Unit 5
Earth Resources: Real-Life Applications
Suggested Time: 20 Hours

Unit Overview

Introduction

This unit will introduce students to minerals that are of economic value. They will come to understand the factors that allow minerals in the different types of deposits to be profitable. Students will know that open pit and underground mining are the two ways of extracting the economic minerals from the ground. Students will briefly be introduced to the various exploration and processing techniques.

Students will also be introduced to energy resources, for example, petroleum. The origin of pertroleum, process of formation, migration and accumulation, extraction and refining techniques will be covered in this unit. Finally, students will consider the notion of sustainable development in relation to existing pertroleum deposits.

Focus and Context

The focus of this unit is to introduce students to economic minerals and energy resources such as petroleum. Both will be explored from formation through to refining, and considered based on the idea of sustainability.

Science Curriculum Links

Students have been previously introduced to minerals and rocks in grade 4 Science. In addition, the properties and features of Earth's crust were explored in grade 7 Science. The notion of sustainability is given treatment in Science 1206 and Environmental Science 3205. Refining techniques relating to petroleum is touched on in Chemistry 2202 in Unit 3 - Organic Chemistry. Refining techniques relating to economic minerals is touched on in Chemistry 3202 in Unit 4 - Electrochemistry.

Curriculum Outcomes

STSE

Students will be expected to

Relationships Between Science and Technology

116-2 analyse and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology

116-4 compile and organize data for the purpose of interpretation and better understanding of exploration techniques

Social and Environmental Contexts of Science and Technology

118-2 analyse from a variety of perspectives, the risks and benefits to society and the environment of applying scientific knowledge, or introducing a particular technology

118-10 propose courses of action on social issues related to science and technology, taking into account an array of perspectives, including that of sustainability

Skills

Students will be expected to

Performing and Recording

213-5 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data

Analyzing and Interpreting

214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs and scatter plots

214-5 interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables

214-10 identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty

214-11 provide a statement that addresses the problem or answers the question investigate in light of the link betweenb data and the conclusion

214-12 explain how data support or refute the hypothesis or prediction

214-18 identify and evaluate potential applications of findings

Communication and Teamwork

215-3 synthesize information from multiple sources or from complex and lengthy texts and make inferences based on this information

Knowledge

Students will be expected to

330-8 describe the importance of minerals and mineral exploration at the local, provincial, national and global levels

330-9 describe the evolution of extraction and the use of several resources obtained from the lithosphere

330-10 describe the processes and techniques involved in processing ore materials

330-11 identify factors involved in developing Earth's resources in a sustainable manner

332-3 describe interations among Earth's spheres

Economic Minerals

Outcomes	Elaborations—Strategies for Learning and Teaching
Students will be expected to	
• describe the importance of minerals and mineral exploration at the local, provincial, national and global levels (330-8)	
- define economic minerals - define ore	Students should know that economic minerals are minerals that can be extracted, processed, and marketed at a profit. Various factors determine if a mineral is an economic mineral. These factors include: interest in the mineral; size of the deposit; mineral concentration; mineral depth below Earth's surface; and market value.
- describe the different types of economic mineral deposits. Include: (i) magmatic (layered and disseminated) (ii) hydrothermal (vein deposits) (iii) placer (iv) secondary enrichment (sedimentation) (v) metamorphism	Students should be able to draw well-labelled diagrams to assist in explaining how each type of deposit forms. The student text contains detailed illustrations to assist with meeting this outcome (Figures 21.5, 21.9, 21.15, 21.17 and 21.18).

Economic Minerals

Suggested Assessment Strategies

Paper and Pencil

- Students could be given information about a certain mineral deposit and evaluate verbally, or in writing, its economic viability.
- Construct illustrations of the different types of economic mineral deposits and attempt to explain their development to the class.

Interview

- A student could sit at a board room table and attempt to convince the board of directors of a mining company that his project should be funded to go into production. The board of directors would have to formulate questions in advance to probe the economic viability of the property.

