Syllabus for the

M.Sc. in Geology

(Four Semester Course)

(Choice Based Credit System)

Effective From

2015-2016

Department of Geology
Centre of Advanced Study
Kumaun University
Nainital 263 002

Syllabus for the
M.Sc. in Geology

Summary of Course Structure

Number of Papers	**:**	17 (15 Compulsory + 02 Elective)
Fieldwork Training	**:**	02 (Two to three weeks at the end of odd semester i.e. 1nd and 3rd Semester)
Total duration	**:**	04 Semester course
Project Oriented Dissertation	**:**	3rd and 4th Semester
Total Credits	**:**	98

Guidelines for the Course and Scheme of Examinations

Candidates who have passed the B.Sc. in science subjects with geology will be considered eligible for admission to the Four Semester M.Sc. in Geology. Initially, the admission will be on the basis merit. However, at later stage the department may initiate its own entrance examination.

The M.Sc. course in Geology shall be imparted to the students for two academic sessions consisting of four semesters as given below. Candidates will be examined and evaluated at the end of each semester in the different courses of theory including internal assessment, and practical (wherever applicable) as per the grade points obtained against each course. The M.Sc. Geology will consist of (a) Core Courses and (b) Elective Course.

Scheme of Examinations

(a) English shall be the medium of instruction and examination.

(b) Examinations shall be conducted at the end of each semester as per the Academic Calendar notified by the Kumaun University.

(c) The core courses will be compulsory for all the students admitted to M.Sc. Geology. There will be **fifteen core courses and two elective papers** covering major branches of Geology and two sessions of **two to three weeks of Geological Field Training.** Each Course shall be of 3 to 5 credits and 25 % of the evaluation will be based on internal assessment by the concerned teacher. Internal assessment will be done on the basis of Seminar/Class Test/Assignments/Attendance etc.

(d) The Elective Course will be offered in second and fourth semester. An advisory group consisting of faculty members of department will suggest the students about the selection of elective papers.

(e) The participation in the Geological Field Training will be compulsory for all the students. After the field training, the students will be required to submit a detailed field report to the concerned teacher for evaluation.

(f) Students will need to carry out project oriented dissertation work during 3 and 4 semesters. The area of Dissertation shall be assigned to the students at the beginning of 3rd semester based on the overall merit of the students. Each student will offer three core branches of geology in order of preference in her/his application and Department will decide candidate's potential supervisor(s). The students may however be allowed opting dissertation works with the Scientists of organization with whom department of geology has signed MoU or with an individual scientist/academician from any organization after approval of Head of the Department. In such cases either supervisor or co-supervisor should be from the department. The students will be required to submit the Project Oriented Dissertation by the end of 4th semester.

(g) The project oriented dissertation will be evaluated jointly by supervisor/co-supervisor and one external examiner. For the purpose of evaluation after 4th semester, the 25% of the grade points will be based on Final Presentation while 75% will be based on evaluation of the thesis.

(h) **As the evaluation will be done by the Grading system, each examination (theory, practicals, field training and dissertation) will be evaluated for 100 marks each.** Following system will be applicable for calculating SGPA (Semester Grade Point Average- SGPA and Composite Grade Point Average -CGPA). Candidate has to clear each paper with minimum of SGPA of 4.5 point.

GRADING SYSTEM:

% age of Marks	**Letter Grade**	**Grade Points (P)**
Greater than or equal to 90	S	10
Greater than or equal to 80 and less than 90	A	9
Greater than or equal to 70 and less than 80	B	8
Greater than or equal to 60 and less than 70	C	7
Greater than or equal to 50 and less than 60	D	6
Greater than or equal to 40 and less than 50	E	5
Passed with Grace	P	0
Below 40	F	-
Non appearance in examinations (Incomplete)	I	-
Incomplete Project/Dissertation/Training	X	-
Non-Completion of Course	Z	-

Declaration of Result:

After appearing at the Examination of Fourth Semester the Candidates can be put into the following two categories.

1. **Passed:** A candidate who has passed in all courses of examinations of I to IV Semesters.
2. **Failed:** All the students who have not PASSED will be categorized as "FAILED".
   A candidate shall be considered to have PASSED Four Semester course, if he/she has obtained Grade E or P above in each subject of the Four Semester courses and SGPA 4.50 or more.

$$\text{SGPA} = \frac{\text{Sum of (Credits X Grade Points) obtained}}{\text{Total Credit of Concerned Semester}}$$

$$\text{CGPA} = \frac{\text{Sum of (Credits X Grade Points) obtained in I, II, III \& IV Semesters}}{\text{Total Credit of I to IV Semester}}$$

CONVERSION OF CGPA/SGPA TO PERCENTAGE:

Conversion of CGPA/DGPA into equivalent percentage of marks can be done as per following formula.

Equivalent Percentage of Marks = CGPA/SGPA x 10

Declaration of Division:

A candidate who has passed in all the courses of examinations of all the Four Semesters taken together will be declared as "Passed". Such passed candidates may be awarded with the division according to the following criterion:

(i) First Division…….CGPA 6.5 and above

(ii) Second Division……...CGPA 4.5 and above but below 6.5

(i) One credit will be defined through the following set of lectures and practicals.

1 credit = 1 hr lecture/week/semester or 2 hr practical/week/semester.

(j) The field trainings will be equivalent to a total of 4 credit points (2 Credit I Semester and 2 Credit III Semester). Dissertation work will be equivalent to 04 credit points. Practicals of each subject will be of 2 credit points

(k) Each theory will have two components:

Internal Assessment	**25 %**
(Attendance/Seminar/Assignment/Test etc.)	
End-Semester Examination	**75 %**

(l) Practicals will be divided into the following two components:

Internal Assessment	**25 %**
(Attendance/ Class performance/Lab Records)	
End-Semester Examination	**75 %**
Final examination	60 %
Viva-voice	15%

(m) General Promotion from One to next semester:
Candidates will get promoted from one to the next semester as per the existing rules of the university.

(n) Improvement examination and/or back paper examination:
Regarding improvement and/or back paper examination the existing rules of the university will be applicable.

M.Sc. Geology Syllabus
(Effective from 2015-16)

There shall be five questions in each paper, all of which shall be compulsory. The structure of the paper shall be as follows

a. All the questions shall carry equal marks.
b. Question no. 1 shall be of objective type covering the entire syllabus.
c. There shall be two questions from each unit (unit I to 4) of which one question is to be attempted.
d. The questions no. 2 to 5 could be long answer type/short answer type including short notes/reasoning/differentiate amongst etc.

