தமிழ்நாடு மத்தியப் பல்கலைக்கழகம்

CENTRAL UNIVERSITY OF TAMIL NADU

तमिलनाडु केन्द्रीय विश्वविद्यालय

ESTABLISHED BY AN ACT OF PARLIAMENT IN 2009

Ph.D. Programme

Curriculum Structure

(2025-26 Onwards)

NEP2020 and NCrF

Department of Geology

School of Earth Sciences,

Central University of Tamil Nadu,

Thiruvarur-610005

Email: hodgeology@cutn.ac.in

A. Vision

To produce and sustain the conditions that enable the students to experience transformative learning in becoming independent and ideal learners through education of global standards. This would be achieved by maintaining high academic standards, sustaining the quality of science teaching, learning offered, providing an intellectual, personal, and socially transformative experience to students.

B. Mission

M1	To provide student-centric learning environment through scientific and innovative pedagogy
M2	To create excellent infrastructure facilities and state-of-the-art laboratories
M3	To encourage research and industry-institute partnerships through collaborative activities for innovation and development
M4	To promote conferences/seminars/workshops/society development programs for creation of avenues for research exchange and knowledge enhancement in thrust areas
M5	To enhance leadership qualities, ethical and moral values, research culture and innovative skills among the students by offering high quality education and other services in a competitive manner

C. Program Educational Objectives (PEO) – Ph.D.

After successful completion of the Doctoral Research Course Work, the scholar will be able to

PEO1 Develop a desire to keep learning throughout life

PEO2 Mould scholars to work in a professional setting

PEO3 Constantly update themselves in areas to their career

PEO4 Develop high level of thinking and problem-solving skills

PEO5 Address the societal needs and work for betterment of society

PEO6 Visualise complex problems in a global scale

PEO7 Train the scholars to conduct independent research as well as working in a team

D. Attributes for Ph.D. in Geology

1. **Disciplinary Knowledge:** Content and pedagogical knowledge synchronised with the geoscience research frameworks
2. **Communication Skills:** Conveying the geo-scientific understanding, ideas, and concepts with Scientific and Technological communities.
3. **Critical Thinking:** Capacity to apply their skills through experimental, analytical, numerical, and model-based research.
4. **Problem Solving:** To identify the research gaps and appropriate remedies for various issues in Earth Sciences.
5. **Co-operation:** Effective collaboration among different organisations and industries working in the domain of geo/planetary sciences.
6. **ICT Skills:** Selecting and integrating appropriate geoscientific technological skills for personal, professional development and knowledge dissemination.
7. **Ethics:** To develop the basics of ethics, research integrity, moral principles, and professional ethics.

E. PEO to Mission Statement Mapping

	PEO1	PEO2	PEO3	PEO4	PEO5	PEO6	PEO7
M1	✓	✓	✓	✓	✓	✓	✓
M2	✓	✓	✓	✓	✓	✓	✓
M3	✓	✓	✓	✓	✓	✓	✓
M4	✓	✓	✓	✓	✓	✓	✓
M5	✓	✓	✓	✓	✓	✓	✓

F. Program Outcomes (PO)

On the successful completion of the program, the student will be able to

PO1 Will be able to identify the knowledge gaps for further understanding.

PO2 Structuring the methodology, execution and designing of research work.

PO3 Analyse critical data/ results and their interpretation for simpler understanding.

PO4 Impact the skills to communicate the research with the scientific community through peer-reviewed publications at the national and international levels.

PO5 Inculcate the practice of performing research professionally, ethically and responsibly.

PO6 Develop substantial skills in solving geological problems for societal benefits.

G. PO to PEO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
PEO1	✓	✓	✓	✓	✓	✓
PEO2	✓	✓	✓	✓	✓	✓
PEO3	✓	✓	✓	✓	✓	✓
PEO4	✓	✓	✓	✓	✓	✓
PEO5	✓	✓	✓	✓	✓	✓
PEO6	✓	✓	✓	✓	✓	✓
PEO7	✓	✓	✓	✓	✓	✓

Department of Geology, School of Earth Sciences, Central University of Tamil Nadu

Ph.D. Programme

(2025-26 Onwards)

Programme Structure

Semester	Courses			Credits		Assessment	
	Code	Title		L P	Total	CIA	ESE
First Semester							
I	GLY3011	Research Methodology		4	4	40	60
I	GLY3012	Research Ethics		2	2	40	60
I	GLY3013	Analytical Techniques in Geosciences and seminar		4	4	40	60
I	GLYEC02	Geospatial Technology and Modelling in groundwater resources	Any one	4	4	40	60
I	GLYEC03	Advances in Structural Geology					
I	GLYEC04	Applied Geochemistry					
I	GLYEC05	Geomechanics					
I	GLYEC06	Natural and Anthropogenic Hazards, and Risk Impact					
I	GLYEC07	MOOC/ SWAYAM /NPTEL Course					
I	GLYEC08	Geology of Economic Mineral Deposits					
I	GLYEC09	Biogeochemistry and Global Biogeochemical Cycles					
I	GLYEC10	Paleoclimatology and Paleoceanography					
				Total	**14**	**400**	

