University of Benghazi
Faculty of Science
Department of Earth Sciences

M.Sc. Program

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Preface

The Department of Earth Sciences at Benghazi (Garyounis) University is pleased to be the leader among all Earth Sciences Departments at other Universities of Great Libyan Jamahiriya to introduce this graduate studies program for M.Sc. degree in Earth Sciences. The Department and its staff members strongly believe in the importance of the graduate studies and the scientific researches to offer great opportunities for graduates who are qualified and eager to pursue their M.Sc. degree in the fields of earth sciences.

The Earth Sciences Department is committed to work hard and faithfully through the stages of the graduate studies to achieve its goals for fine researches and high standard of education with the help and the contributions of the Faculty of Science and the University of Benghazi (Garyounis).

Earth Sciences Department
July 2002,
Revised Apr. 2014

I: Acceptance, Admissions, and Examination Rules

Acceptance:

Applicants are generally accepted according to the graduate studies rules assigned by the Faculty of Science and with regard to the following specifics:

1- The applicant must hold a B.Sc. degree in Earth Sciences with good grades.

2- The field of study and research that the applicant is interested to pursue must be available. A written assurance from the graduate committee about the field of study, the courses, and research availability should be attached to the application.

3- Three recommendation letters from designated referees are required.

4- The applicant must pass a placement exam at the Earth Science Department.

5- Applicant must proof his qualification of the English proficiency in reading and writing.

6- No transfer-program is available. All applicants must fulfill a minimum of 30 credit hours of course work and research as required by the graduate committee.

7- Applicant must obey and respect all rules exercised within the Faculty of Science and the University.

8- All applicants must submit a copy of full documents (including his/her B.Sc. certificate and full record of transcripts) to the Earth Sciences Department prior to July 30.

Admissions:

1- Admissions for new students are applied annually at the beginning of the fall semester only.

2- Enrollment in specific fields of study depends upon the capacity and the interest of staff members.

3- According to the faculty education rules, student is allowed to register officially for (6 to 12 credit hours per semester only) unless otherwise is recommended by his graduate committee in a written form explaining the justifiable reasons with approval from the chairman of the department and the dean of the faculty.

4- Student must study and pass any deficiency courses that are assigned to him by his graduate committee before considering his official acceptance in the M.Sc. program.

5- Student must pay tuition and any other related registration fees to the university prior to his registration.

Examinations:

Graduate studies examinations are performed according to the Faculty of Science education rules, with special attention to the following rules:

1- English is the language of study, research, and exams.

2- Students will be examined in (written and oral) format depending on the subject matter and consent of the course instructor.

3- Student must study and pass any supporting sciences (i.e. math. physics, computer, English,) that are related to his/her special study and research. These courses are to be assigned by the graduate committee and approved by the department.

4- The thesis advisor and the graduate committee with approval of the chairman of the department and the dean of the faculty will choose a thesis examination committee. The thesis should be presented and discussed in an appointed date seminar. The student is expected to give his/her seminar presentation concerning his/her thesis research within the first 30 minutes; afterwards the seminar will go into close session (for the student and and the examiners only) for discussion and evaluation.

5- Grades and course evaluation for graduate students are according to the grading system of the Faculty of Science. The student is considered satisfactorily passing the course if he/she gets a minimum of 2.00 points out of 4.00, providing he must maintain an over all grade point average of at least 3.00 points during his studies.

6- Student will receive fail grade (F), if he/she misses more than 25% of the total amount of lectures, labs, excursions, and seminars of the course.

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II. M.Sc. Program courses of Earth Sciences Department

Serial No.	Course Title	Course No.	Credit hours
1	Advanced Structural Geology	6501	3
2	Regional Tectonics	6502	3
3	Quaternary Geology	6504	3
4	Applied Geomorphology	6505	3
5	Engineering Geology	6506	3
6	Principles of Remote Sensing	6507	3
7	Quantitative Analysis of Remote Sensing Images	6508	3
8	Isotope Geology and Radiometric Dating Techniques	6509	3
9	Special Topics I	6510	3
10	Geochemistry of Sedimentary Rocks	6515	3
11	Igneous Petrology	6516	3
12	Metamorphic Petrology	6517	3
13	Ore Deposits and Economical Geology	6518	3
14	Clays and Industrial Minerals	6519	3
15	Exploration Geochemistry	6520	3
16	Quantitative Analysis of Minerals	6521	3
17	Advanced Geochemistry	6522	3
18	Mineral Exploration Methods	6524	3
19	Special Topics in Geochemistry/Mineralogy	6525	3
20	Sequence Stratigraphy	6530	3
21	Sedimentary Petrology of Clastic Rocks	6531	3
22	Sedimentary Petrology of Non-Clastic Rocks	6532	3
23	Sedimentary Basins Analysis	6534	3
24	Advanced Petroleum Geology	6535	3
25	Advanced Sedimentology	6536	3
26	Analytical and Applied Sedimentology	6537	3
27	Sedimentary Environment and Facies	6538	3
28	Advanced Practical Sedimentology	6539	3
29	Hydrocarbon Source Rocks Evaluation	6540	3
30	Special Topics in sedimentology/stratigraphy	6541	3
31	Applied Paleontology	6545	3
32	Advanced Micropaleontology	6546	3
33	Advanced Palynology	6547	3
34	Vertebrate Paleontology	6548	3

M.Sc. Program courses of Earth Sciences Department (*cont.*)