SEMESTER – I

COURSE NO.	CORE COURSES	Credit
GLG 101	Igneous Petrology	4
GLG 102	Metamorphic Petrology	4
GLG 103	Sedimentology	4
GLG 104	Structural Geology	4
GLG 105	Practical – A Igneous & Metamorphic Petrology (GLG101+GLG102)	2+2
GLG 106	Practical – B Sedimentology & Structural Geology (GLG103+GLG104)	2+2
GLG 107	Field Training	2

Total Number of Credits for Semester I = 26 (16 Theory + 8 Practical+ 2 Field Training)

SEMESTER - II

COURSE NO.	CORE Courses and ELECTIVE Paper (any one out of five papers*)	Credit
GLG 201	Mineralogy and Geochemistry	4
GLG 202	Economic Geology	3
GLG 203	Stratigraphy	3
GLG 204	Palaeontology	3
GLE 205	*Elective Paper	3
GLG 206	Practical - A-Mineralogy and Geochemistry & Economic Geology	2+2
GLG 207	Practical – B- Stratigraphy & Palaeontology	2+2
GLG 208	Practical-C-Elective Paper	2

Total number of credits for semester II = 26 (16 Theory + 10 Practical)

SEMESTER - III

COURSE NO.	CORE COURSES	Credit
GLG 301	Geodynamics	4
GLG 302	Remote Sensing and GIS	4
GLG 303	Ground Water Hydrology	3
GLG 304	Micropaleontoloty and Oceanography	3
GLG 305	Practical – A (GLG 302 + GLG 303)	2+2
GLG 306	Practical – B (GLG 304)	2
GLG 307	Field Training	2
GLG 308	Presentation: Dissertation-I (Problem and Method)	1

Total number of credits for semester III = 23 (14Theory + 6Practical + 2 Field Training +01 Dissertation)

SEMESTER - IV

COURSE NO.	CORE Courses and ELECTIVE Paper (any one out of five papers*)	Credit
GLG 401	Engineering Geology	3
GLG 402	Tectonic Geomorphology	3
GLG 403	Mineral Exploration and Mineral Economics	3
GLE 404	*Elective Paper	3
GLG 405	Practical – A (GLG 401 + GLG 402)	2+2
GLG 406	Practical – B (GLG 403)	2
GLG 407	Dissertation-II Part: Thesis and Final Presentation	2+1

Total number of credits for semester IV = 23 (12Theory + 8 Practical + 3 Dissertation-II Part)

Grand Total Credits: 88 (Core courses) + 10 (Elective) = 98

***Elective Papers (one of the following)**

In II Semester:

GLE 205 (a): Sequence Stratigraphy and Basin Analysis
GLE 205 (b): Advanced Techniques in Structural Geology
GLE 205 (c): Marine Geology
GLE 205 (d): Advanced Mineralogy and Thermodynamics

In IV Semester:

GLE 404 (a): Himalayan Geology
GLE 404 (b): Palaeoclimatology
GLE 404 (c): Advanced Hydrogeology
GLE 404 (d): Fuel Geology

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SEMESTER – I

GLG-101: Igneous Petrology (4 credit, Max marks-100 = (75 External Exam+25 internal assessment)

Theory

Unit-I: Magma generation in the mantle, their nature and evolution; Magmatic processes: Partial melting, fractional crystallization, assimilation, liquid immiscibility.

Unit-II: Study of phase equilibria in binary (Diopside-Anorthite, Forsterite- Silica, Leucite-Silica, Albite- Anorthite, Orthoclase-Anorthite) and ternary silicate systems (Orthoclase-Albite-Silica, Diopsite-Albite-Anorthite, Diopside-Foresterite-Silica, Fayalite-Leucite-Silica) in the light of modern experimental works.

Unit-III: Petrography and interpretation of igneous textures in terms of rate of nucleation and crystal growth; IUGS classification schemes of igneous rocks: Ultramafic, mafic and felsic igneous rocks; total-alkali-silica (TAS) classification of volcanic igneous rocks.

Unit-IV: Petrognesis and tectonic setting of major igneous rock types and suites: Ultramafic rocks- komatiite, lamprophyres, kimberlite; Ophiolites, flood basalt, anorthosite, Tonalite-Trondhjemite-Granodiorite (TTG), granitoids, alkaline rocks and carbonatites with special reference to Indian examples.

Books Recommended

- Phillpotts, A.R. (1994) Principles of Igneous and Metamorphic Petrology, Prentice Hall of India.
- Best, M. G. (2003) Igneous and Metamorphic Petrology, 2nd Edn., Blackwell.
- Bose, M. K. (1997) Igneous Petrology, World Press, Kolkata.
- Cox, K. G., Bell, J. D. and Pankhurst, R. J. (1979) The Interpretation of Igneous Rocks, Unwin Hyman.
- McBirney, A. R. (1993) Igneous petrology. Jones & Bartlet Publication.
- LeMaitre R. W. (2002) Igneous Rocks: A Classification and Glossary of Terms, Cambridge University Press.
- Wilson, M. (1993) Igneous Petrogenesis, Chapman and Hall, London.
- Kumar, S, and Singh, R. N. (2014) Modelling of Magmatic and Allied Processes. Springer, Switzerland.

GLG-102: Metamorphic Petrology (4 credit, Max marks-100 = (75 External Exam+25 internal assessment)

Theory

Unit-I: Mineralogical Phase rule of open and closed systems; Types of metamorphism; Texture of regional & contact metamorphic rocks, deformation and metamorphism; Nature and types of metamorphic reactions; Concept and classification of metamorphic facies; Facies series; Graphical representation of minerals in ACF, AKF, AFM and A'F'M' diagrams; Time relation between phases of deformation and metamorphic crystallization.

Unit-II: Description of each facies of low pressure, medium to high pressure and very high pressure with special reference to characteristics minerals, subdivisions into zones/sub facies, mineral assemblages, metamorphic reactions and pressure-temperature conditions of metamorphism. Introduction to Ultra-high temperature and Ultra-high pressure metamorphism. Metamorphism of shale, mafic and calcareous rocks.

Unit-III: Isograds and Reaction Isograds; Schreinmakers rule and construction of Petrogenetic grids; Metamorphic differentiation; Anatexis and origin of migmatites; Paired metamorphic belts.

Unit-IV: Gibb's free energy; Entropy; Enthalpy; Clausius-Clapeyron equation; Geothermobarometry; Pressure-Temperature-Time (P-T-t) paths.

Books Recommended

- Turner, F.J. (1980) Metamorphic Petrology, McGraw Hill, New York.
- Yardlley, B.W.D. (1989) An introduction to Metamorphic Petrology, Longman Scientific and Technical, New York.
- Philopotts, A.R. (1994) Principles of Igneous and Metamorphic Petrology, Prentice Hall.
- Kretz, R. (1994) Metamorphic Crystallization, John Wiley.
- Bucher, K. and Frey, M. (2002) Petrogenesis of Metamorphic Rocks (7th Rev. Ed.), Springer–Verlag.
- Powell, R. (1978) Equilibrium thermodynamics in Petrology: An Introduction, Harper and Row Publ., London.
- Wood, B.J. and Fraser, D.G. (1976) Elementary Thermodynamics for Geologists, Oxford University Press,
- Spry, A. (1976) Metamorphic Textures, Pergamon Press.
  Winter, J.D. (2001) An introduction to Igneous and Metamorphic Petrology, Prentice Hall.

GLG–103: Sedimentology (4 credit, Max marks-100= (75 External Exam+25 internal assessment)

Theory

Unit- I: Texture – Shape, size, fabric and surface texture, Methods of textural analysis, textural parameters and their significance.

Unit- II: Fluid flow mechanics and formation of sedimentary bed forms. Concept of facies and implication of facies in environmental interpretation and basin analysis.

Unit-III: Diagenesis -Physical and chemical processes. Evidences of diagensis in sandstones, mud rocks and carbonate rocks. Evaporites, siliceous, phosphetic and ferruginous rocks.

Unit- IV: Conglomerates, Petrogenesis of sandstone, problem of greywacke, plate tectonics and sandstone composition, Argillaceous rocks-composition and classification. Dolomites, limestones - their petrographic characteristic and classification.

