GEOL 40300: Environmental Geology

MODULE COORDINATOR: Prof. Frank McDermott

ADDITIONAL LECTURERS: Dr Laia Comas Bru
Prof. Stephen Daly
Prof. Peter Haughton
Assoc. Prof. Julian Menuge

CREDITS: 5	**MODULE LEVEL**: 4	**SEMESTER**: II

PRE-REQUISITES/PRIOR LEARNING:

No prior knowledge of geology is assumed. The module is aimed at graduate-level Environmental Science students.

OVERVIEW OF MODULE:

The purpose of this module is to provide graduate-level Environmental Science students with a basic level of knowledge of Earth materials (minerals, rocks, soils, glacial-tills), basic geological processes and geological structures in 3-D, and geomorphology from a geo-engineering perspective. The role of bedrock geology and unconsolidated deposits (e.g. glacial tills and fluvioglacial deposits) in shaping the landscape is also explored. The module also deals with the links between rock-type and water chemistry (surface and groundwaters) as well as the role of bedrock type in determining the vulnerability of aquifers to pollution.

LEARNING OUTCOMES:

On completion of this module students should be able to:

1. Identify a range of common rock-forming and ore minerals in hand specimen;
2. Identify a range of common igneous, metamorphic and sedimentary rocks in hand specimen;
3. Be aware of the common problems associated with engineering-related human impacts on the landscape, coastlines and groundwater resources and appreciate the role that rock-type plays in determining the chemistry of surface and groundwaters;
4. Understand how different aquifers have different vulnerabilities to surface-derived pollution and be able to make some qualitative predictions based on this knowledge;
5. Interpret simple geological maps.

ASSESSMENT:

Practical work: 15%
(Assessment of practical notebooks and other records of work)

Practical Examination: 20%
(2 hr practical examination on material covered in practical classes)

Written Examination: 65%
(2 hr End of Semester examination on lecture content)

LECTURES:

Lecture 1: Mineralogy. *(Assoc. Prof. J.F. Menuge)*
Chemistry, structure and properties of some principal rock forming minerals and some common ore minerals. Engineering effects of mineral properties.

Lecture 2: Igneous Rocks. *(Assoc. Prof. J.F. Menuge)*
Varieties of formation, occurrence and structures. Chemistry, mineralogy and a simple classification based on these. Engineering properties of igneous rocks.

Lecture 3: Sedimentary Rocks 1. *(Prof. P.D.W. Haughton)*
Definition of clastic rocks, composition of clasts and matrix/cement, parameters for simple classification, depositional environments and sedimentary structures. Engineering properties of clastic sedimentary rocks.

Lecture 4: Sedimentary Rocks 2. *(Prof. P.F. McDermott)*
Non-clastic rocks. Carbonates. Distribution of modern carbonate sediments and depositional settings; range of skeletal components through geological time; mineralogy of carbonates; skeletal and non-skeletal allochems; cements and lime mud matrix; Folk and Dunham classification schemes; ancient and modern ramps and platforms, calciturbidites; dolomite, flint and chert; use of limestone as building stone.

Lecture 5: Large-Scale structures, Oil and Gas. *(Dr L. Comas Bru)*
The structure of the Earth. Earthquakes and their effects. Folds and faults. Petroleum sources, reservoirs and caps. Oil and gas exploration, development and production. Engineering aspects.

Lecture 6: Metamorphic Rocks. *(Prof. J.S. Daly)*
Metamorphic processes, chemistry and fluids. Relationship of metamorphism to deformation, (small-scale) structures e.g. folds, cleavage, joints, veins. Simple classifications. Engineering properties of metamorphic rocks.

Lecture 7: Weathering. *(Dr L. Comas Bru)*
Weathering mechanisms. Resistance and response of rocks to weathering. Chemistry and products of weathering and engineering problems. Soil formation and characteristics. Engineering properties of soils.

Lecture 8: Rivers and Coasts. *(Dr L. Comas Bru)*
Fluvial and coastal environments, processes and features. Engineering problems and solutions in fluvial and coastal regions.

Lecture 9: Engineering in glaciated regions. *(Dr L. Comas Bru)*
Glacial environments, processes and features. Engineering problems and solutions in glacial regions.