Serial No.	Course Title	Course No.	Credit hours
35	Applied Biostratigraphy and Paleoecology	6549	3
36	Oceanography	6550	3
37	Special Topics in Paleontology	6551	3
38	Environmental Geology	6555	3
39	Surface Water Hydrology	6556	3
40	Groundwater Hydrology I	6557	3
41	Groundwater Hydrology II	6558	3
42	Groundwater Flow Modeling	6559	3
43	Hydrogeochemistry and Water Quality	6560	3
44	Regional Hydrogeology	6561	3
45	Geostatistics Methods	6562	3
46	Special Topics in Hydrogeology	6564	3
47	Advanced Well Logging	6570	3
48	Seismic Exploration	6571	3
49	Applied Gravity and Magnetic Methods	6572	3
50	Digital Filtering & Time Series Analysis	6574	3
51	Electromagnetic Methods	6575	3
52	Applied Seismology	6576	3
53	Geophysical Exploration for Minerals	6577	3
54	Seismic Stratigraphy	6578	3
57	Engineering Geophysics	6579	3
58	Environmental Geophysics	6580	3
60	Integrated Exploration Geophysics	6581	3
61	Statistical Methods in Geophysics	6582	3
62	Special Topics in Geophysics I	6591	2
63	Special Topics in Geophysics II	6592	3
64	Graduate Seminar in Geology	6601	1
65	Graduate Seminar in Geophysics	6602	1
	Graduate Thesis-Master of Science in Geology	6700	6
	Graduate Thesis-Master of Science in Geophysics	6701	6

III. Specialties of the M.Sc. Program courses of Earth Sciences Department

1. (Structure/Tectonic)

Selective Courses (At least 9 credits should be fulfilled)				Obligatory Courses (16 credits must be taken)		
Credit hours	**Course Title**	**Course No.**		**Credit hours**	**Course Title**	**Course No.**
3	Quaternary Geology	6504		3	Advanced Structural Geology	6501
3	Quantitative Analysis of Remote Sensing Images	6508		3	Regional Tectonics	6502
3	Isotope Geology and Radiometric Dating Techniques	6509		3	Applied Geomorphology	6505
3	Special Topics: structure/ tectonics / photogeology/ geomorphology	6510		3	Engineering Geology	6506
3	Advanced Sedimentology	6536		3	Principles of Remote Sensing	6507
3	Advanced Well Logging	6570		1	Graduate Seminar in Geology	6601
3	Applied Seismology	6576				

2. Mineralogy/Geochemistry

Selective Courses (At least 9 credits should be fulfilled)				Obligatory Courses (16 credits must be taken)		
Credit hours	**Course Title**	**Course No.**		**Credit hours**	**Course Title**	**Course No.**
3	Isotope Geology and Radiometric Dating Techniques	6509		3	Geochemistry of Sedimentary Rocks	6515
3	Ore Deposits and Economical Geology	6518		3	Igneous Petrology	6516
3	Clays and Industrial Minerals	6519		3	Metamorphic Petrology	6517
3	Quantitative Analysis of Minerals	6521		3	Exploration Geochemistry	6520
3	Mineral Exploration Methods	6524		3	Advanced Geochemistry	6522
3	Special Topics in Geochemistry/Mineralogy	6525		1	Graduate Seminar in Geology	6601
3	Sequence Stratigraphy	6530				
3	Environmental Geology	6555				

3. Sedimentology

Selective Courses (At least 9 credits should be fulfilled)				Obligatory Courses (16 credits must be taken)		
Credit hours	**Course Title**	**Course No.**		**Credit hours**	**Course Title**	**Course No.**
3	Advanced Structural Geology	6501		3	Sequence Stratigraphy	6530
3	Sedimentary Basin Analysis	6534		3	Sedimentary Petrology of Clastic Rocks	6531
3	Analytical and Applied Sedimentology	6537		3	Sedimentary Petrology of Non-Clastic Rocks	6532
3	Sedimentary Environment and Facies	6538		3	Advanced Petroleum Geology	6535
3	Advanced Practical Sedimentology	6539		3	Advanced Sedimentology	6536
3	Hydrocarbon Source Rocks Evaluation	6540		1	Graduate Seminar in Geology	6601
3	Special Topics: sedimentology/stratigraphy	6541				
3	Advanced Well Logging	6570				
3	Seismic Stratigraphy	6578				

4. Paleontology/Biostratigraphy

Selective Courses (At least 9 credits should be fulfilled)				Obligatory Courses (16 credits must be taken)		
Credit hours	**Course Title**	**Course No.**		**Credit hours**	**Course Title**	**Course No.**
3	Quaternary Geology	6504		3	Applied Paleontology	6545
3	Sedimentary Petrology of Clastic Rocks	6531		3	Advanced Micropaleontology	6546
3	Sedimentary Petrology of Non-Clastic Rocks	6532		3	Advanced Palynology	6547
3	Sedimentary Basin Analysis	6534		3	Vertebrate Paleontology	6548
3	Advanced Petroleum Geology	6535		3	Applied Biostratigraphy and Paleoecology	6549
3	Advanced Sedimentology	6536		1	Graduate Seminar in Geology	6601
3	Oceanography	6550				
3	Special Topics: biostratigraphy	6551				
3	Advanced Well Logging	6570				

5. Hydrogeology

Selective Courses (At least 9 credits should be fulfilled)				**Obligatory Courses (16 credits must be taken)**		
Credit hours	**Course Title**	**Course No.**		**Credit hours**	**Course Title**	**Course No.**
3	Advanced Structural Geology	6501		3	Surface Water Hydrology	6556
3	Applied Geomorphology	6505		3	Groundwater Hydrology I	6557
3	Advanced Sedimentology	6536		3	Groundwater Hydrology II	6558
3	Environmental Geology	6555		3	Groundwater Flow Modeling	6559
3	Regional Hydrogeology	6561		3	Hydrogeochemistry and Water Quality	6560
3	Geostatistics Methods	6562		1	Graduate Seminar in Geology	6601
3	Special Topics in Hydrogeology	6564				
3	Advanced Well Logging	6570				
3	Engineering Geophysics	6579				