Suggested Readings:

1. Blatt, H., Middleton, G.V. and Murray, R.C. (1980): Origin of Sedimentary Rocks, Prentice-Hall Inc.
2. Collins, J.D., and Thompson, D.B. (1982): Sedimentary Structures, George Allen and Unwin, London.
3. Lindholm, R.C. (1987) A Practical Approach to Sedimentology, Allen and Unwin, London.
4. Miall, A.D. (2000): Principles of Basin Analysis, Springer-Verlag.
5. Pettijohn;, F.J. (1975): Sedimentary Rocks (3rd Ed.), Harper and Row Publ., New Delhi.
6. Reading, H.G. (1997): Sedimentary Environments and facies, Blackwell Scientific Publication.
7. Reineck, H.E. and Singh, I.B. (1973): Depositional Sedimentary Environments, Springer-Verlag.
8. Selley, R. C. (2000) Applied Sedimentology, Academic Press.
9. Tucker, M.E. (1981): Sedimentary Petrology: An Introduction, Wiley and Sons, New York.
10. Tucker, M.E. (1990): Carbonate Sedimentolgy, Blackwell Scientific Publicatio

GLG-104: Structural Geology (4 credit, Max marks- 100 = (75 External Exam+25 internal assessment)

Theory

Unit-1: Concept of stress and strain. Stress-strain relationships of elastic, plastic and viscous materials. Two dimensional strain and stress analyses. Types of strain ellipses and ellipsoids; their properties and significance. Mechanical principles and properties of rocks and their controlling factors. Theory of rock failure; brittle and ductile deformation.

Unit-II: Mechanics of folding and buckling. Folds geometry and classification. Superimposed folds and their interference patterns. Analytical methods of determining fold style. Causes and dynamics of faulting. Normal faults and strike – slip faults. Overthrust and nappe with implications to thrust tectonics. Thin skinned deformation and decollement. Salt domes and diapers. Concept of balanced cross sections.

Unit-III: Joints, rock cleavage and foliations; their origin, domain character, relationship with major structures and geological significance. Transposed foliations. Linear structures and boudinage; their origin, relationship with major structures and significance. Deformation of linear structures.

Unit-IV: Brittle and ductile shear zones; their geometry, strain pattern, kinematics and significance. Rotation of structural elements. Concept of petrofabric analysis. Use of stereographic and equal area projections for representing different types of fabric.

Suggested Readings:

1. Ramsay J. G, 1967. Folding and Fracturing of Rocks. McGraw Hill.
2. Turner F.J. and Weiss, L.E., 1963. Structural Analysis of Metamorphic Tectonites. McGraw Hill.
3. Davis G. R., 1984. Structural Geology of Rocks and Region. John Wiley.
4. Ramsay J.G. and Huber, M.I., 987. Modern Structural Geology, Vol. I & II. Academic Press.
5. Price N. J. and Cosgrove, J. W., 1990. Analysis of Geological Structures. Cambridge Univ. Press.
6. Bayle B., 1992. Mechanics in Structural Geology. Springer Verlag.
7. Ghosh, S. K., 1995. Structural Geology: Fundamentals of Modern Development. Pergamon.
8. Robert D. Hatcher, 1994. Structural Geology: Principles Concepts and Problems (2nd Edition)
9. Moores E. and Twiss R.J., 1995. Tectonics. Freeman.
10. Valdiya K.S., 1998. Dynamic Himalaya. University Press.
11. Passchier C. w. and Treuw R. a. J., 2005: Microtectonics, Springr.
12. Richard H. Groshong (Jul 24, 2008). 3-D Structural Geology: A Practical Guide to Quantitative Surface and Subsurface Map Interpretation. Springer
13. Donal M. Rangan, 2009. Structural Geology: An introduction to Geometrical Techniques. Cambridge, University Press.

GLG-105: Practical (Credit 2+2=4, Maximum Marks- 100 (75 marks for External and 25 marks for Internal assessment)

PRACTICAL-A: (GLG101+GLG102)

Practical: Igneous petrology

Megascopic and microscopic studies of major igneous rock types: CIPW norm calculation: Introduction to software: Newpet, Sinclass, GCD kit.

Practical: Metamorphic Petrology

Study of metamorphic rocks of different metamorphic facies in hand specimens. Calculation of ACF, AKF, AFM and A'F'M values from the given chemical data/structural formula of minerals and their graphical representation.

Study of metamorphic rocks in thin sections with reference to texture/structure, time relation between phases of deformation and metamorphic crystallization, mineral association, parent rock,

metamorphic facies/sub-facies/zones to which rock can be assigned and representation of assemblage in ACF, AKF, AFM and A'F'M' diagrams.
Estimation of pressure and temperature from important models of Geothermobarometry.

GLG-106: Practical (Credit 2+2=4, Maximum Marks- 100 (75 marks for External and 25 marks for Internal assessment)

PRACTICAL-B: (GLG103+GLG104)

Practical : Sedimentology

Detailed study of clastic and non clastic rocks in hand specimen. Study of assemblages of sedimentary structures in context to their palaeo-environment significance. Microscopic examination of important rock types. Heavy mineral separation, their petrographic characters, graphical representation and representation and interpretation. Grain size analysis by sieving method, plotting of size distribution data as frequency and cummulative curves. Computation of statistical parameters and interpretation.

Practical : Structural Geology

1. Study of naturally deformed rocks in hand specimens.
2. Geometrical analysis of folds and faults.
3. Preparation and interpretation of geological maps.
4. Applications of stereographic and equal area projections.
5. Strain analysis using software and manually.

GLG-107: Field Training (2 credit, Max marks 50)

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SEMESTER – II

GLG-201: Mineralogy and Geochemistry (4 credit, Max marks- 100 = (75 External Exam+25 internal assessment)

Theory

Unit-I: Structural classification of silicates; Study of following group of minerals with reference to chemical and structural formula, classification, atomic structure, chemistry, physical and optical properties, occurrences: Olivine, Garnet, Pyroxene, Amphibole, Mica, Feldspars, Feldspathoids, Silica and Al silicates.

Unit-II: Formation of Uniaxial and Bi-axial interference figures, Interference colors, Pleochroism and determination of pleochroic scheme, Interference figures and determination of optic sign; Extinction; Uniaxial and Biaxial indicatrix and dispersion in minerals. Petrographical microscope; Mica, Gypsum and Quartz plates; Universal stage and their uses in the determination of optical properties of minerals.

Unit-III: Composition of Earth and its constituents (Crust, mantle and core); Ionic and co-ordination number; Rules of ionic substitution, coupled substitution; Distribution coefficient: Capture admission and camouflage, Geochemical classification of elements; Behaviour of major and trace including rare earth elements during magmatic crystallization.

Unit-IV: Near-surface geochemical environment: Eh-pH diagram; Principle of chemical mass balance and rock- cycle; Chemical weathering of minerals and rocks. Radiogenic isotopes in geochronology and petrogenesis: Rb-Sr, Sm-Nd, U-Pb isotopic system.

Books Recommended

- Battey, M.H. (1981) Mineralogy for students 2nd Edn. Longmans. Berry, L.G. and Mason, B. and
- Deer, W.A., Howie, R.A., and Zussman, J. (1992) An Introduction to the rock forming minerals, Longman.
- Sharma, R. S. and Sharma, A. (2014) Crystallography and mineralogy. Graduate Text Book Series, Geological Society of India, Bangalore.
- Klein, C. and Hurlbut, Jr., C.S. (1993) Manual of Mineralogy, John Wiley.
- Kerr, P.F. (1977) Optical Mineralogy 4th Edn., McGraw-Hill
- Putnis, Andrew (1992) Introduction to Mineral Sciences, Cambridge University Press.

