CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA

DEGREE OF M. Sc. Applied Geology

MASTER OF SCENCE IN APPLIED GEOLOGY

(CHOICE BASED CREDIT AND SEMESTER SYSTEM FOR UNDERGRADUATE CURRICULUM)

UNDER THE FACULTY OF SCIENCE

SYLLABUS

(FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2019 – '20 ONWARDS)

BOARD OF STUDIES IN GEOLOGY (PG)

CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA - 680125, KERALA, INDIA

JUNE, 2019

Scheme of PG Programme under CBCSS PG in Applied Geology

Rules, Regulations, and Syllabus

1. TITLE

These regulations shall be called "Regulations for Choice Based Credit Semester System for Post-Graduate Curriculum - 2019 for affiliated Colleges" (CBCSS-PG) 2019.

2. SCOPE, APPLICATION & COMMENCEMENT

The regulations provided herein shall apply to all Regular PG programme in Applied Geology offered by the affiliated colleges under Faculty of Science conducted by the Christ College (Autonomous) for the admissions commencing from 2019, with effect from the academic year 2019-2020.

3. ADMISSION

Those students who possess B.Sc. Degree in Geology, Geology & Water Management as Core Courses with Physics/Chemistry/Mathematics/Statistics/Remote Sensing & GIS as Complementary courses are eligible for admission to this programme

4. DURATION OF THE PROGRAMME

1) The minimum duration for successful completion of M.Sc. (Applied Geology) programme shall be 2 years, split into 4 semesters. The maximum period for completion is 4 years.
2) The duration of each semester shall be 90 working days, inclusive of examinations, spread over five months.
3) Odd semesters shall be held from June to October and even semesters from November to March subjected to the academic calendar of the University.

5. PROGRAMME STRUCTURE AND SCHEME OF EXAMINATIONS

4) The programme shall include three types of courses: Core courses, Elective courses and Audit Courses.
5) Comprehensive Field work/Study Tour, Mapping Camp, Viva-voce, and Project Work / Dissertation shall be treated as Core Courses.
6) Total credit for the programme shall be 80 (eighty), this describes the weightage of the course concerned and the pattern of distribution as detailed below. A student shall accumulate a minimum of 80 credits for the successful completion of the programme.
7) Practical examinations and evaluation of reports of the Field work/Study Tour and Combined Field Mapping shall be conducted at the end of even semesters.
8) There shall be University examination for theory courses at the end of each semester. Each theory course examination will be of 3-hour duration.
9) Practical examinations of second semester shall be of 4-hour duration, whereas the practical

examinations of fourth semester shall be of 3-hour duration.

10) Evaluation of the report of field work shall be conducted along with the second semester practical examination. Evaluation of Combined Field Mapping and Project / dissertation and viva-voce shall be conducted at the end of the programme only.

a. Study Tour/Field Work and Combined Field Mapping Camp.

Extensive field work with emphasis on Stratigraphy, Structural Geology, Economic Geology, Palaeontology, and Petrology extending for 12 to 15 days in different parts of India are integral and mandatory component of the program. The study tour should be organized in such a way that a major portion of the entire tour period is exclusively allocated for field- based studies, including visit to quarries, mines and locations of geological interest, and limited time slots may be reserved to visit Academic/Research institutions.

Mapping camp, extending for 10 to 15 days in a particular location, anywhere in India with emphasis on structural and lithological mapping shall be carried out during third or fourth semester of the programme.

b. Audit courses

In addition to the above courses there will be two Audit Courses (Ability Enhancement Course & Professional Competency Course) with 4 credits each. These have to be done one each in the first two semesters. The credits will not be counted for evaluating the overall SGPA & CGPA. The colleges shall conduct examination for these courses and have to intimate /upload the results of the same to the University on the stipulated date during the III Semester. Students have to obtain only minimum pass requirements in the Audit Courses. The details of Audit courses are given below:

Semester	Course Title	Suggested Area	Details
I	Ability Enhancement Course (AEC)	Internship/Seminar presentation/ Publications/Case study analysis/Industrial or Practical Training/research methodology/ Community linkage programme etc.	
II	Professional Competency Course (PCC)	To test the skill level of students like testing the application level of different software such as QGIS/GtAide/WATCHIT	

Ability Enhancement Course (AEC) GEL 1A 01

Scheme and Evaluation

1. Preparation of a research proposal. Identification. Detailed methodology. Time frame. National and international status of the research problem. Literature survey report.

   Evaluation:

   Relevance - 20%, Novelty - 20% Document - 35%, Presentation / Viva - 25%.

2. Developing e-content for any one module of any course of the student's choice. It might include reading material, questions with answers, glossary, PowerPoint and videos.

   Evaluation:

   Classroom presentation - 50% Developed contents - 40% Originality - 10%

3. Synthesis of any one geological problem using research literature. Evaluation:

   Presentation - 25%, Discussion - 25% Methodology - 25%, Result - 25%

Professional Competency Course (PCC) GEL 2A 02

1. Statistical data analysis and representation of the results using any one software.

   Evaluation:

   Four practical tests of 25% marks each.

2. Developing a new methodology / software / App, for problem solving in geological sciences, significant to the societal needs.

   Evaluation:

   The software / app by direct testing. Methodology - by discussion among the panel of teachers.

3. Writing a research paper following the guidelines of any standard research journal, using open-source data.

   Evaluation:

   Separate review by at least two teachers from the panel.

6. Credits and weightages for various papers, and evaluation scheme

Semester	Course Type	Course Code	Course Title	Hours per week	Credits	Weightage (%)	
						Internal	External
I	Theory	GEL 1C 01	Physical Geology & Geomorphology	4	4	20	80
	Theory	GEL 1C 02	Structural Geology & Geotectonics	5	4	20	80
	Theory	GEL 1C 03	Geoinformatics	4	4	20	80
	Theory	GEL 1C 04	Stratigraphy & Indian Geology	4	4	20	80
	Practical*	GEL 1L 01	Geomorphology, Structural Geology, Geoinformatics	6	3	20	80
	Field Work‡	GEL 1F 01	Study Tour	2	0	0	0
II	Theory	GEL 2C 05	Crystallography & Mineralogy	4	4	20	80
	Theory	GEL 2C 06	Economic Geology	4	4	20	80
	Theory	GEL 2C 07	Hydrogeology	4	4	20	80
	Theory	GEL 2C 08	Applied Palaeontology & Sedimentology	5	4	20	80
	Practical	GEL 2L 02	Crystallography, Mineralogy, Economic Geology, Hydrogeology, Palaeontology & Sedimentology	6	3	20	80

	Field Work‡	GEL 1F 02	Study Tour	2	2	20	80
III	Theory	GEL 3C 09	Igneous & Metamorphic Petrology	5	5	20	80
	Elective1#	GEL 3E 01a	Climatology	4	3	20	80
		GEL 3E 01b	Coal and Petroleum Geology				
	Elective2#	GEL 3E 02a	Environmental Geology	4	3	20	80
		GEL 3E 02b	Quaternary Geology				
	Elective3#	GEL 3E 03a	Marine Geology	4	3	20	80
		GEL 3E 03b	Geotechnical Engineering				
	Practical*	GEL 3L 03	Igneous and Metamorphic Petrology & Elective Course	8	4	20	80
	Field Mapping†	GEL 3M 01	Combined Field Mapping	10-15 Days	0	0	0
IV	Theory	GEL 4C 10	Geochemistry and Isotope Geology	6	4	20	80
	Elective4#	GEL 4E 04a	Exploration Geology	6	4	20	80
		GEL 4E 04b	Disaster Management				
	Elective5#	GEL 4E 05a	Engineering Geology	5	3	20	80
		GEL 4E 05b	Environmental Impact Assessment				
	Practical	GEL 4L 04	Geochemistry & Elective Course	6	3	20	80
	Project	GEL 4P 01	Project/Dissertation	2	4	20	80
	Field Mapping†	GEL 4M 02	Combined Field Mapping	10-15 Days	2	20	80
	Viva-Voce	GEL 4V 01	Viva-Voce	–	2	20	80
Total credits for the programme					**80**		

*Practical exams will be held at the end of even semesters.

‡Evaluation shall be conducted along with second semester practical examination.

#In an academic year, the department may offer any one among these courses.

±The project work may start after first semester of the programme, however, evaluation will be held at the end of 4thsemester.

†Evaluation of the mapping programme shall be held at 4th semester of the programme.

