6	

List of courses that are candidate centric (17GEOR02SX)

17GEOR02S1	GEO EXPLORATION
17GEOR02S2	APPLIED HYDROGEOLOGY
17GEOR02S3	ENVIRONMENTAL GEOLOGY AND GEOLOGICAL HAZARDS
17GEOR02S4	SEDIMENTOLOGY AND MARINE GEOLOGY
17GEOR02S5	MICROPALAEONTOLOGY AND PETROLEUM GEOLOGY

17GEOR0101 ADVANCED MINERALOGY AND PETROLOGY Credits 4

Learning Objectives: To understand the methods of interpretation of minerals and rocks in the field. To apply recent techniques for mapping the minerals and rocks.

Learning Outcomes:

The scholar will be exposed to the field identification to distinguish properties of various mineral groups that formed as rocks in the field. The scholar also will be exposed the method of interpretation of minerals/rocks in terms of physical, optical and chemical properties.

Unit I: Physical and Chemical Properties of Minerals: Physical, Optical and chemical properties of rock forming silicates: - Quartz, Feldspar, Pyroxenes, Amphiboles, Garnet, Feldspathoids, Olivine, Mica. Other silicates: Fluorites, Carbonates, Clay minerals, Kyanite, Sillimanite, Andalusite.

Unit II: Optical Properties of Minerals: Isotropic and Anisotropic Minerals, Optical Properties of Minerals, Uniaxial and Biaxial Indicatrices, Generation of Uniaxial and Biaxial Interference Figures, Determination of Optic Sign, Extinction, Pleochorism, Twinning, X-Ray Diffraction methods.

Unit III: Igneous Petrology: Structure, texture, mineral and chemical composition, Classification, Mode of Occurrence and Origin of Igneous Rocks; Granites, Syenites, Gabbro, Dolerites, Basalts, Anorthosites, Dunite, Peridotite and Carbonatites. Field observation of Igneous Rocks

Unit IV: Sedimentary Petrology: Structure, texture, mineral and chemical composition, Classification, Mode of Occurrence and Origin of Sedimentary Rocks: Clastic and Non-clastic, Grain size distribution and environmental analysis. Fabric Elements and Analysis. Sedimentation and sedimentary environments.

Unit V: Metamorphic Petrology Structure, texture, mineral and chemical composition, Classification, Mode of Occurrence and Origin of Metamorphic Rocks. Facies and Graphic Representation of Metamorphic Rocks. Schist, Gneiss, Anorthosites, Amphibolites, Granulites , Eclogite, Migmatites, Charnockite and Marble.

Reference Books:

1. Deer, W.A, Howie, R.A and Zussman (2013) An Introduction to Rock forming Minerals, 3rd Edition, ELBS Ed. pp.490.
2. Dana's (2006) Textbook of Mineralogy (with Extended Treatise Crystallography and Physical Mineralogy). pp.156.
3. Dana's Manual of Mineralogy (1999) 17th Edition by C. Hurlbut. John Wiley & Sons, New York. pp.609.
4. Hatch F. H. and Wells A. K. (1926) The Petrology of the Igneous Rocks. George Allen and Unwin, Eighth edition, pp. 566.
5. Berry L. G. and Brian Mason (1959) Mineralogy: Concepts, Descriptions Determinations. W. H. Freeman and Company. pp. 612.
6. Turner, F.J. and Verhoogen, J. (2002) Igneous and Metamorphic Petrology – CBS publishers. pp.694.
7. Pettijohn, F.J. (1975) Sedimentary Rocks, Harper & Row, 3rd Edition. pp.628.
8. Tucker, E. (2001) Sedimentary Petrology: An Introduction to the Origin of Sedimentary Rocks, 3rd Edition, Wiley publishers. pp.272.
9. http://www.minsocam.org/msa/Research_Links.html#Mineral_Databases.
10. https://wiu.libguides.com/geology

Methods of Teaching: Class room teaching and Field Studies

17GEOR0102 STRUCTURAL GEOLOGY AND FIELD MAPPING Credits 4

Learning Objectives: To understand the various techniques for assessing the structure, tectonics and its importance. To understand the detailed Geological Field mapping techniques.
Learning Outcomes:
The scholar will be exposed to the structure and tectonics and its interpretation principles in the field. This paper also highlights the field mapping techniques of geological studies.