6. Geophysics

Selective Courses (At least 9 credits should be fulfilled)				**Obligatory Courses (16 credits must be taken)**		
Credit hours	**Course Title**	**Course No.**		**Credit hours**	**Course Title**	**Course No.**
3	Applied Gravity and Magnetic Methods	6572		3	Advanced Well Logging	6570
3	Digital Filtering & Time Series Analysis	6574		3	Seismic Exploration	6571
3	Applied Seismology	6576		3	Electromagnetic Methods	6575
3	Engineering Geophysics	6579		3	Geophysical Exploration for Minerals	6577
3	Environmental Geophysics	6580		3	Seismic Stratigraphy	6578
3	Integrated Exploration Geophysics	6581		1	Graduate Seminar in Geophysics	6602
3	Statistical Methods in Geophysics	6582				
2	Special Topics in Geophysics I	6591				
3	Special Topics in Geophysics II	6592				

IV. DESCRIPTION OF THE M. Sc. COURSES OF THE EARTH SCIENCE DEPARTMENT

1. STRUCTURE /TECTONIC

1. ADVANCED STRUCTURAL GEOLOGY (6501); c. h. (3)

Brittle deformation: extension fractures and shear fractures, its tectonic environment and kinematics. Thrust faults, detachments, propagation and termination of thrusts. Strike slip faults; its geometry and environments, nature of fault zones, mechanics of faulting and relation to other fault types (pull-apart, rhomb-graben and horsts) and regional examples. Normal Faults, including: rift zones and regional crustal extension. Ductile deformation folds, kinematics models of folding, parasitic folds and complex folds. Unconformities; types, significance and applications. Macro- and micro-fabrics, foliations, lineation, symmetry of fabrics and its kinematics analysis. Geological and geophysical techniques in structural geology. The course includes: Lab-work and field-excursions.

2. REGIONAL TECTONICS (6502); c. h. (3)

The main tectonic features of the Earth. Anatomy of orogenic belts. The interpretation of orogenic zones, African example of a continental craton. Structure of constructive boundaries, including the development of rifting. Examples of continental passive margins and their structural levels. Andean and cordilleran belts. The Alpine-Himalayas Fold belts and its Afro- European and near East sub regions. Structure of conservative boundaries. Tectonic development of the Peri-Tethyan. Tectonic framework of Libya.

3. QUATERNARY GEOLOGY (6504), c. h. (3)

Geologic field problems and associated techniques for reconstructing Quaternary environments. Quaternary geologic, climatologic, and hydrologic events recorded in the landforms, stratigraphic sequences, and weathering profiles. Recognition, collection and evaluation of sea level indicators. Field techniques include relative dating analysis, section measurements, morpho- and lithostratigraphic analysis, and map constructions in fluvial, lacustrine, glacial, coastal, and aeolian environments. Laboratory techniques include radiometric-dating techniques mostly used in Quaternary deposits.

4. APPLIED GEOMORPHOLOGY (6505); c. h. (3)

Geological structures and landform (horizontal structures, folded structures, inverted relief, faulted structures. Rock characteristics and landforms. Development of slope. Development of drainage. Semi-arid and arid landforms. Coastal landforms. Libyan- regional examples (e.g.: Quaternary linear fluvio-geomorphological features. Quaternary alluvial and marine terraces, recent and fossil landslides, karst morphology. Studying and analyzing landforms and their distinctive characteristics. The prediction of natural and hazardous earth processes. The impact of man as a geomorphological agent. The role of geomorphologists in planning for land-use.

5. ENGINEERING GEOLOGY (6506); c. h. (3)

Strength of geological material, influence of burial and uplift. Behavior of rocks and soils. Behavior of surfaces. Methods of ground investigations (Bore-hole drilling, measurements of: stress, deformability, shear strength, hydraulic properties). Selected laboratory investigations (composition, structure, strength and hydraulic properties). Problems of slope stability. Methods of ground excavations and ground treatment. Environmental problems.

6. PRINCIPLES OF REMOTE SENSING (6507); c. h. (3)

Relationship between properties of morphology, lithology and remotely sensed images. Techniques of remotely sensed images: Multispectral scanner, Thermal infrared line scanner, and Sideways-looking airborne radar. Diversity of Multispectral scanner systems, orbit details, sensor details. Pictorial and numerical data products. Visual and quantitative interpretation procedures. Continuous and discrete image processing. Digital image processor. Image restoration and correction. Unsupervised and supervised image classification of computer compatible taps. Geographic Information Systems (GIS) application and use. Resources explorations. Interpretation of selected TM and SPOT images of Libyan terrain.

7. QUANTITATIVE ANALYSIS OF REMOTE SENSING (6508), c. h. (3)

Study of spectral reflectance on land and their signature differentiation between vegetation and different types of soil textures. Characteristics of spectral variations due to changes of soil texture, organic matter, mineral content, water content, rain/snow

precipitation, drainage, geomorphological and climatic conditions. Theory of colour and image interpretation. Studying of primary and secondary colour characteristics and filters. Digital image analysis of their composition, software/hardware usage, and data handling. The Geographic Information Systems and their relationship with remote sensing. Project planning and development process of remote sensing.

8. ISOTOPE GEOLOGY AND RADIOMETRIC DATING TECHNIQUES (6509), c.h. (3)

Principles of nuclear physics, radioactive decay equation and mechanisms. Concepts of crystal growth, mantle depletion, mantle degassing, mantle metamorphism, and crustal contamination. Geochemistry of stable isotopes. The chemical properties of isotopes. Isotopic variation in nature. Application of isotopes as natural tracer in surfacial processes and the use of isotopes in interpreting climate. Measurements of high-precession radiocarbon (14C) by gas proportional counting and measurements of the stable isotopes of carbon (13C) and oxygen (18O) by mass spectrometry. Uranium-series dating, Potassium-Argon (40K/40Ar) dating, radiocarbon dating, fission-track dating, and thermoluminscence dating.

9. SPECIAL TOPICS I (6510), c. h. (3)

Intensive treatment of a selected topic in structure, tectonics, geomorphology, photogeology, or remote sensing. Presented by lectures or seminars for graduate students in geology and related special fields. Subject is selected from any of those mentioned areas in geology and varies from year to year.

