Central University of Kerala

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Kasaragod, Kerala, India, 671123

DEPARTMENT OF GEOLOGY

No. CUK/GEO/BOS/MIN/2021/01 Dtd: 17/08/2021

Minutes of the 2nd Meeting of the 2th Board of Studies in Geology held online at 10.00 a.m. on 17/08/2021

The Department of Geology, Central University of Kerala conducted the Board of Studies (BoS) meeting on 17th August, 2021. It was the Second BoS meeting of the second Board of Studies. Due to the COVID-19 pandemic situation the meeting was conducted through online via Google Meet platform. The panel members included invited subject experts, Head of the Department, internal members and department faculties as special invitee. The attendees of the meeting were as follows: -

BoS Attendees:

Invited subject experts

- Prof. (Dr.) Rajneesh Bhutani, Professor, Department of Earth Sciences, Pondicherry University
- Prof. (Dr.) Rajesh Raghunath, Professor, Dept .of Geology, University of Kerala,
- Prof. (Dr.) Prakash Narasimha, K.N., Professor, Department of studies in Earth science, University of Mysore, Manasagangotri
- Dr. A. Anil Kumar, Director, Marine & Coastal Survey Division, Geological Survey of India, Manglaluru.

Internal members from the Central University of Kerala

- Dr. Pratheesh P., Assistant Professor and HOD (i/c), Dept. of Geology.
- Dr. Sijinkumar A.V., Assistant Professor, Dept. of Geology.
- Dr. S. Anbazhagi, Assistant Professor, Dept. of Environmental Science.

Special invitee from the Central University of Kerala

- Dr. Sandeep K., Assistant Professor, Dept. of Geology.
- Dr. Chandan Kumar B., Assistant Professor, Dept. of Geology.

The BoS meeting started with the welcome address by Dr. Pratheesh P., Head of the Department (i/c). Dr. Pratheesh P. gave a brief introduction on the objectives of the BoS meeting. Thereafter, he welcomed all experts and faculty to the meeting, and briefed the agenda of BoS meeting.

The agenda for discussion in the BoS meeting was proposed by the Head of the Department. The main items discussed in the BoS are given below:

(a) The inclusion of programme outcome and course outcomes in the syllabus of department of geology, central university of Kerala thereof.

(b) Consider the revised syllabus for 2021 admission

c) Inclusion of employment oriented courses in syllabus

The details of agenda-wise discussion and the final recommendation by the BoS are given below.

Agenda 1: The inclusion of programme outcome and course outcomes in the syllabus of department of geology, central university of Kerala thereof.

Dr. Pratheesh P. has explained the Faculty Council discussion regarding inclusion of programme outcome and course outcomes in the syllabus. Then Dr. Pratheesh P. invited the Board of Studies opinion. BoS members have accepted the proposed programme outcome and course outcome. Prof. Rajneesh Bhutani opined that there should be some integration of thinking skills in the programme outcome.

Recommendation: Following a detailed discussion on the contents, the members approved the inclusion of programme outcome and course outcomes in the Department of Geology, Central University of Kerala curriculum.

Agenda 2: Consider the revised syllabus for 2021 admission.

Dr. Pratheesh P. has presented the revised syllabus for 2021 along with proposed programme structure. BoS members have accepted the proposed programme structure with some small suggestions.

Prof. Rajneesh Bhutani pointed that Geochemistry was missing from the curriculum, which is very much essential for an earth science. After a long discussion, BoS has decided to incorporate Geochemistry as a compulsory elective paper. Prof. Prakash Narasimha has suggested the usage of 'Planetary Sciences' instead of 'planetary Geosciences'. Dr. A. Anil Kumar has suggested a title change for Oceanography as 'Oceanography and Marine Geology'. Prof. (Dr.) Rajesh Raghunath has recommended some modifications in sequence stratigraphy. Apart from this BoS has recommended a number of additions in the core course discussion.

Recommendation: After a detailed discussion on the revised syllabus, the members unanimously approved the new syllabus for MSc Geology programme in Department of Geology Central University of Kerala. All the recommendations from the experts have incorporated in the revised syllabus.

Agenda 3: Inclusion of employment oriented courses in syllabus.

Dr. Pratheesh P. has explained the feedback received from the Alumni through the Alumni Coordinator, on the inclusion of employability oriented courses. He also pointed that the faculty council has discussed the same and incorporated a new core course 'Geospatial Technology and Engineering Geology' in the proposed syllabus. BoS had a fruitful discussion on the syllabus framework of the newly inducted course.

Recommendation: Following a detailed discussion on the contents, the members approved inclusion of 'Geospatial Technology and Engineering Geology' as core course in the proposed curriculum.

After this, overall agenda discussed in the BoS were summarised by Dr. Pratheesh P. Thereafter, Dr. Sijinkumar A.V. offered the vote of thanks, which conluded the BoS meeting.

Dr. Pratheesh P.

Head (i/c), Department of Geology

केरळकेंद्रीयविश्वविद्यालय

Central University of Kerala

M.Sc. Geology

SCHEME AND SYLLABUS

2021

TITLE OF THE PG PROGRAMME : M.Sc. Geology

PROGRAMME STRUCTURE

This PG programme is offered in four semesters and includes theory and practical classes, field training and a dissertation.

Duration of the Programme	**:**	4 semesters
Number of seats	**:**	38+2 (Supernumerary)
Type of the programme	**:**	Regular
Eligibility for admission	**:**	B.Sc. Geology / B.Sc.Geology and Water Management/B.Sc. (Hons.) Geology with minimum 55% marks or equivalent grade in aggregate and in the concerned subject separately, from a recognized University (studied in 10+2+3 system). B.Sc. triple main programme with Geology as one of the main/major/core subject is also eligible. However, Geology should have equal or more weightage with respect to the other two main subjects. The student must have studied Geology in all the three years of B.Sc. Programme. The B.Sc. triple main programme with Geology as a subsidiary/ minor subject or having less weightage compared to other two main subjects is not eligible.
Admission	**:**	Through CUCET

PROGRAMME STRUCTURE

I SEMESTER		Credits	Lecture hrs./Week	Lab hrs./Week	Field hrs./Week
EGE 5101	Geomorphology	3	3		
EGE 5102	Structural Geology	3	3		
EGE 5103	Stratigraphy	3	3		
EGE 5104	Mineralogy	3	3		
EGE 5191	Lab 1: Structural Geology and Geological Field Mapping	3		4	2
EGE 5192	Lab 2: Mineralogy	3		4	2
	Elective	3	3		
Total		**21**	**15**	**8**	**4**
II SEMESTER					
EGE 5201	Igneous Petrology	3	3		
EGE 5202	Metamorphic Petrology	3	3		
EGE 5203	Sedimentology	3	3		
EGE 5204	Palaeontology	3	3		
EGE 5291	Lab 3: Igneous and Metamorphic Petrology	3		4	2
EGE 5292	Lab 4: Sedimentology and Palaeontology	3		4	2
	Elective	3	3		
Total		**21**	**15**	**8**	**4**
III SEMESTER					
EGE 5301	Economic Geology	3	3		
EGE 5302	Hydrogeology	3	3		
EGE 5303	Geospatial Technology and Engineering Geology	3	3		
EGE 5391	Lab 5: Ore Geology	3	3	4	2
EGE 5392	Lab 6: Hydrogeology and Geospatial Technology	3		4	2
	Elective	3	3		
Total		**18**	**15**	**8**	**4**
IV SEMESTER					
EGE 5491	Dissertation	9		6	12
	Elective	3	3		
Total		**12**	**3**	**6**	**12**
Core Course		**60**			
Elective		**12**			
Total		**72**			

ELECTIVE PROGRAMME

Sl. No	**ELECTIVECOURSES**	Credits	Elective Type
1	Industrial Minerals and Gemstones	3	Internal
2	Geospatial Technology	3	External
3	Coal and Petroleum Geology	3	Internal
4	Environmental Geology and Natural Hazards	3	Open
5	Water Resource Management	3	Open
6	Isotope Geology	3	Internal
7	Quaternary Geology	3	Internal
8	Structural Analysis	3	Internal
9	Planetary Science	3	Open
10	Oceanography and Marine Geology	3	Open
11	Climatology	3	Open
12	Mineral Wealth of India	3	Internal
13	Geostatistics	3	Internal
14	Physical Geology	3	Open
15	Geochemistry	3	Internal
16	**Any PG MOOCs from SWAYAM/NPTEL**	**1-4**	

PROGRAMME OVERVIEW

Geology is the study of our planet Earth. In this programme we mainly address the fundamental questions about the origin, development, and future of the Earth. This course will train the students to acquire the skills in the field of interpretations of geological landforms and structures, distribution and chemistry of earth materials, origin and classifications of rocks, Identification of fossils and palaeo-life, investigations of natural resources and groundwater. It will enable the students to apply the theory and techniques, which they acquire during the programme, to develop a sustainable Earth and environment management. It will also provide an opportunity to learn about how our planet works, and address some of the major issues of our times: from the origin of the solar system, the Earth and life, to the climate system, natural hazards and groundwater investigations. The diverse range of courses cover processes from the Earth's interior, as mapped by seismic waves, to the evolution of the Earth's crust documented in the rocks at its surface. The department has a pretty decent state-of-the-art laboratories and field geological facilities. The course is also having a major field componet. This will enable the students to have real life experience in geological investigations and field work.

PROGRAMME OUTCOMES

The students after completing the Post-graduation shall be able to:

1. Develop thinking skills in spatial and temporal perspectives.
2. Develop thinking skills in geological systems.
3. Undertake field mapping in any part of India with respect to lithology, structure and stratigraphy and produce geological map.
4. Conduct lithological, structural, hydrogeological and geophysical field surveys and prepare geological reports.
5. Carry out petrographical, sedimentological, geochemical, paleontological laboratory analysis and prepare reports.
6. Undertake jobs related to Geology and offer consultancy services to different academic institutes and industry.
7. Apply the geological concepts in theoretical and practical situations, solve geological problems and offer extension services to the society.
8. Carry out independent research work in various branches of Geology.

PROGRAMME SPECIFIC OUTCOMES

At the end of programme, students will be able to:

1. Understand the basic geomorphic principles and evolution of various landforms developed under various structures, lithology and climate.
2. Identify the geological structures and can interpret their spatial and temporal relations.
3. Understand sedimentological principles, carry out sedimentological analysis, data analysis and decipher depositional environment and provenance.
4. Gain knowledge on hydrogeological environment, distribution of ground water, ground water flow direction and carry out electrical resistivity survey and remote sensing techniques for ground water exploration.
5. Undertand the diversified igneous processes which modified the eath surfaces.
6. Understand the various lithological units, stratigraphic succession and general distribution of rocks in India.
7. Gain knowledge on stratigraphic principles and their applications in the field of earth science.
8. To identify fossils and use them to understand the evolution of life, biostratigraphy and past climate, geography and ocean conditions.
9. Demonstrate confidence and accuracy in identifying important ore minerals in hand specimens, in outcrop, and under the microscope, and apply the theories to the solution of problems in the field.
10. Use geospatial technology for a sustainable earth sand environmental management.
11. Synthesis observations, evidence and theory to recognise and explain similarities and differences between different ore mineral groups.
12. Discuss with confidence the theories, principles and outstanding controversies related to commercial mineral deposits.
13. Conceive, design, execute, critique, revise, document and present an original research project and an independent program related to economic geology.

Course Code	EGE 5101	Semester	I
Course Title	Geomorphology		
Credits	3	Type	Core

Course Description

The course focuses on the origin, evolution of landforms, and the physical processes responsible for their creation and modification. This course will examine how surface processes interact to create landscapes and how climate, rock type, structure, and tectonics influence the formation of different landforms. The course also includes quantitative evaluation of landforms by morphometric analysis and identification of landforms from topographic maps and satellite images.

Course Outcome

By the end of the course, students are expected to be able to:

- Understand the key characteristics of fluvial, coastal and tectonic geomorphology.
- Specify the linkages between geomorphic forms and processes.
- Appreciate the importance of tectonics in landform development.
- Ability to classify and describe landforms in a variety of environmental and climatic settings.
- Quantitatively use and evaluate geomorphological data with numerical and statistical methods.
- Identify, interpret and critically evaluate landforms and geomorphic processes from topographic maps, satellite images, and aerial photographs.

Course Structure

Module - 1

Fundamental concepts in geomorphology. Different models for the Evolution of landscape: Davis, Penck, King, Hack.Hill slopes: slope elements, classification, models of slope evolution, slope movement and stability factors. Influence oflithology and structure on geomorphic processes and landforms.Climatic geomorphology: Development of landforms under different climatic conditions.

Module – 2

Fluvial Geomorphology: Erosional and depositional landforms of rivers. Drainage systems and patterns. Stream ordering. Hypsometry. Morphometric elements and parameters - morphometric analysis of drainage basins. Laws of drainage composition,drainage density, stream frequency. Coastal geomorphology: Coastal processes, Coastal erosional and depositional landforms.Effect of sea-level changes. Tectonic geomorphology: Landforms in relation to tectonics. Geomorphic indicators of neotectonic activity.

Module – 3

Geomorphological mapping: Study of geomorphic features from topographic maps, aerial photographs and satellite images. Methods of preparation of the geomorphological map.Application of geomorphology in various fields of earth sciences, viz. Mineral exploration, Hydrogeology, Civil Engineering and Disaster Management. Geomorphology of India.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Agrawal, L.C. (2008). Introduction to Geomorphology. Pointer Publishers, 128p.
- Arthur L. Bloom (1978). Geomorphology (A Systematic Analysis of Late Cenozoic Landforms). Prentice-Hall, 510 p.
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- Ritter, D.F., Kochel, R.C., Miller, J.R. (2006). Process Geomorphology, Waveland Pr Inc., 652p.Huggett, R. (2016): Fundamentals of Geomorphology, Taylor&Francis, 578p.
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- Thornbury, W.D. (1984). Principles of Geomorphology, John Wiley & Sons, 594p.

Course Code	EGE 5102	Semester	I
Course Title	Structural Geology		
Credits	3	Type	Core

Course Description

Structural geology is the study of deformation and deformed structures on earth surface. It will explain the complex deformational history of earth structures in terms of various spatial and chronological units at different scale. Understanding on present day geological structure will provide a clue towards the past geological event, which modified our earth in geological time.

Course Outcome

By the end of the course, students are expected to be able to:

- identify the geological structures in both macroscopic and microscopic scale.
- describe the deformational structures of an area from the geologic maps and outcrop patterns.
- elucidate the deformation history of an area using rock fabrics and geometric relationships
- get a proper enlightenment towards the geological literature

Course Structure

Module - 1

Deformation-concept, component and type. Continuum mechanics and rheology. Elastic, plastic and brittle deformation. Concept of stress. Concept of strain. Stress and strain ellipsoids. Mohr circles. Rock failure. Mohr-Coulomb failure criteria. Faults, Joints and Fractures.

Module - 2

Mechanics of folding and Buckling. Biot-Ramberg theory of buckling. Folds - Geometry of cylindrical, non-cylindrical and conical folds. Fold classifications -Donath and Parker and Ramsay. Fold interference and Superposed folding.

Module - 3

Fabric- Planar and linear fabrics. Tectonites- classification. Foliation -types, classification and origin. Lineation - types, classification and origin. Stereographic projections in structural geology. $\boldsymbol{\pi}$ and $\boldsymbol{\beta}$ diagrams. Geometric analysis of geological structures on macroscopic scale. Petrofabrics.

Evaluation &Grading

Lab Assessment – 10%
Field Assessment – 10%
Skill development (Analytical, Writing and Presentation) – 10%
Class Test – 10%

End Semester Assessment – 60%

References

1. Billings, M. P. (2016) Structural Geology. Pearson Education; Third edition, 624p.
2. Park, R.G. (1989), Foundation of Structural Geology, Blackie, 148p.
3. Ragan, D.M. (1969), Structural Geology, Wiley, 2nd edition, 602p.
4. Turner, E.J. and Weiss, L.E. (1963), Structural Analysis of Metamorphic Tectonites, Mc. Graw Hill, 545p.
5. Hobbs, B.E., Means, W.D. and William, P.F. (1976), An outline of Structural Geology, John Wiley and Sons, 571p.
6. Robert. J.Twiss and Eldridge.M.Moores (2007). Structural Geology, W.H.Freeman and Company, 695p.
7. Ramsay, J.G. (1967) Folding and Fracturing of Rocks. Mc Graw Hill, 586p.
8. Ramsay, J.G. and Huber M.I. (1987) The Techniques of Modern Structural Geology: Folds and Fractures, Academic Press, 391p.

Course Code	EGE 5103	Semester	I
Course Title	Stratigraphy		
Credits	3	Type	Core

Course Description

Stratigraphy is the science of understanding the variations in the successively layered character of rocks and their composition. These rocks may be sedimentary, volcanic, metamorphic or igneous This program aims to teach systematic stratigraphy with special reference to Indian geology with special case studies of world stratigraphy. The students are equipped with different correlation methods and stratigraphic nomenclature.

Course Outcome

By the end of the course, students are expected to be able to:

- Define and apply the principles of stratigraphy in Geological problems, describe the evolution of Precambrian and Proterozoic stratigraphic units of India.
- Summarise the main environmental conditions that occurred in each geological period, illustrate the paleogeography, tectonic history of the Earth during the Precambrian and the Phanerozoic time, apply stratigraphic methods to analyse the evolution of past environments.
- To better understand the newer fields of stratigraphy, include Sequence stratigraphy, seismic stratigraphy, cyclostratigraphy, magnetostratigraphy and chemostratigraphy.
- Intellectual and practical skills in order to apply stratigraphic principles in order to understand the stratigraphy of an area. Compare between different methods of stratigraphic correlation and apply the suitable one in an area.

Course Structure

Module - 1

Development of Stratigraphy: Contributions of the pioneers of Stratigraphy, Code of stratigraphic nomenclature. Major incidents in the Earth's History. The concept of the Precambrian. Distinguishing features and classification of the Precambrian. Precambrian stromatolites, their status as time markers and classification of the Late Proterozoic.

Module - 2

Fundamental and newer classification of stratigraphy, Lithostratigraphy: Procedures for establishing, extending and naming of Lithostratigraphic units. Biostratigraphy: Nature of biostratigraphic units – Life communities and Death assemblages. Procedures for establishing and extending biostratigraphic units. Chronostratigraphy: Formal and Informal chronostratigraphic units, Procedures for establishing and naming of chronostratigraphic units. Concepts of Magnetostratigraphy, Chemostratigraphy, Event stratigraphy and Sequence stratigraphy.

Module - 3

Distribution of Precambrian rocks in India. Indian Standard stratigraphic column, hiatuses and breaks. Models for the evolution of Precambrian crust. Shields - cratons and mobile belts. Low-grade and high-grade terrains. Precambrian shield areas. Precambrian's of southern India. Palaeozoic stratigraphy: Palaeozoic formations of

India with special reference to type localities, history of sedimentation and fossil content. Mesozoic stratigraphy: Mesozoic formations of India with special reference to type localities, history of sedimentation and fossil content. Gondwana Supergroup and Gondwanaland. Deccan Volcanics. Cenozoic stratigraphy: Cenozoic formations of India. Rise of the Himalayas and the evolution of Siwalik basin. Kerala and Cambay basins. Quaternary Stratigraphy – glacial and interglacial cycles. Paleogeography and major events during different periods. Age problems in stratigraphy.

Evaluation &Grading

Lab Assessment – 10%
Skill development (Analytical, Writing and Presentation) – 10%
Class Test – 20%
End Semester Assessment – 60%

References

- Balasubrahmanyan, M. N. (2006), Geology and Tectonics of India: An Overview, IAGR Memoir No.9, 204p.
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- Claude, C. and Albritton J. (1995), Catastrophic Episodes in Earth History, Chapman & Hall, 221p.
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- Pichamuthu, C.S. (1985), Archaean Geology, Indian Soc. of Earth Scientists, Oxford and IBH Publishing Co., New Delhi, vol.14, 221p
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- Spencer, E W (1962) Basic concepts of Historical geology, Oxford IBH, New Delhi
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- Weller, Marvin, J. (1960), Stratigraphic principles and practice, Harper and Brothers, New York, 725 p.

Course Code	EGE 5104	Semester	1
Course Title	Mineralogy		
Credits	3	Type	Core

Course Description

Mineralogy is the branch of geology that deals with the fundamental building blocks of all rocks, i.e., minerals. It involves the systematic study that deals with the characteristics of the individual and group of minerals.The course deals with the analytical, macroscopic and microscopic investigations of minerals to understand their crystal chemistry, crystal structure, physical properties, optical properties and genesis.The course aims to give an overall understanding of how the textures of the minerals control the chemical budget, and in turn aids the chemical evolution of the solid Earth.

Course Outcome

By the end of the course, students are expected to be able to:

- Demonstrate mastery of the terminology of mineralogy
- Demonstrate confidence and accuracy in identifying important minerals in handspecimens, in outcrop, and under the microscope, and apply the theories to the solution of problems in the field.
- Synthesis observations,evidence and theory to recognise and explain similarities and differences between different mineral groups.
- Discuss with confidence the theories, principles and outstanding controversies related to mineralogy.
- Conceive, design, execute, critique, revise, document and present an original research project and an independent program related to mineralogical investigations.

Course Structure

Module - 1

Crystallography – symmetry and its types, crystal faces, crystal forms and crystal habit. Crystal chemistry and structure – fundamentals of crystal chemistry, chemical controls on crystal structure, isostructural minerals, polymorphism, compositional variations, graphical representations. Introduction to X-ray crystallography, chemical analysis of minerals using EPMA, SEM, XRF and Mass spectrometry

Module - 2

Mineral growth and thermodynamics –mineral stability, phase diagrams, mineral nucleation, crystal growth, structural defects, twinning, post-crystallization processes, mineral evolution. Description of common rock forming minerals

Module - 3

Optical mineralogy - Optical properties of minerals: some physical background, refractive index and petrographic microscope, isotropic and anisotropic minerals, polarization and birefringence, optical indicatrix, dispersion, pleochroism. Identification of minerals using a petrographic microscope.

Evaluation &Grading

Lab Assessment – 10%
Skill development (Analytical, Writing and Presentation) – 10%
Class Test – 20%
End Semester Assessment – 60%

References

- Perkins, D., 2014, Mineralogy, Pearson
- Okrusch, M. and Frimmel, H.E., 2020, Mineralogy – an introduction to minerals, rocks and mineral deposits, Springer Publications
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Course Code	EGE 5191	Semester	I
Course Title	Structural Geology and Geological Field Mapping		
Credits	3	Type	Core

Course Description

This course deals with various structural analysis and geological field studies. It will offer the preparation and interpretation of geological maps and sections for the understanding of complex geological history in an area. Stereographic projection or stereonets will enable the students to interpret the deformational events. Geological field work will provide a real life experiences towards the proper understandings of various geological phenomenon.

Course Outcome

By the end of the course, students are expected to be able to:

- Understand the interpretation of geological maps and sections.
- Solve various stereonet based problems .
- Interpretation of geological history and deformational events.
- Perform field identification of geological structures.
- Interpretation and classification of geological terrain based on field work.

Course Structure

Module - 1

Preparation and interpretation of geological maps and sections. Structural problems. Recording and plotting of field data. Study of deformation structures in hand specimen. Study of dip isogons from fold profiles.

Module – 2

Stereographic projection in structural analysis. Application of stereographic projection in solving structural problems. Beta diagram and Pi diagram. Solving problems relating to faults and shear zones.

Module – 3

Topo sheets: Map scales, features in toposheet, finding the coordinates of points. Surveying - Chain Survey- Plane Table Survey – Leveling- Dumpy Level surveying, Total Station and GPS surveys. Geological field visit and mapping of litho-units in igneous, metamorphic and sedimentary terrains. Identification and Mapping of Faults, folds, foliations, cleavages, lineations, joints and shear zones

Evaluation &Grading

Lab assessment – 10 %
Skill development (Analytical and lab skills) – 10%
Field work – 20%
End Semester Assessment – 60%

References

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Course Code	EGE 5192	Semester	1
Course Title	Mineralogy		
Credits	3	Type	Core

Course Description

The course deals with various analytical techniques to investigate the optical properties of minerals, reading mineral chemical and bulk-rock petrochemical data. This course gives a hands on experience to the students on how to use the optical properties and petrochemical data of minerals/rocks to perform rock classification, and investigate the pressure and temperature conditions of formation of a given rock/mineral.

Course Outcome

By the end of the course, students are expected to be able to:

- perform quantitative and qualitative microscopic investigations of minerals.
- develop the ability to read and interpret the mineral chemical and bulk-rock petrochemical datasets.
- perform calculations using geothermeters and geobarometers.

Course Structure

Module - 1

Determination of extinction angle, pleochroism; Determination of birefringence – using Michel Levy's chart and Berek's compensator; Determination of interference figure; Determination of optic sign.

Module – 2

Study of optical characters of the following minerals/mineral groups: olivine, epidote, almandine, pyroxene, amphibole, mica, feldspar and feldspathoid.

Module – 3

Discriptive mineralogy of comon rock forming minerals. Mineral chemical recalculation, Structural Formulas, Crystal Size Distribution

Evaluation &Grading

Lab assessment – 10 %
Skill development (Analytical and lab skills) – 10%
Practical Test – 20%

End Semester Assessment – 60%

References

- Burger, M.J. (1962). Elements of Crystallography, Wiley.
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- Hans- Rudolf Wenk and Andrei Bulakh. (2004). Minerals – Their constitution and Origin, Cambridge University Press.
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Course Code	EGE 5201	Semester	II
Course Title	Igneous Petrology		
Credits	3	Type	Core

Course Description

The study of igneous petrology is basic necessity to know the geological sciences. Igneous rocks are the first to form on Earth's crust by cooling, crystallization, and solidification of plutonic magma or volcanogenic lava. This course will discuss the origin, evolution and classification of igneous rocks on earth surface. It will also discuss the origin and evolution of magma and associated processes.

Course Outcome

By the end of the course, students are expected to be able to:

- understand the origin of magama.
- understand the origin of diversified igneous rocks.
- understand various igneous processes which modified thee earth surfaces.
- classify the igneous rocks.

Course Structure

Module - 1

Igneous processes–Nature and evolution of magma – Generation of magma – Silicate systems - Phase rule and its application in the study of silicate systems - phase diagrams, primary phase diagrams and liquidus projections.

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Module – 2

Equilibria involving two solids + liquid.Eutecticcrystallization – Solid solution series – Incongruent melting. Course of crystallization in typical binary systems. Equilibrium crystallization and melting paths in ternary and quaternary systems. Diopside - Anorthite– Silica; Diopside - Anorthite–Albite; Quartz-Albite-Orthoclase; Reaction principle and reaction series.

Module – 3

Plume magmatism and hot spots- Large Igneous Provinces and dyke swarms. Classification of igneous rocks. Modal composition and Normative mineral composition. Niggli calculation of Fractionation Indices: Larsen Index, Nockolds Index, Mafic Index(MI). CIPW Norm. Granites and granitic rocks. Ultramafic rocks. Alkaline rocks. Kimberlites and ultrapotassic rocks. Anorthosite and carbonatite. Classification of basalts.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Bose, M. K. (1997), Igneous Petrology, The World Press Private Limited, Calcutta, 568 p.
- Carmichael, I. S. E., Turner, F. J. and Verhoogen, J. (1974), Igneous Petrology, McGraw Hill Book Company, 739 p.
- Ehlers, E. G. and Blatt, H. (1981), Petrology, CBS Publishers and Distributors, New Delhi, 732 p.
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Course Code	EGE 5202	Semester	II
Course Title	Metamorphic Petrology		
Credits	3	Type	Core

Course Description

Metamorphic petrology covers the chemical and physical work done in natural systems in response to changing physical conditions. Petrogenetic processes such as recrystallization, continuous and discontinuous reactions, mixed volatile reactions and deformation are addressed. The principles of metamorphic petrology are then applied to a number of orogenic events through geologic time, and modern advances in research in metamorphic petrology are explored

Course Outcome

By the end of the course, students are expected to be able to:

- understand the concept of metamorphism.
- understand the origin of diversified metamorphic rocks.
- understand various metamorphic processes.
- describe metamorphic rocks, their mineral assemblages and textures.

Course Structure

Module - 1

Concepts of metamorphism: Limits of metamorphism, Types of metamorphism, Factors of metamorphism, Role of fluids. Metamorphic structures and textures. Nature of metamorphic reactions. Concept and classification of metamorphic facies and facies series, P-T-t paths

Module – 2

Graphical representation of metamorphic mineral assemblages, composition paragenesis diagrams. Principal Types of Phase Diagrams, ACF, A'KF, AFM Diagrams. ACF and AKF diagrams and representation of metamorphic assemblages.

Module – 3

Metamorphic differentiation; Metamorphism and plate tectonics; Ultra High Temperature (UHT) and Ultra High Pressure (UHP) metamorphism.General characteristics of metamorphic domains – contact metamorphism, Regional metamorphism,Pairedmetamorphic belts, Orogeny and Metamorphism, Prograde and retrograde metamorphism.Metamorphism of carbonate rocks, pelites, mafic and ultramafic rocks.Granulitic rocks of Southern India, Migmatites.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Blatt, H. and Tracy, R.J. (1996), Petrology (Igneous, Sedimentary, Metamorphic), W.H. Freeman and Co. New York.
- Bucher, K. and Martin, F. (2002), Petrogenesis of Metamorphic Rocks (7th Rev. Ed.), Springer–Verlag, 341p.
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- Philpots A.R. and Ague, J.J. (2009), Principles of Igneous and Metamorphic petrology, second edition, Cambridge University press, New York, 667p.
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- Yardley, B.W. (1989), Introduction to Metamorphic Petrology, Longman, New York, 248p.
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- Winkler, H.G.F. (1976), Petrogenesis of Metamorphic rocks, 4th edition, Springer- Verlag, New York, 347p.
- Miyashiro, A. (1994), Metamorphic Petrology, Akiho, Research Press, New Delhi,416p.
- Pitchamuthu. C.S. (1984), Granulites of South India,Geological Society of India.

Course Code	EGE 5203	Semester	II
Course Title	Sedimentology		
Credits	3	Type	Core

Course Description

Sedimentologyis the study of sediments and sedimentary rocks and the processes by which they are formed. The course will provide an understanding of sedimentary processes, collection and analysis of sedimentary data. Italso develops an understanding of the processes involved in the formation and diagenesis of sedimentary rocks. The course deals with the analysis of deposits from a variety of continental, marginal marine and marine sedimentary environments using various sedimentary techniques.This course develops the skills needed to make interpretations of sedimentary successions, decipher sedimentary processes, past environmental conditions and provenance of sediments.

Course Outcome

By the end of the course, students are expected to be able to:

- Describe and interpret sedimentary rocks and their depositional environment.
- Describe and illustrate the various types of sedimentary structures and relate these to the processes which are responsible for these structures.
- Summarise the composition and properties of sedimentary rocks and justify the classification schemes used for these sediments.
- Evaluate the physical, chemical and biological processes that lead to sedimentary rock formation under different environmental conditions.
- Be conversant with the principal environments in which sediments are deposited and be able to identify these in the geological record on the basis of their distinguishing features.
- Interpret sedimentary processes based on the composition of the rock and sedimentary structures.
- Identify the depositional environment of sediments (i.e. continental; shallow and deep marine)
- Identify sedimentary deposits that are characteristic of various types of sedimentary basins

Course Structure

Module - 1

Fluid flow and sediment transport- Reynolds number, Froude Number, Hjulstrom's diagram. Sedimentary Textures:Concept of grain size and classification. Grain size estimation: direct measurement, sieving and settling methods. Modern methods- Laser diffraction analysis. Frequency distribution and grain size (statistical) parameters. Grain shape and fabric.Sedimentary structures: Classification and origin- depositional structures, deformational structures, erosional structures and

biogenic structures.Applications of sedimentary structures in paleo-environmental and paleocurrent studies.

Module – 2

Sedimentary Petrology: Mineralogy, classification and depositional environments of conglomerate, sandstone, limestone and mud rock. Diagenesis of clastic and non-clastic rocks- diagenetic processes and diagenetic environments. Provenance studies: mineral stability, mineralogical maturity and mobility. Use of heavy minerals in provenance studies.

Module – 3

Depositional environments - marine, non-marine, and mixed depositional environments. The association of primary sedimentary structures and textural characteristics with depositional environments and settings. Concept of sedimentary facies, association models. Walther's Law of correlation of sedimentary facies. Typesand classification of sedimentary basins.Basin analysis. Sedimentary basins of India.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Blatt, H., Middleton, G.V. and Murray, R.C. (1980). Origin of Sedimentary Rocks, Prentice-Hall Inc., 768p.
- Collins, J.D. and Thompson, D.B. (1982): Sedimentary Structures, George Allen and Unwin, London, 194p.
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- Lindholm, R.C. (1987). A Practical Approach to Sedimentology, Allen and Unwin, London, 160p.
- Miall, A.D. (2000). Principles of Basin Analysis, Springer-Verlag, 616p.
- Pettijohn, F.J. (1975). Sedimentary Rocks (3rd Ed.), Harper and Row Publ., New Delhi, 718p.
- Prothero, D.R. and Schwab, F., (2003) Sedimentary Geology. W. H. Freeman; 2nd edition, 593p.
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- Selley, R. C. (2000). Applied Sedimentology, Academic Press, 523p.
- Sengupta, S.M. (2015). Introduction to Sedimentology. CBS Publications, 339p.
- Tucker, M.E. (1981). Sedimentary Petrology: An Introduction, Wiley and Sons, New York, 272p.
- Tucker, M.E. (1990). Carbonate Sedimentology, Blackwell Scientific Publication, 482p.

Course Code	EGE 5204	Semester	II
Course Title	Paleontology		
Credits	3	Type	Core

Course Description

Paleontology is the scientific study of life that existed in the geological past. It includes the study of fossils to classify organisms and study their interactions with each other and their environment. The course aim to observe and examine the anatomy, morphology, and evolutionary history of vertebrate and invertebrate organisms and plants, understand the major lineages of organismal life through study of their anatomy and diversity, describe the major events (extinctions, diversifications, and environmental transitions) in the history of life and relate these events to possible causes.

Course Outcome

By the end of the course, students are expected to be able to:

- To understand palaeontological principles, terms, definitions and classifications, the applications of fossils in understanding Earth history.
- Recognize and identify invertebrate fossils, label key anatomical features and explain their function, recognize and classify fossil plants and animal traces, understand general characteristics and evolution of vertebrates.
- Application of fossils to constrain the age of the enclosing rock, identify and describe the principal microfossil groups, describe the methods of sample collection and laboratory preparation of microfossils.
- Summarise the value of microfossils in paleoenvironmental reconstruction, assess the importance of microfossils in hydrocarbon sub-surface exploration.
- Students will master complex and specialized knowledge, concepts and ideas in palaeontology which includes identification and description of vertebrate, invertebrate, plant and micro fossils. To develop research capability and practical competency in the field of palaeontology.

Course Structure

Module - 1

Life during the Precambrian, Diversification of life. Evolution of life during the Palaeozoic, Mesozoic and Cenozoic eras. Cambrian explosion. Fossil record and modes of evolution: Microevolution, Macroevolution and Tree of life. Theory of organic evolution and the factors in the Darwinian theory. Theory of Punctuated Equilibria. Origin of life: extra-terrestrial and terrestrial. Miller's experiment. Mass extinction and its causes.

Module - 2

General characteristics, geologic history, classification and evolution of Pisces, Amphibians, Reptiles, Birds and Mammals (Elephant, Horse and Human being). Human fossils from different parts of the world. Use of fossils in palaeoclimatic, paleoecological and palaeogeographic studies. Major fossil discoveries from India

Module - 3

Micropalaeontology: scope and subdivisions - types, extraction of microfossils from sediments and sedimentary rocks. Foraminifera: their palaeoecology and application in paleoclimate, paleoceanography and biostratigraphy. Radiolaria, Diatoms, Ostracoda, Pteropods, Cocolithophores, Stromatolites and Conodonts – morphology, classification and importance. Palynology: General morphology of spores and pollen and their applications. Palaeobotany: Plant life through geological ages. Gondwana plant fossils. Application of microfossils in petroleum exploration.

Evaluation &Grading

Lab Assessment – 10%
Skill development (Analytical, Writing and Presentation) – 10%
Class Test – 20%
End Semester Assessment – 60%

References

- Benton, J.M. and Harper (2009) Introduction to palaeobiology and the fossil record, Wiley-Blackwell, 608p.
- Benton, M.J (2000). Vertebrate Palaeontology, Blackwell Science, 269p.
- Black, R.M (1989) The elements of palaeontology, Cambridge University Press, 420p
- Brasier. M.D (1980) Microfossils, George Allen and Unwin Ltd, 193p.
- Clarkson, E.N.K (1998). Invertebrate Palaeontology and Evolution, ELBS Publishers. 468p.
- Glaessner,M.F. Principles of Micropalaeontolgy, Hafner Publishing Company, 296p.
- Lehmann.U and Hilimer, G (1983) Fossil Invertebrates, Cambridge University, 350p
- Porthero, D.R. (2004) Bringing fossil to life- An Introduction to Paleontology Mc Graw Hill, 512p.
- Pough.H. F, Heiser, J.B. and McFarland, W.N. (1996). Vertebrate Life, Prentice hall, 720p.
- Raup D.M. and Stanley .S (1985) Principles of Palaeontology, 481p.
- Ray, A.K (2008). Fossils in earth Sciences, Prentice Hall of India Private Limited, 444p.
- Shrock, R.R., Twenhofel, W.H (1953). Principles of Invertebrate Palaeontology, Mc Graw Hill, 816p.

Course Code	EGE 5291	Semester	II
Course Title	Igneous and Metamorphic Petrology		
Credits	3	Type	Core

Course Description

The objective of this course will be to instruct the student in the processes that control the genesis of igneous and metamorphic rocks, with emphasis on its diversification. The laboratory portion of the course will be devoted to applying various classification systems to laboratory specimens. This course will focus on various megascopic, microscopic and analytical studies in the classification of igneous and metamorphic rocks.

Course Outcome

By the end of the course, students are expected to be able to:

- apply fundamental principles of petrology
- describe igneous and metamorphic rocks, their mineral assemblages and textures,
- interpret igneous and metamorphic processes from evidence obtained in hand sample, thin section, and analytical data (mineral composition),
- interpret tectonic setting

Course Structure

Module - 1

Preparation of binary phase diagrams. Megascopic and microscopic identification of igneous rocks. Normative mineralogical calculations of acid, intermediate, basic and ultrabasic rocks (3 each).

.

Module – 2

Preparation of variation diagrams: Harkar, Larsen, Nockold and Allen, Niggli calculation of Fractionation Indices: Larsen Index, Nockolds Index, Mafic Index(MI), Mg-Number, Solidification Index, Felsic Index, Differentiation Index. Spider Diagram.

Module – 3

Study of metamorphic rocks in hand specimen. Preparation of metamorphic rock thin sections. Study of metamorphic rocks in thin sections: metamorphic mineral assemblages, structures and textures, grain boundary relations, strain effects. Plotting and interpretation of chemical data on ACF, AKF diagrams, Schreinmaker's rule and construction of petrogenetic grids, geothermometers and geobarometers.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Ragland.P.C (1989). Basic Analytical Petrology, Oxford University Press, 369p.
- Carmichael, I. S. E., Turner, F. J. and Verhoogen, J. (1974), Igneous Petrology, McGraw Hill Book Company, 739 p.
- Ehlers, E. G. and Blatt, H. (1981). Petrology, CBS Publishers and Distributors, New Delhi, 732 p.
- Faure, G. (2001), Origin of Igneous Rocks: The Isotopic Evidence, Springer-Verlag, New York, 496 p.
- Gupta, A. K. (1998), Igneous Rocks, Allied Publishers Limited, 690 p.
- Hall, A. (1988), Igneous Petrology, ELBS, Longman, 573 p.
- Bucher, K. and Martin, F. (2002), Petrogenesis of Metamorphic Rocks (7th Rev. Ed.),
- Kerr, P.F. (1959), Optical Mineralogy, McGraw Hill Book Company Inc., New York, 442p.
- Philpotts, A.R. (1994), Principles of Igneous and Metamorphic Petrology, Prentice Hall, 684p.
- Philpots A.R. and Ague, J.J. (2009), Principles of igneous and metamorphic petrology, second edition, Cambridge University Press, New York, 667p.

Course Code	EGE 5292	Semester	II
Course Title	Sedimentology and Palaeontology		
Credits	3	Type	Core

Course Description

The course deals with various sedimentological and paleontological techniques like sieve, pipette analysis for grain size determination and microfossils studies. It will provide an understanding of plotting, analysis and interpretation of sedimentary data to infer depositional environment. The course also includes megascopic and microscopic identification of sedimentary rocks.In Paleontology, students will be trained in sample processing for microfossil studies and identification of various microfossil groups.

Course Outcome

By the end of the course, students are expected to be able to:

- Perform grain size analysis of sediment samples using sieving and pipetting techniques.
- Calculation of various grain size statistical parameters, plotting the data and interpretation of depositional environment of sediments.
- Identify and classify the sedimentary rocks based on hand specimen and microscopic examination of thin sections.
- Perform sampling, processing and extraction of micro fossils from sediments.
- Identification of various microfossil groups and its application in geological studies.

Course Structure

Module - 1

Sieve analysis, plotting and interpretation of data (Trask method & Folk and Ward method). Estimation of statistical parameters - mean, skewness, kurtosis and standard deviation (sorting). Pipette analysis and estimation of silt and clay content. Plotting of gravel-sand-mud and sand-silt-clay data in triangular coordinate sheets. Interpretation of depositional environment.

Module – 2

Study and description of hand specimens and thin sections of conglomerate, breccia, sandstone, limestone, silt stone and shale.Sample processing techniques and separation of microfossils from matrix and marine sediments.

Module – 3

Identification of the following types of microfossils (calcareous and siliceous):Planktonic foraminifera, Benthic foraminifera, Ostracods, Pteropods and Radiolaria.Identification and separation of important species of planktonic foraminifera.

Evaluation &Grading

Lab assessment – 10 %
Skill development (Analytical and lab skills) – 10%
Class Test – 20%
End Semester Assessment – 60%

References

- Miall, A.D. (2000): Principles of Basin Analysis, Springer-Verlag, 616p.
- Pettijohn;, F.J. (1975): Sedimentary Rocks (3rd Ed.), Harper and Row Publ., New Delhi, 718p.
- Prothero, D.R., Schwab, F., (2003) Sedimentary Geology. W. H. Freeman; 2nd edition, 593p.
- Reineck, H.E. and Singh, I.B. (1973): Depositional Sedimentary Environments, Springer-Verlag, 439p.
- Tucker, M. E (2011). Sedimentary rocks in the Field. A Practical Guide. 4th Edition. Wiley, 288p.
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- Barghoorn, E.S. (1971) The Oldest Fossils, Scientific American, V. 224, No.5, 30-42.
- Brouver, A. (1967) General Palaeontology, Oliver & Boyd, 216p.
- Cushman, A. J. (1959) Foraminifera, Harward University Press, 605p.
- Glaessner, M.F. (1953) Principles of Micro Palaeontology, McGraw Hill.
- Jain, P.C. and Anantharaman, M.S. (1980) Palaeontology, Evolution and Animal Distribution, Vishal Pub., N.D, 320p.
- Jones, D.J. (1956) Introduction to Microfossils, Harper & Bros. Pub.
- Moore, R.C., Lalicker, C.G. and Fischer, A.G. (1952) Invertebrate Fossils, McGraw Hill.
- Neverson, E. (1962) Stratigraphic Palaeontology, Oxford University Press.
- Swinnerton, H.H. (1961) Outlines of Palaeontology, 3rdedn., Edward Arnold Ltd.
- Tiwari, S.K. (2004) A Text Book of Stratigraphy, Micropalaeontology and Palaeobotany, Kalyani Pub., N.D.

Course Code	EGE 5301	Semester	III
Course Title	Economic Geology		
Credits	3	Type	Core

Course Description

Economic geology is a professional skill development course that deals with the discovery of economic mineral deposits. The economic mineral deposits are the backbone of any nation's economy. A country with significant economic mineral deposits can be a wealthy nation if it has proper technology, manpower and application strategies. The course in economic geology aims to train the students in the professional and academic skills of an economic geologist.This course deals with the economic mineral genesis, global mineral laws and the mineral laws of India, mineral economics and mineral resource exploration techniques.

Course Outcome

By the end of the course, students are expected to be able to:

- Demonstrate mastery of the terminology of economic geology
- Demonstrate confidence and accuracy in identifying important ore minerals in hand specimens, in outcrop, and under the microscope, and apply the theories to the solution of problems in the field.
- Synthesis observations, evidence and theory to recognise and explain similarities and differences between different ore mineral groups.
- Discuss with confidence the theories, principles and outstanding controversies related to commercial mineral deposits.
- Conceive, design, execute, critique, revise, document and present an original research project and an independent program related to economic geology

Course Structure

Module - 1

Mineral resource crisis, factors controlling mineral availability, minerals and global economic patterns, future of ore deposit geology; Geology of ore deposits – classification and deposit models. Textures of ore and gangue minerals; Paragenesis, zoning; Magmatic ore deposits; Hydrothermal ore deposits – magmatic and orogenic environments, sedimentary environments; Ore deposits formed in sedimentary environments; Supergene ores and supergene overprinting of ores.

Module - 2

Mineral law and land access: National Mineral Policy – MM (R & D) Act, 1957 – procedures for grant of mineral concessions in India; Types of land and mineral ownership in different countries; Exploration versus exploitation concessions. Mineral Economics: History and structure of the mineral industry; Profits in the mineral industry; Mineral taxation and mineral profits; Mineral commodity prices; Distribution of profits. Law of the Sea Treaty – marine mineral resources.

Module - 3

Mineral resources and exploration; search for ore deposits and chances of success – geological, geochemical, geophysical, drilling, sampling and other field techniques; Remote sensing applications in mineral exploration; Surveying and exploration; statistical treatment of exploration data and computer applications.

