GEOL 2570
Energy and Mineral Resources

Syllabus

Course description

The University of Manitoba *Undergraduate Calendar* describes this course as follows:

> An introduction to the geological factors and processes responsible for the origin, concentration and distribution of fuels, geothermal resources, metallic and nonmetallic minerals. Available by correspondence only. Not to be held with the former 007.255 or 007.256. Not for credit in a Major or Honours program in Geological Sciences. Prerequisite: one of GEOL 1340 or GEOL 1440 (or the former 007.123, 007.124, 007.132, 007.133, 007.134, or 007.144).

This course will provide an overview of the salient aspects of geology as it relates to the origin, exploration, and exploitation of energy and mineral resources. The topics of energy and mineral use, energy resources, and mineral resources are and will continue to be very important society concerns for most of this century. The degree of constraint exercised *today* by energy and mineral consumers, the actions taken *now* to explore and exploit new deposits of conventional energy and mineral resources, and the *present-day* rate of development and acceptance of unconventional resources will all be critical in dictating our future.

The energy resources that humans can adapt for their own use are those that result directly from the sun (solar), from the moon (lunar/tidal), from the earth (nuclear and geothermal), and indirectly from the sun in the form of fossil fuels, wind, water, or biota. In all cases the geological sciences are the key point of departure for the research, exploration, evaluation, and exploitation of these energy sources. The same is true of virtually every naturally occurring mineral resource.

The purpose of this course is to introduce you to and outline the basic geological factors that help to control the exploration, discovery, and exploitation of *selected* energy and mineral resources. Clearly in a one-term (13 weeks) introductory course such as this, we cannot hope to cover or even mention all of the many interesting facets of energy and mineral resources. In fact, most of this term you will examine our energy resources, with specific emphasis on the non-renewable sources—oil, natural gas, and coal. An important aspect of energy and mineral resources in the twenty-first century, namely the topics of environmental constraints and related concerns about exploration and exploitation, will **not** be covered significantly in this course, although considerable insight into these subjects is provided in your textbook. If you are interested in the geoenvironmental aspects of mineral and energy development, consider taking the sister course GEOL 2390, Environmental Geology.

Contacting your instructor

For information on contacting your instructor as well as other important information from your instructor see the Instructor Letter link in your course website.

Course goals

Why are we interested in energy and mineral resources? It is clear that the world community is dependent on a cheap and readily available supply of energy and certain minerals. Even as nonspecialists, we must be aware of how and where energy and minerals resources occur and how best to use all possible resources.

This course has three main goals:

- To provide you with a better understanding of the role that modern geoscience and geoscientists play in discovering and exploiting energy and mineral resources.
- To examine the details of the major types of energy resources and discuss how the most common types of conventional and
  unconventional energy resources were formed, how they are explored for, and how they are commercially extracted.

- To give you a sufficient understanding of the important decisions that must be made very soon by society. As we near the end of the "petroleum era," we (and our political leaders) will have to be much better informed about the technological options available in order to make acceptable social and political choices. Hard decisions are looming in the realm of mineral and, in particular, energy resources. These decisions will be made either by default and knee-jerk reactions or in full knowledge of the issues and limitations involved; the latter approach will depend on the level of our understanding.

As you systematically progress through the course material during the next thirteen weeks, you will:

- discover the relationship between resource geology and other branches of geology, such as sediment logy, stratigraphy, geochemistry, and structural geology, as well as other physical, chemical, biological, and social sciences;
- demonstrate how near to the end of the "petroleum era" we are in terms of energy resources;
- describe the geopolitics and repercussions of exponential growth in resource demand;
- identify the differences among conventional and unconventional energy and mineral resources;
- identify the differences between a resource, a resource base, and a reserve;
- describe the genesis of the major types of conventional energy resources and how these conventional resources are genetically related to many types of unconventional resources;
- outline how our understanding of basic geological principles and processes can assist in modern exploration and development of a prospect;
- explore the resource setting of Canada's mature and frontier regions;
- locate, on a regional and global basis, areas that appear to be most favourable to future conventional energy exploration and development;
- identify the major types of metallic and non-metallic mineral deposits;
- describe how well-explored and well-developed basins, such as those of western Canada and United States, can be further exploited using modern exploration and exploitation techniques;
- outline the genesis and geological setting of Canada's immense reserves of tar sands;
- show how the source characteristics of conventional and unconventional fossil fuels help control the resulting physical and chemical characteristics of the fuels;
- discover the complex relationship between organic and inorganic sedimentation, chemical setting of the depositional environment, the biological characteristics of the overlying water mass, the post depositional burial history of the sediment, and the resulting coal type and rank; and
- locate, both globally and regionally, classical mineral exploitation areas.