Unit I: Earth Structures: – Bedding and Simple Dipping Strata. **Folds** – Classification, and origin. Manifestation of folds in remote sensing data. **Faults**- Classification, and origin. Manifestation of Fault and its interpretation in Satellite Data. Neotectonic Rift Zones and its Interpretation in Satellite Data. **Lineaments** and Interpretation in Satellite Data. Lineament Density Map Types and Interpretation. Circular Features and its Interpretation in Satellite Data. Intrusive and its interpretation in satellite data. **Unconformity** and its interpretation in Satellite data. Remote sensing application in Structural Geology. Application of Microwave data in structural mapping.

Unit II: Geotectonics: Tectonic Features of the Earth - Continental drift – Sea floor spreading - Plate Tectonics - Elements of Tectonism - Characteristics of Plates - World Plates - Plate Boundaries - Plate Tectonics and Mineral Deposits - Concept of Isostasy - Orogeny & Epiorogeny, Geosynclines– Seismic Belts of the Earth – Seismicity and Plate Movements - Tectonic Frame Work of India–Geodesy in tectonic studies.

Unit III: Geological Field Studies: Introduction, Components of Geological Investigations. Components of Field studies- Topographical Maps, Aerial Photos and Satellite Imageries. Clinometer Compass, Brunton Compass, Procedure of measuring the Trend of Linear Elements, Procedure of Measuring the Inclination of the Planar Surface. The Role of a Pocket Lens, Pen knife, dil.HCL, Sample Bags, Camera, Hammer in the Field.

Unit IV: Geological Mapping: Components of Geological Map- Introduction, The petrographical component and structural component. Methods of Geological Mapping- Common Procedure. Methodology for the Igneous Rocks- Xenoliths and Inclusions. Methodology for the Sedimentary Rocks. The role of current and oscillation ripples. Methodology for the Metamorphic Rocks.

Unit V: Petrographical Field Features of Rocks- Igneous Rocks. Non-Petrographic Field Features of Igneous Rocks, Sedimentary Rocks, Metamorphic Rocks. Data to be collected during Mapping Exercise, Collection of Petrographic Data, Collection of Igneous, Sedimentary and Metamorphic rocks, Collection of structural data- Planar Structure, Linear Structure, Data for Petro Fabric Studies. Field Indicators of Minerals, Rocks and Structures, Indication from geomorphology, Indication from external appearance of rock, Indication from texture, color and structure, Indication from mineral composition, Indications from minerals.

Reference Books:

1. Billings, M. P. (2008) Structural Geology, III edition, Prentice-Hall, Inc. pp.606.
2. Condie, K.C. (2003) Plate Tectonics & Crustal Evolution, Butterworth-Heinemann, Boston, 4th Edition. pp.282.
3. Gupta, R.P. (2003) Remote Sensing Geology, Springer – Verlag. pp.656.
4. Davis, G.H. and Renolds. S.J. (1996) Structural Geology of Rocks and Regions, 2nd edition. Wiley. pp.355.
5. Hobbs, B. E., Means, W. D., & Williams, P. E (1976) An Outline of Structural Geology, John Wiley & Sons, Inc.pp.571.
6. Ramsay, J. G., 1978. Folding and Fracturing of Rocks. New York, McGraw-Hill, pp. 568.
7. Ramsay, J.G., & Huber, M.I., 1983. The Techniques of Modern Structural Geology: V.1: Strain analysis. NY, Academic Press. pp.710.
8. Ramsay, J. G., and Huber, M. I., 1987. The Techniques of Modern Structural Geology, V. 2: Folds and Fractures, NY, Academic Press. pp.776.
9. Ramsay, J. G., and Lisle, R. J., 2000. The Techniques of Modern Structural Geology, V.3, Applications of Continuum Mechanics in Structural Geology. Academic Press. pp.452.
10. https://geomaps.wr.usgs.gov/capabilities/working/pos3_mapping.pdf
11. www.gsi.gov.il/eng/?CategoryID=313&ArticleID=901.
12. www.austingeosoc.org/news/2017/9/15/usgs-geology-web-mapping-resources.