Evaluation &Grading

- Lab Assessment – 10%
- Skill development (Analytical, Writing and Presentation) – 10%
- Class Test – 20%
- End Semester Assessment – 60%

References

- Banerjee (2001), Mineral Resources of India.
- Evans, A.M., (1980) An introduction to Ore geology, Blackwell Scientific Publications, 231p.
- Evans, A. M. (1993), Ore Geology and Industrial Minerals: An Introduction, Blackwell, 403p
- Geological Survey of India (2009), Miscellaneous publication no. 30, part-xxii: Geology and mineral resources of India,152p
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- Indian Bureau of Mines Bulletins of Mineral Information (availabile at IBM website) Ministry of Mines Annual Report 2011-12, 248p.
- Mookherjee, A., (1999), Ore Genesis- A Holistic Approach, Allied Publishers, 657p.
- Ministry of Mines (2011), Report of the working group on mineral exploration & development (other than coal & lignite) for the 12th five-year plan subgroup – on survey and mineral exploration, 310p.
- Nuclear Power in India Indian Nuclear Energy, http://www.world-nuclear.org/info/inf53.html
- Prasad, U (2002), Economic Mineral Deposits, CBS Publishers, New Delhi.
- Soman, K. (2001), Geology of Kerala, GeolSoc of India, Bangalore, 335p
- Stanton, R.L., (1972), Ore Petrology, McGraw Hill Inc, 213p
- Uranium 2009: Resources, Production and Demand, (The Red Book) Nuclear Energy Agency, OECD, 452p.
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- Arogyaswamy, R.N.P. (1980), Courses in Mining Geology, 2nd Ed., Oxford & IBH Pub. Co., New Delhi
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- Banerjee, P.K and Ghosh, S. (1997), Elements of Prospecting for Non-fuel Mineral Deposits, Allied Publishers Pvt Ltd, 320p.
- Kearey, P. and Brooks,M. (1991), An Introduction to geophysical Exploration, Blackwell scientific Publications, Musset, 272p.
- Krisch, R (2006). Groundwater Geophysics, A tool for hydrogeology, Springer – Verlag Berlin Hiedelberg.,Berlin 548 pp
- Lowrie, W (2007). Fundamentals of Geophysics, Cambridge University press, New York, 381pp.
- Mckinstry, H.E. (1947), Mining Geology, 1st Indian Ed., Asia Publishing House, New Delh

- Milsom,J (1989). Field Geophysics,A Geological Society of London Handbook, John Wiley&sons, New York.182 pp.
- Mishra D,C. (2011). Gravity and Magnetic Methods for Geological Studies,BS publications Pvt.Ltd Hyderabad 938pp.

Course Code	EGE 5302	Semester	III
Course Title	Hydrogeology		
Credits	3	Type	Core

Course Description

Hydrogeology is the study ofthe occurrence, distribution, and movement of groundwater below the Earth's surface. The course deals withvarious hydrogeologic processes, hydrological properties of rocks and principles of groundwater flow. It gives an overview of different groundwater exploration methods and water quality standards. The basic skills to apply pumping-test data to determine aquifer properties and an understanding of the chemical constituents in groundwater and surface waters is also provided by the course. The course will provide the theoretical knowledge required for the role of a professional hydrogeologist.

Course Outcome

By the end of the course, students are expected to be able to:

- Define hydrogeological terms, properties, methods of measurement and examine the significance of hydrogeological results.
- Explain the principles of groundwater flow and groundwater chemistry.
- Appraise the different types of aquifers, their composition, flow patterns, chemistry and vulnerability to pollution.
- Demonstrate an understanding of the laws governing groundwater flow in porous media.
- Apply basic quantitative analysis techniques to solve practical hydrogeology problems.
- Analyse of pumping test data to understand aquifer properties

Course Structure

Module - 1

Hydrological cycle and origin of ground water. Classification of rocks with respect to their water bearing properties- aquifers, aquicludes, aquitards, aquifuges. Types of aquifers. Hydrological properties of rocks: Porosity, permeability, void ratio, specific yield and specific retention, hydraulic conductivity, storativity, transmissivity.Barometric efficiency and tidal efficiency.

Module – 2

Groundwater flow: Darcy’s law and its experimental verification, flow nets, fluid potentials.Well hydraulics: Pumping tests and data analysis. Steady radial flow to a well in confined and unconfined aquifers-Theim’s equation, Dupuit-Forhemeir equation. Unsteady radial flow to a well in confined and unconfined aquifers- Theis,

Chow's and Jacob's methods.Application of isotope studies and tracer techniques in ground water flow.

Module – 3

Ground water exploration: Geological methods- lithological and structural mapping. Geophysical methods- Electrical Resistivity methods, Wenner and Schlumberger arrays, Profiling and VES methods. Seismic Refraction methods. Well logging: Spontaneous Potential Logging, Radiation logging, Gamma-gamma ray logging. Use of Aerial photos and satellite imageries in ground water prospecting. Well design criteria: Types, construction, maintenance and development of wells. Physical, chemical and bacterial measures of water quality. Water quality standard for different purposes – Drinking, Domestic, Irrigation and Industrial. Saline water intrusion in coastal aquifers and its prevention – Ghyben-Herzberg relationship. Artificial recharge and rain water harvesting methods.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Bouwer,H. (1978) Groundwater Hydrology. McGraw Hill Education, 480p.
- Davis,S.N. and Dewiest, R.J.N. (1966). Hydrogeology, John Wiley and Sons Inc. New York, 463p.
- Karanth, K.R.(1987). Groundwater Assessment Development and Management, Tata McGraw Hill, 720p.
- Linsley, R.K, Kohler, M.A. and Taulhus, J.L.H. (1975) Applied Hydrology, Tata McGraw Hill, 689p.
- Todd, D.K. (1980) Groundwater Hydrology, John Wiley and Sons, 552p.
- Walton,W.C. (1970) Groundwater Resource Evaluation, McGraw Hill Inc, 664p.
- Reghunath, H.M. (1992) Groundwater. 2nd Edn.Wiley Eastern Limited, 456p.
- Fetter, C.W. (2007) Applied Hydrogeology.Pearson, 624p.

Course Code	EGE 5303	Semester	III
Course Title	Geospatial Technology and Engineering Geology		
Credits	3	Type	Core

Course Description

This course will discuss the fundamentals of geospatial technology and engineering geology. Geospatial technology is an applied branch of earth science which deals with the modern tools contributing to the geographic mapping and analysis of the Earth and human societies. Engineering Geology is the branch of geology which describes the application of geology in engineering studies.

Course Outcome

By the end of the course, students are expected to be able to:

- understand the basics of geospatial technology and engineering geology.
- have an introduction towards remote sensing and GIS .
- have an idea about the applications of remote sensing and GIS.
- understand various geotechnical investigations and interpretations.

Course Structure

Module - 1

Geospatial Technology-Concept, Software and Hardware, Data. Map-Map projections-Map Scale, Datum. Space mission and satellites. Global Positioning System: Basic features, NAVSTAR GPS, GLONASS, IRNASS. Remote sensing- Basic concept, Electromagnetic Energy. Energy sources and radiation principles. Energy interactions in the atmosphere, energy interaction with earth surface features, Spectral Reflectance. Remote Sensing Platforms. Photogrammetry: basic principles – geometric characteristics of aerial photographs. Aerial photo interpretation. Thermal Remote Sensing and Microwave Remote Sensing. Digital image processing. Geographic Information System-Fundamentals of GIS and Components of GIS. Data and database management system

.

Module – 2

Applications of remote sensing in Geology, land use-land cover mapping-NDVI,Natural resource management, Water resources management; Disaster management and Environmental management. Applications of GIS in Geology, Water Resource Management,Environmental Impact Analysis, Urban planning, Disaster Management and Mitigation, Natural Resources Management.

Module – 3

Physical and engineering properties of rocks. Rock deformation and mechanical properties. Principal geological factors affecting engineering projects – Earth movements, stability of slopes and cuttings, groundwater, volcanoes, earthquakes; Geological materials used in construction. Geological considerations in engineering projects and site selection such as dams, reservoirs bridges, highways and tunnels. Geological investigation of engineering projects. Landslide hazard zonation mapping. Aseismic design of buildings and earthquake-resistant structures. Influence of geological conditions on foundation and design of buildings. Seismic zonation.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Campbell, J. B.and Wynne, R. H. (2008), Introduction to Remote Sensing, Fifth Edition, The Guilford Press, New York, 718p.
- Falkner, E. and Morgan D. (2002), Aerial Mapping: Methods and Applications, Lewis Publishers, Boca Raton, 192p.
- Lillesand, T.M., Kiefer,R.W. and Chipman, J.W. (2004), Remote sensing and image interpretation, Fifth Edition, Wiley, NJ, 812p.
- Mather, P.M. and Koch, M. (2011),Computer Processing of Remotely-Sensed Images – An Introduction, Fourth Edition, John Wiley, New York, 462p.
- McCoy, R. M. (2005), Field methods in remote sensing, Guilford Press, New York, 177p.
- DeMers, M. N. (2009), GIS for dummies, Wiley, NJ, 388p.
- Iliffe, J. (2000), Datums and Map Projections for remote sensing, GIS, and surveying, Whittles Publishing, Scotland, 159p.
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- Shekar, S., Xiong, H. eds. (2008), Encyclopaedia of GIS, Springer-Verlag, New York, 1392p.
- Sickle, J. V. (2010), Basic GIS Coordinates, CRC Press, FL, 190p.
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- Jensen, J.R., (2000). Remote Sensing of the Environment an Earth Resource Perspective. New Jersey: Prentice Hall, Inc, 608p.
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- G.L. Prost (2002). Remote sensing for Geologists: A guide to image interpretations. CRC Press, 326p.
- Floyd F. Sabins (1997) Remote Sensing: Principles and interpretations.WH Freeman & Company, 494p.
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- Arogyaswamy, R.N.P (2017). Courses in Mining Geology. Oxford and IBH Publishers, 735p.
- Hartman H. L. and Mutmansky, J.M. (2002). Introductory mining Engineering, John Wiley and Sons Inc.
- Gaudin, A .M. (1938) Principles of Mineral Dressing, McGraw Hill, 554p.
- Petters, W.C. (1987) Exploration and Mining Geology. John Wiley, 706p.
- Reedman, J.H. (1979) Techniques in mineral exploration, Allied Scientific Publishers, 534p.
- Bell, F.G. (1983) Fundamentals of Engineering Geology. Butterworth-Heinemann, 656p.
- Coduto, D.P. (2001) Geotechnical Engineering –Principles and Practices. Prentice Hall of India, Pvt Ltd, New Delhi.
- Duggal, S.K. Pandey, H.K. and Rawal, N. (2014) Engineering Geology, McGraw Hill Education (India) Pvt. Ltd.
- Lee. F. and Griffiths (2007). Engineering Geomorphology, Whittles publishing, 288p.
- Krynine, D.P. and Judd, W.R. (2001) Principles of engineering geology and Geotectonics, CBS Publishers and Distributers, New Delhi.

Course Code	EGE 5391	Semester	III
Course Title	Lab: Ore Geology		
Credits	3	Type	Core

Course Description

The Ore Geology lab is a professional skill development coursethat deals withvarious analytical techniques to investigate the physical and optical properties of ore minerals, ore dressing techniques andpreparation of polished sections. The course also deals with the numerical problems related to exploration geology.

Course Outcome

By the end of the course, students are expected to be able to:

- Perform quantitative and qualitative hand-specimen and microscopic investigations of ore minerals.
- Develop a skill towards solving mineral exploration problems.
- Perform logging of geophysical and geological datasets.
- Design on their own the ore dressing sequences in order to extract ore minerals from the run-of-mines (RoMs).

Course Structure

Module - 1

Megascopic and microscopic study and identification of ore minerals. Preparation and study of orepolished sections.
Gravity, magnetic, seismic and electrical resistivity exploration problems.

Module – 2

Preparation of litho logs using exploration data. Calculation of grade, tonnage and cut-off grade. Ore reserve estimation.

Module – 3

Fundamentals of ore dressing: Crushing, grinding, sizing, concentration by washing, scrubbing, jigging, tabling, floatation. Magnetic and Electrostatic separation. Flow-charts of mineral separation.

Evaluation &Grading

Lab assessment – 10 %
Skill development (Analytical and lab skills) – 10%
Practical Test – 20%

End Semester Assessment – 60%

References

- Arogyaswamy, R.N.P. (1980) Courses in Mining Geology, 2nd Ed., Oxford & IBH Pub. Co., New Delhi
- Banerjee (2001) Mineral Resources of India.
- Banerjee, P.K and Ghosh, S. (1997) Elements of Prospecting for Non-fuel Mineral Deposits, Allied Publishers Pvt Ltd, 320p.
- Kearey, P. and Brooks,M. (1991) An Introduction to geophysical Exploration, Blackwell scientific Publications, Musset, 272p.
- Mckinstry, H.E. (1947) Mining Geology, 1st Indian Ed., Asia Publishing House, New Delhi.
- Prasad, U (2002) Economic Mineral Deposits, CBS Publishers, New Delhi.
- Sinha, R.K and Sharma, N.L. (1970), Mineral Economics, New Delhi Oxford and IBH Pub.co., 317p.

Course Code	EGE 5392	Semester	III
Course Title	Lab 6: Hydrogeology and Geospatial Technology		
Credits	3	Type	Core

Course Description

The course will provide practical skills necessary for solving various hydrogeologic problems and software training in geospatial technoloy. It deals with interpretation of aquifer properties based on hydrogeological data, electrical resistivity survey techniques, preparation of ground water contour and flow direction maps and analysis of water quality data. The students will develop skills in hydrogeologic data collection and interpretation, assessing hydrologic properties of aquifers, identification of ground water potential zones and determine depthof ground water occurrence. In geospatial technology students will be trained to perform various GIS and remote sensing based analysis in Arc GIS, Envi and Q GIS.

Course Outcome

By the end of the course, students are expected to be able to:

- Apply basic quantitative analysis techniques to solve practical hydrogeological problems.
- Acquire practical skills to apply hydrogeological principles and methodologies for groundwater exploration.
- Carry out electrical resistivity survey and interpret the data for determining the depth of groundwater occurrence.
- Prepare groundwater contour maps and flow direction maps.
- Assess groundwater potential zones using remote sensing techniques.
- Prepare water quality diagrams and interpret the quality of water.
- Professionally report findings and recommendations from a groundwater study in written and oral formats.
- Become proficient in GIS and Remotesensing softwares.
- Perfom various GIS and remote sensing analysis

Course Structure

Module - 1

Identification and demarcation of watershed boundaries. Collection and interpretation of well inventory data. Determination of groundwater flow direction. Preparation and interpretation of water table contour map. Pumping test –Evaluation of aquifer parameters from pumping test data. Calculation and evaluation of hydrogeological parameters: porosity, permeability, hydraulic conductivity, transmissivity, specific yield, specific retention, storativity. Problems based on Darcy's law.

Module – 2

Electrical resistivity survey and interpretation of data. Study of Electric resistivity sounding data for delineation of depth of ground water occurrence. Exercises on groundwater exploration using remote sensing techniques. Preparation of ground water potential maps. Analysis of water quality parameters. Graphical representation of water quality data(Bar diagrams, Piper Trilinear diagram, Vector diagram, Circular diagrams, Stiff's polygon). Interpretation of hydrochemical data.

Module – 3

Geospatial Technology- Introduction to software and hardware. Introduction to Remote sensing analysis. Introduction to GPS. Aerial photo interpretation. Geographic Information System- software and applications.

Evaluation &Grading

Lab/field assessment – 10 %
Skill development (Analytical, writing and lab skills) – 10%
Class Test – 20%
End Semester Assessment – 60%

References

- Bouwer,H. (1978) Groundwater Hydrology. McGraw Hill Education, 480p.
- Davis,S.N. and Dewiest, R.J.N. (1966). Hydrogeology, John Wiley and Sons Inc. New York, 463p.
- Karanth, K.R.(1987). Groundwater Assessment Development and Management, Tata McGraw Hill, 720p.
- Linsley, R.K, Kohler, M.A. and Taulhus, J.L.H. (1975) Applied Hydrology, Tata McGraw Hill, 689p.
- Todd, D.K. (1980) Groundwater Hydrology, John Wiley and Sons, 552p.
- Walton,W.C. (1970) Groundwater Resource Evaluation, McGraw Hill Inc, 664p.
- Reghunath, H.M. (1992) Groundwater. 2nd Edn.Wiley Eastern Limited, 456p.
- Fetter, C.W. (2007) Applied Hydrogeology.Pearson, 624p.
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- Falkner, E. and Morgan D. (2002), Aerial Mapping: Methods and Applications, Lewis Publishers, Boca Raton, 192p.
- McCoy, R. M. (2005), Field methods in remote sensing, Guilford Press, New York, 177p.
- G.L. Prost (2002). Remote sensing for Geologists: A guide to image interpretations. CRC Press, 326p.

Course Code	EGE 5491	Semester	IV
Course Title	Dissertation		
Credits	9	Type	Core

Course Description

This course will have an independent project work including field and laboratory investigations of geological significance. Preparation and presentation of Dissertation will be in the fourth semester although the work related to the dissertation can be initiated in the third semester itself.

Course Outcome
By the end of the course, students are expected to be able to:

- have a basic understanding an independent geological fieldwork.
- have a basic understanding on lab investigations.
- have a basic understanding on preparation of research report.
- have a basic understanding on an oral presentation of independent research work.

Course Structure

Project work shall be carried out under the supervision of a teacher in the parent department. The candidate may be permitted to work on the project in an industrial / research organization on the recommendation of the supervising teacher and the Head of the Department. In such cases also, a teacher from the parent department would be the sole supervisor no co-supervisor/ external guide will be permitted. Every student has to do the dissertation work independently. The project title, content and layout should be in university standard format. The project reports of students should not be identical in content.

Evaluation &Grading
Skill development (Lab work and Research report) – 20%
Field work – 20%
Assessment of Dissertation Report – 40%
Presentation and viva voce-20%

Course Code	EGE 5001	Semester	Any
Course Title	Industrial Minerals and Gemstones		
Credits	3	Type	Elective

Course Description

Industrial minerals and gemstones is a professional development course that deals with the occurrences and distribution of industrial minerals, characteristics and economic importance of gemstones, special properties of gemstones and gem testing techniques. The course aims to introduce the skills of gem testing using advanced techniques to the students and enable them to identify and discuss the economic importance of industrial minerals and gemstones.

Course Outcome

By the end of the course, students are expected to be able to:

- Demonstrate mastery of the terminology of industrial minerals and gemmology
- Demonstrate confidence and accuracy in identifying important industrial minerals and gemstones in hand specimens, in outcrop, and under the microscope, and apply the theories to the solution of problems in the field.
- Synthesis observations, evidence and theory to recognise and explain similarities and differences between various industrial minerals and gemstones.
- Discuss with confidence the theories, principles and outstanding controversies related to the origin of industrial minerals and gemstones.

Course Structure

Module - 1

Industrial Minerals - Mode of occurrence - Uses and distribution in India - Ceramic minerals, Granite and Building stones, Cement - Raw materials - Mineral pigments - Refractory and abrasive minerals - Fertilizer minerals- Diamond - Gemstones, Asbestos, Mica, Vermiculite, Barite, Talc, Glass, Sand and Fullers earth.

Module - 2

Introduction to Gems – Precious and Semiprecious stones and their economic importance. Classification of gem stones materials.General characteristics and chemical composition of gemstones. Physical characteristics: Form, cleavage, fracture, hardness and specific gravity; Optical characteristics: colour, lustre, refractive index, reflectivity, pleochroism, and dispersion. Introduction to special optical properties of gemstones: Chatoyancy, Asterism, Luminescence, Play of colours, Labradorescence, Inclusions. Formation of gemstones.

Module - 3

Gem Testing- Refractometers, Polariscope, Dichroscope, Ultra-violet lamps. Principles and Uses. Application of ultra-violet rays, X-rays and Infra-red rays in gem identification. Electrical, thermal and magnetic characters of gemstones. Methods of determination of specific gravity. Distinction between synthetic and natural gemstones. Gem enhancement methods: Polishing, Carving and engraving, colourless/coloured impregnation, heat treatment, coating, irradiation, diffusion, treatment etc. Utility of gemstones: (1) Technical applications and (2) Use as jewels. Occurrence of gems in India. Gem Industry in India.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Anderson B.(2014).Gem Testing, Sutton Press.
- Babu T. M. (1998). Diamonds in India, Geological Society of India, Bangalore.
- Bates, (1969). Geology of Industrial Rocks and Minerals, Dover book earthsciences.
- Baumgart,W., Dunham A.C., and Amstutz, G.C.(1985).Process Mineralogy of CeramicMaterials. Elsevier Science Ltd.
- Cally Hall (1994). Gemstones, Dorling Kindersley.
- Deb,S. (1980). Industrial Minerals and Rocks of India, Allied Publishers (P) Ltd.
- Karanth, R.V. (2000). Gems and Gem Industry in India, Geological Society of India.
- Krishnasamy, S. (1972). India's Mineral Resources, Oxford and IBH Publishers.
- Taggart, A.P. Hand book of Mineral dressing, John Wiley & Sons Inc., 1905p.

Course Code	EGE 5002	Semester	III
Course Title	Geospatial Technology		
Credits	3	Type	Elective

Course Description

This course will discuss the fundamentals of geospatial technology. Geospatial technology is an applied branch of earth science which deals with the modern tools contributing to the geographic mapping and analysis of the Earth and human societies. This course will be offered as an external elective for other branch students. This present course curriculum offers an opportunity for the other branch students to understand the basics of geospatial technology for developing an interest in the principles, practical uses, and resources related to geospatial technologies.

Course Outcome

By the end of the course, students are expected to be able to:

- understand the basics of geospatial technology.
- have an introduction towards remote sensing and GIS .
- have an idea about the applications of remote sensing and GIS.

Course Structure

Module - 1

Concepts and foundation of remote sensing: energy sources and radiation principles, energy interactions in the atmosphere, energy interaction with earth surface features – Spectral Reflectance - Introduction to aerial photographs and aerial photo interpretation. geometric characteristics of aerial photographs. Binocular-Mirror-pocket Stereoscopes. Photogrammetric problems.

Module – 2

Introduction to remote sensing- land use-land cover mapping-NDVI. Applications of remote sensing in Water resources management; Disaster management, Public Health, Urban Planning and Environmental management. Geographic coordinates. Map projections. Global Positioning System: Basic features, NAVSTAR GPS, GLONASS, IRNASS.

Module – 3

Fundamentals of Geographic Information System – data input, data management, data manipulation, data output. Data Input and Editing: Coordinate Conversion. Digitizing, data encoding, re-projection and transformation. Vector and Raster data analysis.Applications of GIS inmapping, Urban planning, Water resources management; Disaster management; Environmental management and public health.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Campbell, J. B.and Wynne, R. H. (2008), Introduction to Remote Sensing, Fifth Edition, The Guilford Press, New York, 718p.
- Falkner, E. and Morgan D. (2002), Aerial Mapping: Methods and Applications, Lewis Publishers, Boca Raton, 192p.
- Lillesand, T.M., Kiefer,R.W. and Chipman, J.W. (2004), Remote sensing and image interpretation, Fifth Edition, Wiley, NJ, 812p.
- Mather, P.M. and Koch, M. (2011),Computer Processing of Remotely-Sensed Images – An Introduction, Fourth Edition, John Wiley, New York, 462p.
- McCoy, R. M. (2005), Field methods in remote sensing, Guilford Press, New York, 177p.
- DeMers, M. N. (2009), GIS for dummies, Wiley, NJ, 388p.
- Iliffe, J. (2000), Datums and Map Projections for remote sensing, GIS, and surveying, Whittles Publishing, Scotland, 159p.
- Konecny, G. (2003), Geoinformation: Remote sensing, photogrammetry and geographic information systems, Taylor& Francis, London, 266p.
- Shekar, S., Xiong, H. eds. (2008), Encyclopaedia of GIS, Springer-Verlag, New York, 1392p.
- Sickle, J. V. (2010), Basic GIS Coordinates, CRC Press, FL, 190p.
- Verbyla, D. L. (2003), Practical GIS analysis, Taylor & Francis, London, 305p.
- Jensen, J.R., (2000). Remote Sensing of the Environment an Earth Resource Perspective. New Jersey: Prentice Hall, Inc, 608p.
- Jensen, J.R., (2005). Introductory Digital Image Processing: A Remote Sensing Perspective. 3rd ed. Upper Saddle River, NJ: Pearson Prentice Hall, 544p.
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- P. A. Burrough, Mcdonnell R A (1998). Principles of geographical information systems. Oxford university press, 332p.

Course Code	EGE 5003	Semester	Any
Course Title	Coal and Petroleum Geology		
Credits	3	Type	Elective

Course Description

This course will discuss the Fundamentals of coal and petroleum geology. It provide proper enlightenment towards the Origin of coal, Petrography of coal, petroleum source rock, reservoir, and trap studies etc.

Course Outcome

By the end of the course, students are expected to be able to:

- have a basic understanding of the petroleum system and petroleum as a resource.
- have an idea about the origin of coal and petroleum.
- have an understanding on the global distribution of coal, oil and gas through geologic ages.

Course Structure

Module – 1

Origin of coal: accumulation of vegetative matter - *in situ* and drift theories; stages of formation of coal.. Classification, Ranks and Grading of coal. Petrography of coal: lithotypes, macerals and microlithotypes. Coal-bed Methane as an energy resource. Physical and chemical characteristics of coal. Geological and geographical distribution of coal deposits in India.

Module – 2

Origin of petroleum- organic and inorganic theories. Transformation of organic matter into petroleum; Kerogen, transformation and maturation of kerogen. Primary and secondary migration of oil and gas. Reservoir rocks: classification and characteristics; Structural traps, stratigraphic traps and combination traps for oil and gas accumulation.

Module – 3

Global distribution of oil and gas through geologic ages. Petroliferous basins of India. Geological setting of major oil and natural gas fields of India. The surface indications and direct detection of hydrocarbons. Introduction to the oil belts of the world. An outline of well-site geological techniques and exploration techniques. Introduction to basin analysis. Gas hydrate and shale gas – origin and extraction.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%

Class Test – 20%
End Semester Assessment – 60%

References

- Deshpande B. G. (1992) The world of petroleum. New Age International, 260p.
- Levorson A. I. (2004) Geology of Petroleum. CBS Publishers and Distributors Pvt Ltd, 260p.
- North F. K. (1985) Petroleum Geology. Alllen&Unwin, Boston, 607p.
- Chandra, D., Singh, R.M. Singh, M.P. (2000): Textbook of Coal (Indian context), Tara Book Agency, Varanasi, 402p.
- Scott, A.C. (1987) Coal and coal-bearing strata: Recent Advances and future prospects, Geological Society, London, Special Publications, 32p.
- Singh, M.P. (1998) Coal and Organic Petrology, Hindustan Publishing Corporation, New Delhi, 128p.
- Stach, E., Mackowsky, M-Th., Taylor, G.H., Chandra, D., Teichumullelr, M. and Teichmuller R. (1982): Stach's Texbook of Coal petrology, GebruderBorntraeger, Stuttgart, 535p.
- Thomas L. (2002) Coal Geology, John Wiley and Sons Ltd., England, 384p.
- Sharma, N.L. and Ram K.S.V. (1966) Introduction to the Geology of Coal and Indian Coalfields. Dhanbad Publications, Dhanbad, 183p.
- Acharyya S.K. (2000) Coal and Lignite Resources of India-An Overview. Geol. Soc. of India, 50p.
- Tissot, B.P and Welte, D.H (2003). Petroleum formation and Occurrence. Springer-Verlag, 699p.
- Selley, R.C (1999) Elements of Petroleum Geology. Academic press, 470p.
- Milton B. Dobrin & Carl H. Savit (1988). Introduction to Geophysical prospecting, McGraw-Hill, 867p.
- Gupta, P. K. and Nandi, P. K. (1995). Wellsite Geological Techniques and Formation Evaluation: A user's manual, Vol. Oil and Natural Gas Corporation, Dehradun.
- Ransom, R.C. (1995) Practical Formation Evaluation, John Wiley and Sons, 490p.
- Rider, M.H. (1985) The Geological Interpretation of Well Logs, Blackie, London, 280p.

Course Code	EGE 5004	Semester	Any
Course Title	Environmental Geology and Disaster Management		
Credits	3	Type	Elective

Course Description

Environmental geology and Disaster Management programme deals with a multidisciplinary approach that covers a broad range of topics, ranging from the concepts of environment to Disasters Management, including natural hazards and their impact on human lives. It will address the interactions between humans and the physical environment. Also discuss sustainable approaches in Environmental management, Land-use management, Disaster risk reduction, Risk management, integrated disaster risk management and post-disaster response

Course Outcome

By the end of the course, students are expected to be able to:

- get a proper enlightenment towards environment management.
- understand the fundamental concepts of natural hazards
- elucidate the sustainable approaches in Disaster Management
- understand the Risk management
- have a preparedness in post-disaster response

Course Structure

Module - 1

Our environment - an introduction. Fundamental concepts of environmental geology. Land-use and its Management –Land use pattern in India. Soil conservation- Strategy, Practices in hilly areas, Controlling gully erosion in ravine lands, Shelter belts in deserts. Energy and environment- Environmental impacts of quarrying and mining, Waste management. Environmental pollution- land, air and water.

Module – 2

Hazards- Introduction to key concepts, terminology. Natural hazards – Geologic and atmospheric. Earthquake, Landslide, Tsunami, Flood, Drought, Cyclone, Volcanic eruption, and Avalanche. Hazard- vulnerability, Exposure, Risk, Crisis, Disasters, Significant aspects of disasters

Module – 3

Disaster risk reduction, Risk management framework, Integrated Disaster risk management and post-disaster response. Natural disasters and their management- Problems, prospects and case studies. Climate change and its impact on coastal environment. Coastal management planning. Disaster management process- Prevention, preparedness, Mitigation, Application of Information technology in Disaster Preparedness, Application of geospatial technology in disaster management,

Trauma and Stress management, First Aid and Emergency procedures, Early Warning systems.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Pritchard, C.L. (2005), Risk Management, ESI International, Virginia, 474p.
- Coates, D.R. (1981) Environmental Geology, John Wiley and sons, 701p.
- Lee, F and Griffiths (2007) Engineering Geomorphology, Whittles publishing, 288p.
- Gupta, H.K. (2003) Disaster Management, University Press, 188p.
- Keller, E.A (2010). Environmental Geology. Pearson, 624p.
- Bennett M.R and Doyle, P. (1997) Environmental Geology, Wiley, 512p.
- Elawan, P.T. (1970) Environmental Geology, Harper and & Raw.
- Rajib Shaw and R.R. Krishnamurthy (2010) "Disaster Management: Global Challenges and Local Solutions", Disaster Prevention and Management, v. 19, No. 4, pp. 518-518.
- Radhakrishna B.P and Ramachandran K.K. (1986). India's Environment, GSI, Bangalore
- Valdiya K.S. (2004) Geology, Environment Society, Orient Blackswan Private Limited, New Delhi, 240p.
- Valdiya K.S. (2013) Environmental Geology, McGraw Hill, New Delhi.
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- www.sdma.ker.in

Course Code	EGE 5005	Semester	Any
Course Title	Water Resource Management		
Credits	3	Type	Elective

Course Description

Water resource management is planning, developing, distributing and managing the optimum use of water resources. It deals with the development and utilization of water resources to meet increasing socioeconomic water demand. The course aims to develop the professional skills required for a career in the management of water resources. The course deals with assessing surface and groundwater resources, water resources planning, integrated water resources management, watershed conservation practices, and water quality evaluation.

Course Outcome

By the end of the course, students are expected to be able to:

- Understand basic principles of water resources management, including surface and groundwater hydrology and water quality.
- Discuss issues regarding water use, management, anddevelopment.
- Assess surface and groundwater resources of a region.
- Develop suitable plans for water resource development and management.
- Estimate sustainable yield of water resources and determine the required storage of water resources.

Course Structure

Module - 1

Introduction to water resources - Ground water, Surface water, Glaciers and Rainwater. History of water resource development, Global water resources, Water cycle, Relation between water resources and environment. Concept of Integrated Water Resource Management (IWRM). Need for Water Resource Management, available water resources, Water scarcity- Lowering of Ground water level, vanishing of fresh water ponds, lakes and wet-lands.

Module – 2

Water supply Planning and Management-Domestic, agricultural and industrial. Cost-benefit analysis in water resource planning, Planning of watershed conservation practices, artificial recharging, contour bunding, sub-surface dams, geo-textile, rainwater harvesting. Estimation of available water resources. Water budgeting. Artificial reservoirs, construction of dams, Design and Planning of Distribution system- Drinking water, Irrigation water, Canal design, principles of irrigation, evapo-transpiration.

Module – 3

Water quality- pollution, Chemical and biological. Different Water quality standards. Water analysis techniques – Rainfall data, Acidic and alkali rain, Soil moisture analysis, evaporation, transpiration, Flood frequency analysis, rainfall - runoff analysis, reservoir function study, Generation of hydro-electric power. Treatment of waste water. Desalination methods.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Cech Thomas V. (2003). Principles of water resources: History, development, management and policy. John Wiley& Sons.
- Todd, D.K. (2004) Ground Water Hydrology, John Wiley & Sons, 636p.
- Karanth, K.R. (1987) Groundwater Assessment, Development and Management. Tata McGraw Hill, New Delhi, 720p.
- Mays, L.W. Water resource engineering, John Wiley& Sons
- Linsley R.K and Franzini J.B (1979) Water resource engineering, McGraw-Hill
- Mays L.W. (1996) Water resources hand book, McGraw-Hill.
- Jain S.K. and SnghV.P.,Water resources system planning and Management Elsevier
- Walton, W.C. Ground Water Resources evaluation, McGraw-Hill.

Course Code	EGE 5006	Semester	Any
Course Title	**Isotope Geology**		
Credits	3	Type	Elective

Course Description

Isotope Geology is an aspect of geology based upon the study of natural variations in the relative abundances of isotopes of various elements. This program introduces the student to theoretical and practical aspects of radiometric geochronology and stable isotope geology. The isotopic geochemistry has a great importance in geology is radiometric age dating.

Course Outcome

By the end of the course, students are expected to be able to:

- Demonstrate advanced knowledge of the geochemistry of rocks. Recognize the importance of isotope investigation of waters and of the atmosphere. Understand appropriate sample preparation procedures for analytical isotope geochemistry
- Demonstrate a basic understanding of the analytical methods used to measure element concentration in geochemistry. Understand precision and accuracy of geochemical measurements.
- Describe geochemical data in the context of environmental processes and application of stable and unstable isotopes in earth system science.

Course Structure

Module - 1

Isotope geochemistry: Physical and chemical properties of isotopes; stable and unstable isotopes. Unstable or radio-isotopes**:** radiometric dating methods, Principles of isotope dating. U –Th - Pb methods, principles, merits and demerits. K-Ar method. Ar gain, Ar loss and their effects. Ar^{40} - Ar^{30} method. Rb–Sr method. Whole- rock and isochron methods. Sr loss. Sm -Nd method. Rb - Sr and Sm - Nd ratios and their significance. Fission track dating. ^{14}C dating. Suitability of samples or materials for dating. Preparation of samples for dating. Interpretation of isotope dates. Limitations of isotope dating. Distribution of dates in space and time.

Module – 2

Stable Isotopes**:** Geochemistry, Notation. Theoretical Considerations. The Mass Spectrometer- principles, components and sensitivity. Thermal-ionization mass spectrometry (TIMS), ICP-MS, LA-MS, Secondary-Ion Mass Spectrometry (SIMS). Measurement of stable isotopes using isotope ratio Mass Spectrometer (IRMS). Isotope Fractionation in Hydrologic and Biological Systems.

Carbon Isotope Fractionation during Photosynthesis. Nitrogen Isotope Fractionation during biological processes. Oxygen and Hydrogen Isotope Fractionation during

precipitation, evaporation and absorption by Plants. Paleoclimatology. The Marine Quaternary $\delta^{18}O$ Record and Milankovitch Cycles.

Module – 3

Sulfur Isotopes and Ore Deposits. Stable Isotopes in the mantle and magmatic system. Stable Isotopic Composition of the Mantle. Boron isotopes. Stable Isotopes in Crystallizing Magmas. Combined Fractional Crystallization and Assimilation. Isotope Geothermometry. Paleothermometer, carbonate thermometer, $^{18}O/^{16}O$ isotope composition of silicates and high-temperature thermometry, isotopic cycle of water, Paleothermometry and the water cycle: paleoclimatology, paleoclimatic records: sediment and ice. Carbonate paleoclimatology.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Allegre, C. (2008), Isotope Geology, Cambridge University Press, New York, 534p.
- Baskaran, M. (ed) (2011), Handbook of Environmental Isotope Geochemistry, Springer-Verlag, Berlin, 943p.
- Claude Hillaire–Marcel and Anne De Vernal (2007) Proxies in Late Cenozoic Paleoceanography (2007), Elsevier, Amsterdam, Tokyo, 843p.
- Gill, R. (1989), Chemical Fundamentals of Geology, HarperCollins Publishers Ltd, UK, 292p.
- Hoefs, J. (2009), Stable Isotope Geochemistry, 6th Edition, Springer-Verlag, Berlin, 293p.
- Krauskopf, K. B. (1967), Introduction to geochemistry, McGraw-Hill Book Co., New York, 721 p.
- Mason, B, Moore and Carleton, B. (1982), Principles of geochemistry, John Wiley & Sons, New York, 344 p.
- Mook, W. G. (2000), Environmental Isotopes in the Hydrological Cycle: Principles and Applications, Vol 1, UNESCO/IAEA, Paris, 297p.
- Valley, J. and Cole, D. (2001), Stable Isotope Geochemistry, Reviews in Mineralogy 43, Mineralogical Society of America, Washington DC, 660p.
- White, W. M., Geochemistry, 695p (Unpublished book, available online)
- Wolfsberg, M., Hook, V.W.A., Paneth, P. and Rebelo, L.P.N. (2010), Isotope Effects in the Chemical, Geological, and Bio Sciences, Springer-Verlag, Berlin, 477p.

Course Code	EGE 5007	Semester	Any
Course Title	**Quaternary Geology**		
Credits	3	Type	Elective

Course Description

Quaternary Geology programme provides a comprehensive examination of the climate and geological events during the Quaternary period (last 2.6 million years). The Quaternary period comprises the Pleistocene and the Holocene and is the youngest of the geological periods. To provide an advanced understanding of the causes and consequences of climatic changes on long and short timescales with specific reference to glaciated terrains during the Quaternary Period. The students are exposed to different methods, proxies and archives for reconstructing Quaternary climate change.

Course Outcome

By the end of the course, students are expected to be able to:

- Provide a comprehensive examination of Quaternary glacial and interglacial environments drawing on a range of case studies from both modern and ancient glaciated regions
- Advanced understanding of the causes and consequences of climatic changes on long and short timescales with specific reference to glaciated terrains during the Quaternary Period (last 2.6 million years)
- Describe the variety of proxy records that are available for reconstructing Quaternary climate change.
- Understand the processes involved in producing different proxy records and be aware of the complexities involved in interpreting those records.
- Synthesize the findings from different proxy records to form a coherent picture of Quaternary climate change.
- Critically evaluate the advantages and disadvantages of different techniques and their usefulness in reconstructing Quaternary environments.
- Show analytical skills in the written, summative assignment, and Critical engagement with research papers related to Quaternary research, Present scientific information and debates in an oral presentation.

Course Structure

Module - 1

Definition of Quaternary; concept and importance of Quaternary, Quaternary chronostratigraphic unit, standard sub-divisions of the Quaternary Period and their climatic significance, standard global stratotype sections, Plio-Pleistocene boundary. Quaternary Glaciations – causes, the pattern of glacial-interglacial cycles and associated eustatic changes. Milankovitch orbital cycles. Lines of evidence for Recent and historical sea-level fluctuations; Ice core records of glaciations during the Pleistocene and Holocene; Pleistocene faunal extinctions.

Module – 2

Tools for Quaternary studies- application of stable isotopes of oxygen and carbon. Marine isotope stages in the Quaternary, biostratigraphy and magneto-stratigraphy. Paleoclimatic archives and Proxies for paleoenvironmental/ paleoclimatic changes. Various Archives of Quaternary history: tree rings (dendrochronology), corals, speleothems (cave deposits), peat deposits, ice cores, lake sediments, marine sediments, glaciers, fluvial deposits. The 'proxy indicators' for the reconstruction of Quaternary environments--geological, geochemical (major and trace elements), biological (microfossils, pollen), sedimentological, isotopic (oxygen, carbon and nitrogen isotopes) and magnetic proxies.

Module – 3

Quaternary dating methods – Radiocarbon chronology - other radiogenic clocks. Fission track and thermoluminescence dating methods. Planetary clocks. Quaternary Stratigraphy of India– continental records (fluvial, glacial, aeolian, palaeosols and duricrust); marine records.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Sirocko, F., Claussen, M., Goni, M.F.S. and Litt, T. (Eds., (2008): The Climate of Past Interglacials, Elsevier, 638p.
- Burrough, W.J.S. (2005): Climate Change in Prehistory, Cambridge University Press, 368p.
- Rapp, D. (2009): Ice Ages and Interglacial – Measurements, Interpretation and Models, Springer, 243p.
- Saltzman, B. (2002): Dynamical Paleoclimatolgy – Generalised Theory of Global Climate Change, Academic Press, 354p.
- Birks, H. J. B. and Birks, H. H. (1980): Quaternary Paleoecology, Edward Arnold, 369p.
- Battarbee, R.W. and Binney, H.A. edt. (2008), Natural Climate Variability and Global Warming – A Holocene Perspective, Wiley Blackwell, 354p.
- Bloom, A.J. (2010): Global Climate Change – Convergence of Disciplines, Sinauer Associates, 269p
- Bradley, R. S. (1999): Paleoclimatology – Reconstructing Climates of the Quaternary, Elsevier, 613p.
- Dawson A.G., (1992): Ice Age Earth: Late Quaternary Geology and Climate (Physical Environment), Routledge, 293p.
- Lowe, J.J. and Walker, M.J.C., (1997): Reconstructing Quaternary Environments Longman, 446p.
- Mathur, U.B., (2006): Quaternary Geology, Indian Perspective, Geological Society of India, Bangalore, Vol: 67, 344p.

Course Code	EGE 5008	Semester	Any
Course Title	Structural analyses		
Credits	3	Type	Elective

Course Description

Structural analyses designate investigations of geometric features in the rocks to elucidate large-scale structures and tell their history. The objective of this course is to introduce the fundamentals of structural analysis including kinematic and dynamic analytical techniques. Plate tectonics and its relationships with structural analysis will also be covered throughout. The important relationship of geologic time with deformational structures is covered within the context of various macroscopic and microscopic stuctures.

Course Outcome

By the end of the course, students are expected to be able to:

- learn to recognize and classify geologic structures associated with folding and fracturing of the lithosphere.
- understand the Fault movement analysis
- elucidate the meso- and micro-fabric elements associated with igneous and metamorphic processes
- introduced to structural analysis with computer software

Course Structure

Module - 1

Deformation: Translation – Rotation – Dilation – Distortion. Deformation and changes in length and angle. Rheology. Geological significance of displacements. Deformation mechanisms and processes: Cataclastic flow – pressure solution – intracrystalline deformation – recrystallisation – diffusion – grain boundary sliding.

.

Module – 2

Principles of displacement and strain. Homogeneous and heterogeneous strain. Finite strain theory. Stress-Strain diagrams. Factors affecting stress-strain relations. Concept of strain ellipse. Rapid methods of strain determination. Strain analysis- analysis of strain in linear, initially circular/spherical objects. Various methods of strain analysis. Strain partitioning. Strain in three dimensions. Simple and pure shear. Shear zones - geometry and classification. Shear indicators. Shear zone rocks - Mylonites and fragmental rocks produced by shearing. Shear sense indicators, Stress-strain relationships in different types of shear zones. Deep crustal fluids and shear zones. Shear zones of Southern India

Module – 3

Fabric development: Progressive deformation. Rotation, pressure solution, recrystallisation and plastic deformation of grains. Tectonites – S and L tectonites.Microfabric analysis – sampling techniques. Modern techniques in microstructural analysis – 4-axes Universal stage – X-ray texture goniometry – Transmission Electron Microscopy – SEM-EBSD. Fabric symmetry – Crystallographic Preferred Orientation – Lattice Preferred Orientation. Kinematic analysis.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Dennis, J.G. (1987), Structural Geology: an introduction, Wm.C.Brown Publishers, Dubuque, 437 p.
- Ramsay, J.G. (1967), Folding and fracturing of rocks, Mc. Graw Hill, New York, 563 p.
- Ramsay, J.G. and Huber, M. (1983), The techniques of modern structural geology, Academic Press, London, V.1, 305 p.
- Davis, G. H. (1984), Structural Geology of rocks and regions, John Wiley&Sons, New York, 492 p.
- Passchier, C.W. and Trouw, R. A. J. (1996), Microtectonics, Springer, Berlin, 289 p.
- Hancock, P. L. (1994), Continental Deformation, Pergamon Press, New York, 421 p.
- Marshak, S. and Mitra, G. (1988), Basic Methods of Structural Geology, Prentice Hall, New Jersey, 446 p.
- Ramsay, J. G. (1980), Shear Zone Geometry: a review, Jour. Struct. Geol., V.2, N.1/2, pp 83-99.
- Sibson, R. H. (1977), Fault Rocks and Fault Mechanisms, Jour. Geol. Soc., London, V.133, pp191-213 .

Course Code	EGE 5009	Semester	Any
Course Title	Planetary Science		
Credits	3	Type	Elective

Course Description

Planetary Geoscience, is a planetary science discipline concerned with the geology of the celestial bodies such as the planets and their moons, asteroids, comets, and meteorites. It studies objects ranging in size from micrometeoroids to gas giants, aiming to determine their composition, dynamics, formation, interrelations and history. This programme also includes such topics as determining the internal structure of the terrestrial planets, and also looks at planetary volcanism and surface processes such as impact craters, fluvial and aeolian processes

Course Outcome

By the end of the course, students are expected to be able to:

- To understand the geology of the celestial bodies such as the planets and their moons, asteroids, comets, and meteorites.
- To have a better knowledge including their composition, dynamics, formation, interrelations and history of a celestial objects ranging in size from micrometeoroids to gas giants
- Interpret the data concerning the internal structure of the terrestrial planets, and also looks at planetary volcanism and surface processes such as impact craters, fluvial and aeolian processes.

Course Structure

Module - 1

Milky Way and the solar system. Modern theories on the origin of solar system: condensation and accretion of planets and other planetary bodies. Members of the solar system. The Sun-Planetary and Orbital characteristics. General characteristics of the terrestrial planets- crust, surface features, thermal history, volcanism.