CIA: Continuous Internal Assessment — ESE: End Semester Examination

As per the NCrF Credit Level 8.0 (Doctoral Degree) PhD scholars need to earn 40 credits per year. In order to obtain a PhD degree, He/She has to secure minimum credit points of 320. However, first year of their doctoral research consists of course work 14 credits and research 26 credits (total 40 credits in first year).

a. Common Evaluation Scheme for all the courses

	Unit-I	Unit-II	Unit-III	Unit-IV	Unit-V	Total
Internal/ Assignments	8	8	8	8	8	8
External	12	12	12	12	12	12
Total	**20**	**20**	**20**	**20**	**20**	**20**

b. Mapping Course Outcome with Internal Assessment (40 Marks)

Evaluation Criteria	Marks
Assignments/ Seminar/Attendance	**20**
Test	**20**
Total	**40**

c. Common Mapping Course Outcome with External Assessment (60 Marks)

Category	Marks
Part – A (Objective - 10 x 1 = 10 marks)	10
Part – B (Short Answer - 5 x 3= 15 marks)	15
Part – C (Essay- 5 x 7 = 35 marks)	35
Total	**60**

d. Common Rubric for Assignments

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content 50%**	Ideas are detailed, well developed, supported with specific evidence and facts and	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3, CO4

		examples					
2	**Organiza-tion 50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organisational tools are weak or missing	No organisation	Not attended	CO1, CO2, CO3, CO4

e. Common Rubric for Seminar

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**
1	**Knowledge and Understanding 50%**	Exceptional knowledge of facts, terms and concepts	Detailed knowledge of facts, terms and concepts	Considerable knowledge of facts, terms and concepts	Minimal knowledge of facts, terms and concepts	Not Attended	CO1, CO2, CO3, CO4
2	**Presentation 50%**	Well Communicated with logical sequences, examples and references	Communicated with sequences	Just Communicated	No coherent comunication	Not Attended	CO1, CO2, CO3, CO4

f. Common Model Question Paper

Part A **[10 x 1= 10]**

(Objective type: multiple choice, fill in the blanks, one word answer)

*Answer **ALL** the questions. Each Question carries one mark.*

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

Part B **[5x 3= 15]**

(Short answer type: answer should not exceed 200 words)

*Answer **ALL** the questions. Each Question carries three marks.*

11.
12.
13.
14.
15.

Part C **[5 x 7 = 35]**

(Essay answer type: answer should not exceed 400 words)

*Answer **ANY FIVE** questions. Each Question carries seven marks.*

16. Compulsory question (critical thinking and analysis)
17. (a or b)
18. (a or b)
19. (a or b)
20. (a or b)

SEMESTER - I				
Course Code	**Course Name**	**L**	**P**	**Credits**
GLY3011	Research Methodology	4	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO1	Provide students with the fundamental knowledge of research methods	Understand
CO2	Design used in and analyse and interpret methods of quantitative and qualitative data.	Understand
CO3	Understand how using valid scientific methods of measurement and scaling can improve and create knowledge.	Analyse
CO4	Develop, complete, write, and present a valid and ethical research report.	Evaluate

b. Syllabus

Units	Content	Hrs.
I	Introduction to Research: Basic Research, Pure Research, Applied Research Modern Scientific approach to Research; Interdisciplinary approach and its implications	12
II	Methods of Research- Qualitative and quantitative methods of research like Historical, case study, ethnography, exposit facto, documentary and content analysis, survey (Normative, descriptive, evaluative etc.), field and experimental studies;	12
III	Development of research proposal, its elements, identification of research problem-criteria of sources and definition, review of literature and collection of references, development of objectives, development of hypotheses and applications. Skills required for conducting research; sources of research data- primary and secondary sources;	12
IV	Concept of sampling, Sampling techniques- concept, types (random, purposive, stratified random, probability and non-probability); Tools and techniques of data collection for qualitative and quantitative research- observation, interview, questionnaire, rating scale, inventory, check list, content analysis; Tools of data analysis and decision-making Reliability and validity of tools.	12
V	Basics of communication skills, types of scientific communication, structure of a research paper; principles of report writing and guidelines according to style manuals, writing and presentation of preliminary, main body and reference section of report, picture and graphs, evaluation of research report;	12

	characteristics of scientific writing and guidelines of style manual, effective illustration, reference style and presentation of scientific papers and synopsis.	