Course materials

Required texts

The following required materials are available for purchase from the University of Manitoba Bookstore. Please order your materials immediately, if you have not already done so. See your *Distance and Online Education Student Handbook* for instructions on how to order your materials.

Craig, J. R., Vaughan, D. J. and Skinner, B. J. (2011). *Earth Resources and the Environment*. 4th edition. Upper Saddle River, NJ: Pearson Prentice Hall.

This text is also available online as an E-textbook at CourseSmart http://www.coursesmart.com/

Bott, R. (2013). *Our Petroleum Challenge: Sustainability into the 21st Century.* 8th ed. Canadian Center for Energy Information. Available as a free pdf at http://www.capp.ca/publications-and-statistics/third-party-reports

Students should download the free supplementary booklet *Evolution of Canada's Oil and Gas Industry* at https://web.archive.org/web/20130228131045/http://www.centreforenergy.com/shopping/uploads/122.pdf.

Course content

Not so long ago, most people thought that the supply of energy and the availability of minerals were inexhaustible. Oil and gas were so cheap and plentiful that no one was concerned if these products were wasted. Even as recently as a decade ago, the reserves of coal in North America were considered to be so great that they would supply our demand for the next 300 years. This complacency about energy supplies in particular was, of course, abruptly and dramatically shattered with the "energy crises" of the 1970s. A world that had become used to cheap and plentiful supplies of oil was suddenly faced with the combination of a limited supply and a much higher cost for this now essential commodity.

You will spend most of your time in this course exploring and discovering the various geological factors that interact to form viable and commercial energy and mineral resources. Obviously no single, one-term course can fully cover the entire range of energy and mineral resources. The topics you will cover represent an overview of selected concepts and principles and will deal mainly with components of conventional and unconventional *energy* resources. As you read these notes and the textbook, and work your way through the practice exercises and review questions, you will find yourself sharpening your critical faculties. One of the primary goals of this course (and, indeed, any university course you take) is to allow you to distinguish the overstated and the untrue information that is often presented as fact in popular press from accurate information and reasonable interpretations.

Just a word of advice concerning the use of the course materials: these course notes are intended to supplement your textbook reading. Therefore, you should spend as much time (and probably more) reading and understanding the textbook assignments (both books) as you do on these course notes. There are many aspects of the course, particularly in the mineral resources unit, that are not covered in detail in these notes but are discussed at length in the textbook. Conversely, as with most textbooks, the Craig et al. volume deals with a number of topics and areas that we will **not** address in this course. This is particularly true of the very important areas of environmental impact of resource exploitation (e.g., chapter 4 in Craig et al.), and water and soil resources (chapters 11 and 12 in Craig et al.). Finally, you should have successfully completed one of the introductory "first-year" courses in geological sciences (e.g., Physical and Historical Geology, Earth and Planetary Science, Dynamic Earth, etc.). You will find that you will frequently be using the concepts, information, and techniques learned in the introductory course to better grasp the fundamentals of energy and mineral resources. The introductory chapters in Craig et al. will be useful in helping you review these important concepts from earlier Earth sciences courses.

This course is organized in such a way as to familiarize you first with the basic concepts of energy and mineral resources and reserve terminology, then with the geology of conventional energy resources, followed by unconventional sources, and finally mineral resources. Within this broad framework, specific sections will deal with the following topics (in order of coverage):

Module 1 Terminology and Basic Concepts

Unit 1 Energy Fundamentals

Unit 2 Energy and Mineral Resources: Sources and Terminology

Unit 3 Fundamentals of Energy and Mineral Crises

Module 2 Energy Resources

Unit 4 Oil and Natural Gas: Introduction, History, and Geochemistry

Unit 5 Drilling Technology

Unit 6 The Petroleum Source Rock

Unit 7 Petroleum Migration and the Petroleum Reservoir Rock

Unit 8 The Big Picture: The Sedimentary Basin and Basin Exploration Philosophy

Unit 9 Coal and Oil Shales

Unit 10 Canada's Energy Saviour: The Tar Sands and Heavy Oil

Module 3 Mineral Resources

Unit 11 Economic Geology, Iron, Alloy Metals, and Base Metals

Unit 12 Light Metals and Non-metallic Minerals

Evaluation and grading

Assignments

Four assignments and/or problems sets will be completed and evaluated during the term. Each assignment is worth 10% of your final mark. There is also a two-hour final exam worth 60% of your final mark. The exam will be written during the exam period. The format of this final examination will be provided to you about midway through the course.