Module – 2

Moon: The Earth-Moon System, General Physiography, Atmosphere, Tectonic features, Craters, Degradational features, History of the Moon and time scale, Lunar volcanism, Lunar rocks, soil and internal structure, Lunar phases and cycles, Lunar influence on Earth. Mars: Phobos and Dimos, Physiography, Atmosphere, Craters, Volcanism, Tectonism, Hydrology, Martian rocks and soils.

Module – 3

Meteorites: Chondrites, SNC meteorites, Refractory inclusions, Iron meteorites and Parent body cooling rates, meteorite chronology. Asteroids: Classification and composition, Surface features, Asteroid sources, Past asteroid impacts on the Earth. KT events – iridium anomaly, Comets and other Icy bodies. Planetary images, Digital and Analog studies of Martian, Lunar samples with those of Earth samples. Planetary missions. Lunar and Mars Missions. Chandrayan and Mangalyan. Exploring the planets and asteroids for minerals.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Condie, K.C. (2011): Earth as an evolving Planetary system, II edn. Elsevier, Amsterdam, 574p.
- Dalrymple, G.B. (1991): The Age of the Earth, Stanford University Press, California, 474p
- de Pater, I and Lissauer, J.J. (2010): Planetary Sciences, Cambridge University Press, 2nd Edition. 326p
- McBride, N and Gilmour, I (Eds) (2004): An introduction to the solar system, Cambridge University Press, 269p
- Seeds, M and Backman, D. (2010): The Solar System, Brooks/Cole, 7th Edition, 326p.

Course Code	EGE 5010	Semester	Any
Course Title	Oceanography and Marine Geology		
Credits	3	Type	Elective

Course Description

Oceanography is the study of all aspects of the ocean and covers a wide range of topics, from marine life and ecosystems to currents and waves, the movement of sediments, and seafloor geology. The program aims to give a broad outline of the geological evolution of the ocean basins, the methods employed to investigate the superficial and deep structural features of the sea bed and techniques used in the investigation of the marine geological environment. It also covers oceanographic expeditions, marine mineral resources and paleoceanographic reconstructions.

Course Outcome

By the end of the course, students are expected to be able to:

- Have a solid grounding in marine geology and understand the framework provided by plate Tectonics.
- Describe sediments found in different water depths and settings, and understand the sedimentary processes leading to their deposition. Describe the main geological and geophysical techniques for observing the seabed and sub-seabed.
- Understand the driving forces behind, consequences, and importance of sea-level changes in the geological record.
- Handling of marine and oceanographic instruments, Interpretation of oceanographic data like seismic data and SONAR data.
- Interpret the paleoceanography from marine sediments, importance of scientific expeditions and marine mineral resources and their potential importance.

Course Structure

Module - 1

Ocean floor: Morphologic and tectonic domains. Bathymetric features- Submarine Canyons, Mid-Ocean ridges and Trenches. Morphologic and tectonic domains of the Indian Ocean. Origin of ocean basins. Physico-chemical characteristics and chemistry of seawater: temperature, salinity, density, light transmission, sound transmission in seawater. Gases in seawater. Carbon dioxide and pH of seawater- ocean acidification. Instruments used in the study of seawater.

Module – 2

Offshore exploration techniques: Instruments and Measurements-Position fixing systems-GPS. Sampling devices - Grabs, Dredgers, Corers, Water Samplers. Various platforms for ocean studies. Tools for studying the ocean floor: Echo-sounding

methods, Side scan Sonar, Current meters, SCUBA diving-submersibles. Ocean floor drilling - JOIDES, DSDP, ODP, IODP.

Module – 3

Marine sediments: Distribution and geochronology of marine sediments. Eustatic changes of sea level and its effects. Calcite Compensation Depth (CCD). Turbidity currents and turbidites. World ocean circulation patterns— ocean water masses; role of ocean in deciding global climate. Paleoceanography, Paleoceanographic reconstructions based of microfossils. UN Convention on the Law of the Sea (UNCLOS)- EEZ-coastal zone environment and its protection - CRZ Act. Mineral resources of the ocean basins, factors controlling their distribution. Origin and distribution of polymetallic nodules.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Balkema, A.A. (2001): Descriptive Physical Oceanography, Balkema Publishers, Tokyo, 420p
- Beer, T (1997): Environmental Oceanography, CRC Press, New York, 402p
- Emery, K.O. and Skinner, B.J. (1977): Mineral Deposits of the Deep Ocean Floor. Marine Minerals (United States).22p
- Ghosh, A.K. and Mukhopadhyay, R. (1999): Mineral Wealth of the Ocean, Oxford & IBH Pub. Co., New Delhi, 260p
- Gross, G.M. (1967): Oceanography, Merril Physical Science Series. 150p
- Gross, G.M. (1995): Principles of Oceanography, VII edn., Prentice Hall, 240p.
- King, C.A.M. (1979): Introduction to Physical and Biological Oceanography, Edward Arnold, 373p.
- Lal, D.S. (2018): Climatology and Oceanography, Sharada Pustak Bhawan, Allahabad, 502p
- Pinet, P.R. (2000): Invitation to Oceanography, II edn., Jones & Bartlett.
- Qasim, S.Z. (1998): Glimpses of Indian Ocean, University Press.
- Qasim, S.Z. (1999): The Indian Ocean, Oxford & IBH Pub. Co., New Delhi.
- Shepard, F.P, (1963): Submarine Geology, II edn., Harper & Row.
- Siddhartha, K. (2013): Oceanography A Brief Introduction, Kitab Mahal, Allahabad.
- Sverdrup, H.V. et al. (1961): The Oceans, Asia Publishing House.
- Trujillo, A.P and Thurman, H.V. (2013): Essentials of Oceanography, Pearson, Boulevard.

Course Code	EGE 5011	Semester	Any
Course Title	Climatology		
Credits	3	Type	Elective

Course Description

Climatology is the study of the nature of the climate, the causes, and interpretations of its spatial variation and its association with biosphere.The course provides an overview of the physical processes responsible for determining global and regional climate, including radiative energy transfer, the atmospheric and surface energy balances, and the general atmospheric circulation. The course also deals with the components of the climatic system, precipitation and condensation mechanisms, climate change and its causes, and climate classification. Special emphasis will be given to high frequency internal climatic variability such as ENSO, IOD etc. etc. Some basic elements of meteorology is also covered in the course.

Course Outcome

By the end of the course, students are expected to be able to:

- Provide a reasoned account of weather and climates at different spatial scales - local, regional, and global.
- Explain the Earth's atmosphere characteristics and the role of each atmosphere layer.
- Comprehend general atmospheric circulation, the relevant theories and how the ocean and atmospheric circulation patterns redistribute heat and energy across the Earth.
- Understand the sensitivity of the Earth’s climate and its various feedback mechanisms
- Describe and explain the forms and exchanges of radiation and heat energy and discuss the laws related toEarth's radiation balance.
- Calculate adiabatic lapse rates and evaluate conditions of stability and instability in the atmosphere.
- Describe and explain natural and anthropogenic causes of climate change and the internal variability of climate.
- Understand global teleconnection indices (ENSO, NAO) and their role in weather forecasting.
- Read, evaluate, and discuss present climatic and weather phenomena taking place around the world.

Course Structure

Module - 1

Fundamental principles of climatology and meteorology. Scales and parameters of meteorology- pressure, wind, temperature, humidity, radiation. Atmosphere, its composition and structure. Radiation: Radiation laws, short wave and long wave

radiations, Albedo, Emissivity,Greenhouse effect, Radiation Budget of Earth. Latitudinal and seasonal variations of insolation, temperature, pressure.

Module – 2

Factors affecting wind motion. General circulation of the atmosphere: Hadley, Ferrel and Polar cells. Primary(tropical easterlies, westerlies, polar easterlies, jet streams), Secondary (monsoons andtropical cyclones) and Tertiary circulation system (periodic and non-periodic local winds). Coriolis Effect and geostrophic winds. Cloud classification.Process of condensation. Precipitation mechanisms: Bergeron process, coalescence process. Types of precipitation, artificial precipitation. Electric field in the atmosphere. Atmospheric equilibrium: stability and instability.

Module – 3

Climate change and variability:Causes and impacts of climate change.Forcing and feedback processes.Global warming and ozone layer depletion. High and low frequency variability:Madden–Julian oscillation (MJO), Quasi-biennial oscillation (QBO), North Atlantic oscillation (NAO), Indian Ocean Dipole (IOD), El Niño–Southern Oscillation (ENSO)Pacific decadal oscillation (PDO), Atlantic Multi-decadal oscillation (AMO). Sunspot cycles and its effect on Earth's climate. Climate types and distribution, Koppen'sclassification of climate. Basics of weather forecasting, hazardous weather elements like thunderstorms, duststorms, tornadoes.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Critchfield, H. J. (2009) General climatology, PHI Learning, New Delhi.
- Lal, D. S. (2011). Climatology, Sharda PustakBhavan.
- Lal, D. S. (2013) Climatology and Oceanography, Sharda PustakBhavan.
- Savindra Singh (2005). Climatology, PrayagPustakBhavan.
- Siddhartha, K. (2016). Climatology-Atmosphere, weather and climate. Kitab Mahal, New Delhi.
- Stringer, E. T. (1972). Foundations of Climatology, W.H.Freeman & Co Ltd.
- Burroughs, W.J. (2001) Climate change, A multidisciplinary Approach, Cambridge University Press.

Course Code	EGE 5012	Semester	Any
Course Title	Mineral Wealth of India		
Credits	3	Type	Elective

Course Description

The course Mineral Wealth of India aims to introduce the students to the various critical, strategic, and essential mineral deposits of India. It highlights the importance of the economic mineral deposits in the industrial and economic growth of the country. It also highlights the cause and importance of inequal distribution of the mineral resources in the country.

Course Outcome

By the end of the course, students are expected to be able to:

- Demonstrate mastery of the terminology of various economic mineral resources of India
- Demonstrate confidence and accuracy in identifying the types, grades and mineralogy of the important mineral deposits of India.
- Synthesis observations, evidence and theory to recognise and explain similarities and differences between various mineral deposits.
- Discuss with confidence the theories, principles and outstanding controversies related to mineral wealth of the country.

Course Structure

Module - 1

Comparison between Global and Indian mineral resources and reserves; Strategic, critical and essential minerals of India. State-wise share of mineral production in India.

Module - 2

Mineral Deposits of India: Iron ore deposits – Mineralogy, classification, grade, origin and distribution in India, BIF – BHQ, BMQ, Iron ore deposits especially of Kerala, Bihar, Orissa and Karnataka.

Types, grades, mineralogy, uses, origin and Indian occurrences of: Manganese ore deposits (especially of Bihar, Orissa); chromium ore deposits (especially of southern India), Bauxite deposits (classification based on origin and shape); and copper ore deposits (especially of Khetri and Malanjkhand). Origin and occurrence of Lead and Zinc, Mica, Gold, PGE, Diamond, Uranium and Thorium deposits.

Module - 3

Mineral Deposits of India. Placer deposits of Kerala – General geologic and geomorphic setting, Ilmenite and rutile, monazite, Zircon, Sillimanite, Garnet, origin of Chavara Placer deposits, silica sands.

Non-metallic deposits – Refractory minerals: acid refractories – silica – Clay Deposits: Origin and Mineralogy, china clay deposits of Kerala – Kyanite – Neutral refractories: chromite – graphite – asbestos – Basic refractories – Magnesite – dolomite. Minerals used in Fertilizer industry: phosphorite, apatite. Minerals used in Cement industry: limestone – gypsum. Minerals used in Chemical industry.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Banerjee (2001), Mineral Resources of India.
- Geological Survey of India (2009), Miscellaneous publication no. 30, part-xxii: Geology and mineral resources of India,152p
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- Ministry of Mines (2011), Report of the working group on mineral exploration & development (other than coal & lignite) for the 12th five year plan sub group – on survey and mineral exploration, 310p.
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- Prasad, U (2002), Economic Mineral Deposits, CBS Publishers, New Delhi.
- Soman, K. (2001), Geology of Kerala, Geol. Soc. of India, Bangalore, 335p.

Course Code	EGE 5013	Semester	Any
Course Title	Geostatistics		
Credits	3	Type	Elective

Course Description

Geostatistics is a professional skill development course that deals with the application of the statistics knowledge to solve the geological problems. The course aims to train the students in application of statistical principles to the geological problems involving huge data sets to arrive at simple solutions. The major application of geostatistics is found in the field of mineral exploration. An appropriate background in the branch of geostatistics helps the student of geology to secure a job in private sector companies working in the field of mineral exploration.

Course Outcome

By the end of the course, students are expected to be able to:

- Demonstrate mastery of the terminology of geostatistics
- Demonstrate confidence and accuracy in identifying applying the statistical principles to the problems related to geology.
- Discuss with confidence the theories and principles of geostatistics.
- Conceive, design, execute, critique, revise, document and present an original research project and an independent program related to the applications of geostatistics.

Course Structure

Module - 1

Introduction to statistics: sampling, data collection, random variables, probability, frequency function; Applications of statistical methods in earth sciences – quantification and prediction.

Univariate statistical methods, frequency analysis, simulation; Statistical distributions.

Module - 2

Stochastic modelling and forecasting – introduction, modelling, applications, spectral analysis; Concepts of regionalized variables and variogram modelling; Concepts of dispersion, extension and estimation variances.

Module - 3

Kriging variance and procedure, simple kriging; Introduction to advanced geostatistics; applications of computer programs for statistical calculations – open source statistical programs

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

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- Kitanidis, P.K., Introduction to Geostatistics, Cambridge University Press., pp.271.
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Course Code	EGE 5014	Semester	Any
Course Title	Physical Geology		
Credits	3	Type	Elective

Course Description

Physical geology is the branch of geology that deals with the aspects related to earth's structure, composition, physical properties, constituent rocks and minerals and surficial features. It is essentially a discipline that overlaps different branches of geology such as geophysics, geochemistry, mineralogy, petrology, structural geology and geomorphology. The course aims to give a fundamental understanding of our planet earth and the processes that shape our earth.

Course Outcome

By the end of the course, students are expected to be able to:

- Demonstrate mastery of the terminology of physical geology
- Understand the structure of the earth and the processes that resulted the structures
- Understand various structural features of the rock units
- Discuss with confidence the internal and external geological processes and the resultant landforms
- Understand the importance of geological resources.

Course Structure

Module - 1

Introduction to Earth systems. Earth's interior and geophysical properties – internal structure, isostasy, gravity measurements, magnetic field, geothermal gradient and heat flow. Sea floor – features, seamounts, guyots and aseismic ridges, reefs; age of the sea floor. Plate tectonics – history, plates and plate motion, causes for plate motion.

Module - 2

Mountain belts and the continental crust – characteristics, thickness and density of rocks, features of active mountain ranges; evolution of mountain belts; growth of continents. Geologic structures – tectonic forces at work, structures as a record of geologic past, folds and faults. Time and Geology – key to the past, relative time, numeric age, age of the Earth.

Module - 3

Internal geological processes – igneous and metamorphic. External geological processes - weathering and soil, soil mechanics, mass wasting; Action of wind, water, glaciers; Waves, beaches and coasts. Geologic resources.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%

End Semester Assessment – 60%

References

- Kearey, P., Klepeis, K. A., & Vine, F. J. (2009). Global tectonics. John Wiley & Sons, Sussex, UK, 482p.
- Tarbuck, E. J., Lutgens, F. K., Tasa, D., &Linneman, S. (2005). Earth: an introduction to physical geology. Upper Saddle River: Pearson/Prentice Hall; 912p.
- Skinner, B. J., Porter, S. C., Park, J. J., & Levin, H. L. (2004). Dynamic Earth: An introduction to physical geology, John Wiley & Son, New York, 570p.
- Plummer, C. C., McGeary, D., & Carlson, D. H. (2005). Physical Geology: Earth Revealed. 9th ed; McGraw-Hill Education, New York; 600p.
- Jain, S. (2014). Fundamentals of physical geology., Springer; New Delhi; 488p.
- Kolay, A.K. (2010), Soil Geology. Atlantic Publications; 256p.
- Thompson and Turk (1998) Introduction to physical geology, Saunders College Publishing, Orlando; 398p.
- Monroe J.S., Wicander R, Hazlett R (2007), Physical Geology: Exploring the Earth, 6th ed, Thomson Books, Belmont, USA; 725p.
- Fletcher C. (2014), Physical Geology: Science of the Earth; 2nd ed., John Wiley and Sons, USA; 704p.
- W. Kenneth Hamblin (1991), Introduction to Physical Geology, Macmillan Publishing Company. New York; 378p.

Course Code	EGE 5015	Semester	Any
Course Title	Geochemistry		
Credits	3	Type	Elective

Course Description

The course gives an introduction to fundamental geochemical tools and directions like aqueous geochemistry, trace element geochemistry and isotope geochemistry, and how these can be used to understand the formation of the elements and the solar system, the Earth´s geochemical composition and differentiation into different reservoirs, the age of rocks, global geochemical cycles, the surface environment, and chemical traces of early life.

Course Outcome

By the end of the course, students are expected to be able to:

- describe the composition of the Earth´s main geochemical reservoirs
- explain element fractionation and how this can be used to understand endogenous and exogenous geochemical processes
- describe how radiogenic isotope signatures can be used to trace the source of minerals, rocks and fluids

Course Structure

Module - 1

Elements in the Universe – Significance of element abundance, elements and nuclides, measuring cosmic and solar system abundances, spectral analysis, the composite abundance curve, cosmic element production. Meteorites – Classification andchemical analysis of meteorites.Elements in the solar system – Cosmo chemical classification, element fractionation in the solar system, evolution of the solar system and chemical evolution of the Earth.

Module - 2

Goldschmidt's geochemical classification of elements. Geochemistry of important elements: Alkalis, alkaline earths, hydrogen, aluminium, carbon, silicon, nitrogen, oxygen and sulphur.Distribution of elements in igneous, sedimentary and metamorphic rocks.

Module - 3

Basic principles in geochemistry: Geochemical environment, surficial and deep seated environment, geochemical cycle, geochemical dispersion, - primary and secondary dispersion, dispersion halos, geochemical mobility, geochemical reactions, association of elements, indicator elemens, pathfinder elements, patterns of geochemical distribution, background value, geochemical anomaly, significant and non-significant anomaly, threshold.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%

End Semester Assessment – 60%

References

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- Arthur, W., Hawkes, H.E. and Webb, J.S. (1979), Geochemistry in Mineral Exploration, Academic Press, USA, 657p.
- Mason, Brian, Moore and Carleton, B. (1982), Principles of geochemistry, John Wiley&Sons, New York, 344 p.
- Gill, R. (1989), Chemical Fundamentals of Geology, HarperCollins Publishers Ltd, UK, 292p.
- Holt, K.H.W. (1971), Geochemistry, Rinehart and Winston Inc, USA.
- Rankama, K. and Sahama, T.H.G. (1950), Geochemistry, Univ. Chicago press, 911p.
- Walther. J.V.(2010) Essentials of Geochemistry, Jones and Barlett Publishers, New Delhi. 797p.

Course Code	EGE 5016	Semester	I or II
Course Title	Any PG MOOCs from SWAYAM/NPTEL		
Credits	1-4	Type	Elective

Course Description

Under this category students are free to choose any SWAYAM/NPTEL courses with a minimum of one to maximum of four credits. Students are permitted to engage the MOOC's only in first or second semester. None credit courses will not be considered in grade card. In case of any credit deficiency due to MOOC courses, students have to manage the same by themselves. University is not responsible for any MOOC examinantion delay, hence it is encouraged only in first and second semesters.

NAAC assessment. In order to speed up research publications related to policy matters it is proposed to set up Centre for Policy Research and Governance in the University by giving additional charge to any one of the senior faculty members.

RESOLVED to set up a Centre for Policy Research and Governance in the University by giving additional charge to any one of the senior faculty members.

AC 20:07 Formulation of 4 year graduate course as per National Education Policy- 2020.

The Academic Council noted that as stipulated in the National Education Policy- 2020 University proposed to introduce 4 year graduate courses. Deans Committee has been authorized to prepare courses. Next year BS (Science and Technology) and BS (Informatics) are proposed to Introduce.

RESOLVED that two four-year multidisciplinary Bachelor's programmes with an option for multiple exits be started in the University. The courses may be BS (Data Science) and BS (Nano Science & Technology) and the exact name of the Degree Programmes shall be decided later. If a student exits the programme after Year 1: the student will receive a vocational certificate; Year 2: an Advanced Diploma; Year 3: Bachelor's degree; Year 4: Bachelor's degree with research.

AC 20:08 TO APPROVE the Minutes of the meeting of Board of Studies and Syllabus.

The Academic Council noted that the following Departments conducted their meetings of BoS for revision of syllabus:

(1.) **Dept. of Mathematics: -**

Approved the Minutes of the meeting of Board of Studies of Department of Mathematics held on 06.07.2020.

(2). **Dept. of Public Health and Community Medicine: -**

APPROVED the Minutes of the meeting of Board of Studies of Department of Public Health and Community Medicine held on 08.07.2020.

(3.) **Dept. of English and Comparative Literature:** -

The Academic Council noted that a meeting of Board of Studies Dept. of English and Comparative Literature was held on 07.07.2020, and the recommendation item No. 1 is against CBCS guidelines, hence the Vice-Chancellor rejected the recommendation of the BoS. However, Item No. 2 Film Appreciation Course (online) with three credits and two exit systems has been recommended to place before Academic Council for its consideration and approval.

APPROVED the Minutes of the meeting of Board of Studies of Dept. of English and Comparative Literature held on 07.07.2020 except the recommendation of Item No.1 as it is against CBCS guidelines.

(4.) **Dept. of Chemistry**

APPROVED the Minutes of the meeting of Board of Studies of Department of Chemistry held on 08.07.2020.

(5.) **Dept. of Computer Science**

APPROVED the Minutes of the A meeting of Board of Studies of Dept. of Computer Science held on 09.07.2020.

(6.) **Dept. of Law**

APPROVED the Minutes of the meeting of Board of Studies of Department of Law held on 18.08.2020.

(7.) **Dept. of Education**

APPROVED the Minutes of the meeting of Board of Studies of Department of Education held on 06.07.2020,

(8) Department of Geology

APPROVED the Minutes of the Board of Studies of Department of Geology held on 17.07.2020.

AC 20:09 TO CONSIDER starting of offline classes as per Academic Calendar 2020-2021.

The item deferred.

AC 20:10 TO CONSIDER the Proposal for Online Certificate and PG Diploma Course in Life Skills Education.

The Academic Council noted that Prof. (Dr.). M. N Mohamedunni Alias Musthafa, Dean, School of Education and Coordinator, Centre for Life Skill Education, submitted a proposal for an Online Certificate Course (6 months, 1 - Semester) and PG Diploma Course (12 months, 2- Semester)

Central University of Kerala

Established by the Parliament of India vide the Central University Act, 2009(No.25 of 2009)

Kasaragod, Kerala, India, 671123

DEPARTMENT OF GEOLOGY

No. CUK/GEO/BOS/MIN/2020/01 Dtd: 17/07/2020

Minutes of the 1st Meeting of the 2th Board of Studies in Geology held online at 10.00 a.m. on 17/07/2020

The Department of Geology, Central University of Kerala conducted the Board of Studies (BoS) meeting on 17th July, 2020. It was the first BoS meeting of the second Board of Studies. Due to the COVID-19 pandemic situation the meeting was conducted through online via Google Meet platform. The panel members included invited subject experts, Head of the Department, internal members and department faculties as special invitee. The attendees of the meeting were as follows: -

BoS Attendees:

Invited subject experts

- Prof. (Dr.) Rajneesh Bhutani, Professor, Department of Earth Sciences, Pondicherry University
- Prof. (Dr.) Rajesh Raghunath, Professor, Dept .of Geology, University of Kerala,
- Prof. (Dr.) Prakash Narasimha, K.N., Professor, Department of studies in Earth science, University of Mysore, Manasagangotri
- Dr. A. Anil Kumar, Director, Marine & Coastal Survey Division, Geological Survey of India, Manglaluru.

Internal members from the Central University of Kerala

- Dr. Pratheesh P., Chairperson of BoS, Assistant Professor and HOD (i/c), Dept. of Geology.
- Dr. Sijinkumar A.V., Assistant Professor, Dept. of Geology.
- Dr. Dr. S. Anbazhagi, Assistant Professor, Dept. of Environmental Science.

Special invitee from the Central University of Kerala

- Dr. Sandeep K., Assistant Professor, Dept. of Geology.
- Dr. Dr. Chandan Kumar B., Assistant Professor, Dept. of Geology.

The BoS meeting started with the welcome address by Dr. Pratheesh P., Head of the Department (i/c). Dr. Pratheesh P. gave a brief introduction of the Dept. of Geology as well as the objectives of the BoS. Thereafter, he welcomed all experts and faculty to the meeting, and briefed the agenda of BoS meeting.

The agenda for discussion in the BoS meeting was proposed by the Head of the Department. The main items discussed in the BoS are given below:

1. The inclusion of MOOC course in the syllabus of department of geology, central university of Kerala thereof.
2. Consider the eligibility criteria of a foreign student thereof.
3. The inclusion of the foreign students eligibility criteria for the admission of M.Sc. Geology Programme.
4. Any other matter permitted by the Chair.

The details of agenda-wise discussion and the final recommendation by the BoS are given below.

Agenda 1: The inclusion of MOOC course in the syllabus of department of geology, central university of Kerala thereof.

Dr. Pratheesh P. has explained the Faculty Council discussion regarding inclusion of MOOC course in the syllabus. Then Dr. Pratheesh P. invited the Board of Studies opinion.

Prof. Rajneesh Bhutani opined that MOOC from swayam and ePG Pathshala can be incorporated as an elective only and the faculty members of the department can lend a hand in the right course selection for the students. Prof. Rajesh Raghunath pointed that the department has to consider the credit transfer, credit inclusion, MOOC course timetable and examinations, before considering the course request from a student. Prof. Rajesh Raghunath also mentioned that the department has to restrict the number of MOOC courses as one or a maximum of two. Prof. Prakash Narasimha, K.N. has expressed his concerns over the applicability of MOOC courses in a field based subject like geology. Dr. A. Anil Kumar suggested that department has to encourage the students to avail some additional credits related to geology through the MOOC platform and the department faculty has to help the students in right course selection. Dr. S. Anbazhagi suggested that the faculty adviser can select a bunch of MOOC course suitable for students and can introduce the same. Prof. Rajneesh Bhutani also supported this suggestion.

Recommendation: Following a detailed discussion on the contents, the members approved the inclusion of MOOC courses from the swayam or ePG Pathshala in the Department of Geology, Central University of Kerala curriculum as an elective/ additional credit programme. The number of the elective courses through MOOC during the academic period will be restricted as one or a maximum of two. Department will encourage the students to acquire maximum additional credits through MOOC platform. Faculty advisor from the department will help the students to find suitable course and in course registration.

Agenda 2: Consider the eligibility criteria of a foreign student thereof.

Dr. Pratheesh P. has explained the background of the agenda

Prof. Rajneesh Bhutani pointed that the international candidate Mr. Jafar from Sudan, who applied for the admission has engaged the all prerequisite subjects in his BSc Honours degree, hence he may be permitted. Prof. Prakash Narasimha motioned that he engaged geology in his all semesters, hence he may be permitted. Prof. Rajesh Raghunath and Dr. A. Anil Kumar also supported that opinion.

Recommendation: After a small discussion on the agenda, the members unanimously approved the candidature of Mr. Jafar from Sudan for MSc Geology programme in Department of Geology Central University of Kerala.

Agenda 3: The inclusion of the foreign students eligibility criteria for the admission of M.Sc. Geology Programme.

Dr. Pratheesh P. has explained the requirement of the agenda 3 on the background of agenda 2. He also pointed that the degree names in foreign universities are highly diversified; hence it is difficult to consider a particular degree name as a typical eligibility criteria.

Prof. Rajneesh Bhutani suggested that, instead of providing some degree names in the eligibility criteria of foreign students, department can admit the students on the basis of prerequisite subjects mandatory for the MSc geology. Prof. Prakash Narasimha pointed that the university has to fix cretin eligibility criteria for the foreign students in their English language proficiency. In order to cope up with this, Prof. Rajesh Raghunath suggested, university can make a mandatory requirement of English medium teaching in the undergraduate level as one of

the eligibility criteria. Dr. A. Anil Kumar also supported the idea and suggested that the department should admit the foreign students who studied geology through an English medium in their undergraduate programme.

Recommendation: Following a detailed discussion on the contents, the members approved the eligibility criteria for foreign students as any BSc/ B.Sc Honours degree with Geology as a core paper (department will scrutinise the application for prerequisite mandatory subjects). A testimonial of English language proficiency is also required for fulfilling the admission.

After this, overall agenda discussed in the BoS were summarised by Dr. Pratheesh P. Thereafter, Dr. Sijinkumar A.V. offered the vote of thanks, which conluded the BoS meeting.

Dr. Pratheesh P.
Chairperson, Board of Studies in Geology
Head (i/c), Department of Geology
Central University of Kerala

केरळ केंद्रीय विश्वविद्यालय
Central University of Kerala

M.Sc. Geology

SCHEME AND SYLLABUS

2020

Title of the PG Programme : M.Sc. Geology

Programme structure

The PG programme is offered in four semesters and includes theory and practical classes, field training and a dissertation.

Duration of the Programme	**:**	4 semesters
Number of seats	**:**	40
Type of the programme	**:**	Regular
Eligibility for admission	**:**	B.Sc. Geology / B.Sc. Geology and Water Management/B.Sc. (Hons.) Geology with minimum 55% marks or equivalent grade in aggregate and in the concerned subject separately, from a recognized University (studied in 10+2+3 system). B.Sc. triple main programme with Geology as one of the main/major/core subject is also eligible. However, Geology should have equal or more weightage with respect to the other two main subjects. The student must have studied Geology in all the three years of B.Sc. Programme. The B.Sc. triple main programme with Geology as a subsidiary/ minor subject or having less weightage compared to other two main subjects is not eligible.
Admission	**:**	Through CUCET

CORE COURSES

I SEMESTER		Credits	Lecture hrs.	Lab hrs.	Field hrs.
EGE 5101	Geomorphology and Sedimentology	4	4		
EGE 5102	Structural Geology	4	4		
EGE 5103	Palaeontology and Stratigraphy	4	4		
EGE 5191	Lab 1: Structural Geology and Geological Field Mapping	3		4	2
EGE 5192	Lab 2: Sedimentology and Palaeontology	3	3		
	Elective	3	3		
II SEMESTER					
EGE 5201	Igneous and Metamorphic Petrology	4	4		
EGE 5202	Mineralogy and Geochemistry	4	4		
EGE 5291	Lab 3: Igneous and Metamorphic Petrology	3		6	
EGE 5292	Lab 4: Mineralogy and Crystallography	3		6	
	Elective	3	3		
	Elective	3	3		
III SEMESTER					
EGE 5301	Economic Geology	4	4		
EGE 5302	Hydrogeology	4	4		
EGE 5391	Lab 5: Ore Geology	3		6	
EGE 5392	Lab 6: Hydrogeology	3		6	
	Elective	3	3		
	Elective	3	3		
IV SEMESTER					
EGE 5490	Dissertation	8		4	12
EGE 5491	Field Geology	3			6

ELECTIVE COURSES

ELECTIVES		Credits
EGE 5001	Industrial Minerals and Gemstones	3
EGE 5002	Engineering Geology	3
EGE 5003	Geospatial Technology	3
EGE 5004	Coal and Petroleum Geology	3
EGE 5005	Environmental Geology and Natural Hazards	3
EGE 5006	Water Resource Management	3
EGE 5007	Isotope Geology	3
EGE 5008	Quaternary Geology	3
EGE 5009	Structural Analysis	3
EGE 5010	Planetary Geoscience	3
EGE 5011	Oceanography	3
EGE 5012	Climatology	3
EGE 5013	Mineral Wealth of India	3
EGE 5014	Geostatistics	3
EGE 5015	Physical Geology	3
EGE 50XX	Any PG MOOCs from SWAYAM	Any

Credit Distribution

Course	Semester-wise credits				Total credits
	I	II	III	IV	
Core	**18**	**14**	**14**	**11**	**57**
Elective	**3**	**6**	**6**	**-**	**15**
Total	**21**	**20**	**20**	**11**	**72**

EGE 5101. Geomorphology and Sedimentology (4 credits)

Unit – 1

Fundamental concepts in geomorphology. Different models for the Evolution of landscape: Davis, Penck, King, Hack. Hill slopes: slope elements, classification, models of slope evolution, slope movement and stability factors. Landforms in relation to climate, rock type, structure and tectonics. Fluvial Geomorphology: Erosional and depositional landforms of rivers. Drainage systems and patterns. Morphometric elements and parameters - morphometric analysis of drainage basins. Coastal geomorphology: Coastal erosional and depositional landforms.

Unit – 2

Geomorphic indicators of neotectonic movements: Stream channel morphological changes, drainage modifications, fault reactivation, uplift–subsidence pattern in coastal areas. Application of geomorphology in various fields of earth sciences, viz. Mineral prospecting, Hydrogeology, Civil Engineering. Geomorphology of India – Origin and evolution of Peninsular India, Extra-peninsular India and the Indo-Gangetic Plain.

Unit – 3

Textural parameters of clastic and non-clastic sediments. Grain size: classification and concept of grade scale. Grain size estimation: direct measurement, sieving and settling methods. Grain size parameters (statistical) and their applications. Grain shape and fabric. Sedimentary structures: Classification and origin. Different types of stratification, deformation structures, erosional structures, biogenic structures, sand dykes and sills: applications in paleo-environmental and paleocurrent studies.

Unit – 4

Mineralogy, classification and depositional environments of conglomerate, sandstone, limestone and mud rock. Diagenesis: processes and evidence in siliciclastic, carbonate and argillaceous rocks. Provenance of sediments. Depositional environments - marine, non-marine, and mixed depositional environments. The association of primary sedimentary structures and textural characteristics with depositional environments and settings. Concept of sedimentary facies, association models. Overview of sedimentary basins; Basin development and classification: Cratonic basins, Divergent margin basins, Convergent margin basins, Downwarp basins. Fore arc and back arc basins. Sedimentary basins of India.

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- Gary Nichols (2016) Sedimentology and Stratigraphy. Wiley India, 336p.
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- Selley, R. C. (2000) Applied Sedimentology, Academic Press, 523p.
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- Tucker, M.E. (1990): Carbonate Sedimentology, Blackwell Scientific Publication, 482p.

EGE 5102. Structural Geology (4 credits)

Unit - 1

Deformation. Components of deformation: Homogeneous and heterogeneous deformation. Ideal material behaviours. Rheology- Elastic, plastic and brittle deformation. Deformation at the microscale. Concept of stress: Stress tensor-Stress matrix. Concept of strain: Simple shear and pure shear, Mohr circles for strain. Stress and strain ellipsoids. Faults, Joints and Fractures - Brittle and shear failure. Mohr-Coulomb failure criteria. Deep fractures. Analysis of fractures. Fault geometry and nomenclature. Features of fault planes. Use of stress and strain ellipsoids in the study of faults and joints.

Unit- 2

Buckling- Biot-Ramberg theory of buckling. Folds - cylindrical, non-cylindrical and conical folds. Geometry and classification of cylindrical folds. Canoe fold and inverted canoe fold. Minor folds and their use in determining the major fold structure. Mechanics of folding. Fold classifications of Donath and Parker and Ramsay. Superposed folding. Fold interference patterns - dome and basin, mushroom and boomerang patterns and Ramsay's classification.

Unit - 3

Tectonites: classification, tectonic fabric. Foliation: axial-plane foliation and its origin, fracture cleavage, crenulation cleavage and transposed foliation. Foliations and folds. Use of axial plane foliation and fracture cleavage in the determination of major structures. Lineation - types, classification and origin.

Unit- 4

Geologic bodies and scale, structural co-ordinates. Spatial orientation of planar and linear fabrics. Fundamentals of geometric analysis. Measurement and recording of structural attitudes. Stereographic and equal area projections in structural geology. $\boldsymbol{\pi}$ and $\boldsymbol{\beta}$ diagrams. Geometric analysis of simple and complex structures on macroscopic scale. Geometric analysis of folds. Analysis of fractures and faults.

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EGE 5103. Palaeontology and Stratigraphy (4 credits)

Unit - 1

Life during the Precambrian, Diversification of life. Evolution of life during the Palaeozoic, Mesozoic and Cenozoic eras. Cambrian explosion. Fossil record and modes of evolution: Microevolution, Macroevolution and Tree of life. Theory of organic evolution and the factors in the Darwinian theory. Theory of Punctuated Equilibria. Origin of life: extra-terrestrial and terrestrial. Miller's experiment. Mass extinction and its causes. Use of fossils in palaeoclimatic, paleoecological and palaeogeographic studies. Major fossil discoveries from India.

Unit - 2

Micropalaeontology: scope and subdivisions - types, extraction of microfossils from sediments and sedimentary rocks. Foraminifera: their palaeoecology and application in

paleoclimate, paleoceanography and biostratigraphy. Radiolaria, Diatoms, Ostracoda, Pteropods, Cocolithophores, Stromatolites and Conodonts – morphology, classification and importance. Palynology: General morphology of spores and pollen and their applications. Palaeobotany: Plant life through geological ages. Gondwana plant fossils. Application of microfossils in petroleum exploration. General characteristics, geologic history, classification and evolution of Pisces, Amphibians, Reptiles, Birds and Mammals (Elephant, Horse and Human being). Human fossils from different parts of the world.

Unit – 3

Development of Stratigraphy: Contributions of the pioneers of Stratigraphy, Major incidents in the Earth's History. Stratotype: Unit, Boundary, Holo-, Hypo-, Para-, Neo-, Lecto- stratotypes. Requirements for stratotypes. Establishment of stratigraphic units: Procedures for the establishment and description of surface and subsurface stratigraphic units.

Lithostratigraphy: Procedures for establishing, extending and naming of Lithostratigraphic units. Revision of Lithostratigraphic units. Biostratigraphy: Significance of fossils, Nature of biostratigraphic units – Life communities and Death assemblages. Procedures for establishing and extending biostratigraphic units, Revision of biostratigraphic units. Chronostratigraphy: Formal and Informal chronostratigraphic units, Procedures for establishing and naming of chronostratigraphic units. Sequence Stratigraphy: Stratigraphic Architecture, Depositional systems and systems tracts, Sequence Boundaries. Fluvial, Lacustrine, Eolian, Marginal marine and Shallow Marine, Deltaic and Deep Marine siliciclastic Sequences.

Unit – 4

The concept of the Precambrian. Distinguishing features and classification of the Precambrian. The Problem of the base of the Cambrian. Precambrian stromatolites, their status as time markers and classification of the Late Proterozoic. Distribution of Precambrian rocks in India. Indian Standard stratigraphic column, hiatuses and breaks. Models for the evolution of Precambrian crust. Shields - cratons and mobile belts. Low-grade and high-grade terrains. Precambrian shield areas. Precambrians of southern India. Major Phanerozoic Basins in India: General description, age, development, evolution, stratigraphy and classification of the Gondwana, Kaveri, Kerala and Cambay Basins. Paleogeography and major events during different periods. Age problems in stratigraphy.

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EGE 5191. Lab 1: Structural Geology and Geological Field Mapping (3 credits)

Unit- 1

Preparation and interpretation of geological maps and sections. Structural problems. Recording and plotting of field data. Study of deformation structures in hand specimen. Study of dip isogons from fold profiles.

Unit- 2

Stereographic projection in structural analysis. Application of stereographic projection in solving structural problems. Beta diagram and Pi diagram. Solving problems relating to faults and shear zones.

Unit- 3

Topo sheets: Map scales, features in toposheet, finding the coordinates of points. Surveying - Chain Survey- Plane Table Survey – Leveling- Dumpy Level surveying, Total Station and GPS surveys. Geological field visit and mapping of litho-units in igneous, metamorphic and sedimentary terrains. Identification and Mapping of Faults, folds, foliations, cleavages, lineations, joints and shear zones.

References

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- Ramsay, J.G. (1967) Folding and fracturing of rocks. Mc Graw Hill, 586p.

EGE 5192. Lab 2: Sedimentology and Paleontology (3 credits)

Unit- 1

Sieve analysis, plotting and interpretation of data (Trask method & Folk and Ward method). Estimation of statistical parameters - mean, skewness, kurtosis and standard deviation (sorting). Pipette analysis and estimation of clay content. Plotting of gravel-sand-mud and sand-silt-clay data in triangular coordinate sheets.

Unit- 2

Study and description of hand specimens and thin sections of conglomerate, breccia, sandstone, limestone, mudstone and shale.

Separation of heavy and light minerals from sediments. Preparation of grain mounts and mineral identification

Unit- 3

Sample processing techniques and separation of microfossils from matrix and marine sediments.

Identification of the following types of microfossils (calcareous and siliceous):

Planktonic foraminifera, Benthic foraminifera, Ostracods, Pteropods and Radiolaria.

Identification and separation of important species of planktonic foraminifera.

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EGE 5201. Igneous and Metamorphic Petrology (4 credits)

Unit - 1

Thermodynamics – elementary concepts, stability phase diagrams; thermodynamics of solutions, applications; kinetics. Phase rule and diagrams, phase relations, crystal melt equilibria; Binary, Ternary and Quaternary systems. geothermometry and geobarometry.

Unit - 2

Igneous processes and diversity in igneous rocks. Compositional variation in magmas. Variation diagrams – binary and ternary diagrams. Trace elements in igneous processes – melting and crystallization models – application of trace elements to petrogenesis. Radiogenic tracers. Classification of igneous rocks. Granite and granitic rocks. Ultramafic rocks. Alkaline rocks. Kimberlite and ultrapotassic rocks. Anorthosite and carbonatite. Plume magmatism and hot spots - Large Igneous Provinces and dyke swarms. Taphrogenic intrusives of Kerala.

Unit - 3

Concepts of metamorphism, Role of fluids, Metamorphic structures and textures, Metamorphic reactions; Metamorphic zones, grades, facies, facies-series.

Unit - 4

Metamorphic differentiation; Metamorphism and plate tectonics; Ultra-High Temperature (UHT) and Ultra-high Pressure (UHP) metamorphism. General characteristics of metamorphic domains – contact metamorphism, regional metamorphism; Paired metamorphic belts; Orogeny and Metamorphism; Retrograde metamorphism. Migmatites.

References

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- Ehlers, E. G. and Blatt, H. (1981), Petrology, CBS Publishers and Distributors, New Delhi, 732 p.
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EGE 5202. Mineralogy and Geochemistry (4 credits)

Unit- 1

Optical properties of minerals: some physical background, refractive index and petrographic microscope, isotropic and anisotropic minerals, polarization and birefringence, optical indicatrix, dispersion, pleochroism. Identification of minerals using a petrographic microscope.

Unit- 2

Mineral genesis: mineral-forming environments, mineral crystallization and deposit types, multi-stage processes, generations and paragenesis, crystal growth, typomorphism of minerals.
Application of modern techniques in mineral studies - XRD, DTA, XRF, ICP, EPMA.

Unit- 3

Origin and cosmic abundance of elements. Geochemical and cosmo-chemical classification of elements. Primary differentiation of elements: Distribution and behaviour of major, trace and Rare Earth Elements (REE's) in igneous, sedimentary and metamorphic environments. Geochemistry of the Earth's crust, mantle and core. Geochemistry of meteorites. Evolution of the solar system and chemical evolution of the Earth.

Unit- 4

Geochemical Cycle. Mobility of elements, Isomorphism, polymorphism and atomic substitution. Basic principles in geochemical exploration: Geochemical environment, surficial and deep-seated environment, geochemical dispersion, - primary and secondary dispersion, association of

elements, indicator elements, geochemical anomaly. Analytical techniques: Methods using Flame photometer, Spectrophotometer, Atomic Absorption Spectrometer, XRF, ICP-MS/AES.

References

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- Philips, F.C., 1963, Introduction to Crystallography, Thomas Nelson.
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EGE 5291. Lab 3: Igneous and Metamorphic Petrology (3 credits)

Unit- 1

Preparation of binary phase diagrams. Megascopic and microscopic identification of igneous rocks. Normative mineralogical calculations of acid, intermediate, basic and ultrabasic rocks (3 each).

Unit- 2

Preparation of variation diagrams: Harkar, Larsen, Nockold and Allen, Niggli calculation of Fractionation Indices: Larsen Index, Nockolds Index, Mafic Index(MI), Mg-Number, Solidification Index, Felsic Index, Differentiation Index. Spider Diagram.

Unit- 3

Study of metamorphic rocks in hand specimen. Preparation of metamorphic rock thin sections. Study of metamorphic rocks in thin sections: metamorphic mineral assemblages, structures and textures, grain boundary relations, strain effects.

Plotting and interpretation of chemical data on ACF, AKF diagrams, Schreinmaker's rule and construction of petrogenetic grids.

References

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EGE 5292. Lab 4: Mineralogy and Crystallography (3 credits)

Unit- 1

Determination of extinction angle, pleochroism; Determination of birefringence – using Michel Levy's chart and Berek's compensator; Determination of interference figure; Determination of optic sign.

Unit- 2

Study of optical characters of the following minerals/mineral groups: olivine, epidote, almandine, pyroxene, amphibole, mica, feldspar and feldspathoid.

Unit- 2

Crystallography - crystalline state - Lattices- Point, Line, Space. Zone and determination of Zone symbols, determination of Axial Ratio and Napier's Rule.
Crystal systems- Symmetry elements of normal (holohedral) classes.
Crystal projection – Spherical projection of cube, octahedron and dodecahedron. Stereographic projection of normal class of Isometric, Tetragonal and Hexagonal systems.

References

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EGE 5301. Economic Geology

Unit – 1

Mineral resource crisis, factors controlling mineral availability, minerals and global economic patterns, future of ore deposit geology; Geology of ore deposits – classification and deposit models. Textures of ore and gangue minerals; Paragenesis, zoning; Magmatic ore deposits; Hydrothermal ore deposits – magmatic and orogenic environments, sedimentary environments; Ore deposits formed in sedimentary environments; Supergene ores and supergene overprinting of ores.

Unit – 2

Mineral law and land access: National Mineral Policy – MM (R & D) Act, 1957 – procedures for grant of mineral concessions in India; Types of land and mineral ownership in different countries; Exploration versus exploitation concessions. Mineral Economics: History and structure of the mineral industry; Profits in the mineral industry; Mineral taxation and mineral profits; Mineral commodity prices; Distribution of profits. Law of the Sea Treaty – marine mineral resources.