6.1. Evaluation and grading

- The evaluation scheme for each course shall contain two parts; (a) Internal/ Continuous Assessment (CA) and (b) External / End Semester Evaluation (ESE).
- Of the total, 20% weightage shall be given to internal evaluation / Continuous assessment and the remaining 80% to External/ESE and the ratio and weightage between Internal and External is 1:4.
- Primary evaluation for Internal and External shall be based on 6 letter grades (A^+, A, B, C, D and E) with numerical values (Grade Points) of 5, 4, 3, 2, 1 & 0 respectively.
- Grade Point Average: Internal and External components are separately graded and the combined grade point with weightage 1 for Internal and 4 for external shall be applied to calculate the Grade Point Average (GPA) of each course. Letter grade shall be assigned to each course based on the categorization based on Ten-point Scale provided below:

Letter Grade	Grade Range	Range of Percentage	Merit Indicator
O	4.25 – 5.00	85.00 – 100	Outstanding
A^+	3.75 – 4.24	75.00 – 84.99	Excellent
A	3.25 – 3.74	65.00 – 74.99	Very Good
B^+	2.75 – 3.24	55.00 – 64.99	Good
B	2.50 – 2.74	50.00 – 54.99	Satisfactory
C	2.25 – 2.49	45.00 – 49.99	Average
P	2.00 – 2.24	40.00 – 44.99	Pass
F	< 2.00	Below 40	Failure
I	0	-	Incomplete
Ab	0	-	Absent

- No separate minimum is required for Internal evaluation for a pass, but a minimum P Grade is required for a pass in the external evaluation. However, a minimum P grade is required for pass in a course.
- A student who fails to secure a minimum grade for a pass in a course will be permitted to write the examination along with the next batch.
    - Improvement of Course- The candidates who wish to improve the grade/ grade point of the external examination of a course/s they have passed already can do the same by appearing in the external examination of the concerned semester along with the immediate junior batch.
    - Betterment Programme One time- A candidate will be permitted to improve the CGPA of the Programme within a continuous period of four semesters immediately following the completion of the programme allowing only once for a particular semester. The CGPA for the betterment appearance will be computed based on the SGPA secured in the original or betterment appearance of each semester whichever is higher.

6.2.1. Semester Grade Point Average (SGPA) – Calculation

The SGPA is the ratio of sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses taken by a student. After the successful completion of a semester, Semester Grade Point Average (SGPA) of a student in that semester is calculated using the formula given below:

$$\text{Semester Grade Point Average – SGPA } (Sj) = \Sigma(Ci \times Gi)/Cr$$

(SGPA= Total Credit Points awarded in a semester / Total credits of the semester)

Where 'Sj' is the j^{th} semester, 'Gi' is the grade point scored by the student in the i^{th} course 'Ci' is the credit of the i^{th} course, 'Cr' is the total credits of the semester.

6.2.2. Cumulative Grade Point Average (CGPA) - Calculation

Cumulative Grade Point Average (CGPA) = Σ(Ci x Si)/Cr

(CGPA= Total Credit points awarded in all semesters/Total credits of the programme)

Where Ci is the credit of the Ist semester Si is the SGPA of the Ist semester and Cr is the total number of credits in the programme. The CGPA is also calculated in the same manner taking into account all the courses undergone by a student over all the semesters of a programme. The SGPA and CGPA shall be rounded off to 2 decimal points.

For the successful completion of a semester, a student should pass all courses and score a minimum SGPA of 2.0. However, the students are permitted to move to the next semester irrespective of their SGPA.

6.3. Internal evaluation

The internal evaluation shall be based on predetermined transparent system. This assessment shall be based on a predetermined transparent system involving periodic written tests, assignments, seminars and viva-voce in respect of theory courses and based on tests, lab skill and records/viva in respect of practical courses.

The internal evaluation of combined field mapping and study tour/fieldwork will be based on punctuality, fieldwork skill/ability in recording geological parameters, specimen collection and viva. The details of marks assigned to various components for internal evaluation are as follows:

6.3.1. Components of Internal Evaluation / Continuous Assessment

6.3.1.1. Theory

Sl. No.	Component	Percentage	Weightage
i)	Examination/Test	40%	2
ii)	Seminars/Presentation	20%	1
iii)	Assignment	20%	1
iv)	Attendance	20%	1
	Total		**5**

6.3.1.2. Practical

Sl. No.	Component	Percentage	Weightage
i)	Lab skill	40%	4
ii)	Records	20%	3
iii)	Practical Test/Viva	20%	3
	Total		**10**

6.3.1.3. Combined field mapping/Study tour

Sl. No.	Criteria	Weightage
1.	Field work/involvement	4
2.	Specimen collection/preparation of maps	2
3.	Report	2
4.	Viva-Voce	2
	Total	**10**

6.3.1.4. Dissertation

For a pass in Project Work, a student has to secure a minimum of P Grade in External and Internal examination combined. If the students could not secure minimum P Grade in the Project work, they will be treated as failed in that attempt and the students may be allowed to rework and resubmit the same in accordance with the University exam stipulations. There shall be no improvement chance for Project Work.

Sl. No.	Criteria	Weightage	
		External	Internal
1.	Relevance of the topic and Statement of problem	8	2
2.	Methodology & Analysis	8	2
3.	Quality of Report & Presentation	8	2
4.	Viva-Voce	16	4
	Total	**40**	**10**

The marks for viva-voce can be given based on the subject knowledge/subject aptitude of the candidate.

For a pass in Comprehensive viva-voce, a student has to secure a minimum of D Grade in External and Internal examination combined. If the students could not secure minimum D Grade in the Project work, they will be treated as failed in that attempt and the student may re appear for the same next time in accordance with the University exam stipulations. There shall be no improvement chance for Comprehensive viva-voce.

To ensure transparency of the evaluation process, the internal assessment grade awarded to the students in each course in a semester shall be published on the notice board at least one week before the commencement of external examination. There shall not be any chance for improvement for internal grade.

6.4. Pattern of Questions for External Evaluation/ESE

The external Examination in theory courses is to be conducted by the University with question papers set by external experts. Each theory question paper may contain 4 short answer types of questions out of 7, of weightage 2; 4 short essays out of 7 of weightage 3; and 2 long essays out of 4, with weightage of 5. The evaluation of the answer scripts shall be done by examiners based on a well-defined scheme of valuation. The

external evaluation shall be done immediately after the examination preferably in a Centralized Valuation Camp.

Sl. No.	Type of Questions	Individual weightage	Total Weightage	Number of questions to be answered
1.	Short Answer type questions	2	2 × 4 = 8	4 out of 7
2.	Short essay/ problem solving type	3	3 × 4 = 12	4 out of 7
3.	Long Essay type questions	5	5 × 2 = 10	2 out of 4

6.5. Attendance

The students admitted in the PG programmes shall be required to attend at least 75 percent of the total number of classes (theory as well as practical) held during each semester. The students having less than prescribed percentage of attendance shall not be allowed to appear for the University examination.

Condonation of shortage of attendance for a maximum of 9 days (10% of the working days in a semester) in the case of single condonation and 18 days (20% of the working days in a semester) in the case of double condonation in a semester subject to a maximum of two times (for single condonation only) during the whole period of Post Graduate programme may be granted by the University as per the existing procedures. In the case of double condonation, only one condonation shall be allowed during the entire programme.

SEMESTER I

GEL 1C 01 - PHYSICAL GEOLOGY AND GEOMORPHOLOGY

Number of Contact Hours: 64 hrs

Number of Credits: 4

Course Outline

Module 1:

- Earth and the solar system, Meteorites and other extra-terrestrial materials, Planetary evolution of the earth. Heterogeneity of the earth's crust. Major tectonic features of the Oceanic and Continental crust.
- Thermal history of the Earth - Geothermal gradient. Heat budget of the earth, Heat flow.

Module 2:

- Gravity measurements. Positive and negative gravity anomalies. Geoid, spheroid; Isostasy
- Basic concepts of seismology and internal structure of the earth. Physico-chemical and seismic properties

of the earth's interior. Modern techniques for prediction of earthquakes.

Module 3:

- Geomorphic principles and processes. Theory of uniformitarianism. Control of geomorphological features by geologic structures, lithology, climate and time. Geomorphologic cycles. Models of landscape evolution.
- Streams-stream hydraulics- Drainage basin, Morphometric analysis of drainage basins. Fluvial-denudational and erosional landforms. Concept of rejuvenation and interruptions in the evolution of land.
- Coastal Geomorphology. Landforms of wave erosion and deposition. Beach Profiling
- Desert Geomorphology – Processes of erosion and transport – erosional and depositional features – dunes, rock varnish, pediment, inselbergs, wadis

Module 4:

- Wetlands- Geological significance, classification and mode of formation. The Indian scenario - conservation and management in India. Backwaters (Kayals) of Kerala. Soils- formation, classification, soil profile, soils of India and Kerala.
- Geomorphology of Kerala- classification, relief features, geological Significance, rivers of Kerala. Geomorphic features of the Indian subcontinent.

Module 5:

- Hill slopes- forms in relation to lithology and structural weakness in rocks; control and mass movement, modification by overland flow of hill slopes. Slope stability.
- Applied Geomorphology: Application of Geomorphology in Civil Engineering, Hydrogeology, and Environmental Studies.