2. MINERALOGY/ GEOCHEMISTRY

1. GEOCHEMISRTY OF SEDIMENTARY ROCKS (6515), c. h. (3)

A major purpose of this course is to show how chemical data of sedimentary rocks can be used to identify geological environments using major and trace elements and radiogenic or stable isotopes. The interaction between geological fieldwork and the interpretation of geochemical data. The different analytical methods currently used in modern geochemistry. The course will feature large and small group discussion, assessment, profiles and case studies. Learning will be developed in friendly and supportive atmosphere within an emphasis on open discussion. This course is intensive updating information illustrated throughout with practical examples.

2. IGNEOUS PETROLOGY (6516), c. h. (3)

Petrogenesis, Tectonomagmatic setting of Igneous rocks; Classification of volcanic and plutonic rocks, Selected topics on the genesis of igneous rocks, Course emphasizes physico-chemical processes and how these relate to volcanic and ore-forming processes, Selected topics on synthesis techniques at high temperature and high pressure. The course will focus on integrating detailed petrographic studies, major and trace element geochemistry and thermodynamics to develop models for the generation, migration and crystallization of magma. From such studies we will develop an appreciation for the global scale geochemical dynamic that regulate the redistribution of heat and material within the earth. This course will include hands-out labs.

3. METAMORPHIC PETROLOGY (6517), c. h. (3)

Basis of metamorphic petrology; chemical equilibria; progressive metamorphism, metamorphic facies and facies series, metamorphic textures; metamorphism of sedimentary and igneous rocks; metamorphic rocks of the Caribbean. Principles and theories of metamorphic rock genesis. Static, dynamic and polyphasal cystalloblastic growth. Process of solid-state crystallization in metamorphic environments and the place of metamorphism in global tectonics. Special topics in metamorphic petrology.

4. ORE DEPOSITS AND ECONOMICAL GEOLOGY (6518), c. h. (3)

1. Ore bodies from magmatic and fluid processes- Ore deposit processes, magmatic and hydrothermal sources, pathways, agents, deposition, energy, structural controls to mineralization, analytical techniques in ore deposit studies, Layered intrusives, Pt/Cr deposits, primary diamonds, Ni-Cu-Co sulfide deposits of magmatic origin, porphyry Cu-Mo-Au systems. The content for each deposit type includes descriptive and genetic models, exploration techniques, controls to mineralization, typical mining and processing routes, environmental issues, ore mineralogy and petrology and case histories. There is a special independent group study of a particular deposit or region and presentation of a seminar and poster for display.

2. Sedimentary ores and industrial minerals- Processes formation of metal ores and industrial minerals sedimentary rocks. Geology of iron ores, processing of iron ores, iron and steel manufacturing processes and requirements for industrial materials. Economics of iron and steel manufacture, Formation of residual ores, Description of bauxites, lateritic iron, manganese and nickel ores, Placer deposits (titanium, zircon gold), Chemical sediments (gypsum, halite and other evaporites, and phosphorites), Aggregate, geology processing, market trends, uses in construction.

5. CLAYS AND INDUSTRIAL MINERALS (6519), c. h. (3)

This course is designed to appreciate the interaction between market requirements and the application of mineral science in the provision of raw materials for industry within the constraints of environmental responsibility. Furthermore, clays are immensely important commercially and have a vital raw material for chemical industrial applications. The main objective is to develop an understanding of the ways in which industrial mineral raw materials are evaluated for specific commercial applications and the effects of geological influences on raw material quality.

6. EXPLORATION GEOCHEMISTRY (6520), c. h. (3)

This module covers exploration techniques with equal emphasis on exploration geophysics and geochemical exploration. Exploration geophysics emphasizes aeromagnetic interpretation and geochemical exploration focuses on supergene processes and exploration

in regolith-covered areas. Conventional and remote sensing techniques. In exploration and mapping; major, trace element and isotope chemistry of mineralized rocks, weathering processes and supergene geochemical exploration, exploration case study.

7. QUANTITATIVE ANALYSIS OF MINERALS (6521), c. h. (3)

Use of transmitted and reflected light microscopes, Petrography and ore mineralogy, Mineral associations, textural relationships and paragenesis, Implication for processing, Major methods of mineral processing, Advanced mineralogical and chemical analysis techniques (XRD, SEM plus qualitative and quantitative mineral analysis, chemical analysis by XRF, AAS, wet chemistry, thermal analysis, IR analysis). Determination of physical properties of industrial rocks and minerals (color measurements, sieving, aggregate testing, plasticity measurement, surface area measurement). Oral and report presentations on the quality of selected industrial minerals using Laboratory data acquired during the module.

8. ADVANCED GEOCHEMISTRY (6522), c. h. (3)

Age of the earth; Geochronology, time scale and global stratigraphic correlation; Inorganic geochemistry, application to petroleum geology; Principles of Isotope geology, radioactive and stable isotope geology, radiogenic Isotope geology. The application of chemical thermodynamics to geochemical problems. Development of the three laws of thermodynamics, Gibbs free energy and equilibria constants. Introduction to various topics in aqueous geochemistry such as mineral equilibria, ion exchange and redox equilibria, Laboratory session will involve various experiments related to mineral solubility, chemical kinetics, acid-base equilibria and chemical modeling.

9. MINERAL EXPLORATION METHODS (6524), c. h. (3)

Class and Laboratory work on the application of stream sediment and soil geochemical techniques to mineral exploration and baseline studies for environmental impact monitoring. Topics include principles of geochemical dispersion; choice of media for sampling, field methods and sampling theory, analytical methods and quality control, and trace interpretation, Extensive use is made of computer-based data analysis.

10. SPECIAL TOPICS IN GEOCHEMISTRY/MINERALOGY (6525), c. h. (3)

Selected topics in geochemistry, to suit interests of the course participants.