- Winchell, A.N. (1962) Elements of Optical Mineralogy, John Wiley.
- Allegre, C.J. and Michard, G. (1974) Introduction to Geochemistry, Reidel, Holland.
- Evans, R.C. (1964) Introduction to Crystal Chemistry, Cambridge Univ. Press.
- Faure, G. (1998) Principles and applications of geochemistry, 2nd Edn., Prentice Hall, New Jersy, 593p.
- Faure, G. (1986) Principles of Isotope Geology, 2nd Edn., John Wiley.
- Krauskopf, K.B. (1967) Introduction to Geochemistry, McGraw Hill.
- Mason, B. and Moore, C.B. (1991) Introduction to Geochemistry, Wiley Eastern.
- Rollinson, H.R. (1993) Using geochemical data: Evaluation, Presentation, Interpretation, Longman, U.K.

GLG 202: Economic Geology (3 credit, Max marks- 75 = (55 External Exam+20 internal assessment)

Theory

Unit-I: Geological setting, characteristics and genesis of ferrous, base and noble metals.

Unit-II: Methods of mineral deposit studies including ore microscopy, fluid inclusions and isotopic systematic.

Unit-III: Origin, migration and entrapment of petroleum. Properties of source and reservoir rocks. Structural, stratigraphic and combination traps. Petroliferous basins of India.

Unit-IV: Origin of coal deposits. Classification, rank and grading of coal. Coal resources of India. Gas hydrates, coal bed methane and nuclear resources. Occurrence of mineral resources in the Himalaya.

Suggested Readings:

1.Craig, J.M. & Vaughan, D.J., 1981: Ore Petrography and Mineralogy-John wiley
2.Evans, A.M., 1993: Ore Geology and Industrial Minerals-Blackwell
3.Sawkins, F.J., 1984: Metal deposits in relation to plate tectonics-Springer Verlag
4.Stanton, R.L., 1972: Ore Petrography-McGraw Hill
5.Torling, D.H., 1981: Economic Geology and Geotectonics-blackwell Sci publ.
6.Barnes, H.L., 1979: Geochemistry of Hydrothermal Ore Deposits-John Wiley
7.Klemm, D.D. and Schneider, H.J., 1977: Time and Strata Bound Ore Deposits-Springer Verilog
8.Guibert, J.M. and Park, Jr. C.F., 1986: The Geology of Ore Deposits-Freeman
9.Mookherjee, A., 2000: Ore genesis-a Holistic Approach-Allied Publisher

GLG 203: Stratigraphy (3 credit, Max marks- 75 = (55 External Exam+20 internal assessment)

Theory

Unit I

Recent development in stratigraphic classification, Code of stratigraphic nomenclature. Concept of sequence stratigraphy. Modern methods of stratigraphic correlation.Steps in stratigraphic studies. Approaches of paleogeography. Earth's climatic history.

Unit II

Brief ideas of quantitative, magneto, sesmic ,chemo and event stratigrphy. Evolution and biostratigrapy – controlling factor, zonation, time significance, quantitative stratigraphy, cyclostratigraphy ,pedostratigraphy.

Unit III

Evolution of the early crust,lithological,geochemical and stratigraphic characterstics of graniteGreenstone and granulite belts of India and global correlation.Proterozoic formations of Peninsular – Extrapeninsular India.

Unit IV

Precambrian life, stratigraphic records India. Boundry problems: Archaen-Proterozoic , Precambrian- Cambrian, Permo-Triassic, Cretaceous –Tertiary, Neogene-Quaternery. In Brief: Paleozoic-Mesozoic and Cenozoic stratigraphy, fossils, Paleogeography, Paleoclimate, Tectonism and economic deposits. Concept status scheme of classification.

Suggested Books

1. Stratigraphic Principles & Practice, J. Marvin Weller
2. Principles of stratigraphy V-2, Amadeus W. Grabau
3. Principles of Straligraphy, Carl O. Dunban and John Rodgers
4. Stratigraphy, D.N. Wadia
5. Geology of India & Burma, M.S. Krishnan
6. Fundamentals of historical geology and stratigraphy of India, Ravindra Kumar
7. A Guide to Stratigraphic Classification, Terminology and Procedure, Hollis Hedberg , John Wiley and Sons

GLG – 204: Palaeontology (3 credit, Max marks- 75 = (55 External Exam+20 internal assessment)

Theory

Unit 1: Theories of origin of life. Organic evolution-Punctuated equilibrium and phyletic gradualism models. Mass extinctions and their causes. Ichnology, classification and use.

Unit-2: Palaeobiology (palaeoecology, communities, modern environments, functional morphology and taphonomy).

Unit 3: Brief morphology, evolution and classification of Brachiopoda, Mollusca (Cephalopoda, Gastropoda, Bivalvia), Trilobita.

Unit 4: Evolution of vertebrates, dinosaurs and its extinction.

Selected Readings:

1. Raup and Stanley, Principles of Palaeontology,
2. Bilal U. Haq and A. Boersome , Introduction to Marine Micropalaeontology,
3. G.Bignot , Elements of Micropalaeontology,
4. Clarkson, E.N.K. (1986). Invertebrate Palaeontology and Evolution. ELBS, London.
5. Cushman, J.A. (1940). The Formanifera, their classification and use. Harvard Univ. Press.
6. Moore, R.C. Lalliker, C.G. and Fischer, A.G. (1952). Text book of Invertebrate Palaeontology.
7. David Raup and Stanley (1985). Principles of Palaeontology., CBS Pub., Delhi
8. Glaessner, M.F. (1945). Principles of Micropaleontology. Melbourne Univ. Press.
9. Schrock, Twenhofel and Williams (1953). Principles of Invertebrate Palaeontology. CBS, Delhi

Elective paper

GLG – 205(a): Sequence Stratigraphy and Basin Analysis (Elective paper) (3 credit, Max marks- 75 = (55 External Exam+20 internal assessment)

Theory

Unit- 1 : Concept of sequence Stratigraphy. Evolution, order and duration of sequences. Applications and significance of sequence Stratigraphy

Unit-2 : Concept of facies and basin analysis. Walthers law and sedimentary environments. Sedimentary cycles, rhythms and cyclothems. Modern and ancient sedimentary environments. Continental clastic depositional sedimentary models-alluvial, fluvial, lacustrine, aeolian and glacial deposits.

Unit-3: Transitional and marine sedimentary facies models – deltaic, tidal flats, barrier islands , terrigenous shelves and shallow seas. Carbonate platforms and reefs and sabakhas, Continental rise and ocean basins

Unit-4: Sedimentation pattern and depositional environments of selected undeformed sedimentary basins of India. Himalayan sedimentary basins, Tectonic classification of sedimentary basins.

Books Recommended

(1) Reading H. G. 1996 : Sedimentary Environments and Facies, Balckwell
(2) Reading H.E. and Singh , I.B. 1980 : Depositional Sedimentary Environments, Springer Verlag
(3) Boggs Sam Jr, 1995 . Principles of Sedimentary and Stratigraphy , Prentice Hall
(4) Selley R.C.,1998. Applied Sedimentology, Academic Press
(5) Miall, A.D. 2000 : Principles of Sedimentary Basin Analysis, Springer Verlag
(6) Eirsele , G . 1992 : Sedimentary Basins , Springers Verlag .
(7) Bhattacharya A and Chakraborti , C .2000 . Analysis of Sedimentary Successions, Oxford and IBH .

Practical- 205 (a)

Prepration of lithologs , Interpretation and reading depositional environments from the given idealized lithologs and data, Heavy mineral identification and provenance interpretation . Petrography of selected sedimentary rock types. Staining and Mineral identification in Carbonate rocks.