References

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2. Cox. A. Plate tectonics and geomagnetic reversals, Freeman, 1973
3. Eicher.L.D., Geologic Time, Prentice Hall, 1968
4. Hamilton, E. I., Applied geochronology, Academic Press, 1965
5. Holmes, A. Principles of Physical Geology, Ronald, London, 1972
6. King, C.A.M. Beaches and Coasts, Arnold, London, 1972
7. Leopold, L. Wolmen, C. and Miller J.P. Fluvial processes in Geomorphology, EPH Publishing House, New Delhi, 1976
8. Pethick, J., An introduction to coastal geomorphology, Arnold Heinman publishers, (India), New Delhi, 1984
9. Schumm S.A. (Ed), Drainage Basin morphology- In Bench mark papers in Geology
10. Shartna, H. S. Indian geomorphology, Concept Publishing. Co, New Delhi, 1990
11. Thornbury, W.D. Principles of Geomorphology, Wiley, 1968

12. Windley, B.F., The evolving continents, John Wiley, & Sons
13. Savindra Singh, Geomorphology, Pravalika publications, Allahabad

GEL 1C 02 - STRUCTURAL GEOLOGY AND GEOTECTONICS

Number of Contact Hours: 80 hrs

Number of Credits: 4

Course Outline

Module 1:

- Geological mapping and map reading; Attitudes of planes and lines and their representation.
- Brittle and ductile deformation; Behaviour of minerals and rocks under deformation conditions; Rheology.
- Concept of stress and strain; Relationships for elastic, plastic and viscous materials; Strain and displacement; Graphical representation of finite strain: Strain ellipsoid; Flinn diagram and Mohr Circle.
- Folds: Mechanics of folding; Geometric classification after Ramsay; Genetic classification after Donath and Parker; Minor folds and their uses in determining the major fold structure; Pumpelley's rule.
- Superposed folding and interference patterns

Module 2:

- Joints and fractures: Distinction; Joint formation in response to loading and stress; Fracture development and propagation; Classification of joints and extension fractures.
- Faults: Dynamics of faulting; Displacement, slip and separation; Fault geometry and classification; Characteristics of faults and fault zones.
- Crustal scale faults: Strike-slip, transpression, and transtension

Module 3:

- Tectonites: Fabric elements and classification; S-C fabric; Petrofabric analysis.
- Shear Zones: Brittle and ductile shear zones, geometry and products of shear zones; shear sense indicators; Mylonites and cataclasites, their origin and significance.
- Stereographic projections: linear and planar features.

Module 4:

- Physico-chemical and seismic properties of earth's interior.
- Comparisons of terrestrial planetary interiors.
- Major tectonic features of the earth: Birth and growth of Ocean basins and Continental crust;
- Tectonic evolution of Earth's continental crust; Hadean, Archaean, and post-Archaean continental crust.
- Introduction to planetary tectonics.

Module 5:

- Plate tectonic system in Earth: Lithosphere-Asthenosphere system; Driving mechanism;
- Mantle convection; Heat transfer and tectonics
- Plate kinematics: Relative motion of plates on a sphere; Finite and absolute plate motions.
- Kinds of plate movements and features associated with plate interactions.

Module 6:

- Orogens: Tectonic elements of Collisional; Accretionary; Intracratonic orogens.
- Mid-Ocean ridges: Composition and Structure; Magnetic anomaly stripes
- Continental shield areas and mountain chains
- Palaeomagnetism and its application for determining palaeoposition of continents.
- Geodynamic evolution of the Indian plate

References

1. Artemieva, I.M., 2011. *The Lithosphere- An Interdisciplinary Approach*. Cambridge University Press, 773 p.
2. Condie, K.C., 2011. *Earth as an Evolving Planetary System,* Academic Press, Oxford, UK, 574p.
3. Davis, G.H., Reynolds, S.J., Kluth, C.F., 2012. *Structural Geology of Rocks and Regions.* 3rd Edition, John Wiley & Sons, Inc. 839 p.
4. Fossen, H., 2010. *Structural Geology.* Cambridge University Press, 463 p.
5. Frisch, W., Meschede, M., and Blakey, R., 2011. *Plate Tectonics: Continental Drift and Mountain Building,* Springer-Verlag, Berlin Heidelberg, 212p.
6. Ghosh, S.K., 1993. *Structural Geology: Fundamentals and Modern Concepts.* Pergamon Press, Inc., 598 p.
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8. Moores, E.M., Twiss, R.J., 2014. *Tectonics.* W.H. Freeman, 672 p.
9. Passchier, C.W., Trouw, R.A.J., 2005. *Microtectonics.* Springer-Verlag, 366 p.
10. Stüwe, K., 2007. *Geodynamics of the Lithosphere*. Springer-Verlag, 493 p.
11. Turcotte, D.L. and Schubert, G., 2014. *Geodynamics,* 3rd Edition, Cambridge University Press, 636 p.
12. Van der Pluijm, B.A., Marshak, S., 2004. *Earth Structure: An Introduction to Structural Geology and Tectonics.* W.W. Norton & Company, Inc., 656 p.

GEL 1C 03 - GEOINFORMATICS

Number of Contact Hours: 64 hrs

Number of Credits: 4

Course Outline

Module 1:

- Brief history and development of remote sensing**.** Geometry and type of aerial photographs. Scale of photographs.
- Tilt and height displacement. Vertical exaggeration. Stereoscopy. Mosaics.
- Elements of photo interpretation: tone, texture, pattern, drainage and lineaments.

Module 2:

- Electromagnetic spectrum, Methods of Energy Transfer.
- Principles of Satellite Remote Sensing. Platforms and sensors.
- Resolution concepts- Spatial, Spectral, Radiometric and Temporal resolution. Multi Spectral Scanners (MSS).
- Spectral signatures. Indian remote sensing satellite missions.

Module 3:

- Principles and applications of thermal detectors, Thermal Infra-Red scanners- airborne and space borne TIR sensors. Microwave remote sensing, RADAR
- Application of remote sensing in mineral exploration, ground water exploration**,** land use/land cover mapping and geomorphology.

Module 4:

- Fundamentals of digital image processing and classification: Image rectification and restoration.
- Image enhancement: contrast stretching, filtering, PCA images, FCC, Image ratioing.
- Image classification and accuracy assessment - supervised & unsupervised classification

Module 5:

- Geographic Information Systems (GIS). GIS as a tool to integrate information, technologies and theoretical areas. History of GIS.
- Fundamentals of cartography and geodesy. Geographical data. Data and information. Types of information. Subdivision of information. Layers. Geographical information models.
- Data sources. Software and technology. Desktop GIS. Five fundamental functionalities of a desktop GIS: data input and output, visualization, editing, analysis, and map design. Web mapping. Clients and servers. Mobile GIS.

Module 6:

- Databases. Relational databases. Database management systems. Queries.
- Spatial analysis. Spatial queries. Topological analysis. Measurement. Combination. Transformations. Terrain analysis. Descriptive statistics. Inference. Optimization and decision-making.

  Visualization of geographical data. Basic ideas about data visualization. Maps and cartographic

communication. Types of thematic maps. Visualization in a GIS

- GIS Applications in urban planning, groundwater studies, mineral exploration, disaster management, climate change analysis

References

1. Avery, T.E. Interpretation of aerial photographs, Burges Publishing Co 1968
2. Estes, J.W. and Leslie W. Senger, Remote Sensing - Techniques for Environmental analysis, Hamilton Publishing Co., 1974
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11. ESRI. Understanding Geographic Information System. The Arc lnfo Method, Wiley Publishers
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13. Peter A. Burrough and Ruchael, A. McDonnell, Principles of Geographical Information System, Oxford Publishers
14. Star, J. Ester, J. Geographic Information System - An introduction, Prentice Hall,1990

GEL 1C 04 - STRATIGRAPHY AND INDIAN GEOLOGY

Number of Contact Hours: 64 hrs

Number of Credits: 4

Course Outline

Module 1:

- Stratigraphic principles and evolution. Contributions of Steno, Lehmann, Fushel, Werner, Hutton, Lyell and Smith.
- Recent developments in stratigraphic classification. Code of stratigraphic nomenclature – Stratotypes,

Global Boundary Stratotype Sections and Points (GSSP). Lithostratigraphic, chronostratigraphic and biostratigraphic subdivisions. Methods of startigraphic correlation including Shaw"s Graphic correlation.

Module 2:

- Elements of Magnetostratigraphy, cyclostratigraphy, pedostratigraphy, chemostratigraphy and sequence stratigraphy.
- Major geological events during the different periods of earth history. Mass extinction - Meteoric impact Theory - Volcanic eruption theory.

Module 3:

- Pre-Cambrian stratigraphy. Classification of Indian Pre-Cambrian with particular reference to Karanataka and Kerala. Greenstone belts and granulites of South India. Classification, lithology, ages, correlation of Sargur schist, Dharwar Supergroup, Cuddapah Supergroup and Vindhyan Supergroups.

Module 4

- Phanerozoic stratigraphy of India with reference to the type areas– their correlation with equivalent formations in other regions. Rise of the Himalayas and Evolution of Siwallik

Module 5

- Stratigraphic boundary problems with reference to Indian subcontinent - Vindhyan, Saline Series and Deccan Traps.

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16. Weller, Stratigraphic Principles and Practice, Harper and Row, 1959
17. Windley, B. F., The Evolving Continents, I Edn., John Wiley, 1977
18. Ramakrishnan & Vaidhyanathan,Geology of India, Geological Society of India Publication, 2008

SEMESTER II

GEL 2C 05 - CRYSTALLOGRAPHY AND MINERALOGY

Number of Contact Hours: 64 hrs

Number of Credits: 4

Course Outline

Module 1:

- Crystallography-Crystalline State-Repetition theory. Translation periodicity of crystals. Basic rotational symmetries and possibility of simultaneous rotational symmetries in different directions of crystals-symmetrical plane and symmetrical lattices.
- Derivation of 32 crystal classes. Stereographic projection of crystals.

Module 2:

- Crystal notation- Schoenflies notation. Herman Mauguin symbols-comparison between Schoenflies and International notations.
- Calculation of crystal elements to test the knowledge of the application of tangent relation, anharmonic ratios, Napier's theorem and equation of the normal.
- X-ray diffraction method- basic principles. X-ray diffractometer- Powder methods- Bragg’s law and its application- Calculation of cell dimensions-identification of minerals from X-ray diffraction patterns.

