GEOLOGIC JOURNEY

TEACHER RESOURCE GUIDE

THE GREAT LAKES • THE ROCKIES • THE CANADIAN SHIELD
THE APPALACHIANS • THE ATLANTIC COAST

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GEOLOGIC JOURNEY

Teacher Resource Guide

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Using the *Geologic Journey* Teacher Resource Guide

Each of the five episodes in the *Geologic Journey* series focuses on one area of Canada. Each of the episodes has been divided into a number of chapters. This allows the classroom teacher to use part (or parts) of the episode with a specific focus. Alternatively, with ample preparation and discussion about the keywords and concepts in the episode, classes may view the entire episode for an overview of the area. The educational *Geologic Journey* DVDs are chaptered to match the chapters in the guide activities. Users of the VHS videos of the series will need to locate the chapter start points using the running-time references indicated at the beginning of each unit.

The Great Lakes

Chapter 1: Niagara Falls

Chapter 2: The Legacy of the Grenville Mountains

Chapter 3: Salt Mines: An Underground Laboratory

Chapter 4: Ice Sheets and Glaciers

The Rockies

Chapter 1: Plate Tectonics: Formidable Forces

Chapter 2: From Sea to Sky: Folding and Thrusting

Chapter 3: Rocky Mountain Resources and Land Use

Chapter 4: Erosion on a Grand Scale

The Canadian Shield

Chapter 1: Meet the Torngats

Chapter 2: The Geology of Human Activity

Chapter 3: The Search for Gold

Chapter 4: The Sudbury Basin and Manicouagan

Chapter 5: Diamonds: The New Resource

The Appalachians

Chapter 1: Coal: Getting It Out of the Ground

Chapter 2: Colliding Plates, Making Mountains

Chapter 3: New Technologies, New Theories

Chapter 4: Want to Be an Earth Scientist?

Chapter 5: Earthquake Hazard

The Atlantic Coast

Chapter 1: Tales from the Ocean Floor

Chapter 2: Experiment in the Precambrian Oceans

Chapter 3: Mass Extinction . . . and Something New Out of Africa

Introduction

Using This Guide

This guide will assist you in getting the most out of the *Geologic Journey* series. Each episode—both in the video and the units in this guide—has its own "character." Consistency of presentation in this guide will help you to plan your use of each of the episodes.

- Each unit in this Teacher Resource Guide is divided into chapters, and student questions are formed around the activities associated with each chapter. The format for each chapter generally includes an introduction, the keywords that will be encountered, the curriculum objectives covered by the student questions, materials required, student activities, extension activities, and suggestions for assessment.
- Questions are ordered specifically to lead students through three modes: activating their knowledge base, acquiring new knowledge (usually from the video), and applying their knowledge to new situations.
- Generally, questions are asked in *student* terms. Rather than saying "ask the students to," the questions are worded in terms that relate directly to the students themselves. This will facilitate your use of the questions. They can be distributed ahead of time, modified to develop "blackline masters," or formatted into assessment instruments.
- All of the questions are numbered in the same three-digit format. For example, questions related to *The Great Lakes* (the first episode in the series, and the first unit in this guide) all begin with "1"; those on *The Canadian Shield* begin with "3." For your convenience, each episode has been divided into chapters, and the second number in the sequence relates to the chapter within the episode. Each chapter has a focus around which a number of questions are asked. This is reflected in the third number. For example, question 2.3.5 would be the fifth question in the episode on the Rockies, and would be found in activity #3 – Rocky Mountain Resources and Land Use.
- The running times (i.e., lengths) of the chapters are provided on the Introduction page of each unit.
- Figures (maps, diagrams, charts) and Images (screen grabs from the video) are indicated in sequence for each episode/unit. Figures are provided in this guide. Figures and Images can be downloaded from the *Geologic Journey* Web site at www.cbc.ca/geologic/teacher.html.
- The map of North America on page ix provides a context for the locations and land features that figure predominantly in the *Geologic Journey* series. The map is also available at www.cbc.ca/geologic/teacher.html.

Introduction

The concepts introduced in the video and the treatment of these concepts in the Teacher Resource Guide vary in difficulty. The following chart summarizes the chapters and the grades to which the chapters apply.

As with all student materials, the suggested grade level is just as is stated—a proposed level of difficulty. Teachers will apply their own knowledge of the level of student understanding about the topic to make pedagogical decisions concerning use of the video content and this guide.

Episode	Chapter	Grade			
		9	10	11	12
The Great Lakes	Niagara Falls	•	•	•	
	The Legacy of the Grenville Mountains		•	•	•
	Salt Mines: An Underground Legacy	•	•	•	•
	Ice Sheets and Glaciers	•	•	•	
The Rockies	Plate Tectonics: Formidable Forces		•	•	•
	From Sea to Sky: Folding and Thrusting	•	•	•	•
	Rocky Mountain Resources and Land Use		•	•	•
	Erosion on a Grand Scale		•	•	•
The Canadian Shield	Meet the Torngats		•	•	•
	The Geology of Human Activity		•	•	•
	The Search for Gold	•	•	•	
	The Sudbury Basin and Manicouagan		•	•	•
	Diamonds: The New Resource	•	•	•	•
The Appalachians	Coal: Getting It Out of the Ground	•	•	•	•
	Colliding Plates, Making Mountains		•	•	•
	New Technologies, New Theories		•	•	•
	Want to Be an Earth Scientist?	•	•	•	•
	Earthquake Hazard		•	•	•
The Atlantic Coast	Tales from the Ocean Floor		•	•	•
	Experiment in the Precambrian Oceans		•	•	•
	Mass Extinction . . . and Something New Out of Africa		•	•	•

Introduction

Although the focus for the *Geologic Journey* series is the photography and the commentary, teachers may wish to match up a particular teaching method or tool. The following chart lists these and the appropriate activities in the Teacher Resource Guide. Alternatively, teachers can use the teaching method/tool from one area and adapt it to a different area. For example, the model for concept mapping could be applied to a number of different areas merely by changing the key concept.

Role-Playing/Decision-Making	Great Lakes – 1
Image Analysis	Great Lakes – 2, Rockies – 4, Atlantic Coast – 1, 2
Research Using the Internet	Great Lakes – 2, Atlantic Coast – 1, 2, 3
Research Reporting	Great Lakes – 3, Rockies – 4, Canadian Shield – 3, 5, Appalachians – 1, 2
Concept Mapping	Great Lakes – 4, Atlantic Coast – 1, 2
Preparing an Audio-Visual Presentation	Great Lakes – 4
Developing Models	Rockies – 1, 2, 4
Sketching	Rockies – 2
Debating	Rockies – 3, Shield – 5, Appalachians – 1
K-W-L Charting	Shield – 1, Atlantic Coast – 1
Mapping	Shield – 1
Issue Analysis	Shield – 4
Analysis of Maps and Diagrams	Appalachians – 1, 2
Developing Organizers	Appalachians – 3, Atlantic Coast – 3
Testing Hypotheses	Appalachians – 3, 4
Newspaper-Article Writing	Atlantic Coast – 1
“Think-Pair-Share”	Atlantic Coast – 2
Jigsaw	Atlantic Coast – 2

Geologic time is a constant in all of the episodes. This is often a confusing element for students, particularly at the younger grades. To assist with this aspect, a geologic time chart is provided in association with the fourth episode—The Appalachians (page 4-9). It is duplicated on page vii in a different format and includes the major events and times mentioned in all five episodes of the series.

Introduction

Geologic Timeline

Episode	Time BP	Event
Great Lakes	12 000	Niagara Falls starts to wear back Escarpment
Great Lakes	14 000	Ice starts to melt from most recent glaciation
Great Lakes	after 2 000 000	Glacial erosion of Great Lakes basins
Great Lakes	2 000 000	Most recent glaciation periods starts
Rockies	58 000 000	Intrusion into the old Precambrian rock of the Rockies near Boulder, Colorado
Canadian Shield	65 000 000	Dinosaurs
Rockies	180 000 000	Beginning of the formation of the Rockies
Atlantic Coast	200 000 000	Break-up of Pangaea, Atlantic Ocean opens, major volcanic activity in the southern U.S.
Appalachians	300 000 000	Formation of Appalachians
Rockies	350 000 000	Formation of Pangaea supercontinent and rocks that formed the Rockies laid down in shallow seas
Great Lakes	400 000 000	Exposure of roots of Grenville Mountains, North America located at equator, Michigan Basin formed
Appalachians	400 000 000	Single micro-continent smashes into North America
Atlantic Coast	485 000 000	Age of chromite found in western Newfoundland
Atlantic Coast	500 000 000	Age of oceanic crust found in western Newfoundland
Appalachians	500 000 000	Age of zircons found in Newfoundland
Atlantic Coast	560 000 000	Ediacaran fauna of eastern Newfoundland
Canadian Shield	600 000 000	Erosion of Grenville Mountains, formation of Canadian Shield landscape
Appalachians	1 200 000 000 to 1 000 000 000	Earlier Appalachian Mountains formed
Great Lakes	1 300 000 000	Super continent of Rodinia
Canadian Shield	1 800 000 000	Massive meteorite strike near Sudbury
Canadian Shield	2 000 000 000	Rocks found in the Torngats formed as sediments Formation of diamonds – destruction of ocean crust and kimberlite formed
Canadian Shield	2 700 000 000	Deposition of gold in the Torngats
Canadian Shield	3 800 000 000 to to 3 300 000 000	Mountain-building phases (2) form Torngats
Canadian Shield	4 000 000 000	Age of some of the rocks in Canadian Shield, some found in NWT (Slave Craton) – first continents appear
Great Lakes	4 500 000 000	Age of the Earth