Methods of Teaching: Class room teaching and Field Studies

17GEOR0103 APPLIED GEOMORPHOLOGY Credits 4

Learning Objectives: To understand the process of the geological ecosystems like Aeolian, Riverine, Coastal and Glacial geomorphic process, products and its exposure on the earth.

Learning Outcomes:

The scholar will be exposed to the development of Earth landforms due to the various geological agents. This paper also highlights the Remote sensing applications to the geomorphic studies.

Unit I: **Fluvial Landforms**: Stages of Stream Development, Specific landform features (Oxbows, levees, cut offs, floodplains, and meanders). Erosional, Transportation and Depositional Features. **Arid Landforms**: Stages of Arid Landform Development; Landform features; Stream gradients indicated by contours. **Karst Landforms**: Stages of Karstic Landform Development, Hydrogeologic gradients; Artesian aquifer systems. Structural Landforms; Landforms due to subsidence and upliftment, Block faulting,Fault offset recognition

Unit II: Glacial Landforms: Erosional, Transportation and Depositional Features. Continental glacial cycles; Causes of continental glaciation, Continental glacial landform features. **Aeolian (Wind) Landforms:** Erosional, Transportation and Depositional Features. Desert climate zones; Dune formation; Rain-shadow zones, Dune landforms and migration; Loess deposits. Tectonic Interactions with Landscapes and Climate Earth's Climate Zones; Rain-shadow effects; Carbon geochemical cycle and global climate effects.

Unit III: Coastal Landforms: Coastal process: Erosional and depositional landforms, Types of Coast, Shoreline Change and its impacts, Sea level rise, Coastal zone management, Coastal regulation zone, Coastal protection structures, Sea water intrusion.

Unit IV: Topographic Maps and Interpretation: Map scales; Map Projections; Map Coordinates; Magnetic Declination. Topographic Maps; Digital Maps. Construction of Contours from Elevation Data; Computer Contouring Methods, Topographic Profiles with Geologic Cross Sections. Computer contouring methods using Surfer and Excel. GPS Surveying and Mapping, Total Station Survey Techniques for Topographic Mapping.

Unit V: **Remote Sensing Applications in Geomorphic Studies**: Manifestations of Fluvial, Arid, Aeolian, Coastal, Denudational and Karst Topography through Aerial and Satellite remote sensing data. Applied Geomorphology in Natural Resource Mapping, Regional Planning and Watershed Management.

Reference Books:

1. Radhakrishnan, V. (1987) Physical Geology, V.V.P. Publishers. pp.256.
2. Thornbury, W.D. (2002) Principles of Geomorphology, John Wiley and Sons, 2nd Edition. pp.362
3. Grotzinger, J., Jordan, T., Press, F and Siever, R., (2007), Understanding Earth (5th ed.), W.H. Freeman and Co. pp.568.
4. Bloom, A. (2005) Geomorphology. Pearson. pp. 482.
5. Gupta, R.P. (2003) Remote Sensing Geology, Springer – Verlag. pp. 656.
6. Holmes, A. (1965) Principles of Physical Geology. Ronald. pp.1288.
7. http://www.geographynotes.com/articles/applied-geomorphology-meaning-two-main-lines-specific-applications-and-techniques/779
8. https://www.intechopen.com/books/studies-on-environmental-and-applied-geomorphology
9. http://www.crcnetbase.com/Introduction to process Geomorphology.
10. https://sudartomas.files.wordpress.com/2012/11/introduction to coastal processes and geomorphology.pdf

Methods of Teaching: Class room teaching and Field Studies

17GEOR0104 RESEARCH METHODOLOGY IN GEOLOGICAL STUDIES **Credits 4**

Learning Objectives: To understand the research methods of Geoscientific Writing for the journals and thesis.
Learning Outcomes: The scholar will be exposed on Geological writing for the journal publications and thesis writing.