Tasks and Assignments:

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

References

1. Panneerselvam, R. (2013). Research Methodology, Prentice Hall of India, New Delhi.
2. Kothari C R (2004). Research Methodology (Methods and Techniques) New Age Publications (2nd Edi)
3. Gautam, N.C. (2004). Development of Research tools, Shree Publishers, New Delhi
4. Gupta Santosh (2005). Research Methodology and Statistical Techniques, Deep and Deep Publications.
5. Sharon Lohr, "Sampling: Design and Analysis" Duxbury Press

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓			✓
CO2	✓	✓	✓			✓
CO3		✓	✓	✓	✓	✓
CO4				✓	✓	✓

SEMESTER - I				
Course Code	**Course Name**	**L**	**P**	**Credits**
GLY3012	Research Ethics	2	-	2

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO1	Understand the basics of philosophy of science and ethics, research integrity, publication ethics.	Understand
CO2	Guide in presenting plagiarism tools for a valid and ethical research report, Indexing and citation databases, open access publications, research metrics.	Understand

b. Syllabus

Units	Content	Hrs.
I	Definition of research ethics; confidentiality in maintaining the analysis data; scientific misconduct in research practice; essential ethical principles for research students, plagiarism, falsification, fabrication;.	6
II	Redundant Publications: duplicate and overlapping publications, salami slicing; selective reporting and misinterpretation of data	6
III	Definition, introduction, and importance of publication ethics; Conflicts of interest, publication misconduct and violation of publication ethics; identification of predatory publishers and journals.	6
IV	Introduction to open access publication; introduction to software tools to identify predatory publications and journal suggestion tools like Elsevier Journal Finder, Springer, Journal Suggester, etc.;	6
V	Use of plagiarism software like Turnitin, Urkund and other open-source software tools; introduction to Indexing databases, citation databases and research metrics.	6

Tasks and Assignments:

Each student is required to undergo the following:

✓ Assignments

✓ Seminars

✓ Class Tests

References

1. Nicholas H. Steneck. Introduction to the Responsible Conduct of Research. Office of Research Integrity. 2007.

2. Ethics in Science Education, Research and Governance Edited by Kambadur Muralidhar, Amit Ghosh Ashok Kumar Singhvi. Indian National Science Academy, 2019.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1					✓	✓
CO2	✓		✓	✓	✓	

SEMESTER - I				
Course Code	**Course Name**	**L**	**P**	**Credits**
GLY3013	Analytical Techniques in Geosciences and seminar	4	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO1	Analyse and interpret various geochemical data using common geochemical analytical techniques	Apply
CO2	Understand the principles of statistical analysis in geosciences	Understand
CO3	Use computer software and programing language for geological data interpretation	Analyse
CO4	Communicate their research findings with the scientific community	Evaluate

b. Syllabus

Units	**Content**	**Hrs.**
I	Preparation of samples for microscopic examination and chemical analysis, Chromatographic methods of analysis: High Performance Liquid Chromatography (HPLC) and Gas Liquid Chromatography (GLC),Ion-exchange chromatography; UV-Visible spectroscopy, Flame photometry and Atomic absorption spectrometry; Inductively coupled plasma spectroscopy.	12
II	Introduction to principles of common geochemical analysis techniques; X-Ray diffraction (XRD), X-Ray Fluorescence (XRF) and Scanning Electron Microscopy (SEM), Electron Probe Micro Analyzer (EPMA) and its applications.	12
III	Statistical methods; standard deviation; skewness and kurtosis; scatter diagrams; frequency distribution; histogram; correlation, covariance, correlation coefficient and regression. Chi square distribution; probability; students 't' test, 'f' test; confidence interval, analysis; calculation of variance-covariance, simple linear models; cluster analysis.	12
IV	Hands on basic computer skills MS Word, Excel, PPT, Origin, CorelDRAW. Basic idea of the use of Python for statistical analysis.	12
V	Application of geospatial technology in earth sciences. Assignments and Seminar presentation based on scholar's area of interest	12
Tasks and Assignments: Each student is required to undergo the following:		

✓ Assignments
✓ Seminars
✓ Class Tests

References

1. Potts, P. J. (2012). A handbook of silicate rock analysis. Springer Science and Business Media.
2. Gill, R. (2014). Modern Analytical Geochemistry: an introduction to quantitative chemical analysis techniques for Earth, environmental and materials scientists. Routledge.
3. Merriam D.F., (Ed.) (2000). Computer Methods in the Geosciences, Elsevier.
4. Davis, J. C., (2002). Statistics and data analysis in geology, third edition, John Wiley and Sons, Singapore.
5. Simon W., (2000). Houlding Geostatistics: Modeling and Spatial Analysis, Springer: Har/CdrEdition (8 June 2000), CD-ROM: 161 pages, 2000.
6. Hohn, M.E. (1988). Geostatistics and Petroleum Geology, New York: Van Nostrand Reinhold,
7. Ott, R. L. and Longnecker, M (2015). An introduction to statistical methods and data analysis, Cengage Learning, USA.
8. Lutz, M, (2013). Learning Python, O'Reilly Media, Inc., USA.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓		✓	✓
CO2	✓	✓	✓		✓	✓
CO3		✓	✓		✓	✓
CO4				✓	✓	✓