Period / Epoch		Era	Time before present (millions of years)
Holocene	Quaternary	Cenozoic Era	0
Pleistocene	Quaternary	Cenozoic Era	1.8
Neogene		Cenozoic Era	2.3
Paleogene		Cenozoic Era	65
Cretaceous		Mesozoic Era	146
Jurassic		Mesozoic Era	200
Triassic		Mesozoic Era	251
Permian		Paleozoic Era	299
Carboniferous		Paleozoic Era	359
Devonian		Paleozoic Era	416
Silurian		Paleozoic Era	444
Ordovician		Paleozoic Era	488
Cambrian		Paleozoic Era	542
		Precambrian Era	1 000
			2 000
			3 000
			4 000
			4 600

Introduction

Resources

In association with this video series and Teacher Resource Guide, CBC's *Geologic Journey* Web site—www.cbc.ca/geologic/—provides additional information that can supplement and enhance the classroom use of *Geologic Journey*. The Web site contains:

- a field guide – www.cbc.ca/geolocic/field_guide/table_of_contents.html
- a summary and video clips of each of the episodes
- an overview of the series
- an opportunity to meet some of the scientists involved in the series (these interviews are also contained on the educational videos)
- an excerpt from *Canada Rocks: The Geologic Journey*, by Nick Eyles and Andrew Miall
- the teacher site (www.cbc.ca/geologic/teacher.html), which includes:
  - Answer Key: suggested responses to the student questions, where appropriate
  - Images: downloadable screen grabs (still images) from the videos required for activities as indicated in the guide
  - Figures: downloadable versions of the maps, charts, and diagrams found in this guide
  - A PDF file of this complete guide

There are some basic geology texts available that will supplement the *Geologic Journey* series. One that matches up well with the series is *Canada Rocks*: *The Geologic Journey* by Nick Eyles and Andrew Miall (Fitzhenry and Whiteside, 2007. ISBN13:978-155041-860-6). This text has been developed in a form that is easily accessible to non-specialists, is well-illustrated, and will help educators to make the connections with local points of geologic significance. The content is organized around the theme of plate tectonics—also central to *Geologic Journey*—with an emphasis on geologic time.

Introduction

Northern America

Legend:

1 Fathom Five National Marine Park
2 Bruce Peninsula National Park
3 Gros Morne National Park
4 Shenandoah National Park
5 Lake Superior
6 Lake Michigan
7 Lake Huron
8 Lake Erie
9 Lake Ontario
10 Georgian Bay
11 Montmorency Falls
12 Niagara Falls
13 Niagara River
14 Gulf of St Lawrence
15 Lobster Cove
16 Mistaken Point
Logan's Line
Niagara Escarpment
New Madrid Fault Line

Introduction

This episode of *Geologic Journey* explores the major geologic events linked to the birth of the Great Lakes. The episode focuses on several aspects, including how the Great Lakes were born and their evolution over millions of years. The episode also deals with the procedures used by geologists to study rocks both above and below the Earth's surface to understand how the forces of nature have played a role in the development of these lakes.

The Great Lakes episode is divided into four chapters:

- Chapter 1: Niagara Falls 7:45 minutes
- Chapter 2: The Legacy of the Grenville Mountains 14:00 minutes
- Chapter 3: Salt Mines: An Underground Laboratory 10:30 minutes
- Chapter 4: Ice Sheets and Glaciers 12:45 minutes

The episode can be viewed in its entirety (44 minutes), or can be divided into the four chapters indicated. The viewing questions are associated with each of the chapters but could be consolidated into a series of questions covering the entire episode. Suggested responses to the viewing questions can be found in the Answer Key on the Web site at www.cbc.ca/geologic/teacher.html.

An alternative approach, well suited to an introduction to the geology of the Great Lakes, is to use an organizer that focuses on the geologic and economic significance associated with each chapter.

Chapter	Geologic Significance	Economic Importance
Niagara Falls		
Grenville Mountains		
Salt Mines		
Ice Sheets and Glaciers		

The Great Lakes

1

CHAPTER 1

Niagara Falls

Keywords

erosion, clay, cap rock, Niagara Escarpment, Niagara Gorge, Niagara Falls, continental and oceanic crust, mantle, cavitation

Introduction

Chapter 1 of *The Great Lakes* explores Niagara Falls—the “jewel in the Great Lakes crown.” Students learn about the erosion of the Niagara Gorge, the power of Niagara Falls, and the reasons why this area is considered to be the “birthplace of modern geology.”

Curriculum Objectives

- describe the components of the internal structure of the Earth
- understand the factors determining the rates at which physical processes occur, e.g., erosion and differential weathering
- evaluate the role of humans and technology in controlling erosion

Materials Required

- *Geologic Journey: The Great Lakes* video

Student Activities

1.1.1 Initially, divide the class into two groups: those who have visited Niagara Falls, and those who have not; then, to facilitate the group work, divide these two groups into smaller groups of 4 or 5 students. Ask both groups of students to discuss and record responses (as a group) to the following questions.

- What do the Niagara Falls look and sound like?
- What is the economic significance of the Falls?
- What is the geologic significance of the Falls?
- In what ways are the Falls part of the Canadian identity?

1.1.2 Compare the responses from the “have visited” and the “have not visited” groups. You may find that even though some students have not visited Niagara Falls, they will have had exposure to video or pictures and may be able to respond to at least one or more of the questions. This prior knowledge attests to the significance of the Falls as part of Canada’s physical landscape. As students watch the footage in *Geologic Journey* they will be able to add more information regarding the economic and geologic significance of the Falls.

Video Review

Watch Chapter 1 of the video with a focus on the “profound geologic significance” of Niagara Falls. Responses to the following questions will assist in an understanding of this statement.

1.1.3 What is the annual rate of retreat of the Falls?

1.1.4 In volume, how do Niagara Falls rate in terms of waterfalls of the world?

1.1.5 How fast does water fall over the Falls?

1.1.6 Why are Niagara Falls considered to be “the birthplace of modern geology”?

1.1.7 Time is an important concept in geology. Complete the following chart indicating various times mentioned in the video.

Description	Time
British geologist Charles Lyell’s estimate (in the 19th century) of the number of years that the Falls had been eroding “backward”	
The 19th century estimate of the age of the Earth	
The current (21st century) scientific estimate of the age of the Earth	

1.1.8 Describe the components of the internal structure of the Earth identified in this chapter.

1.1.9 How do the movements of these components help us to date the Earth?

1.1.10 Should humans use knowledge and technology to slow the erosion process at Niagara Falls?

In the summer of 2007, Niagara Falls were chosen as one of the Seven Wonders Canada by a panel of judges selected by the CBC and by Canadian citizens (www.cbc.ca/sevenwonders/index.html).

A unique type of erosion occurs at Niagara Falls. As water cascades over the Falls, it loses internal pressure, and air escapes as bubbles or cavities. These cavities collapse when the water comes to a rest, sending out shock waves and disintegrating the surrounding rock. This type of erosion is known as cavitation. This relatively rapid form of erosion has caused Niagara Falls to retreat at a rate of a approximately 1.2 metres per year in the past. However, in recent years, the International Joint Commission has managed the flow. It has been reduced by diversion for hydroelectric power generation and general flow control. These human activities have dramatically reduced the rate of erosion to 30-35 cm per year. Further use of the water for a variety of purposes could reduce the rate of erosion even further—to one metre every 25 or 30 years, or a rate of 3-4 cm per year. This represents a reduction in the rate of retreat (caused by human activity) of 95+ per cent!

In groups of four, assume one of the following roles:

- a local business owner in Niagara Falls
- an environmentalist
- a geologist
- a representative from the hydro-power sector

Decide on your position (in your role) on the issue of whether or not the flow of water over the Falls should be reduced (as is currently the case), slowing the process of erosion. Present your position and the reasons for your particular point of view and try to influence others in your group to agree with your point of view.

Following discussion of the issue, present a report on your group decision to the whole class, explaining the rationale for your decision.

Which member of the group made the most persuasive argument?