Unit – 3

Mineral resources and exploration; search for ore deposits and chances of success – geological, geochemical, geophysical, drilling, sampling and other field techniques; Remote sensing applications in mineral exploration; Surveying and exploration; statistical treatment of exploration data and computer applications.

Unit -4

Mining terminology; Appraisal of exploration data for mining; Mine planning and development; Life cycle assessment (LCA) method; Open-cast mining methods; Underground mining methods; Alluvial mining and quarrying.
Mine hazard and safety works; Mine monitoring; Mine reclamation.

References

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EGE 5302. Hydrogeology

Unit – 1

Definitions of and differences between - Hydrology, Hydrogeology, and Groundwater hydrology. Hydrologic cycle and processes – Precipitation, Evaporation and transpiration, Runoff, infiltration. Water balance. Origin and types of waters – meteoric, juvenile, magmatic and metamorphic. Groundwater storage –Aquifer, Aquiclude, Aquifuge and Aquitard. Types of aquifers – Confined, Unconfined, Bounded aquifers, Sloping Piezometric and Phreatic aquifers. Springs.

Hydrological properties of rocks – Porosity, Permeability, Void ratio, Specific yield and Specific retention, Hydraulic conductivity, Transmissivity and Storativity. Elastcity of aquifers, barometric efficiency and barometric tidal efficiency. Geological fame work in

relation to hydrogeological environment: Rock types and distribution, rock matrix, factures, weathered rocks and superficial materials.

Unit – 2

Groundwater flow - Water table and Piezometric surface - Flow characteristics of water – Head distribution, Laminar and turbulent flow. Darcy's law and its experimental verification. Flow through aquifers. Hydrological boundaries, flow nets. Groundwater tracers. Well hydraulics: Aquifer tests, organization and conduct of pumping tests, data analysis of pumping test, Recovery test, drawdown, cone of depression and cone of impression, Steady radial flow to a well in confined and unconfined aquifers – Thiem's equation and Dupuit-Forhemeir equation. Unsteady radial flow to a well in confined and unconfined aquifers – Theis equation – Theis, Chow and Cooper-Jacob methods – Isotropic non-leaky artesian aquifers.

Unit – 3

Groundwater exploration: Geological and Hydrological methods, Surface investigations of groundwater - Geophysical methods, Electrical Resistivity methods – Wenner and Schlumberger methods, Seismic refraction methods, Gravity and magnetic methods. Application of remote sensing and GIS in groundwater exploration.

Unit – 4

Water well designing - Types and mode of construction – Methods of deep well drilling-construction design – development and maintenance of wells.

Quality of Groundwater: Chemical quality- Different chemical parameters and their analysis, – Sodium Adsorption Ratio (SAR) – Water quality standard for different purposes – Drinking, Domestic, Irrigation and Industrial.

Threats to groundwater quality and reserve: Saline water intrusion in coastal and other aquifers and its prevention – Ghyben-Herzberg relationship. Artificial recharge and rain water harvesting methods.

References

- Bouwer,H. (1978) Groundwater Hydrology. McGraw Hill Education, 480p.
- Davis,S.N. and Dewiest, R.J.N. (1966). Hydrogeology, John Wiley and Sons Inc. New York, 463p.
- Karanth.K.R.(1987). Groundwater Assessment Development and Management, Tata McGraw Hill, 720p.
- Linsley, R.K, Kohler, M.A. and Taulhus, J.L.H. (1975) Applied Hydrology, Tata McGraw Hill, 689p.
- Todd, D.K. (1980) Groundwater Hydrology, John Wiley and Sons, 552p.
- Walton,W.C. (1970) Groundwater Resource Evaluation, McGraw Hill Inc, 664p.
- Reghunath, H.M. (1992) Groundwater. 2nd Edn.Wiley Eastern Limited, 456p.
- Fetter, C.W. (2007) Applied Hydrogeology. Pearson, 624p.

EGE 5391. Lab 5: Ore Geology

Unit- 1

Megascopic study and identification of ore minerals. Preparation and study of polished sections. Gravity, magnetic, seismic and electrical resistivity exploration problems.

Unit- 2
Preparation of litho logs using exploration data. Calculation of grade, tonnage and cut-off grade. Ore reserve estimation.

Unit- 3
Fundamentals of ore dressing: Crushing, grinding, sizing, concentration by washing, scrubbing, jigging, tabling, floatation. Magnetic and Electrostatic separation. Flow-charts of mineral separation.

References

- Arogyaswamy, R.N.P. (1980) Courses in Mining Geology, 2nd Ed., Oxford & IBH Pub. Co., New Delhi
- Banerjee (2001) Mineral Resources of India.
- Banerjee, P.K and Ghosh, S. (1997) Elements of Prospecting for Non-fuel Mineral Deposits, Allied Publishers Pvt Ltd, 320p.
- Kearey, P. and Brooks,M. (1991) An Introduction to geophysical Exploration, Blackwell scientific Publications, Musset, 272p.
- Mckinstry, H.E. (1947) Mining Geology, 1st Indian Ed., Asia Publishing House, New Delhi.
- Prasad, U (2002) Economic Mineral Deposits, CBS Publishers, New Delhi.
- Sinha, R.K and Sharma, N.L. (1970), Mineral Economics, New Delhi Oxford and IBH Pub.co., 317p.

EGE 5392. Lab 6: Hydrogeology

Unit- 1
Identification and demarcation of watershed boundaries, Collection and interpretation of well inventory data, Determination of groundwater flow direction, Preparation of water table contour map.

Unit- 2
Estimation of permeability. Analysis of hydrographs and estimation of infiltration capacity. Pumping test – Time, Drawdown and time recovery tests. Evaluation of aquifer parameters, Study of depth and yield of bore wells.

Unit- 3
Study of Electric resistivity sounding data for delineation of fresh and saline aquifers. Study of geophysical well logs. Exercises on groundwater exploration using remote sensing techniques. Preparation of ground water potential maps.
Graphical representation of water quality data: various diagrammatic representations – interpretation of hydrochemical data – Hill-Piper Trilinear diagram, Durov's diagram and U.S. Salinity diagram.

References

- Bouwer, H. (1978) Groundwater Hydrology. McGraw Hill Education, 480p.
- Davis, S. N. and R. J. M. Dewiest R. J. M. (1966). Hydrogeology. 463p.

- Karanth.K.R.(1987). Groundwater Assessment Development and Management, Tata McGraw Hill, 720p.
- Patric, A.D., Franklin W.S. (1997) Physical and chemical hydrogeology, ohn Wiley & Sons; 2nd edition, 528p.
- Poehis D.J and Gregory J.S. (2011). Encyclopedic dictionary of Hydrogeology, Academic press, 528p.
- Reghunath, H.M. (1992) Groundwater. 2nd Edn.Wiley Eastern Limited, 456p.
- Fetter, C.W. (2007). Applied Hydrogeology. CBS Publishers & Distributors.

EGE 5490. Dissertation (8 credits)

Independent project work including field and laboratory investigations of geological significance. Preparation and presentation of Dissertation will be in the fourth semester although the work related to the dissertation can be initiated in the third semester itself. The Dissertation entails fieldwork, lab investigations, preparation of report, its presentation and viva voce.

It will have the following components**:**
(a) Literature review and origin of the research problem
(b) Objective/s and Methodology
(c) Observations and the data **recorded by the candidate**.
(d) Details of laboratory investigations,
(e) Synthesis of results and interpretation
(f) Concluding remarks and future direction.

Project work shall be carried out under the supervision of a teacher in the parent department. The candidate may be permitted to work on the project in an industrial / research organization on the recommendation of the supervising teacher and the Head of the Department. In such cases, a teacher from the parent department would be the supervisor/ internal guide and an expert from the industry/ research organization the co-supervisor/ external guide. Every student has to do the dissertation work independently. The project title, content and layout should be unique. The project reports of students should not be identical in content.

EGE 5491. Field Geology (3 credits)

Unit -1

Principles of geological field studies and mapping. Preparations for field studies and mapping. Selecting and preparing a base map. Field equipment. Geological symbols and notations. Lithological and structural mapping. Identification and recording of rock types and structures in the field. Locating points in the field. Measurement and recording of field data. Finding and tracing the contacts between rock units, correlating geologic units, mapping geologic structures, outcrop maps, —locating field data and geologic features in the map.

Unit- 2

Locating points in the field. Measurement and recording of field data. Finding and tracing the contacts between rock units, correlating geologic units, mapping geologic structures, outcrop maps, —locating field data and geologic features in the map.

Unit- 3

Preparing final geological map and reports: Report writing, major illustrations, photographs, drawings, diagrams, designing the report, format and specific parts of the report.
Field studies in terrains of geological significance and preparation of reports.

References

- Richard J. Lisle, Peter Brabham and John W. Barnes (2011). Basic Geological Mapping (Geological Field Guide). Revised 5th Edition. Wiley-Blackwell.
- Angela L. Coe (2010). Geological Field Techniques. 1st Edition. Wiley-Blackwell. 336p.
- Lahee, F.H. (2002). Field Geology. 6th Edition, CBS Publishers.

ELECTIVE COURSES

EGE 5001. Industrial Minerals and Gemstones (3 credits)

Unit – 1

Industrial Minerals - Mode of occurrence - Uses and distribution in India - Ceramic minerals, Granite and Building stones, Cement - Raw materials - Mineral pigments - Refractory and abrasive minerals - Fertilizer minerals- Diamond - Gemstones, Asbestos, Mica, Vermiculite, Barite, Talc, Glass, Sand and Fullers earth.

Unit – 2

Introduction to Gems – Precious and Semiprecious stones and their economic importance. General characteristics and chemical composition of gemstones. Physical characteristics: Form, cleavage, fracture, hardness and specific gravity; Optical characteristics: colour, lustre, refractive index, reflectivity, pleochroism, and dispersion.
Introduction to special optical properties of gemstones: Chatoyancy, Asterism, Luminescence, Play of colours, Labradorescence, Inclusions.
Formation of gemstones. Qualities and Classification of gem materials

Unit – 3

Gem Testing- Refractometers, Polariscope, Dichroscope, Ultra-violet lamps. Principles and Uses. Application of ultra-violet rays, X-rays and Infra-red rays in gem identification. Electrical, thermal and magnetic characters of gemstones. Methods of determination of specific gravity. Distinction between synthetic and natural gemstones. Gem enhancement methods: Polishing, Carving and engraving, colourless/coloured impregnation, heat treatment, coating, irradiation, diffusion, treatment etc. Utility of gemstones: (1) Technical applications and (2) Use as jewels. Occurrence of gems in India. Gem Industry in India.

References

- Anderson B. (2014). Gem Testing, Sutton Press.
- Babu T. M. (1998). Diamonds in India, Geological Society of India, Bangalore.
- Bates, (1969). Geology of Industrial Rocks and Minerals, Dover book earthsciences.
- Baumgart, W., Dunham A.C., and Amstutz, G.C. (1985). Process Mineralogy of Ceramic Materials. Elsevier Science Ltd.
- Cally Hall (1994). Gemstones, Dorling Kindersley.
- Deb, S. (1980). Industrial Minerals and Rocks of India, Allied Publishers (P) Ltd.

- Karanth, R.V. (2000). Gems and Gem Industry in India, Geological Society of India.
- Krishnasamy, S. (1972). India's Mineral Resources, Oxford and IBH Publishers.
- Taggart, A.P. Hand book of Mineral dressing, John Wiley & Sons Inc., 1905p.

EGE 5002. Engineering Geology (3 credits)

Unit – 1

Physical and engineering properties of rocks – bulk density, unit weight, specific gravity, porosity, dry and saturated unit weights; Rock deformation and mechanical properties – Hooke's law, volumetric strain, elastic moduli, compressive, tensile and shear strength, stresses. Principal geological factors affecting engineering projects – Earth movements, stability of slopes and cuttings, groundwater, volcanoes, earthquakes; Geological materials used in construction.

Unit – 2

Geological considerations in engineering projects such as dams, reservoirs and tunnels. Various types of support, Geological consideration in the selection of dam site and reservoir, transportation routes - Bridges and highways. Methods of tunnelling; Classification of ground for tunnelling purposes;

Unit – 3

Mass Movements with special emphasis on landslide and causes of hill slope instability. Classification of landslides. Geological investigation of landslides. Landslide hazard zonation mapping using remote sensing, GIS-subjective, and objective rating techniques – mitigation measures. Aseismic design of buildings; influence of geological conditions on foundation and design of buildings. Earthquake-resistant structures. Seismicity in India and seismic zonation maps.

References

- Arogyaswamy, R.N.P (2017). Courses in Mining Geology. Oxford and IBH Publishers, 735p.
- Hartman H. L. and Mutmansky, J.M. (2002). Introductory mining Engineering, John Wiley and Sons Inc.
- Gaudin, A .M. (1938) Principles of Mineral Dressing, McGraw Hill, 554p.
- Petters, W.C. (1987) Exploration and Mining Geology. John Wiley, 706p.
- Reedman, J.H. (1979) Techniques in mineral exploration, Allied Scientific Publishers, 534p.
- Bell, F.G. (1983) Fundamentals of Engineering Geology. Butterworth-Heinemann, 656p.
- Coduto, D.P. (2001) Geotechnical Engineering –Principles and Practices. Prentice Hall of India, Pvt Ltd, New Delhi.
- Duggal, S.K. Pandey, H.K. and Rawal, N. (2014) Engineering Geology, McGraw Hill Education (India) Pvt. Ltd.
- Lee. F. and Griffiths (2007). Engineering Geomorphology, Whittles publishing, 288p.
- Krynine, D.P. and Judd, W.R. (2001) Principles of engineering geology and Geotectonics, CBS Publishers and Distributers, New Delhi.

EGE 5003. Geospatial Technology (3 credits)

Unit – 1

Concepts and foundation of remote sensing: energy sources and radiation principles, energy interactions in the atmosphere, energy interaction with earth surface features – Spectral Reflectance - Spectral Response Patterns - data acquisition and interpretation, reference data – elements of photographic system - Introduction to aerial photographs and aerial photo interpretation. Binocular-Mirror-pocket Stereoscopes. Photogrammetric problems.
Introduction to remote sensing- land use-land cover mapping-NDVI. Applications of remote sensing in Geology, Natural resource management, Water resources management; Disaster management and Environmental management.

Unit – 2

Photogrammetry: basic principles – geometric characteristics of aerial photographs - visual image interpretation – stereoscopes –photogrammetric workstations – landform identification and evaluation. Applications of photogrammetry in Geology, Natural resource management, and Urban planning and management.
Geodesy: Ellipsoid – Geoid. Datums – datum shift, datum transformation. Geographic coordinates. Cartesian coordinates. Coordinate conversions. Map projections. Global Positioning System: Basic features, GNSS, NAVSTAR GPS, GLONASS, IRNASS.

Unit – 3

Fundamentals of Geographic Information System – data input, data management, data manipulation, data output. Data Input and Editing: Coordinate Conversion. Digitizing, data encoding, re-projection and transformation. Vector and Raster data analysis. Interpolation and overlay techniques. Preparation and layout of maps. Query analysis. Familiarization of different GIS environments including proprietary and open source such as ArcGIS, QGIS and GRASS. Introduction to Web GIS –Definition- concept-components. Applications of GIS in Geology, Natural resource management, mapping, Urban planning, Water resources management; Disaster management; Environmental management and public health.

References

- Campbell, J. B.and Wynne, R. H. (2008), Introduction to Remote Sensing, Fifth Edition, The Guilford Press, New York, 718p.
- Falkner, E. and Morgan D. (2002), Aerial Mapping: Methods and Applications, Lewis Publishers, Boca Raton, 192p.
- Lillesand, T.M., Kiefer,R.W. and Chipman, J.W. (2004), Remote sensing and image interpretation, Fifth Edition, Wiley, NJ, 812p.
- Mather, P.M. and Koch, M. (2011),Computer Processing of Remotely-Sensed Images – An Introduction, Fourth Edition, John Wiley, New York, 462p.
- McCoy, R. M. (2005), Field methods in remote sensing, Guilford Press, New York, 177p.
- DeMers, M. N. (2009), GIS for dummies, Wiley, NJ, 388p.
- Iliffe, J. (2000), Datums and Map Projections for remote sensing, GIS, and surveying, Whittles Publishing, Scotland, 159p.
- Konecny, G. (2003), Geoinformation: Remote sensing, photogrammetry and geographic information systems, Taylor& Francis, London, 266p.
- Shekar, S., Xiong, H. eds. (2008), Encyclopaedia of GIS, Springer-Verlag, New York, 1392p.
- Sickle, J. V. (2010), Basic GIS Coordinates, CRC Press, FL, 190p.

- Verbyla, D. L. (2003), Practical GIS analysis, Taylor & Francis, London, 305p.
- Jensen, J.R., (2000). Remote Sensing of the Environment an Earth Resource Perspective. New Jersey: Prentice Hall, Inc, 608p.
- Jensen, J.R., (2005). Introductory Digital Image Processing: A Remote Sensing Perspective. 3rd ed. Upper Saddle River, NJ: Pearson Prentice Hall, 544p.
- G.L. Prost (2002). Remote sensing for Geologists: A guide to image interpretations. CRC Press, 326p.
- Floyd F. Sabins (1997) Remote Sensing: Principles and interpretations.WH Freeman & Company, 494p.
- P. A. Burrough, Mcdonnell R A (1998). Principles of geographical information systems. Oxford university press, 332p.

EGE 5004. Coal and Petroleum Geology (3 credits)

Unit – 1

Origin of coal: accumulation of vegetative matter - *in situ* and drift theories; stages of formation of coal.. Classification, Ranks and Grading of coal.

Petrography of coal: lithotypes, macerals and microlithotypes. Coal-bed Methane as an energy resource. Physical and chemical characteristics of coal. Geological and geographical distribution of coal deposits in India.

Unit – 2

Origin of petroleum- organic and inorganic theories. Transformation of organic matter into petroleum; Kerogen, transformation and maturation of kerogen. Primary and secondary migration of oil and gas. Reservoir rocks: classification and characteristics; Structural traps, stratigraphic traps and combination traps for oil and gas accumulation.

Unit – 3

Global distribution of oil and gas through geologic ages. Petroliferous basins of India. Geological setting of major oil and natural gas fields of India. The surface indications and direct detection of hydrocarbons. Introduction to the oil belts of the world. An outline of well-site geological techniques and exploration techniques. Introduction to basin analysis.

Gas hydrate and shale gas – origin and extraction.

References

- Deshpande B. G. (1992) The world of petroleum. New Age International, 260p.
- Levorson A. I. (2004) Geology of Petroleum. CBS Publishers and Distributors Pvt Ltd, 260p.
- North F. K. (1985) Petroleum Geology. Alllen&Unwin, Boston, 607p.
- Chandra, D., Singh, R.M. Singh, M.P. (2000): Textbook of Coal (Indian context), Tara Book Agency, Varanasi, 402p.
- Scott, A.C. (1987) Coal and coal-bearing strata: Recent Advances and future prospects, Geological Society, London, Special Publications, 32p.
- Singh, M.P. (1998) Coal and Organic Petrology, Hindustan Publishing Corporation, New Delhi, 128p.

- Stach, E., Mackowsky, M-Th., Taylor, G.H., Chandra, D., Teichumullelr, M. and Teichmuller R. (1982): Stach's Texbook of Coal petrology, GebruderBorntraeger, Stuttgart, 535p.
- Thomas L. (2002) Coal Geology, John Wiley and Sons Ltd., England, 384p.
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- Acharyya S.K. (2000) Coal and Lignite Resources of India-An Overview. Geol. Soc. of India, 50p.
- Tissot, B.P and Welte, D.H (2003). Petroleum formation and Occurrence. Springer-Verlag, 699p.
- Selley, R.C (1999) Elements of Petroleum Geology. Academic press, 470p.
- Milton B. Dobrin & Carl H. Savit (1988). Introduction to Geophysical prospecting, McGraw-Hill, 867p.
- Gupta, P. K. and Nandi, P. K. (1995). Wellsite Geological Techniques and Formation Evaluation: A user's manual, Vol. Oil and Natural Gas Corporation, Dehradun.
- Ransom, R.C. (1995) Practical Formation Evaluation, John Wiley and Sons, 490p.
- Rider, M.H. (1985) The Geological Interpretation of Well Logs, Blackie, London, 280p.

EGE 5005. Environmental Geology and Disaster Management (3 credits)

Unit – 1

Our environment - an introduction. Fundamental concepts of environmental geology, History of environmental degradation.

Land-use and its Management – Land as a Resource, Spheres of land management, Land capability Management, Human settlement and Land use, Slums, requirement of urban planning, Rural planning, Land use pattern in India. Soil conservation- Strategy, Practices in hilly areas, Controlling gully erosion in ravine lands, Shelter belts in deserts.

Unit – 2

Energy and environment-Global aspects, Indian aspects, Energy from fossil fuel, alternative energy, Environmental impacts of quarrying and mining, Waste management. Environmental pollution- land, air and water. Hazards- Introduction to key concepts, terminology. Natural hazards – Geologic and atmospheric. Earthquake, Landslide, Tsunami, Flood, Drought, Cyclone, Volcanic eruption, and Avalanche.

Unit – 3

Hazard, vulnerability, Exposure, Risk, Crisis, Disasters, Significant aspects of disasters, Disaster risk reduction, Risk management framework, Integrated Disaster risk management and post-disaster response. Natural disasters and their management- Problems, prospects and case studies. Climate change and its impact on coastal environment. Coastal management planning. Disaster management process- Prevention, preparedness, Mitigation, Application of Information technology in Disaster Preparedness, Application of geospatial technology in disaster management, Trauma and Stress management, First Aid and Emergency procedures, Early Warning systems.

References

- Pritchard, C.L. (2005), Risk Management, ESI International, Virginia, 474p.
- Coates, D.R. (1981) Environmental Geology, John Wiley and sons, 701p.
- Lee, F and Griffiths (2007) Engineering Geomorphology, Whittles publishing, 288p.

- Gupta, H.K. (2003) Disaster Management, University Press, 188p.
- Keller, E.A (2010). Environmental Geology. Pearson, 624p.
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- Rajib Shaw and R.R. Krishnamurthy (2010) "Disaster Management: Global Challenges and Local Solutions", Disaster Prevention and Management, v. 19, No. 4, pp. 518-518.
- Radhakrishna B.P and Ramachandran K.K. (1986). India's Environment, GSI, Bangalore
- Valdiya K.S. (2004) Geology, Environment Society, Orient Blackswan Private Limited, New Delhi, 240p.
- Valdiya K.S. (2013) Environmental Geology, McGraw Hill, New Delhi.
- www.ndma.gov.in
- www.sdma.ker.in

EGE 5006. Water Resource Management (3 credits)

Unit –1

Introduction to water resources - Ground water, Surface water, Glaciers and Rainwater. History of water resource development, Global water resources, Water cycle, Relation between water resources and environment. Concept of Integrated Water Resource Management (IWRM). Need for Water Resource Management, available water resources, Water scarcity- Lowering of Ground water level, vanishing of fresh water ponds, lakes and wet-lands.

Unit –2

Water supply Planning and Management-Domestic, agricultural and industrial. Cost-benefit analysis in water resource planning, Planning of watershed conservation practices, artificial recharging, contour bunding, sub-surface dams, geo-textile, rainwater harvesting. Estimation of available water resources. Water budgeting. Artificial reservoirs, construction of dams, Design and Planning of Distribution system- Drinking water, Irrigation water, Canal design, principles of irrigation, evapo-transpiration.

Unit –3

Water quality- pollution, Chemical and biological. Different Water quality standards. Water analysis techniques – Rainfall data, Acidic and alkali rain, Soil moisture analysis, evaporation, transpiration, Flood frequency analysis, rainfall - runoff analysis, reservoir function study, Generation of hydro-electric power. Treatment of waste water. Desalination methods.

References

- Cech Thomas V. (2003) Principles of water resources: History, development, management and policy. John Wiley& Sons.
- Todd, D.K. (2004) Ground Water Hydrology, John Wiley & Sons, 636p.
- Karanth, K.R. (1987) Groundwater Assessment, Development and Management. Tata McGraw Hill, New Delhi, 720p.
- Mays, L.W. Water resource engineering, John Wiley& Sons

- Linsley R.K and Franzini J.B (1979) Water resource engineering, McGraw-Hill
- Mays L.W. (1996) Water resources hand book, McGraw-Hill.
- Jain S.K. and SnghV.P.,Water resources system planning and Management Elsevier
- Walton, W.C. Ground Water Resources evaluation, McGraw-Hill.

EGE 5007. Isotope Geology (3 credits)

Unit – 1

Isotope geochemistry: Physical and chemical properties of isotopes; stable and unstable isotopes. Unstable or radio-isotopes**:** radiometric dating methods, Principles of isotope dating. U –Th - Pb methods, principles, merits and demerits. K-Ar method. Ar gain, Ar loss and their effects. Ar^{40} - Ar^{30} method . Rb–Sr method. Whole- rock and isochron methods. Sr loss. Sm - Nd method. Rb - Sr and Sm - Nd ratios and their significance. Fission track dating. ^{14}C dating. Suitability of samples or materials for dating. Preparation of samples for dating. Interpretation of isotope dates. Limitations of isotope dating. Distribution of dates in space and time.

Unit – 2

Stable Isotopes**:** Geochemistry, Notation. Theoretical Considerations. The Mass Spectrometer- principles, components and sensitivity. Thermal-ionization mass spectrometry (TIMS), ICP-MS, LA-MS, Secondary-Ion Mass Spectrometry (SIMS). Measurement of stable isotopes using isotope ratio Mass Spectrometer (IRMS). Isotope Fractionation in Hydrologic and Biological Systems.

Carbon Isotope Fractionation during Photosynthesis. Nitrogen Isotope Fractionation during biological processes. Oxygen and Hydrogen Isotope Fractionation during precipitation, evaporation and absorption by Plants. Paleoclimatology. The Marine Quaternary $\delta^{18}O$ Record and Milankovitch Cycles.

Unit – 3

Sulfur Isotopes and Ore Deposits. Stable Isotopes in the mantle and magmatic system. Stable Isotopic Composition of the Mantle. Boron isotopes. Stable Isotopes in Crystallizing Magmas. Combined Fractional Crystallization and Assimilation.

Isotope Geothermometry. Paleothermometer, carbonate thermometer, $^{18}O/^{16}O$ isotope composition of silicates and high-temperature thermometry, isotopic cycle of water, Paleothermometry and the water cycle: paleoclimatology, paleoclimatic records: sediment and ice. Carbonate paleoclimatology.

References

- Allegre, C. (2008), Isotope Geology, Cambridge University Press, New York, 534p.
- Baskaran, M. (ed) (2011), Handbook of Environmental Isotope Geochemistry, Springer-Verlag, Berlin, 943p.
- Claude Hillaire–Marcel and Anne De Vernal (2007) Proxies in Late Cenozoic Paleoceanography (2007), Elsevier, Amsterdam, Tokyo, 843p.
- Gill, R. (1989), Chemical Fundamentals of Geology, HarperCollins Publishers Ltd, UK, 292p.
- Hoefs, J. (2009), Stable Isotope Geochemistry, 6th Edition, Springer-Verlag, Berlin, 293p.
- Krauskopf, K. B. (1967), Introduction to geochemistry, McGraw-Hill Book Co., New York, 721 p.

- Mason, B, Moore and Carleton, B. (1982), Principles of geochemistry, John Wiley & Sons, New York, 344 p.
- Mook, W. G. (2000), Environmental Isotopes in the Hydrological Cycle: Principles and Applications, Vol 1, UNESCO/IAEA, Paris, 297p.
- Valley, J. and Cole, D. (2001), Stable Isotope Geochemistry, Reviews in Mineralogy 43, Mineralogical Society of America, Washington DC, 660p.
- White, W. M., Geochemistry, 695p (Unpublished book, available online)
- Wolfsberg, M., Hook, V.W.A., Paneth, P. and Rebelo, L.P.N. (2010), Isotope Effects in the Chemical, Geological, and Bio Sciences, Springer-Verlag, Berlin, 477p.

EGE 5008. Quaternary Geology (3 credits)

Unit – 1

Definition of Quaternary; concept and importance of Quaternary, Quaternary chronostratigraphic unit, standard sub-divisions of the Quaternary Period and their climatic significance, standard global stratotype sections, Plio-Pleistocene boundary. Quaternary Glaciations – causes, pattern of glacial-interglacial cycles and associated eustatic changes. Milankovitch orbital cycles. Lines of evidence for Recent and historical sea level fluctuations; Ice core records of glaciations during the Pleistocene and Holocene; Pleistocene faunal extinctions.

Unit – 2

Tools for Quaternary studies- application of Oxygen Isotope Stratigraphy (OIS), biostratigraphy and magneto-stratigraphy. Paleoclimatic archives and Proxies for paleoenvironmental/ paleoclimatic changes. Various Archives of Quaternary history: tree rings (dendrochronology), corals, speleothems (cave deposits), peat deposits, ice cores, lake sediments, marine sediments, glaciers, fluvial deposits. The 'proxy indicators' for the reconstruction of Quaternary environments--geological, geochemical (major and trace elements), biological (microfossils, pollen), sedimentological, isotopic (oxygen, carbon and nitrogen isotopes) and magnetic proxies.

Unit – 3

Quaternary dating methods – Radiocarbon chronology - other radiogenic clocks. Fission track and thermoluminescence dating methods. Planetary clocks. Quaternary Stratigraphy of India– continental records (fluvial, glacial, aeolian, palaeosols and duricrust); marine records.

References

- Sirocko, F., Claussen, M., Goni, M.F.S. and Litt, T. (Eds., (2008): The Climate of Past Interglacials, Elsevier, 638p.
- Burrough, W.J.S. (2005): Climate Change in Prehistory, Cambridge University Press, 368p.
- Rapp, D. (2009): Ice Ages and Interglacial – Measurements, Interpretation and Models, Springer, 243p.
- Saltzman, B. (2002): Dynamical Paleoclimatolgy – Generalised Theory of Global Climate Change, Academic Press, 354p.
- Birks, H. J. B. and Birks, H. H. (1980): Quaternary Paleoecology, Edward Arnold, 369p.
- Battarbee, R.W. and Binney, H.A. edt. (2008), Natural Climate Variability and Global Warming – A Holocene Perspective, Wiley Blackwell, 354p.

- Bloom, A.J. (2010): Global Climate Change – Convergence of Disciplines, Sinauer Associates, 269p
- Bradley, R. S. (1999): Paleoclimatology – Reconstructing Climates of the Quaternary, Elsevier, 613p.
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- Mathur, U.B., (2006): Quaternary Geology, Indian Perspective, Geological Society of India, Bangalore, Vol: 67, 344p.

EGE 5009. Structural Analysis (3 credits)

Unit – 1

Deformation: Translation – Rotation – Dilation – Distortion. Deformation and changes in length and angle. Rheology. Geological significance of displacements. Deformation mechanisms and processes: Cataclastic flow – pressure solution – intracrystalline deformation – recrystallisation – diffusion – grain boundary sliding.

Unit – 2

Principles of displacement and strain. Homogeneous and heterogeneous strain. Finite strain theory. Stress-Strain diagrams. Factors affecting stress-strain relations. Concept of strain ellipse. Rapid methods of strain determination. Strain analysis- analysis of strain in linear, initially circular/spherical objects. Various methods of strain analysis. Strain partitioning. Strain in three dimensions. Simple and pure shear. Shear zones - geometry and classification. Shear indicators. Shear zone rocks - Mylonites and fragmental rocks produced by shearing. Shear sense indicators, Stress-strain relationships in different types of shear zones. Deep crustal fluids and shear zones. Shear zones of Southern India.

Unit – 3

Fabric development: Progressive deformation. Rotation, pressure solution, recrystallisation and plastic deformation of grains. Tectonites – S and L tectonites.Microfabric analysis – sampling techniques. Modern techniques in microstructural analysis – 4-axes Universal stage – X-ray texture goniometry – Transmission Electron Microscopy – SEM-EBSD. Fabric symmetry – Crystallographic Preferred Orientation – Lattice Preferred Orientation. Kinematic analysis.

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EGE 5010. Planetary Geoscience (3 credits)

Unit – 1

Milky Way and the solar system. Modern theories: condensation and accretion of planets and other planetary bodies. Members of the solar system. The Sun-Planetary and Orbital characteristics. General characteristics of the terrestrial planets- crust, surface features, thermal history, volcanism

Unit – 2

Moon: The Earth-Moon System, General Physiography, Atmosphere, Tectonic features, Craters, Degradational features, History of the Moon and time scale, Lunar volcanism, Lunar rocks, soil and internal structure, Lunar phases and cycles, Lunar influence on Earth.
Mars: Phobos and Dimos, Physiography, Atmosphere, Craters, Volcanism, Tectonism, Hydrology, Martian rocks and soils.

Unit – 3

Meteorites: Chondrites, SNC meteorites, Refractory inclusions, Iron meteorites and Parent body cooling rates, meteorite chronology.
Asteroids: Classification and composition, Surface features, Asteroid sources, Asteroid impacts on the Earth. Comets and other Icy bodies. Planetary images, Digital and Analog studies of Martian, Lunar samples with those of Earth samples. Planetary missions. Lunar and Mars Missions. Chandrayan and Mangalyan.Exploring the planets and asteroids for minerals.

Reference

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- McBride, N and Gilmour, I (Eds) (2004): An introduction to the solar system, Cambridge University Press, 269p
- Seeds, M and Backman, D. (2010): The Solar System, Brooks/Cole, 7th Edition, 326p.

EGE 5011: Oceanography (3 credits)

Unit- 1

Ocean floor: Morphologic and tectonic domains. Bathymetric features- Submarine Canyons, Mid-Ocean ridges and Trenches. Morphologic and tectonic domains of the Indian Ocean. Origin of ocean basins. Physico-chemical characteristics and chemistry of seawater: temperature, salinity, density, light transmission, sound transmission in seawater. Gases in seawater. Carbon dioxide and pH of seawater- ocean acidification. Instruments used in the study of seawater.

Unit- 2

Offshore exploration techniques: Instruments and Measurements-Position fixing systems-GPS. Sampling devices - Grabs, Dredgers, Corers, Water Samplers. Various platforms for ocean studies. Tools for studying the ocean floor: Echo-sounding methods, Side scan Sonar, Current meters, SCUBA diving-submersibles. Ocean floor drilling - JOIDES, DSDP, ODP, IODP.

Unit- 3

Marine sediments: Distribution and geochronology of marine sediments. Eustatic changes of sea level and its effects. Calcite Compensation Depth (CCD). Turbidity currents and turbidites. World ocean circulation patterns— ocean water masses; role of ocean in deciding global climate. Paleoceanography, Paleoceanographic reconstructions based of microfossils. UN Convention on the Law of the Sea (UNCLOS)- EEZ-coastal zone environment and its protection - CRZ Act. Mineral resources of the ocean basins, factors controlling their distribution. Origin and distribution of polymetallic nodules.

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- Gross, G.M. (1995): Principles of Oceanography, VII edn., Prentice Hall, 240p.
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EGE 5012: Climatology (3 credits)

Unit-1

Fundamental principles of climatology. Atmosphere, its composition and structure. Greenhouse effect. Earth's radiation balance; latitudinal and seasonal variations of insolation, temperature, pressure. Fundamentals of meteorology, Scales of meteorology, Parameters of meteorology- pressure, wind, temperature, humidity, radiation; Radiation: Radiation laws, short wave and long wave radiations; Albedo; Emissivity; Radiation Budget of Earth.

Unit-2
General circulation of the atmosphere: Hadley cells, tropical easterlies, westerlies, polar easterlies, monsoon, Jet streams, tropical cyclones, local winds. Coriolis Effect and geostrophic winds. Cloud classification, condensation nuclei, growth of cloud drops and ice-crystals, precipitation mechanisms: Bergeron process, coalescence process. Types of precipitation, artificial precipitation. Electric field in the atmosphere.

Unit-3
Climate variability and forcings, causes and impacts of climate change, feedback processes, low frequency variability, Madden-Julian Oscillation (MJO), ENSO, QBO (quasi-biennial oscillation) and sunspot cycles. Classification of climate – Koppen's and Thornthwaite's schemes of classification. Synoptic weather forecasting, prediction of weather elements such as rain, maximum and minimum temperature and fog; hazardous weather elements like thunderstorms, duststorms, tornadoes.

References:

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EGE 5013: Mineral Wealth of India (3 credits)

Unit-1
Comparison between Global and Indian mineral resources and reserves; Strategic, critical and essential minerals of India. State-wise share of mineral production in India.

Unit-2
Mineral Deposits of India: Iron ore deposits – Mineralogy, classification, grade, origin and distribution in India, BIF – BHQ, BMQ, Iron ore deposits especially of Kerala, Bihar, Orissa and Karnataka.

Types, grades, mineralogy, uses, origin and Indian occurrences of: Manganese ore deposits (especially of Bihar, Orissa); chromium ore deposits (especially of southern India), Bauxite deposits (classification based on origin and shape); and copper ore deposits (especially of Khetri and Malanjkhand). Origin and occurrence of Lead and Zinc, Mica, Gold, PGE, Diamond, Uranium and Thorium deposits.

Unit-3
Mineral Deposits of India. Placer deposits of Kerala – General geologic and geomorphic setting, Ilmenite and rutile, monazite, Zircon, Sillimanite, Garnet, origin of Chavara Placer deposits, silica sands.
Non-metallic deposits – Refractory minerals: acid refractories – silica – Clay Deposits: Origin and Mineralogy, china clay deposits of Kerala – Kyanite – Neutral refractories: chromite – graphite – asbestos – Basic refractories – Magnesite – dolomite. Minerals used in Fertilizer

industry: phosphorite, apatite. Minerals used in Cement industry: limestone – gypsum. Minerals used in Chemical industry.

References

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- Prasad, U (2002), Economic Mineral Deposits, CBS Publishers, New Delhi.
- Soman, K. (2001), Geology of Kerala, Geol. Soc. of India, Bangalore, 335p.

EGE 5014: Geostatistics (3 credits)

Unit-1

Introduction to statistics: sampling, data collection, random variables, probability, frequency function; Applications of statistical methods in earth sciences – quantification and prediction. Univariate statistical methods, frequency analysis, simulation; Statistical distributions.

Unit-2

Stochastic modelling and forecasting – introduction, modelling, applications, spectral analysis; Concepts of regionalized variables and variogram modelling; Concepts of dispersion, extension and estimation variances.

Unit-3

Kriging variance and procedure, simple kriging; Introduction to advanced geostatistics; applications of computer programs for statistical calculations – open source statistical programs

References

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- J. Awange, B. Palancz, R.H. Lewis, L. Volgyesi, Mathematical Geosciences, Springer Publ., pp.615.
- Olea, R.A., Geostatistics for Engineers and Earth Scientists, Springer Publ., pp.309.

EGE 5015: Physical Geology (3 credits)

Unit – 1

Introduction to Earth systems. Earth's interior and geophysical properties – internal structure, isostasy, gravity measurements, magnetic field, geothermal gradient and heat flow. Sea floor – features, seamounts, guyots and aseismic ridges, reefs; age of the sea floor. Plate tectonics – history, plates and plate motion, causes for plate motion.

Unit – 2

Mountain belts and the continental crust – characteristics, thickness and density of rocks, features of active mountain ranges; evolution of mountain belts; growth of continents. Geologic structures – tectonic forces at work, structures as a record of geologic past, folds and faults. Time and Geology – key to the past, relative time, numeric age, age of the Earth.

Unit – 3

Internal geological processes – igneous and metamorphic. External geological processes - weathering and soil, soil mechanics, mass wasting; Action of wind, water, glaciers; Waves, beaches and coasts. Geologic resources.

References

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10. W. Kenneth Hamblin (1991), Introduction to Physical Geology, Macmillan Publishing Company. New York; 378p.

to make a comparative statement to take a considered decision requiring further enhancement of Ph.D Evaluation fee for future.

AC3:06:04	Amendment of Ordinance 28 - Reg:-

Draft amended Ordinance No. 28 of Central University of Kerala (Emoluments, Terms & Conditions of Service of the Controller of Examinations) has been placed before the Academic Council for approval

Decision:

The Academic Council approved the amendment proposed in Ordinance No.28.

AC3:06:05	Counting of Past Service for Direct Recruitment and Promotion for Teachers – Reg.

The counting of past services for direct recruitment and promotion was placed as an item in the AC vide item No. 03:3:03(01.06.2018);

Accordingly, the Academic Council while approving the minutes of the committee have pointed out that the experience of State funded research institutions and Industry experience may also be counted by referring the matter back to the Committee. The Committee was asked to submit its report to the next AC.

This was placed in EC (03.08.30) dated 27th June 2018 for approving the above resolutions of the AC. The EC approved the proposal and decided that the experience in Research /Technical institutions of State Governments in equivalent grade /similar duties also may be counted along with national institutions.

The Committee again met to finalize the aspect based on the EC decisions and submitted its report which is attached here. The experience of the State Funded Research Institutions other centrally funded technical institutions and industrial experience shall be counted provided the respective experience should strictly comply with the stipulations mentioned vide minutes dated 14.3.2018 as placed in AC of 1.6.2018.

Decision:

The Academic Council noted that the matter was already approved by Executive Council. The Academic Council further pointed out that the experiences also are to be in tune with clauses 10 'a' to 'g' of the UGC Regulation 2018.

AC3:06:06	Approval of the BoS Minutes and Syllabus – Reg.

The Academic Council has considered the BoS Meeting Minutes and revised Syllabus of the following Departments and decided to approve the same with decisions mainly as follows:

(i) **Genomic Science**

The Academic Council ratified the syllabus. The Department removed the topic Bio-Physics and added System Biology, Bio Statistics, Bio Informatics and also Lab for all the semesters. Academic Council approved the same. The revised syllabus of M.Sc Genomic Science is being implemented from 2019-20 academic year onwards.

(ii) **Geology**

The Academic Council ratified the syllabus. All Core Courses have 04 credits and electives with 03 credits. Syntax format adopted uniformly. The Department combined a few courses thereby making the courses to 04 or 05 from the earlier 08 & 09. Also adopted new eligibility (Introduction of B.Sc. Triple main from the existing B.Sc. Geology (only)). The revised syllabus of M.Sc. Geology is being implemented from 2019 academic year onwards.

(iii) **English and Comparative Literature**

The Academic Council approved the syllabus revision which took place after 02 years. Comprising of 15 core courses and 22 electives. Besides there is an addition of one innovative programme for 120 hours. All are now inclusive of Dalit courses. This is made effective from 2019-20 onwards.

(iv) **Management Studies**

The Academic Council ratified modified syllabus and scheme of Evaluation for MBA (General) which is effective from 2019 onwards.

(v) **BA International Relations**

The Academic Council ratified the revised syllabus of the BA (International Relations) commencing from the academic year 2019-20 with the following decisions;

i) The core courses of BA International Relations has changed.
ii) Change of Dissertation from 100 marks to CA (40 marks) and ESA (60 marks) has been approved
iii) There is no change in credits.
iv) There is an introduction of new paper titled 'Issues in international Politics' in 6th semester.

(vi) **Tourism Studies**

The Department in order to meet industry requirements has included Audit Courses (NIL credits) (Core course). There shall be 03 field visits in Core courses. Sustainable Tourism Management Course also added besides inclusion of One MOOC Course by replacing Viva-Voce.

4 Elective Courses towards industrial requirements were also made. Total 20 Core Courses, 12 electives, 3 Audit Courses (NIL Credits).

The Academic Council authorized Dr. Mustafa to coordinate with Department of Tourism to make necessary changes in the course on personality and Life Skills. With this change the Academic Council approved the syllabus.

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No. CUK/GEO/BOS/MIN/2019/01 Dtd: 28/06/2019

Minutes of the Meeting of Board of Studies in Geology held at Conference Hall, Central University of Kerala, Periye at 10.00 a.m. on 28/06/2019

The Department of Geology, Central University of Kerala conducted the Board of Studies (BoS) meeting on 28th June, 2019 at the Room No. 317, Sabarmati Building. The meeting started at 10.30 am and ended at 2.30 pm. The panel members included invited subject experts, Head of the Department and internal members. The attendees of the meeting were as follows: -

BoS Attendees:
Invited subject experts

- Dr. R. Shankar, Professor (retired), Dept. of Marine Geology, Mangalore University, Mangalagangothri-574199
- Dr. V. Prasannakumar, Professor (Rtd) and Emeritus Fellow, University of Kerala
- Dr. Ganesha Raj, General Manager, Regional Remote Sensing Centre- South, NRSC, ISRO, Bengaluru-560037

Internal members from the Central University of Kerala

- Dr. Sandeep K, Assistant Professor and HOD (i/c), Dept. of Geology.
- Dr.Pratheesh P, Assistant Professor, Dept. of Geology.
- Dr.Jeyabalan Sangeetha, Assistant Professor, Dept. of Environmental Science.

* Absentees: Shri. Suresh Chandran, Dy. Director General (Rtd), Geological Survey of India, Thiruvananthapuram.

The BoS meeting started with the welcome address by Dr.Sandeep K, Head of the Department (i/c). The agenda for discussion in the BoS meeting was proposed by the Head of the Department. The main items discussed in the BoS are given below:

1. The revision of the structure and content of the syllabus in connection with the Academic Council decision to adopt equal credits for core and elective courses offered by various departments and follow uniform syntax for course codes.
2. Consider and decide on the proposals from the Faculty Council concerned with the curriculum.
3. Consider and decide on the proposal from the Director, Geological Survey of India, Mangalore to include Gt Aide (Academy) in the syllabus.

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4. Eligibility criteria for the M.Sc. Geology Programme.

5. Any other matter permitted by the Chair.

The details of agenda-wise discussion and the final recommendation by the BoS are given below.

Agenda 1: The revision of the structure and content of the syllabus in connection with the Academic Council decision to adopt equal credits for core and elective courses offered by various departments and follow uniform syntax for course codes.