3. SEDIMENTOLOGY

1. SEQUENCE STRATIGRAPHY (6530), c. h. (3)

Sequence stratigraphy is a recently emerging subject. It is the result of a merger of different disciplines including sedimentology, biostratigraphy and geophysics. The course covers four main parts. The first presents a brief history of sequence stratigraphy. The second covers the concepts and principles. The third deals with sequence stratigraphic tools such as seismic stratigraphy, outcrop and well data, chronostratigraphic charts and biostratigraphy. Finally, the application of sequence stratigraphy to different depositional systems in sedimentological context. A strong background in sedimentology and basic stratigraphy is a perquisite.

2. SEDIMENTARY PETROLOGY OF CLASTIC ROCKS (6531), c. h. (3)

The emphasis of the course will be on the analysis and description of sedimentary rocks under polarizing microscope and in the field that would lead to sound interpretation of their paragenetic history. It includes mudrocks, sandstone and conglomerates. The classification of these rocks especially rocks; include particle morphology, techniques of grain size analysis, statistical measures, mineral classification, composition and diagenesis of clastic rocks. Finally, sandstone properties and tectonics.

3. SEDIMENTARY PETROLOGY OF NON-CLASTIC ROCKS (6532), c. h. (3)

The non-clastic rocks include limestone and dolomite as well as evaporites, cherts, ironstones, phosphorites and coal. The main thrust of the course will be on limestone classification, carbonate minerals and grains, sedimentation of carbonate grains and reefs, diagenesis of carbonate rocks. Dolomite and dolomitization. Controls of carbonate facies sedimentation and diagenesis.

4. SEDIMENTARY BASINS ANALYSIS (6534), c. h. (3)

Study of modern concepts of stratigraphy and facies analysis. The scientific definition of facies, and their types and environmental characteristics. Emphasis on stratigraphic correlation techniques using lithostratigraphy, biostratigraphy, chronostratigraphy, and geochronometry. Basin mapping methods; structure, isopach contouring, lithofacies maps, paleogeological maps integrated with geophysical data and stratigraphic cross sections. Also, the depositional system and environment is studied for both clastic and nonclastic

sediments in relation to their burial history using some case studies. The regional and global stratigraphy cycles in relation to eustatic sea level change supported by seismic stratigraphic evidences. The sequence concept in basin analysis. Basin models and basinal case studies of Sirt, Hamada, North Sea, Western Canadian, and other common basins are analyzed.

5. ADVANCD PETROLEUM GEOLOGY (6535), c. h. (3)

Detailed study of selected topics in petroleum geology. Special emphasis on typical examples of oil and gas fields from North Africa, Middle East, and other parts of the world. Each student is assigned a special topic to be studied in details and submitting a written report and discussing the subject in the class.

6. ADVANCED SEDIMENTOLOGY (6536), c. h. (3)

Advanced sedimentology course deals with understanding and recognition of modern and ancient carbonate and siliciclastic depositional environments, facies and sequences. It is an intensive, integrated practical, theoretical and problem solving course with emphasis on application sedimentology to petroleum source and reservoir rock recognition and prediction. Understanding of the theoretical aspects is enhanced by the use of applied problems in which the student will use provided surface and subsurface data in economic decision making. Students are also trained in sedimentological data acquisition skills and interpretation of field sections or subsurface cores.

7. ANALYTICAL AND APPLIED SEDIMENTOLOGY (6537), c. h. (3)

The analysis of various lithofacies within different types of sedimentary basins. Generally, sedimentary basins from different parts of the world and their economical values will be of particular interest. Emphasis will be on the analysis of Libyan and Middle Eastern sedimentary basins.

8. SEDIMENTARY ENVIRONMENTS AND FACIES (6538), c. h. (3)

A comprehensive study covering depositional environments of recent sediments and sedimentary rocks, as well as their related facies models. Most of continental, mixed and marine sedimentary environments will be systematically discussed with emphasis on physical, chemical and biological processes, products and characteristics of various associated lithofacies.

9. ADVANCED PRACTICAL SEDIMENTOLOGY (6539) c. h. (3)

This course deals with detailed description of sedimentary features and the analytical methods used to evaluate them. Several standard techniques will be used to stress the value of statistical analysis in sedimentological research. The material to be covered includes: Analytical studies of most important sedimentary structures and trace fossils. Analysis of grain size, morphology and fabric, as well as minerals staining and peels. Heavy mineral analysis and their applications. Mineral identification by using X-ray diffraction techniques and available sample diffractograms. Classification of sedimentary rocks and environmental and facies analysis. Lab work will include various exercises to be completed independently by students.

10. HYDROCARBON SOURCE ROCKS EVALUATION (6540). c. h. (3)

Study of chemical composition of organic matter. The organic matter in nature and its production, accumulation, preservation, and environment. Processes of transformation of organic matter, kerogen, and petroleum through genesis process. Methods of study and evaluation of sedimentary organic matter using various optical and chemical approaches. Types of kinetic modeling on formation of hydrocarbons. Applications on type of organic matter and maturation of organic matter parameters and biomarkers. Also, applying geochemical correlations to indicate hydrocarbon migration. Case studies of basin modeling and the process of generation/migration and accumulation of hydrocarbons.

11. SPECIAL TOPICS IN SEDIMENTOLOGY/STRATIGRAPHY (6541) c. h. (3)

Intensive treatment of a selected topic in sedimentology, stratigraphy, petroleum geology, or other related subjects. Presented by lectures or seminars for graduate students in geology and related special fields. Subject is selected from any of those mentioned areas in geology and varies from year to year.

4. PALEONTOLOGY / BIOSTRATIGRAPHY

1. APPLIED PALAEONTOLOGY (6545) c. h. (3)

Part one: *Description and classification of fossils*. Preservation and the fossil record. Describing a single specimen. Ontogenetic variation. The population as a unit. The species as a unit. Grouping of species into higher categories. Identification of fossils.