Journal

- Students could imagine that they are a particular type of economic mineral. They will document their journey to becoming a certain type of economic mineral deposit. Students should be encouraged to be as creative as possible while clearly outlining the relevant science involved in the development process.

Performance

- Create a poster showing the distribution of common mineral deposits similar to Fig. 21.3 of the student text.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST p. 583

ST pp. 583-597

Conventions used in Resources Column

ST = Student Text

Economic Minerals -- Exploration, Extraction and Processing

Outcomes	Elaborations—Strategies for Learning and Teaching
Students will be expected to	
• describe the evolution of extraction and the use of several resources obtained from the lithosphere (330-9)	
- identify the types of mines. Include: (i) open pit (ii) underground	Students should know that extraction from open pit mines occurs on the Earth's surface. As a result, the potential exists for considerable destruction to both surface soil and vegetation, and the release of significant amounts of mine dust. Open pit mines are usually accessed by surface terracing, thereby allowing technological equipment to follow the shape of the deposit. Open pit mines are safer and less costly. Students should know that extraction beneath the Earth's surface takes place in underground mines. Underground mines result in less damage to surface soil and vegetation. Additionally, mine dust levels in the atmosphere are less. Underground mines are usually accessed through shafts and/or elevators and are more costly and less safe. Underground mines are usually chosen if the deposit is located at a significant depth beneath Earth's surface but also depends on the shape of the deposit.
- identify exploration techniques. Include: (i) seismic records (ii) remote sensing (iii) prospecting (iv) observing drill cores (v) cross-sections (vi) geological mapping (vii) magnetic survey (viii) gravity survey (ix) geochemistry	Teachers should only list these exploration techniques for the purpose of student awareness. Some techniqes will be covered extensively in the core laboratories. The core lab entitled Geologic Mapping and Cross-Sctions will cover seismic records, observing drill cores, cross-sections and geological mapping. The core lab entitled Seismic Reflection Imaging will cover seismic records and cross sections.

Economic Minerals -- Exploration, Extraction and Processing

Suggested Assessment Strategies

Performance

- On a map, indicate the location of current and former mines in Newfoundland and Labrador.
- Students could enter into a debate relating to safety issues in an underground mine. Those representing the workers will express concerns related to safe working conditions. Those advocating for the mine will argue that safety concerns can be addressed.

Presentation

- Research the types of mines, collect images and assemble information and present your findings as a PowerPoint, web page etc.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 444-447, 419

Economic Minerals -- Exploration, Extraction and Processing (continued)

Outcomes

Students will be expected to

- analyse and describe examples where technologies were developed based on scientific understanding (116-4)
- compile and organize data using appropriate formats and data treatments to facilitate interpretation of the data (213-5)
- compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs and scatter plots (214-3)
- interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables (214-5)
- identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty (214-10)
- provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion (214-11)
- explain how data support or refute the hypotheses or prediction (214-12)
- identify and evaluate potential applications of findings (214-18)

Elaborations—Strategies for Learning and Teaching

Core Laboratory Activity: Geologic Mapping and Cross-Sections

The laboratory outcomes 116-4, 213-5, 214-3, 214-5, 214-11 and 330-9 are addressed, in whole or in part, by completing **CORE LAB #6**: “Geologic Mapping and Cross-Sections”.

Core Laboratory Activity: Seismic Reflection Imaging

The laboratory outcomes 116-4, 214-5, 214-10, 214-12, 214-18 and 330-9 are addressed, in whole or in part, by completing **CORE LAB #7**: “Seismic Reflection Imaging”.

Economic Minerals -- Exploration, Extraction and Processing (continued)

Suggested Assessment Strategies

Performance

- Using a rubric or checklist, assess students ability to compile and display information in a cross-section.
- Using a rubric or checklist, assess student ability to interpret seismic reflection data.

Presentation

- After completing CORE LAB #6, create a multi-media presentation for a gold mining company indicating your findings and recommendations for future exploration or processing.