There was elaborate discussion on this item and the structure and content of the syllabus. Dr. Sandeep K presented the proposed structure and courses for the four semesters. He also explained the rationale for combining two courses together in the proposed syllabus in order to adopt equal and uniform credits as suggested by the Academic Council of the university. Dr. Prasannakumar suggested to remove the 'Geoinformatics' component from the course EGE 5191 Lab 1: Structural Geology, Geological Field Mapping and Geoiformatics as it will be difficult to conduct the practical examination of the 'geoinformatics' together with Structural Geology and Geological Field Mapping. He suggested to include those contents in the elective course EGE 5003: Geomatics. Dr. Ganesha Raj suggested to rename the elective course EGE 5003: Geomatics to 'Geospatial Technology'. Dr. Prasannakumar suggested to remove the contents of Physical Geology from the elective course EGE 5002: Physical and Engineering Geology. Dr. Shankar suggested that 'Physical Geology' can be a separate elective course. Dr. R Shankar and Dr. Ganesha Raj suggested to revise the title of the course 'EGE 5005: Environmental Geology and Natural Hazards' to 'EGE 5005: Environmental Geology and Disaster Management' as the course contains contents on human-induced hazards and a unit on Disaster Management.

Recommendations: Following detailed discussion on the structure and contents of the syllabus recommended by the faculty council, BoS members consensually proposed following changes in the course structure.

- All the courses were rearranged so that there are 4 credits for core courses (theory), 3 credits for core courses (practical/lab) and elective courses.
- The core course 'EGE 5191: Lab 1: Structural Geology, Geological Field Mapping and Geoinformatics' is renamed as 'Structural Geology and Geological Field Mapping'. It is

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decided to include the 'Geographic Information Systems' component of the course to the elective paper 'EGE 5003: Geomatics'.

- The elective course EGE 5003: Geomatics is renamed as 'Geospatial Technology' with the addition of practical components transferred from the core course 'EGE 5191: Lab 1: Structural Geology, Geological Field Mapping and Geoinformatics'.
- The elective course 'EGE 5002 Physical and Engineering Geology' is renamed as 'EGE 5002: Engineering Geology'. The physical geology component is included in the separate elective 'EGE 5015: Physical Geology' which is added to the elective courses.
- The elective course 'EGE 5005: Environmental Geology and Natural Hazards' is renamed as 'EGE 5005: Environmental Geology and Disaster Management'.
- The final course distribution and syllabus structure is shown below:

I SEMESTER		Credits	Lecture hrs.	Lab hrs.	Field hrs.
EGE 5101	Geomorphology and Sedimentology	4	4		
EGE 5102	Structural Geology	4	4		
EGE 5103	Palaeontology and Stratigraphy	4	4		
EGE 5191	Lab 1: Structural Geology and Geological Field Mapping	3		4	2
EGE 5192	Lab 2: Sedimentology and Palaeontology	3	3		
	Elective	3	3		
II SEMESTER					
EGE 5201	Igneous and Metamorphic Petrology	4	4		
EGE 5202	Mineralogy and Geochemistry	4	4		
EGE 5291	Lab 3: Igneous and Metamorphic Petrology	3		6	
EGE 5292	Lab 4: Mineralogy and Crystallography	3		6	
	Elective	3	3		
	Elective	3	3		
III SEMESTER					
EGE 5301	Economic Geology	4	4		
EGE 5302	Hydrogeology	4	4		
EGE 5391	Lab 5: Ore Geology	3		6	
EGE 5392	Lab 6: Hydrogeology	3		6	
	Elective	3	3		
	Elective	3	3		
IV SEMESTER					
EGE 5490	Dissertation	8		4	12
EGE 5491	Field Geology	3			6

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ELECTIVES		Credits
EGE 5001	Industrial Minerals and Gemstones	3
EGE 5002	Engineering Geology	3
EGE 5003	Geospatial Technology	3
EGE 5004	Coal and Petroleum Geology	3
EGE 5005	Environmental Geology and Natural Hazards	3
EGE 5006	Water Resource Management	3
EGE 5007	Isotope Geology	3
EGE 5008	Quaternary Geology	3
EGE 5009	Structural Analysis	3
EGE 5010	Planetary Geoscience	3
EGE 5011	Oceanography	3
EGE 5012	Climatology	3
EGE 5013	Mineral Wealth of India	3
EGE 5014	Geostatistics	3
EGE 5015	Physical Geology	3

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2. Consider and decide on the proposals from the Faculty Council concerned with the curriculum.

Dr. Sandeep presented the proposed contents of the each core and elective course by the Faculty Council. There was an elaborate discussion on this item. Dr. R Shankar suggested to add Author/s, Year, Title, Publisher's name and place, Total no. of pages in references list wherever it is missing. Dr. R Shankar, Dr. V Prasannakumar, Dr. Ganesha Raj and Dr. Jayabalan Sangeetha suggested a few corrections and modifications in the contents of the courses proposed by the Faculty Council.

Recommendations: Following detailed discussion on the contents of the courses recommended by the faculty council, BoS members approved the overall syllabus with the following minor changes:

- 'The association of primary sedimentary structures and textural characteristics with depositional environments or settings' is included in the core course 'EGE 5101: Geomorphology and Sedimentology'.
- 'Analysis of fractures and faults, Coulomb failure criteria, Buckling- Biot-Ramberg theory of buckling' is included in the core course 'EGE 5102: Structural Geology'.

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- 'Binary, Ternary and Quaternary systems' are added in the core course EGE 5201: Igneous and Metamorphic Petrology.
- The units of the core course 'EGE 5292: Lab 4: Mineralogy and Crystallography' are re-arranged with Mineralogy units coming first. The content 'Stereographic projections of the symmetries of Normal classes of Isometric, Tetragonal and Hexagonal systems. Gnomonic projection of normal class Isometric system' in the unit-3 are deleted.
- The collection of well-inventory data and ground water quality has been added in the core course EGE 5392: Hydrogeology.
- The third unit is added in the core course 'EGE 5491: Field Geology'.
- The components of the core course 'EGE 5490: Dissertation' are re-arranged.
- The units of the elective course 'EGE 5002: Engineering Geology' are re-arranged.
- The 'Geographic Information Systems' component core course 'EGE 5191: Lab 1: Structural Geology and Geological Field Mapping' is included in the elective course 'EGE 5003: Geospatial Technology'.
- The units of the elective course 'EGE 5004: Coal and Petroleum Geology' are re-arranged with allotment of one unit for the 'coal' and two units for 'petroleum'.
- In the elective course 'EGE 5005: Environmental Geology and Disaster Management', the contents of the unit-2 'Water Resources-Hydrological Considerations, Problems and Management – Nature of ground water, Infiltration of rain water, water table, Movement of ground water' are deleted.
- 'Water quality standards' are added in the elective course 'EGE 5006: Water Resource Management'.
- In the elective course 'EGE 5007. Isotope Geology', the 'Oxygen and Hydrogen Isotope Fractionation during precipitation and evaporation' and 'Boron isotopes' have been added.
- The archives and proxies in the elective course 'EGE 5008: Quaternary Geology' have been re-arranged.
- 'Lunar and Mars Missions, Chandrayan and Mangalyan, Exploring the planets and asteroids for minerals' are added in the elective course 'EGE 5010. Planetary Geoscience'.
- The unit-1 is re-drafted in the elective course EGE 5011: Oceanography.
- The unit-1 is re-drafted in the elective course EGE 5013: Mineral Wealth of India.

भूविज्ञान विभाग
केरल केंद्रीय विश्वविद्यालय
Central University of Kerala
पेरिया डाक, कासरगोड
Periye P.O, Kasaragod
DEPARTMENT OF GEOLOGY

- Author/s, year, title, publisher's name and place, total no. of pages were added in references list wherever it was missing.

Agenda 3: Consider and decide on the proposal from the Director, Geological Survey of India, Mangalore to include Gt Aide (Academy) in the syllabus (Annexure 1).

The members discussed the proposal from the Director, Geological Survey of India, Mangalore to include Gt Aide, which is a freeware with applications in various courses of Geology. However, Dr. Prasannakumar suggested that it is not right to include the contents proposed in the syllabus as there are many such freewares available for various purposes in geology. However, he suggested that it can be used in the class and its applications can be taught to students without mentioning a specific software in syllabus.

Recommendations: Following detailed discussion on the subject, it is decided not to include any specific software in the syllabus.

Agenda 4: Minimum eligibility criteria for the admission to M.Sc. Geology Programme.

The revised eligibility criterion of the M.Sc. Geology Programme has been already approved by the members through e-mail communication. The members discussed and ratified the same.

Recommendations: The members approved and ratified the revised eligibility criteria as follows:

B.Sc. Geology / B.Sc.Geology and Water Management/B.Sc. (Hons.) Geology with minimum 55% marks or equivalent grade in aggregate and in the concerned subject separately, from a recognized University (studied in 10+2+3 system). B.Sc. Tripple main programme with Geology as one of the main/major/core subject is also eligible. However Geology should have equal or more weightage with respect to the other two main subjects. The student must have studied Geology in all the three years of B.Sc. Programme. The B.Sc. tripple main programme with Geology as a subsidiary/ minor subject or having less weightage compared to other two main subjects is not eligible.

After this, overall agenda discussed in the BoS were summarised by Dr. Sandeep. The BoS approved the revised M.Sc. Geology syllabus recommended by the Faculty Council with minor modifications and revisions. Thereafter, Dr. Sandeep offered vote of thanks, which concluded the BoS meeting.

Dr. Sandeep K
Head (I/c), Dept. of Geology
Central University of Kerala
Periye P.O., Kasaragod

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Central University of Kerala

Established by the Parliament of India vide the Central University Act, 2009(No.25 of 2009)

Tejaswini Hills, Periye (P.O.), Kasaragod, Kerala, India, 671316

DEPARTMENT OF GEOLOGY

Members present at the 2nd Meeting of the Board of Studies, Dept. of Geology held on 28th June, 2019 in the Department of Geology, Central University of Kerala

Sl. No.	Members present	Signature
1.	Dr. Sandeep K Assistant Professor and HOD (i/c) Dept. of Geology, Central University of Kerala	28/6/19
2.	Dr. Pratheesh P Assistant Professor Dept. of Geology, Central University of Kerala	28/06/19
3.	Dr. Jeyabalan Sangeetha Assistant Professor Dept. of Environmental Science, Central University of Kerala	28/06/19
4.	Dr. R. Shankar Professor (retired), Dept. of Marine Geology, Mangalore University, Mangalagangothri-574199	28/06/19
5.	Dr. V. Prasannakumar Professor (Rtd) and Emeritus Fellow, University of Kerala	28 06 19
6.	Dr. Ganesha Raj General Manager, Regional Remote Sensing Centre- South, NRSC, ISRO Bengaluru-560037	28/6/19
7.	Shri. Suresh Chandran Dy. Director General (Rtd) Geological Survey of India	absent

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DEPARTMENT OF GEOLOGY

Central University of Kerala

M.Sc. Geology

SCHEME AND SYLLABUS

2019

Title of the PG Programme : M.Sc. Geology

Programme structure

The PG programme is offered in four semesters and includes theory and practical classes, field training and a dissertation.

Duration of the Programme	**:**	4 semesters
Number of seats	**:**	38
Type of the programme	**:**	Regular
Eligibility for admission	**:**	B.Sc. Geology / B.Sc. Geology and Water Management/B.Sc. (Hons.) Geology with minimum 55% marks or equivalent grade in aggregate and in the concerned subject separately, from a recognized University (studied in 10+2+3 system). B.Sc. triple main programme with Geology as one of the main/major/core subject is also eligible. However, Geology should have equal or more weightage with respect to the other two main subjects. The student must have studied Geology in all the three years of B.Sc. Programme. The B.Sc. triple main programme with Geology as a subsidiary/ minor subject or having less weightage compared to other two main subjects is not eligible.
Admission	**:**	Through CUCET

CORE COURSES

I SEMESTER		Credits	Lecture hrs.	Lab hrs.	Field hrs.
EGE 5101	Geomorphology and Sedimentology	4	4		
EGE 5102	Structural Geology	4	4		
EGE 5103	Palaeontology and Stratigraphy	4	4		
EGE 5191	Lab 1: Structural Geology and Geological Field Mapping	3		4	2
EGE 5192	Lab 2: Sedimentology and Palaeontology	3	3		
	Elective	3	3		
II SEMESTER					
EGE 5201	Igneous and Metamorphic Petrology	4	4		
EGE 5202	Mineralogy and Geochemistry	4	4		
EGE 5291	Lab 3: Igneous and Metamorphic Petrology	3		6	
EGE 5292	Lab 4: Mineralogy and Crystallography	3		6	
	Elective	3	3		
	Elective	3	3		
III SEMESTER					
EGE 5301	Economic Geology	4	4		
EGE 5302	Hydrogeology	4	4		
EGE 5391	Lab 5: Ore Geology	3		6	
EGE 5392	Lab 6: Hydrogeology	3		6	
	Elective	3	3		
	Elective	3	3		
IV SEMESTER					
EGE 5490	Dissertation	8		4	12
EGE 5491	Field Geology	3			6

ELECTIVE COURSES

ELECTIVES		Credits
EGE 5001	Industrial Minerals and Gemstones	3
EGE 5002	Engineering Geology	3
EGE 5003	Geospatial Technology	3
EGE 5004	Coal and Petroleum Geology	3
EGE 5005	Environmental Geology and Natural Hazards	3
EGE 5006	Water Resource Management	3
EGE 5007	Isotope Geology	3
EGE 5008	Quaternary Geology	3
EGE 5009	Structural Analysis	3
EGE 5010	Planetary Geoscience	3
EGE 5011	Oceanography	3
EGE 5012	Climatology	3
EGE 5013	Mineral Wealth of India	3
EGE 5014	Geostatistics	3
EGE 5015	Physical Geology	3

Credit Distribution

Course	Semester-wise credits				Total credits
	I	II	III	IV	
Core	**18**	**14**	**14**	**11**	**57**
Elective	**3**	**6**	**6**	**-**	**15**
Total	**21**	**20**	**20**	**11**	**72**

EGE 5101. Geomorphology and Sedimentology (4 credits)

Unit – 1

Fundamental concepts in geomorphology. Different models for the Evolution of landscape: Davis, Penck, King, Hack. Hill slopes: slope elements, classification, models of slope evolution, slope movement and stability factors. Landforms in relation to climate, rock type, structure and tectonics. Fluvial Geomorphology: Erosional and depositional landforms of rivers. Drainage systems and patterns. Morphometric elements and parameters - morphometric analysis of drainage basins. Coastal geomorphology: Coastal erosional and depositional landforms.

Unit – 2

Geomorphic indicators of neotectonic movements: Stream channel morphological changes, drainage modifications, fault reactivation, uplift–subsidence pattern in coastal areas. Application of geomorphology in various fields of earth sciences, viz. Mineral prospecting, Hydrogeology, Civil Engineering. Geomorphology of India – Origin and evolution of Peninsular India, Extra-peninsular India and the Indo-Gangetic Plain.

Unit – 3

Textural parameters of clastic and non-clastic sediments. Grain size: classification and concept of grade scale. Grain size estimation: direct measurement, sieving and settling methods. Grain size parameters (statistical) and their applications. Grain shape and fabric. Sedimentary structures: Classification and origin. Different types of stratification, deformation structures, erosional structures, biogenic structures, sand dykes and sills: applications in paleo-environmental and paleocurrent studies.

Unit – 4

Mineralogy, classification and depositional environments of conglomerate, sandstone, limestone and mud rock. Diagenesis: processes and evidence in siliciclastic, carbonate and argillaceous rocks. Provenance of sediments. Depositional environments - marine, non-marine, and mixed depositional environments. The association of primary sedimentary structures and textural characteristics with depositional environments and settings. Concept of sedimentary facies, association models. Overview of sedimentary basins; Basin development and classification: Cratonic basins, Divergent margin basins, Convergent margin basins, Downwarp basins. Fore arc and back arc basins. Sedimentary basins of India.

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EGE 5102. Structural Geology (4 credits)

Unit - 1

Deformation. Components of deformation: Homogeneous and heterogeneous deformation. Ideal material behaviours. Rheology- Elastic, plastic and brittle deformation. Deformation at the microscale. Concept of stress: Stress tensor-Stress matrix. Concept of strain: Simple shear and pure shear, Mohr circles for strain. Stress and strain ellipsoids. Faults, Joints and Fractures - Brittle and shear failure. Mohr-Coulomb failure criteria. Deep fractures. Analysis of fractures. Fault geometry and nomenclature. Features of fault planes. Use of stress and strain ellipsoids in the study of faults and joints.

Unit- 2

Buckling- Biot-Ramberg theory of buckling. Folds - cylindrical, non-cylindrical and conical folds. Geometry and classification of cylindrical folds. Canoe fold and inverted canoe fold. Minor folds and their use in determining the major fold structure. Mechanics of folding. Fold classifications of Donath and Parker and Ramsay. Superposed folding. Fold interference patterns - dome and basin, mushroom and boomerang patterns and Ramsay's classification.

Unit - 3

Tectonites: classification, tectonic fabric. Foliation: axial-plane foliation and its origin, fracture cleavage, crenulation cleavage and transposed foliation. Foliations and folds. Use of axial plane foliation and fracture cleavage in the determination of major structures. Lineation - types, classification and origin.

Unit- 4

Geologic bodies and scale, structural co-ordinates. Spatial orientation of planar and linear fabrics. Fundamentals of geometric analysis. Measurement and recording of structural attitudes. Stereographic and equal area projections in structural geology. $\boldsymbol{\pi}$ and $\boldsymbol{\beta}$ diagrams. Geometric analysis of simple and complex structures on macroscopic scale. Geometric analysis of folds. Analysis of fractures and faults.

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EGE 5103. Palaeontology and Stratigraphy (4 credits)

Unit - 1

Life during the Precambrian, Diversification of life. Evolution of life during the Palaeozoic, Mesozoic and Cenozoic eras. Cambrian explosion. Fossil record and modes of evolution: Microevolution, Macroevolution and Tree of life. Theory of organic evolution and the factors in the Darwinian theory. Theory of Punctuated Equilibria. Origin of life: extra-terrestrial and terrestrial. Miller's experiment. Mass extinction and its causes. Use of fossils in palaeoclimatic, paleoecological and palaeogeographic studies. Major fossil discoveries from India.

Unit - 2

Micropalaeontology: scope and subdivisions - types, extraction of microfossils from sediments and sedimentary rocks. Foraminifera: their palaeoecology and application in

paleoclimate, paleoceanography and biostratigraphy. Radiolaria, Diatoms, Ostracoda, Pteropods, Cocolithophores, Stromatolites and Conodonts – morphology, classification and importance. Palynology: General morphology of spores and pollen and their applications. Palaeobotany: Plant life through geological ages. Gondwana plant fossils. Application of microfossils in petroleum exploration. General characteristics, geologic history, classification and evolution of Pisces, Amphibians, Reptiles, Birds and Mammals (Elephant, Horse and Human being). Human fossils from different parts of the world.

Unit – 3

Development of Stratigraphy: Contributions of the pioneers of Stratigraphy, Major incidents in the Earth's History. Stratotype: Unit, Boundary, Holo-, Hypo-, Para-, Neo-, Lecto- stratotypes. Requirements for stratotypes. Establishment of stratigraphic units: Procedures for the establishment and description of surface and subsurface stratigraphic units.

Lithostratigraphy: Procedures for establishing, extending and naming of Lithostratigraphic units. Revision of Lithostratigraphic units. Biostratigraphy: Significance of fossils, Nature of biostratigraphic units – Life communities and Death assemblages. Procedures for establishing and extending biostratigraphic units, Revision of biostratigraphic units. Chronostratigraphy: Formal and Informal chronostratigraphic units, Procedures for establishing and naming of chronostratigraphic units. Sequence Stratigraphy: Stratigraphic Architecture, Depositional systems and systems tracts, Sequence Boundaries. Fluvial, Lacustrine, Eolian, Marginal marine and Shallow Marine, Deltaic and Deep Marine siliciclastic Sequences.

Unit – 4

The concept of the Precambrian. Distinguishing features and classification of the Precambrian. The Problem of the base of the Cambrian. Precambrian stromatolites, their status as time markers and classification of the Late Proterozoic. Distribution of Precambrian rocks in India. Indian Standard stratigraphic column, hiatuses and breaks. Models for the evolution of Precambrian crust. Shields - cratons and mobile belts. Low-grade and high-grade terrains. Precambrian shield areas. Precambrians of southern India. Major Phanerozoic Basins in India: General description, age, development, evolution, stratigraphy and classification of the Gondwana, Kaveri, Kerala and Cambay Basins. Paleogeography and major events during different periods. Age problems in stratigraphy.

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EGE 5191. Lab 1: Structural Geology and Geological Field Mapping (3 credits)

Unit- 1

Preparation and interpretation of geological maps and sections. Structural problems. Recording and plotting of field data. Study of deformation structures in hand specimen. Study of dip isogons from fold profiles.

Unit- 2

Stereographic projection in structural analysis. Application of stereographic projection in solving structural problems. Beta diagram and Pi diagram. Solving problems relating to faults and shear zones.

Unit- 3

Topo sheets: Map scales, features in toposheet, finding the coordinates of points. Surveying - Chain Survey- Plane Table Survey – Leveling- Dumpy Level surveying, Total Station and GPS surveys. Geological field visit and mapping of litho-units in igneous, metamorphic and sedimentary terrains. Identification and Mapping of Faults, folds, foliations, cleavages, lineations, joints and shear zones.

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EGE 5192. Lab 2: Sedimentology and Paleontology (3 credits)

Unit- 1

Sieve analysis, plotting and interpretation of data (Trask method & Folk and Ward method). Estimation of statistical parameters - mean, skewness, kurtosis and standard deviation (sorting). Pipette analysis and estimation of clay content. Plotting of gravel-sand-mud and sand-silt-clay data in triangular coordinate sheets.

Unit- 2

Study and description of hand specimens and thin sections of conglomerate, breccia, sandstone, limestone, mudstone and shale.

Separation of heavy and light minerals from sediments. Preparation of grain mounts and mineral identification

Unit- 3

Sample processing techniques and separation of microfossils from matrix and marine sediments.

Identification of the following types of microfossils (calcareous and siliceous):

Planktonic foraminifera, Benthic foraminifera, Ostracods, Pteropods and Radiolaria.

Identification and separation of important species of planktonic foraminifera.

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EGE 5201. Igneous and Metamorphic Petrology (4 credits)

Unit - 1

Thermodynamics – elementary concepts, stability phase diagrams; thermodynamics of solutions, applications; kinetics. Phase rule and diagrams, phase relations, crystal melt equilibria; Binary, Ternary and Quaternary systems. geothermometry and geobarometry.

Unit - 2

Igneous processes and diversity in igneous rocks. Compositional variation in magmas. Variation diagrams – binary and ternary diagrams. Trace elements in igneous processes – melting and crystallization models – application of trace elements to petrogenesis. Radiogenic tracers. Classification of igneous rocks. Granite and granitic rocks. Ultramafic rocks. Alkaline rocks. Kimberlite and ultrapotassic rocks. Anorthosite and carbonatite. Plume magmatism and hot spots - Large Igneous Provinces and dyke swarms. Taphrogenic intrusives of Kerala.

Unit - 3

Concepts of metamorphism, Role of fluids, Metamorphic structures and textures, Metamorphic reactions; Metamorphic zones, grades, facies, facies-series.

Unit - 4

Metamorphic differentiation; Metamorphism and plate tectonics; Ultra-High Temperature (UHT) and Ultra-high Pressure (UHP) metamorphism. General characteristics of metamorphic domains – contact metamorphism, regional metamorphism; Paired metamorphic belts; Orogeny and Metamorphism; Retrograde metamorphism. Migmatites.

References

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- Wilson, M. (1989), Igneous Petrogenesis, Chapman and Hall, 466 p.
- Blatt, H. and Tracy, R.J. (1996), Petrology (Igneous, Sedimentary, Metamorphic), W.H. Freeman and Co. New York.
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- Powell, R. (1978), Equilibrium thermodynamics in Petrology: An Introduction, Harper and Row Publ., London, 284 p.
- Rastogy, R.P. and Mishra, R.R. (1993), An Introduction to Chemical Thermodynamics, Vikash Publishing house.
- Spear, F. S. (1993), Mineralogical Phase Equilibria and Pressure – Temperature – Time Paths, Mineralogical Society of America, 799p.
- Spry, A. (1976), Metamorphic Textures, Pergamon Press, 350p.
- Winter, J.D. (2001), An introduction to Igneous and Metamorphic Petrology, Prentice Hall 697p.
- Wood, B.J. and Fraser, D.G. (1976), Elementary Thermodynamics for Geologists, Oxford University Press, London, 303p.
- Yardley, B.W.D., Mackenzie, W.S. and Guilford, C. (1995), Atlas of Metamorphic Rocks and their Textures, Longman Scientific and Technical, England, 120p.
- Yardley, B.W. (1989), Introduction to Metamorphic Petrology, Longman, New York, 248p.
- Vernon, R.H. and Clarke, G.L. (2008), Principles of Metamorphic Petrology, Cambridge, 446p.
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- Miyashiro, A. (1994), Metamorphic Petrology, Akiho, Research Press, New Delhi,416p.
- Pitchamuthu. C.S. (1984), Granulites of South India, Geological Society of India.

EGE 5202. Mineralogy and Geochemistry (4 credits)

Unit- 1

Optical properties of minerals: some physical background, refractive index and petrographic microscope, isotropic and anisotropic minerals, polarization and birefringence, optical indicatrix, dispersion, pleochroism. Identification of minerals using a petrographic microscope.

Unit- 2

Mineral genesis: mineral-forming environments, mineral crystallization and deposit types, multi-stage processes, generations and paragenesis, crystal growth, typomorphism of minerals.
Application of modern techniques in mineral studies - XRD, DTA, XRF, ICP, EPMA.

Unit- 3

Origin and cosmic abundance of elements. Geochemical and cosmo-chemical classification of elements. Primary differentiation of elements: Distribution and behaviour of major, trace and Rare Earth Elements (REE's) in igneous, sedimentary and metamorphic environments. Geochemistry of the Earth's crust, mantle and core. Geochemistry of meteorites. Evolution of the solar system and chemical evolution of the Earth.

Unit- 4

Geochemical Cycle. Mobility of elements, Isomorphism, polymorphism and atomic substitution. Basic principles in geochemical exploration: Geochemical environment, surficial and deep-seated environment, geochemical dispersion, - primary and secondary dispersion, association of

elements, indicator elements, geochemical anomaly. Analytical techniques: Methods using Flame photometer, Spectrophotometer, Atomic Absorption Spectrometer, XRF, ICP-MS/AES.

References

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- Philips, F.C., 1963, Introduction to Crystallography, Thomas Nelson.
- Philips, W.R., 1971, Mineral Optics – Principles and Techniques, Freeman.
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- Mason, Brian, Moore and Carleton, B. (1982), Principles of geochemistry, John Wiley&Sons, New York, 344 p.
- Gill, R. (1989), Chemical Fundamentals of Geology, HarperCollins Publishers Ltd, UK, 292p.
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EGE 5291. Lab 3: Igneous and Metamorphic Petrology (3 credits)

Unit- 1

Preparation of binary phase diagrams. Megascopic and microscopic identification of igneous rocks. Normative mineralogical calculations of acid, intermediate, basic and ultrabasic rocks (3 each).

Unit- 2

Preparation of variation diagrams: Harkar, Larsen, Nockold and Allen, Niggli calculation of Fractionation Indices: Larsen Index, Nockolds Index, Mafic Index(MI), Mg-Number, Solidification Index, Felsic Index, Differentiation Index. Spider Diagram.

Unit- 3

Study of metamorphic rocks in hand specimen. Preparation of metamorphic rock thin sections. Study of metamorphic rocks in thin sections: metamorphic mineral assemblages, structures and textures, grain boundary relations, strain effects.

Plotting and interpretation of chemical data on ACF, AKF diagrams, Schreinmaker's rule and construction of petrogenetic grids.

References

- Ragland.P.C (1989). Basic Analytical Petrology, Oxford University Press, 369p.
- Carmichael, I. S. E., Turner, F. J. and Verhoogen, J. (1974), Igneous Petrology, McGraw Hill Book Company, 739 p.
- Ehlers, E. G. and Blatt, H. (1981). Petrology, CBS Publishers and Distributors, New Delhi, 732 p.
- Faure, G. (2001), Origin of Igneous Rocks: The Isotopic Evidence, Springer-Verlag, New York, 496 p.
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- Kerr, P.F. (1959), Optical Mineralogy, McGraw Hill Book Company Inc., New York, 442p.
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- Philpots A.R. and Ague, J.J. (2009), Principles of igneous and metamorphic petrology, second edition, Cambridge University Press, New York, 667p.

EGE 5292. Lab 4: Mineralogy and Crystallography (3 credits)

Unit- 1

Determination of extinction angle, pleochroism; Determination of birefringence – using Michel Levy's chart and Berek's compensator; Determination of interference figure; Determination of optic sign.

Unit- 2

Study of optical characters of the following minerals/mineral groups: olivine, epidote, almandine, pyroxene, amphibole, mica, feldspar and feldspathoid.

Unit- 2

Crystallography - crystalline state - Lattices- Point, Line, Space. Zone and determination of Zone symbols, determination of Axial Ratio and Napier's Rule.
Crystal systems- Symmetry elements of normal (holohedral) classes.
Crystal projection – Spherical projection of cube, octahedron and dodecahedron. Stereographic projection of normal class of Isometric, Tetragonal and Hexagonal systems.

References

- Burger, M.J. (1962). Elements of Crystallography, Wiley.
- Dana,E.S (1962). Text book of Mineralogy Revised by Ford,W.E.,Wiley..
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- Winchell, A.N (1949). Elements of Optical Mineralogy, Part –I Principles and Methods, Wiley, New York.

EGE 5301. Economic Geology

Unit – 1

Mineral resource crisis, factors controlling mineral availability, minerals and global economic patterns, future of ore deposit geology; Geology of ore deposits – classification and deposit models. Textures of ore and gangue minerals; Paragenesis, zoning; Magmatic ore deposits; Hydrothermal ore deposits – magmatic and orogenic environments, sedimentary environments; Ore deposits formed in sedimentary environments; Supergene ores and supergene overprinting of ores.

Unit – 2

Mineral law and land access: National Mineral Policy – MM (R & D) Act, 1957 – procedures for grant of mineral concessions in India; Types of land and mineral ownership in different countries; Exploration versus exploitation concessions. Mineral Economics: History and structure of the mineral industry; Profits in the mineral industry; Mineral taxation and mineral profits; Mineral commodity prices; Distribution of profits. Law of the Sea Treaty – marine mineral resources.

Unit – 3

Mineral resources and exploration; search for ore deposits and chances of success – geological, geochemical, geophysical, drilling, sampling and other field techniques; Remote sensing applications in mineral exploration; Surveying and exploration; statistical treatment of exploration data and computer applications.

Unit -4

Mining terminology; Appraisal of exploration data for mining; Mine planning and development; Life cycle assessment (LCA) method; Open-cast mining methods; Underground mining methods; Alluvial mining and quarrying.
Mine hazard and safety works; Mine monitoring; Mine reclamation.

References

- Banerjee (2001), Mineral Resources of India.
- Evans, A.M., (1980) An introduction to Ore geology, Blackwell Scientific Publications, 231p.
- Evans, A. M. (1993), Ore Geology and Industrial Minerals: an Introduction, Blackwell, 403p
- Geological Survey of India (2009), Miscellaneous publication no. 30, part-xxii: Geology and mineral resources of India,152p
- Geological Survey of India, Detailed information dossier (DID) of ores in India, (Available at GSI portal: www.portal.gsi.gov.in).

- Indian Bureau of Mines Bulletins of Mineral Information (availabile at IBM website) Ministry of Mines Annual Report 2011-12, 248p.
- Mookherjee, A., (1999), Ore Genesis- A Holistic Approach, Allied Publishers, 657p.
- Ministry of Mines (2011), Report of the working group on mineral exploration & development (other than coal & lignite) for the 12th five-year plan sub group – on survey and mineral exploration, 310p.
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- Soman, K. (2001), Geology of Kerala, GeolSoc of India, Bangalore, 335p
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- Uranium 2009: Resources, Production and Demand, (The Red Book) Nuclear Energy Agency, OECD, 452p.
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- Zoellner, T. (2009) Uranium: war, energy, and the rock that shaped the world, Viking, London, 353p.
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- Arthur, W., Hawkes, H.E. and Webb, J.S. (1979), Geochemistry in Mineral Exploration, Academic Press, USA, 657p.
- Banerjee, P.K and Ghosh, S. (1997), Elements of Prospecting for Non-fuel Mineral Deposits, Allied Publishers Pvt Ltd, 320p.
- Kearey, P. and Brooks,M. (1991), An Introduction to geophysical Exploration, Blackwell scientific Publications, Musset, 272p.
- Krisch, R (2006). Groundwater Geophysics, A tool for hydrogeology, Springer – Verlag Berlin Hiedelberg.,Berlin 548 pp
- Lowrie, W (2007). Fundamentals of Geophysics, Cambridge University press, New York, 381pp.
- Mckinstry, H.E. (1947), Mining Geology, 1st Indian Ed., Asia Publishing House, New Delh
- Milsom,J (1989). Field Geophysics, A Geological Society of London Handbook, John Wiley&sons, New York.182 pp.
- Mishra D, C. (2011). Gravity and Magnetic Methods for Geological Studies,BS publications Pvt.Ltd Hyderabad 938pp.

EGE 5302. Hydrogeology

Unit – 1

Definitions of and differences between - Hydrology, Hydrogeology, and Groundwater hydrology. Hydrologic cycle and processes – Precipitation, Evaporation and transpiration, Runoff, infiltration. Water balance. Origin and types of waters – meteoric, juvenile, magmatic and metamorphic. Groundwater storage –Aquifer, Aquiclude, Aquifuge and Aquitard. Types of aquifers – Confined, Unconfined, Bounded aquifers, Sloping Piezometric and Phreatic aquifers. Springs.

Hydrological properties of rocks – Porosity, Permeability, Void ratio, Specific yield and Specific retention, Hydraulic conductivity, Transmissivity and Storativity. Elastcity of aquifers, barometric efficiency and barometric tidal efficiency. Geological fame work in

relation to hydrogeological environment: Rock types and distribution, rock matrix, factures, weathered rocks and superficial materials.

Unit – 2

Groundwater flow - Water table and Piezometric surface - Flow characteristics of water – Head distribution, Laminar and turbulent flow. Darcy's law and its experimental verification. Flow through aquifers. Hydrological boundaries, flow nets. Groundwater tracers. Well hydraulics: Aquifer tests, organization and conduct of pumping tests, data analysis of pumping test, Recovery test, drawdown, cone of depression and cone of impression, Steady radial flow to a well in confined and unconfined aquifers – Thiem's equation and Dupuit-Forhemeir equation. Unsteady radial flow to a well in confined and unconfined aquifers – Theis equation – Theis, Chow and Cooper-Jacob methods – Isotropic non-leaky artesian aquifers.

Unit – 3

Groundwater exploration: Geological and Hydrological methods, Surface investigations of groundwater - Geophysical methods, Electrical Resistivity methods – Wenner and Schlumberger methods, Seismic refraction methods, Gravity and magnetic methods. Application of remote sensing and GIS in groundwater exploration.

Unit – 4

Water well designing - Types and mode of construction – Methods of deep well drilling-construction design – development and maintenance of wells.

Quality of Groundwater: Chemical quality- Different chemical parameters and their analysis, – Sodium Adsorption Ratio (SAR) – Water quality standard for different purposes – Drinking, Domestic, Irrigation and Industrial.

Threats to groundwater quality and reserve: Saline water intrusion in coastal and other aquifers and its prevention – Ghyben-Herzberg relationship. Artificial recharge and rain water harvesting methods.

References

- Bouwer,H. (1978) Groundwater Hydrology. McGraw Hill Education, 480p.
- Davis,S.N. and Dewiest, R.J.N. (1966). Hydrogeology, John Wiley and Sons Inc. New York, 463p.
- Karanth.K.R.(1987). Groundwater Assessment Development and Management, Tata McGraw Hill, 720p.
- Linsley, R.K, Kohler, M.A. and Taulhus, J.L.H. (1975) Applied Hydrology, Tata McGraw Hill, 689p.
- Todd, D.K. (1980) Groundwater Hydrology, John Wiley and Sons, 552p.
- Walton,W.C. (1970) Groundwater Resource Evaluation, McGraw Hill Inc, 664p.
- Reghunath, H.M. (1992) Groundwater. 2nd Edn.Wiley Eastern Limited, 456p.
- Fetter, C.W. (2007) Applied Hydrogeology. Pearson, 624p.

EGE 5391. Lab 5: Ore Geology

Unit- 1

Megascopic study and identification of ore minerals. Preparation and study of polished sections. Gravity, magnetic, seismic and electrical resistivity exploration problems.

Unit- 2
Preparation of litho logs using exploration data. Calculation of grade, tonnage and cut-off grade. Ore reserve estimation.

Unit- 3
Fundamentals of ore dressing: Crushing, grinding, sizing, concentration by washing, scrubbing, jigging, tabling, floatation. Magnetic and Electrostatic separation. Flow-charts of mineral separation.

References

- Arogyaswamy, R.N.P. (1980) Courses in Mining Geology, 2nd Ed., Oxford & IBH Pub. Co., New Delhi
- Banerjee (2001) Mineral Resources of India.
- Banerjee, P.K and Ghosh, S. (1997) Elements of Prospecting for Non-fuel Mineral Deposits, Allied Publishers Pvt Ltd, 320p.
- Kearey, P. and Brooks,M. (1991) An Introduction to geophysical Exploration, Blackwell scientific Publications, Musset, 272p.
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- Sinha, R.K and Sharma, N.L. (1970), Mineral Economics, New Delhi Oxford and IBH Pub.co., 317p.

EGE 5392. Lab 6: Hydrogeology

Unit- 1
Identification and demarcation of watershed boundaries, Collection and interpretation of well inventory data, Determination of groundwater flow direction, Preparation of water table contour map.

Unit- 2
Estimation of permeability. Analysis of hydrographs and estimation of infiltration capacity. Pumping test – Time, Drawdown and time recovery tests. Evaluation of aquifer parameters, Study of depth and yield of bore wells.

Unit- 3
Study of Electric resistivity sounding data for delineation of fresh and saline aquifers. Study of geophysical well logs. Exercises on groundwater exploration using remote sensing techniques. Preparation of ground water potential maps.
Graphical representation of water quality data: various diagrammatic representations – interpretation of hydrochemical data – Hill-Piper Trilinear diagram, Durov's diagram and U.S. Salinity diagram.

References

- Bouwer, H. (1978) Groundwater Hydrology. McGraw Hill Education, 480p.
- Davis, S. N. and R. J. M. Dewiest R. J. M. (1966). Hydrogeology. 463p.

- Karanth.K.R.(1987). Groundwater Assessment Development and Management, Tata McGraw Hill, 720p.
- Patric, A.D., Franklin W.S. (1997) Physical and chemical hydrogeology, ohn Wiley & Sons; 2nd edition, 528p.
- Poehis D.J and Gregory J.S. (2011). Encyclopedic dictionary of Hydrogeology, Academic press, 528p.
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- Fetter, C.W. (2007). Applied Hydrogeology. CBS Publishers & Distributors.

EGE 5490. Dissertation (8 credits)

Independent project work including field and laboratory investigations of geological significance. Preparation and presentation of Dissertation will be in the fourth semester although the work related to the dissertation can be initiated in the third semester itself. The Dissertation entails fieldwork, lab investigations, preparation of report, its presentation and viva voce.

It will have the following components**:**
(a) Literature review and origin of the research problem
(b) Objective/s and Methodology
(c) Observations and the data **recorded by the candidate**.
(d) Details of laboratory investigations,
(e) Synthesis of results and interpretation
(f) Concluding remarks and future direction.

Project work shall be carried out under the supervision of a teacher in the parent department. The candidate may be permitted to work on the project in an industrial / research organization on the recommendation of the supervising teacher and the Head of the Department. In such cases, a teacher from the parent department would be the supervisor/ internal guide and an expert from the industry/ research organization the co-supervisor/ external guide. Every student has to do the dissertation work independently. The project title, content and layout should be unique. The project reports of students should not be identical in content.

EGE 5491. Field Geology (3 credits)

Unit -1
Principles of geological field studies and mapping. Preparations for field studies and mapping. Selecting and preparing a base map. Field equipment. Geological symbols and notations. Lithological and structural mapping. Identification and recording of rock types and structures in the field. Locating points in the field. Measurement and recording of field data. Finding and tracing the contacts between rock units, correlating geologic units, mapping geologic structures, outcrop maps, —locating field data and geologic features in the map.

Unit- 2
Locating points in the field. Measurement and recording of field data. Finding and tracing the contacts between rock units, correlating geologic units, mapping geologic structures, outcrop maps, —locating field data and geologic features in the map.

Unit- 3

Preparing final geological map and reports: Report writing, major illustrations, photographs, drawings, diagrams, designing the report, format and specific parts of the report.
Field studies in terrains of geological significance and preparation of reports.

References

- Richard J. Lisle, Peter Brabham and John W. Barnes (2011). Basic Geological Mapping (Geological Field Guide). Revised 5th Edition. Wiley-Blackwell.
- Angela L. Coe (2010). Geological Field Techniques. 1st Edition. Wiley-Blackwell. 336p.
- Lahee, F.H. (2002). Field Geology. 6th Edition, CBS Publishers.

ELECTIVE COURSES

EGE 5001. Industrial Minerals and Gemstones (3 credits)

Unit – 1

Industrial Minerals - Mode of occurrence - Uses and distribution in India - Ceramic minerals, Granite and Building stones, Cement - Raw materials - Mineral pigments - Refractory and abrasive minerals - Fertilizer minerals- Diamond - Gemstones, Asbestos, Mica, Vermiculite, Barite, Talc, Glass, Sand and Fullers earth.

Unit – 2

Introduction to Gems – Precious and Semiprecious stones and their economic importance. General characteristics and chemical composition of gemstones. Physical characteristics: Form, cleavage, fracture, hardness and specific gravity; Optical characteristics: colour, lustre, refractive index, reflectivity, pleochroism, and dispersion.
Introduction to special optical properties of gemstones: Chatoyancy, Asterism, Luminescence, Play of colours, Labradorescence, Inclusions.
Formation of gemstones. Qualities and Classification of gem materials

Unit – 3

Gem Testing- Refractometers, Polariscope, Dichroscope, Ultra-violet lamps. Principles and Uses. Application of ultra-violet rays, X-rays and Infra-red rays in gem identification. Electrical, thermal and magnetic characters of gemstones. Methods of determination of specific gravity. Distinction between synthetic and natural gemstones. Gem enhancement methods: Polishing, Carving and engraving, colourless/coloured impregnation, heat treatment, coating, irradiation, diffusion, treatment etc. Utility of gemstones: (1) Technical applications and (2) Use as jewels. Occurrence of gems in India. Gem Industry in India.

References

- Anderson B. (2014). Gem Testing, Sutton Press.
- Babu T. M. (1998). Diamonds in India, Geological Society of India, Bangalore.
- Bates, (1969). Geology of Industrial Rocks and Minerals, Dover book earthsciences.
- Baumgart, W., Dunham A.C., and Amstutz, G.C. (1985). Process Mineralogy of Ceramic Materials. Elsevier Science Ltd.
- Cally Hall (1994). Gemstones, Dorling Kindersley.
- Deb, S. (1980). Industrial Minerals and Rocks of India, Allied Publishers (P) Ltd.

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- Krishnasamy, S. (1972). India's Mineral Resources, Oxford and IBH Publishers.
- Taggart, A.P. Hand book of Mineral dressing, John Wiley & Sons Inc., 1905p.

EGE 5002. Engineering Geology (3 credits)

Unit – 1

Physical and engineering properties of rocks – bulk density, unit weight, specific gravity, porosity, dry and saturated unit weights; Rock deformation and mechanical properties – Hooke's law, volumetric strain, elastic moduli, compressive, tensile and shear strength, stresses. Principal geological factors affecting engineering projects – Earth movements, stability of slopes and cuttings, groundwater, volcanoes, earthquakes; Geological materials used in construction.

Unit – 2

Geological considerations in engineering projects such as dams, reservoirs and tunnels. Various types of support, Geological consideration in the selection of dam site and reservoir, transportation routes - Bridges and highways. Methods of tunnelling; Classification of ground for tunnelling purposes;

Unit – 3

Mass Movements with special emphasis on landslide and causes of hill slope instability. Classification of landslides. Geological investigation of landslides. Landslide hazard zonation mapping using remote sensing, GIS-subjective, and objective rating techniques – mitigation measures. Aseismic design of buildings; influence of geological conditions on foundation and design of buildings. Earthquake-resistant structures. Seismicity in India and seismic zonation maps.

References

- Arogyaswamy, R.N.P (2017). Courses in Mining Geology. Oxford and IBH Publishers, 735p.
- Hartman H. L. and Mutmansky, J.M. (2002). Introductory mining Engineering, John Wiley and Sons Inc.
- Gaudin, A .M. (1938) Principles of Mineral Dressing, McGraw Hill, 554p.
- Petters, W.C. (1987) Exploration and Mining Geology. John Wiley, 706p.
- Reedman, J.H. (1979) Techniques in mineral exploration, Allied Scientific Publishers, 534p.
- Bell, F.G. (1983) Fundamentals of Engineering Geology. Butterworth-Heinemann, 656p.
- Coduto, D.P. (2001) Geotechnical Engineering –Principles and Practices. Prentice Hall of India, Pvt Ltd, New Delhi.
- Duggal, S.K. Pandey, H.K. and Rawal, N. (2014) Engineering Geology, McGraw Hill Education (India) Pvt. Ltd.
- Lee. F. and Griffiths (2007). Engineering Geomorphology, Whittles publishing, 288p.
- Krynine, D.P. and Judd, W.R. (2001) Principles of engineering geology and Geotectonics, CBS Publishers and Distributers, New Delhi.

EGE 5003. Geospatial Technology (3 credits)

Unit – 1

Concepts and foundation of remote sensing: energy sources and radiation principles, energy interactions in the atmosphere, energy interaction with earth surface features – Spectral Reflectance - Spectral Response Patterns - data acquisition and interpretation, reference data – elements of photographic system - Introduction to aerial photographs and aerial photo interpretation. Binocular-Mirror-pocket Stereoscopes. Photogrammetric problems.

Introduction to remote sensing- land use-land cover mapping-NDVI. Applications of remote sensing in Geology, Natural resource management, Water resources management; Disaster management and Environmental management.

Unit – 2

Photogrammetry: basic principles – geometric characteristics of aerial photographs - visual image interpretation – stereoscopes –photogrammetric workstations – landform identification and evaluation. Applications of photogrammetry in Geology, Natural resource management, and Urban planning and management.