What factors made arriving at consensus easy or difficult?

Suggestions for Assessment

Teachers may choose to assess students on their participation in the group exercise or in their presentations to the class or use peer and self-evaluation instruments.

Extensions

Additional information on the "Future of the Falls" can be found at the Niagara Parks Web site, www.niagaraparks.com/nfgg/geology.php.

2

CHAPTER 2

The Legacy of the Grenville Mountains

Keywords

Rodinia, Georgian Bay, tectonics, orogeny, Grenville Mountains, Laurentia, folding, flow rocks, uranium-lead dating, banded gneisses

Introduction

Chapter 2 of *The Great Lakes* explores the birth of the Great Lakes, beginning with the emergence of Rodinia, 1.3 billion years ago. Students learn about the root rocks of the ancient, and massive, Grenville Mountains, located in the Georgian Bay region of Ontario. They learn how geologists study such rocks for clues about the Earth's early history.

Curriculum Objectives

- describe the process of formation and the characteristics of the major rock types (igneous, sedimentary, metamorphic)
- differentiate between continental and oceanic plates and examine the processes at work along their boundaries
- explain why the physical evidence found on the surface of the Earth supports the theory of plate tectonics

Materials Required

- *Geologic Journey: The Great Lakes* video
- Image 1.1 – Image 1.10 These images provide graphic evidence of the properties of flow and folding in the rocks.

Student Activities

1.2.1 Brainstorm the topic "Magnificent Mountains" to get students engaged with the topic. Identify mountain ranges in Canada and their locations as well as the approximate elevations of highest peaks. Prepare a similar list of mountains outside Canada.

1.2.2 What mountains exist today in the area of southwestern Ontario and Toronto? If you have difficulty identifying these, you are probably not alone. Except for the skiing areas in Collingwood, which have a vertical difference in elevation of less than 100 metres, there are no mountain "ranges" in Ontario. However, this was not always the case. Chapter 2 of the video outlines the early history of this area, especially the Grenville Mountains.

1.2.3 What elements led to the birth of the Grenville Mountains?

1.2.4 What did the Grenville Mountains likely look like?

1.2.5 What happened when the glaciers on top of the Grenville Mountains melted?

1.2.6 There is evidence of rocks "flowing" at the Grenville site. What causes rocks to flow?

1.2.7 How is heat created within rocks?

1.2.8 What is the importance of the rocks to the research of geologists?

1.2.9 Why do the vanished Grenville Mountains continue to interest Tom Krogh?

1.2.10 What method of geographic investigation does Professor Krogh use to date the roots of the Grenville Mountains?

1.2.11 What information about the mountains has this technique produced?

1.2.12 How large a sample of sedimentary rock is required for a uranium-lead dating analysis?

1.2.13 What role have the Grenville Mountains played in Canadian art?

Professor Culshaw refers to the rocks at Georgian Bay as the "Louvre of crustal geology." The Louvre is an art museum in Paris, France, that houses some of the most significant art in the world.

"Reading" Rocks

With a partner, view Images 1.1 to 1.10, of the rocks at Grenville. (Full-colour copies of all the images referenced in this guide are available online at www.cbc.ca/geologic/teacher.html) Image 1.1 to Image 1.10 provide graphic evidence of the properties of flow and folding in the rocks.

1.2.14 Imagine that you and your partner are explorers who have discovered these rocks for the first time. You believe the rocks are of geologic significance and write a report that captures the beauty and unique features of the rocks. In your report, describe:

- the physical aspects of the rocks (size, colour, proximity to other landforms)
- the unique geologic features of the rocks—for example, evidence of flow and folding—and what these features tell us about the Earth's history

Suggestions for Assessment

Assessment may be based on the students' observations and analysis following the two questions above.

Extension Activities

1.2.15 Explore the role that the Canadian landscape has played in Canadian art. Painter Ed Bartram is featured in this episode. His paintings could be studied in depth, or a comparison could be made between his work and that of the Group of Seven (e.g.,Tom Thomson's painting of the rocks at Byng Inlet on Georgian Bay). Many images of Canadian art are available online. One good starting point is the Web site of the McMichael Gallery at www.mcmichael.com/collection/.

1.2.16 Tom Krogh discussed how improvements in uranium-lead dating have helped geologists. How have improvements in radiometric dating methods and tools helped scientists to learn more about the history of the Earth?

3

CHAPTER 3

Salt Mines: An Underground Laboratory

Keywords

Michigan basin, Silurian period

Introduction

Chapter 3 of *The Great Lakes* begins with an exploration of the Michigan salt-water basin that existed 400 million years ago. Students learn that massive coral reefs, identical to those found in places like the Caribbean and off Australia's Gold Coast in the Great Barrier Reef, once existed here. They also learn how the salt-water basin turned into salt deposits far under the Earth's surface. These deposits continue to provide jobs and economic benefits across the Great Lakes region.

Curriculum Objectives

- describe how rocks deep below the Earth's surface hold information about the age and climate of a particular region
- explain the economic importance of salt mines

Materials Required

- *Geologic Journey: The Great Lakes* video
- Image 1.11 – Solitary Coral
- Image 1.12 – Branching Types
- Image 1.13 – Crynoids

Student Activities

Show students pictures of fossilized coral found at www.cbc.ca/geologic/teacher.html.

- Image 1.11 – Solitary Coral
- Image 1.12 – Branching Types
- Image 1.13 – Crynoids

The following questions will help students to focus on what they are seeing in the images.

1.3.1 What am I looking at (major features, identifying marks)?

1.3.2 Hypothesize about the age and original location of these fossils.

When discussing student responses, teachers will be able to clarify that these coral fossils were found along Lake Michigan. Coral existed in this area millions of years ago because the Michigan basin used to be filled with salt water.

View Chapter 3 of the video and respond to the following questions.

1.3.3 How and when was the Michigan basin created?

1.3.4 What does the existence of coral indicate about the type of climate that existed millions of years ago?

1.3.5 How has the existence of a salt-water basin million of years ago had an impact on jobs and economic resources today?

1.3.6 How old are the rocks at the lowest depths of the salt mine?

1.3.7 How can the walls of the salt mine be read to explain the Earth's climate millions of years ago?

1.3.8 In what ways has salt been a valued commodity historically?

1.3.9 How do mining companies determine if a mine will be economically viable?

1.3.10 What do the "muddy" deposits tell geologists?

1.3.11 What do the ripples on the ceiling of the mine indicate?

At one point in history, salt was so valuable that soldiers used to be paid in salt.

Before the invention of modern chemical preservatives, salt was used to keep food from spoiling.

Extension Activity

1.3.12 Consider the following facts about the Sifto Salt Mine at Goderich, Ontario, the largest salt mine in the world.

- Forty-five per cent of Canada's salt is mined at this one facility.
- Each year, over 100 large lake and ocean freighters dock at Goderich to load salt from the mine.

A mine can have a great impact on a community. In small groups, explore the impact of a mine on the local economy and community. Choose one of the salt mines listed below and investigate the history, economic impact, and impact in other areas such as tourism and the environment. As a group, prepare a report for the other members of the class on "your" mine. Links to these mines can be found at the Natural Resources Canada Web site at http://mmsd1.mms.nrcan.gc.ca/mmsd/producers/default_e.asp.

- The Canadian Salt Company, Pugwash, Nova Scotia
- PCS Mining and Milling Operations, Sussex Salt, Sussex, New Brunswick
- The Canadian Salt Company, Seleine Mine, Magdalen Islands, Quebec
- Sifto Salt Company, Goderich, Ontario
- The Canadian Salt Company, Ojibway Mine, Sandwich Township, Ontario
- Mosaic Potash Esterhazy, K1 and K2 Mines, Esterhazy, Saskatchewan

Suggestions for Assessment

Teachers may assess students on their written reports or their presentations to class. Alternatively, teachers may have students complete peer and self-evaluations.

4

CHAPTER 4
Ice Sheets and Glaciers

Keywords

Scarborough Bluffs, till, Laurentide ice shield (sheet), Paleo-Indians, isotopes, glacial meltwater, glacial rebound

Introduction

Chapter 4 explores four of the major factors that played a role in the development of the Great Lakes: the role of the glaciers in carving out the basin for the Great Lakes, the melting of the glaciers, the rebounding of the Earth's crust, and climate change. Students also learn about the vanished Lucas Falls, falls that were at least as large as Niagara Falls.

Curriculum Objectives

- understand the relationship between the present characteristics of the Great Lakes and the processes that shaped them
- evaluate the impact of human-caused changes on the Great Lakes today
- gather geographic information from a variety of sources

Materials Required

- *Geologic Journey: The Great Lakes* video

Student Activities

Factors that Impacted the Creation of the Great Lakes

1.4.1 In small groups, hypothesize the elements that contributed to the formation of the Great Lakes. After you view this chapter, return to your notes and insert any additional information that you learned.