SEMESTER - I				
Course Code	**Course Name**	**L**	**P**	**Credits**
GLYEC02	Geospatial Technology and Modelling in groundwater resources	4	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO1	Provide scholars with the fundamental knowledge of Geospatial Technology and its application in groundwater resources.	Understand
CO2	Handling the remote sensing and GIS software	Analyse
CO3	Groundwater Exploration	Evaluate
CO4	Groundwater modelling and assessment	Evaluate

b. Syllabus

Units	**Content**	**Hrs.**
I	The fundamental concept of remote sensing - EMR (Electro-Magnetic Radiation) and its interaction with earth's surface and atmosphere, spectral bands and its characteristics; Digital Image Processing – Radiometric correction, Geometric correction, Noise removal, Edge detection, spatial filters. GNSS, GIS – Data model and its application	12
II	Hydrological Properties of Rocks: Porosity, Permeability, Specific Yield and Specific Retention, Base Flow, Transmissivity and Storage Coefficient - Hydraulic Conductivity – Aquifers: Types - unconfined, confined, leaky and perched aquifers:	12
III	Darcy's Law: Validity of Darcy's Law - Ground Water Flow Equations: Steady, Unsteady and Radial Flow: Surface water quality and quantity assessment: Graphical Representation and Interpretation of Water Quality Data.	12
IV	Drilling Methods for Groundwater Bore Wells, Tube wells. Problems are due to the over-exploitation of groundwater, hard rock aquifer systems. Measurement of aquifer properties (Hydraulic Conductivity Transmissivity, Storativity) in different geological environments.	12
V	Remote sensing, GIS and GNSS for groundwater exploration with case studies. Outline of methods of groundwater exploration - Groundwater provinces of India and Tamil Nadu. Groundwater modelling and its application. Groundwater Assessment including water budget.	12
Tasks and Assignments:		

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

References

1. Anbazhagan. S, Venkatachalapathy, R. Neelakantan, R (2009). Exploration Geology and Geoinformatics, 1st Edition, Macmillan India Ltd., ISBN: 10:0230-63867-8
2. Jensen, J. R. (2005). Introductory Digital Image Processing, Prentice-Hall, New Jersey
3. Joseph, G. (2004). Fundamentals of Remote Sensing, Universities Press, Hyderabad, India
4. Lillesand, T. M., Kiefer, R. W. and Chipman, J. W. (2008). Remote Sensing and Image Interpretation, John Wiley and Sons, New Delhi
5. Sabins, Floyd F. Jr. (1997). Remote Sensing: Principles and Interpretation, W.H.Freeman, New York.
6. David Keith Todd, Larry W. Mays, (2013). Groundwater Hydrology, Wiley son's publication.
7. Fetter, C. W. (2007). Applied Hydrology, CBS Publications.
8. Herman Bouwer, (2014). Groundwater Hydrology, McGraw hill education private limited.
9. Raghunath, H.M. (2003). Groundwater, New age international publications.
10. Deman, MCJ. Smith G.S and Verstappen, H. T. (1986). Remote Sensing for resources development and environmental management, A. A. Ballkema Publishers, Totterdam, Netherlands.
11. Ramakrishnan. S. (1998). Groundwater, CBS Publishers and Distributors.
12. Siddan Anbazhagan, Arumugam Jothibasu, Guru Balamurugan. (2019). Climate Change in Water Resources. Allied Publishers, New Delhi, India. ISBN: 978-93-87997-82-0

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓		✓	
CO2		✓	✓		✓	✓
CO3		✓	✓		✓	✓
CO4				✓	✓	✓

SEMESTER - I				
Course Code	**Course Name**	**L**	**P**	**Credits**
GLYEC03	Advances in Structural Geology	4	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO1	Explain the stresses acting in the earths and its resultant deformation, explain concept of strain and its significance.	Understand
CO2	Analyse the tectonics in brittle and ductile regime and relationship between deformation and crystallisation.	Analyse
CO3	Explain the meso and micro-deformation and construct the retrodeformation.	Apply
CO4	Analyse the petrofabric elements, paleo-earthquake deformation and the theory of plate tectonics	Apply

b. Syllabus

Units	**Content**	**Hrs.**
I	Mechanical properties of rocks; Types, representation and role of stresses in rock deformation; Dynamics of faulting under different stress regimes; Strain ellipsoids, Techniques of Strain analyses.	12
II	Thin- and thick-skinned tectonics; Thrust Geometry and Fault-related folds; Relation between Deformation and Crystallisation, Detailed analysis of Shear zone.	12
III	Crystallographic and Lattice preferred orientation of minerals and their implications; Penetrative and non-penetrative fabrics and their use in structural analyses.	12
IV	Analysis of meso and microscopic structures in deformed rocks; Concept of Balanced Cross Section.	12
V	Petrophysical properties of rocks; Petrofabric analyses; Paleoseismology; Application of Anisotropy of Magnetic Susceptibility in fabric analysis of rocks; Plate tectonics and geodynamics of plate boundaries	12

