

**Master of Science in Geology**  
**Program code: 046010**

**INTRODUCTION**

The Department of Earth and Environmental Sciences (College of Science) offers a Master of Science program in **Geology**. The program is designed to gain expertise in specialized fields in geology and to prepare graduates for further academic study or career development. Faculty research covers a wide range of fields in Geology and Geophysics with particular reference to environmental aspects. Only thesis option is offered.

*According to the University Council decision dated 4/2/2007, Thesis students admitted with effect from September 2007 are exempted from the comprehensive examination.*

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**PROGRAM REQUIREMENTS**

**30 TOTAL COURSE CREDITS**

**10 COMPULSORY (credits in parenthesis)**

0460-503	Geology of the Arabian Gulf	(2)
0460-504	Interpretation of Geological Maps	(1)
0460-508	Computer Studies and Data Analysis in Geology	(3)
0460-509	Analytical Techniques	(2)
0460-590	Graduate Seminar	(2)

**11 ELECTIVES\* (credits in parenthesis)**

0460-502	Graduate Field Studies	(2)
0460-506	Advanced Petrographic techniques	(2)
0460-511	Igneous Petrology	(3)
0460-515	Metalliferous Deposits	(3)
0460-521	Metamorphic Petrology	(3)
0460-525	Nonmetalliferous Deposits	(3)
0460-531	Micropaleontology	(3)
0460-533	Concepts in Paleontology	(3)
0460-535	Carbonate Sediments and Evaporates	(3) Equivalent to 2090-539
0460-537	Clastic Sediments	(3)
0460-539	Advanced Stratigraphy	(3) Equivalent to 2090-535
0460-541	Advanced Marine Geology	(3)
0460-553	Hydrogeology	(3)
0460-554	Structural Geology	(3)
0460-555	Geomorphology	(3)
0460-556	Petroleum Exploration Methods	(3)
0460-558	Seismic Stratigraphy	(1)

0460-559	Engineering Geology	(3)
0460-560	Advanced Mineralogy	(3)
0460-561	Remote Sensing	(3)
0460-562	Environmental Geology	(3)
0460-563	Geophysics	(3)
0460-564	Geographic Information System (GIS)	(3)
0460-565	Advanced Seismology	(3)
0460-566	Advanced Geophysics for Engineers	(3)

\*Students may substitute up to 6 credit hours from the upper undergraduate elective courses in the department of earth and environmental sciences (400-level) with the approval of the Program Director.

## 9 COMPULSORY COURSES

0460-597	Thesis	(0)
0460-598	Thesis	(0)
2000-599	Thesis	(9)

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## ***COURSE DESCRIPTION***

### **0460-502: GRADUATE FIELD STUDIES CR: 2**

The course involves field investigation and writing a report on the geology of an area inside or outside Kuwait. New areas may be selected every year. Emphasis will be on synthesis of the geology of an area or a region.

### **0460-503: GEOLOGY OF THE ARABIAN GULF CR: 2**

General survey of the Gulf. Topography, Geomorphology settings and provinces. Lithological sequences of the Precambrian and Phanerozoic sedimentary and volcanic rocks. Generalizations of intrusive rocks. Geochronology and tectonic evolution since the Proterozoic. Deformation episodes. Recent sedimentary basins. Mineral deposits and metallogenesis.

### **0460-504: INTERPRETATION OF GEOLOGICAL MAPS CR: 1**

Types of information recorded on geological maps. Interpretation of standard geological maps in terms of lithology, stratigraphy, structure, tectonic

setting, geomorphology, economic geology and geological history. Examples of more special maps (e.g. structural, geophysical, geochemical) and their interpretation.

### **0460-506: ADVANCED PETROGRAPHIC TECHNIQUES CR: 2**

This integrative study of igneous, metamorphic and sedimentary rocks mainly uses transmitted light microscopes, but includes some applications of reflected light optics. The emphasis is on the description and interpretation of textural features but also includes some identificatory methods. The course is almost entirely practical.

### **0460-508: COMPUTER STUDIES AND DATA ANALYSIS IN GEOLOGY CR: 3**

A survey of the most commonly used statistical and numerical analytical methods in geology with computer applications using software packages such as STATGRAF, MATHCAD and ROCKWARE. It is intended to teach data summarization, analysis and pattern recognition

techniques as a research tool for geologists, rather than a rigorous mathematical treatment.

**0460-509: ANALYTICAL TECHNIQUES**

**CR: 2**

Characterization of geological materials using modern and state-of-the-art techniques. The course is divided into three categories and students should select two categories that are relevant to their field of specialization. The categories are: Geophysical methods, Geochemical methods, and Image analysis and GIS.

**0460-511: IGNEOUS PETROLOGY**

**CR: 3**

Occurrence, origin and crystallization of igneous rocks and interpretation of their composition, texture, and spatial distribution. Processes of formation in relation to field and experimental data (with special emphasis on interpretation of phase diagrams). Theory and experimental evidence for equilibrium. Physiochemical state of liquid-solid interactions in silicate melts. Medium of emplacement and structural setting. Laboratory investigation of selected rock suites.