Unit I: Concept and Definition of Research; Academic Research, Basic and Fundamental Research, Applied Research, Theoretical, Conventional and Experimental Research. Concepts and needs of research hypothesis. Objective processes and steps in research methodology; Research proposal and concepts. Developing research proposal in the field of Geosciences.

Unit II: Literature Survey and Review, Research Literatures and Electronic Media including Internet, Use of Digital Library, Online Resources; Necessity of Review of Literatures. Research approach and identifying Gap areas from literature review; problem formulation and statement of research objectives; Developing of bibliography.

Unit III: Pre-field preparations: preparation of maps, survey of the study area through satellite imageries, google earth. Field mapping and documentation. Types and Procedure of sampling- grab sampling, random sampling, stratified random sampling, stratified profile sampling, lateral sampling, sampling documentation. Introduction to field mapping and section measurement. Introduction on laboratory techniques of data analysis and their limitations.

Types of data: primary and secondary data. Source and authenticity of secondary data.

Unit IV: Research Methodology and techniques used in the field and laboratory for geological samples, Field and Lab, developing hypothesis, Collection of primary data from the field, Execution of project, Data analysis, Interpretations of field and lab data, Dissemination of research results through conferences, workshops, synthesis of data, report writing and publication of research paper.

Unit V: Research Methodology is an art of scientific investigations, Geological questions and new insights of a geological event or phenomenon. Planning, Selection, Formulation and Execution of research project, Thrust area of the project, Objectives of

the project and the Course of action (work plan), Methods of sampling, and analytical techniques: Collection of air, water, soil and rock samples, Preparation of samples for microscopic examination and chemical analysis, Analytical Techniques.

References Books:

1. Kothari C.R. (1990) Research Methodology, 12th Edition. pp.82.
2. Srinivasa Rao Koneru, (2010) Geo scientific writing: A guide to language and composition styles, GSI-Bangalore. pp.147.
3. Clifford Jones, J. (2015) Concepts in Scientific Writing, 1st Edition.pp.70. www.Bookboon.com
4. Graham Basten, (2010) Introduction to Scientific research projects. 1st Edition, pp.46., www.Bookboon.com
5. Simon Kendal, (2015) How to Write a Research Paper. 1st Edition, pp.46., www.Bookboon.com
6. Thomas L. Isenhour, (2013) the evolution of Modern Science. 1st Edition, pp.46. www.Bookboon.com.
7. http://www.bbamantra.com/research-methodology.
8. https://www.scribd.com/doc/185378498/Research-Methodology-Full-Notes
9. https://www.cartercenter.org/resources/pdfs/health/ephti/library/lecture_notes/health_science_students/ln_research_method_final.pdf
10. http://iiscs.wssu.edu/drupal/node/4673

Methods of Teaching: Class room teaching and Field Studies

17GEOR0205 INSTRUMENTATION, ANALYTICAL METHODS AND QUANTITATIVE TECHNIQUES **Credits 4**

Learning Objectives: To understand the different geological instrument, geo statistical analysis and its operation principles.

Learning Outcomes: The scholar will be exposed on various geological equipment's working principles, applications and data interpretation for the geological research.

Unit I: **Laboratory Techniques of Data Analysis:** Understanding of petrological and stereo zoom microscopes. Identification of common rock forming minerals. Sample preparation techniques for petrological sections studies, geochemical and palaeontological studies. Mechanical, optical and analytical techniques used in geological sciences. Principles and geological application of Optical Microscope, Ore Microscope - Trinocular Microscope, Cathodeluminescence and Thermoluminescence.