Factors that Impact the Great Lakes Today

1.4.2 With a partner, or in a small group, talk about your personal experiences with the Great Lakes.

1.4.3 Which, if any, of the Great Lakes have you been to?

1.4.4 What activities did you participate in while at the Lake(s) (for example, swimming, kayaking, fishing)?

1.4.5 Were the beaches clean?

1.4.6 Has a beach closure ever prevented you from swimming in one of the Great Lakes? If yes, what was the reason for the closure?

While viewing this chapter of the video, students can focus on the following:

1.4.7 What role did the glaciers play in the formation of the Great Lakes?

1.4.8 What unusual rock did Nick Eyles identify in the cliffs of the Scarborough Bluffs?

1.4.9 What type of water originally filled the Great Lakes?

1.4.10 When did the most recent glaciers melt?

1.4.11 What issue is marine geologist Steve Blasco studying?

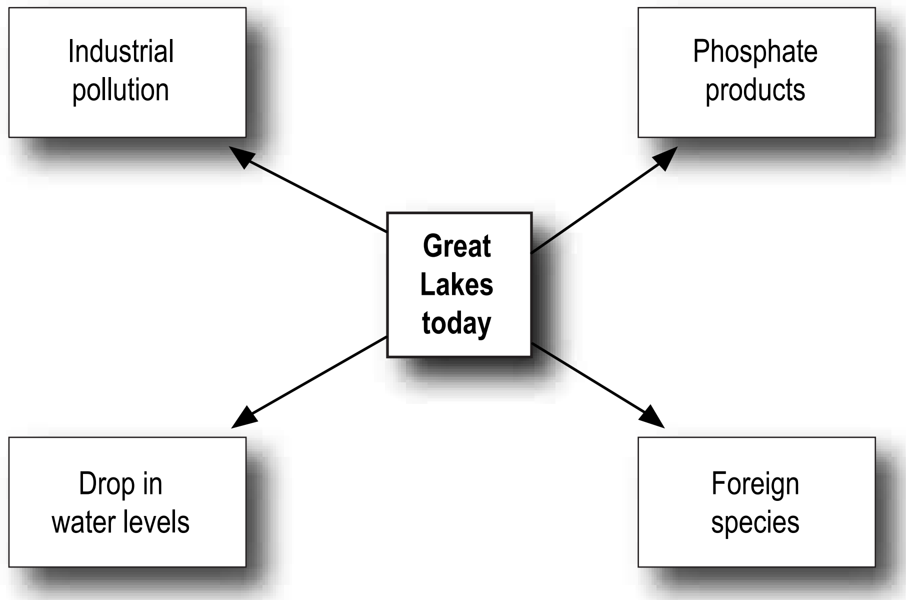
1.4.12 Why does Professor Blasco want to study the drowned white cedar?

1.4.13 How large were the vanished Lucas Falls?

1.4.14 Where were they located?

1.4.15 As you discussed in your group, the Great Lakes are being impacted by a number of factors today. Develop a concept map to illustrate the relationship between these factors. (A concept map is a visual representation of the relationships between concepts.)

For example:



Anishinabe has been translated as "original man" or "the people." The term is used by Ojibwa-speaking peoples in Ontario.

What does your concept map indicate about the future of the Great Lakes?

Suggestions for Assessment

Teachers may choose to assess the content of concept maps. Teachers may choose to have students transfer the concept maps onto posters to display in the room.

Extension Activity

Many of the physical changes explored in this episode occurred very slowly, and over a long period of time. Conduct further research on the formation of the Niagara Escarpment and the Great Lakes and plot the major developments on a timeline. A good starting point for your timeline may be the beginning of the Paleozoic Era, 520 – 570 million years ago.

The Great Lakes

Teacher Background

This activity for this episode asks students to produce a television program about factors that are currently impacting the Great Lakes. Before you divide students into groups, identify three or four who are tech-savvy. That group of students should be responsible for videotaping the group presentations, editing the footage, and preparing the final television show. These students should be familiar with how to book video equipment from the school A/V office, and may be currently taking a Media course. An alternate approach could involve students in a round-robin debate, covering the same content.

Materials Required

- video camera, props (if applicable), and video editing equipment (either in the school or at a student's home)

Student Activity

Your group will be appearing on a television show about the future of the Great Lakes. Each individual in the group will prepare a short report on one factor impacting the Great Lakes and present that information on camera. Your televised material will be added to that of other groups presenting on similar issues, and the final product will be played back to the class.

Topics and sources to get you started:

- "Drain hole" at the St. Clair River near Port Huron, Michigan. An introduction to this issue can be found in an August 15, 2007, article on CTV news online at www.ctv.ca/servlet/ArticleNews/story/CTVNews/20070815/great_lakes_070815/20070815?hub=Canada.
- Invasive species in the Great Lakes. Information can be found at the Great Lakes Information Network Web site at www.great-lakes.net/envt/flora-fauna/invasive/invasive.html.
- Chemical pollutants. Information can be found at the Environment Canada Web site at www.ec.gc.ca/water/en/manage/poll/e_hotspt.htm.
- Agricultural pollution. A starting point on this topic can be found at the Ontario government's Ministry of the Environment Web site at www.ene.gov.on.ca/envision/water/greatlakes/coa/Agriculture_EN.pdf.
- Elevated hormone levels. A starting point on this topic can be found at the Web site of the Sierra Club of Canada at www.sierraclub.ca/national/media/inthenews/item.shtml?x=1350.

Suggestions for Assessment

Teachers may choose to have students assess the "performances" of other group members. Students may evaluate their own contributions to the work of the final product.

2: The Rockies

Introduction

This episode of *Geologic Journey* is divided into four chapters:

- Chapter 1 Plate Tectonics: Formidable Forces 12:45 minutes
- Chapter 2 From Sea to Sky: Folding and Thrusting 7:30 minutes
- Chapter 3 Rocky Mountain Resources and Land Use 12:30 minutes
- Chapter 4 Erosion on a Grand Scale 11:00 minutes

Chapter 1 identifies the main characters—the tectonic plates and their compressional forces that brought terranes or exotic fragments of rock on a collision course with the earlier western edge of North America. The basalts at Hesquiat are featured. Chapter 2 provides an examination of the architecture of the Rockies, with an emphasis on the differences between the Front and Main Ranges. Chapter 3 outlines the importance of the Rockies in terms of the meeting of human needs and the impact of utilizing the resources contained in the Rockies. The sculpting of the Rockies through erosion, particularly by ice, is the focus for Chapter 4.

The episode can be viewed in its entirety (44 minutes), or can be divided into the four chapters indicated. The viewing questions are associated with each of the chapters but could be consolidated into a series of questions covering the entire episode. Suggested responses to the viewing questions can be found in the Answer Key on the Web site at www.cbc.ca/geologic/teacher.html.

1 CHAPTER 1 Plate Tectonics: Formidable Forces

Keywords

plate tectonics, convergent margins, divergent margins, transform margins, terranes, plates, Cordillera, accretion, subduction, North American Plate, Pacific Plate, Juan de Fuca Plate, Pangaea, viscosity

Introduction

The story of the Rocky Mountains is only one part of the history of how the western edge of North America was built. One hundred and eighty million years ago, the edge of the continent was close to the current location of the Alberta/British Columbia border. A shallow tropical continental shelf formed along the margin of the continent. All of the land west of this location has been added to the original continental edge due to the forces of plate tectonics. The converging plates built up the Cordillera. North America started to move westward as part of the break-up of the supercontinent Pangaea, ploughing toward and over the Pacific Ocean floor. With this movement, the ocean crust was overridden by, and subducted beneath, the continental edge. Coincident with this movement, volcanic islands (offshore island arcs and ocean plateaus), ocean basin sediments, displaced continental fragments, and even parts of the ocean floor itself were scraped off and plastered onto the old continental edge. These terranes, which make up most of British Columbia and the Cordillera, are all "exotic" rock units in that they are internally consistent but then change abruptly across large faults.

Curriculum Objectives

- explain the relationship between plates, tectonic activities—including earthquakes—and mountain building
- describe the differences between oceanic and continental rocks and explain the processes at work along plate boundaries
- understand the role of terranes as exotic rock units

Materials Required

- *Geologic Journey: The Rockies* video
- The Geological Survey of Canada Web site at http://gsc.nrcan.gc.ca/cordgeo/terrane_e.php
- Block diagram of southwest B.C. at http://geoscape.nrcan.gc.ca/vancouver/earth_e.php
- This Dynamic Planet plate tectonic map at http://mineralsciences.si.edu/tdpmap/

An amount of ocean floor equal in length to one third of the Earth's circumference has been subducted below North America in the last 150 million years.

Our Cordilleran terranes may have formed on the ocean floor thousands of kilometres away from where they are now docked to the edge of North America.