Tasks and Assignments:

Each student is required to undergo the following:

✓ Assignments

✓ Seminars

✓ Class Tests

References

1. Ghosh, S.K. (1993). Structural Geology: Fundamentals and Modern Developments. Pergamon Press.
2. Jayangondperumal, R. Thakur, V.C., Vivek, J., Priyanka, R.S. and Gupta, A.K. (2018). Active Tectonics of Kumaun and Garhwal Himalaya, 151 pp. Springer Natural Hazard Series.
3. Marshak, S. and Mitra, G. (1988). Basic Methods of Structural Geology. Printice Hall.
4. Ramsay, J.G. (1967): Folding and fracturing of rocks. McGraw Hill.
5. Ramsay, J.G. and Huber, M.I. (1983). Techniques of Modern Structural Geology, Vol. I, Strain Analysis. Academic Press.
6. Ramsay, J.G. and Huber, M.I. (1987). Techniques of Modern Structural Geology, Vol. II, Folds and Fractures. Academic Press.
7. Twiss, R.J. and Moores, E.M. (2006). Structural Geology, 2nd Edition. W. H. Freeman.
8. Tarling, D.H. and Hrouda, F. (1993). The Magnetic Anisotropy of Rocks. Chapman and Hall, London.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓			✓
CO2	✓	✓	✓			✓
CO3		✓	✓		✓	✓
CO4		✓	✓		✓	✓

SEMESTER - I				
Course Code	**Course Name**	**L**	**P**	**Credits**
GLYEC04	Applied Geochemistry	4	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO1	Understand the geochemical behavior of elements in various reservoirs of the Earth and their interaction with different environmental components.	Understand
CO2	Explain the principles of geochemistry to understand the behavior of various elements in aquatic and sedimentary environments.	Analyse
CO3	Apply the geochemistry of rocks and minerals in mineral exploration and petrogenesis.	Apply
CO4	Demonstrate the relationship between geological processes and health risks associated with humans, animals and plants	Apply

b. Syllabus

Units	Content	Hrs.
I	Introduction to the chemical composition, properties and evolution of various reservoirs of the Earth. Classification, mineralogy, origin and significance of meteorites. Geochemical classification of elements. Element partitioning in mineral/rocks formation and concept of distribution coefficient. The applications of trace elements in the petrogenesis.	12
II	Introduction to radioactivity, geochronology and isotopic mass fractionation. Radiogenic and stable isotopic systematics. Decay scheme of K–Ar, Ar–Ar, Rb–Sr, Sm–Nd and U–Th–Pb systems. Stable isotope geochemistry of carbon, oxygen, hydrogen, sulphur and its applications in petrology and paleoclimatology.	12
III	Geochemistry of natural waters, water quality, water sampling techniques, analytical methods in hydro chemical studies, interpretation of physical and chemical data of water, graphical representation methods in presenting hydro chemical data. Introduction to sediment geochemistry, Geochemical processes involved in rock weathering and soil formation.	12
IV	Distribution of elements in the Earth crust, primary and secondary dispersion of elements, controls of dispersion, mobility of elements, geochemical association of elements, application of pathfinder elements in mineral exploration, determination of geochemical anomaly, background and threshold value, geochemical survey methods, geochemical sampling techniques- litho-geochemical sampling, pedo-geochemical sampling, atmo-	12

	geochemical sampling, heavy mineral sampling and biogeochemical sampling. Interpretation of geochemical data in mineral exploration.	
V	Fundamentals of agricultural geochemistry, sources of trace elements and metals in soils, pollution assessment in soils, health effects associated with toxicity/deficiency of various elements in plants and crops. Definition, concepts and history of medical geology, chemical constituents of the human body, essential elements and toxic elements, dose-response curve. Geophagy and health benefits of geologic materials. Geologic sources of health risks – fluorosis, silicosis, arsenicosis, iodine deficiency diseases (IDD), Radon hazards, heavy metal poisoning and nitrate contamination in ground water.	12

Tasks and Assignments:

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

References

1. Clark, I. (2015). Groundwater geochemistry and isotopes. CRC press.
2. Dissanayake, C. B., and Chandrajith, R. (2009). Introduction to Medical Geology. Erlangen Earth Conference Series. Springer.
3. Eby, G. N. (2016). Principles of environmental geochemistry. Waveland Press.
4. Faure, G. (1977). Principles of isotope geology. John Wiley and Sons.
5. Levinson, A. A. (1980). Exploration geochemistry. Applied Publishing, Wilmette, IL.
6. Moon, C., Whateley, M., and Evans, A. (2005). Introduction to mineral exploration. Wiley-Blackwell.
7. Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.
8. Schaefer, B. F. (2016). Radiogenic isotope geochemistry: A guide for industry professionals. Cambridge University Press.
9. Selinus, O. (2013). Essentials of medical geology: revised edition. Springer.
10. White, W. M. (2020). Geochemistry. John Wiley and Sons.
11. Winter, J. D. (2013). Principles of igneous and metamorphic petrology. Pearson education.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓			✓
CO2	✓	✓	✓			✓
CO3	✓	✓	✓			
CO4	✓	✓	✓	✓		✓

SEMESTER - I					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
GLYEC05	Geomechanics	4	-	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO1	Explain various concepts of rock mechanics and geomechanics used in various engineering projects	Understand
CO2	Study rock failure mechanism, rock mass classifications and the concept of rock slope engineering, landslide study	Apply
CO3	Analyse the concept of flow of fluids in porous media and wellbore stability	Analyse
CO4	Evaluate the importance of geomechanics in various conventional and unconventional engineering projects	Evaluate

b. Syllabus

Units	Content	Hrs.
I	Basic principles of geomechanics and its application. Concept of stress-strain-deformation in the reservoir; Mohr's circle of stress and strain. Physical, mechanical properties of rocks and their significance.	12
II	Theories of rock failure mechanics. Discontinuities in rock masses. Concepts of rock mass classification. Geological and geomechanical consideration for evaluation of sites for engineering projects.	12
III	Rock slope engineering and Landslide investigation. Fluid flow in porous media and constitutive laws; stress around vertical, horizontal, and deviated wells.	12
IV	Determination of in-situ stresses. Wellbore failure and stress determination in deviated wells. Wellbore stability; cap rock integrity.	12
V	Reservoir compaction and subsidence; hydraulic fracturing; geomechanics of unconventional hydrocarbon reservoirs; geomechanics of carbon storage and enhanced oil/gas recovery; induced seismicity and risks.	12

Tasks and Assignments:

Each student is required to undergo the following:

✓ Assignments

✓ Seminars

✓ Class Tests

References

1. Deb, D., Verma, A.K. (2016). Fundamental and applications of rock mechanics. PHI Learning Private Limited.

2. Jaeger, J.C., Cook, N.G.W., Zimmerman, R.W. (2007). Fundamental of rock mechanics. Blackwell Publishing Ltd.
3. Singh, B., Goel, R.K. (2011). Engineering rock mass classification. Elsevier Inc.
4. Zoback, M.D. (2010). Reservoir Geomechanics, Cambridge University Press.
5. Zoback, M., and Kohli, A. (2019). Unconventional Reservoir Geomechanics: Shale Gas, Tight Oil, and Induced Seismicity. Cambridge, Cambridge University Press.
6. Ahmed, T. and McKinney, P. D. (2005). Advanced Reservoir Engineering, Gulf Professional Publishing.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓		✓	✓
CO2	✓	✓	✓			✓
CO3	✓	✓	✓			✓
CO4	✓	✓	✓	✓		✓

SEMESTER - I					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
GLYEC06	Natural and Anthropogenic Hazards and Risk Impact Assessment	4	-	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO1	Describe common natural hazards and their impact on human settlements and natural systems.	Understand
CO2	Apply critical thinking approach to development of new risk reduction policies. Evaluate the common methods used to mitigate and prepare for each type of hazard event.	Apply
CO3	Describe Risk Impact Assessment (RIA) and Risk Management.	Evaluate
CO4	Examine Hazard, Risk, Vulnerability, and Capacity (FIRVC) analysis in sectoral applications.	Evaluate

b. Syllabus

Units	**Content**	**Hrs.**
I	Introduction to natural and anthropogenic hazards-Definitions of natural and anthropogenic hazards; Type of natural and anthropogenic hazards; Geophysical Hazards-Intro to geophysical hazards (e.g., earthquake, volcanic eruption, rock fall, landslide, avalanche, and subsidence); Introduction to methods for analysing geophysical hazards.	12
II	Hydrometeorological hazards-Introduction to hydrometeorological hazards (e.g., flood, drought, storm, extreme temperature, wildfire, and wet mass movement); Introduction to methods for analysing hydrometeorological hazards. Biological hazards-Introduction to biological hazards (e.g., epidemic, insect infestation, and animal stampede): Introduction to methods for analysing biological hazards.	12
III	Introduction to risk assessment-Introduction to disaster risk management and risk assessment; Hazard Assessment-Hazard types; Main concepts of hazard assessment; Frequency magnitude – relationships; Vulnerability assessment-Types of vulnerability; social vulnerability; physical vulnerability; methods for vulnerability assessment; participatory GIS; Spatial Multi Criteria Evaluation.	12
IV	Elements at risk assessment-Types of elements at risk; classification of buildings, infrastructure, lifelines, critical facilities; population information;	12

	collection of elements at risk information; Risk assessment-Loss estimation models; HAZUS; qualitative risk assessment; QRA;	
V	Basics of flood risk, seismic risk, landslide and technological risk assessment; Risk management-Risk evaluation; risk governance; risk communication; cost benefit analysis; Using risk information for emergency planning; spatial planning and Environmental Impact Assessment.	12