Module 4:

- Plane polarized and cross polarized light; Behaviour of isotropic and anisotropic minerals in polarized light.
- Double refraction; Refractive index; Birefringence; Interference colours and determination of order.
- Conoscopic observations of minerals under petrological microscope: Formation of interference figures; Uniaxial and biaxial interference figures; Determination of the Optic sign of uniaxial and biaxial minerals.
- Optical indicatrices of uniaxial and biaxial minerals.
- Vibration directions and sign of elongation in minerals. Extinction and extinction angle. Determination of Optic axial angle (2V).

Module 5:

- Structural and chemical principles of minerals: chemical bonds; ionic radii; coordination number (CN).
- Structure, chemistry, physical and optical characters and paragenesis of mineral groups: Olivine, pyroxene,

amphibole, mica and spinel groups; Feldspar, quartz, feldspathoid, aluminum silicate, epidote, garnet and zeolite groups. Accessory minerals: Apatite, calcite, corundum, scapolite, sphene and zircon.

Module 6:

- Earth mineralogy: Average mineralogical composition of crust and mantle.
- Mineral transformations in the mantle with depth

References

1. Dyar, M.D., Gunter, M.E., 2007. *Mineralogy and Optical Mineralogy.* Min. Soc. America, 705p.
2. Demange, M., 2012. *Mineralogy for Petrologists: Optics, Chemistry, and Occurrence of Rock Forming Minerals*. CRC Press (Taylor & Francis Group), 182 p.
3. Nesse, W.D., 2012. *Introduction to Optical Mineralogy.* Oxford University Press; 4 editions, 384p.
4. Pichler, H., Riegraf, C.S., 2011. *Rock-forming Minerals in Thin Section*. Springer, 220 p.
5. Deer, W.A., Howie, R.A., Zussman, J., 2013. *Introduction to the Rock-forming Minerals*. Mineralogical Society of Great Britain & Ireland, 510 p.

GEL 2C 06 - ECONOMIC GEOLOGY

Number of Contact Hours: 64 hrs

Number of Credits: 4

Course Outline

Module 1:

- Ore, Tenor, grade and specification for minerals.
- Classification of ore deposits - Lindgren and Bateman classifications
- Ore microscope- polishing and mounting of ores. Physical and optical properties of important ore minerals. Textures and structures of ore and gangue minerals.
- Fluid inclusions studies

Module 2:

- Metallogenic epochs and provinces, Strata bound and stratiform ore deposits - distribution, form, setting and origin. Mineralization at plate boundaries, Ore forming solutions and their migration. Wall rock alteration.
- Major theories of ore genesis. Paragenetic sequences, Zoning, Controls of ore localization.

Module 3:

- Ores in igneous rocks - ores of mafic and ultramafic associations - Ultra mafic-mafic chromium platinoid associations - form, distribution, setting, constitution and origin. Ores of felsic associations – the carbonatite associations - form, distribution, setting, constitution and origin. Anorthosite - Fe- Titanium oxide association, distribution, form, setting, constitution and origin

Module 4:

- Genetic classification of U and Th deposits. Geology and genesis of U deposits of Jaduguda. Pb-Zn deposits of Rajasthan, Cu deposits of Singhbhum and Malanjkhand, East Coast Bauxite, Iron ore deposits of Bailadila and Kudremukh.
- Strategic, critical and essential minerals of India.
- National Mineral Policy of India

Module 5:

- Coal Geology classification, petrography, genesis and periods of coal formation Distribution of coal fields of India, Neyveli Lignite Field.
- Petroleum Geology Introduction- physical properties and chemical composition, occurrence and origin. Source materials and source locations -conversion to petroleum. Reservoir rocks classification of reservoir traps -general, structural, stratigraphic, salt domes. Distribution of oil fields in India.
- A brief introduction to gas hydrates.

Reference

1. Anthony, M. Evans, An introduction to Ore Geology, Blackwell Scientific Publication, 1980
2. Ashok Mukherji, Ore Genesis - A Holistic approach, Prentice Hall, Calcutta
3. Bateman A. M., Economic Mineral Deposits, Wiley, 1962
4. Brian Mason, Principles of Geochemistry, Wiley, 1966
5. Brown, J. C, and Dey, A. K., India's Mineral Wealth, Oxford, 1936
6. Cameron, E. N., Ore Microscopy, Wiley, 1961
7. Edwards, A. B., Textures of the Ore Minerals, Aus. Inst. Min. and Met. 1960
8. Jenson and A. M. Bateman, Economic Mineral deposits, 111 Edn. John Wiley
9. Krauskopf, K., Introduction to Geochemistry, McGraw Hill, 1967
10. Levorson, A. I., Geology of Petroleum, McGraw Hill, 1958
11. Lindgren, Mineral Deposits, McGraw Hill, 1933
12. Nininger, R. D., Minerals for atomic energy, von Nostrand, 1956
13. Park C. G., and Mac Diarmid, R. A. Ore Deposits, Freeman, 1964
14. Rankama, K., and Sahama, T. G., Geochemistry, Chicago Uty. Press, 1949
15. Stanton, R. K., Ore Petrology, McGraw Hi 11 , 1972
16. Tissot, B. P., and Welta, D. H., Petroleum formation and occurrence, Springer Verlag, 1978
17. Van Krcsalon, D. Coal, Elsevier, 1961

GEL 2C 07 - HYDROGEOLOGY

Number of Contact Hours: 64 hrs

Number of Credits: 4

Course Outline

Module 1:

- Origin of water: meteroic, juvenile, magmatic and sea waters, Hydrologic cycle: precipitation, runoff, infiltration and evapotranspiration, Hydrographs.
- Subsurface movement and vertical distribution of groundwater, Springs. Classification of aquifers. Concepts of drainage basin and groundwater basin.
- Hydrological properties of rocks – specific yield, specific retention, porosity, hydraulic conductivity, transmissivity, storage coefficient. Determination of permeability in laboratory and in field. Water table fluctuations – causative factors, concept of barometric and tidal efficiencies. Water table contour maps.

Module 2:

- Theory of groundwater flow. Forces causing ground water movements. Darcy's Law and its applications.
- Unconfined, confined, steady, unsteady and radial flow conditions. Pump tests – methods, data analysis and interpretation for hydrogeologic boundaries. Evaluation of aquifer parameters using Thiem, Theis, Jacob and Walton methods.

Module 3:

- Groundwater quality – physical and chemical properties of water. Quality criteria for different uses - domestic, irrigation and industrial. Graphical presentation of water quality data - Stiff diagram, Pie diagram, Piper's trilinear diagram and USSL diagram.
- Problems of arsenic and fluoride in groundwater. Saline water intrusion in coastal and other aquifers. Ghyben-Herzberg relation. Prevention and control of saline water intrusion. Radioisotopes in hydrogeological studies.

Module 4:

- Ground water exploration -Geologic and hydrogeologic methods. Surface geophysical methods –electrical resistivity method: Wenner and Schlumberger configurations for vertical electrical sounding.
- Subsurface geophysical methods – well logging for delineation of aquifers. Remote sensing for groundwater exploration - hydrogeomorphic mapping of the terrain using different images of different satellite missions, lineament mapping, shallow groundwater potential zone mapping using satellite images.

Module 5:

- Types of wells, drilling methods, construction, design, development and maintenance of wells, specific capacity and its determination.
- Groundwater problems related to foundation work, mining, canals and tunnels. Problems of over

exploitation and groundwater mining. Groundwater development in urban areas and rain water harvesting, Artificial recharge methods.

- Groundwater provinces of India.

Reference

1. Bouwer,H Groundwater Hydrology. 1978
2. Davies and De Wiest, Hydrogeology, John Wiley and Sons, 1966
3. Dominico, P. A. Concepts and models in Groundwater Hydrogeology, McGrawHill
4. Fletcher, G. Driscoll, Groundwater and wells, Science Publ., Jodhpur, 1986
5. Karanth, K. R., Groundwatcr and wells, Science Publ., Jodhpur, 1986
6. Linsley, R. K., Jkohler, M. A., and Paulhus, J. L. H., Applied Hydrology, Tata McGrawHill, 1975
7. Raghunath, H. M., Groundwater, Wiley Eastern, 1987
8. Todd, D. K., Groundwater Hydrology, John Wiley and Sons, 1980
9. Tolman, C. F., Groundwater, McGraw Hill
10. Walton, W. C, Groundwater Resource Evaluation, McGraw Hill, 1970
11. Freeze and Cherry – Groundwater.

GEL 2C 08 - APPLIED PALAEONTOLOGY AND SEDIMENTOLOGY

Number of Contact Hours: 80 hrs

Number of Credits: 4

Course Outline

Module 1:

- Fossils and fossilization Definition and morphology. Modes of preservation and geometry of fossils.
- Physico- chemical conditions of fossilisation. Significance of fossils.

Module 2:

- Vertebrate paleontology: Succession of vertebrate life through geologic time. Broad classification.
- General characteristics and Evolution histories of Dinosaurs, Equus, Elephus and Man.