Geodesy: Ellipsoid – Geoid. Datums – datum shift, datum transformation. Geographic coordinates. Cartesian coordinates. Coordinate conversions. Map projections. Global Positioning System: Basic features, GNSS, NAVSTAR GPS, GLONASS, IRNASS.

Unit – 3

Fundamentals of Geographic Information System – data input, data management, data manipulation, data output. Data Input and Editing: Coordinate Conversion. Digitizing, data encoding, re-projection and transformation. Vector and Raster data analysis. Interpolation and overlay techniques. Preparation and layout of maps. Query analysis. Familiarization of different GIS environments including proprietary and open source such as ArcGIS, QGIS and GRASS. Introduction to Web GIS –Definition- concept-components. Applications of GIS in Geology, Natural resource management, mapping, Urban planning, Water resources management; Disaster management; Environmental management and public health.

References

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- Sickle, J. V. (2010), Basic GIS Coordinates, CRC Press, FL, 190p.

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EGE 5004. Coal and Petroleum Geology (3 credits)

Unit – 1

Origin of coal: accumulation of vegetative matter - *in situ* and drift theories; stages of formation of coal.. Classification, Ranks and Grading of coal.

Petrography of coal: lithotypes, macerals and microlithotypes. Coal-bed Methane as an energy resource. Physical and chemical characteristics of coal. Geological and geographical distribution of coal deposits in India.

Unit – 2

Origin of petroleum- organic and inorganic theories. Transformation of organic matter into petroleum; Kerogen, transformation and maturation of kerogen. Primary and secondary migration of oil and gas. Reservoir rocks: classification and characteristics; Structural traps, stratigraphic traps and combination traps for oil and gas accumulation.

Unit – 3

Global distribution of oil and gas through geologic ages. Petroliferous basins of India. Geological setting of major oil and natural gas fields of India. The surface indications and direct detection of hydrocarbons. Introduction to the oil belts of the world. An outline of well-site geological techniques and exploration techniques. Introduction to basin analysis.

Gas hydrate and shale gas – origin and extraction.

References

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EGE 5005. Environmental Geology and Disaster Management (3 credits)

Unit – 1

Our environment - an introduction. Fundamental concepts of environmental geology, History of environmental degradation.

Land-use and its Management – Land as a Resource, Spheres of land management, Land capability Management, Human settlement and Land use, Slums, requirement of urban planning, Rural planning, Land use pattern in India. Soil conservation- Strategy, Practices in hilly areas, Controlling gully erosion in ravine lands, Shelter belts in deserts.

Unit – 2

Energy and environment-Global aspects, Indian aspects, Energy from fossil fuel, alternative energy, Environmental impacts of quarrying and mining, Waste management. Environmental pollution- land, air and water. Hazards- Introduction to key concepts, terminology. Natural hazards – Geologic and atmospheric. Earthquake, Landslide, Tsunami, Flood, Drought, Cyclone, Volcanic eruption, and Avalanche.

Unit – 3

Hazard, vulnerability, Exposure, Risk, Crisis, Disasters, Significant aspects of disasters, Disaster risk reduction, Risk management framework, Integrated Disaster risk management and post-disaster response. Natural disasters and their management- Problems, prospects and case studies. Climate change and its impact on coastal environment. Coastal management planning. Disaster management process- Prevention, preparedness, Mitigation, Application of Information technology in Disaster Preparedness, Application of geospatial technology in disaster management, Trauma and Stress management, First Aid and Emergency procedures, Early Warning systems.

References

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- www.ndma.gov.in
- www.sdma.ker.in

EGE 5006. Water Resource Management (3 credits)

Unit –1

Introduction to water resources - Ground water, Surface water, Glaciers and Rainwater. History of water resource development, Global water resources, Water cycle, Relation between water resources and environment. Concept of Integrated Water Resource Management (IWRM). Need for Water Resource Management, available water resources, Water scarcity- Lowering of Ground water level, vanishing of fresh water ponds, lakes and wet-lands.

Unit –2

Water supply Planning and Management-Domestic, agricultural and industrial. Cost-benefit analysis in water resource planning, Planning of watershed conservation practices, artificial recharging, contour bunding, sub-surface dams, geo-textile, rainwater harvesting. Estimation of available water resources. Water budgeting. Artificial reservoirs, construction of dams, Design and Planning of Distribution system- Drinking water, Irrigation water, Canal design, principles of irrigation, evapo-transpiration.

Unit –3

Water quality- pollution, Chemical and biological. Different Water quality standards. Water analysis techniques – Rainfall data, Acidic and alkali rain, Soil moisture analysis, evaporation, transpiration, Flood frequency analysis, rainfall - runoff analysis, reservoir function study, Generation of hydro-electric power. Treatment of waste water. Desalination methods.

References

- Cech Thomas V. (2003) Principles of water resources: History, development, management and policy. John Wiley& Sons.
- Todd, D.K. (2004) Ground Water Hydrology, John Wiley & Sons, 636p.
- Karanth, K.R. (1987) Groundwater Assessment, Development and Management. Tata McGraw Hill, New Delhi, 720p.
- Mays, L.W. Water resource engineering, John Wiley& Sons

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- Jain S.K. and SnghV.P.,Water resources system planning and Management Elsevier
- Walton, W.C. Ground Water Resources evaluation, McGraw-Hill.

EGE 5007. Isotope Geology (3 credits)

Unit – 1

Isotope geochemistry: Physical and chemical properties of isotopes; stable and unstable isotopes. Unstable or radio-isotopes**:** radiometric dating methods, Principles of isotope dating. U –Th - Pb methods, principles, merits and demerits. K-Ar method. Ar gain, Ar loss and their effects. Ar^{40} - Ar^{30} method . Rb–Sr method. Whole- rock and isochron methods. Sr loss. Sm - Nd method. Rb - Sr and Sm - Nd ratios and their significance. Fission track dating. ^{14}C dating. Suitability of samples or materials for dating. Preparation of samples for dating. Interpretation of isotope dates. Limitations of isotope dating. Distribution of dates in space and time.

Unit – 2

Stable Isotopes**:** Geochemistry, Notation. Theoretical Considerations. The Mass Spectrometer- principles, components and sensitivity. Thermal-ionization mass spectrometry (TIMS), ICP-MS, LA-MS, Secondary-Ion Mass Spectrometry (SIMS). Measurement of stable isotopes using isotope ratio Mass Spectrometer (IRMS). Isotope Fractionation in Hydrologic and Biological Systems.

Carbon Isotope Fractionation during Photosynthesis. Nitrogen Isotope Fractionation during biological processes. Oxygen and Hydrogen Isotope Fractionation during precipitation, evaporation and absorption by Plants. Paleoclimatology. The Marine Quaternary $\delta^{18}O$ Record and Milankovitch Cycles.

Unit – 3

Sulfur Isotopes and Ore Deposits. Stable Isotopes in the mantle and magmatic system. Stable Isotopic Composition of the Mantle. Boron isotopes. Stable Isotopes in Crystallizing Magmas. Combined Fractional Crystallization and Assimilation.

Isotope Geothermometry. Paleothermometer, carbonate thermometer, $^{18}O/^{16}O$ isotope composition of silicates and high-temperature thermometry, isotopic cycle of water, Paleothermometry and the water cycle: paleoclimatology, paleoclimatic records: sediment and ice. Carbonate paleoclimatology.

References

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- Baskaran, M. (ed) (2011), Handbook of Environmental Isotope Geochemistry, Springer-Verlag, Berlin, 943p.
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EGE 5008. Quaternary Geology (3 credits)

Unit – 1

Definition of Quaternary; concept and importance of Quaternary, Quaternary chronostratigraphic unit, standard sub-divisions of the Quaternary Period and their climatic significance, standard global stratotype sections, Plio-Pleistocene boundary. Quaternary Glaciations – causes, pattern of glacial-interglacial cycles and associated eustatic changes. Milankovitch orbital cycles. Lines of evidence for Recent and historical sea level fluctuations; Ice core records of glaciations during the Pleistocene and Holocene; Pleistocene faunal extinctions.

Unit – 2

Tools for Quaternary studies- application of Oxygen Isotope Stratigraphy (OIS), biostratigraphy and magneto-stratigraphy. Paleoclimatic archives and Proxies for paleoenvironmental/ paleoclimatic changes. Various Archives of Quaternary history: tree rings (dendrochronology), corals, speleothems (cave deposits), peat deposits, ice cores, lake sediments, marine sediments, glaciers, fluvial deposits. The 'proxy indicators' for the reconstruction of Quaternary environments--geological, geochemical (major and trace elements), biological (microfossils, pollen), sedimentological, isotopic (oxygen, carbon and nitrogen isotopes) and magnetic proxies.

Unit – 3

Quaternary dating methods – Radiocarbon chronology - other radiogenic clocks. Fission track and thermoluminescence dating methods. Planetary clocks. Quaternary Stratigraphy of India– continental records (fluvial, glacial, aeolian, palaeosols and duricrust); marine records.

References

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- Mathur, U.B., (2006): Quaternary Geology, Indian Perspective, Geological Society of India, Bangalore, Vol: 67, 344p.

EGE 5009. Structural Analysis (3 credits)

Unit – 1

Deformation: Translation – Rotation – Dilation – Distortion. Deformation and changes in length and angle. Rheology. Geological significance of displacements. Deformation mechanisms and processes: Cataclastic flow – pressure solution – intracrystalline deformation – recrystallisation – diffusion – grain boundary sliding.

Unit – 2

Principles of displacement and strain. Homogeneous and heterogeneous strain. Finite strain theory. Stress-Strain diagrams. Factors affecting stress-strain relations. Concept of strain ellipse. Rapid methods of strain determination. Strain analysis- analysis of strain in linear, initially circular/spherical objects. Various methods of strain analysis. Strain partitioning. Strain in three dimensions. Simple and pure shear. Shear zones - geometry and classification. Shear indicators. Shear zone rocks - Mylonites and fragmental rocks produced by shearing. Shear sense indicators, Stress-strain relationships in different types of shear zones. Deep crustal fluids and shear zones. Shear zones of Southern India.

Unit – 3

Fabric development: Progressive deformation. Rotation, pressure solution, recrystallisation and plastic deformation of grains. Tectonites – S and L tectonites.Microfabric analysis – sampling techniques. Modern techniques in microstructural analysis – 4-axes Universal stage – X-ray texture goniometry – Transmission Electron Microscopy – SEM-EBSD. Fabric symmetry – Crystallographic Preferred Orientation – Lattice Preferred Orientation. Kinematic analysis.

References

- Dennis, J.G. (1987), Structural Geology: an introduction, Wm.C.Brown Publishers, Dubuque, 437 p.
- Ramsay, J.G. (1967), Folding and fracturing of rocks, Mc. Graw Hill, New York, 563 p.
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EGE 5010. Planetary Geoscience (3 credits)

Unit – 1

Milky Way and the solar system. Modern theories: condensation and accretion of planets and other planetary bodies. Members of the solar system. The Sun-Planetary and Orbital characteristics. General characteristics of the terrestrial planets- crust, surface features, thermal history, volcanism

Unit – 2

Moon: The Earth-Moon System, General Physiography, Atmosphere, Tectonic features, Craters, Degradational features, History of the Moon and time scale, Lunar volcanism, Lunar rocks, soil and internal structure, Lunar phases and cycles, Lunar influence on Earth.
Mars: Phobos and Dimos, Physiography, Atmosphere, Craters, Volcanism, Tectonism, Hydrology, Martian rocks and soils.

Unit – 3

Meteorites: Chondrites, SNC meteorites, Refractory inclusions, Iron meteorites and Parent body cooling rates, meteorite chronology.
Asteroids: Classification and composition, Surface features, Asteroid sources, Asteroid impacts on the Earth. Comets and other Icy bodies. Planetary images, Digital and Analog studies of Martian, Lunar samples with those of Earth samples. Planetary missions. Lunar and Mars Missions. Chandrayan and Mangalyan.Exploring the planets and asteroids for minerals.

Reference

- Condie, K.C. (2011): Earth as an evolving Planetary system, II edn. Elsevier, Amsterdam, 574p.
- Dalrymple, G.B. (1991): The Age of the Earth, Stanford University Press, California, 474p
- de Pater, I and Lissauer, J.J. (2010): Planetary Sciences, Cambridge University Press, 2nd Edition. 326p
- McBride, N and Gilmour, I (Eds) (2004): An introduction to the solar system, Cambridge University Press, 269p
- Seeds, M and Backman, D. (2010): The Solar System, Brooks/Cole, 7th Edition, 326p.

EGE 5011: Oceanography (3 credits)

Unit- 1

Ocean floor: Morphologic and tectonic domains. Bathymetric features- Submarine Canyons, Mid-Ocean ridges and Trenches. Morphologic and tectonic domains of the Indian Ocean. Origin of ocean basins. Physico-chemical characteristics and chemistry of seawater: temperature, salinity, density, light transmission, sound transmission in seawater. Gases in seawater. Carbon dioxide and pH of seawater- ocean acidification. Instruments used in the study of seawater.

Unit- 2

Offshore exploration techniques: Instruments and Measurements-Position fixing systems-GPS. Sampling devices - Grabs, Dredgers, Corers, Water Samplers. Various platforms for ocean studies. Tools for studying the ocean floor: Echo-sounding methods, Side scan Sonar, Current meters, SCUBA diving-submersibles. Ocean floor drilling - JOIDES, DSDP, ODP, IODP.

Unit- 3

Marine sediments: Distribution and geochronology of marine sediments. Eustatic changes of sea level and its effects. Calcite Compensation Depth (CCD). Turbidity currents and turbidites. World ocean circulation patterns— ocean water masses; role of ocean in deciding global climate. Paleoceanography, Paleoceanographic reconstructions based of microfossils. UN Convention on the Law of the Sea (UNCLOS)- EEZ-coastal zone environment and its protection - CRZ Act. Mineral resources of the ocean basins, factors controlling their distribution. Origin and distribution of polymetallic nodules.

References

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- Pinet, P.R. (2000): Invitation to Oceanography, II edn., Jones & Bartlett.
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- Sverdrup, H.V. et al. (1961): The Oceans, Asia Publishing House.
- Trujillo, A.P and Thurman, H.V. (2013): Essentials of Oceanography, Pearson, Boulevard.

EGE 5012: Climatology (3 credits)

Unit-1

Fundamental principles of climatology. Atmosphere, its composition and structure. Greenhouse effect. Earth's radiation balance; latitudinal and seasonal variations of insolation, temperature, pressure. Fundamentals of meteorology, Scales of meteorology, Parameters of meteorology- pressure, wind, temperature, humidity, radiation; Radiation: Radiation laws, short wave and long wave radiations; Albedo; Emissivity; Radiation Budget of Earth.

Unit-2
General circulation of the atmosphere: Hadley cells, tropical easterlies, westerlies, polar easterlies, monsoon, Jet streams, tropical cyclones, local winds. Coriolis Effect and geostrophic winds. Cloud classification, condensation nuclei, growth of cloud drops and ice-crystals, precipitation mechanisms: Bergeron process, coalescence process. Types of precipitation, artificial precipitation. Electric field in the atmosphere.

Unit-3
Climate variability and forcings, causes and impacts of climate change, feedback processes, low frequency variability, Madden-Julian Oscillation (MJO), ENSO, QBO (quasi-biennial oscillation) and sunspot cycles. Classification of climate – Koppen's and Thornthwaite's schemes of classification. Synoptic weather forecasting, prediction of weather elements such as rain, maximum and minimum temperature and fog; hazardous weather elements like thunderstorms, duststorms, tornadoes.

References:

- Lal, D. S. (2011) Climatology, Sharda Pustak Bhavan.
- Critchfield, H. J. (2009) General climatology, PHI Learning, New Delhi.
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- Siddhartha, K. (2016): Climatology-Atmosphere, weather and climate. Kitab Mahal, New Delhi.
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- Stringer, E. T. (1972) Foundations of Climatology, W.H.Freeman & Co Ltd.

EGE 5013: Mineral Wealth of India (3 credits)

Unit-1
Comparison between Global and Indian mineral resources and reserves; Strategic, critical and essential minerals of India. State-wise share of mineral production in India.

Unit-2
Mineral Deposits of India: Iron ore deposits – Mineralogy, classification, grade, origin and distribution in India, BIF – BHQ, BMQ, Iron ore deposits especially of Kerala, Bihar, Orissa and Karnataka.

Types, grades, mineralogy, uses, origin and Indian occurrences of: Manganese ore deposits (especially of Bihar, Orissa); chromium ore deposits (especially of southern India), Bauxite deposits (classification based on origin and shape); and copper ore deposits (especially of Khetri and Malanjkhand). Origin and occurrence of Lead and Zinc, Mica, Gold, PGE, Diamond, Uranium and Thorium deposits.

Unit-3
Mineral Deposits of India. Placer deposits of Kerala – General geologic and geomorphic setting, Ilmenite and rutile, monazite, Zircon, Sillimanite, Garnet, origin of Chavara Placer deposits, silica sands.
Non-metallic deposits – Refractory minerals: acid refractories – silica – Clay Deposits: Origin and Mineralogy, china clay deposits of Kerala – Kyanite – Neutral refractories: chromite – graphite – asbestos – Basic refractories – Magnesite – dolomite. Minerals used in Fertilizer

industry: phosphorite, apatite. Minerals used in Cement industry: limestone – gypsum. Minerals used in Chemical industry.

References

- Banerjee (2001), Mineral Resources of India.
- Geological Survey of India (2009), Miscellaneous publication no. 30, part-xxii: Geology and mineral resources of India,152p
- Geological Survey of India, Detailed information dossier (DID) of ores in India, (Available at GSI portal: www.portal.gsi.gov.in).
- Indian Bureau of Mines Bulletins of Mineral Information (availabile at IBM website) Ministry of Mines Annual Report 2011-12, 248p.
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- Nuclear Power in India Indian Nuclear Energy, http://www.world-nuclear.org/info/inf53.html
- Prasad, U (2002), Economic Mineral Deposits, CBS Publishers, New Delhi.
- Soman, K. (2001), Geology of Kerala, Geol. Soc. of India, Bangalore, 335p.

EGE 5014: Geostatistics (3 credits)

Unit-1

Introduction to statistics: sampling, data collection, random variables, probability, frequency function; Applications of statistical methods in earth sciences – quantification and prediction. Univariate statistical methods, frequency analysis, simulation; Statistical distributions.

Unit-2

Stochastic modelling and forecasting – introduction, modelling, applications, spectral analysis; Concepts of regionalized variables and variogram modelling; Concepts of dispersion, extension and estimation variances.

Unit-3

Kriging variance and procedure, simple kriging; Introduction to advanced geostatistics; applications of computer programs for statistical calculations – open source statistical programs

References

- Sarma D.D., Geostatistics with applications in Earth Sciences, Springer Publ., pp.205.
- J.-P. Chiles and P. Delfiner, Geostatistics; Modeling spatial uncertainty, Wiley Publ., pp.731.
- H. Wackernagel, Multivariate Geostatistics, Springer Publ., pp.257.
- Kitanidis, P.K., Introduction to Geostatistics, Cambridge University Press., pp.271.
- C. Lantuejoul, Geostatistical Simulation, Springer Publ., pp.262.
- J. Awange, B. Palancz, R.H. Lewis, L. Volgyesi, Mathematical Geosciences, Springer Publ., pp.615.
- Olea, R.A., Geostatistics for Engineers and Earth Scientists, Springer Publ., pp.309.

EGE 5015: Physical Geology (3 credits)

Unit – 1

Introduction to Earth systems. Earth's interior and geophysical properties – internal structure, isostasy, gravity measurements, magnetic field, geothermal gradient and heat flow. Sea floor – features, seamounts, guyots and aseismic ridges, reefs; age of the sea floor. Plate tectonics – history, plates and plate motion, causes for plate motion.

Unit – 2

Mountain belts and the continental crust – characteristics, thickness and density of rocks, features of active mountain ranges; evolution of mountain belts; growth of continents. Geologic structures – tectonic forces at work, structures as a record of geologic past, folds and faults. Time and Geology – key to the past, relative time, numeric age, age of the Earth.

Unit – 3

Internal geological processes – igneous and metamorphic. External geological processes - weathering and soil, soil mechanics, mass wasting; Action of wind, water, glaciers; Waves, beaches and coasts. Geologic resources.

References

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service in a scale of pay is required for counting for promotions to next higher stage.

The Deans' Committee Meeting (18.07.2017) has also expressed their views favoring PDF experience only for Direct Recruitment.

Finally, it was decided to write to UGC for clarification on counting PDF experience equivalent to that of teaching experience with regard to CAS promotions.

The Academic Council members congratulated the IQAC for their commendable work on CAS & Direct Recruitment aspect finalization in tune with the UGC regulations. The AC has approved the formats and all guidelines and recommended for further approval of Executive Council.

The IQAC team requested for an Administrative approval for publishing the CAS & Direct Recruitment formats.

The Vice Chancellor informed that, the administrative approval will be given after obtaining approval from the Executive Council.

3:02:04	***Starting of Open and Distance Learning (ODL) at Central University of Kerala-reg:-***

The Academic Council appreciated the initiative of the University for starting Open Distance Learning Programmes (ODL) at the Central University of Kerala and offered its best wishes to Dr. Mohamedunni Alias Musthafa, the designated Nodal Officer to launch the ODL Programmes.

A crucial decision in launching of ODL may be required with regard to fund position. Even though, ODL Programmes are entitled for loan and grant facility, some amount of initial investment is required from the part of University. The Vice Chancellor requested the co-operation of all faculty in designing Courses in this regard.

It was also decided by the Academic Council to start Diploma and Certificate Courses for the ongoing students to begin with the ODL Programmes. The Proposal to setup ODL will be submitted to Executive Council for approval.

3:02:05	***Approval of BoS Meeting Minutes and Syllabus for the Academic year 2017- 18 - reg:-***

The Academic Council approved the BoS and Minutes concerning of the following Departments:

- *Dept. of Linguistics:* The BoS of the Department met on 13th October 2016 and revised the syllabus of PG programme in Linguistics and Language Technology. This has the effect from June 2017-18 admissions.
- *Dept. of Education* The BoS met on 2nd June 2017and resolved to approve;
  - The Scheme, Regulations and Syllabi for the three year Integrated B.Ed.-M.Ed. and four year Integrated BSc-B.Ed. programmes.
  - To start a Centre for Life Skill Education under the School of Education.
  - Approve the Scheme, Regulations and Syllabi for the Certificate Course in Life Skills and Post Graduate Diploma programme in Life Skill Education.
- Master of Public Health: The first BoS met on 16th and 17th of May 2017 has recommended for some modifications in the eligibility criteria for MPH admissions. A sub-committee for reviewing the added qualifications of Master of Public Health (MPH) has been constituted with Director of Research (DoR) , Dean, School of Medicine and Public Health (SMPH) and the Dean School of Biological Sciences (SBS). Other members will be chosen soon by the Vice Chancellor.
- Dept. of Geology: The first meeting of BoS met on 27th July 2017 has approved and ratified the MSc Geology curriculum prepared by the Consultative committee.
- Hindi and Comparative Literature: The first meeting of BoS met on 8th July 2017 and streamlined syllabus with additional courses. The total credits for successful completion of 4 Semester Course have been modified from 64 to 72 credits as per CBCS regulations.
- *Dept. of Environmental Science:* The BoS which met on 7th July 2017 has approved the modified Syllabus of MSc Environmental Science after a thorough discussions on the contents of the Core and Elective papers.

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DEPARTMENT OF GEOLOGY

No. CUK/GEO/BOS/MIN/2017/01 Dtd: 27/07/2017

Minutes of the 1st Meeting of Board of Studies in Geology held at Conference Hall, Central University of Kerala, Perive at 10.30 a.m. on 27/07/2017

The Department of Geology, Central University of Kerala conducted the Board of Studies (BoS) meeting on 27th July, 2017. It was the first BoS meeting since the establishment of the department in 2016. The venue was Conference Hall, Central University of Kerala, Main Campus, Periya. The meeting started at 10.30 am and ended at 2.30 pm. The panel members included invited subject experts, Head of the Department and internal members. The attendees of the meeting were as follows: -

BoS Attendees:
Invited subject experts

- Dr. R. Shankar, Professor, Dept. of Marine Geology, Mangalore University, Mangalagangothri-574199
- Dr. V. Prasannakumar, Professor (Rtd) and Emeritus Fellow, University of Kerala
- Dr. Ganesha Raj, General Manager, Regional Remote Sensing Centre- South, NRSC, ISRO, Bengaluru-560037
- Shri. Suresh Chandran, Dy. Director General (Rtd), Geological Survey of India, Thiruvananthapuram.

Internal members from the Central University of Kerala

- Dr. Sandeep K, Assistant Professor and HOD (i/c), Dept. of Geology,
- Dr.Pratheesh P, Assistant Professor, Dept. of Geology.
- Dr.Jeyabalan Sangeetha, Assistant Professor, Dept. of Environmental Science.

The BoS meeting started with the welcome address by Dr.Sandeep K, Head of the Department (i/c). Dr.Sandeep gave a brief introduction of the Dept. of Geology as well as the objectives of the BoS. Thereafter, he welcomed all experts and faculty to the meeting, and briefed the agenda of BoS meeting.

The agenda for discussion in the BoS meeting was proposed by the Head of the Department. The main items discussed in the BoS are given below:

1. The approval and ratification of the M.Sc. Geology Curriculum prepared by the Consultative Committee.

2) Consider and decide on proposals from the Faculty Council regarding curriculum.

(a) The inclusion of elective course 'Oceanography' and the syllabus thereof (Annexure 1).

(b) The inclusion of core course 'Palaeontology Practical' and the syllabus thereof (Annexure 2).

(c) The inclusion of elective course 'Climatology' and the syllabus thereof (Annexure 3).

(d) The inclusion of elective course 'Geotectonics' and the syllabus thereof (Annexure 4).

(e) Changing the GEOL-5303 core course title from 'Exploration Geophysics' to 'Exploration Geology'.

(f) Modification in the core courses GEOL5106 (Survey and Geological Field Training) GEOL5206 (Field Geology) (Annexure 5 and 6).

(g) The inclusion of B.Sc. triple main course offered by many universities (with geology as one of the main subjects) as eligibility for admission to M.Sc. Geology Programme.

3. Any other matter permitted by the Chair.

The details of agenda-wise discussion and the final recommendation by the BoS are given below.

Agenda 1: The approval and ratification of the M.Sc. Geology Curriculum prepared by the Consultative Committee.

The syllabus of M.Sc. Geology Programme was discussed course-wise.

1.1. GEOL 5101: Geomorphology

Dr. Sandeep inquired whether some of the contents in the course can be elaborated. In particular, the 'Theories of landscape evolution' can be elaborated by mentioning the models such as 'Davis, Penck, Hack, Morisawa and King's'. Dr.Prasannakumar replied that if some points in the course need to be elaborated, it can be done. Dr. R Shankar opined that 'Classification of sediment constituents' can also include biogenic and organic deposits also.Dr. Sandeep inquired whether some portions of the course can be deleted as it is already studied by students in graduate level. However, Dr.Prasannakumar pointed out that it can be retained. Dr.Ganesha Raj suggested to include more references in the course particularly the book by 'A L. Bloom'.Dr.JeyabalanSangeetha inquired whether it is possible to complete whole course content within a semester. Dr. Ganesh Raj also opined that the syllabus itself is too heavy. However,

Dr.Prasannakumar suggested that some of the portions can be coveredas seminar and assignment topics.

Recommendation: Following a detailed discussion on the contents, the members approved the course 'Geomorphology' with minor modifications like elaboration of some points and adding a few more references.

1.2. GEOL 5102: Structural Geology

Dr.Pratheesh P inquired whether the word 'mechanical properties' in Unit-1 can be replaced with 'deformation'. However, Dr. Prasannakumar and Dr. Suresh Chandran opined that it can be retained as such. Dr. Ganesh Raj suggested that more references can be added particularly the book by 'Billings'.

Recommendation: Following a detailed discussion on the contents, the members approved the course 'Structural Geology' with addition of a few more references.

1.3. GEOL 5103: Palaeontology

Dr. Ganesh Raj suggested that a portion on 'applications of palaeontology' in various fields especially in oil field can be added in the course syllabus. Dr.Prasannakumar and Shri. Suresh Chandran opined that a portion on 'palynology' can be added in Unit-3. Shri Suresh Chandran also opined that the palaeontology course can be shifted to third semester whereas sedimentology and sedimentology practical can be shifted to first semester. Dr. R Shankar pointed out that the term 'classification' is redundant in Unit-3 and the term 'human' can be used instead of 'man' in Unit-4. He also suggested including total number of pages and year of publications in many of the references.

Recommendation: Following a detailed discussion on the contents, the members approved the course 'Palaeontology' with minor modification and revision of the course content and references. Members also recommended to shift the course from First semester to Third Semester.

1.4. GEOL 5104: Structural Geology Practical

Dr.Pratheesh suggested to include '3 point problems' in the course. All the members of BoS consented to this suggestion.

Recommendation: Following a detailed discussion on the contents, the members approved the course 'Structural Geology Practical' with minor modification and revision of the course content.

1.5. GEOL 5105: Mineral Opties Practical

Shri. Suresh Chandran inquired how Mineral Opties Practical can be taught without theory course. Dr.Prasannakumar replied that the theory component is included in the practical course itself. All the members consented to this opinion.

Recommendation: Following a detailed discussion on the contents, the members approved the course 'Mineral Opties Practical'.

1.6. GEOL 5106. Survey and Geological Field Training

Shri. Suresh Chandran and Dr. Ganesh Raj opined that the 'Total Station survey' can be included in the course. However, Dr.Prasannakumar opined that if one is well-versed in basics of survey, total station survey would be easy. Dr. Ganesh Raj also opined that Total Station andGPS surveys can be added in the course. Dr. Shankar suggested that Bhima and Kalladgi terrain are ideal locations for field studies and mapping.

Recommendation: Following a detailed discussion on the contents, the members approved the course 'Survey and Geological Field Training' with minor modification and revision.

1.7. GEOL 5201. Igneous Petrology

Dr. Shankar suggested to revise the term 'process' to 'processes' in Unit-I.

Recommendation: Following a detailed discussion on the contents, the members approved the course 'Igneous Petrology' with minor modification.

1.8. GEOL 5202. Metamorphic Petrology and Thermodynamics

Dr. R Shankar suggested some minor revisions in Units 2 and 4.

Recommendation: Following a detailed discussion on the contents, the members approved the course 'Metamorphic Petrology and Thermodynamics' with minor modifications.

1.9. GEOL 5203. Geochemistry

Dr.Pratheesh suggested to shift the course from second semester to first semester. Dr.Prasannakumar answered to him that geochemistry, igneous petrology and metamorphic petrology should be taught in a single semester. All the members consented to retain it in second semester. Dr. R Shankar suggested some minor revisions.

Recommendation: Following a detailed discussion on the contents, the members approved the course 'Geochemistry' with minor modifications.

1.10. GEOL 5204. Igneous Petrology Practical

Dr. Ganesh Raj suggested to correct the 'Magascopic' to 'megascopic'.

Recommendation: Following a detailed discussion on the contents, the members approved the course 'Igneous Petrology Practical' with minor modifications.

1.11. GEOL 5205. Metamorphic Petrology Practical

Dr. Shankar suggested deleting the first sentence as the following sentence says the same thing. It was consented by all the members.

Recommendation: Following a detailed discussion on the contents, the members approved the course 'Metamorphic Petrology Practical' with minor revision.

1.12. GEOL 5206. Field Geology

Dr. R Shankar suggested some minor revisions.

Recommendation: Following a detailed discussion on the contents, the members approved the course 'Field Geology' with minor revision.

1.13. GEOL 5301. Sedimentology

Shri. Suresh Chandran opined that the course can be shifted to First Semester. He also suggested that 'sedimentary petrology' can also be included in the course. Dr.Prasannakumar and Dr. Shankar pointed out that the sedimentary petrology is already included in the sedimentology practical. Dr. Shankar suggested some minor corrections in the terms.

Recommendation: Following a detailed discussion on the contents, the members approved the course 'sedimentology' with minor revision. Members also agreed to shift the course to First Semester.

1.14. GEOL 5302. Ore Geology

Dr. Shankar suggested to specify the deposits in the deep sea floor (Unit-5). Members agreed that it can be specified as polymetallic nodules, gas hydrates, phosphorites, lime mud and seafloor massive sulphides (SMS). Dr. R Shankar also suggested some minor revision of the terms in the course content. Dr. Prasannakumar suggested to delete the term 'sea water' in Unit-5. Shri. Suresh Chandran opined that extraction of elements can be deleted as it is beyond the scope of the course. He also opined that 'offshore exploration' can be added in Unit-5.

Recommendation: Following a detailed discussion on the contents, the members approved the course 'Ore Geology' with minor revision.

1.15. GEOL 5303. Exploration Geophysics

All the members suggested and agreed to change the course title to 'Exploration Geology' as it contains geological, geophysical and geochemical methods of exploration.Dr. R Shankar also suggested some minor revision. Dr.Ganesha Raj suggested to include remote sensing and GIS based exploration methods.

Recommendation: Following a detailed discussion on the contents, the members approved the course 'Exploration Geology' with minor revision. Members also agreed to change the course title to Exploration Geology.

1.16. GEOL 5304. Sedimentology Practical

Dr. Shankar suggested to revise 'graphical parameters' to 'statistical parameters'.

Recommendation: Following a detailed discussion on the contents, the members approved the course 'Sedimentology Practical' with minor revision.

1.17. GEOL 5305. Economic Geology Practical

Shri.Suresh Chandran suggested to delete the 'bore hole problems'. Dr. Shankar enquired what is intended to be done under the heading 'mining methods'. Dr.Prasannakumar replied that students can be exposed to different mining methods. Dr. Shankar inquired whether there are lab facilities to carry out ore dressing practicals. Dr.Prasannakumaranswered him that it can be carried out at metallurgy department of nearby engineering colleges.

Recommendation:Following a detailed discussion on the contents, the members approved the course 'Economic Geology Practical' with minor revision.

1.18. GEOL 5306. GIS and Image Interpretation Practical

Dr.Ganesha Raj opined that the topics like database creation, modelling, GIS softwares (ArcGIS, Q-GIS, WebGIS), image processing softwares, object based and contextual based methods can be included in the course.

Recommendation: Following a detailed discussion on the contents, the members approved the course 'GIS and Image Interpretation Practical' with a few additions.

1.19. GEOL 5401. Hydrogeology

Dr. Shankar suggested some minor modifications in the terms. Dr.Ganesha Raj suggested including artificial recharge and rain water harvesting methods in Unit-5.

Recommendation: Following a detailed discussion on the contents, the members approved the course 'Hydrogeology' with a few additions.

1.20. GEOL 5402. Stratigraphy

Dr. Shankar suggested to change 'south India' to 'southern India'. He also opined that 'Precambrian of southern India, Major Phanerozoic Basins in India: General description, age, development, evolution, stratigraphy and classification of the following basins in India - Gondwana, Kavert, Kerala and Cambay Basins' can be shifted to Unit-4. Dr.Ganesha Raj suggested to add more references including the book by 'M.S. Krishnan'.

Recommendation: Following a detailed discussion on the contents, the members approved the course 'stratigraphy' with a few modifications.

1.21. GEOL 5403. Hydrogeology Practical

Dr. Ganesha Raj suggested to include 'Preparation of ground water potential map' in the course.

Recommendation: Following a detailed discussion on the contents, the members approved the course 'Hydrogeology Practicals' with minor revision.

1.22. GEOL 5409. Dissertation

Dr. Shankar suggested that the internal guides for the dissertation work should be on the basis of student's research interests and specialisation of teachers. Suresh Chandran opined that the work can be started from the First Semester itself. The members agreed to change the course code to GEOL5404. Dr. Sandeep inquired with Dr.JeyabalanSangeetha how the dissertation topics are decided. Dr.JeyabalanSangeetha replied that the topics are decided according to research interests of students and specialisations of guides.

Recommendation: Following a detailed discussion on the contents, the members approved the course 'Dissertation' with minor revision and change of course code.

1.23. GEOL 501. Industrial Minerals and Gemstones

Dr. Shankar suggested some minor revisions in the contents.

Recommendation: Following a detailed discussion on the contents, the members approved the elective course 'Industrial Minerals and Gemstones'.

1.24. GEOL 502. Mining and Engineering Geology

Dr. Shankar suggested some minor revisions in the contents. Dr. Ganesha Raj suggested to include application of remote sensing and GIS (Unit-5) and mine monitoring (Unit-3).

Recommendation: Following a detailed discussion on the contents, the members approved the elective course 'Mining and Engineering Geology'.

1.25. GEOL 503. Geomatics

Dr.Ganesha Raj suggested to delete the term 'cosmetic operations' in Unit-2. He also suggested including application of GIS in various fields and adding more references.

Recommendation: Following a detailed discussion on the contents, the members approved the elective course 'Geomatics'.

1.26. GEOL 504. Coal and Petroleum Geology

Dr. Shankar suggested some minor revisions in the contents.

Recommendation: Following a detailed discussion on the contents, the members approved the elective course 'Coal and Petroleum Geology'.

1.26. GEOL 505. Environmental Geology and Natural Hazards

Dr. Ganesha Raj suggested to include coastal environment and climate change, coastal management plans and tsunamis in Unit-4. Dr. Shankar suggested some minor revisions in the contents.

Recommendation: Following a detailed discussion on the contents, the members approved the elective course 'Environmental Geology and Natural Hazards'.

1.27. GEOL 506. Water Resource Management

Dr. Ganesha Raj suggested to include glaciers (in Unit-1), treatment of waste water and desalinization (Unit-5). Dr. Shankar suggested some minor revisions in the contents.

Recommendation: Following a detailed discussion on the contents, the members approved the elective course 'Water Resource Management'.

1.28. GEOL 507. Isotope Geology

Dr. Shankar suggested some minor revisions in the contents. He suggested to delete some of the content in Unit-5 which is already included in Unit-4.

Recommendation: Following a detailed discussion on the contents, the members approved the elective course 'Isotope Geology'.

1.29. GEOL 508. Quaternary Geology

Dr. R Shankar opined that 'varves and tree rings' can be deleted in Unit-4. He also suggested some minor revisions in the contents and adding 'fission track and thermoluminescence dating methods' in Unit-4.

Recommendation: Following a detailed discussion on the contents, the members approved the elective course 'Quaternary Geology'.

1.30. GEOL 509. Structural Analysis

There were no revisions suggested by members.

Recommendation: Following a detailed discussion on the contents, the members approved the elective course 'Structural Analysis'.

1.31. GEOL 510. Planetary Geoscience

Dr.Ganesha Raj opined that 'planetary missions' can be included in Unit-5, Dr. Shankar suggested some minor revisions in the contents.

Recommendation : Following a detailed discussion on the contents, the members approved the elective course 'Planetary Geoscience'.

Agenda 2: Consider and decide on proposals from the Faculty Council regarding curriculum.

Dr. Sandeep introduced the recommendation of Faculty Council regarding the syllabus.

2.1. The inclusion of elective course 'Oceanography' and the syllabus thereof (Annexure 1).

Dr. Sandeep explained the rationale for including 'Oceanography' as one of the elective courses. The rationale was that Oceanography is one of the important papers in CSIR-JRF/NET examinations. There was an elaborate discussion regarding the inclusion of 'Oceanography' as an open elective course in the programme. The proposed syllabus (Annexure 1) of the course was also discussed.

Recommendation: Following a detailed discussion on the contents, the members approved the elective course 'Oceanography'.

2.2. The inclusion of core course 'Palaeontology Practical' and the syllabus thereof (Annexure 2).

There was an elaborate discussion regarding the inclusion of 'Palaeontology Practical' as core course in the programme. The proposed syllabus (Annexure 2) of the course was also discussed.

Recommendation: Following a detailed discussion on the contents, the members approved the core course 'Palaeontology Practical'. It is also agreed that the course would be included in Third Semester.

2.3. The inclusion of elective course 'Climatology' and the syllabus thereof (Annexure 3).

Dr. Sandeep explained the rationale for including Climatology as one of the elective courses. The rationale is that Climatology is one of the important paper in CSIR-JRF/NET

examination syllabus. There was an elaborate discussion regarding the inclusion 'Climatology' as an open elective course in the programme. The proposed syllabus (Annexure of the course was also discussed.

Recommendation: Following a detailed discussion on the contents, the members approved t elective course 'Climatology'.

2.4. The inclusion of elective course 'Geotectonics' and the syllabus thereof (Annexure 4).

There was an elaborate discussion regarding the inclusion of 'Geotectonics' as elective course in the programme. The proposed syllabus (Annexure 4) of the course was al discussed.

Recommendation: Following a detailed discussion on the contents, the members did n approve the elective course 'Geotectonics' as contents of the course already included in many of the core courses offered in the programme.

2.5. Changing the GEOL-5303 core course title from 'Exploration Geophysics' 'Exploration Geology'.

This was already discussed earlier in agenda 1.15.

2.6. Modification in the core courses GEOL5106 (Survey and Geological Field Training GEOL5206 (Field Geology) (Annexure 5 and 6).

Dr. Sandeep explained the rationale for revising the syllabus of core courses GEOL510 (Survey and Geological Field Training) and GEOL5206 (Field Geology). The rationale was th both courses have overlapping contents. There was an elaborate discussion regarding th modification of course content. The proposed revised syllabus (Annexure 5 and 6)of the cours was also discussed.

Recommendation: Following a detailed discussion on the contents, the members approved to th recommendation of Faculty Council to revise the contents of 'Survey an Geological Field Training' and 'Field Geology'.

(g) The inclusion of B.Sc. triple main course offered by many universities (with geology as on of the main subjects) as eligibility for admission to M.Sc. Geology Programme.

Dr. Sandeep introduced the existing eligibility criteria and presented the recommendation of Faculty Council to include B.Sc. triple main course offered by many universities (wit geology as one of the main subjects) as eligibility for admission. The proposal was rejected by

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the external members as it would be difficult to assess the weightage given to 'geology part' in such courses.

Recommendation: Following a detailed discussion on the eligibility criteria, with respect to minimum educational qualification for M.Sc. Geology admission, the BoS members recommended not to include B.Sc. triple main course with Geology as one of the subjects. The members recommended the following categories of educational qualifications:

- B.Sc. Geology
- B.Sc. Geology and Water Management

Agenda 3: Any other matter

Dr.Pratheesh inquired whether course 'Disaster Management' can be initiated by the Department in Distance Education mode. Dr.Prasannakumar pointed out that decision regarding the distance education would not come under the purview BoS.

After this, overall agenda discussed in the BoS were summarised by Dr. Sandeep. The BoS approved the M.Sc. Geology syllabus formed by the consultative committee with minor modifications and revisions.

Thereafter, Dr. Sandeep offered vote of thanks, which concluded the BoS meeting.

Dr.Sandeep K.
Head (I/c), Dept. of Geology
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ANNEXURE 1:

GEOL511: Oceanography (3 credits)

Unit- 1

History of development of Oceanography and Marine Geology. Physiochemical characteristics and chemistry of sea water: temperature, salinity, density, light transmission, sound transmission in sea water. Gases in sea water. Role of carbon dioxide in keeping the pH of seawater and ocean acidification. Instruments used in the study of seawater. Ocean floor: Morphologic and tectonic domains. Bathymetric provinces- Submarine Canyons, Mid-Ocean ridges and Trenches. Morphologic and tectonic domains of Indian Ocean.

Unit- 2

Offshore exploration techniques: Instruments and measurements—Position fixing systems—GPS. Tools for studying ocean water—sampling devices—Grabs, dredgers, Corers, Water Samplers, etc. - various platforms for ocean studies. Tools for studying the ocean floor—Echo-sounding methods—Sidescan Sonar—Current meters—SCUBA diving—submersibles. Ocean floor drilling—IODP/ES.

Unit- 3

Marine sediments: Distribution and geochronology of marine sediments. Eustatic changes of sea level and its effects. Carbonate Compensation Depth (CCD). Turbidity currents and turbidites. World ocean circulation patterns—role of ocean in deciding global climate—ocean water masses.

Unit- 4

Origin of ocean basins and palaeooceanography. Paleoceanographic reconstructions based of microfossils. Law of the Seas - UNCLOS, EEZ—coastal zone environment and its protection - CRZ Act.Mineral resources of the ocean basins, factors controlling their distribution.Origin and distribution of polymetallic nodules.

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ANNEXURE 2:

GEOL 5106: Palaeontology Practical (1 credit)

Sample processing Techniques and separation of microfossils from matrix and marine sediments

Identification of following types of microfossils (Calcareous and Siliceous)

Planktonic foraminifera, Benthic foraminifera, Ostracods, Pteropods and Radiolaria

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ANNEXURE 3:

GEOL 512: Climatology (3 credits)

Unit-1

Fundamental principles of climatology.Atmosphere, its composition and internal structure.Greenhouse effect.Earth's radiation balance: latitudinal and seasonal variation of insolation, temperature, pressure.Fundamentals of meteorology, Scales of meteorology. Parameters of meteorology- pressure, wind, temperature, humidity, radiation; Radiations; Radiation laws, short wave and long wave radiations; Albedo; Emissivity; Radiation Budget of Earth.

Unit-2

General circulation of the atmosphere: Hadley cells, tropical easterlies, westerlies, polar easterlies, monsoon, Jet streams, tropical cyclones, local winds, Coriolis Effect and geostrophic winds, Cloud classification, condensation nuclei, growth of cloud drops and ice-crystals, precipitation mechanisms: Bergeron process, coalescence process, Types of precipitation, artificial precipitation.Electric field in the atmosphere.

Unit-3

Climate variability and forcings, causes and impacts of climate change, feedback processes, low frequency variability, MJO (Madden-Julian oscillation), ENSO, QBO (quasi-biennial oscillation) and sunspot cycles. Classification of climates – Koppen's and Thornthwaite's scheme of classification.

Unit-4

Synoptic weather forecasting, prediction of weather elements such as rain, maximum and minimum temperature and fog; hazardous weather elements like thunderstorms, dust storms, tornadoes. Basic principles of general circulation modelling, role of the ocean in climate modelling, interannual variability of ocean fields (SST, winds, circulation, etc.) and its relationship with monsoon, concepts of ocean – atmosphere coupled models.

Unit-5

Indian climatology with special reference to seasonal distribution and variation of temperature, humidity, wind and precipitation; Climate zones of India.