Part two: *Concise review to the major macrofossil groups*. Morphology, classification, ecology, and stratigraphical use of the major macrofossil groups: Mollusks, Echinoderms, Bryozoans, Sponges, Cnidarians, Graptolites and Trilobites

Part three*: The use of paleonotological data*. Adaptation and Functional Morphology. Biostratigraphy. Palaeoecology. Evolution and the Fossil Record. Biogeography.

2. ADVANCED MICROPALAEONTOLOGY (6546); c. h. (3)

Part one: *Basic concepts in micropaleontology*. Palaeontology and Micropaleontology. The kingdom of life and the geologic time scale. Taxonomy, taxonomy hierarchy and the species concept. Nomenclature and identification of fossil species. Oil and micropaleontology

Part two: *Concise review of the major microfossil groups.* Morphology, classification, ecology, and stratigraphical use of the major microfossil groups (Foraminifera, Ostracods, Radiolarians, Silicoflagellates, Diatoms and Conodonts).

Part three: *Applications and interpretations.* Sampling and processing techniques of major microfossil groups. Application of microfossils in biostratigraphy and age determination. Application of microfossils biofacies and palaeoenvironmental analysis. Application of microfossils in oil exploration (Case studies). Application of microfossils in the palaeogeography, palaeoecology, and paleoclimate studies (examples). Application of microfossils in environmental Geology (Case studies)

3. ADVANCED PALYNOLOGY (6547); c. h. (3)

Part one: *Basic concepts in palynology*. Palaeontology and palynology. Taxonomy, and the species concept. Nomenclature and identification of fossil species. Palynostratigraphical schemes. Geochemical interpretation of kerogen and palynofacies data.

Part two: *Concise review of palynomorph groups*. Morphology, classification, ecology, and stratigraphical use of the major palynomorph groups: spore and pollen, dinoflagellate cysts and acritarchs.

Part three: *Applications and interpretations*. Sampling and processing techniques of major palynomorph groups. Application of palynology in biostratigraphy and age determination. Application of palynology in palaeoenvironmental studies. Application of palynology in source-rock evaluation and maturity relationships using spore color data, kerogen type and organic yield.

4. VERTEBRATE PALAEONTOLOGY (6548); c. h. (3)

Part one: *Basic concepts in vertebrate paleontology. Palaeontology* and the vertebrates. Vertebrate origins. Geological time and the vertebrates. The basis of the vertebrate's classification

Part two: *Concise review of the major vertebrate groups.* Morphology, classification, ecology, and evolution of the major groups (fishes, the amphibians, reptiles, dinosaurs, the birds, the mammals, human and human evolution

Part three: *Case studies and exercises*. Evolution of the important vertebrates groups. Mass extinction of the important vertebrate groups. Palaeoecology and biogeography of the important vertebrate groups. Vertebrate biostratigraphy (Examples)

5. APPLIED BIOSTRATIGRAPHY AND PALAEOECOLOGY (6549), c. h. (3)

Part one: *Basic concepts in biostratigraphy*. Rock-stratigraphic units. Biostratigraphic units (The biozone). Correlation with fossils. Stratigraphic ranges and zones. Time and time-rock units. Accuracy of correlation.

Part two: *Basic concepts in paleoecology*. Fundamental ecologic principals. The marine ecosystem. Life habitats. Spatial distribution of populations. Fossil communities. Post-mortem information loss.

Part three: *Applications and interpretations*. Stratigraphic schemes currently utilized in Libya (Examples). Biostratigraphic correlation of well logs (Advanced Exercises). Construction of chronostratigraphic sections (Advanced Exercises). Formation and palaeoenvironmental interpretation (Case studies). Fossils as environmental indicators (Advanced Exercises).

6. OCEANOGRAPHY (6550); c. h. (3)

Part one: *Basic concepts in oceanography*. History of oceanography. The origin of earth, its oceans, and life. Marine provinces. Marine sediments. Properties of water.

Part two: *Ocean circulation*. Horizontal Circulation. Vertical circulation. World ocean circulation. Waves and tides. The shorelines

Part three: *The marine environment*. Biological productivity. Animal of the pelagic environment. Animal of benthic environment. Marine pollution.

7. SPECIAL TOPICS IN PALAEONTOLOGY (6551), c. h. (3)

Selected topics in one of the following branches of Palaeontology:

- Invertebrate Palaeontology (Prerequisites: 6545)
- Vertebrate Palaeontology (Prerequisites: 6548)
- Micropaleontology (Prerequisites: 6546)
- Palynology (Prerequisites: 6547)

5. HYDROGEOLOGY

1. ENVIRONMENTAL GEOLOGY (6555), c. h. (3)

Environmental geology is an applied science focusing on the entire spectrum of possible interactions between people and the physical environment. Evaluation of the natural hazards such as floods, landslides, earthquakes and volcanic activity to minimize loss of life and property. Evaluation of the landscape for site selection, land-use planning and environmental impact analysis. Evaluation of the earth materials, such as elements, minerals, rocks, soils and water, to determine their potentialities as resources of waste disposal sites and the effect on human health and to assess the need of conservation practices. The evaluation of the terrestrial, marine and freshwater habitat by studying their fauna and flora and to compare their present distribution with the past life. This assessment will help to draw a suitable regulations and legislation relating to conservation of natural habitats.

2. SURFACE WATER HYDROLOGY (6556), c. h. (3)

The course treats surface water resources in catchments and its interaction with ground water and thus to estimate ground water recharge and discharge processes. The hydro-meteorological elements (precipitation, evaporation and soil moisture) are discussed with techniques of runoff measurements. The course indicates methodology for the determination of geomorphic parameters of catchments. Analysis of stream runoff and corresponding effective rain fall on catchments leading to the determination of unit hydrograph function for different base storm periods. Furthermore, an instantaneous Unit Hydrograph function (IUH) can be determined by use of linear transform methods. The derived functions can be subsequently utilized to estimate the resource potential of the studied catchments basins.