Distribution of marks

Item	Percentage
1	10%
2	10%
3	10%
4	10%
Final exam	60%
Total	100%

Assignment due dates

Assignment	Sept. - Dec.	Jan. - Apr.	May - Aug.
Assignment 1	Sept. 30	Jan. 30	May 30
Assignment 2	Oct. 15	Feb. 14	June 15
Assignment 3	Oct. 30	Feb. 28	June 30
Assignment 4	Nov. 12	Mar. 12	July 12

Note: If you are unable to submit an assignment on time, contact your instructor well in advance of the due date, for we cannot guarantee that the instructor will accept late assignments.

The final exam will be written at the University of Manitoba (UM), Fort Garry campus or at an approved off-campus location. **Students needing to write at an off-campus location must declare a location by the specified deadline date** (see off-campus declaration and policy under Student Resources on course homepage). **Students writing at the UM Fort Garry campus do not need to declare an exam location.**

The Registrar's Office is responsible for the final exam schedule which is available approximately one month after the start of the course.

A word of caution about the assignments and the final examination

Some students find that they do very well on the assignments, but they do not do nearly as well on the final examination. While your grades on the assignments will give you some idea of how well you are mastering the material, they may not indicate how well you will do on the examination, because the examination is written under very different circumstances. Because the assignments are open-book, they do not require the amount of memorization that a closed-book examination requires nor are they limited to a specific time period. Some students have told us that, based on the high marks they received on the assignments, they were overconfident and underestimated the time and effort needed to prepare for the final examination.

Please keep all this in mind as you prepare for the examination. If your course has a sample exam or practice questions, use them to practice for the examination by setting a time limit and not having any books available. Pay careful attention to the description of the type of questions that will be on your final examination. Preparing for multiple-choice questions involves a different type of studying than preparing for essay questions. Do not underestimate the stress involved in writing a time-limited examination.

Grading scale

Letter grade	Percentage range	Description
A+	90-100	Exceptional
A	80-89	Excellent
B+	75-79	Very good
B	70-74	Good
C+	65-69	Satisfactory
C	60-64	Adequate
D	50-59	Marginal
F	49 and below	Failure

Please note: All final grades are subject to departmental review.

Plagiarism, cheating, and examination impersonation

You should acquaint yourself with the University's policy on plagiarism, cheating, and examination impersonation as detailed in the General Academic Regulations and Policy section of the University of Manitoba *Undergraduate Calendar*. Note: These policies are also located in your *Distance and Online Education Student Handbook* or you may refer to Student Affairs at http://www.umanitoba.ca/student.

Distance and Online Education (DE) Student Resources

In your course website there are links for the following:

- Contacting Distance and Online Education Staff
- Distance and Online Student Handbook
- Distance and Online Education Website

Acknowledgments

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Bill Last was born in Illinois and immigrated to Canada shortly after receiving his B.Sc. degree in Geology from the University of Wisconsin in 1971. After working four years as a petroleum exploration geologist with Shell Canada Ltd., he moved to Winnipeg where he completed his Ph.D. at the University of Manitoba. He worked as a research officer in the Tar Sands/Heavy Oil Division of the Alberta Geological Survey until 1980, when he joined the faculty at the University of Manitoba in the Department of Geological Sciences.

Professor Last's main research interests are in the fields of sediment logy, petroleum geology, and environmental geology. With over 150 publications to his credit, he has maintained a long research involvement in western Canada. His research efforts in the area of energy resources are currently directed mainly at organic geochemistry and sediment logy of Cretaceous oil shale in western Canada and porosity genesis and development in Mesozoic oil reservoirs in Manitoba. He is editor-in-chief of *Journal of Pale limnology*; associate editor of *Sedimentary Geology*, *International Journal of Salt Lake Research,* and *Prairie Forum* and past associate editor of *Bulletin of Canadian Petroleum Geology*. He has written or edited six books on pale limnology and geolimnology and is the Series Co-Editor of the book series *Developments in Paleoenvironmental Research*. He teaches undergraduate courses in petroleum geology, environmental geology, well log analysis, sediment logy, energy resources, and basin analysis. His graduate course offerings include advanced sediment logy, petroleum geochemistry, and evaporate sediment logy and geochemistry.

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