Driving from the west coast of Vancouver Island to the Rockies is a distance of at least 600 km. This is an area that "came from away"; that is, it did not exist as part of North America 180 million years ago.

Student Activities

2.1.1 If 180 million years ago the western periphery of North America was close to the current British Columbia/Alberta border, suggest ways in which the additional land could have developed in this area.

View Chapter 1 of the video and respond to the following questions.

2.1.2 What are the key questions that are posed in this chapter about the Rockies?

2.1.3 What do you feel is meant by the phrase "the Rockies are full of transformations"?

2.1.4 In the video, it is stated that "the pressure on the rocks bent them like pipe cleaners. It shattered them like crystal." Which two processes are identified in this statement?

2.1.5 What does the term *exotic rock* mean?

2.1.6 What is meant by the term *subduction*?

2.1.7 What kind of rocks did Stephen Johnston observe at Hesquiat?

2.1.8 What were their characteristics?

2.1.9 Suggest ways in which this type of rock might have formed.

2.1.10 Where do huge thicknesses of this type of rock form today?

2.1.11 What does this tell us about the origin of the Hesquiat basalts of the Karmutsen Formation?

2.1.12 Go to the Geological Survey of Canada Web site at http://gsc.nrcan.gc.ca/cordgeo/terrane_e.php and scroll down to the map of the Cordilleran Terranes.

- On a map of Western Canada, locate the old (ancestral) North American Margin.
- Locate Hesquiat on the western side of Vancouver Island.
- Hesquiat is part of a terrane. Which one?
- How many terranes are indicated?
- Do they have particular shapes?

Extension Activities

The following two model-building activities involve a variety of hands-on materials.

2.1.13 Develop a model to represent the plates of the Pacific Northwest, the process of subduction, and the development of the Rockies.

Materials

The following materials will be required for each group of students involved in the model building. If it is a demonstration for the class, only one set is required.

- 2 blue thin camping foamies approximately 1.4 x 0.5 m (representing the Pacific Plate and the Juan de Fuca Plate)
- 1 piece of mattress foam approximately 50 x 80 cm and 10 cm thick (representing the North American Plate)
- Masking tape
- Labels for Pacific Plate, North American Plate, Juan de Fuca Plate, Cascadia Subduction Zone, Juan de Fuca Ridge
- 3 cut-out arrows
- Random objects such as paper cones, hard foam shapes (to simulate volcanic islands, bits of continents)

Review the three types of plate margins and demonstrate the convergence of the thin ocean crust and the thicker continental crust by bringing the foamies and the mattress foam together.

Use the Block diagram of southwest B.C. at http://geoscape.nrcan.gc.ca/vancouver/earth_e.php and the interactive This Dynamic Planet plate tectonic map at http://mineralsciences.si.edu/tdpmap/ and the materials to construct models of the three plates that interact in the western part of North America and offshore. Add labels and arrows to indicate plate movement and identify the ridge and subduction zones. Two chairs can help to hold the diverging plates together. Simulate the addition of terranes by adding volcanic islands (hard foam shapes) to the Juan de Fuca Plate. Repeat the plate motion.

- Why did the ocean crust subduct?
- What are some of the consequences of subduction?
- What happens to the sediments and the rocks on the leading edge of the North American Plate when the islands collide with the North American Plate?
- What happens every time a terrane is added?

2.1.14 The concept of viscosity can also be demonstrated to illustrate some of the distinctiveness of igneous rocks based on viscosity. This could be a teacher demonstration or a small-group activity.

Materials

- Transparent plastic cups (two for each group doing the experiment)
- Dark-coloured soft drink (cola, root beer) to nearly fill one cup of each group
- Clear corn syrup (to ¾ fill the other cup)
- drinking straws (one for each cup)
- newspapers (to keep the work space somewhat clean)

Procedure

- Fill the cups, one with the soft drink, the other with corn syrup, and place on the newspapers.
- Using a straw, lightly blow into the soft drink until you start to produce bubbles.
- Now with the same amount of "blow" blow into the corn syrup (nothing will happen).
- Blow harder until you get the corn syrup to "erupt."

Based on observations, respond to the following questions.

- How are the eruptions of soft drink and corn syrup different?
- How are the "magmas" different from each other? How would this relate to the types of volcanoes each might form?
- Which type of magma would have formed the Hesquiat basalts?
- Write a story about the formation of the basalts at Hesquiat outlining why these basalts didn't get subducted like the rest of the ocean crust.
- Using a map of the Pacific Ocean floor (e.g., National Geographic Pacific Ocean Floor wall map, or map of the Pacific Ocean floor in any atlas), identify some potential future terranes that may be added to North America if it continues to move westward toward and over the Pacific Ocean crust.

Web Links

The following Web sites provide helpful background information for both teachers and students.

- http://earthquakescanada.nrcan.gc.ca/index_e.php – maps of earthquakes locations in Western Canada
- http://gsc.nrcan.gc.ca/volcanoes/gscvol_e.php – more about the volcanoes caused by subducting plates

2

CHAPTER 2

From Sea to Sky: Folding and Thrusting

Keywords

folding, thrust faulting, brittle and plastic deformation, Front Ranges, Main Ranges, Precambrian, Paleozoic, Mesozoic, stratigraphy, paleogeography, sedimentary rocks

Introduction

On the eastern edge of the Cordillera, towering over the Alberta Plains, the Rocky Mountains are the dramatic evidence of the massive collisions that occurred to the west. The Rockies consist mostly of sedimentary rocks, which were laid down from the Precambrian until the early Mesozoic, between 700 and 50 million years ago, on or near the margin of ancient North America. When the Cordilleran terranes were added (in at least two episodes of intense compression—late Jurassic Columbia Orogeny and the early Tertiary Laramide Orogeny), these sedimentary deposits were bulldozed eastward, thrust and folded over the ancient continental edge to form the majestic Rocky Mountains. All of this mountain building happened between 100 and 55 million years ago. Rocks are our window into the Earth's past. These activities will look at the story in stone: how the limestone layers formed and the sequence of events that ensued.

Curriculum Objectives

- describe the environmental conditions of life on Earth during one of the geologic eras
- identify the mechanisms of change within the lithosphere (e.g., mountain building)
- analyze the relationships between the present characteristics of specific landforms and the processes that shaped them
- describe and explain the relationship between mountain building, faulting, folding, plate tectonics, and earthquake activity
- analyze the features and causes of deformation in rocks

Materials Required

- *Geologic Journey: The Rockies* video
- Images 2.1 – 2.6 showing rock layering configurations
- Cross-sectional diagram of the Rockies (Figure 2.1)
- Photos of folds and faults in the Rocky Mountains at www.aapg.org/slide_bank/rockies/slideset.cfm (specifically photos 33, 39, 40, 43, 48)
- Modelling clay (at least two colours)
- Fine marker
- Sharp knife

Student Activities

Before viewing the video, review the concepts of folding and faulting. If students have not had previous experience with these concepts, consider doing Extension Activities 2.2.18 and 2.2.19 prior to viewing the video.

2.2.1 How could you model the concept of folding using everyday materials?

2.2.2 How could you model the concept of faulting using everyday materials?

2.2.3 What difficulties would you experience in "modelling" geological activity such as folding and faulting?

View Chapter 2 of the video and respond to the following questions.

2.2.4 Identify areas in the video where the concepts of folding and faulting are evident.

2.2.5 Why do some rocks fold and others break (fault)?

2.2.6 View Images 2.1 to 2.5. (Full-colour copies of all the images referenced in this guide are available online at www.cbc.ca/geologic/teacher.html.) Describe in detail the orientation of the rocks.

2.2.7 How does the orientation of the rocks in the first group (Images 2.1 to 2.3) compare with those in the second group (Images 2.4 and 2.5)?

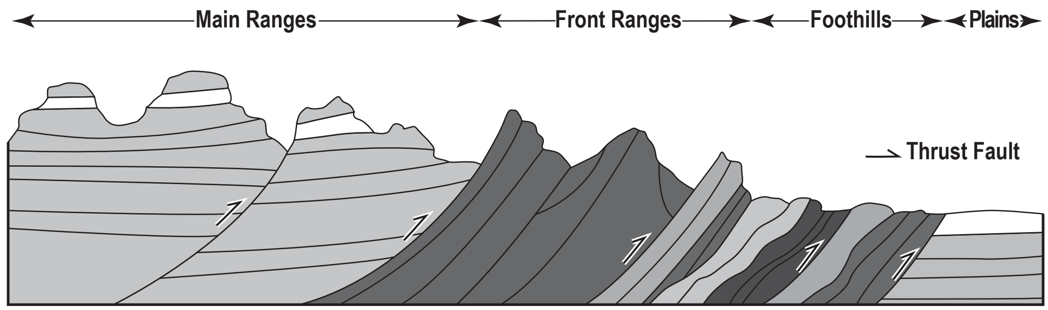
2.2.8 Sketch the main rock layers in each photo.