Interview

- After completing CORE LAB #6, select several sites outside the existing drill sites and ask students to indicate whether they would prospect for gold at those sites and to explain their reasoning. Using a rubric, assess their ability to apply their findings.
- After completing CORE LAB #7, use a rubric or checklist to assess student ability to interpret seismic reflection imaging and identify locations of possible oil traps.

Paper and Pencil

- Identify possible sources of error or uncertainty in measurement in the construction of the cross-section.
- Illustrate and explain how seismic reflection imaging works.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

Core Lab #6: "Geologic Mapping and Cross -Sections", Appendix B

Core Lab #7: "Seismic Reflection Imaging", Appendix B

Economic Minerals -- Exploration, Extraction and Processing (continued)

Outcomes

Students will be expected to

- describe the processes and techniques involved in processing ore materials (330-10)
  - describe techniques for processing ore deposits. Include:
    - (i) floatation
    - (ii) gravity separation
    - (iii) heap leaching
    - (iv) pyromet
    - (v) hydromet

Elaborations—Strategies for Learning and Teaching

Teachers should give very brief treatment to each of these processing techniques.

Floatation involves mixing grounded ore with water, oil, and chemicals. The grounded ore becomes suspended in the water and is subjected to bubbles of air due to the presence of chemicals. This causes the minerals and/or elements of value to float to the top where they can be scraped off.

Gravity separation involves feeding grounded ore into a pulsating body of water, which serves to settle out the heavy material while floating away the light material. If the heavy material is what one wishes to retain, then it is taken from the bottom. If the light material is what one wishes to retain, then it is taken from the top.

Heap leaching commences by placing the grounded ore as a layer onto impermeable material. The “heap” of material is irrigated with a liquid, which percolates down through dissolving away the valuable minerals and/or elements.

Pyromet involves using heat to separate the minerals and/or elements of value from the ore. Heating separates the materials by density and the desired minerals and/or elements can be removed.

Hydromet is a chemical method that involves oxidation and acid leaching to separate out the desired minerals and/or elements.

Economic Minerals -- Exploration, Extraction and Processing (continued)

Suggested Assessment Strategies

Performance

- Students could take part in a quiz-quiz trade activity to identify exploration and processing techniques.

Presentation

- Choose an exploration or processing technique. Research it and create a class presentation.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

Energy Resources -- Petroleum Formation

Outcomes	Elaborations—Strategies for Learning and Teaching
Students will be expected to	
• describe the processes and techniques involved in extracting and refining hydrocarbons (330-10)	
- define petroleum - define crude oil - define hydrocarbons	Students should know that petroleum is a naturally occurring flammable liquid that is found in geologic formations below Earth's surface and consists of a mixture of hydrocarbons. Petroleum can also be referred to as crude oil; however, both crude oil and natural gas are generally accepted under the term petroleum. Students should know that crude oil is a mixture of hydrocarbons that exist in a liquid state in underground reservoirs and remain in a liquid state once subjected to atmospheric conditions. Students should know that hydrocarbons are chemical compounds that involve hydrogen and carbon atoms. Examples include: butane, propane, ethane, and methane (i.e. wet gases). Note that if predominantly methane exists, then it is referred to as dry gas.
- describe the origin and the process of formation of petroleum. Include: (i) organic matter (ii) preservation potential	Students should understand that microscopic marine animals (zooplankton) and plants (phytoplankton) are the main sources of organic matter in the production of petroleum. Examples of such microscopic species are diatoms, foraminifera, radiolarian, and benthic algae. The abundance of organic matter is determined by the amount of light, water depth, latitude, water temperature, water turbidity, and the abundance of nutrients preferred by plants (e.g. phosphates and nitrates). Students should know that preservation potential means the conditions that favour the preservation of organic matter. The two most important conditions are: 1. anaerobic conditions (low oxygen content) and; 2. rapid sedimentation by fine-grained material. Anaerobic conditions can exist in swamp and lagoon environments. Examples of fine-grained material include mud-size, silt-size, and sand-size particles.
• describe interactions among Earth's spheres (332-3)	This is another example of the interconnectedness of the spheres and thus is a direct reference to a systems approach.