GLE- 205 (b): Advance techniques in Structural Geology (Elective paper) (3 Credit, Max marks- 75 = (55 External Exam+20 internal assessment)

Theory

Unit-1: Principles of geological mapping and map reading, projection diagrams. Strain markers in naturally deformed rocks and graphical representation of strain. Strain pattern and folding. Measurement of strain in deformed rocks.

Unit-2: Structural analysis of folds, cleavages, lineations, joints and faults. Tectonites and their type. Concept of petrofabric and symmetry- field and laboratory techniques and graphical solutions.

Unit-3: Types of fabric, fabric elements and interpretation on macroscopic to microscopic scale. Use of Crystallographic Preferred Orientation (CPO) and Anisotropy of Magnetic Susceptibility (AMS) in petrofabric.

Unit-4: Time-relationship between crystallization and deformation. Unconformities and basement-cover relations. structural behaviour of igneous rocks, diapirs and salt domes.

Practical- 205 (b)

1. Preparation and interpretation of balanced cross sections.
2. Uses of stereographic techniques in solving structural problems.
3. Plotting and interpretation of petrofabric data and diagrams.
4. Measurement of strain in naturally deformed rocks

Suggested Readings:

1. Turner F.J. and Weiss, L.E., 1963. Structural Analysis of Metamorphic Tectonites. McGraw Hill.
2. Davis G. R., 1984. Structural Geology of Rocks and Region. John Wiley.
3. Ramsay J.G. and Huber, M.I., 987. Modern Structural Geology, Vol. I & II. Academic Press.
4. Stephen Marshak and Gautum Mitra. 1988. Basic Methods of Structural Geology.
5. Price N. J. and Cosgrove, J. W., 1990. Analysis of Geological Structures. Cambridge Univ. Press.
6. Bayle B., 1992. Mechanics in Structural Geology. Springer Verlag.
7. Tarling D. H. and Hrouda F, 1993: The Magnetic Anisotropy of Rocks. Chapman and Hall, Landon.
8. Valdiya K.S., 1998. Dynamic Himalaya. University Press.
9. Passchier C. w. and Treuw R. a. J., 2005: Microtectonics, Springr.
10. Richard H. Groshong (Jul 24, 2008). 3-D Structural Geology: A Practical Guide to Quantitative Surface and Subsurface Map Interpretation. Springer
11. Donal M. Rangan, 2009. Structural Geology: An introduction to Geometrical Techniques. Cambridge, University Press.
12. Davis G. R., Stephen J. Reynolds and Charles F. Kluth. 2011. Structural Geology of Rocks and Region. Amazon Press

GLG-205 (c): Marine Geology (Elective paper) (3 credit, Max marks- 75 = (55 External Exam+20 internal assessment)

Theory

Unit-1: Definition and Scope of the subject. History of development of Oceanography, Ocean Drilling Programme (ODP),and its major accomplishments.

Unit-2: Ocean Circulation, Surface Circulation, Concept of mixed layers, Thermocline and pycnocline, Concept of upwelling, El Nino, Deep ocean circulation, Formations of Bottom waters, Water masses of the world oceans and sea sediments (oozes etc.).

Unit-3: Paleoceanography: Approaches to palaeoceanographic reconstructions. Reconstruction of monsoon variability by using marine proxy records. Eustatic Changes.

Unit-4: Global climate pattern and energy budget, Climate controlling factors. Plate tetconics and climate change Milankovitch cycles, Atmosphere and Ocean interaction and its effect on

climate. An overview of Paleoclimatic reconstruction; Pleistocene Glacial-Interglacial cycles; Future climate: Anthoropogenic activity and its effect on Global climate.

Practical- 205 (c)
Study of modern surface water mass assemblages of various microfossils from different oceans. Depth biotopes and estimation of plaeodepth of the ocean using microfossils group. Thermocline and deep surface waters of the modern oceans.

Suggested Redding:

1. 1. Paleocenography by J.J. Bhatt
2. Ocenography by Savander Singh
3. Paleoclimatology: climate through ages by C.E. Brooks
4. Climate Change in Pre history by W.J. Burrough
5. Introduction to Physical Oceanography by R.h. Stewart
6. Gross, M.G, 1977. *Oceanography: A view of the Earth,* Prentice Hall.
7. Haq and Boersma, 1978. *Introduction to Marine Micropaleontology,* Elsevier.
8. Hasllett, S.K., 2002. *Quaternary Environmental Micropalaeontology,* Oxford University Press, New York.
9. Tolmazin, D_1985. *Elements of Dynamic Oceanography,* Allen and Unwin.
10. Bigg, G., 1999 Ocean and Climate. Springer- Verlag
11. Bradley, F., 2000. Paleoclimatology: Reconstructing Climates of the Quaternary. Springer- Verlag
12. Maher and Thompson, 2000. Quaternary Climates, Environments and Magnetism. Cambridge University Press.
13. Williams, Durnkerley, Decker, Kershaw and Chhappell, 1998. Quaternary Environments. Wiley and Sons.

GLG-205 (d): Advanced Mineralogy and Thermodynamics (Elective paper) (3 Credit, Max marks- 75 = (55 External Exam+20 internal assessment)

Theory

Unit-1: Fundamental concepts: Equilibrium, disequilibrium, steady state; exact/inexact Differentials; first and second laws of thermodynamics; combined first and second laws; enthalpy; free energy functions; criteria for spontaneity and equilibrium; the third law of thermodynamics and finite entropies.

Unit-II: Phase equilibria in simple systems: 6Derivation of Gibbs phase rule; chemography; free energy surfaces; Clapeyron equation; Morey-Schreinemakers rules; calculation of univariant lines in simple systems

Unit-III: Thermodynamics of solutions: Partial molal properties, chemical potential; Gibbs-Duhem equation and phase rule; ideal solutions; non-ideal solutions, fugacity, activity, standard

states, activity coefficients, and excess functions; solution modeling and equation of state; calculation of activities in gas mixtures, ideal and non-ideal crystalline solutions; electrolyte theory.

Unit-IV: Phase equilibria: The equilibrium constant; temperature, pressure and compositional dependence of equilibrium constant; chemical potential diagrams; oxidation-reduction diagrams; calculation of one-, two- and three-component phase diagrams.Thermodynamic data: Measurements and estimations; sources of data; computerized Phase diagram. constructions; TWQ and THERMOCALC software.

Suggested Readings

1..Chemical Thermodynamics: Basic Theory and Methods. By I. M. Klotz and R. M. Rosenberg. The Benjamin/Cummings Publishing Company.
2. Thermodynamics of Solids. By R. A. Swalin. John Willey & Sons.
3. Geochemical Thermodynamics. By D. K. Nordstrom and J. A. Munoz. The Benjamin/Cummings Publishing Company.
4. Short Course on Application of Thermodynamics to Petrology and ore Deposits. By H. J. Greenwood (Editor). Mineralogical Association of Canada.
5. Elementary Thermodynamics for Geologists. By B. J. Wood and D. G. Fraser. Oxford University Press.
6. Anderson, G.M. Thermodynamics of Natural Systems, Cambridge University Press, 2005.
7. Winter, J. D. Introduction to Igneous and Metamorphic Petrology. Prentice-Hall, 2001.
8. Drever, J.I. The Geochemistry of Natural Waters, 3rd Edn., Prentice Hall, 1997.
9. Faure, G. Principles of Isotope Geology, 2nd Edn., John Wiley, 1986.
10. Mason, B. and Moore, C. B. Principles of Geochemistry, 4th Edn., John Wiley, 1982.