4. GROUNDWATER HYDROLOGY I (6557), c. h. (3)

Fluid flow characteristics and constitutive relations are discussed for a Newtonian fluid. Also the theory of hydraulic potential and the multiphase flow are discussed. The Naviour-Stokes equation and the Ghybenm-Hersberg model for seawater intrusion are discussed with the concept of velocity potential. The course includes the derivation of the governing equation for subsurface flow for compressible flow in rigid media and the analysis

of compressible groundwater flow in deformable media with consequent land surface subsidence. The course introduces ground flow problems using the finite element method (steady state) and comparing the numerical results with analytical solutions using Fourier's series and Green's function.

5. GROUNDWATER HYDROLOGY II (6558), c. h. (3)

The course will concentrate on groundwater evolution and subsequent development. Discussion concerning the hydrologic budget of groundwater in a basin followed with the studies of well hydraulic and well losses with associated assumptions and working equations. Special consideration is given to the hydraulics of unconfined flow around a pumping well. Well design criteria are discussed with particular emphasis on stresses created by loads on casing and screens in addition to well development procedures. Detail discussions concerning well drilling methods and drilling fluids. Detailed well pumping tests to determine well loss parameters and aquifer transmissivities and strativities using several methods of approach.

3. GROUNDWATER FLOW MODELING (6559), c. h. (3)

The course includes discussions of physical and analog simulation models followed with detailed accounts of approximate numerical models like the integrated finite difference method, the finite difference and finite elements simulation models. The resulting simultaneous equations are assembled by Ritz or Galerkin methods. The finite difference and elements simultaneous equations are solved by explicit and implicit schemes.

6. HYDROGEOCHEMISTRY AND WATER QUALITY (6560), c. h. (3)

The course treats the chemical structure of water, its polarity and occurrences of mass in groundwater as related to the physical characteristics of the geological environments and the chemical constituents of groundwater. Equilibrium activity reactions models and deviation from equilibrium are treated with kinetic reactions. Description of groundwater chemical data and their geochemical interpretations when their spatial variations are determined. Furthermore, classification of groundwater into hydrochemical facies and water quality determinations are compared with international and local standards. Geochemical reactions in fresh natural water systems are treated in some detail. The determination of the

radioactive and environmental isotopes of groundwater is utilized in age dating and interpretation of groundwater recharge situations.

7. REGIONAL HYDROLOGY (6561), c. h. (3)

In this course, papers and regional studies of groundwater basins in the domain of Libyan territories and their extensions in the neighboring countries are discussed. Examples of these basins are the Kufra, Sirt, El Hamada, Al Hamra and Murzuk basins. Aquifer system existing in Libya, Chad, Sudan and Egypt. The course will cover aquifers simulations schemes, which had been performed in the above-mentioned basins. The course discusses the huge groundwater development initiated by the Great Man-River Project.

8. GEOSTATISTICS METHODS (6562), c. h. (3)

A review of basic statistical concepts and applications is given as an introduction. This includes an account of curve fitting, interpolation, regression and correlation using the method of least square. This will lead to the theory of regionalized variables and the theory of Lagrange's multipliers. Computation of various variogram models for the regionalized variables. The variograms thus obtained are utilized in point and block kringing. Computer programs are constructed in FORTRAN language to compute the variograms, kringed realizations and corresponding estimation variances for each kringed point or block.

9. SPECIAL TOPICS IN HYDROGEOLOGY (6564) c. h. (3)

Intensive treatment of a selected topic in hydrogeology, or other related subjects. Presented by lectures or seminars for graduate students in geology and related special fields. Subject is selected from any of those mentioned areas in geology and varies from year to year.

6. GEOPHYSICS

1. ADVANCED WELL LOGGING (6570), c. h. (3)

Advanced qualitative and quantitative applications of well logging devices in borehole study. Analysis of characterization of logging response in recognition to rock type, facies and environments dealing with various conditions of alluvial, continental, and marine type deposits. Case studies of common and complex stratigraphic and structural hydrocarbon reservoirs. New techniques of well log devices applied to reservoir formation evaluation.

2. SEISMIC EXPLORATION (6571), c. h. (3)

Detailed description of seismic data acquisition for both general and detailed geological investigations. Problems encountered in both land and marine seismic surveying. Processes, by which raw seismic data are treated to the final display of the compressed, enhanced and migrated seismic sections. Practical and theoretical aspects of the extraction of structural, stratigraphical, lithological and pore fluid information from seismic data. Interpretation and the inferences of sediment source direction, depositional environment, and prospect leads.

3. APPLIED GRAVITY AND MAGNETIC METHODS (6572), c. h. (3)

Advanced topics of potential field theory and their implications for data reduction and interpretation. Fundamentals and practical aspects of land, marine and airborne gravity and magnetic surveying. Data enhancement techniques including filtering, calculation of second derivatives of potential, continuation, reduction to the pole for magnetic data, calculation by solid angles, two-dimensional and three-dimensional calculations. Matrix formulation and modeling for the inversion of potential field data. Interpretation of different maps, case studies of large-scale and small-scale geological features.

4. DIGITAL FILTERING AND TIME SERIES ANALYSIS (6574), c. h. (3)

The application of time series analysis in geophysics, topics include sampling theorem, spectral analysis, z-transform, convolution, deconvolution, correlation, phase delay and group delay, matrices and multi-channel time series, and stability of inverse filters (Z-plane singularities of digital filtering). Basic concepts of analogue filtering. Digital filters of

seismic signals and their amplitude and phase characteristics. Principles of least squares filtering, predictive deconvolution, F-K techniques in seismic processing, and shaping filters. The elimination of ghost reflections, reverberations, short period and long period multiple reflections.