Tasks and Assignments:

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

References

1. Alexander, D. E. (2013). Resilience and disaster risk reduction: An etymological journey. Natural Hazards and Earth System Sciences Discussions, 1(2), 1257-1284. https://doi.org/10.5194/nhessd-1-1257-2013
2. Below. R. and Wallemaca. P. (2018). Annual disaster statistical review 2017. CRED, Centre for Research on the Epidemiology of Disasters.
3. Change, I. P. 0. C. (2007). Climate change 2007: the physical science basis: summary for policymakers. Geneva: IPCC.
4. Coppola, D. P. (2006). Introduction to international disaster management. Elsevier. ISBN: 9780080465739
5. O'Brien, G., O'Keefe, P., Rose, J., and Wisner, B. (2006). Climate change and disaster management. Disasters, 30(1), 64-80. https://doi.org/10.1111/j.1467-9523.2006.00307.x
6. Thomalla, F., Downing, T., Spanger-Siegfried, E., Han, G., and Rockström, J. (2006). Reducing hazard vulnerability: Towards a common approach between disaster risk reduction and climate adaptation. Disasters. 30(1), 39-48. https://doi.org/10.1111/j.1467-9523.2006.00305.x
7. Multi Hazards Risk Assessment – Theory Book, C.J. van Western (end), D. Alkema, M.C.J. Damen, N, Kerle, and N.C. Kindma. (2011). United Nations University – ITC School on Disaster Geoinformation Management (UNU-ITC DGIM), Version 2011.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓			✓
CO2	✓	✓	✓		✓	✓
CO3			✓	✓	✓	
CO4				✓	✓	✓

SEMESTER - I				
Course Code	**Course Name**	**L**	**P**	**Credits**
GLYEC08	Geology of Economic Mineral Deposits	4	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO1	Understand the ore mineral association in igneous and sedimentary rocks.	Understand
CO2	Elemental mobility and concentration in different geological settings.	Analyse
CO3	Textures in the understanding of ore deposit.	Apply
CO4	Application of ore genesis model to different ore forming processes.	Apply

b. Syllabus

Units	Content	Hrs.
I	Concept of ore mineral deposits; nature of mineral deposits in igneous rocks, sedimentary rocks; Criteria and guides for ore mineral search; Metallogenetic epochs and provinces.	12
II	Physico-chemical environment of ore formation; Geochemical exploration: mobility of elements, primary and secondary dispersion of ore minerals, geochemical anomaly, pathfinder elements; various geochemical sampling.	12
III	Textures in the understanding of ore deposit with case studies; application of ore microscopy in mineral exploration; selection of minerals for mineral chemistry and mineral mapping through petrography.	12
IV	Introduction to fluid inclusion studies: principles and sample selection, interpretation of the data with case studies; understanding the fertility of the terrain with the fluid chemistry.	12
V	Porphyry indicator minerals, porphyry vectoring and fertility tools; understanding the control of mineralization with mineral chemistry; concealed deposits using integrated studies including isotope studies.	12

Tasks and Assignments:

Each student is required to undergo the following:

✓ Assignments

✓ Seminars

✓ Class Tests

References

1. Craig, J.R. and Vaughan. (1994). Ore microscopy and ore petrography. John Wiley and Sons.
2. Jensen, M.L. and Bateman, A.M. (1981). Economic mineral deposits. John Wiley and Sons.
3. Misra, K.C. (1999). Understanding mineral deposits. Kluwer Academic Publishers.
4. Pracejus, B. (2015). The ore minerals under the microscope: an optical guide. (Vol. 3, 2nd Ed.) Elsevier.
5. Robb, L. (2005). Introduction to ore-forming processes. Blackwell.
6. Gandhi, S. M., and Sarkar, B. C. (2016). Essentials of mineral exploration and evaluation. Elsevier.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓		✓
CO2	✓	✓	✓	✓		✓
CO3		✓	✓	✓	✓	✓
CO4		✓	✓		✓	✓