GLG–206: Practical- A (GLG201+GLG202) (Credit 2+2=4, Maximum Marks- 100 (75 marks for External and 25 marks for Internal assessment)

Practical : Mineralogy and Geochemistry

Study of physical and optical properties of important rock forming minerals; Determination of An content of plagioclase feldspars; Determination of elongation and optic sign of minerals; Determination of Pleochroism and absorption schemes.

Construction of geochemical variation diagrams (Spidergrams; Harker's variation diagrams; addition-substraction diagrams); Calculation of stoichriometric formula from chemical analysis of minerals.

Practical : Economic Geology

Study of ores in hand specimen. Geographical distribution of classic ore deposits of India and world. Study of metallic minerals under the reflecting microscope.

GLG–207: Practical- B (GLG203+GLG204) (Credit 2+2=4, Maximum Marks-100 (75 marks for External and 25 marks for Internal assessment)

Practical: Stratigraphy

Study of characteristics stratigraphic rocks of India and their distribution. Choronostratigraphi/ Lithostratigraphic placement of important stratigraphic rocks of India.

Practical: Palaeontology

Systematic description of Brachiopoda, Bivalvia, Cephalopoda and Gastropoda; vertebrates

GLG-208: Practical-C- (GLG205, Elective Paper) (Credit 2, Maximum Marks-50 (38 marks for External and 12 marks for Internal assessment

Practical- 205 (a) : Sequence Stratigraphy and Basin Analysis

Prepration of lithologs , Interpretation and reading depositional environments from the given idealized lithologs and data, Heavy mineral identification and provenance interpretation . Petrography of selected sedimentary rock types. Staining and Mineral identification in Carbonate rocks.

Or

Practical- 205 (b): Advanced Techniques in Structural Geology

1. Preparation and interpretation of balanced cross sections.
2. Uses of stereographic techniques in solving structural problems.
3. Plotting and interpretation of petrofabric data and diagrams.
4. Measurement of strain in naturally deformed rocks

Or

Practical- 205 (c): Marine Geology

Study of modern surface water mass assemblages of various microfossils from different oceans. Depth biotopes and estimation of plaeodepth of the ocean using microfossils group. Thermocline and deep surface waters of the modern oceans.

Or

Practical- 205 (d): Advanced Mineralogy and Thermodynamics

Department of Geology, Kumaun University, Nainital-263002 (New CBCS Syllabus w.e.f. July 2015)

SEMESTER – III

GLG- 301: Geodynamics (4 credit, Max marks-100 = (75 External Exam+25 internal assessment)

Theory

Unit-I: Planetary evolution of the earth and its internal structure. Heterogeneity of the earth crust. Major tectonic features of the Oceanic and Continental crust. Isostacy and epeirogeny.

Unit-II: Gravity and magnetic anomalies and heat flow patterns at Mid-ocean ridges, deep sea trenches, continental shield areas and mountain chains. Continental drift-geological and geophysical evidence, mechanics, objections, present status. Nature of plate margins.

Unit-III: Palaeomagnetism, magnetostratigraphy, seafloor spreading, mechanics of plate motion and Plate Tectonics. Island arcs, oceanic islands, hotspots and plume tectonics. Seismic belts of the earth vis-a-vis plate movements

Unit-IV: Orogeny, geodynamic evolution of Indian cratons and mobile belts. Structure and origin of the Himalaya. Metallogeny in relation to plate tectonics. Neotectonic movements-concepts and evidence.

Suggested Readings:

1. Valdiya, K.S., Aspects of tectonics
2. Kearey P., Klepeis K.A., & Nive F.J., Global Tectonics
3. Valdiya, K.S., Making of India
4. Windley B.F., Evolving Continents
5. Willey, P.J., Plate Tectonics
6. Condie, K.C., Plate Tectonics
7. Cox, A. And Hort, R.B., Plate Tectonics
8. Moores, E. and Twiss, R.J. 1995: Tectonics-Freeman
9. Keary, P. and Vine, F.J. 1990: Global Tectonics-Balckwell
10. Storetvedt, K.N. 1997: Our Evolving Planet: Earth's History in New Perspective-Bergen (Norway), Alma Mater Fortag
11. Valdiya, K.S., 1998: Dynamic Himalaya-Universal Press, Hyderabad
12. Summerfield, M.A., 2000: Geomorphology and Global Tectonics-Springer Verlag

GLG- 302: REMOTE SENSING AND GIS (4 credit, Max marks-100 = (75 External Exam+25 internal assessment)

Theory

Unit I: Definition of remote. Remote sensing platforms: Air- and space-based.

Unit II: Types and characteristics of sensors. Concepts of mono-band, multispectral and hyperspectral remote sensing. Basics of optical, thermal and microwave remote sensing. Concept of LiDAR. Characteristics of IRS sensors.

Unit III: The structure of Digital Image. Conceptual aspects of Digital Image Processing. Basic processes of image rectification, enhancement and classification.

Definition and components of Geographic Information System (GIS). Raster and vector data formats. Basic knowledge about data acquisition, manipulation, analyses and representation in GIS.

Unit IV: Application of remote sensing and GIS in geomorphological investigations, tectonic investigations, lithological mapping, groundwater exploration, mineral exploration, Oil & Gas exploration and geohazard management.

Recommended Books

1. Lillesand, T.M., Kiefer, R. W. and Chapman, J. (2007): Remote Sensing and Image Interpretation, 6th Edition. Wiley
2. Gupta, R. P. (2003). Remote Sensing Geology. 2nd Edition. Springer
3. Drury, S.A. (1993). Image Interpretation in Geology. 2nd Edition. Chapman & Hall
4. Jensen, J.R. (2000). Remote Sensing of the Environment, An earth Resource Perspective. Pearson Education.
5. DeMers M.N. (2008). Fundamentals of geographic Information System. 4th Edition. Wiley
6. Richards, J.A. and Jia, X. (2006). Remote Sensing Digital Image Analysis: An Introduction. 4th Edition, Springer

GLG- 303: Ground Water Hydrology (3 credit, Max marks-75 = (55 External Exam+20 internal assessment)

Theory

Unit-I: Hydrological Cycle, Ground Water- origin, type and occurrence. Hydrological properties of rocks- porosity, permeability, specific yield, specific retention, hydraulic conductivity, transmissibility and storage coefficient. Subsurface movement and vertical distribution of Ground Water.

Unit- II: Aquifer and their types. Confined and unconfined aquifers. Darcy Law, its range and validity.

Unit-III: Quality of Ground water: Chemical characteristics of ground water in relation to various uses- domestic, irrigation and industrial purposes. Ground water artificial recharge-methods and factors controlling recharge.

Unit-IV: Geological and geophysical methods of ground water exploration.

Books Recommended:

1. Todd, D.K., 1980: Groundwater Hydrology- John Wiley
2. Davis, S.N. and De Wiest, R.J.M., 1966: Hydrogeology- Johm Wiley
3. Freeze, R.A. and Cherry, J.A., 1979: Ground Water- Prentice Hall
4. Fetter, C.W., 1990: Applied Hydrogeology- Merill Publishing
5. Ragunath, N.M., 1982: Ground Water- Wiley Eastern
6. Karanth, K.R., 1987: Groundwater Assessment- Development and Management- Tata McGraw Hill
7. Alley, W.M., 1993: Regional Ground Water Quality- VNR, New York
8. Subramaniam, V., 2000: Water- Kingston Publication, London.

GLG- 304: Micropaleontology and Oceanography (3 credit, Max marks-75 = (55 External Exam+20 internal assessment)

Theory

Unit-I

Definition and scope of the subject, surface and subsurface sampling methods, sample processing and techniques.