Module 3:

- Micropalaeontology - Scope and classification of microfossils.
- Techniques in collection, separation, preparation and preservation of microfossils
- Classification, morphology, ecology, palaeoecology and stratigraphic importance of the following - Foraminifera, Ostracoda, Bryozoa, Radiolaria, Diatoms and Conodonts.
- Palynology: General morphology of spores and pollens –classifications. geological significance and Application

- Application of microfossils in the petroleum exploration, palaeoenvironments, Palaeoecology and Palaeoclimate. Estimation ofPalaeotemperature

Module 4:

- Sedimentary processes, lithification and diagenesis of siliceous and Carbonate sediments. Elements of Hydraulics - behaviour of particles in fluids. Heavy minerals and their significance in Provenance studies.

Module 5:

- Sedimentary Textures - Grain size classification, grade scale and sediment classes. Grain size analysis-sieving and pipette analysis, graphic representation of size analysis data; statistical parameters and their geological significance. Sedimentary structures: classification, genesis and significance

Module 6:

- Sedimentary Facies and Depositional environments - Terrestrial, marine and transitional environments. Lithologies and structures formed in various environments. Brief description about Basin analysis. Plate Tectonics and sedimentation

Reference

1. Shrock R.R., Berk Twenhofel W.H. Principles of Invertebrate Palaeontology, McGraw Hill, 1953
2. Colebert H. Edwin, Evolution of the vertebrates, John Wiley and Sons, 1961
3. Biial u. Haq Anne Boersma, Introduction to Marine Micro-Palaeontology, Elsevier, 1998
4. Woods Henry, Invertebrate Palaeontology, Cambridge University Press, 1961
5. Tucker, Sedimentary Petrology: An introduction. John Willey & Sons, New York, 1981
6. Gary Nichols, Sedimentology and Stratigraphy, Wiley and Blackwell, 2009
7. S.M. Sengupta, Introduction to Sedimentology, CBS Publishers & Distributors Pvt. Ltd.

SEMESTER III

GEL 3C 09 - IGNEOUS AND METAMORPHIC PETROLOGY

Number of Contact Hours: 80 hrs

Number of Credits: 5

Course Outline

Module 1:

- Bowen's reaction principle and reaction series. Major, minor, trace and rare earth element geochemistryof igneous rocks. Significance of isotopic studies in the petrogenesis of igneous rocks.
- Tectonomagmatic environment and igneous provinces. Compositional variation in magmas.
- Genetic significance of the textures and structures of the igneous rocks.

- Phase rule and its application in the study of silicate systems - phase diagrams, primary phase diagrams and liquidus projections.

Module 2:

- Equilibrium crystallization and melting paths in igneous systems.
- Phase diagrams- Unary, binary, ternary and quaternary diagrams. Study of the course of crystallization of the following chemical systems:
- Ternary systems:
- Forsterite- Diopside – Silica, Diopside - Anorthite –Forsterite,
- Diopside - Anorthite –Albite, Albite – Anorthite- Orthoclase $MgO - Al_2O_3 - SiO_2$.
- Quaternary system: Diopside- Anorthite- Albite- Forsterite.

Module 3:

- Classification of igneous rocks- Shand, Streckeisen and CIPW Mode and Norm.
- Variation diagrams. Differentiation index.
- Petrography and petrogenesis of Kimberlites and Carbonatite:s Anorthosites, Basalts, Ultramafites and Ophiolites, Monomineralic rocks, Alkaline rocks, Pegmatites, Lamprophyres, Granites.

Module 4:

- Equilibrium aspects of metamorphic reactions: Driving force; Variance and Kinds; Exchange reactions.
- Phase diagrams and graphic representation of mineral assemblages; chemographic projections – ACF, AKF, AFM diagrams.
- Mineral assemblages, equilibriumreaction textures and geo-thermo barometry. Experimental and thermodynamic appraisal of metamorphic reactions.
- Metamorphic facies and facies series; Prograde and retrograde metamorphism; Role of fluids in metamorphic reactions.
- Metamorphism in space and time: Plate tectonics and metamorphic processes; Paired metamorphic belts, Archaean and Proterozoic terrains; Extraterrestrial Metamorphism (Impact and Shock Metamorphism); polymetamorphism

Module 5:

- Petrogenetic significance of metamorphic textures and structures.
- Progressive, contact and regional metamorphism of argillaceous, carbonate, basic igneous, and ultramafic rocks.
- Metamorphic differentiation, anatexis and origin of migmatites; regional metamorphism.
- Paired metamorphic belts in reference to plate tectonics.

Reference

1. Barker, A.J., 1990. *Introduction to Metamorphic Textures and Microstructures.* Blackie, 162p.
2. Bucher, K. and Grapes, R., 2011. *Petrogenesis of Metamorphic Rocks*. Springer-Verlag, Berlin-

Heidelberg, 428p.

3. Frost, C.D., Frost, B.R, 2013. *Essentials of Igneous and Metamorphic Petrology,* Cambridge University Press, 336p.
4. Gupta, A.K., 2007. *Petrology and Genesis of Igneous Rocks.* Narosa Publishing House, 496 p.
5. Kretz, R., 1994. *Metamorphic Crystallization.* John Wiley & Sons, 507p.
6. Miyashiro, A., 1978. *Metamorphism and Metamorphic Belts*. 3rd Edition. George Allen & Unwin, London, 492p.
7. Spear, F.S., *Metamorphic Phase Equilibria and Pressure-Temperature-Time Paths.* Mineralogical Society of America, Monograph, 799p.
8. Spry, A., 1974. *Metamorphic Textures.* Pergamon Press Ltd., 350 p.
9. Vernon, R.H., 1983. *Metamorphic Processes: Reactions and Microstructure Development.* George Allen and Unwin, 247P
10. Vernon, R.H. and Clarke, G.L., 2008. *Principles of Metamorphic Petrology.* Cambridge University Press, 446p.
11. Winter, J.D., 2011. *Principles of Igneous and Metamorphic Petrology*, Prentice-Hall, 728p.

SEMESTER IV

GEL 4C 10 - GEOCHEMISTRY AND ISOTOPE GEOLOGY

Number of Contact Hours: 96 hrs

Number of Credits: 4

Course Outline

Module 1:

- Overview of the origin of the elements.
- Nuclides and atoms. Electronic configuration of atoms arrangement of atoms in periodic table, electronegativity, ionization potential, chemical bonding.
- Chemistry of the universe, stars, nucleosynthesis, origin of the solar system, meteorites.
- Structure and composition of earth.
- Distribution of elements in core, mantle, hydrosphere and atmosphere

Module 2:

- Elementary crystal chemistry and thermodynamics
- Temperature and Equations of State; Laws of thermodynamics; Entropy; Enthalpy; Gibbs free energy;
- Trace elements and REE and their importance in fractional crystallization during magmatic/partial melting.
- Geochemistry of weathering transportation and deposition.

Module 3:

- Introduction to isotope geochemistry; applications in magmatic systems
- Major, minor and trace elements and their representation on variation and discriminant diagrams for presentation of geochemical data (bivariate, multivariate, element ratio variation, enrichment-depletion and vector diagrams)
- Geochemical cycle and principles of geochemical prospecting

Module 4:

- Radioactivity, Decay of radioactive atoms and growth of radiogenic atoms
- Geochronology and age of the Earth: Law of Radioactivity; Principles of isotopic dating, Decay schemes and Derivation of equation of age.
- Radiogenic isotope systems: K-Ar; Rb-Sr, Sm-Nd; Lu-Hf; Re-Os; U-Th–Pb methods of dating.

Module 5:

- Stable isotope systems; Notations; Mass independent fractionation; H, C, O, N and S isotopic systems
- Introduction to non-traditional stable isotope systems and their applications
- Modern Analytical techniques: Methods based on Flame photometer, Spectrophotometer, AAS, XRF, ICP-MS, TIMS, SIMS, SHRIMP.
- Fission track and other radiation damage methods of dating

Reference

1. Albarède, F., 2009. *Geochemistry: An Introduction*. Cambridge University Press, 356 p.
2. Faure, G., 1998. *Principles and Applications of Geochemistry.* Pearson, 624 p.
3. Faure, G., Mensing, T.M., *Isotopes: Principles and Applications*. Wiley, 928 p.
4. Hoefs, J., 2015. *Stable Isotope Geochemistry.* 7th Edition, Springer, 389 p.
5. White, W.M., 2015. *Isotope Geochemistry*. Wiley, 492 p

GEL 3E 01 a - CLIMATOLOGY

Number of Contact Hours: 64 hrs

Number of Credits: 3

Course Outline

Module 1:

- Latitudes & Longitudes | Standard Time, Motions of the earth: Rotation and Revolution, Atmosphere: Role, Structure & Composition Temperature Distribution on Earth Insolation & Heat Budget, Geographical distribution of the climatic types – Koppen's and Thornthwaite's classification of climate, Global warming.