SEMESTER - I					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
GLYEC09	Biogeochemistry and Global Biogeochemical Cycles	4	-	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO1	Understand global biogeochemical cycles of key elements (CNOPS) and their major controlling factors, sources and sinks	Understand
CO2	Understand how these elemental cycling affects global climate on different timescales	Understand
CO3	Critically analyse recent scientific literature on changes to global biogeochemical cycles	Analyse
CO4	Apply analytical tools in this field in problem solving, data synthesis and interpretation	Apply

b. Syllabus

Units	**Content**	**Hrs.**
I	The early history of life; evolution of metabolism, sedimentary hydrocarbons and biomarkers for early life; Biomineralization.	12
II	Biogeochemistry of primary production in the sea; plankton respiration, net community production, and the organic carbon cycle in the oceanic water column; terrestrial net primary production and its controlling mechanisms; respiration in terrestrial ecosystem.	12
III	The geologic history of carbon cycle and the contemporary carbon cycle; the oxygen, nitrogen, phosphorous and sulfur cycles through the earth system: global processes, major sources and ultimate sinks.	12
IV	Geological processes on stable isotope distribution in marine sediments: geochemical influences on $^{18}O/^{16}O$, $^{13}C/^{12}C$, $^{15}N/^{14}N$ and $^{34}S/^{32}S$; $\delta^{18}O$ of seawater and marine carbonates; $\delta^{13}C$ of seawater, marine organic matter and marine carbonates; $\delta^{15}N$ in marine ecosystems and organic matter; $\delta^{34}S$ of seawater and pore waters and marine sediments.	12
V	Developments in clean lab practices; stable isotope techniques for gas source mass spectrometry; preparation of sediments and suspended particles for C, N, S analyses with elemental (CHNS) analyser interfaced with isotope ratio mass spectrometry (EA-IRMS)	12
Tasks and Assignments: Each student is required to undergo the following: ✓ Assignments ✓ Seminars ✓ Class Tests		

Reference Books

1. Holland, H.D., K.K. Turekian. (2014). Treatise on Geochemistry, Volume 10: Biogeochemistry (Karl, D.M., W.H. Schlesinger, volume editors), Harvard University Cambridge (Elsevier), 2nd Edition, 649 pp.
2. Schlesinger, W.H., E.S. Bernhardt. (2013). Biogeochemistry: An Analysis of Global Change, Academic Press (Elsevier), 3rd Edition, 688 pp.
3. Berner, E.K., R.A. Berner (1996). Global Environment: Water, Air, and Geochemical Cycles, Princeton University Press, 2nd Edition, 464 pp.
4. Schulz, H.D., M. Zabel. (2006). Marine Geochemistry, Springer, 2nd Edition, 574 pp.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓			✓
CO2	✓	✓	✓	✓	✓	✓
CO3			✓	✓	✓	
CO4				✓	✓	✓

SEMESTER - I					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
GLYEC10	Paleoclimatology and Paleoceanography	4	-	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO1	Discuss climate varies on all timescales: tectonic to decadal to annual	Understand
CO2	Understand process influencing climate change depends on timescale of interest	Understand
CO3	Critically analyse recent scientific literature on changes to Earth's climate in the past and present	Analyse
CO4	Data (paleo and modern instrumental), theory, and modeling are essential to reconstruct Earth's climate	Apply

b. Syllabus

Units	Content	Hrs.
I	Framework of Climate Science - Overview of the climate system; Radiation and heat transfer in the atmosphere, ocean, vegetation, ice; Feedbacks in the climate system; Climate data, climate archives and dating methods.	12
II	Tectonic-scale Climate Change: Carbon dioxide (CO_2) and long-term climate; Plate tectonics and long-term climate; Greenhouse climate; Greenhouse to icehouse climate - last 50 million years.	12
III	Orbital-scale Climate Change: Astronomical control of solar radiation; Insolation control of monsoons and ice sheets; Orbital-scale changes in CO_2 and methane.	12
IV	Millennial-scale Climate Change: Last glacial-interglacial cycle - Dansgaard-Oeschger (DO) cycles and Heinrich events; Last Glacial Maximum – Reconstruction of ice sheets, sea level, dust, temperature, ocean circulation, and atmospheric CO_2.	12
V	Deglacial and Holocene Climate: Deglacial climate changes, Holocene monsoon and temperature; Rapid climate changes: records from ice cores, land and ocean archives; Climate records from corals: Past ENSO variability; Climate of the last 1000 years; An overview of Intergovernmental Panel on Climate Change (IPCC) reports on anthropogenic CO_2 and current global warming.	12

Tasks and Assignments:

Each student is required to undergo the following:

✓ Assignments

✓ Seminars

✓ Class Tests

Reference Books

1. Ruddiman, W. F. (2001). Earth's Climate: Past and Future. W.H. Freeman and Company, 3rd Edition, 445 pp.
2. Raymond S. Bradley. (2013). Paleoclimatology: Reconstructing Climates of the Quaternary, Academic Press, 3rd Edition, 675 pp.
3. Crowley, T.J., G.R. North. (1991). The Earth's Climate: Paleoclimatology, Oxford University Press, 339 pp.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓			
CO2	✓	✓	✓	✓	✓	✓
CO3			✓	✓	✓	✓
CO4				✓	✓	✓