Unit-II

History of development of Oceanography. Methods of measuring properties of sea water.Ocean drilling Programme (ODP) and its major accomplishments.

Unit-III

Ocean circulation, surface circulation and concept of mixed layers. Thermocline and Pycnocline, concept of upwelling. El Nino and deep Ocean circulation. Formation of bottom, bottom water, water masses of the world ocean and sea sediments (oozes etc.).

Unit-IV

Introduction, detailed morphology, geological distribution evolution and applications of Foraminifers, ostracoda, Calcareous Nannofossils, radiolaria, diatoms and conodonts.

Suggested Reading:

1. Introduction to marine micropalaeontology, Bibal U. Haq
2. Elements of Micropalaeontology, by G. Pignot
3. Applied Geological Micropalaeontology, Pokorng Valdimir

GLG- 305: Practical- A (GLG302+GLG303) (Credit 2+2=4, Maximum Marks- 100 (75 marks for External and 25 marks for Internal assessment)

Practical: Remote Sensing and GIS

Determination of the scale of aerial photographs and imageries. Visual interpretation of aerial photographs and imageries for geomorphological, lithological, tectonic and mapping.

Practical Ground Water Hydrology

Hydrological properties of rock and soil characteristics- Specific gravity, degree of saturation, moisture content, void ratio, porosity and permeability. Delineation and description of hydrochemical and Ground water province of India.

GLG- 306: Practical- B (GLG 304) (Credit-2, Maximum Marks- 50 (38 marks for External and 12 marks for Internal assessment)

Practical: Micropaleontology and Oceanography

Techniques of separation of microfossil from the matrix, Types of microfossils, Study of representative genera of microfossils and their specification and systematic description preparation of bio-zonation charts.

GLG-307: Field Training (Credit-2, Maximum marks-50)

GLG-308: Presentation: Dissertation-I Part (Credit-1, Maximum marks-25)

Department of Geology, Kumaun University, Nainital-263002 (New CBCS Syllabus w.e.f. July 2015)

SEMESTER – IV

GLG- 401: Engineering Geology (3 credit, Max marks-75 = (55 External Exam+20 internal assessment)

Theory

Unit-I

Role of geology in major engineering projects. Engineering properties of rocks and soils.

Unit-II

Geological consideration for evaluation of Dams and reservoir sites. Reservoir induced seismicity. Dam foundation rock problems. Grouting and Rock bolting. Problem of piping in reservoir areas.

Unit-III

Geological evaluation of tunnel alignment. Bridges, their types and causes of their failure. Building, their types and influence of geological conditions on foundation

Unit-IV

Mass movement with emphasis on landslide. Causes of hill slope instability and preventive measure.

Book Recommended

1. Sharma P.V., Environmental and Engineering Geophysics
2. Krynine D.P. and Judd W.R., Principles of Engineering Geology and Geotechniques
3. Bell F.G., Fundamental of Engineering Geology
4. Jeger C., Rock Mechanics and Engineering
5. Valdiya K.S., Environmental Geology
6. C.C. Mathewson, Engineering Geology
7. A.C. Mc Lean and Gribble C.D., Geology for Civil Engineers
8. D.P. Coduto, Geotechnical Engineering
9. Dunn I.S., Anderson L.R. and Kiefer F.W., Fundamentals of Geotechnical Analysis

GLG- 402: Tectonic Geomorphology (3 credit, Max marks-75 = (55 External Exam+20 internal assessment)

Theory

Unit-I: Definition and scope of tectonic geomorphology. Landscape evolution. Concept of Form-Process relationship in landscape evolution.

Unit-II: Geomorphic Markers of active tectonics: Planar and Linear. Landforms of active strike-slip faults, normal faults, reverse faults and folds. River response to active tectonics. Sudden (coseismic) versus gradual modifications in river systems. Tectonic modifications of alluvial and bedrock-channeled rivers: longitudinal profiles, river pattern, sinuosity, drainage patterns and drainage anomalies. Effects of base level.

Unit-III: Geomorphic Indices of active tectonics – Morphometric analysis: mountain-front sinuosity, hypsometric curve and hypsometric integral, drainage basin asymmetry, stream-length gradient index, and valley-floor width to valley height ratio.

Unit-IV: Fundamentals of space geodetic techniques of measuring active tectonic deformations: Global Positioning System (GPS) and Radar Interferometry.

Recommended Books

1. Burbank, D.W. and Anderson, R.S. (2011). Tectonic Geomorphology 2nd Edition. Blackwell Science.
2. Burbank, D.W. and Anderson, R.S. (2001). Tectonic Geomorphology 1st Edition. Blackwell Science.
3. Keller, E.A. and Pinter, N. (1996). Active tectonics: Earthquakes, Uplift, and Landscape. Prentice Hall
4. Bull, William. (2009). Tectonically active landscapes. Wiley-Blackwell
5. Schumm, S.A, Dumont, J.F. and Holbrook, J.M. (2000). Active tectonics and alluvial rivers. Cambridge University Press.
6. Bull, W. (2007). Tectonic Geomorphology of Mountains: A new approach to palaeoseismology. Blackwell Publishing

GLG- 403: Mineral Exploration and Mineral Economics (3 credit, Max marks-75 = (55 External Exam+20 internal assessment)

Theory

Unit-I: Concept of exploration. Geological, geophysical, geochemical and geobotanical criteria and methods of surface and sub-surface exploration.

Unit-II: Pitting, trenching, drilling and sampling methods. Methods of petroleum and ground water exploration. Estimation of grade and reserve of ores.

Unit-III: Principles of mineral beneficiation. Communition classification, liberation, concentration, floatation methods, jigging, electromagnetic and magnetic separation, amalgamation, syndication.

Unit-IV: Strategic, critical and essential minerals. India's status in mineral production. National Mineral Policy. Substitution and conservation. Mineral concession rules. Marine mineral resources and Law of Sea.

Suggested Readings:

1. Mckinstry, H.E., 1962: Mining Geology. II Ed.-Asia Publishing House
2. Clark, G.B., 1967: Elements of Mining.III Ed.-John Wiley
3. Arogyaswami, R.P.N., 1996: Courses in Mining Geology. IV Ed.-Oxford IBH
4. Mason, B.C. (1982). Principles of Geochemistry, John Wilay & Sons.
5. Jeffery, G.H, Basett, J., Mendhan, J. and Denney, R.C. (1989). Vogel's text book of quantitative Chemical analysis. 5th ed. ELBS.
6. Gill, R. (Editor), (1977). Modern analytical geochemistry. Longman , Singapore.
7. Jeffery, P.G. and Hutchison, D., (1983). Chemical methods of rock analysis. Pergamon press, Oxford, N.Y.
8. Rose, A.W., Hawkes, H.E. and Webb, J. A., (1979). Geochmeistry in Mineral Exploration. Academic Press.
9. Skoorg, D.A. et al. (2004). Fundamental of analytical chemistry. 8th ed. Thomson Books.

Elective Paper

GLG- 404 (a): Himalayan Geology (Elective paper) (3 credit, Max marks-75 = (55 External Exam+20 internal assessment)

Theory

Unit-I: Geological terrains of Indian Subcontinent. Precambrian-Proterozoic rocks in the Himalaya, their metamorphism and igneous activities.

Unit-II: Himalayan province between Cambrian and Permian. Gondwana tectonics and pre-Himalayan palaeogeograpgy.

Unit-III: Cretaceous volcanism and the Himalayan Mesozoic startigraphy, the tectonic evolution of northern margin of the Indian plate. Collision of India with Asia and the emergence and evolution of the Himalaya, evolution of Himalayan Foreland basin.