2.2.9 Develop a comparative chart to compare the images to Figure 2.1 (Cross-section of the Rockies), showing a slice through the Front and Main Ranges.

If you piled up all the sedimentary rocks that were once laid down flat at the ancient edge of North America, you would have a thickness of approximately 15 km (that is around 15 times the depth of the Grand Canyon).

If you undid all of the horizontal shortening (i.e., pulled all of the thrust-fault slices back so they were in their original positions), rocks now exposed at Field near the British Columbia/Alberta border would have been located close to Vernon, over 200 km to the west.

Figure 2.1 – Cross-section of the Rockies



2.2.10 Which do you think are oldest (happened first), the Main Ranges or the Front Ranges? How can you tell?

2.2.11 Make a clay model of rock structure based on Image 2.5 or Image 2.6, or from the following Web site: http://geoscape.nrcan.gc.ca/calgary/topics/landscape_e.php. Use different colours of modelling clay for the different layers. The limestone, which is 520 million years old, is light grey in colour, and the shale and sandstone (75 million years old) are usually darker and look more eroded. Draw the thrust faults in black using a fine marker.

2.2.12 Describe the sequence of events that produced the rock features.

2.2.13 Make sketches of how the area might have looked when each event occurred. This is what earth scientists called stratigraphers do.

2.2.14 Research to determine how stratigraphers resolve or infer the ages of the specific rock units.

2.2.15 Many of the most spectacular mountains in the Rockies are made of limestone. What conditions do you need to form limestone? Where do limestones form today?

2.2.16 Make a sketch of how the area might have looked when the limestones were forming.

2.2.17 Draw a pair of sketches to illustrate the differences between the original mountains in this area (which would have been as high as the Himalayas) and their appearance today. Why are the two sketches different?

Extension Activities

2.2.18 Develop models to illustrate folding and faulting, and sketch the results of the model development for comparison with features in the video.

Materials Required

- Transparent plastic box
- Strong cardboard cut to tightly fit box as a vertical partition (it should be taller than the box so that it can be held and pushed sideways)
- Dry sand
- White flour

Stand the cardboard vertically at one end of the plastic box and pour a layer of sand into the plastic box until it is about 1 cm deep. Sprinkle a thin layer of flour on top of the sand. Alternate layers of sand and flour until the box is about half full.

Slowly move the cardboard toward the opposite end of the box, simulating the force of the terranes pushing against the flat-lying sedimentary layers at the edge of ancient North America.

Sketch how the layers have changed.

What structures can you identify?

2.2.19 Review the photos of folds and faults in the Rocky Mountains at www.aapg.org/slide_bank/rockies/slideset.cfm (specifically photos 33, 39, 40, 43, 48)

Materials Required
- Snack-size zip-closure bags
- Measuring cup
- Spoon
- 125 ml cornstarch
- 60 ml water

Place the cornstarch and water in the bag to make “rock ooze”; close the bag and squeeze to mix.

Experiment with the ooze – hit it hard, squeeze it, place heavy objects on top of it.

How can you make the ooze flow (fold)?

How can you make the ooze break (fault)?

How do these two actions relate to the tectonic forces pushing the sedimentary rocks toward the east over millions of years?

Compare the structures you generate with those in the Rocky Mountain photos.

2.2.20 What other evidence (in addition to mountains, folds and thrust faults) indicates that major tectonic forces are at work in the Rockies?

Web Links

- Go to http://geoscape.nrcan.gc.ca/calgary/topics/landscape_e.php and scroll down to view the paleogeography during different eras of Earth history in the Rockies, and check out http://jan.ucc.nau.edu/~rcb7/mollglobe.html, a site where you can view global reconstructions at different times in the Earth’s past. Scroll down and click on the time frames (from Late Cambrian onward) to view the global paleogeography during the development of the western edge of North America and the Rockies.

3 CHAPTER 3 Rocky Mountain Resources and Land Use

Keywords

mining, industrial minerals, non-renewable resources, land use, building stone, cement, limestone, World Heritage sites, tourism, metallic minerals

Introduction

In this chapter the focus is on how different the Rockies are in Canada compared with the same range in the United States. The Canadian Rockies are made up mainly of sedimentary rocks, laid down as sediments on the edge of a large continent, and then compressed horizontally, causing folds and thrust faults. There was little volcanic activity or uplift like there was to the south, where the Rockies were formed by the uplifting of blocks of ancestral North America. This was accompanied by much volcanic activity. The Canadian Rockies do not have the copper, gold, silver, and molybdenum wealth found to the south, in the Colorado Mineral Belt, but the Canadian Rockies do supply important resources. They also have an impact on the economy in other ways.

The activities focus on the impact the Rockies have on our lives. We also look for areas in the Canadian Cordillera with similar conditions to those of the Colorado Mineral Belt.

Curriculum Objectives

- relate geological processes to the existence of mineral resources
- identify the differences between non-renewable and renewable resources
- identify the natural resources on which tourism is based
- explain the effects of selected natural systems and phenomena on travel and tourism
- propose courses of action on social issues related to science and technology
- analyze specific examples of how tourist activities can threaten fragile environments
- compare viewpoints of individuals, businesses, non-government organizations, and other groups about sustainable use of the Earth and its resources
- analyze the positive and negative impacts of ecotourism on people and the natural environment in selected destination regions
- demonstrate an understanding of the effects of human activities on various aspects of the environment

Materials Required

- *Geologic Journey: The Rockies* video
- Map of the Rocky Mountains – road map, good atlas map showing parks, ski resorts, walking routes, towns, transportation routes

Student Activities

2.3.1 Create a list to indicate some of the ways that Canadians use and value the Rockies.

2.3.2 Suggest how proximity to the Rockies might change one's view of the value of the Rockies to oneself, the province, or the nation.

View this chapter of the video and visit a selection of these Web sites:

- www.ags.gov.ab.ca/publications/atlas_www/A_CH34/CH_34_F.shtml#lie
- http://geoscape.nrcan.gc.ca/calgary/topics/resources_e.php
- www.bcminerals.ca/files/bc_industrial_mineral_operations/000240.php
- www.graymont.com/locations_exshaw.shtml
- www.bcminerals.ca/files/bc_industrial_mineral_operations/000239.php

2.3.3 Summarize the geology-related resources of the Rockies in chart form using the following as an example.

Material	Location	Uses
"Rundle Rock" (sandstone)		
Paskapoo sandstone		
Devonian Palliser limestone		
Wapiabi shale		
Gypsum		
Dolomitic shale		
Ordovician quartzite		
Ammolite		
Coal		
Oil		

2.3.4 In groups, use the list created in 2.3.1 of uses of the Rockies and categorize these uses in terms of psychological, physical, social, and economic needs.

2.3.5 For each human need met by the Rockies, use the table below to consider the characteristics and how the activity may impact upon the natural environment of the Rockies.

Human Need	Contributing Characteristic(s)	Potential Impact on the Rockies
e.g. Tourism	Natural beauty, wilderness, mountains, rivers	Overcrowding, building of facilities such as hotels etc., degradation of natural environment

2.3.6 Identify some of the activities that have taken place in this region to maintain the features or characteristics that attract people in the first place.

2.3.7 List the ways in which the human occupation of the Rockies has detracted from the Rockies themselves.

Similar mineral deposits rich in copper, zinc, and iron sulphides as well as gold, silver, and manganese are presently forming at black smoker sites along mid-ocean ridges around the world.

Extension Activities

2.3.8 Debate the statement "pristine wilderness areas are best left with no development so that they can be preserved."

Web Links

- The Web site of the British Columbia Mining and Mineral Exploration Overview 2006 (www.empr.gov.bc.ca/DL/GSBPubs/Reviews/2006/EX-REVIEW_IC2007-1.pdf) provides important information on metallic minerals in the Rockies. Although there are few volcanic rocks in the Canadian Rockies, there are many volcanic and intrusive rocks in the terranes of the Cordillera. These provide the hydrothermal fluids to form similar mineral deposits to those in the Colorado Mineral Belt.

2.3.9 Using the Web site above, identify the locations and mine names where gold, silver, copper, and molybdenum are mined or being developed.

4

CHAPTER 4

Erosion on a Grand Scale

Keywords

erosion, glacial processes, landforms of glacial erosion, landforms of glacial deposition, climate change, glacial history, rock resistance

Introduction

Making mountains into their present form involves the powerful processes of erosion wearing away at the mountains grain by grain, pebble by pebble. Many of the peaks are considerably lower than they were when first formed. The processes eroding the mountains are varied and include erosion by ice (very important over the last two million years or so), water, gravity (causing slope failures on the steep slopes), and wind. What will the future of the mountains be?