Energy Resources -- Petroleum Formation

Suggested Assessment Strategies

Journal

- Outline your understanding of pertroleum, crude oil and hydrocarbons.
- Discuss the role of interrlationships amoung spheres in relation to petroleum formation.

Performance

- Construct a poster or collage demonstrating the interation of the spheres in relation to the formation of petroleum.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST p. 602

ST pp. 602-603

Energy Resources -- Petroleum Formation (continued)

Outcomes	Elaborations—Strategies for Learning and Teaching
Students will be expected to	
• describe the processes and techniques involved in extracting and refining hydrocarbons (330-10)	
- define kerogen	Students should know that kerogen is a mixture of organic matter in sediments from which petroleum is released.
- identify the three phases in the evolution of organic matter to petroleum. Include: (i) diagenesis (ii) catagenesis (iii) metagenesis	Teachers should limit treatment of this outcome to the information provided below as these terms are not addressed in the student textbook. *Diagenesis:* During diagenesis there is shallow burial of organic matter at near normal temperature and pressure as well as some decay. Methane, carbon dioxide, and water are released leaving behind the complex hydrocarbon called kerogen. *Catagenesis:* Deeper burial results in increased temperature and pressure. Petroleum is released from the kerogen – first oil is released and second gas is released. *Metagenesis:* The metagenesis phase involves even higher temperature and pressure verging on metamorphism. The only hydrocarbon that is released during this phase is methane. At this point the petroleum has matured enough to migrate to traps.
- describe the components involved in the formation of petroleum traps. Include: (i) source rock (ii) reservoir rock (iii) cap rock	Students should know that source rocks must contain an abundance of organic matter. Petroleum is often created and released from the source rock while lithification is occurring. Examples of source rocks are shale and limestone. Students should know that a reservoir rock requires high porosity and high permeability since it is the rock which petroleum moves through and is stored in. Note that porosity is the volume of pore spaces or holes between sediment grains and that permeability is the interconnectiveness of the pores, thereby allowing the movement of the petroleum. The porosity of a material is influenced by particle shape and size and the degree of sediment sorting. Large, rounded, well-sorted particles offer higher porosity, particularly if the amount of cement between them is limited. Usually, the higher the porosity and the larger the pore spaces, the higher the permeability. Examples of reservoir rocks are sandstone, dolomite, and conglomerate since they have both high porosity and permeability.

Energy Resources -- Petroleum Formation (continued)

Suggested Assessment Strategies

Presentation

- Create a presentation outlining the formation of petroleum, including the three phases in the evolution of organic matter to petroleum.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 602-603

ST pp. 602-603

ST pp. 603-604

Energy Resources -- Petroleum Formation (continued)

Outcomes	Elaborations—Strategies for Learning and Teaching
Students will be expected to	
• describe the processes and techniques involved in extracting and refining hydrocarbons (330-10) **(continued)**	
- describe the components involved in the formation of petroleum traps. Include: (i) source rock (ii) reservoir rock (iii) cap rock	Students should know that a cap rock is an impermeable rock that serves to trap petroleum from either escaping to the surface or spreading throughout the rock as opposed to being confined. Students should realize that petroleum exists within reservoir rock between sediment as opposed to being confined as a whole volume of liquid petroleum. “There are no ponds of petroleum in the ground”. Students should realize that properties of the subsurface could be better understood using wire-line logging, which uses various technological tools depending on the properties (e.g., porosity, permeability, rock types, presence of water, oil, and gas) desired to be understood.
• analyse and describe examples where scientific understanding was enhanced or revised as a result of the invention of technology (116-2) • interpret patterns and trends in data, and infer of calculate linear and non-linear relationships among variables (214-5) • explain how data support or refute the hypothesis or prediction (214-12) • synthesize information from multiple sources or from complex and lengthy texts and make inferences based on this information (215-3)	The Core STSE component of this unit incorporates a broad range of outcomes. More specifically, it addresses, in whole or in part, outcomes 116-2, 214-5, 214-12, 215-3, and 330-10. The STSE component, “Well Logging”, can be found in Appendix A.