Module 2:

- Lapse rate – Atmospheric stability, Latent Heat of Condensation, Atmospheric Pressure Belts and Wind

Systems, Factors Affecting Wind movement, Coriolis Force, Types of Winds: Permanent, Secondary & Local Winds

Module 3:

- Temperature Inversion: Types & Effects on Weather, Geostrophic Wind, Jet Streams & Rossby Waves, Major Jet Steams: Subtropical Jet Stream & Polar Jet Stream

Module 4:

- Air Mass - Air masses based on Source Regions, Fronts, Types of Fronts: Stationary Front, Warm Front, Cold Front & Occluded Front, Humidity: Relative Humidity & Dew point, Condensation, Forms of Condensation: Dew, Fog, Frost, Mist, Types of Clouds

Module 5:

- Smog: Photochemical smog &Sulfurous smog, Precipitation: Types of Precipitation, Types of Rainfall, Thunderstorm, Thunder & Lightning, Tornado, Tropical Cyclones: Favourable Conditions for Formation, Stages of Formation & Structure, Storm Surge, Naming of Cyclones, Cyclones in Arabian Sea, Bay of Bengal, Temperate Cyclones (Mid Latitude Cyclone or Extra tropical cyclones or Frontal Cyclones)

Reference

1. Berneard Hauruitz and James, M. Austin, Climatology, Mc Graw Hill publications, New York& London.
2. D.S. Lal., Climatology
3. Austin Miller. A., Climatology
4. B.S. Negi., Climatology and oceanography.
5. Climatology: Thomas A Blair
6. Grant R Bigg: The Oceans and Climate

GEL 3E 01 b - COAL AND PETROLEUM GEOLOGY

Number of Contact Hours: 64 hrs

Number of Credits: 3

Course Outline

Module 1:

- Formation of coal, periods of coal formation,Causes of coalification, Schurmann's and Hilts rule.Physical properties of coal – colour, lustre, fracture, cleavage, hardness, specific gravity, softening property, caking property, calorific values.
- Varieties and Ranks of Coal – Stages in coal formation – humificaion and coalification processes.Origin of coal seams – Views supporting insitu and drift theory

Module 2:

- Chemical composition of Coal – Proximate analysis of coal - moisture content, volatile matter,content, ash or mineral matter content, fixed carbon and calorific value. Ultimate analysis of coal –Carbon, hydrogen, nitrogen, oxygen and phosphorus. Unit coal
- Petrography of coal – Stope's classification – vitrain, clarain, durain and fusain. Classification of Macerals – Origin definitely due to woody or cortical tissues, plant material other than woody tissues and origin not traced.

Module 3:

- Structure of coal seams – roof, floor and coal seam.
- Application of coal petrography, coke, uses of coke, coal seam methane.
- Geology of the Raniganj and Jharia coal fields. Neyveli lignite fields.

Module 4:

- Origin of petroleum, source beds, transformation of organic matter to petroleum- biochemical changes, geochemical changes – temperature, pressure, radioactivity, catalysts.
- Classification – solid, liquid and gaseous forms.Physical properties of petroleum – colour, odour, specific gravity, viscosity, flash point, optical activity, boiling point, fluorescence.

Module 5:

- Chemistry of petroleum - Parafins, olefin series, acetylene series, diolefin series, bezene series and napthene series. Other petroleum constituents – sulpur compounds, nitrogen compounds, oxygen compounds and inorganic constituents.
- Migration of petroleum- Primary migration - compaction, capillary action, bacterial action.
- Secondary migration – differential specific gravity, hydraulic movementof currents, differential gas pressure, cementation and diastrophic movements. Distance of migration. Accumulation of oil – Pools, fields and provinces.

Module 6:

- Reservoir rocks - Classification of reservoir rocks – Fragmental reservoir rocks, chemical, biochemical reservoir rocks and miscellaneous reservoir rocks. Cap rocks or roof rocks. Oil Traps – Structural traps, stratigraphic traps and combination traps. Salt domes.Petroleum accumulation as related to marine transgression and regression.
- Geographic distribution of petroleum, stratigraphic distribution of petroleum,Geology of the important petroliferous basins in India – Bombay, Cauvery and Assam.

Reference

1. Sharma,N.L. and Ram,K.S.V. (1966), Introduction to the geology of Coal and Indian Coal fields, Oriental Publishers, Jaipur, 148p.
2. Sharma,N.L. and Ram,K.S.V. (1964), Introduction to India’s economic Minerals,Dhanbad Publications,

258p.
3. Thomas,L. (1984), Hand book of Practical Coal geology, John Wiley& Sons, USA,338p.
4. Shelly,R. (2000), Elements of Petroleum Geology, Second edition, Academic Press,London, UK.
5. Sing, L. (2000), Oil and Gas fields of India, ONGC Publication, 382p.
6. Bhaddari,L.L.edt. (1983), Petroleum basins of India, Petroleum Asia Journal,Volume VI, No 4.

GEL 3E 02 a - ENVIRONMENTAL GEOLOGY

Number of Contact Hours: 64 hrs

Number of Credits: 3

Course Outline

Module 1:

- Fundamental concepts of environmental Geology - Sustainability - Earth as a System - Hazardous Earth Processes - Scientific Knowledge and Values Geology as a basic environmental science, obligation to the future. Earth's place in space

Module 2:

- Types of Hazards. Geological Hazards and disasters.Disaster management – Planning activities, hazard prediction, forecasting and early warning. Risk reduction measures, mitigation and preparedness.
- Environmental consequences of natural hazards like earthquakes, landslides and volcanic activity. Geological processes and hazards created by human. Urban development. Soil conservation. Wastes created by human activity such as mining and industrial activities

Module 3:

- Environmental impact assessment (EIA) – Principles, procedures, baseline environmental status, impact prediction, environmental management plan, environment impact statement (EIS).EIA: Origin, goals, principles and significance; Regulatory bodies, Concept of rapid and comprehensive EIA, – Principles and process; EIA notification (MOEF) 1994, 2006; Steps of EIA; Screening and scoping; Acquisition of base line data, its importance.

Module 4:

- Resources and Pollution: Water Pollution: Oxygen - Demanding Waste - Pathogenic Organisms - Nutrients - Toxic Substances - - Surface Water Pollution and Treatment- Point Source and Non-point Source - Ground water Pollution and Treatment. Sources of groundwater pollution, salt water intrusion, acid mine drainage
- Air pollution: Sources of air pollution –indoor air pollution. Effects of air pollution - human health, atmospheric acidity, acid deposition. Earth's atmosphere and energy balance, global warming, greenhouse effect, greenhouse gases, human contribution for greenhouse warming, environmental impacts of global

warming, strategies to reduce global warming. Ozone depletion

Module 5:

- Waste management Prevention, minimization, re-use, recycling. Waste disposal methods Waste generation due to mining, environmental impacts of mining activities on land surface, air and water environment. Mine site decommissioning.

Reference

1. Keller A.E. (1992), Environmental geology, VIIIth edition, Prentice Hall.
2. Donald R Coates, 1981. Environmental Geology. John Wiley and sons
3. Howard A.D & Irwin Remson (1978) – Geology in Environmental Planning –McGraw Hill Publishers
4. Donald R Coates, 1981. Environmental Geology. John Wiley and sons
5. Andrew De Wet, Dorothy Merritts, and Kirsten Menking, 2014 Environmental Geology: An Earth Systems Approach. Atlantic Publishers.

GEL 3E 02 b - QUATERNARY GEOLOGY

Number of Contact Hours: 64 hrs

Number of Credits: 3

Course Outline

Module 1:

Introduction to Quaternary period and types of Quaternary deposits. End of the Tertiary period and prologue to the Quaternary period, tectonic movements, magnetic polarity reversals, global sea level, and littoral sedimentation, Quarternary soil types, shallow water reserves and sediments used in human activities.

Module 2:

Relative chronologies and correlation, use of flora and fauna, non-radioactive techniques, radioactive techniques. dating methods- radiocarbon, U/Th, Pb-Pb with case studies and dendrochronology

Module 3:

Causes of Quaternary climate change, manifestation of Quaternary climate change and current issues in climate change, Human and Quaternary climate change, fauna at the PlioceneQuaternary transition, emergence of hominids and evolution of Man.

Module 4:

The climate between 2.5 yr and 130,000 yr, ice ages, glaciations, last glaciations and the last glacial maximum, the deglaciation and the Holocene, Ocean and deep-sea environments, terrestrial environments, lake and desert environments, soils. Humid tropical environments, subtropical arid zones and warm deserts, fluctuation in the polar region and Mediterranean environments.

Module 5:

Recent crustal movements and young magmatism, post glacial crustal uplift, analysis of Quaternary sediments from borehole data, climate modeling and prediction of climate change.

Reference

1. Bradley, R.S. Quaternary paleoclimatology, methods of paleoclimate reconstruction, Allen and Unwin, US 1985.
2. Riser, J.A.M., Quaternary Geology and the Environment, Springer, Praxis Publishing, Chichister, UK. 2001.

GEL 3E 03 a - MARINE GEOLOGY

Number of Contact Hours: 64 hrs

Number of Credits: 3

Course Outline

Module 1:

- History of Marine geological studies-contribution of Challenger Expedition. Continental margin: features of continental shelf, continental slope and continental rise.
- Sea bottom topography-Submarine canyons, trenches, volcanoes, mid-oceanic ridges and abyssal plains.

Module 2:

- Physical properties of sea water: distribution of temperature, pressure and density. Thermocline, Pycnocline, Halocline.
- Chemical properties of sea water-elements and dissolved gases present in sea water. Salinity and distribution of salinity

Module 3:

- Marine sediments: Distribution and classification. CCD. Marine mineral resources – Mn Nodules, Phosphatic nodules, Gas hydrates.