**0460-515: METALLIFEROUS DEPOSITS**

**CR: 3**

Geologic characteristics, distribution and classification of metallic deposits and their economic features. Magmatic, metamorphic and hydrothermal processes leading to concentrations of the principal metals, including emplacement and wall rock alteration. Type of mineralization and genesis. exploration methods. Laboratory use of reflected and transmitted light microscopy and study of suites from known districts.

**0460-521: METAMORPHIC PETROLOGY**

**CR: 3**

Occurrence, characteristics and origin of metamorphic rocks. Role of fluid phases during re crystallization. Interpretation of mineral assemblages and textures in terms of T, P and chemical potential (e.g. graphic analysis, reaction sequence, Gibbs-free energy). Petrogenesis of mineral assemblages, and the metamorphic facies concept. Tectonic setting of metamorphism and associated structural deformation. Laboratory investigation of selected rock suites.

**0460-525: NONMETALLIFEROUS DEPOSITS**

**CR: 3**

Origin, distribution and classification of nonmetallic deposits of industrial minerals and rocks (including coal). Emphasis on surface and sedimentary mechanisms such as alluvial, weathering and secondary enrichment processes. Methods of exploration and economic characteristics. Laboratory work involves study of groups of non-metallic minerals.

**0460-531: MICROPALEONTOLOGY**

**CR: 3**

Importance and applications of microfossils in biostratigraphy, paleoecology and paleoclimatology and their role in solving geological problems. Review of the different groups of microfossils, with emphasis on their ecology, stratigraphic value, evolution and hard-part morphology and its relationships to environment. Laboratory and workshop methods for studying microfossils, and development of these methods.

**0460-533: CONCEPTS IN PALEONTOLOGY**

**CR: 3**

A seminar series of lectures and discussions on the development of the science of paleontology. Preservation and the fossil record. Species and population concept. Community concept, its reality, recognition and provinces. Ontogenetic variation, evolution, extinction, origin of life, and life in the Precambrian. Paleontology in relation to biostratigraphy, paleoecology, evolution, and paleoclimatology.

**0460-535: CARBONATE SEDIMENTS AND EVAPORATES**

**CR: 3**

Skeletal and non-skeletal components of carbonate sediments and their mineralogical stability in marine environments. Recognition of suitable marine environments for formation of the major carbonate particles type (e.g. oolites, pisolites, stromatolites, peloids, grapestones and micrites). Diagenetic alteration by heat and pressure. Factors controlling deposition and formation of Recent dolomite. Element distribution in carbonates and its relationships to activity of organisms. Carbonate cements. Sabkhas and evaporate generation. Thermodynamic treatment of the carbonate and evaporite systems. Techniques used

in carbonate and evaporite mineralogy (e.g. petrographic, staining, XRD and SEM, AA).

**0460-537: CLASTIC SEDIMENTS**

**CR: 3**

Mineralogy of clastic rocks. Petrographic examination of sandstones and arenites and its implication to paleogeography and depositional tectonic environments. Argillitic sediments and methods used for their analysis. Processes and characteristics of different sedimentary regimes and interrelationships among fluvial, deltaic, strand plain, lagoon, tidal flat, shelf and slope depositional environments. Application of the principles of facies analysis. Brief treatment of the tectonic framework of clastic sedimentation.

**0460-539: ADVANCED STRATIGRAPHY**

**CR: 3**

Scope of stratigraphy. Analysis and classification of sedimentary basins (architecture, geometry and tectonic evolution). Basis of well-log analysis. Advanced methods in stratigraphic analysis with particular emphasis on statistical methods (cluster and trendsurface analysis and other multivariate techniques). Magnetic and seismic stratigraphy. Data collection, reduction and interpretation. Case studies from Kuwait and the Arabian Gulf Region.

**0460-541: ADVANCED MARINE GEOLOGY**

**CR: 3**

A comprehensive treatment of the origin and development of major structural features of the ocean basins and continental margins. Methods used in data acquisition and interpretation of sedimentary and volcanic processes on the ocean bottom. Structure, stratigraphy and composition of the ocean floor as revealed by geophysical techniques. Study of geologic time by review of case studies from the Mesozoic and Cenozoic geologic record. Introduction to basic shipboard techniques used by geologic, physical, chemical and biological oceanographers.

**0460-553: HYDROGEOLOGY**

**CR: 3**

Aspects of the systems approach to hydrology. Ground water movement, well hydraulics, aquifer and well tests. Saline water encroachment. Water chemistry. Groundwater exploration. Hydrological data presentation. Model studies and numerical analysis of groundwater. Basin-wide groundwater

development. Basic patterns of water resources management.