Energy Resources -- Petroleum Formation (continued)

Suggested Assessment Strategies

Paper and Pencil

- Explain how well-logging increases our understanding of the subsurface.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 603-604

Appendix A

Energy Resources -- Petroleum Formation (continued)

Outcomes	Elaborations—Strategies for Learning and Teaching
Students will be expected to	
• describe the processes and techniques involved in extracting and refining hydrocarbons (330-10)	
- describe the types of petroleum traps. Include: (i) anticline trap (ii) fault trap (iii) salt dome trap (iv) stratigraphic trap	Teachers should realize that there are three types of stratigraphic traps, but treatment should be limited to the limestone reef type. Students should be able to draw well-labelled diagrams of each of the petroleum traps and be able to simply identify each in diagrams. The following components are important in relation to each type of petroleum trap: source rock; reservoir rock; cap rock; as well as the structure of petroleum (i.e. oil and natural gas) in the trap.
- describe the distribution of petroleum in a reservoir	Students should realize that the physical property density is used for the purpose of distributing petroleum in a reservoir. Water is denser than oil and oil is denser than gas. Therefore, when drilling into a petroleum trap, gas is encountered first followed by oil and then water. Note that some reservoirs may have all three components, whereas some reservoirs may only have two components or one component.

Energy Resources -- Petroleum Formation (continued)

Suggested Assessment Strategies

Performance

- Create a poster showing the various ways in which petroleum is trapped, similar to Fig. 21.24 on page 604 of the course textbook.
- Students could be asked to construct a specific trap using plasticine. Students would have to include the source, reservoir, and cap rock. They could even be creative and use sand as the reservoir rock and inject it with water and then vegetable oil. This would show how oil migrates in a petroleum trap.
- Add water and vegetable oil to a beaker and observe. What happens? Why?

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 603-604

ST pp. 605-609

Energy Resources -- Petroleum Extraction and Refining

Outcomes

Students will be expected to

- describe the processes and techniques involved in extracting and refining hydrocarbons (330-10)

(continued)

- describe the two main means of extracting petroleum from Earth, include:
  - (i) drilling
  - (ii) surface extraction (open pit mining)

Elaborations—Strategies for Learning and Teaching

Students should realize that drilling can take place on land, ice, or water. It is important for students to realize that a proportion of petroleum in a trap is under natural pressure and therefore, will be released naturally when tapped by a drill. There will be another proportion of petroleum that will remain in the trap due to loss of pressure.

Students could think about a bottle of soda that has a high gas content that is under some pressure due to extreme shaking. If the bottle was opened, a proportion of the soda will be released naturally from the bottle. The soda remaining in the bottle will not be under pressure and other techniques (e.g. pumping in water and filling the reservoir) will be required to get the soda from the trap.

The Alberta oil sands, also called tar sands, are an example of petroleum being extracted directly from the surface (open-pit mining). Because the petroleum migrated towards the surface and volatiles (e.g. water) were lost to the atmosphere, the petroleum experienced increasing viscosity (i.e. thickness), thereby preventing it from spreading out and/or dissipating. The reservoir consisted of loose (unconsolidated) sediment that therefore, exhibited high porosity and permeability.

In some instances, steam is injected directly into the tar sands to mobilize the hydrocarbons, which are then recovered from pumps much like conventional crude oil. Discussion The use of steam extraction technology in Fort McMurray's Athabasca oil sands is an excellent STSE opportunity.

Energy Resources -- Petroleum Extraction and Refining

Suggested Assessment Strategies

Performance

- Research an existing pertoleum deposit and identify the method of extraction. For example, Hibernia crude is extracted through drilled wells and require water and gas to force the oil out of the reservoir.

Paper and Pencil

- Outline the geological conditions that allowed for the formation of petroleum near Earth's surface near Fort McMurray. Information on the extraction process could also be included. Note: Students would require time to conduct research on this topic prior to writing the entry.