Module 4:

- Coastal processes: waves, currents and tides. Coastal geomorphology, classification of coasts; Coastal erosion.
- Coastal protection structures -seawalls, jetties, groins. Coastal Regulatory zone (CRZ).
- Sea level Changes and Eustatic changes of sea level: evidences and implications

Module 5:

- Circulation: general circulation of the atmosphere boundaries - major surface currents of the world oceans, Coriolis effect, Ekman spiral, geostrophic currents, upwelling and sinking, diverging and converging surface water, Thermohaline circulation.
- Coupled ocean atmosphere system. EL Nino southern oscillation (ENSO), LaNina

Reference

1. John, L. Mero, Oceanic Mineral resources
2. Ph, H. Kuenen, Marine Geology, John Wiley and Sons.
3. Keith S.Stowe, Ocean Science. John Wiley and Sons
4. Kenneth, J.P., Marine Geology, Prentice Hall Inc., 1982
5. Shepard, F. P., Submarine Geology, Harper and Row Publishers, New York
6. Sverdrup, H. V., et al, The Ocean
7. Trask, P. D., Recent Marine sediments, Dover publications, 1939
8. Weisberg, J., and Parish, R, Introductory Oceanography. McGraw Hill, 1974
9. William, L. Donn, Meteorology
10. J. P. Riley R. Chester, Chemical Oceanography, Academic Press
11. L. Pickard W. J. Emery, Descriptive Physical Oceanography, Pergamon.
12. Colin D Woodroffe, Coasts: Form, Process and Evolution, Cambridge.

GEL 3E 03 b - GEOTECHNICAL ENGINEERING

Number of Contact Hours: 64 hrs

Number of Credits: 3

Course Outline

Module 1:

- Geo-technical engineering as a field science related to construction. Scope of geotechnical engineering. Ground investigations – Introduction, Types of ground investigation, Geological mapping for ground investigation

Module 2:

- Field investigations - Introduction, Excavations and boreholes - Shallow trial pits, Deep trial pits and shafts, Headings (adits), Hand auger boring, Light cable percussion drilling, Mechanical augers, Wash boring and other methods, Backfilling excavations and boreholes.

Module 3:

- Sampling frequency of sampling. Sampling the ground - General principles, Sample quality. Disturbed samples from boring tools or from excavating equipments, Types of samplers - Open-tube samples and samplers, Stationary piston sampler, Continuous soil sampling, Sand samplers, Rotary core samplers, Window sampler, Block samples. Handling and labelling of samples.

Module 4:

- Field and lab tests Field tests – Introduction, Tests in boreholes - Standard penetration test (SPT). Permeability test and Packer test. Pressure meter test. Pumping tests.
- Geophysical surveying (Electrical resistivity, Gravity, Magnetic, Seismic methods.

- Laboratory tests on samples - Tests on soil - Classification tests - Moisture content/ water content determination, Liquid and plastic limits (Atterberg Limits), Particle size distribution (grading) by sieving. Soil strength tests - Triaxial compression test and unconfined compression test. Compaction-related tests - Dry density (dry unit weight).

Module 5:

- Logging - Description of soils and rocks Description of soils - Mass characteristics of soils. Material characteristics of soils – Colour, Particle shape, grading and composition. Description and classification of rocks - General description - Strength of rock material, Structure, Colour, Texture, Grain size, State of weathering, Rock name. Total core recovery (TCR), solid core recovery (SCR), Rock Quality Designation (RQD).

Reference

1. Canadian Geotechnical Society, Canadian Foundation Engineering Manual. 3rd Ed
2. Canadian Geotechnical Society, Technical Committee on Foundations, BiTech Publishers Ltd., Richmond, British Columbia, 1992.
3. Nielsen, David M., (ed.). Practical Handbook of Ground-Water Monitoring. Lewis Publishers Inc., Chelsea, Michigan, 1991.
4. Coduto, D.P., Component: Geotechnical Engineering: Principles and Practices. Prentice Hall, NJ, 1999.
5. Hoek, Evert and John Bray, Rock Slope Engineering. London: Institution of Mining and Metallurgy, 1981.

GEL 4E 04 a - EXPLORATION GEOLOGY

Number of Contact Hours: 96 hrs

Number of Credits: 4

Course Outline

Module 1:

- Methods of surface and subsurface exploration. Prospecting for economic minerals.
- Drilling and its types. Different methods of sampling and assaying.
- Methods of ore reserve estimation.

Module 2:

- Geochemical exploration techniques. Mobility of elements, pathfinder elements, threshold values and geochemical anomalies.
- Mode of occurrence of trace elements. Primary dispersion pattern of deep-seated origin. Diffusion and leakage anomalies.
- Geochemical surveys, principles and methods of sampling. Anomalies in ground and surface waters and

sediments.

- Biochemical anomalies. Geobotanical survey techniques. Geobotanical indicators.

Module 3:

- Geophysical exploration - Principles, scope, chief methods and their application.
- Electrical methods - principles, instruments used. Self-potential methods, resistivity methods. Application in ground water exploration.

Module 4:

- Gravity methods - Density and rock types, correlation of gravity data, regional and local anomalies. Sample interpretation, instrument used -gravimeter.
- Magnetic methods - field procedure, magnetometer, interpretation of magnetic data, correlations and applications. Principles of air borne survey.
- Seismic method- Seismic waves, travel velocity in various geological formations – Principles Field operations. Refraction and reflection survey - correction of seismic data - methods if interpretation - determination of attitude and depth of formation. Various types of shooting. Seismic instruments and records.

Module 5:

- Radiometric methods principles of radioactivity, methods, types of counters: G.M. counters and Scintilometers. Field methods and interpretations.
- Geophysical well logging Electrical, radiometric, sonic and thermal logging of boreholes.

Reference

1. Compton.R.R., Manual of Field Geology, John Wiley
2. Dobrin M.B, Introduction to Geophysical Prospecting, Pergamon Press
3. Elements of Prospecting and Exploration, Kalyan Publishers
4. Ginzburg, I., Principles ofGeochefnical prospecting, Pergamon Press
5. Griflithis, D. and Kind, R. F., Applied Geophysics for Geologists and Engineers, Pergamon Press
6. Kovalarkim, Biochemical exploration for mineral deposits Co-Xinian Press
7. Lahee, F. H., Field Geology, Mc Graw Hill
8. Low, G.W., Geological Field Methods, Harper and brothers
9. Malyyuga,D.F.,Biochemical methods of prospecting, Consultants Bureau,NewYork
10. Reedman, J. H., Techniques in Mineral Exploration, Allied Scientific Publishers
11. Sinha, R. K.., and Sharma, N. L, Mineral Economics, Oxford and I.B.H. – Publishers
12. Swapan Haldar, Mineral Exploration, Principles and Applications, Elsevier.
13. S.M. Gandhi, B.C. Sarkar, Essentials of Mineral Exploration and Evaluation, Elsevier.

GEL 4E 04 b - DISASTER MANAGEMENT

Number of Contact Hours: 96 hrs

Number of Credits: 4

Course Outline

Module 1:

- Introduction – Hazard and Disaster Vulnerability, Risks. Different Types of Disaster: A) Natural Disaster: such as Flood, Cyclone, Earthquakes, Landslides etc B) Man-made Disaster: such as Fire, Industrial Pollution, Nuclear Disaster, Biological Disasters, Accidents (Air, Sea, Rail & Road), Structural failures (Building and Bridge), War & Terrorism etc.
- Water and Climate Disaster: flood, hail storms, cloudburst, cyclones, heat and snow avalanches, cold waves, droughts, sea erosion, thunder and lightning. Geological Disaster: landslides, earthquakes, mine fires, dam failures and general fires. Biological Disaster: epidemics, pest attacks, cattle epidemic and food poisoning. Nuclear and Industrial Disaster: chemical and industrial disasters, nuclear accidents. Accidental Disaster: urban and forest fires, oil spill, mine flooding incidents, collapse of huge building structures.

Module 2:

- Risk and Vulnerability Analysis Risk: Its concept and analysis Risk Reduction Vulnerability: Its concept and analysis Strategic Development for Vulnerability Reduction
- Earthquakes, Floods, Drought, Landslides, Cyclones. Disaster Prevention and Mitigation
- Refugee operations during disasters, Human Resettlement and Rehabilitation issues during and after disasters, Inter-sectoral coordination during disasters, Models in Disasters.

Module 3:

- Disaster Preparedness and Response Preparedness Disaster Preparedness: Concept and Nature Disaster Preparedness Plan Prediction, Early Warnings and Safety Measures of Disaster. Role of Information, Education, Communication, and Training,

Module 4:

- Disaster Management: Role of Government, International and NGO Bodies. Role of IT in Disaster Preparedness Role of Engineers on Disaster Management. Response Disaster Response: Introduction Disaster Response Plan Communication, Participation, and Activation of Emergency Preparedness Plan Search, Rescue, Evacuation and Logistic Management Role of Government, International and NGO Bodies Psychological Response and Management

Module 5:

- Rehabilitation, Reconstruction and Recovery Reconstruction and Rehabilitation as a Means of Development. Damage Assessment Post Disaster effects and Remedial Measures. Creation of Long-term Job Opportunities and Livelihood Options, Disaster Resistant House Construction 6. Sanitation and

Hygiene Education and Awareness, Dealing with Victims' Psychology, Long-term Counter Disaster Planning Role of Educational Institute.