Lecture 10: Hydrogeology. *(Prof. P.D.W. Haughton)*
Groundwater cycles, water tables, aquifers, water wells and yield tests. Groundwater related engineering projects.

Lecture 11: Impacts of Climate Change – adaptation and resiliance. *(Dr L. Comas Bru)*
Overview of climate change impacts and projections. Vulnerabilities of the energy, transport and water infrastructures systems to the effects of climate change. Interdependencies between systems. Engineers' role in the process of adaptation and resilience.

Lecture 12: Towards zero emissions. *(Dr L. Comas Bru)*
The 2015 Paris Agreement. Decarbonisation of the energy system in Ireland. Zero Emission Fossil fuel plants: Carbon Capture and Storage (CCS). Renewable energies. Energy efficiency and storage. Enhanced oil recovery. Carbon capture and storage (CCS): concept and challenges. Electricity storage.

Lecture 13: Rivers. *(Dr L. Comas Bru)*
Morphological classification or river channels and geological controls on water chemistry.

Lecture 14: Heavy metals. *(Dr L. Comas Bru)*
Geological and geochemical controls on the mobility of toxic heavy metals in the near-surface environment.

Lecture 15: Weathering processes. *(Dr L. Comas Bru)*
Weathering processes, soil solutions and surface water chemistry.

Lecture 16: Organic compounds. *(Dr L. Comas Bru)*
A geoscience perspective of organic contaminants in the environment

PRACTICAL CLASSES

Practical 1: Common minerals and igneous rocks. *(Senior Postgraduate Demonstrator)*
Description and identification of common rock-forming minerals and igneous rocks. Examination of a range of common economic minerals. Examination of a variety of textures and structures commonly exhibited by igneous rocks.

Practical 2: Sedimentary Rocks. *(Senior Postgraduate Demonstrator)*
Description and identification of five clastic and five carbonate sedimentary rocks. Examination and identification of sedimentary structures and textures and their significance.

Practical 3: Metamorphic Rocks. *(Senior Postgraduate Demonstrator)*
Description and identification of seven common metamorphic rocks. Examination and identification of common metamorphic textures.

Practical 4: Reactive Minerals. *(Senior Postgraduate Demonstrator)*
Physical, chemical and biological weathering processes.

Practical 5: Geological Maps I: Introduction to geological maps. *(Senior Postgraduate Demonstrator)*
Introduction to topographic and structure contours. Horizontal and dipping strata. Construction of simple cross-sections.

Practical 6: Geological Maps II: Three point problems. *(Senior Postgraduate Demonstrator)*
Construction of structure contours from three outcrop/borehole data points in dipping strata to obtain complete outcrop pattern.

Practical 7: Water chemistry. *(Dr L. Comas Bru)*
Express water chemistry analyses in units of meq/l and assess if they are complete and/or accurate. Use Piper diagrams to characterise groundwater types in five localities in Ireland. Interpret the data in terms of the geological environments from which the waters are derived.

Practical 8: Redox conditions in seasonally anoxic sediments. *(Dr L. Comas Bru)*
Use dissolved oxygen to estimate redox conditions for bottom water and pore water samples from Chesapeake Bay (US). Interpret data on the basis of redox controls on Fe and Mn.

Practical 9: Redox control son heavy metal mobility. *(Dr L. Comas Bru)*
Prediction of metal mobility (divalent metal cations) as a function of pH and Eh conditions inferred from redox couples in estuarine (high organic content) and in open marine (low organic content) sediment pore waters.

Practical 10: Groundwater contamination case study. *(Dr L. Comas Bru)*
Introduce the Bemidji contaminated site case study. Explain how the processes of contaminant plume degradation can be used to determine the presence of aerobic or anaerobic conditions. Estimate Eh values over time and use Eh-pH diagrams to estimate the likely behaviour of Fe-Mn hydroxides.

FIELD CLASSES:

Killiney *(Dr L. Comas Bru)*
Fieldtrip in the Killiney area. Relationship between topography and underlying geology. Leinster granite/schist contacts. Contact metamorphic effects. Shoreline processes. Glacial and fluvioglacial deposits. Coastal erosion.