**0460-554: STRUCTURAL GEOLOGY**

**CR: 3 PR: 0460-504**

Stress and Strain. Ductile deformation processes. Brittle failure of rocks. Folds and their associated foliations and lineations. Normal and growth faults. Continental rifts: detachment and planar fault models, half grabens and transfer zones. Thrust faults: ramps, thrust duplexes, thrust-related folds. Wrenching: parallel, divergent, and convergent wrenching; wrenching mechanisms; 2nd order wrench structures, pull-apart and push-up structures; flower structures. Determining stress orientations using meso- and macrostructures. Diapiric structures and salt tectonics.

**0460-555: GEOMORPHOLOGY**

**CR: 3**

Advanced treatment of processes producing landforms. An emphasis will be on fundamental mathematical and dynamic approaches in solving problems in fluvial processes. Aspects of coastal morphology. Applications are designed to stimulate the student's understanding of local problems directly linked to desertification and coastal development.

**0460-556: PETROLEUM EXPLORATION METHODS**

**CR: 3**

Review of origin, migration and accumulation of petroleum. Geochemical methods in oil discovery, well logs and formation evaluation, dip meter logs, geophysical prospection, seismic stratigraphy. Basin evaluation.

**0460-558: SEISMIC STRATIGRAPHY**

**CR: 1**

Review of the principles of seismic exploration procedures. Relation of seismic reflections to significant geological features; seismic facies; stratigraphic interpretation of seismic facies; recognition of unconformities; qualitative and quantitative seismic correlation.

**0460-559: ENGINEERING GEOLOGY**

**CR: 3**

Surface processes. Mechanical properties of soils and rocks. Engineering classification of rocks.

Data collection and presentation; field methods and laboratory methods. Engineering geological maps. Applications to foundations, dams, tunnels, highway and coastal constructions. earthquake risk and land slides. Case studies.

**0460-560: ADVANCED MINERALOGY**  
**CR: 3**

This course is an introduction to mineralogical techniques and interpretation of mineralogical determinations. Methods employed include X-rays (power and single-crystal methods), optical measurements, and DTA. Mineral groups are selected for study as being appropriate to the fields of specialisation of the students. The course is largely practical and a large part of the assessment is based upon individual practical work.

**0460-561: REMOTE SENSING**  
**CR: 3**

Electromagnetic radiation and its interaction with earth surface features. current land observation satellites and remote sensing systems. Multispectral, hyperspectral, thermal and microwave scanning. Data acquisition, correcting, registration and display. Problems of scale, resolution and accuracy in assessment. Current applications in natural resource and hazard mapping.

**0460-562: ENVIRONMENTAL GEOLOGY**  
**CR: 3**

Interaction between geological processes and natural/human environment. resource (soil, water, mineral) depletion, pollution, conservation and sustainability. Hazard (seismic, land-slide/subsidence, volcanic, coastal) assessment, prediction and mitigation. Modern methods (GIS, Remote Sensing, Geo-statistics) of data intergration, environmental mapping and land-use planning.

**0460-563: GEOPHYSICS**  
**CR: 3**

Origin of the solar system. Earth's internal structure and gravity field, the concept of isostasy. Geomagnetism, palaeomagnetism and continental drift; marine magnetic anomalies and sea-floor spreading. Earthquake seismology, the propagation of seismic waves; crystal structure, earthquake source mechanisms. Continental and

oceanic heat flow; cooling of the lithosphere. Global geophysics from space.

**0460-564: GEOGRAPHIC INFORMATION SYSTEM (GIS)**  
**CR: 3**

Components of Geographic Information Systems and basic requirements. Spatial data models, structures and axioms. Database structures and storage. Spatial data input, verification and output. Data interpolation and surface mapping. analysis of continuous fields using filters, derivatives, clumping. Data error analysis and quality control. Current applications, issues and trends in GIS.

**0460-565: ADVANCED SEISMOLOGY**  
**CR: 3**

An advanced study to the nature of earthquake motion, seismograph theory, seismic waves at different distances. Locating earthquakes, foreshocks and aftershocks and earthquake swarms, geography and distribution of shallow and deep focus earthquake with tectonic associations. Reservoir-induced earthquakes. Intensity of earthquake effects, isoseismal curves and accelerations. source mechanism estimation. Earthquake risk and protective measure. seismicity of the Arabian plate with emphasis on Kuwait.

**0460-566: ADVANCED GEOPHYSICS FOR ENGINEERING**  
**CR: 3**

Advanced studies on the theory and practice of geophysical methods in exploration for energy, minerals, groundwater and engineering applications. These will include seismic reflections, seismic refraction, electrical, electromagnetic, gravity and radio-metric methods of exploration, including the planning and conduct of field surveys for general and particular applications, and the theory and practice of the data processing and interpretation of geophysical results in terms of geological problems, conditions and occurrences.

**0460-590: GRADUATE SEMINAR**  
**CR: 2**

Student selects a topic not related to his thesis thoroughly researches the subject, writes a detailed paper, and presents a seminar on the subject. All faculty members will participate in evaluating the seminar.

**0460-597:    THESIS  
CR: 0**

**0460-598:    THESIS  
CR: 0**

**2000-599:    THESIS  
CR: 9**