Journal

- Pretend you are a droplet of crude oil. Document your journey through the refining process, ending in a gasoline powered engine.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 605-609, 614

Energy Resources -- Petroleum Extraction and Refining (continued)

Outcomes

Students will be expected to

- describe the processes and techniques involved in extracting and refining hydrocarbons (330-10)

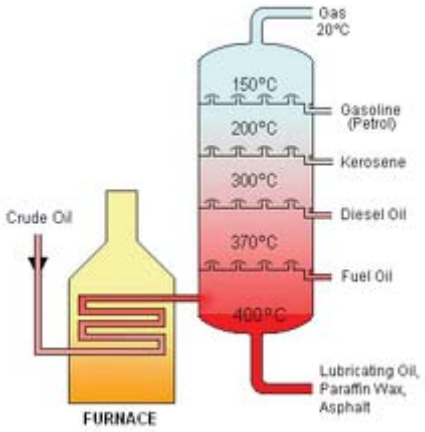
(continued)

- describe the methods of refining petroleum. Include:
  - (i) distillation
  - (ii) cracking
  - (iii) reforming

Elaborations—Strategies for Learning and Teaching

Teachers should give very brief treatment to this outcome.

Once petroleum is extracted from the sub-surface and is de-salted and de-watered, it enters a distillation column. Heat is added to the column to separate the petroleum into fractions based on boiling points (cracking). The bottom fraction is removed to another column for further separation. Students should be shown an image of a distillation column similar to the one below. Students should observe some "fractions" in the image, which could include: asphalt; paraffin wax; lubricants; jet fuel; diesel; kerosene, and gasoline from the graphic.



Source: http://upload.wikimedia.org/wikipedia/commons/thumb/3/3c/Crude_Oil_Distillation.png/225px-Crude_Oil_Distillation.png

Reforming involves heat, pressure, and the use of catalysts (speed up reaction rates) to reform different hydrocarbon compounds.

Energy Resources -- Petroleum Extraction and Refining (continued)

Suggested Assessment Strategies

Presentation

- Students could be given a list of hydrocarbons that are used in our daily lives. They would have to research the temperatures (boiling points) at which these hydrocarbons were separated in a distillation column.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

Energy Resources -- Moving Towards a Sustainable Future

Outcomes

Students will be expected to

- analyse from a variety of perspectives, the risks and benefits to society and the environment of applying scientific knowledge, or introducing a particular technology (118-2)
- identify factors involved in developing Earth's resources in a sustainable manner (330-11)
- propose courses of action on social issues related to science and technology, taking into account and array of perspectives, including that of sustainability (118-10)
  - describe sustainable development in relation to the use of Earth resources
  - identify and describe core components involved in the sustainable development of Earth resources

Elaborations—Strategies for Learning and Teaching

Students should brainstorm what is meant by sustainable development and how it relates to extracting and processing Earth resources. Students should consider economics, the environment, and any political/social/cultural aspects that relate to extraction of resources in one of the examples lsited below. Teachers could have students think about Newfoundland and Labrador's offshore petroleum deposits (e.g., Hibernia, Hebron, Terra Nova, White Rose, and Avalon Ben Nevis) in relation to sustainability. Students could also explore the oil sands near Fort McMurray and consider whether or not sustainable practices are being used. Teachers could also have students explore Newfoundland and Labrador mines and/or mineral deposits (e.g. Voisey's Bay and the Long Harbour processing facility) in relation to sustainability. Students should realize that the decisions we make today will impact our future.

Students should brainstorm some fo the "sustainable factors" that relate to the examples being discussed. It is important to note that such factors are dependant on the example being discussed.

Energy Resources -- Moving Towards a Sustainable Future

Suggested Assessment Strategies

Journal

- Write a personal response outlining your feelings, attitudes and beliefs towards the development of a Newfoundland offshore oil field or the development of Alberta's oil sands. Explore the notion of sustainability and consider the degree to which it is being exercised in either of the above examples.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

CBC Documentary: The Nature of Things with David Suzuki, "Tipping Point: The Age of the Oil Sands"