Reference

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GEL 4E 05 a - ENGINEERING GEOLOGY

Number of Contact Hours: 80 hrs

Number of Credits: 3

Course Outline

Module 1:

- Geological studies and evaluation in planning, design, construction and problems of major civil structures.
- Elementary concepts of rock mechanics and soil mechanics. Site investigation techniques for civil engineering structures, Building stone and aggregate properties.
- Engineering properties of rocks, and soils.

Module 2:

- Dams: parts, types, forces acting on dams and reservoir problems. Geologic aspects of dam investigation.
- Tunnels: parts, classification, ground conditions, geological considerations. **G**eological and geotechnical aspects of Bridge, Highways, Foundations.

Module 3:

- Geological hazards and mitigation- landslides and earth quakes, Landslides: classification, analysis of slope stability, monitoring slope movements, hazard zonation mapping.
- Aseismic design of building, Geotechnical case studies of major projects in India.

Module 4:

- Mining geology: Planning, exploration, exploratory mining of surfaces and underground mineral deposits (methods and types).
- Mining methods - Alluvial mining-river sand mining, Mining of beach placers, Clay mining, Coal mining, Seabed mining, Exploration of petroleum

Module 5:

- Fundamentals of ore dressing: crushing, grinding, sizing, concentration by washing, scrubbing, jigging, tabling, floatation, magnetic and electrostatic separation, mineral legislation in India

Reference

1. Compton, R. R., Manual of Field Geology, John Wiley
2. Reedman, J. K, Techniques in Mineral Exploration, Allied Scientific Publishers
3. Arogyaswamy, R. N. F., Courses in Mining Geology, Oxford and IBH Pub. Co.

4. Fox, Engineering Geology
5. Peters, W. C, Exploration and Mining Geology, John Wiley
6. Bell, F.G. Fundamentals of Engineering Geology, Butterworths, 1983
7. Krynine and Judd, Principle of Engineering Geology and Geotectonic, McGraw Hill. 1957
8. Rose, A. W., Hawkes, H. F., and Webb, J. S., Geochemistry in Mineral Exploration, Academic Press
9. Gokhale, K.V.G.K. Principles of Engineering Geology B.S. Publications, 2006

GEL 4E 05 b - ENVIRONMENTAL IMPACT ASSESSMENT

Number of Contact Hours: 80 hrs

Number of Credits: 3

Course Outline

Module 1:

Environmental Impact Assessment (EIA): Definition, purpose and characteristics of EIA; global evolution of EIA; participants in EIA process, stages of EIA, types of EIA. Environmental inventory. Baseline data on EIA- environmental data, project data and project alternative data. Measurement of impact– physical, social, economic, natural; Public participation in environmental decision making; Framework of Environmental Assessment; Description of environmental setting; environmental impact factors and area consideration. Environmental Impact Statement (EIS) and Environmental Management Plan (EMP).

Module 2:

Environmental Impact Analysis: Impact identification and methods of impact identification- adhoc method, checklist, matrix, network, overlay and index methods; impact prediction and predictive methodologies, impact evaluation (assessment) and impact mitigation.

Module 3:

Basic steps for the impact identification, prediction and assessment of air, water, noise, vegetation and wildlife environment with case studies.

Module 4:

EIA in India: An overview of history, current procedures, practices and guidelines.

Module 5:

EIA of water resource projects, industries, mining and quarrying, highway construction, tourism developments.

Reference

1. Bregman, J.I. and Mackenthum, K.M. 1992. Environmental impact statements. Chelsia Michigan: Lewis.
2. Calow, P. 1997. Handbook of environmental risk assessment and management. Oxford: Blackwell Science.

3. Canter, W. Larry. 1996. Environmental impact assessment. McGraw-Hill International editions. 660p.
4. Fortlage, C. 1990. Environmental assessment: a practical guide. Aldershot: Gower
5. Glasson, J; Therivel, R and Chadwick, Al. 1999. Introduction to environmental impact assessment. UCL Press. 496p.

CORE COURSE: GEOLOGY (PRACTICAL)

GEL 1L 01 - GEOMORPHOLOGY, STRUCTURAL GEOLOGY, GEOINFORMATICS

Number of Contact Hours: 96 hrs

Number of Credits: 3

Course Outline

Scheme:

Geomorphology:

- Interpretation of toposheets and identification of geomorphic features, fluvial and coastal land forms. Calculation of surface area and slope. Study of drainage pattern and morphometric analysis.

Structural Geology:

- Interpretation of geologic maps. Trigonometric, graphic and stereographic solutions to problems in structural geology. Geometric analysis of planar and linear structures. Fabric diagrams, Rose diagrams and histograms

Geoinformatics

- Introduction to QGIS
- Georeferencing, Plotting of points, lines, polygons.
- Length and area calculation
- Map making – layout creation
- Gt.Aide: gridding of polygons, creation of sample locations, survey tracks etc. and planning for field studies.
- Basics of digital image processing using open-source software
- Band combinations of satellite data
- Gathering satellite images from USGS and Bhuvan
- Extraction of features
- Classification of features.

Gt. Aide reference:

- **Gt Aide (Academy): An Aide for Interactive Learning.** A C Dinesh, Sajesh P V & Nisha N V, 2019.

GEL 2L 02 - CRYSTALLOGRAPHY, MINERALOGY, ECONOMIC GEOLOGY, HYDROGEOLOGY, PALAEONTOLOGY AND SEDIMENTOLOGY

Number of Contact Hours: 96 hrs

Number of Credits: 3

Course Outline

Scheme:

Crystallography:

- Spherical projection of Cube, Octahedron and Dodecahedron.
- Stereographic projection of holohedral classes of all the systems, pyritohedral, tetrahedral, plagiohcdral classes of Isometric system and Rhombohedral classes of Hexagonal system.
- Gnomonic projections of the normal class of Isometric, Tetragonal, Hexagonal and Orthorhombic systems.
- Calculations of Axial ratios, Zone symbols, Napier's rule, Laws of anharmonic ratio.

Mineralogy:

- Identification of mineral specimens based on physical properties
- Determination of the following optical characters by classical methods:
    - Order of interference colour
    - Sign of elongation
    - Birefringence
    - Scheme of pleochroism
    - Optic orientation
    - Determination of the vibration directions of polariser and analyzer
    - Extinction and extinction angle determination
    - Optic sign
    - Refractive index by Becke line method
    - Identification of thin sections of important rock forming minerals
- Recalculation of mineral formula from EPMA analysis – Garnet; Pyroxene; Feldspar; biotite; hornblende

Economic Geology:

- Identification of important ore minerals. Collection and display of data on production, consumption and export of important minerals. Identification of ore minerals under ore microscope. Genetic significance of important ore.

Hydrogeology:

- Preparation and interpretation of water table contour maps.
- Problems on Porosity, permeability, void ratio and Darcy's Law. Computation of aquifer parameters from pump test data.
- Graphical representation of hydro chemical data - Piper trilinear diagram, USSL Diagram, Stiffs polygon.
- Calculation of various parameters based on chemical data, electrical resistivity survey and interpretation of data

Applied Palaeontology:

- Separation of microfossils and preparation of slides of Ostracoda, Foraminifera and Bryozoa.
- Identification and study of microfossils in slides, at least 10 Nos.

Sedimentology:

- Sieve analysis - plotting of sieve analysis data - histogram, Folk and Ward, Trask methods.
- Measurement and calculation of shape parameters, plotting and interpretation of these data Separation of light and heavy minerals.
- Preparation of grain mounts. Study of grain mounts of Magnetite, Ilmenite, Monazite, Rutile, Garnet, Sillimanite, Zircon, Quartz, Leucoxene and Hornblende.
- Microscopic and megascopic study of sedimentary rocks.

GEL 3L 03 - IGNEOUS AND METAMORPHIC PETROLOGY AND ELECTIVE COURSE

Number of Contact Hours: 128 hrs

Number of Credits: 4

Course Outline

Scheme:

Igneous and Metamorphic Petrology:

- Preparation of thin sections of igneous and metamorphic rock samples. (2 nos. each). Petrography of igneous and metamorphic rocks. Textures and structures of igneous and metamorphic rocks and their genetic significance with neat sketches
- Determination of modal composition, Calculation of norm (25 exercises). Niggli values. Variation diagrams Harker, Larsen, Niggli. Calculation of Differentiation index. Peacock alkali-lime index. Use of triangular diagram in the classification of igneous rocks. Use of triangular diagram in the classification of igneous rocks.
- Identification of metamorphic mineral paragenesis in hand specimens and thin sections and arranging them according to the intensity of metamorphism. Graphical representation of metamorphic mineral

parageneses. ACF and AKF diagrams. AFM diagrams.

- Construction of phase diagrams based on experimental data of the following systems- Albite- anorthite, Forsterite-fayalite, Diopside- anorthite, Diopside - albite, Forsterite -silica.

GEL 4L 04 - GEOCHEMISTRY AND ELECTIVE COURSE

Number of Contact Hours: 96 hrs

Number of Credits: 3

Course Outline

Scheme:

Geochemistry:

- Calculation of isotope proportions in samples.
- Determination of pH of groundwater samples
- Determination of Na and K using flame photometer
- Calculation of bulk rock compositions from modal mineralogy and mineral chemistry
- Calculation of δ18O in water reservoirs and ice-cores
- Calculation of palaeo sea-surface temperatures
- Calculation of age of rock samples based on different decay schemes