Unit-IV: Quaternary development and Holocene-recent tectonic movements and earthquakes in the Himalaya.

Suggested Readings:

1. Geology of the Himalayas by A. Gansser, 1964
2. Geology of Kumaun Lesser Himalayaby K.S. Valdiya., 1980
3. Dynamic Himalaya by K. S. Valdiya, 1998
4. Emergence and Evolution of Himalaya by K. S. Valdiya, 2001
5. The making of India: Geodynamic Himalaya by K. S. Valdiya, 2010
6. Geological Study of the Himalayan Mountains An Observation on the Principal Peaks of the Great Range by F. Willford, J.A. Hodgson
7. Tectonic Geology of the Himalaya by P.S. Saklani
8. Geology of the Himalayas Comprising of the Studies on Shivalik Hills, Kashmir, Kumaon, Garhwal, Nepal, Sikkim and Bhutan by Edwin T. Atkinson
9. Dimensions Of Himalayan Geology written by Dr. A.K. Biyani

GLG- 404(b): Palaeoclimatology (3 credit, Max marks-75 = (55 External Exam+20 internal assessment)

Theory

Unit-I

Definition of Palaeoclimatology and the Quaternary. Quaternary Stratigraphy – Oxygen Isotope stratigraphy, biostratigraphy and magnetostratigraphy. Quaternary climates – glacial-interglacial cycles,

Unit-II

Proxy indicators of paleoenvironmental/ paleoclimatic changes, - land, ocean and cryosphere (ice core studies). Responses of geomorphic systems to climate, sea level and tectonics on variable time scales in the Quaternary,

Unit-III

Quaternary dating methods, –radiocarbon, Uranium series, Luminescence, Amino-acid, relative dating methods. Quaternary stratigraphy of India– continental records (fluvial, glacial, aeolian, palaeosols and duricrust); marine records;

Unit-IV

Continental-marine correlation of Quaternary record. Quaternary geomorphic processes. Landscape evolution in Quaternary. Concept of tectonic geomorphology. Evolution of man and Stone Age cultures.

Suggested Reading:

1. Bull, W.B., 1991. *Geomorphic Response to Climate Change,* Oxford University Press. 2:
   Bull, W.B., 2007. *Tectonic Geomorphology of Mountains,* Blackwell Publishing.
2. Burbank, W.B., and Anderson, R.S., 2001. *Tectonic Geomorphology,* Blackwell Science.
3. Keller, E.A. and Pinter N., 2001. *Active Tectonics: Earthquakes, Uplift, and Landscape,* Prentice Hall.
4. McCalpin, J., 1998. *Paleoseismology,* Academic Press.
5. Schumm, S.A. and Holbrook, 2000. *Active Tectonic and Alluvial Rivers,* Cambridge University Press!
6. Willett, S. D., 2006. *Tectonics, Climate, and Landscape Evolution,* Geological Society of America Publication.
7. Yeats R.S., Sieh. K.E. and Allen, C.R. 1997. *The geology of earthquakes,* New York. Oxford University Press.
8. Thornbury, W.D. (1969). Principles of Geomorphology. 2nd Edition. New Age International (P) Ltd.
9. Kale, V.S. and Gupta, A. (2001). Introduction to Geomorphology. Orient Longman.
10. Keller, E.A. and Pinter, N. 1996 Active Tectonics: Earthquakes, Uplifts and Landscape. Prentice Hall

GLG- 404(c): Advanced Hydrogeology (3 credit, Max marks-75 = (55 External Exam+20 internal assessment)

Theory

Unit-I

Hydrological cycle. Springs and their types. Origin, occurrence and movement of ground water. Ground water quality estimation and methods of treatment for various use. Ground water quality map of India.

Unit-II

Well Hydraulics: Confined, unconfined, steady, unsteady and radial flow. Water level fluctuations, their causative factors and their measurements. Methods of pumping test and analysis of test data. Evaluation of aquifer parameters.

Unit-III

Saline water intrusion on coastal aquifers, their causes and remedial measures.

Unit-IV

Surface and subsurface geological and geophysical methods of ground water exploration. Radioisotopes in hydrological studies.

Suggested Readings

1. Tolman C.F.,1937 :Groundwater; Mcgraw Hill, New York and London.
2. Todd D.K., 1995: Ground water Hydrology; John Wiley and Sons

3. Driscoll F.G., 1988: Ground water and wells, UOP, Johnson Div. St. Paul. Min. USA
4. Raghunath H.M.,1990: Groundwater, Wiley Eastern Ltd.
5. Karanth K.R. 1989 : Hydrology, Tata Mc Graw Hill6.
6. Davis, S.N.and De Wiest, R.J.M., 1966: Hydrogeology- Johm Wiley
7. Freeze, R.A. and Cherry, J.A., 1979: Ground Water- Prentice Hall
8. Fetter, C.W., 1990: Applied Hydrogeology, Merill Publishing
9. Karanth, K.R., 1987: Groundwater Assessment- Development and Management- Tata McGraw Hill
10. Alley, W.M., 1993: Regional Ground Water Quality- VNR, New York
11. Subramaniam, V., 2000: Water- Kingston Publication, London.

GLG- 404(d): Fuel Geology (3 credit, Max marks-75 = (55 External Exam+20 internal assessment)

Theory

Unit-I: Definition, origin, rank, and types of coal. Physical and petrographic characters: concept of Lithotypes, microlithotypes, and macerals. Utilization of coal. Application of coal petrology in solving geological problems and in hydrocarbon exploration.

Unit-II: Coal forming epochs in geological past, coal deposits of India and their distribution. Case study of some coal fields of India. Prospecting and reserves estimation, and production Coal-bed Methane: generation and exploration of coal as reservoir of methane.

Unit-III: Nature of petroleum: chemical composition and physical prospecting of organic matters and hydrocarbon. Origin of petroleum: organic and inorganic theories. Migration of oil and gas. Transformation of organic matter into Kerogen, organic maturation, thermal cracking of kerogen. Formation of petroleum in relation to geological processes: temperature, time, and pressure. Petroleum exploration-surface indication of oil and gas. Role of sedimentology in oil exploration, subsurface interpretation of sedimentary environments from cuttings and well log.

Unit-IV: Physico – chemical behavior of U and Th, classification of radioactive minerals. Mode of occurrence and association of atomic minerals in nature, atomic minerals as source of energy. Methods of prospecting and productive geological horizons of India. Origin of hydrothermal, syngenetic, pegmatitic and carbonatitic deposits of U and Th Placer deposits of Th. Nuclear power stations of the country and future prospects.

GLG- 405: Practical- A (GLG401+GLG402) (Credit 2+2=4, Maximum Marks-100 (75 marks for External and 25 marks for Internal assessment)

Practical: Engineering Geology

Study of engineering geological maps, preparation of cross sections and description of the terrain. Stress distribution in rocks and soils. Shear strength, angle of repose and utility of Mohr's circle, Problems related to hill slope instability and interpretation of geological maps for landslide problems

Practical: Tectonic Geomorphology

Exercises on mapping of tectonic geomorphological features and computation of geomorphic indices, using map and remote sensing data.

GLG- 406: Practical- B (GLG403) (Credit 2, Maximum Marks- 50 (38 marks for External and 12 marks for Internal assessment)

Practical: Mineral Exploration and Mineral Economics

Ore reserve estimation and vetting of easy values. Interpretation of bore hole logs. Interpretation of seismic and resistivity data. Study of gravity data maps and their interpretation.

GLG-407: Dissertation-II Part: Thesis and final presentation (Credit-2+1, Maximum marks-75)