Curriculum Objectives

- distinguish among agents of erosion
- investigate and distinguish between glacial erosion and glacial depositional processes as they relate to alpine valley glaciers and continental ice sheets
- demonstrate an understanding that the Earth's surface is dynamic, in that it is constantly being reshaped (e.g., mountain building, erosion)
- explain the potential effects of long-term climate change (e.g., global warming) on different parts of the world
- investigate cycles of glaciation throughout Earth's history and review the evidence for these events

Materials Required

- *Geologic Journey: The Rockies* video
- A collection of photos of mountains and mountain ranges from around the world
- A school atlas
- Images 2.7– 2.10
- Earth science or geography textbook
- Glacial feature photo glossary (www.sfu.ca/~jkoch/older_stuff/glacierglossary.html)
- Modelling clay
- Knife
- Small pieces (50 g each) of three rock types: limestone, sandstone, and mudstone or shale
- Calgary Geoscape Web site http://geoscape.nrcan.gc.ca/calgary/topics/landscape_e.php

Student Activities

2.4.1 Compare photos of the Rocky Mountains, the Appalachians, and the Himalayas. List some of the obvious differences. Suggest why some mountain ranges look vastly different from others.

2.4.2 The following is a list of mountain ranges from around the world. In small groups, decide on criteria for grouping, and group the mountains based on your criteria.

- Rockies
- Andes
- Appalachians
- Urals
- Alps
- Scottish Highlands
- Great Dividing Range (Australia)
- Torngats
- Westen Ghats (India)

View Chapter 4 of the video.

2.4.3 Using Chapter 4 and Images 2.7 to 2.10, identify features caused by glacial erosion: U-shaped valleys, cirques, arêtes, hanging valleys, horns, glacial lakes, polished rock, glacial striations, and grooves. (Full-colour copies of all the images referenced in this guide are available online at www.cbc.ca/geologic/teacher.html.)

2.4.4 How has glaciation shaped the Rockies?

2.4.5 Identify and make a sketch to illustrate deposits left by the ice as it melted and dropped its load of sediment eroded from the high peaks.

2.4.6 Use modelling clay, the image from the video showing the glacial erosion features, and the Calgary geoscape Web site, and "carve" the landscape to illustrate the role of glaciation on mountains in the Rockies.

Layer the modelling clay, starting with a thick blue layer (1 cm) for the limestones formed at the edge of the ancient North American continent during the Paleozoic. Cover this with a thinner (25 mm) layer of yellow clay to simulate the sandstones and shales deposited during the Mesozoic Era. Cut through the clay on a low angle (from the bottom left toward the top right) to simulate the thrust fault and then apply a compressional force to push the layers from the west over the eastern section.

Use a knife to erode the mountains to the present-day form as shown in the photo and the Calgary Geoscape Web site. Most of the Paleozoic limestone and all of the Mesozoic shale and sandstone can be eroded off the top of Mount Yamnuska to give the present-day shape. The older limestone is on top of the younger sandstones and shales, and the elevation of the mountain is about one quarter of its previous height.

2.4.7 This activity uses small pieces (50 g each) of three rock types: limestone, shale or mudstone, and sandstone (some of which may be available in the local area).

Describe each of the rock types.

Place each in separate plastic containers and shake briskly for 10 – 15 seconds.

Re-examine the rock and describe the changes in appearance.

Summarize the changes in a "before and after" chart.

Which withstood erosion (the hard shaking) the best?

If all three of these rock types were exposed to erosional forces at the tops of mountains, which would be most and the least resistant?

How do the results match with the type of rock identified in *Geologic Journey* as making up most of the spectacular scenery in the Rockies?

2.4.8 What are the scientists looking for and measuring to tell them whether the ice is disappearing or not?

2.4.9 What other evidence did you see in the video that would suggest that the ice is indeed melting away?

Extension Activities

2.4.10 Research the pattern of glaciation in the past two million years and reconstruct a timeline showing when the Rockies were covered in ice and when they were ice-free. Project your pattern into the future.

2.4.11 The video talks about cycles. Research glacial cycles from earlier than the Pleistocene. Illustrate your findings in chart or graph form.

2.4.12 Where do scientists find the evidence for older glaciations?

Web Links

- Geological Survey of Canada, Miscellaneous Report 72, 2002; 1 sheet, available from http://geoscape.nrcan.gc.ca/calgary/index_e.php as a free download

3: The Canadian Shield

Introduction

The Canadian Shield is the largest single expanse of ancient rock anywhere on the planet. It stretches from the Arctic Ocean to Mexico. Some of the Shield lies exposed where erosion forces have been active, but at the outer limits it is buried deep under younger rocks. Once seen as barren and inhospitable, the Shield has hidden treasures waiting to be revealed by the relentless grind of erosional processes or discovered by the diligence of those who search for their individual prizes.

The treasures held by the Canadian Shield vary from the resources of nickel, copper, and gold, their associated jobs that help to drive the economic engine of the country, and the treasures of discovery related to the activity of early organic life forms and early human activity.

The episode is divided into five chapters. The first chapter examines the basic characteristics of the Shield—size, age, and the processes that have created and modified it. The geology of human activity and the high level of technology employed in the quest for answers about the Shield's mysteries are the areas of focus for the next chapter. Chapter 3 examines the resource riches and the connected economic activity generated by these discoveries. This is followed by "case studies" of the mineral riches of the Sudbury Basin and the impact structure at Manicouagan. Finally, the search among the oldest rocks on Earth for the newest source of wealth on the Shield—diamonds—is examined. The low-tech methods used in this treasure hunt are contrasted with the high-tech methods used in the Torngats.

- Chapter 1: Meet the Torngats 13:00 minutes
- Chapter 2: The Geology of Human Activity 10:00 minutes
- Chapter 3: The Search for Gold 7:15 minutes
- Chapter 4: The Sudbury Basin and Manicouagan 10:00 minutes
- Chapter 5: Diamonds: The New Resource 4:45 minutes

The episode can be viewed in its entirety (44 minutes) or divided into the five chapters indicated. The viewing questions are associated with each of the chapters but could be consolidated into a series of questions covering the entire episode. Suggested responses to the viewing questions can be found in the Answer Key on the Web site at www.cbc.ca/geologic/teacher.html.

The Canadian Shield 1

CHAPTER 1

Meet the Torngats

Keywords

zircon, chert, magma, pyrite, sandstone, shale, prehistoric coal, geologic time

Introduction

Chapter 1 of *The Canadian Shield* explores the Torngat Mountains of eastern Quebec (part of Nunavik): the ancient rocks, the mountain-building processes, and the importance of zircon as the “black box” of the mountain-building record.

Students should have a basic understanding of the concept of plate tectonics as well as the processes that are involved in the changes that occur on land, as well as under it, such as mountain building, and erosion. Chapter 2 in The Appalachians could serve well as an introduction to plate tectonics and mountain building for students with little background in this area. An ability to read and interpret maps and other images of the Shield’s landscape is also valuable.

Curriculum Objectives

- recognize that physical evidence found on the surface of the Earth and at the bottom of the oceans supports the theory of plate tectonics
- identify the mechanisms of change within the lithosphere (e.g., mountain building)

Materials Required

- *Geologic Journey: The Canadian Shield* video
- Blank K-W-L charts (or students may prepare their own from a model, see Figure 5.3, p. 5-6)
- Base map of North America
- Image 3.1 – Coal Seam
- Image 3.2 – Zircon

Student Activities

3.1.1 Students will develop a K-W-L chart to illustrate what they “already know” (K), “want to know” (W), and “what they learn” (L) from the video. The first two columns (K and W) should be filled in prior to showing the video.

The K-W-L charts can be used in a variety of ways. One method is to have pairs of students share their information, then have the pairs join to form a group of four, and then have the groups of four post results for the whole class. This can be done in different ways. Students can share the K and W information before viewing the video and then complete the L column after the video, or the three columns can be shared after watching this chapter of the video.

View Chapter 1 of the video and Images 3.1 and 3.2 and respond to the following questions. (Full-colour copies of all the images referenced in this guide are available online at www.cbc.ca/geologic/teacher.html.)

3.1.2 Identify two pieces of evidence that the Canadian Shield is the oldest physical region in Canada. Make use of the term *geologic time* in your response.

3.1.3 Explain why the Torngat Mountains of Labrador are of interest to the researchers from Memorial University.

3.1.4 What do the geologists hope to find in the rock samples gathered in the Torngat Mountains?

3.1.5 Explain the importance of zircons to the expedition.

3.1.6 Provide two examples from the video that support the concept of mountain building in this region.

3.1.7 Why is prehistoric coal an indicator of primitive life on Earth?

3.1.8 To understand the extent of the Canadian Shield, develop a map of the Shield’s location throughout North America. Use a blank map of North America, the description from this video, and information from a classroom atlas to identify the boundaries of the Shield. Transfer this information to your base map, noting that there are areas of the Canadian Shield that underlie other physical regions. Mark the following locations mentioned in the video on your map.