References:

- Lal, D. S. (2011): Climatology, ShardaPustakBhavan.
- Critchfield, H. J. (2009): General climatology, PHI Learning, New Delhi.
- Lal, D. S. (2013): Climatology and Oceanography, ShardaPustakBhavan.
- Siddhartha, K. (2016): Climatology-Atmosphere, weather and climate, KitabMahal, New Delhi.
- Savindra Singh (2005): Climatology, PrayagPustakBhavan.
- William James Burroughs, 2001, Climate change, A multidisciplinary Approach, Cambridge University Press.
- Stringer, E. T. (1972): Foundations of Climatology, W H.Freeman& Co Ltd

ANNEXURE 4:

GEOL513: Geotectonics (3 credits)

Unit 1

History of Plate tectonics – Continental drift, sea-floor spreading and the birth of plate tectonics, geosynclinals theory, impact of plate-tectonics, Interior of the Earth – velocity structure, composition, layers-crust, mantle and core, isostasy, lithosphere and asthenosphere.

Unit 2

Framework of plate-tectonics – plates and plate margins, relative and absolute plate motions, hotspots and superplumes, triple junctions; Ocean ridges – topography, structure, depth-age relationship of oceanic lithosphere; origin of the oceanic crust, propagating rifts and microplates, oceanic fracture zones; Continental rifts and rifted margins – general characteristics, rift initiation, rifted continental margins, Wilson cycle.

Unit 3

Subduction Zones – ocean trenches, morphology of island arc systems, variation in subduction zone characteristics, accretionary prisms, volcanic and plutonic activity, metamorphism at convergent margins, backare basins, Orogenic belts – ocean-continent convergence, compressional sedimentary basins, continent-continent collision, arc-continent collision, terrane accretion and continental growth.

Unit 4

Precambrian tectonics and the supercontinent cycle – Precambrian heat flow, Archean tectonics, Proterozoic tectonics, supercontinent cycle; Mechanism of plate tectonics – contracting and expanding earth hypothesis, implications of heat flow, driving mechanism of plate-tectonics, mechanism of the supercontinent cycle.

Unit 5

Implications of plate tectonics - Environmental change – changes in sea level and sea water chemistry, changes in oceanic circulation and the Earth's climate, land areas and climate; Economic geology – autochthonous and allochthonous mineral deposits, deposits in sedimentary basins, deposits related to climate, geothermal power; Natural hazards.

References

- Condie, K.C. (1976) Plate tectonics and crustal evolution, Pergamon Press, 282p.
- Kroner, A. (1981) Precambrian plate tectonics, Elsevier, 781p.
- Kearey, P., Klepeis, K.A. and Vine, F.J. (2009) Global Tectonics, Wiley-Blackwell, 482p.
- Patwardhan, A.M. (2010) The dynamic Earth system, PHI Pvt. Ltd., 422p.
- Foulger, G.R. (2010) Plates vs plumes – a geological controversy, Wiley-Blackwell, 340p.
- Molnar, P. (2015) Plate tectonics – a very short introduction, 152p.

ANNEXURE 5:

GEOL 5106: Survey and Geological Field Training (2 credits)

Surveying - Processes involved in Surveying, Objectives of survey, Different units of measurement.
Chain Survey: Running the survey line, Plotting the survey, Area calculation
Plane Table Survey: Plane Table Surveying, Plotting and Area calculation.
Leveling : The Dumpy level : Permanent and temporary adjustments of the Dumpy, Dumpy Level surveying, finding the level difference.
Topo sheets: Map scales, features in toposheet, finding the coordinates of points.

Basic procedures in the field: Taking a compass bearing, taping and pacing, locating the position in the map, Use of GPS, brunton compass, clinometer. Observations in the field, interpretation of the outcrop, taking field notes, drawing and photographing outcrops, measuring attitudes of planar and linear features, finding and collecting fossils, collecting rock samples-their identification and naming.
Identifying the characteristics of igneous, metamorphic, and sedimentary rocks in field, Identification and Mapping of Faults—folds—foliations, cleavages, lineations, joints, shear zones. Field visits to places of geological significance and field studies. Field studies in igneous, metamorphic and sedimentary terrain. Preparation of field reports.

References

- Punmia.B.C.,Ashok.K.Jain and Arun.K.Jain (2010). Surveying Vol I and II. Laxmi Publications pvt.Lyd, New Delhi
- Basak.N.N. (2012). Surveying and Levelling .Mc-Graw Hill Publishing Company, New Delhi.
- Lahee, F.H. (2002). Field Geology. 6th Edition. CBS Publishers.
- Gokhale, N.W. (2009). A Guide to Field Geology. 1st Edition. CBS Publishers.
- Mathur, S.M. (2001). Guide to Field Geology (Revised Edition). 1st Edition. Phi Learning.

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Kasaragod, Kerala, India, 671123
DEPARTMENT OF GEOLOGY

ANNEXURE 6:

GEOL 5206: Field Geology (2 credits)

Principles of geological mapping.Training in field mapping.Preparations for field mapping.Field equipments.Geological symbols and notations.Lithological and structural mapping.Identification and recording of rock types and structures in the field.Measurement and recording of field data. Finding and tracing contacts between rock units, correlating geologic units, mapping geologic structures, outcrop maps, locating points in the field. Selecting and preparing a base map—locating field data and geologic features.

Techniques of geological mapping in igneous, metamorphic and sedimentary terrains.Structural mapping: Mapping of Faults—folds –foliations, cleavages, lineations, joints, shear zones. Preparing final geological map and reports: report writing, major illustrations, photographs, drawings, diagrams, designing the report, format and specific parts of the report. Field mapping in terrains of geological significance and preparation of reports.

References:

- Richard J. Lisle, Peter Brabham and John W. Barnes (2011). Basic Geological Mapping (Geological Field Guide). Revised 5th Edition. Wiley-Blackwell.
- Angela L. Coe (2010). Geological Field Techniques. 1st Edition. Wiley-Blackwell. 336p.
- Lahee, F.H. (2002). Field Geology. 6th Edition, CBS Publishers.

Central University of Kerala

M.Sc. Geology

SCHEME AND SYLLABUS

2018

Title of the PG Programme : M.Sc. Geology

Programme structure

The PG programme is offered in four semesters and includes theory and practical classes, field training and a dissertation.

Duration of the Programme	**:**	4 semesters
Type of the programme	**:**	Regular
Number of seats	**:**	30
Eligibility for admission	**:**	B.Sc. Geology/B.Sc. Geology and Water Management
Admission	**:**	Through CUCET

CENTRAL UNIVERSITY OF KERALA

SCHEME OF M.Sc. GEOLOGY PROGRAMME

I SEMESTER		Credits	Lecture hrs.	Lab hrs.	Field hrs.
GEOL 5101	Geomorphology	2	2		
GEOL 5102	Structural Geology	3	3		
GEOL 5103	Sedimentology	3	3		
	Elective	3	3		
GEOL 5104	Structural Geology Practical	2		4	
GEOL 5105	Mineral Optics Practical	2		4	
GEOL 5106	Sedimentology Practical	1		2	
GEOL 5107	Survey and Geological Field Training	2			4
II SEMESTER					
GEOL 5201	Igneous Petrology	3	3		
GEOL 5202	Metamorphic Petrology and Thermodynamics	3	3		
GEOL 5203	Geochemistry	2	2		
	Elective				
	Elective				
	Elective				
GEOL 5204	Igneous Petrology Practical	1		2	
GEOL 5205	Metamorphic Petrology Practical	1		2	
GEOL 5206	Field Geology	2			4
III SEMESTER					
GEOL 5301	Paleontology	3	3		
GEOL 5302	Ore Geology	3	3		
GEOL 5303	Exploration Geology	3	3		
	Elective				
	Elective				
	Elective				
GEOL 5304	Paleontology Practical	1		2	
GEOL 5305	Economic Geology Practical	1		2	
GEOL 5306	GIS and Image Interpretation Practical	2		4	
IV SEMESTER					
GEOL 5401	Hydrogeology	3	3		
GEOL 5402	Stratigraphy	3	3		
	Elective				
	Elective				
GEOL 5403	Hydrogeology Practical	1		2	
GEOL 5404	Dissertation	8		4	8

CENTRAL UNIVERSITY OF KERALA

M.Sc. Geology - Course Details

CORE COURSES

I SEMESTER		Credits
GEOL 5101	Geomorphology	2
GEOL 5102	Structural Geology	3
GEOL 5103	Sedimentology	3
GEOL 5104	Structural Geology Practical	2
GEOL 5105	Mineral Optics Practical	2
GEOL 5106	Sedimentology Practical	1
GEOL 5107	Survey and Geological Field Training	2

II SEMESTER		
GEOL 5201	Igneous Petrology	3
GEOL 5202	Metamorphic Petrology and Thermodynamics	3
GEOL 5203	Geochemistry	2
GEOL 5204	Igneous Petrology Practical	1
GEOL 5205	Metamorphic Petrology Practical	1
GEOL 5206	Field Geology	2

III SEMESTER		
GEOL 5301	Paleontology	3
GEOL 5302	Ore Geology	3
GEOL 5303	Exploration Geophysics	3
GEOL 5304	Paleontology Practical	1
GEOL 5305	Economic Geology Practical	1
GEOL 5306	GIS and Image Interpretation Practical	2

IV SEMESTER		
GEOL 5401	Hydrogeology	3
GEOL 5402	Stratigraphy	3
GEOL 5403	Hydrogeology Practical	1
GEOL 5404	Dissertation	8

CENTRAL UNIVERSITY OF KERALA

M.Sc. Geology - Course Details

ELECTIVE COURSES

INTERNAL ELECTIVES		Credits
GEOL 501	Industrial Minerals and Gemstones	2
GEOL 502	Mining and Engineering Geology	3
GEOL 503	Geomatics	3
GEOL 504	Coal and Petroleum Geology	3
GEOL 505	Environmental Geology and Natural Hazards	3
GEOL 506	Water Resource Management	3
GEOL 507	Isotope Geology	2
GEOL 508	Quaternary Geology	2
GEOL 509	Structural Analysis	2
GEOL 510	Planetary Geoscience	2

OPEN ELECTIVES		Credits
GEOL 511	Oceanography	3
GEOL 512	Climatology	3

Credit Distribution

Course	Semester-wise credits				Total credits
	I	II	III	IV	
Core	**14**	**12**	**13**	**15**	**54**
Elective	**3**	**6-9**	**6-9**	**4-6**	**19-27**
Total	**17**	**18-21**	**19-22**	**19-21**	**73-81**

CENTRAL UNIVERSITY OF KERALA

M.Sc. Geology – Detailed Syllabus

GEOL 5101. Geomorphology (2 credits)

Unit – 1

Fundamental concepts in geomorphology. History of the development of geomorphic ideas—ancient and modern. Different models in the Evolution of landscape: Davis, Penck, King, Hack and Morisawa. Hill slopes: slope elements, classification, models of slope evolution, slope movement and stability factors. Landforms in relation to climate, rock type, structure and tectonics. Geomorphic processes and landforms – fluvial, glacial, eolian, coastal and karst.

Unit – 2

Fluvial Geomorphology: Fundamental concepts: Base level, relations between channel width, depth and current velocity, sediment transport and erosion—types of load and modes of transportation, concept of grade, meandering and braided rivers. Processes of river erosion, transportation and deposition. Erosional and depositional landforms of rivers. Concept of rejuvenation and interruptions in the cycle of erosion. Drainage systems and patterns.

Morphometric elements and parameters - morphometric analysis of drainage basins.

Unit – 3

Coastal geomorphology: shorelines, tides, coastal currents, waves, marine erosion, transportation and deposition. Coastal erosional and depositional landforms. Coastal classification. Coastal dynamics.

Morphology of the ocean floor, Marine deposition, littoral deposits, shallow water deposits, deep sea deposits, Classification of sediment constituents - authigenic deposits: biogenic and organic, terrigenous deposits, sub marine canyons and turbidite fans.

Unit – 4

Geomorphic indicators of neotectonic movements: Stream channel morphology changes, drainage modifications, fault reactivation, uplift –subsidence pattern in coastal areas.

Application in various fields of earth sciences viz. Mineral prospecting, Hydrogeology, Civil Engineering and Environmental studies. Geomorphology of India – Origin and evolution of Peninsular, Extra-peninsular and Indo- Gangetic plains.

References

- Halis, J.R. (1983): Applied Geomorphology.
- Holmes, A. (1992): Holmes Principles of Physical Geology, Edited by P. McL. D. Duff. Chapman and Hall.
- Sharma, H.S. (1990): Indian Geomorphology, Concept Publishing Co., New Delhi.
- Sparks, B.W. (1979): Geomorphology, Longman, London,
- Chorley, R.J., Schumm, S.A. and Sugden, D.E. (1984): Geomorphology, Methuen & Co.
- Thornbury, W.D. (1984): Principles of Geomorphology, John Wiley
- Ritter, D.F., Kochel, R.C., Miller, J.R. (2006): Process Geomorphology, Waveland
- Huggett, R. (2007): Fundamentals of Geomorphology, Routledge
- Savindra Singh (2007): Geomorphology, Prayag Pustak Bhawan, Allahabad.

- Strahler A. N. and Strahler, A. H. (2008): Modern Physical Geography, John Wiley & Sons, New York.
- Arthur L. Bloom (1978): Geomorphology (A Systematic Analysis of Late Cenozoic Landforms). Prentice-Hall, 510 p

GEOL 5102. Structural Geology (3 credits)

Unit - 1

Mechanical principles, properties of rocks and their controlling factors. Elastic, plastic and brittle deformations. Faults and fractures - Brittle and shear failure. Fault geometry and nomenclature. Features of fault planes. Deep fractures. Joints. Analysis of fractures. Concept of strain. Stress and strain ellipsoids and their use in the study of faults and joints.

Unit - 2

Folds - cylindrical, non-cylindrical and conical folds. Geometry and classification of cylindrical folds. Canoe fold and inverted canoe fold. Minor folds and their use in determining the major fold structure. Mechanics of folding. Fold classifications of Donath and Parker and Ramsay. Superposed folding. Fold interference patterns -dome and basin, mushroom and boomerang patterns and Ramsay's classification.

Unit - 3

Tectonites - classification, tectonic fabric. Foliation - axial-plane foliation and its origin, fracture cleavage, crenulation cleavage and transposed foliation. Foliations and folds. Use of axial plane foliation and fracture cleavage in the determination of major structures. Lineation - types, classification and origin.

Unit - 4

Geologic bodies and scale, structural co-ordinates. Spatial orientation of planar and linear fabrics. Fundamentals of geometric analysis. Measurement and recording of structural attitudes. Stereographic and equal area projections in structural geology. $\boldsymbol{\pi}$ and $\boldsymbol{\beta}$ diagrams. Geometric analysis of simple and complex structures on macroscopic scale. Geometric analysis of folds.

References

- Park, R.G. (1989), Foundation of Structural Geology, Blackie, 148p.
- Ragan, D.M. (1969), Structural Geology, Wiley, 2nd edition, 602p.
- Turner, E.J. and Weiss, L.E. (1963), Structural Analysis of Metamorphic Tectonites, Mc. Graw Hill, 545p.
- Hobbs, B.E., Means, W.D. and William, P.F. (1976), An outline of Structural Geology, John Wiley and Sons, 571p.
- Robert. J.Twiss and Eldridge.M.Moores (2007). Structural Geology, W.H.Freeman and Company, 695p.
- Ramsay, J.G. (1967) Folding and Fracturing of Rocks. Mc Graw Hill, 586p.
- Ramsay, J.G. and Huber M.I. (1987) The Techniques of Modern Structural Geology Academic Press, London
- Passchier C.W. and Trouw R.A.J. (2005) Microtectonics. Springer Verlag. 371 p.
- Billings M.P. (1972) Structural Geology, Prentice Hall College Div; 3 edition,473p.

GEOL 5103. Sedimentology (3 credits)

Unit – 1

Provenance of sediments. Textural parameters of clastic and non-clastic sediments. Grain size-classification and concept of grade scale. Grain size estimation-direct measurement, sieving and settling methods. Grain size parameters (statistical) and their applications.

Unit – 2

Sedimentary structures-Classification and origin. Different types of stratification, deformation structures, erosional structures, biogenic structures, sand dykes and sills - applications in paleo-environmental and paleocurrent studies.

Unit – 3

Mineralogy, classification and depositional environment of conglomerates, sandstones, limestones and mud rocks.Diagenesis: processes and its evidence in siliciclastic, carbonate and argillaceous rocks

Unit – 4

Depositional environments - marine, non-marine, and mixed depositional environments.
Concept of Sedimentary facies, association models.

Unit – 5

Overview of sedimentary basins; Basin development and classification-Cratonic basins, Divergent margin basins, Convergent margin basins, Downwarp basins. Fore arc and back arc basins. Tectonic framework of sedimentary basins of India.

References

- Blatt, H., Middleton, G.V. and Murray, R.C. (1980): Origin of Sedimentary Rocks, Prentice-Hall Inc.
- Collins, J.D., and Thompson, D.B. (1982): Sedimentary Structures, George Allen and Unwin, London.
- Lindholm, R.C. (1987) A Practical Approach to Sedimentology, Allen and Unwin, London.
- Miall, A.D. (2000): Principles of Basin Analysis, Springer-Verlag.
- Pettijohn;, F.J. (1975): Sedimentary Rocks (3rd Ed.), Harper and Row Publ., New Delhi.
- Reading, H.G. (1997): Sedimentary Environments and facies, Blackwell Scientific Publication.
- Reineck, H.E. and Singh, I.B. (1973): Depositional Sedimentary Environments, Springer-Verlag.
- Selley, R. C. (2000) Applied Sedimentology, Academic Press.
- Tucker, M.E. (1981): Sedimentary Petrology: An Introduction, Wiley and Sons, New York.
- Tucker, M.E. (1990): Carbonate Sedimentology, Blackwell Scientific Publication. Course No.GLM203:
- Prothero, D.R., Schwab, F., (2003) Sedimentary Geology. W. H. Freeman; 2nd edition.

GEOL 5104. Structural Geology Practical (2 credits)

Preparation and interpretation of geological maps and sections. Structural problems. Recording and plotting of field data. Study of deformation structures in hand specimen. Study of dip isogons from fold profiles. Stereographic projection in structural analysis. Application of stereographic projection in solving structural problems. Beta diagram and Pi diagram. Solving problems of faults and shear zones.

References

- Park, R.G., (1989), Foundation of structural Geology. Blackie, 148p.
- Ragan, D.M. (1969), Structural Geology, Wiley, 2nd edition, 602p.
- Turner, E.J. and Weiss, L.E. (1963), Structural Analysis of Metamorphic Tectonites, Mc. Graw Hill, 545p.
- Ramsay, J.G. (1967) Folding and fracturing of rocks. Mc Graw Hill, 586p.

GEOL 5105. Mineral Optics Practical (2 credits)

Crystallography - crystalline state - Lattices- Point, Line, Space. Zone and determination of Zone symbols, determination of Axial Ratio and Napier's Rule.
Crystal systems- Symmetry elements of normal (holohedral) classes.
Crystal projection – Spherical projection of cube, octahedron and dodecahedron. Stereographic projection of normal class of Isometric, Tetragonal, Hexagonal and Orthorhombic systems. Gnomonic projection of normal class Isometric system.

Refractive index and birefringence. Interference colours, optical accessories - Unit retardation plate, quartz wedge, mica plate, Berek compensator and Bertrand ocular. Optical characteristics: Indicatrices. Dichroism and pleochroism, pleochroic haloes, conoscopic study and interference figures. Optic orientation, extinction angle, optic axial angle, optic sign and optic anomalies. Dispersion and dispersion types. The 4-axis universal stage and its basic principles.

Classification and structure of silicates. Application of modern techniques in mineral studies - XRD, DTA, XRF, ICP,EPMA. Distinctive optical characters of the following minerals/ mineral groups: Olivine, epidote, almandine, pyroxenes, amphiboles, micas, feldspars and feldspathoids.

References

- Burger, M.J. (1962). Elements of Crystallography, Wiley.
- Dana,E.S (1962). Text book of Mineralogy Revised by Ford,W.E.,Wiley..
- Deer., Howie, R.A.and Zussman, J. (1964). Rock forming minerals, Vol.1,2,3,4 and 5, Longman.
- Hans- Rudolf Wenk and Andrei Bulakh. (2004). Minerals – Their constitution and Origin, Cambridge University Press.
- Smith. J.V. (1982). Geometrical and structural Crystallography. John Wiley & Sons.
- Burger. M.J. (1970). Contemporary Crystallography. Mc Graw – Hill book company.
- Naidu, P.R.J. (1958). Four axes Universal Stage, Commercial Printing and Publishing house.
- Philips,F.C. (1963). Introduction to Crystallography, Thomas Nelson.

- Phillips W.J (1980). An introduction to Mineralogy for Geologists. John Wiley & Sons.
- Phillips, R.W (1971). Mineral Optics ; Principles and Techniques, W.H.Freeman and Co, San Francisco.
- Kerr, P.F. (1959) Optical Mineralogy, Mc Graw Hill, New York.
- Winchell, A.N (1949). Elements of Optical Mineralogy, Part –I Principles and Methods, Wiley, New York.

GEOL 5106. Sedimentology Practical (1 credit)

Sieve analysis, plotting and interpretation of data (Trask method & Folk and Ward method). Estimation of statistical parameters-mean, skewness, kurtosis and standard deviation (sorting). Pipette analysis and estimation of clay content. Plotting of gravel-sand-mud and sand-silt-clay in triangular coordinate sheet.
Study and description of hand specimens and thin sections of conglomerate, breccia, sandstones, limestones, mudstone and shale.
Separation of heavy and light minerals from sediments. Preparation of grain mounts and mineral identification.

References

- Friedman, G. M. and Sanders, F. E. (1978) Principles of Sedimentology, Wiley, 792 p.
- Lindholm, R. C. (1987) A practical Approach to Sedimentology. Springer-Verlag, 279 p
- Selley, R. C. (2000) Applied Sedimentology, Academic Press, 523 p.
- Milner H.B. (1962, revised edition) Sedimentary Petrography (Vol.I&II)
- D. W. Lewis, &. Mc Conchie, D. (1994). Practical Sedimentology, 2nd ed: Chapman & Hall, London
- D. W. Lewis, &. Mc Conchie, D. (1994) Analytical Sedimentology, 2nd ed: Chapman & Hall, London
- W. C. Krumbein and F. J. Pettijohn (1988). Manual of Sedimentary Petrography**.**SEPM

GEOL 5107. Survey and Geological Field Training (2 credits)

Surveying - Processes involved in Surveying, Objectives of survey, Different units of measurement.
Chain Survey: Running the survey line, Plotting the survey, Area calculation
Plane Table Survey: Plane Table Surveying, Plotting and Area calculation.
Leveling: The Dumpy level: Permanent and temporary adjustments of the Dumpy. Dumpy
Level surveying, finding the level difference.
Total Station and GPS surveys.
Topo sheets: Map scales, features in toposheet, finding the coordinates of points.

Basic procedures in the field: Taking a compass bearing, taping and pacing, locating the position in the map, Use of GPS, brunton compass, clinometer. Observations in the field, interpretation of the outcrop, taking field notes, drawing and photographing outcrops, measuring attitudes of planar and linear features, finding and collecting fossils, collecting rock samples-their identification and naming.

Identifying the characteristics of igneous, metamorphic, and sedimentary rocks in field. Identification and Mapping of Faults—folds—foliations, cleavages, lineations, joints, shear zones.
Field visits to places of geological significance and field studies. Field studies in igneous, metamorphic and sedimentary terrain. Preparation of field reports.

References

- Punmia.B.C., Ashok K Jain and Arun K Jain (2010). Surveying Vol I and II. Laxmi Publications pvt. Ltd, New Delhi
- Basak.N.N. (2012). Surveying and Levelling, Mc-Graw Hill Publishing Company, New Delhi.
- Lahee, F.H. (2002). Field Geology. 6th Edition, CBS Publishers.
- Gokhale, N.W. (2009). A Guide to Field Geology. 1st Edition, CBS Publishers.
- Mathur, S.M. (2001). Guide to Field Geology (Revised Edition), 1st Edition. Phi Learning.

GEOL 5201. Igneous Petrology (3 credits)

Unit - 1

Igneous processes –Nature and evolution of magma – Generation of magma – Silicate systems - Phase rule and its application in the study of silicate systems - phase diagrams, primary phase diagrams and liquidus projections. Equilibria involving two solids + liquid. Eutectic crystallization – Solid solution series – Incongruent melting.

Unit - 2

Course of crystallization in typical binary systems. Reaction principle and reaction series. Modal composition and Normative mineral composition. CIPW Norm. Interpretation of igneous textures in terms of rate of nucleation and crystal growth.

Unit - 3

Equilibria involving three solids + liquid. Co-precipitational, monoresorptional and biresorptional relations. Equilibrium crystallization and melting paths in ternary and quaternary systems. Anorthite - Wollastonite – Silica; Diopside - Anorthite– Silica; Diopside - Anorthite–Albite; Albite – Anorthite–Orthoclase; MgO - Al_2O_3 - SiO_2.Basalt system – classification of basalts. Origin of basalts

Unit - 4

Igneous processes and diversity in igneous rocks. Compositional variation in magmas. Variation diagrams – binary and ternary diagrams. Trace elements in igneous processes – melting and crystallization models – application of trace elements to petrogenesis. Radiogenic tracers.

Unit - 5

Classification of igneous rocks. Granites and granitic rocks. Ultramafic rocks. Alkaline rocks. Kimberlites and ultrapotassic rocks. Anorthosite and carbonatite. Plume magmatism and hot spots-Large Igneous Provinces and dyke swarms. Taphrogenic intrusives of Kerala.

References

- Bose, M. K. (1997), Igneous Petrology, The World Press Private Limited, Calcutta, 568 p.
- Carmichael, I. S. E., Turner, F. J. and Verhoogen, J. (1974), Igneous Petrology, McGraw Hill Book Company, 739 p.
- Ehlers, E. G. and Blatt, H. (1981), Petrology, CBS Publishers and Distributors, New Delhi, 732 p.
- Faure, G. (2001), Origin of Igneous Rocks: The Isotopic Evidence, Springer-Verlag, New York, 496 p.
- Gupta, A. K. (1998), Igneous Rocks, Allied Publishers Limited, 690 p.
- Hall, A. (1988), Igneous Petrology, English Language Book Society/Longman, 573 p.
- Hughes, C. J. (1982), Igneous Petrology, Elsevier, 551 p.
- Le Maitre, R. W. (2002), Igneous Rocks: A classification and Glossary of Terms. Second Edition, Cambridge University Press, 236 p.
- Mueller, R.F. and Saxena, S. K. (1977), Chemical Petrology, Springer Verlag, 394 p.
- Ragland, P. C. (1989), Basic Analytical Petrology, Oxford Unversity Press, 369 p.

- Raymond, L. A. (1995), Petrology, Wm. C. Brown Publishers, 742 p.
- Sood, M. K. (1981), Modern Igneous Petrology, A Wiley-Interscience, 244 p.
- Wilson, M. (1989), Igneous Petrogenesis, Chapman and Hall, 466 p.

GEOL 5202. Metamorphic Petrology and Thermodynamics (3 credits)

Unit - 1

Concepts of metamorphism: Limits of metamorphism, Types of metamorphism, Factors of metamorphism, Role of fluids. Mineralogical phase rule for closed and open systems. Application of phase rule in metamorphic mineral paragenesis. Metamorphic structures and textures.

Unit - 2

Nature of metamorphic reactions. Concept and classification of metamorphic facies and facies series. Mineral facies classification of Eskola, Fyfe, and Turner and Verhoogen. Grade classification of Winkler. Facies series. Description of facies of low, medium to high and very high pressure with special reference to characteristic minerals, subdivision into zones/subfacies.

Unit - 3

Graphical representation of metamorphic mineral assemblages, composition paragenesis diagrams. Principal Types of Phase Diagrams, ACF, A'KF, AFM Diagrams. ACF and AKF diagrams and representation of metamorphic assemblages. Significance of tie lines.

Unit - 4

Metamorphic differentiation; Metamorphism and plate tectonics; Ultra High Temperature (UHT) and Ultra High Pressure (UHP) metamorphism. General characteristics of metamorphic domains – contact metamorphism, Regional metamorphism, Paired metamorphic belts, Orogeny and Metamorphism, Retrograde metamorphism. Metamorphism of carbonate rocks, pelites, mafic and ultramafic rocks.Granulitic rocks of Southern India, Migmatites.

Unit - 5

Laws of thermodynamics – Gibb's free energy, entropy – solid-solid and dehydration reactions. Clausius-Clapeyron equation. Geothermobarometry. Isograds and reaction isograds – Schreinmaker's rule and construction of petrogenetic grids. Pressure-Temperature-Time paths.

References

- Blatt, H. and Tracy, R.J. (1996), Petrology (Igneous, Sedimentary, Metamorphic), W.H. Freeman and Co. New York.
- Bucher, K. and Martin, F. (2002), Petrogenesis of Metamorphic Rocks (7th Rev. Ed.), Springer–Verlag, 341p.
- Kerr, P.F. (1959), Optical Mineralogy, McGraw Hill Book Company Inc., New York,
- Philpots A.R. and Ague, J.J. (2009), Principles of Igneous and Metamorphic petrology, second edition, Cambridge University press, New York, 667p.
- Powell, R. (1978), Equilibrium thermodynamics in Petrology: An Introduction, Harper and Row Publ., London, 284 p.

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- Spear, F. S. (1993), Mineralogical Phase Equilibria and Pressure – Temperature – Time Paths, Mineralogical Society of America, 799p.
- Spry, A. (1976), Metamorphic Textures, Pergamon Press, 350p.
- Winter, J.D. (2001), An introduction to Igneous and Metamorphic Petrology, Prentice Hall 697p.
- Wood, B.J. and Fraser, D.G. (1976), Elementary Thermodynamics for Geologists, Oxford University Press, London, 303p.
- Yardley, B.W.D., Mackenzie, W.S. and Guilford, C. (1995), Atlas of Metamorphic Rocks and their Textures, Longman Scientific and Technical, England, 120p.
- Yardley, B.W. (1989), Introduction to Metamorphic Petrology, Longman, New York, 248p.
- Vernon, R.H. and Clarke, G.L. (2008), Principles of Metamorphic Petrology, Cambridge, 446p.
- Winkler, H.G.F. (1976), Petrogenesis of Metamorphic rocks, 4th edition, Springer-Verlag, New York, 347p.
- Miyashiro, A. (1994), Metamorphic Petrology, Akiho, Research Press, New Delhi,416p.
- Pitchamuthu. C.S. (1984), Granulites of South India,Geological Society of India.

GEOL 5203. Geochemistry (2 credits)

Unit - 1

Elements in the Universe – Significance of elemental abundance, elements and nuclides, measuring cosmic and solar system abundances, spectral analysis, the composite abundance curve, cosmic element production. Meteorites – Classification and chemical analysis of meteorites. Elements in the solar system – Cosmo-chemical classification, element fractionation in the solar system, evolution of the solar system and chemical evolution of the Earth.

Unit - 2

Goldschmidt's geochemical classification of elements. Geochemistry of important elements: Alkalis, alkaline earths, hydrogen, aluminium, carbon, silicon, nitrogen, oxygen and sulphur. Distribution of elements in igneous, sedimentary and metamorphic rocks.

Unit - 3

Basic principles in geochemistry: Geochemical environment, surficial and deep seated environment, geochemical cycle, geochemical dispersion, - primary and secondary dispersion, dispersion halos, geochemical mobility, geochemical reactions, association of elements, indicator elements, pathfinder elements, patterns of geochemical distribution, background value, geochemical anomaly, significant and non-significant anomalies, threshold.

Unit - 4

Equilibrium in geological systems: Mineral stability, law of mass action, Le Chatelier's rule, influence of temperature and pressure. Systems – open and closed systems, phase, phase diagram, phase rule,

components, enthalpy and change in enthalpy, free energy and free energies of formation. Eh-pH limits of natural environments

Unit - 5

Chemistry of minerals – Bonding in minerals-ionic, covalent, metallic, Vander Vaals, Hydrogen and minerals with more than one type of bond. Isotope geochemistry: Physical and chemical properties of isotopes; stable and unstable isotopes. Isotopes of carbon, sulphur and oxygen. Isomorphism, Polymorphism, Solid solution- interstitial and omission solid solution, Exsolution. Stability fields of selected minerals-. Polymorphs of silica, alumino-silicates, calcium carbonate.

References

- Krauskopf, K. B. (1967), Introduction to Geochemistry, McGraw-Hill Book Co., New York, 721 p.
- Arthur, W., Hawkes, H.E. and Webb, J.S. (1979), Geochemistry in Mineral Exploration, Academic Press, USA, 657p.
- Mason, Brian, Moore and Carleton, B. (1982), Principles of geochemistry, John Wiley&Sons, New York, 344 p.
- Gill, R. (1989), Chemical Fundamentals of Geology, HarperCollins Publishers Ltd, UK, 292p.
- Holt, K.H.W. (1971), Geochemistry, Rinehart and Winston Inc, USA.
- Rankama, K. and Sahama, T.H.G. (1950), Geochemistry, Univ. Chicago press, 911p.
- Walther. J.V.(2010) Essentials of Geochemistry, Jones and Barlett Publishers, New Delhi. 797p.

GEOL 5204. Igneous Petrology Practical (1 credit)

Preparation of binary phase diagrams. Megascopic and microscopic identification of various rocks. Normative mineralogical calculations of acid, intermediate, basic and ultrabasic rocks (3 each). Preparation of variation diagrams: Harkar, Larsen, Nockold and Allen, Niggli Calculation of Fractionation Indices: Larsen Index, Nockolds Index, Mafic Index(MI), Mg- Number, Solidification Index, Felsic Index, Differentiation Index. Spider Diagram.

References

- Ragland.P.C (1989). Basic Analytical Petrology, Oxford University Press, 369p.
- Carmichael, I. S. E., Turner, F. J. and Verhoogen, J. (1974), Igneous Petrology, McGraw Hill Book Company, 739 p.
- Ehlers, E. G. and Blatt, H. (1981). Petrology, CBS Publishers and Distributors, New Delhi, 732 p.
- Faure, G. (2001), Origin of Igneous Rocks: The Isotopic Evidence, Springer-Verlag, New York, 496 p.
- Gupta, A. K. (1998), Igneous Rocks, Allied Publishers Limited, 690 p.
- Hall, A. (1988), Igneous Petrology, ELBS, Longman, 573 p.

GEOL 5205. Metamorphic Petrology Practical (1 credit)

Study of metamorphic rocks in hand specimen. Preparation of metamorphic rock thin sections. Study of metamorphic rocks in thin sections. Metamorphic mineral assemblages. Structures and textures of metamorphic rocks. Grain boundary relations. Strain effects. Plotting and interpretation of chemical data on ACF,AKF diagrams.

References

- Bucher, K. and Martin, F. (2002), Petrogenesis of Metamorphic Rocks (7th Rev. Ed.),
- Kerr, P.F. (1959), Optical Mineralogy, McGraw Hill Book Company Inc., New York,
- Philpotts, A.R. (1994), Principles of Igneous and Metamorphic Petrology, Prentice Hall,
- Philpots A.R. and Ague, J.J. (2009), Principles of igneous and metamorphic petrology, second edition, Cambridge University Press, New York, 667p.

GEOL 5206. Field Geology (2 credits)

Principles of geological mapping. Training in field mapping. Preparations for field mapping. Field equipments. Geological symbols and notations. Lithological and structural mapping. Identification and recording of rock types and structures in the field. Measurement and recording of field data.
Finding and tracing contacts between rock units, correlating geologic units, mapping geologic structures, outcrop maps, locating points in the field. Selecting and preparing a base map—locating field data and geologic features.

Techniques of geological mapping in igneous, metamorphic and sedimentary terrains. Structural mapping: Mapping of Faults—folds—foliations, cleavages, lineations, joints, shear zones.
Preparing final geological map and reports: report writing, major illustrations, photographs, drawings, diagrams, designing the report, format and specific parts of the report.
Field mapping in terrains of geological significance and preparation of reports.

References:

- Richard J. Lisle, Peter Brabham and John W. Barnes (2011). Basic Geological Mapping (Geological Field Guide). Revised 5th Edition. Wiley-Blackwell.
- Angela L. Coe (2010). Geological Field Techniques. 1st Edition. Wiley-Blackwell. 336p.
- Lahee, F.H. (2002). Field Geology. 6th Edition, CBS Publishers.

GEOL 5301. Paleontology (3 credits)

Unit - 1

Life in Precambrian, Diversification of life. Evolution of life in the Palaeozoic, Mesozoic and Cenozoic eras. Ecological concepts and Palaeo-ecology. Palaeocommunities.Use of fossils in palaeoclimatic and palaeogeographic studies.

Unit - 2

Fossil record and modes of evolution: Microevolution, Macroevolution and Tree of life. Patterns of evolution. Theory of organic evolution and the factors in the Darwinian theory. Theory of Punctuated Equilibria. Fossil form and Function: Growth and form, Variation in form and shape within species, Evolution and Development, Ontogeny and Phylogeny, Developmental genes, Interpreting the functions of fossils, circumstantial evidences.

Unit - 3

Micropalaeontology: scope and subdivisions - types, extraction of microfossils from sediments and sedimentary rocks. Foraminifera: their palaeoecology and application in paleoclimate, paleoceanography and biostratigraphy. Radiolaria, Diatoms, Ostracoda, Pteropods, Cocolithophores, Stromatolites and Conodonts – morphology, classification and importance.

Unit - 4

Palynology - General morphology of spores and pollens and their applications. Palaeobotany: Plant life through geological ages. Gondwana plant fossils. Application of microfossils in petroleum exploration.

Unit - 5

General characteristics, geologic history, classification and evolution of Pisces, Amphibians, Reptiles, Birds and Mammals (Elephants, Rhinoceros, Horse and Human beings). Human fossils in different parts of the world.

References

- Benton, J.M. and Harper (2009) Introduction to palaeobiology and the fossil record, Wiley-Blackwell, 608p.
- Benton, M.J and David A.T. Harper (2009). Palaeobiology and the Fossil Record, Wiley-Blackwell, 608p.
- Benton, M.J (2000). Vertebrate Palaeontology, Blackwell science, 269p.
- Black, R.M (1989) The elements of palaeontology, Cambridge University Press, 420p
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- Clarkson, E.N.K (1998). Invertebrate Palaeontology and Evolution, ELBS Publishers.
- Glaessner,M.F. Principles of Micropalaeontolgy, Hafner Publishing Company.
- Lehmann.U and Hilimer, G (1983) Fossil Invertebrates, CambridgeUniversity, 350p
- Porthero, D.R. (2004) Bringing fossil to life- An Introduction to Paleontology Mc Graw Hill, 512p.
- Pough.H. F, Heiser, J.B. and McFarland, W.N. (1996). Vertebrate Life, Prentice hall.
- Raup D.M. and Stanley .S (1985) Principles of Palaeontology, 481p.
- Ray, A.K (2008). Fossils in earth Sciences, Prentice Hall of India Private Limited.

- Shrock, R.R., Twenhofel, W.H (1953). Principles of Invertebrate Palaeontology, Mc Graw Hill, 816p.

GEOL 5302. Ore Geology (3 credits)

Unit – 1

Textures and structures of ore and gaugue minerals. Fluid inclusions; wall rock alteration.Paragenetic sequences; zoning, dating of ore deposits. Major theories of ore genesis. Mineralization in space and time: Global distribution of ore deposits; Metallogenic provinces and epochs; plate tectonic controls in mineralization. Principles and applications of ore microscopy.

Unit – 2

Ore deposits and environments. Diamond deposits in Kimberlites and Lamporites- Alkaline igneous ore environments; the pegmatitic environments; orthomagmatic deposits of Cr, Pt, Ti, Fe, Cu, Ni deposits associated with basic and ultrabasic rocks. Disseminated sulphide, Oxide and sulphate deposits of sedimentary and volcanic environments, hydrothermal deposits. Stratabound deposits, sedimentary deposits; role of metamorphism in ore genesis. Ore deposits associated with weathering and weathered surfaces.

Unit – 3

Mineral Deposits of India: Iron ore deposits – Mineralogy, classification, grade, distribution in India, BIF – BHQ, BMQ, Iron ore deposits especially of Kerala, Bihar, Orissa, Karnataka

Types, grades, mineralogy, uses, origin and occurrences of Manganese ore deposits (especially of Bihar, Orissa); chromium ore deposits (especially of southern India), Bauxite deposits (classification based on origin and shape); and copper ore deposits (especially of Khetri and Malanjkhand) in India. Origin and occurrence of Lead and Zinc, Mica, Gold, PGE, Diamond, Uranium and Thorium deposits of India.

Unit - 4

Mineral Deposits of India. Placer deposits of Kerala – General geologic and geomorphic setting, Ilmenite and rutile, monazite, Zircon, Sillimanite, Garnet, origin of Chavara Placer deposits, silica sands.

Non-metallic deposits – Refractory minerals: acid refractories – silica – Clay Deposits: Origin and Mineralogy, china clay deposits of Kerala – Kyanite – Neutral refractories: chromite – graphite – asbestos – Basic refractories – Magnesite – dolomite. Minerals used in Fertilizer industry: phosphorite, apatite. Minerals used in Cement industry: limestone – gypsum. Minerals used in Chemical industry.

Unit – 5

Mineral resources of the sea – sources of marine minerals, continental shelves, Deposits under the surficial sediments of the continental shelves, deposits in the deep sea floor: polymetallic nodules, gas hydrates, phosphorites, lime mud and seafloor massive sulphides (SMS). Law of the Sea Treaty – Exclusive economic zone, International Area of the sea bed, International Seabed Authority – India's strategy for future exploitation of seabed deposits. Offshore exploration.

National mineral policy – MM (R&D) Act, 1957 – Procedures for Grant of Mineral Concessions in India – UNFC classification – Global mineral reserves and resources – Minerals and sustainable

development –Strategic, Critical and Essential minerals of India. State-wise share of mineral production in India

References

- Banerjee (2001), Mineral Resources of India.
- Evans, A.M., (1980), An introduction to Ore geology, Blackwell Scientific Publications, 231p.
- Evans, A. M. (1993), Ore Geology and Industrial Minerals: an Introduction, Blackwell, 403p
- Geological Survey of India (2009), Miscellaneous publication no. 30, part-xxii: Geology and mineral resources of India,152p
- Geological Survey of India, Detailed information dossier (DID) of ores in India, (Available at GSI portal: www.portal.gsi.gov.in).
- Indian Bureau of Mines Bulletins of Mineral Information (availabile at IBM website) Ministry of Mines Annual Report 2011-12, 248p.
- Mookherjee, A., (1999), Ore Genesis- A Holistic Approach, Allied Publishers, 657p.
- Ministry of Mines (2011), Report of the working group on mineral exploration & development (other than coal & lignite) for the 12th five year plan sub group – on survey and mineral exploration, 310p.
- Nuclear Power in India Indian Nuclear Energy, http://www.world-nuclear.org/info/inf53.html
- Prasad, U (2002), Economic Mineral Deposits, CBS Publishers, New Delhi.
- Soman, K. (2001), Geology of Kerala, GeolSoc of India, Bangalore, 335p
- Stanton, R.L., (1972), Ore Petrology, McGraw Hill Inc, 213p
- Uranium 2009: Resources, Production and Demand, (The Red Book) Nuclear Energy Agency, OECD, 452p.
- Wellmer, F.W., Dalheimer, M. and Wagner, M. (2008), Economic Evaluation in Exploration, Springer-Verlag, Berlin.
- Zoellner, T. (2009) Uranium : war, energy, and the rock that shaped the world, Viking, London, 353p.

GEOL 5303. Exploration Geology (3 credits)

Unit – 1

Geological Exploration: Trenching and Pitting; Drilling:- Design of programme drilling methods. Vertical and inclined holes. Types of logging of boreholes, borehole deviations. Sampling: Sampling pattern of exposures. Mine working trenches, pits, drill holes, channels, and placers, Bulk sampling.

Unit – 2

Geophysical prospecting :The principles and limitations of geophysical exploration methods Gravity survey: Principles, Bouger anomaly, correction methods and interpretation. Magnetic Survey - Principles, Earth's magnetic field, methods, interpretation and applications. Seismic survey: - Generation, propagation and sensing of seismic waves, wave types, travel time graphs for different media and interfaces. Seismic velocities in geological materials. Seismic surveys, source, recorders, reflection and refraction surveys and interpretation of profiles.

Unit – 3

Electrical surveys: Electrical properties of rocks, theory of current flow in different media, resistivity survey, Application and interpretation of data. Self-potential(SP) survey, applications and interpretation. Induced polarization(IP) survey, applications and interpretation. Electromagnetic surveys: Depth of penetration of electromagnetic fields, detection of electromagnetic fields. Tilt angle, VLF, AFMAG methods, Air-borne electromagnetic surveying

Radiometric surveying: Radioactive decay, Instruments used (Geiger counter, Gamma ray spectrometer, Radon emanometer, Scintillation counter, Field surveys.

Unit – 4

Geochemical exploration: Principles, Geochemical anomalies, relief, indicators and pathfinder elements, geochemical environment, dispersion and mobility, trace element studies. Sampling and analysis. Sampling and sampling methods, sample variability – appropriate sampling. Important sampling techniques - Grab/Chip sampling, Channel or Groove Sampling: Bulk sampling, Placer sampling, Subsurface sampling, Borehole samples, Check samples

Unit – 5

Biogeochemical prospecting Geo-botanical prospecting - Biogeochemical anomalies, geo-botanical indicators – Types of indicators- universal and local indicators. Surface and underground mapping. Geophysical logging – Introduction to drilling, Principles of well logging, formation evaluation- Types of logging techniques – Electrical(resistivity, induction, self potential), Radiometric(Gamma Ray, Neutron-Gamma ray), Temperature, Sonic, Magnetic, Gravity and Caliper Logging.
Remote sensing and GIS based exploration methods.

