

GEOL 2570 Energy and Mineral Resources

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Bill Last was born in Illinois and emigrated 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 sedimentology, 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 sedimentology of Cretaceous oil shales in western Canada, and porosity genesis and development in Mesozoic oil reservoirs in Manitoba. He is editor-in-chief of *Journal of Paleolimnology*, 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 paleolimnology 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, sedimentology, energy resources, and basin analysis. His graduate course offerings include advanced sedimentology, petroleum geochemistry, and evaporite sedimentology and geochemistry.

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Introduction and outline of the Course

Unit 1 Terminology and Basic Concepts

Part 1 Energy Fundamentals

Part 2 Energy and Mineral Resources: Sources and Terminology

Part 3 Fundamentals of Energy and Mineral Crises

Unit 2 Energy Resources

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

Assignment 1

Part 5 Drilling Technology

Part 6 The Petroleum Source Rock

Part 7 Petroleum Migration and the Petroleum Reservoir Rock

Assignment 2

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

Part 9 Coal and Oil Shales

Assignment 3

Part 10 The Athabasca Tar Sands: Canada's Energy Savior

Unit 3 Mineral Resources

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

Assignment 4

Part 12 Light Metals and Nonmetallic Minerals

Course description

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 which humans can adapt for their own use are those which 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 which 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 spend examining 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 21st 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 to 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 7.239 Environmental Geology.

Course Materials

Required Texts

Craig, J.R., Vaughan, D.J. and Skinner, B. J., 2001. *Resources of the Earth: Origin, Use, and Environmental Impact*. Prentice Hall Inc., Upper Saddle River, New Jersey, 520 pp.

Bott, R., 1999. *Our Petroleum Challenge* (6th edition). Petroleum Communication Foundation. 101 pp.

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 1970's. 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 be spending 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 over the next thirteen weeks 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. I strongly suggest that you spend every bit as much time (and probably even 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 part, 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, I will assume you 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 lessons will deal with the following topics (in order of coverage):

Your Course at a Glance

<p>Week 1 Energy fundamentals</p>	<p>Week 2 Energy and mineral resources: sources and terminology</p>	<p>Week 3 Fundamental of energy and mineral "crises"</p>
<p>Week 4 Oil and natural gas: introduction, history, and geochemistry Assignment 1 due</p>	<p>Week 5 Drilling Technology</p>	<p>Week 6 The petroleum source rock Assignment 2 due</p>
<p>Week 7 Petroleum migration and the petroleum reservoir rock</p>	<p>Week 8 The big picture: the sedimentary basin and basin exploration philosophy Assignment 3 due</p>	<p>Week 9 Coal, Oil Shales and Tar Sands</p>
<p>Week 10 Economic geology, iron, alloy metals, and base metals Assignment 4 due</p>	<p>Week 11 Economic geology, iron, alloy metals, and base metals (continued)</p>	<p>Week 12 Light metals, nonmetallic, and industrial mineral resources</p>
<p>Week 13 Light metals, nonmetallic, and industrial mineral resources (continued)</p>		