5. ELECTROMAGNETIC METHODS (6575), c. h. (3)

Theory and development of equations of electromagnetic fields in conducting media. Solution of forward and inverse problems with natural and controlled sources, magneto telluric and related methods. Time domain and frequency domain electromagnetic field components behavior on earth. Study of electrical properties of Earth's materials. Applications of electromagnetic methods in shallow and deep geophysical prospecting. Advanced methods and techniques in enhancing field measurements and data quality. Case study of recent developments and applications of EM methods.

6. APPLIED SEISMOLOGY (6576), c. h. (3)

Fundamental principles of elastic wave theory, ray geometry and inversion of time-distance curves. Earthquake scales, spectra of periods of ground oscillations, measure of high-mode dispersion, and cross-correlation. Designs and techniques of seismological observatory. Earthquakes and the internal earth structures, waves and major discontinuities and the resulting phases (multiple reflections) of seismic waves. Seismological data interpretation, earthquakes source analysis and fault plane solution. Seismic zoning and micro zoning and their significance for earthquake prediction and risk evaluation of a given area.

7. GEOPHYSICAL EXPLORATION FOR MINERALS (6577), c. h. (3)

Applied studies in mineral exploration using various surface geoelectrical method and techniques, including; Self Potential, Magnetic, Magneto telluric, Induced Polarization, Radioactive Gamma-Ray, Frequency and Time- Domain Electromagnetic methods, with emphasis on the physical and electrical properties of rocks used in defining economical ore minerals. Case studies of examples of worldwide prospecting efforts for minerals with emphasis on new techniques used.

8. SEISMIC STRATIGRAPHY (6578), c. h. (3)

Qualitative analysis of seismic reflection data, seeking the recovery of stratigraphic information. Detailed investigation of the major pitfalls of seismic data interpretation, and the limitations of vertical and horizontal seismic resolutions. Identification and mapping of seismic sequences, recognition of seismic facies changes and their relation to Stratigraphy and global changes of sea level. Seismic criteria for the identification and recognition of Clastic depositional reservoirs and Carbonate build-ups, and the interpretation of their depositional environments. Direct identification of hydrocarbon accumulation. Stratigraphic modeling, correlation, and case studies from different oil fields.

9. ENGINEERING GEOPHYSICS (6579), c. h. (3)

Applied shallow geophysical techniques for evaluation of civil site parameters; elastic coefficients, geologic structure, groundwater, earthquake seismology and seismic hazards. Also the applications of resistivity, magnetic, electromagnetic, self-potential, seismic refraction, and ground penetrating radar in shallow investigations.

10. ENVIRONMENTAL GEOPHYSICS (6580), c. h. (3)

Applications of different reliable and economical acceptable geophysical methods to investigate evaluate and make proper decisions regarding the increasing demands to the solutions of environmental problems. This course designed to cover a broad range of stimulating topics such as the determination of general seismic risk of a given area, monitoring volcanic activities, pre-constructing site investigation and evaluation, mapping of landfills and waste repositories. Locating of narrow mineshafts, and corroded steal drums containing toxic chemicals or military ordnance (shells, bombs, etc.). Detection of radioactivity, archaeological applications such as locating of tombs, detection of buried mines and public utility cables. Hydrogeological applications such as leak detection, seawater intrusion and monitoring of ground-water pollution.

11. INTEGRATED EXPLORATION GEOPHYSICS (6581), c. h. (3)

Advanced studies dealing with integrating several geophysical methods include; seismic refraction and reflection, gravity, magnetic, potential field, electrical, electromagnetic and well logging for regional and deep basin stratigraphic and structural

analysis for oil and mineral explorations. Case study of applications of modern geophysical field techniques to the solution of complex geological problems.

12. STATISTICAL METHODS IN GEOPHYSICS (6582), c. h. (3)

Data analysis, fitting, smoothing, fast integration. Explicit and implicit statistical methods in solving simultaneous equations. Finite difference and finite elements theory in solving differential equations. Theory of inversion and its application in inverse problem solution. Solution of complex dispersion equations including multiple root finding.

13. SPECIAL TOPICS IN GEOPHYSICS I (6591), c. h. (2)

Intensive treatment of selected geophysical topics presented through faculty lectures, guest lectures, and student reports. For students in geophysics and related fields.

14. SPECIAL TOPICS IN GEOPHYSICS II (6592), c. h. (3)

Intensive treatment of selected topics in geophysics presented by lectures or seminars for students in geophysics and related special fields. Subject is selected from all areas in geophysics and varies from year to year.

1. GRADUATE SEMINAR IN GEOLOGY (6601), c. h. (1)

The graduate seminar course is designed to give the student an opportunity to research a topic that is not part of his thesis research to present and defend these ideas and to write them up in a format comparable to that used in current scientific journals. Each student will be expected to present a seminar to follow class members (and any others who wish to attend).

The subject matter of the seminar is very important. It should not duplicate any previous thesis topic or that of a thesis course in progress, nor a previous course presentation. It may be in a related field, but must not be closely allied to the student's research, past or present. The seminar should be an up-to-date presentation on a topic that the student had investigated in some depth. It is to the student's advantage to choose a topic that is at least somewhat controversial; there will be a question period after the oral presentation. All graduate students are expected to attend all seminars throughout each year of residence.

2. GRADUATE SEMINAR IN GEOPHYSICS (6602), c. h. (1)

Review of current research topics and problems in geophysics. Instruction on presenting seminars, writing papers and preparing abstracts may be included. The graduate seminar is designed to develop student perspective on observational and theoretical methods and on relation of specific research to broader developments in geophysics and interdisciplinary aspects of geophysics through faculty-guided topics that would be presented in seminars by students and discussed by graduate students and faculty staff. Weekly seminars throughout the year.

1. GRADUATE THESIS-MASTER OF SCIENCE IN GEOLOGY (6700), c. h. (6)

2. GRADUATE THESIS-MASTER OF SCIENCE IN GEOPHYSICS (6701), c. h. (6)

********** End of M.Sc. Program **********