References

- Arogyaswamy, R.N.P. (1980), Courses in Mining Geology, 2nd Ed., Oxford & IBH Pub. Co., New Delhi
- Arthur, W., Hawkes, H.E. and Webb, J.S. (1979), Geochemistry in Mineral Exploration, Academic Press, USA, 657p.
- Banerjee, P.K and Ghosh, S. (1997), Elements of Prospecting for Non-fuel Mineral Deposits, Allied Publishers Pvt Ltd, 320p.
- Kearey, P. and Brooks,M. (1991), An Introduction togeophysical Exploration, Blackwell scientific Publications, Musset, 272p.
- Krisch ,R (2006). Groundwater Geophysics,A tool for hydrogeology,Springer –Verlag Berlin Hiedelberg.,Berlin 548 pp
- Lowrie, W (2007). Fundamentals of Geophysics, Cambridge University press, New York, 381pp.
- Mckinstry, H.E. (1947), Mining Geology, 1st Indian Ed., Asia Publishing House, New Delh
- Milsom,J (1989). Field Geophysics ,A Geological Society of London Handbook, John Wiley&sons, New York.182 pp.
- Mishra D,C., (2011). Gravity and Magnetic Methods for Geological Studies,BS publications Pvt.Ltd Hyderabad 938pp.

GEOL 5305. Economic Geology Practical (1 credit)

Megascopic study and identification of ore minerals. Preparation and study of polished sections.
Seismic and Electrical Resistivity exploration problems.
Preparation of lithologs using exploration data. Calculation of grade, tonnage and cutoff grade. Reserve estimation. Types of reserves. Ore reserve calculation.
Mining: Mining Terminologies. Mining methods: Alluvial mining, Open Cast mining, Underground mining, Coal mining, Sea bed mining.
Fundamentals of ore dressing: Crushing, grinding, sizing, concentration by washing, scrubbing, jigging, tabling, floatation. Magnetic and Electrostatic separation. Flow charts of mineral separation.

References

- Arogyaswamy, R.N.P. (1980), Courses in Mining Geology, 2nd Ed., Oxford & IBH Pub. Co., New Delhi
- Banerjee (2001), Mineral Resources of India.
- Banerjee, P.K and Ghosh, S. (1997), Elements of Prospecting for Non-fuel Mineral Deposits, Allied Publishers Pvt Ltd, 320p.
- Kearey, P. and Brooks,M. (1991), An Introduction to geophysical Exploration, Blackwell scientific Publications, Musset, 272p.
- Mckinstry, H.E. (1947), Mining Geology, 1st Indian Ed., Asia Publishing House, New Delhi.
- Prasad, U (2002), Economic Mineral Deposits, CBS Publishers, New Delhi.
- Sinha, R.K and Sharma, N.L. (1970), Mineral Economics, New Delhi Oxford and IBH Pub.co., 317p.

GEOL 5306. GIS and Image Interpretation Practical(2 credits)

Geographic information systems – data encoding- data management, data manipulation, data output. Data Input and Editing: Coordinate Conversion. Digitizing, data encoding, re-projection and transformation. Vector and Raster data analysis. Interpolation and overlay techniques. Display of images, Colour look up tables, Query analysis. Familiarization of different GIS environments including proprietary and open source such as ArcGIS, QGIS, MapInfo, Erdas etc.
Introduction to database, use and application of DBMS and RDBMS, Database System Concepts and Architecture; Classification of database management systems. Database design.

Digital Image analysis using softwares. Geometric correction- Radiometric correction – Noise removal. Image Enhancement-Contrast Manipulation - Edge Enhancement – Spatial feature manipulation –Fourier Analysis. Multi Image Manipulation- Spectral Ratioing –Principal and Canonical Components– Vegetative Components – Intensity – Hue – Saturation – Colour Space Transformation. Graphical representation of the spectral response patterns, unsupervised classification- Hybrid –Classification – Classification of Mixed Pixels.

References

Mather, P.M. and Koch, M. (2011),Computer Processing of Remotely-Sensed Images – An Introduction, Fourth Edition, John Wiley, New York, 462p.

DeMers, M. N. (2009), GIS for dummies, Wiley, NJ, 388p.

Iliffe, J. (2000), Datums and Map Projections for remote sensing, GIS, and surveying, Whittles Publishing, Scotland, 159p.

Konecny, G. (2003), Geoinformation: Remote sensing, photogrammetry and geographic information systems, Taylor& Francis, London, 266p.

Sickle, J. V. (2010), Basic GIS Coordinates, CRC Press, FL, 190p.

Verbyla, D. L. (2003), Practical GIS analysis, Taylor & Francis, London, 305p.

Curran, P. (1985) Principles of Remote Sensing, Longman, London, 260p.

Shiv N. Pandey (1987) Principles and applications of Photogeology, Wiley Eastern Limited, 366p.

Drury S.A, (1990) A Guide to Remote Sensing - Interpreting Images Of Earth, Oxford Science Publications, Oxford.

GEOL 5401. Hydrogeology (3 credits)

Unit – 1

Definitions and differences of - Hydrology, Hydrogeology, Geohydrology and Groundwater hydrology. Hydrologic cycle and processes – Precipitation, Evaporation and transpiration, Runoff, infiltration. Water balance. Origin and types of waters – meteoric, juvenile, magmatic and metamorphic. Groundwater storage –Aquifer, Aquiclude, Aquifuge and Aquitard. Types of aquifers – Confined, Unconfined, Bonded aquifers Sloping Piezometric and Phreatic aquifers. Springs.

Hydrological properties of rocks – Porosity, Permeability, Void ratio Specific yield and Specific retention, Hydraulic conductivity, Transmissivity and Starativity. Elastcity of aquifers, barometric efficiency and barometric tidal efficiency. Geological fame work in relation to Hydro geological environment: Rock types and distribution, rock matrix, factures, weathered hard rocks and superficial materials.

Unit – 2

Groundwater flow-Water table and Piezometric surface- Flow characteristics of water – Head distribution, Laminar and turbulent flow. Darcy's law and its experimental verification. Flow through aquifers. Differential equation governing ground water flow. Hydrological boundaries, flow nets. Groundwater tracers.

Well hydraulics: Aquifer tests, organization and conduct of pumping tests, data analysis of pumping test, Recovery test, drawdown, cone of depression and cone of impression, Steady radial flow to a well in confined and unconfined aquifers – Thiem's equation and Dupuit- Forhemeir equation. Unsteady radial flow to a well in confined and unconfined aquifers – Theis equation – Theis, Chow and Cooper-Jacob methods – Isotropic non-leaky artesian aquifers.

Unit – 3

Groundwater exploration: Geological and Hydrological methods, Surface investigations of groundwater- Geophysical methods, Electrical Resistivity methods – Wenner and Schlumberger methods, Seismic refraction methods, Gravity and magnetic methods. Application of remote sensing and GIS in Groundwater exploration. Mapping methods, Remote sensing data, Field reconnaissance and data acquisition.

Unit – 4

Water well designing - Types and mode of construction – Methods of deep well drilling- Cable tool method, Rotary method, Air rotary method, Rotary Percussion method, Reverse Circulation Rotary Method, DTH method – construction design – development and maintenance of wells. Production specification, well production, specific capacity pumps and pumping equipment.

Unit – 5

Quality of Groundwater: Chemical quality- Different chemical parameters and their analysis, Graphical representation of water quality data: various diagrammatic representations – interpretation of hydrochemical data – Hill-Piper Trilinear diagram, Durov's diagram and U.S. Salinity diagram – Sodium Adsorption Ratio (SAR) –Water quality standard for different purposes – Drinking, Domestic, Irrigation and Industrial.

Threats to groundwater quality and reserve: Saline water intrusion in coastal and other aquifers and its prevention – Ghyben-Herzberg relationship. Water management, groundwater system planning. Groundwater development – safe yield, Groundwater provinces of India. Groundwater depletion due to mining. Artificial recharge and rain water harvesting methods.

References

- Bouwer,H. Groundwater Hydrology,1978.
- Davis,S.N. and Dewiest, R.J.N. Hydrogeology, John Wiley and Sons Inc. New York,1966.
- Karanth.K.R.Groundwater Assessment Development and Management, Tata McGraw Hill,1987.
- Linsley,R.K, Kohler, M.A. and Taulhus, J.L.H. Applied Hydrology, Tata McGraw Hill,1975.
- Todd,D.K. Groundwater Hydrology, John Wiley and Sons, 1980.
- Walton,W.C. Groundwater Resource Evaluation, McGraw Hill Inc,1970.
- Reghunath, H.M. Groundwater.2nd Edn.Wiley Eastern Limited. 1992.
- Sharma H.S. Well Hydraulics and Tube Wells.

GEOL 5402. Stratigraphy (3 credits)

Unit – 1

Development of Stratigraphy: Contributions of the pioneers of Stratigraphy, Major incidents in the Earth History. Stratotype: Unit, Boundary, Holo-, Hypo-, Para-, Neo-, Lecto- stratotypes. Requirements for stratotypes. Establishment of stratigraphic units: Procedures for the establishment and description of surface and subsurface stratigraphic units. Revision or redefinition of previously established units, Recommended editorial procedures.

Unit – 2

Lithostratigraphy : Procedures for establishing , extending and naming of Lithostratigraphic units. Revision of Lithostratigraphic units. Biostratigraphy: Significance of fossils, Nature of biostratigraphic units – Life communities and Death assemblages. Procedures for establishing and extending biostratigraphic units, Revision of biostratigraphic units. Chronostratigraphy: Formal and Informal chronostratigraphic units, Procedures for establishing and naming of chronostratigraphic units.

Unit – 3

Sequence Stratigraphy: Stratigraphic Architecture, Depositional systems and systems tracts, Sequence Boundaries. Fluvial, Lacustrine, Eolian, Marginal marine and Shallow Marine, Deltaic and Deep Marine siliciclastic Sequences. Mass extinctions and biodiversity loss: Pattern and timing, selectivity and periodicity of mass extinctions. The big five mass extinction events, Recovery after mass extinction, Extinction today.

Unit – 4

The concept of the Precambrian. Distinguishing features and classification of the Precambrian. The Problem of the base of the Cambrian. Precambrian stromatolites, their status as time markers and classification of the Late Proterozoic. Chelogenic and orogenic cycles. Models for the evolution of Precambrian crust. Shields - cratons and mobile belts. Low-grade and high-grade terrains. Precambrian shield areas.

Precambrian of southern India. Major Phanerozoic Basins in India: General description, age, development, evolution, stratigraphy and classification of the following basins in India - Gondwana, Kaveri, Kerala and Cambay Basins.

Unit – 5

World stratigraphy: Classic localities and distribution of systems, palaeogeography and major events during different periods. Age problems in stratigraphy.

References

- Balasubrahmanyan, M. N. (2006), Geology and Tectonics of India: An Overview, IAGR Memoir No.9, 204p.
- Benton, M J and David A.T. Harper, Introduction to palaeobiology and the fossil record, Wiley-Blackwell
- Brookfield, E B. (2004), Principles of Stratigraphy, Blackwell Publishing Ltd.
- Claude, C. and Albritton J. (1995), Catastrophic Episodes in Earth History, Chapman & Hall.
- Donovan, S K (Ed.), (1989). Mass Extinctions – Processes and Evidence, Belhaven Press
- Gradstein, F M, Ogg,JG,Schmitz, M D and Ogg, G M The Geological Time Scale 2012 Vol I and Vol II, Elsevier, Amsterdam
- Hedberg, H.D. (Ed.), International Stratigraphic Guide - International Subcommission on Stratigraphic Classification of IUGS Commission on Stratigraphy.
- Kumar, R, (1985), Fundamentals of Historical Geology and stratigraphy of India, Wiley Eastern Ltd., New Delhi, 254p.
- Lemon, R.R. (1990), Principles of Stratigraphy, Merrill Publishing Company, 559p.
- Miall, A D (2000). Principles of Sedimentary Basin Analysis, Springer Verlag.
- Naganna, C. (Ed.), (1975), Studies in Precambrians, Bangalore University, 291p.
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- Naqvi, S.M. and Rogers, J.W. (Eds.) (1987), Precambrian of South India, Geological Society of India, 575p.
- Pichamuthu,C.S. (1985), Archaean Geology, Indian.soc.of. Earth sciences, Oxford and IBH Publishing Co., New Delhi, vol.14, 221p
- Ramakrishnan, M. and Vaidyanathan, R. (2008), "Geology of India," Geological Society of India, Bangalore, Vol. 1 & 2.
- Schoch, R.M. and Reinhold, V.N. (1969), Stratigraphy -Principles and Methods, New York, 375p.
- Spencer, E W (1962) Basic concepts of Historical geology, Oxford IBH, New Delhi
- Stanley S M (2005) Earth system history, II Edn., W H freeman & Co., New York
- Weller, Marvin, J. (1960), Stratigraphic principles and practice, Harper and Brothers, New York, 725 p.

GEOL 5403. Hydrogeology Practical (1 credit)

Identification and demarcation of Watershed boundaries, Interpretation of well inventory data, Determination of groundwater flow direction, Preparation of water table contour map. Estimation of permeability. Analysis of hydrographs and estimation of infiltration capacity. Pumping test – Time, Drawdown and time recovery tests. Evaluation of aquifer parameters, Study of depth and yields of bore wells. Study of Electric resistivity sounding data for delineation of fresh and saline aquifers. Study of geophysical well logs. Exercises on groundwater exploration using remote

sensing techniques. Exercises related on ground water modeling with given data. Preparation of ground water potential maps.

Reference

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- Chaw, V.T,1984, Hand book of applied hydrology, New York McGraHill Book Co Inc.
- Davis, S. N. And R. J. M. Dewiest R. J. M., 1966. Hydrogeology.
- Johnson Division, 1975, Groundwater and wells, UOP Inc.
- Karanth, K.R. 1987. Groundwater Assessment Development and Management, Tata McGraw Hill,
- Patric, A.D., Franklin W.S.1997, Physical and chemical hydrogeology,Wiley.
- PoehisD.J,Gregory J.S. 2011. Encyclopedic dictionary of Hydrogeology, Academic press.
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- Todd, D.K, 1980. Groundwater hydrogeology John Wiley and Sons, New York.

GEOL 5404. Dissertation (8 credits)

Independent project work including field and laboratory investigations of geological significance. Dissertation report and presentation shall be in the fourth semester while the work related to the course can be initiated in the third semester itself.

Elective courses (Internal)

GEOL 501. Industrial Minerals and Gemstones (2 credits)

Unit – 1

Industrial Minerals - Mode of occurrence - Use and distribution in India - Ceramic minerals, Granites and Building stones, Cement - Raw Minerals - Mineral pigments - Refractory and abrasive minerals - Fertilizer minerals- Diamond - Gemstones, Asbestos, Mica, Vermiculite, Barite, Talc, Glass, Sand and Fullers earth.

Unit – 2

Introduction to Gems –Precious and Semiprecious stones and their economic importance. General characteristics and chemical composition of gemstones. Physical characteristics: Form, cleavage, fracture, hardness and specific gravity; Optical characteristics: colour, lustre, refractive index, reflectivity, pleochroism, and dispersion.

Introduction to special optical properties of gemstones.Chatoyancy, Asterism, Luminescence, Play of colours, Labradorescence, Inclusions.
Formation of gemstones. Qualities and Classification of gem materials

Unit – 3

Gem Testing- Refractometers, Polariscope, Dichroscope, Ultra Violet lamps Principles and Uses. Application of ultraviolet rays, X-rays and Infra-red rays in gem identification. Electrical, thermal and magnetic characters of gem. Methods of determination of Specific Gravity. Distinction between synthetic and natural gemstones.

Unit – 4

Gem enhancement methods and their identification: Polishing, Carving and engraving, colourless/coloured impregnation, heat treatment, coating, irradiation, diffusion, treatment etc.
Utility of gemstones: (1) Technical applications and (2) Application as jewels. Occurrence of Gems in India. Gem Industry in India.

References

- Anderson B., 2014.Gem Testing, Sutton Press.
- Babu T. M. 1998. Diamonds in India, Geological Society of India, Bangalore-.
- Bates, 1969. Geology of Industrial Rocks and Minerals, Dover book earthsciences.
- Baumgart,W., DunhamA.C., and Amstutz,G.C., 1985.Process Mineralogy of Ceramic Materials.Elsevier Science Ltd.
- Cally Hall, 1994. Gemstones, Dorling Kindersley.
- Deb,S. 1980. Industrial Minerals and Rocks of India, Allied Publishers (P) Ltd.,.
- Karanth, R.V. 2000. Gems and Gem Industry in India, Geological Society of India.
- Krishnasamy, S. 1972. India's Mineral Resources, Oxford and IBH Publishers.
- Taggart, A.P. Hand book of Mineral dressing, Willey.

GEOL 502. Mining and Engineering Geology (3 credits)

Unit – 1

Mining terminology, Application of geology in mining, Duties of a mining geologist, guides in the location of ore deposit- physiographic, lithologic, stratigraphic, mineralogic and structural guides, Appraisal of exploration data for exploratory mining, Mine planning, Mine development. Types of mining- Alluvial Mining, Quarrying and Open cast Mining, Underground Mining. Open Cast Mining Methods- Excavation, Benching, Levelling. Methods of breaking rocks- Blasting practices- Drilling blast holes, Transportation of ore.

Unit – 2

Underground Mining - Methods for metallic and non-metallic minerals- Modes of entry - Adit, Tunnel, Incline or vertical Shaft. Underground exploration methods in mining, geotechnical investigations for mine planning, mining machinery, transportation: haulage and hoisting. Mine organization and operations- Shaft Sinking, drifting, cross cutting, winzing, stoping, room & pillaring, top – slicing, sub – level caving and block caving; Mine drainage; Mine support and ventilation; illumination.

Unit – 3

Drilling methods. Diamond core drilling – Drilling rod, core barrel and types of bits – Sampling of drill core- Logging and storage of core – Interpretation and analysis of drill core data.

Mine hazards and Safety works- Mine inundation, Fire and Rock burst, Subsidence. Support of mine excavation; timber treatment, safety measures in underground and open cast mines, rescue work. Mine monitoring.

Unit – 4

Geology in civil engineering. Engineering properties of rocks-Strength, Durability, Hardness. Rock as construction material- Foundation, Building stone, Aggregate. Various stages of geological investigations for civil engineering projects.

Geological considerations in engineering projects such as dams, reservoirs, tunnels, Methods of tunnelling; Classification of ground for tunnelling purposes; Various types of support, Geological consideration in the selection of Dam site and reservoirs – Rock types, Fault , Fold, Joints. Transportation routes - Bridges and highways.

Unit – 5

Reservoir sedimentation: Causes and effects. Geological factors, monitoring and desilting methods. Coastal erosion and its effects. Nearshore dynamics, erosion mechanisms- Long shore drift. Coastal erosion and its effects and controlling methods, construction of sea-walls, groins and harbours.

Mass Movements with special emphasis on landslide and causes of hill slope instability. Classification of landslides. Geological investigation of landslides. Landslide hazard zonation mapping using remote sensing and GIS-subjective and objective rating techniques – mitigation measures. Aseismic designs of buildings; influence of geological condition on foundation and design of buildings. Earthquake resistant structures. Seismicity in India and seismic zonation maps,

References

- Arogyaswamy, R.N.P, Courses in mining geology, Oxford and IBH pub.Co.

- Hartman ,H.L. Mutmansky, J.M. Introductory mining Engineering, John Wiley and Sons Inc. 2002.
- Gaudin, A .M. Principles of Mineral Dressing, McGraw Hill,1938.
- Petters, W.C. Exploration and Mining Geology. JohnWiley
- Reedman, J.H. Techniques in mineral exploration, Allied Scientific Publishers.
- Umathy, R.M., Text book of Mining geology, Dattsons 2002.
- Bell,F.G. Fundamentals of Engineering Geology,BS Publications, 1983
- Coduto, D.P. Geotechnical Engineering –Principles and Practices. Prentice Hall of India, Pvt Ltd, New Delhi.2001
- Duggal S.K. Pandey, H.K. and Rawal N. Engineering Geology, McGraw Hill Education (India) Pvt.Ltd.2014.
- Lee.F. and Griffiths, 2007, Engineering Geomorphology, Whittles publishing
- Krynine,D.P.andJudd,W.R. Principles of engineering geology and Geotectonics,CBS Publishers and Distributers, New Delhi,2001.
- John, R.B. and Jerome V. Degraff , Principles of engineering geology, John Wiley and Sons Inc. 1976.

GEOL 503. Geomatics (3 credits)

Unit – 1

Concept and foundations of remote sensing: energy sources and radiation principles, energy interactions in the atmosphere, energy interaction with earth surface features – Spectral Reflectance - Spectral Response Patterns - data acquisition and interpretation, reference data –elements of photographic system - types of aerial photographs.

Photogrammetry: basic principles – geometric characteristics of aerial photographs - visual image interpretation – stereoscopes –photogrammetric workstations – landform identification and evaluation

Unit – 2

Digital Image Processing: Properties of Digital Remote Sensing Data – Data Formats: BSQ, BIL, GeoTIFF, JPEG, HDF. Preprocessing –destriping, Geometric correction and registration, image enhancement, image transformation, change detection, image classification: supervised & unsupervised classification, data merging. Thermal, multispectral and hyperspectral sensing: Hyperspectral sensing, Microwave sensing - radars, SLAR system, spatial resolution of SLAR, interpretation of SLAR – SRTM.

Unit – 3

Fundamentals of GIS :Components of GIS. Geodesy: Ellipsoid – Geoid. Datums – benchmarks, triangulation survey, Great Trigonometrical Survey of India, datum shift, datum transformation. Geographic coordinates. Cartesian coordinates. Coordinate conversions. Map projections. Global Positioning System: Basic features, GNSS, NAVSTAR GPS, GLONASS, IRNASS. Introduction to Web GIS: Definition, concept of Web GIS, History of Web GIS, components of web GIS. Applications of web GIS. Overview of Web GIS. Application of remote sensing and GIS: Geology, Natural resource management, mapping and decision making; Urban planning and management; Water resources management; Disaster management; Environmental management; Demography, health, business and humanities.

Unit – 4

Vector data model. Arcs, nodes, vertices, polygon inclusions, boundary generalization. Spaghetti vs. Topological vector models. Shape files and coverages. Vector features and attribute tables – Relational Database Management Systems. Raster data model –vector vs. raster, raster to vector & vector to raster conversion. Data structures for elevation data: TIN, DEM. Data Input and Editing in GIS – Data Sources. Map registration – Georeferencing, GCPs, Coordinate Conversion, Data Editing – Detecting and correcting errors, transformation and Generalization, Edge matching and rubber sheeting. Metadata

Unit – 5

Spatial Data Analysis: Local, neighbourhood and global spatial operations. Selection. Set algebra: <, >, =, <>. Boolean operators: OR, AND, NOT Measurements in GIS, Queries, Reclassification, Buffering and neighbourhood analysis, Integrating data by map overlay. Spatial selection operations: Raster vs Vector buffers. Overlay operations, Raster vs. Vector overlay operations, point-in-polygon overlay, clip, intersection, union. Network analysis – geocoding. Terrain analysis.

References

Campbell, J. B.and Wynne, R. H. (2008), Introduction to Remote Sensing, Fifth Edition, The Guilford Press, New York, 718p.

Falkner, E. and Morgan D. (2002), Aerial Mapping: Methods and Applications, Lewis Publishers, Boca Raton, 192p.

Lillesand, T.M., Kiefer,R.W. and Chipman, J.W. (2004), Remote sensing and image interpretation, Fifth Edition, Wiley, NJ, 812p.

Mather, P.M. and Koch, M. (2011),Computer Processing of Remotely-Sensed Images – An Introduction, Fourth Edition, John Wiley, New York, 462p.

McCoy, R. M. (2005), Field methods in remote sensing, Guilford Press, New York, 177p.

DeMers, M. N. (2009), GIS for dummies, Wiley, NJ, 388p.

Iliffe, J. (2000), Datums and Map Projections for remote sensing, GIS, and surveying, Whittles Publishing, Scotland, 159p.

Konecny, G. (2003), Geoinformation: Remote sensing, photogrammetry and geographic information systems, Taylor& Francis, London, 266p.

Shekar, S., Xiong, H. eds. (2008), Encyclopaedia of GIS, Springer-Verlag, New York, 1392p.

Sickle, J. V. (2010), Basic GIS Coordinates, CRC Press, FL, 190p.

Verbyla, D. L. (2003), Practical GIS analysis, Taylor & Francis, London, 305p.

Jensen, J.R., (2000). Remote Sensing of the Environment an Earth Resource Perspective. New Jersey: Prentice Hall, Inc, 608p.

Jensen, J.R., (2005). Introductory Digital Image Processing: A Remote Sensing Perspective. 3rd ed. Upper Saddle River, NJ: Pearson Prentice Hall, 544p.

G.L. Prost (2002). Remote sensing for Geologists: A guide to image interpretations. CRC Press, 326p.

Floyd F. Sabins (1997) Remote Sensing: Principles and interpretations.WH Freeman & Company, 494p.

P. A. Burrough, Mcdonnell R A (1998). Principles of geographical information systems. Oxford university press, 332p.

GEOL 504. Coal and Petroleum Geology (3 credits)

Unit – 1

Origin of coal: accumulation of vegetable matter - in situ and drift theories; stages of formation of coal - humification and coalification processes.

Unit – 2

Classification, Ranks and Grading of coal - sapropelic coal, boghead coal, channel coal, humic coal, peat, lignite, sub-bitminous coal, bitminous coal, semi-anthracite, anthracite.
Petrography of coal: lithotypes, macerals and microlithotypes
Coal Bed Methane as an energy resource. Physical and chemical characteristics of coal; Proximate and Ultimate analysis.

Unit – 3

Coal formation in the geological past - Carboniferous, Permian, Triassic, Jurassic, Cretaceous and Tertiary. Global distribution of coal deposits. Geological and geographical distribution of coal deposits in India.Gondwana coal fields and Tertiary coal. Lignite deposits of India.

Unit – 4

Origin of petroleum-organic and inorganic theories. Transformation of organic matter into petroleum; Kerogen, transformation and maturation of kerogen. Gas hydrates and shale gas – origin and extraction.

Unit – 5

Primary and secondary migration of oil and gas. Reservoir rocks: classification and characteristics; Structural traps, stratigraphic traps and combination traps for oil and gas accumulation. Global distribution of oil and gas through ages. Geological setting of major oil and natural gas fields in India.

References

- Deshpande B. G. (1992) The world of petroleum. New Age International
- Levorson A. I. (2004) Geology of Petroleum. CBS Pub.
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- Chandra, D., Singh, R.M. Singh, M.P. (2000): Textbook of Coal (Indian context), Tara Book Agency, Varanasi.
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- Thomas L. (2002): Coal Geology, John Wiley and Sons Ltd., England.
- Sharma, N.L. and Ram K.S.V. (1966) Introduction to the Geology of Coal and Indian Coalfields .Dhanbad Publications, Dhanbad
- Acharyya S.K. (2000) Coal and Lignite Resources of India-An Overview. Geol. Soc. Of Indi
- Holson G.D and Tiratsoo, E.N, 2004: Introduction to Petroleum Geology. Gulf Publication, Houston, Texas.
- Tissot, B.P and Welte, D.H, 2003: Petroleum formation and Occurrence. Springer-Verlag.
- Selley, R.C, 1999: Elements of Petroleum Geology. Academic press.

GEOL 505. Environmental Geology and Natural Hazards(3 credits)

Unit – 1

Our environment - an introduction, Solar energy, Hydrological cycle, Rock cycle, Geochemical cycle, Biogeochemical cycle, Fundamental concepts of environmental geology, History of environmental degradation.

Unit – 2

Land-use and its Management – Land as a Resource, Spheres of land management, Land capability Management, Human settlement and Land use, Slums, requirement of urban planning, Rural planning, Land use pattern in India. Soils-Nature of soil, soil profile, Origin of soils. Classification of Soils, Soil types of India. Change of strength. Soil conservation-strategy, Practices in hills, Controlling gully erosion in ravine lands, Shelter belts in deserts.

Unit – 3

Water Resources-Hydrological Considerations, Problems and Management – Nature of ground water, Infiltration of rain water, water table, Movement of ground water. Energy and environment-Global aspects, Indian aspects, Energy from fossil fuel, alternative energy, Environmental impact of quarrying and mining, Waste management.

Unit – 4

Hazards- Introduction to key concepts, terminology. Natural hazards – Geologic and atmospheric. Earthquake, Landslides, Tsunami, Flood, Drought, Volcanic eruptions, Tsunamis and Avalanches. Hazard, vulnerability, Exposure, Risk, Crisis, Disasters, Significant aspects of disasters, Disaster risk reduction, Risk management framework, Integrated Disaster risk management and post-Disaster response. Natural disasters and their management- Problems, prospects and case studies. Climate change and its impact on coastal environment. Coastal management planning.

Unit – 5

Disaster management process- Prevention, preparedness, Mitigation, Application of Information technology in Disaster Preparedness, Application of GIS in disaster management, Trauma and Stress management, First Aid and Emergency procedures, Warning systems.

References

- Pritchard, C.L. 2005, Risk Management, ESI International, Virginia.
- Coates, D.R. 1981, Environmental Geology, John Wiley and sons
- Lee, F and Griffiths, 2007, Engineering Geomorphology, Whittles publishing
- Gupta, H.K. 2003, Disaster Management, University Press.
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- Bennett M.R and Doyle, P. Environmental Geology, Wiley
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- Shaw, Rand.Krishnamurthy, R.R 2009, Disaster Management, University Press
- Radhakrishna B.P and Ramachandran K.K., 1986, India's Environment,GSI,Bangalore
- Valdiya K.S., 2004, Geology Environment Society, University Press
- Valdiya K.S., 2013, Environmental Geology, McGraw Hill, New Delhi
- www.ndma.gov.in
- www.sdma.ker.in

GEOL 506. Water Resource Management(3 credits)

Unit –1

Introduction to water resources - Ground water, Surface water, Glaciers and Rainwater. History of water resource development, Global water resources, Water cycle, Relation between water resources and environment. Concept of Integrated Water Resource Management (IWRM).

Unit –2

Need for Water Resource Management, available water resources, Water scarcity- Lowering of Ground water level, vanishing of fresh water ponds, lakes and wet-lands.

Unit –3

Water supply Planning and Management-Domestic, agricultural and industrial. Cost benefit analysis in water resource planning, Planning of watershed conservation practices, artificial recharging, contour bunding, sub-surface dams, geo-textile, rainwater harvesting.

Unit –4

Estimation of available water resources. Water budgeting. Artificial reservoirs, construction of dams, Design and Planning of Distribution system- Drinking water, Irrigation water, Canal design, principles of irrigation, evapotranspiration.

Unit –5

Water quality-pollution, Chemical and biological. Different Water quality analysis, Water analysis techniques – Rainfall data, Acidic and alkali rain, Soil moisture analysis, evaporation, transpiration, Flood frequency analysis, rainfall - runoff analysis, reservoir function study, Generation of Hydropower. Treatment of waste water. Desalinisation of water.

References

- Cech Thomas V. 2003, Principles of water resources: History, development, management and policy. John Wiley& Sons
- Todd,D.K. Ground Water Hydrology, John Wiley& Sons
- Karanth K.R,Ground water Assessment Development And Management, Tata McGraw-Hill Publication Company Ltd.
- Mays, L.W. Water resource engineering, John Wiley& Sons
- Linsley R.K and Franzini J.B (1979) Water resource engineering, McGraw-Hill
- Mays L.W.1996, Water resources hand book, McGraw-Hill.
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- Jain S.K. and SnghV.P.,Water resources system planning and Management Elsevier
- Walton, W.C. Ground Water Resources evaluation, McGraw-Hill

GEOL 507. Isotope Geology (2 credits)

Unit – 1

Isotope geochemistry: Physical and chemical properties of isotopes; stable and unstable isotopes. Unstable isotopes**:** Isotope dating methods, Principles of isotope dating. U –Th - Pb methods, principles, merits and demerits. K-Ar method. Ar gain, Ar loss and their effects. Ar^{40} - Ar^{30} method .

Unit – 2

Rb–Sr method. Whole rock and isochron methods. Sr loss. Sm -Nd method. Rb - Sr and Sm - Nd ratios and their significance. Fission track dating. ^{14}C dating. Preparation of samples for dating. Suitability of samples or materials for dating. Interpretation of isotope dates. Limitations of isotope dating. Distribution of dates in space and time.

Unit – 3

Stable Isotopes**:** Geochemistry, Notation. Theoretical Considerations. The Mass Spectrometer-principles, components and sensitivity. Thermal-ionization mass spectrometry (TIMS), ICP-MS, LA-MS, Secondary-Ion Mass Spectrometry (SIMS). Measurement of stable isotopes using isotope ratio Mass Spectrometer. Isotope Geothermometry. Isotope Fractionation in Hydrologic and Biological Systems.

Unit – 4

Carbon Isotope Fractionation during Photosynthesis. Nitrogen Isotope Fractionation in biological processes. Oxygen and Hydrogen Isotope Fractionation by Plants. Paleoclimatology. The Marine Quaternary $\delta^{18}O$ Record and Milankovitch Cycles.

Sulfur Isotopes and Ore Deposits. Stable Isotopes in the mantle and magmatic systems. Stable Isotopic Composition of the Mantle. Stable Isotopes in Crystallizing Magmas. Combined Fractional Crystallization and Assimilation.

Unit – 5

Paleothermometer, carbonate thermometer, $^{18}O/^{16}O$ isotope composition of silicates and high-temperature thermometry, isotope cycle of water, Paleothermometry and the water cycle: paleoclimatology, paleoclimatic records: sediments and polar ice. Carbonate paleoclimatology.

References

- Allegre, C. (2008), Isotope Geology, Cambridge University Press, New York, 534p.
- Baskaran, M. (ed) (2011), Handbook of Environmental Isotope Geochemistry, Springer-Verlag, Berlin, 943p.
- Claude Hillaire–Marcel and Anne De Vernal (2007) Proxies in Late Cenozoic Paleoceanography (2007), Elsevier, Amsterdam, Tokyo, 843p.
- Gill, R. (1989), Chemical Fundamentals of Geology, HarperCollins Publishers Ltd, UK, 292p.
- Hoefs, J. (2009), Stable Isotope Geochemistry, 6th Edition, Springer-Verlag, Berlin, 293p.
- Krauskopf, K. B. (1967), Introduction to geochemistry, McGraw-Hill Book Co., New York, 721 p.
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- Mook, W. G. (2000), Environmental Isotopes in the Hydrological Cycle: Principles and Applications, Vol 1, UNESCO/IAEA, Paris, 297p.
- Valley, J. and Cole, D. (2001), Stable Isotope Geochemistry, Reviews in Mineralogy 43, Mineralogical Society of America, Washington DC, 660p.
- White, W. M., Geochemistry, 695p (Unpublished book, available online)
- Wolfsberg, M., Hook, V.W.A., Paneth, P. and Rebelo, L.P.N. (2010), Isotope Effects in the Chemical, Geological, and Bio Sciences, Springer-Verlag, Berlin, 477p.

GEOL 508. Quaternary Geology (2 credits)

Unit – 1

Definition of Quaternary; concept and importance of Quaternary, Quaternary chronostratigraphic unit, standard sub-divisions of the Quaternary Period and their climatic significance, standard global stratotype sections, Plio-Pleistocene boundary

Unit – 2

Quaternary Glaciations – causes, pattern of glacial-interglacial cycles and associated eustatic changes, Lines of evidence for Recent and historic sea level fluctuations; Ice core records of glaciations during Pleistocene and Holocene; Pleistocene faunal extinctions.

Unit – 3

Tools for Quaternary studies-application of Oxygen Isotope Stratigraphy (OIS) biostratigraphy and magneto-stratigraphy in the study of the Quaternary. Proxy indicators of paleoenvironmental/ paleoclimatic changes- land, ocean and cryosphere. Ocean Records - microfossils, oxygen isotopes, trace element analysis, pollen analysis, ice core studies and varves. Dendrochronology – tree rings as a tool for paleoclimate, Fluvial and lacustrine records.

Unit – 4

Quaternary dating methods – Radiocarbon chronology - other radiogenic clocks. Fission track and thermoluminescence dating methods. Planetary clocks. Milankovitch orbital cycles. Quaternary

Stratigraphy of India– continental records (fluvial, glacial, aeolian, palaeosols and duricrust); marine records.

References

- Sirocko, F., Claussen, M., Goni, M.F.S. and Litt, T. (Eds., (2008): The Climate of Past Interglacials, Elsevier.
- Burrough, W.J.S. (2005): Climate Change in Prehistory, Cambridge University Press.
- Rapp, D. (2009): Ice Ages and Interglacials – Measurements, Interpretation and Models, Springer.
- Saltzman, B. (2002): Dynamical Paleoclimatolgy – Generalised Theory of Global Climate Change, Academic Press.
- Birks, H. J. B. and Birks, H. H. (1980): Quaternary Paleoecology, Edward Arnold.
- Battarbee, R.W. and Binney, H.A. edt. (2008), Natural Climate Variability and Global Warming – A Holocene Perspective, Wiley Blackwell.
- Bloom, A.J. (2010): Global Climate Change – Convergence of Disciplines, Sinauer Associates.
- Bradley, R. S. (1999): Paleoclimatology – Reconstructing Climates of the Quaternary, Elsevier.
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- Jansen, E., J. Overpeck, K.R. Briffa, J.-C. Duplessy, F. Joos, V. Masson-Delmotte, D. Olago, B. Otto-Bliesner, W.R. Peltier, S. Rahmstorf, R. Ramesh, D. Raynaud, D. Rind, O. Solomina, R. Villalba and D. Zhang, 2007: Palaeoclimate. In: *Climate Change 2007*: *The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

GEOL 509. Structural Analysis (2 credits)

Unit – 1

Deformation: Translation – Rotation – Dilation – Distortion. Deformation and changes in length and angle. Rheology. Geological significance of displacements. Deformation mechanisms and processes: Cataclastic flow – pressure solution – intracrystalline deformation – recrystallisation – diffusion – grain boundary sliding.

Unit – 2

Principles of displacement and strain. Homogeneous and heterogeneous strain. Finite strain theory. Stress-Strain diagrams. Factors affecting stress-strain relations. Concept of strain ellipse. Rapid methods of strain determination. Strain analysis- analysis of strain in linear, initially circular/spherical objects. Various methods of strain analysis. Strain partitioning. Strain in three dimensions.

Unit – 3

Simple and pure shear. Shear zones - geometry and classification. Shear indicators. Shear zone rocks - Mylonites and fragmental rocks produced by shearing. Shear sense indicators, Stress-strain relationships in different types of shear zones. Deep crustal fluids and shear zones. Shear zones of Southern India

Unit – 4

Fabric development: Progressive deformation. Rotation, pressure solution, recrystallisation and plastic deformation of grains. Tectonites – S and L tectonites.Microfabric analysis – sampling techniques. Modern techniques in microstructural analysis – 4-axes Universal stage – X-ray texture goniometry – Transmission Electron Microscopy – SEM-EBSD. Fabric symmetry – Crystallographic Preferred Orientation – Lattice Preferred Orientation. Kinematic analysis.

References

- Dennis, J.G. (1987), Structural Geology: an introduction, Wm.C.Brown Publishers, Dubuque, 437 p.
- Ramsay, J.G. (1967), Folding and fracturing of rocks, Mc. Graw Hill, New York, 563 p.
- Ramsay, J.G. and Huber, M. (1983), The techniques of modern structural geology, Academic Press, London, V.1, 305 p.
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- Passchier, C.W. and Trouw, R. A. J. (1996), Microtectonics, Springer, Berlin, 289 p.
- Hancock, P. L. (1994), Continental Deformation, Pergamon Press, New York, 421 p.
- Marshak, S. and Mitra, G. (1988), Basic Methods of Structural Geology, Prentice Hall, New Jersey, 446 p.
- Ramsay, J. G. (1980), Shear Zone Geometry: a review, Jour. Struct. Geol., V.2, N.1/2, pp 83-99.
- Sibson, R. H. (1977), Fault Rocks and Fault Mechanisms, Jour. Geol. Soc., London, V.133, pp191-213 .

GEOL 510. Planetary Geoscience (2 credits)

Unit – 1

Milky Way and the solar system. Modern theories: condensation and accretion of planets and other planetary bodies. Members of the solar system. The Sun-Planetary and Orbital characteristics. General characteristics of the terrestrial planets- crust, surface features, thermal history, volcanism

Unit – 2

Moon: The Earth- Moon System, General Physiography, Atmosphere, Tectonic features, Craters, Degradational features, History of the Moon and time scale, Lunar volcanism, Lunar rocks, soil and internal structure, Lunar phases and cycles, Lunar influence on Earth

Unit – 3

Mars: Phobos and Dimos, Physiography, Atmosphere, Craters, Volcanism, Tectonism, Hydrology, Martian rocks and soils, Mars Missions.

Unit – 4

Meteorites: Chondrites, SNC meteorites, Refractory inclusions, Iron meteorites and Parent body cooling rates, meteorite chronology

Asteroids: Classification and composition, Surface features, Asteroid sources, Asteroid impacts on the Earth. Comets and other Icy bodies.

Unit – 5

Planetary images, Digital image processing, Analog studies of Martian, Lunar samples with those of Earth samples. Planetary missions.

Reference

- Condie, K C (2011), Earth as an evolving Planetary system, II edn. Elsevier, Amsterdam, 574p.
- Dalrymple, G B (1991) The Age of the Earth, Stanford University Press, California, 474p
- de Pater, I and Lissauer, J J (2010) Planetary Sciences, Cambridge University Press, 2nd Edition.
- McBride, N and Gilmour, I (Eds) (2004) An introduction to the solar system, Cambridge University Press
- Seeds, M and Backman, D (2010) The Solar System, Brooks/Cole, 7th Edition.

Elective courses (Open)

GEOL511: Oceanography (3 credits)

Unit- 1

History of development of Oceanography and Marine Geology. Physiochemical characteristics and chemistry of sea water: temperature, salinity, density, light transmission, sound transmission in sea water. Gases in sea water. Role of carbon dioxide in keeping the pH of seawater and ocean acidification. Instruments used in the study of seawater. Ocean floor: Morphologic and tectonic domains. Bathymetric provinces- Submarine Canyons, Mid-Ocean ridges and Trenches. Morphologic and tectonic domains of Indian Ocean.

Unit- 2

Offshore exploration techniques: Instruments and measurements—Position fixing systems—GPS. Tools for studying ocean water—sampling devices—Grabs, dredgers, Corers, Water Samplers, etc. – various platforms for ocean studies. Tools for studying the ocean floor—Echo-sounding methods—Sides can Sonar—Current meters—SCUBA diving—submersibles. Ocean floor drilling--JOIDES.

Unit- 3

Marine sediments: Distribution and geochronology of marine sediments. Eustatic changes of sea level and its effects. Carbonate Compensation Depth (CCD). Turbidity currents and turbidites. World ocean circulation patterns—role of ocean in deciding global climate—ocean water masses.

Unit- 4

Origin of ocean basins and palaeooceanography, Paleoceanographic reconstructions based of microfossils. Law of the Seas - UNCLOS, EEZ—coastal zone environment and its protection - CRZ Act. Mineral resources of the ocean basins, factors controlling their distribution. Origin and distribution of polymetallic nodules.

References

- Balkema, A.A. (2001): Descriptive Physical Oceanography, Balkema Publishers, Tokyo.
- Beer, T (1997): Environmental Oceanography, CRC Press, New York.
- Dickinson, W.R. & Yarborough, H., Plate Tectonics and Hydrocarbon Accumulation,
- Emery, K .O. & Skinner, B.J. Mineral Deposits of the Deep Ocean Floor.
- Ghosh, A.K. and Mukhopadhyay, R. (1999): Mineral Wealth of the Ocean, Oxford & IBH Pub. Co., New Delhi.
- Gross, G.M. (1967): Oceanography, Merril Physical Science Series.
- Gross, G.M. (1995): Principles of Oceanography, VII edn., Prentice Hall.
- King, C.A.M. (1979): Introduction to Physical and Biological Oceanography, Edward Arnold.
- Pinet, P.R. (2000): Invitation to Oceanography, II edn., Jones & Bartlett.
- Qasim, S.Z. (1998): Glimpses of Indian Ocean, University Press.
- Qasim, S.Z. (1999): The Indian Ocean, Oxford & IBH Pub. Co., New Delhi.
- Shepard, F.P, (1963): Submarine Geology, II edn., Harper & Row.
- Sverdrup, H.V. et al. (1961): The Oceans, Asia Publishing House.

GEOL 512: Climatology (3 credit)

Unit-1

Fundamental principles of climatology. Atmosphere, its composition and internal structure. Greenhouse effect. Earth's radiation balance; latitudinal and seasonal variation of insolation, temperature, pressure. Fundamentals of meteorology, Scales of meteorology, Parameters of meteorology- pressure, wind, temperature, humidity, radiation; Radiations: Radiation laws, short wave and long wave radiations; Albedo; Emissivity; Radiation Budget of Earth.

Unit-2

General circulation of the atmosphere: Hadley cells, tropical easterlies, westerlies, polar easterlies, monsoon, Jet streams, tropical cyclones, local winds. Coriolis Effect and geostrophic winds. Cloud classification, condensation nuclei, growth of cloud drops and ice-crystals, precipitation mechanisms: Bergeron process, coalescence process. Types of precipitation, artificial precipitation. Electric field in the atmosphere.

Unit-3

Climate variability and forcings, causes and impacts of climate change, feedback processes, low frequency variability, MJO (Madden-Julian oscillation), ENSO, QBO (quasi-biennial oscillation) and sunspot cycles. Classification of climates – Koppen's and Thornthwaite's scheme of classification.

Unit-4

Synoptic weather forecasting, prediction of weather elements such as rain, maximum and minimum temperature and fog; hazardous weather elements like thunderstorms, duststorms, tornadoes. Basic principles of general circulation modelling, role of the ocean in climate modeling, interannual variability of ocean fields (SST, winds, circulation, etc.) and its relationship with monsoon, concepts of ocean – atmosphere coupled models.

Unit-5

Indian climatology with special reference to seasonal distribution and variation of temperature, humidity, wind and precipitation, Climate zones of India.

References:

- Lal, D. S. (2011): Climatology, Sharda Pustak Bhavan.
- Critchfield, H. J. (2009): General climatology, PHI Learning, New Delhi.
- Lal, D. S. (2013): Climatology and Oceanography, Sharda Pustak Bhavan.
- Siddhartha, K. (2016): Climatology-Atmosphere, weather and climate. Kitab Mahal, New Delhi.
- Savindra Singh (2005): Climatology, Prayag Pustak Bhavan.
- William James Burroughs, 2001, Climate change, A multidisciplinary Approach, Cambridge University Press.
- Stringer, E. T. (1972): Foundations of Climatology, W.H.Freeman & Co Ltd.