Unit II: Introduction to advanced laboratory techniques: Working principles and concepts of Differential Thermal Analysis (DTA), X-ray Diffractions (XRD), Scanning Electron Microscope (SEM), ICP MS, X-ray fluorescence (XRF), Energy-dispersive X-ray spectroscopy (EDS, EDX, or XEDS), Mass spectrometer, CT-scan Tomography, Fission Track Dating, Techniques of sample preparation, applications and limitations of the above instruments for Geological studies.

Unit III: **Geospatial Technology Tools:** Visual Interpretation Instruments, Stereoscopes, Parallax Bar, GPS & DGPS, LiDAR instruments, UAV, Thermal Scanners. Mapping basics (Types, Scale of maps, Legends, Source representation, map layout), Survey of India Toposheets, Geological Survey of India, Soil Survey of India (Source, Procedure for obtaining and representing the map output, Scale Types, Legends in the said maps).

Unit IV: Geostatistics I: **Making predictions:** Spatial interpolation - Elements and types: Global versus Local, Exact versus Inexact. Stochastic versus Deterministic, Abrupt versus Smooth. **Global interpolation** - Trend, Order of polynomial, logistic option. **Local Interpolation** – Thiessen polygon (Vornoii plots), Inverse Distance

Weighting (IDW), Spline, Kriging. Cluster Analysis: Concept, Cluster analysis- Construction of Dendograms, rooted and unrooted trees, interpreting phylogenetic relationships. Concept, Methods, Euclidean distance, Merits & demerits. Application in the studies of Earth sciences, Markov Chain Analysis. Concept and characteristics, Application in the field of Earth Sciences.

Unit V: Geostatistics II: **Practical Exposure on Exploratory spatial data analysis:** Univariate description - Frequency tables, Histogram, Cumulative frequency table, Normal probability plots. Summary / Descriptive statistics. **Bivariate description** - Scatter plot. correlation, covariance, correlation coefficient, linear regression. Structural analysis: Variogram - Plotting of variogram. **Spatial interpolation:** Local Interpolation - Thiessen polygon (Vornoii plots) (manual and software) Inverse Distance Weighting (IDW), Spline, Kriging (use of software). Factor analysis. Principal Component Analysis. Cluster Analysis: Problems and interpretation of results. Markov- chain analysis: Problems and interpretation of results.

Reference Books:

1. Jeffery, P.G. and Hutchinson, D. (1981) Chemical Methods of Rock Analysis, Pergamon Press. pp.379.
2. Thompson, M. and Walsh, J.N. (1983) A Handbook of Inductively Coupled Plasma Spectrometry, Blackie. pp.273.
3. Van Loon, J.C. (1980) Analytical Atomic Absorption Spectroscopy, Academic Press. pp.337.
4. David Keith Todd, Larry W. Mays, (2013) Groundwater Hydrology, Wiley. pp.636.
5. Arogyaswamy, R.N.P. (1980) Courses in Mining Geology. Oxford & IBH. pp. 145-178.
6. Lillesand, T.M. And Kiefer, P.W. (2007) Remote Sensing and Image Interpretation, 3rd Edition, John Wiley & Sons. pp.804.
7. Anji Reddy, M. (2008) Text Book of Remote Sensing and Geographical Information Systems, 3rd Edition, BS Publications. pp.656.
8. Cullity B. D. (1978) Elements of X-ray Diffraction, Addison-Wesley Publishing Company. pp.664.
9. Goldstein, J. (1979) Introduction to Analytical Electron Microscopy, Plenum Press. pp.601.
   http://web.uniplovdiv.bg/plamenpenchev/mag/books/anchem/Handbook%20of%20Analytical%20Techniques, %202%20Volume%20Set.pdf
11. https://pubs.usgs.gov/bul/1770/report.pdf
12. http://tupa.gtk.fi/julkaisu/erikoisjulkaisu/ej_015_synopsis.pdf

Methods of Teaching: Class room teaching and Field Studies.