- Grand Canyon
- Torngat Mountains
- Nain
- Labrador
- Rama Bay
- Northwest Territories
- Abitibi region
- Hudson Bay
- Sudbury
- René Levasseur Island
- Manicouagan
- Yellowknife

The traditional Inuit gave the region the name Torngait, which means "a place of spirits." Their master spirit, Torngarsoak, was believed to take the form of a great polar bear that controlled the life of the sea animals.

3.1.9 Pangaea is the name of the supercontinent from the past that ultimately broke up and gave rise to our current continental pattern. The tectonic processes at work from the time of Pangaea until the present day have been consistent. Were the tectonic processes at work **prior** to Pangaea consistent with the current process? Prepare a written response to support a position with at least one solid argument based in geologic foundations.

Extension Activity

3.1.10 Visit the Smithsonian National Museum of Natural History Web site for Geologic Time (http://paleobiology.si.edu/geotime/main/index.html) and use this resource to explore changes that have occurred over time from both the concept of human processes as well as Earth processes. What is the significance of the Acasta Gneiss mentioned in relationship to the Hadean Era?

Suggestions for Assessment

Teachers may choose to assess students on their participation in the group exercise, or evaluate the map work or the written response using their own assessment and evaluation tools.

GEOLOGIC JOURNEY

The Canadian Shield 2

CHAPTER 2

The Geology Of Human Activity

Keywords

Rama Chert, Archaean Era, laser ablation, ICPMS

Introduction

The focus for this chapter is human activity and the relationships of human activity to the geology of the area. By finding shaped pieces of Rama Chert, a very strong glass-like material, scientists deduce that early humans used these pieces as tools. The chert may contain elements of earlier organic life that also can be used to indicate biologic activity from earlier times.

The process of mountain building is an important part of this chapter. Scientists need to find zircon samples from the highest peaks of the Torngats because it is at these heights that the rock has not yet been reset by the intrusion of younger volcanic rock, and the zircon samples can be used for accurate dating of the rock samples.

Using laser technology in a laboratory at Memorial University, the scientists reveal the secrets of the zircon and discover the age of the rock samples they have brought back from the Torngats.

Curriculum Objectives

- understand the role of erosional agents in shaping physical features
- analyze the relationships between the present characteristics of local landforms and the processes that shaped them
- identify the mechanisms of change within the lithosphere (e.g., mountain building)
- evaluate the role of technology in changing relationships between humans and the environment

Materials Required

- *Geologic Journey: The Canadian Shield* video
- Image 3.3 – Rama Chert knife
- Diagram showing the concept of plate tectonics (Figure 4.4, page 4-6) or one of the hands-on activities found in Chapter 1 of *The Rockies*.

Student Activities

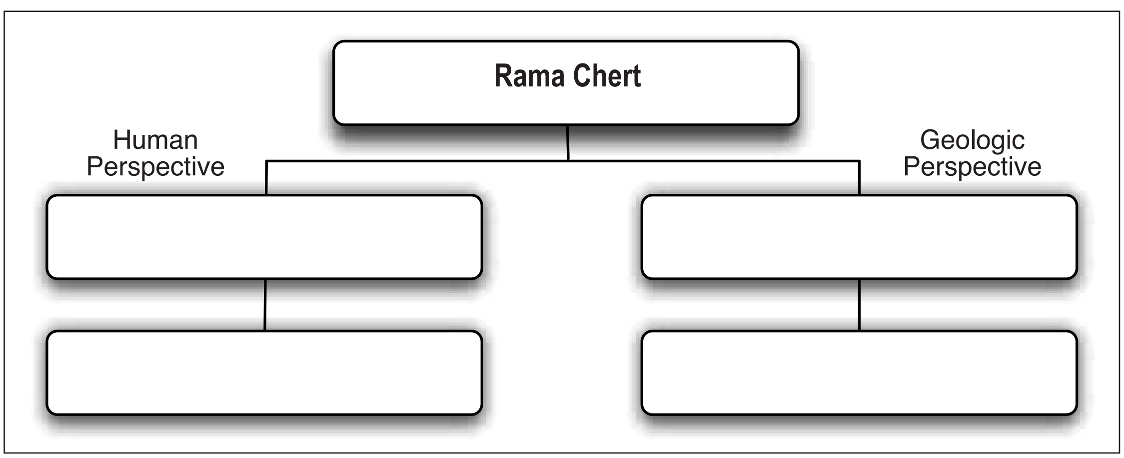
3.2.1 What do you think occurs along the contact points for land masses?

View Chapter 2 of the video and respond to the following questions.

3.2.2 What evidence did you see that supports the hypothesis that the rocks at mountain peaks were once found on the ocean floor?

3.2.3 What is the connection between Rama Chert and early human activity?

3.2.4 Using Rama Chert as the starting point, list two points on each side of the chart to show the different perspectives—human and geologic—that have been discussed in this chapter as they relate to the chert.



The Canadian Shield is the largest physiographic region in Canada. It can be found in six provinces and two territories.
In Ontario, it covers nearly two-thirds of the province.

3.2.5 What is the value of rock samples from the mountain peak vs. samples from lower altitudes?

3.2.6 How is the age of the zircon samples determined?

3.2.7 What evidence indicates that there has been more than one mountain-building event?

3.2.8 Scientists who study the actions of the Earth depend on many different levels of technology. These range from relatively low-level technology such as pick and shovels to high-tech laser technology. Prepare a comparison chart to compare the advantages and the disadvantages of high-tech and low-tech methods of studying the Earth.

Technology	Advantages	Disadvantages
High Technology		
Low Technology		

3.2.9 Prepare a summary note outlining the value of technology to the study of the Earth and offering specific examples of advantages and disadvantages for low and high tech.

3.2.10 Conduct research to determine the role of satellites and satellite imagery in the discovery and analysis of new mineral deposits.

3.2.11 What educational "track" would you have to take in order to use the high-tech elements involved in mineral discovery and exploitation?

Extension Activities

3.2.12 Visit the Parks Canada Web site (www.pc.gc.ca) to find the Torngat Mountains National Park Reserve page. Read the sections on A Cultural Landscape, The Physical Landscape, and the Torngat Geology. Develop a one-page, two-fold brochure to promote the Torngats as a unique vacation destination.

3.2.13 In 1860, a visiting geologist from the U.S. described the Torngats as "where rocks revel in their freedom." How has this chapter of the video, nearly 150 years later, substantiated this statement?

Suggestions for Assessment

Students can be assessed for participation and completion of the work for this section.

CHAPTER 3

The Search for Gold

Keywords

crucible, geologic plumbing, silica, verdigris

Introduction

The concepts of geologic time and mountain building are central to this chapter. Scientists searching for gold look for the clues to the existence of this treasure. Deformed rock features may indicate the presence of the base of a former mountain chain. Here, the heat and pressure were so extreme that they dehydrated the rocks and forced fluids containing gold up to the surface—a process referred to as "plumbing." Other indicators of gold are veins of white quartz and copper.

The concept of risk and reward is one that could be shared with the students as it pertains to the search for gold. When gold is found it can be beneficial financially, but if the search is not successful, it can be a very expensive task with no reward.

Curriculum Objectives

- understand the role of erosional agents in shaping physical features
- analyze the roles of natural features and processes in providing economic resources for society
- identify the educational requirements, job descriptions, current opportunities, and future prospects for selected careers that require geographic knowledge and skills

Materials Required

- School atlas with a physical plate showing mining activity in Canada
- Geologic Timeline (Figure 4.8, page 4-9)
- *Geologic Journey: The Canadian Shield* video
- Image 3.4 – Gneiss Formation

Student Activities

3.3.1 We all know something about gold. Using previously acquired knowledge, answer the following questions to see how much you really know.

True / False Gold can be found in the shield areas of the world.

True / False Ore found at the roots of old shield mountains has been exposed due to erosion.

True / False Val d'Or, Quebec, Timmins, Ontario, and Yellowknife, Northwest Territories, all have gold deposits.

True / False Gold has played an important role in the history of Canada.

True / False Gold is the only significant element mined in the Canadian Shield.

True / False Quartz is an indicator that gold may be present in an area.

View Chapter 3 of the video and respond to the following questions.

3.3.2 Explain the importance of finding copper mixed in with the quartz deposit.

3.3.3 Explain the relationship between the deposits of gneiss and the old mountain chain.

3.3.4 What is the significance of the geologic process known as "plumbing" to the search for gold.

3.3.5 Develop a concept map to indicate the consequences of finding new deposits of resources for remote communities in the Canadian Shield. Begin with three positive and three negative points, and then branch out from each point to provide two more thoughts on the subtopic.

3.3.6 In this chapter of the video, the search for gold takes only a few minutes. Suggest two steps that would need to be taken prior to a helicopter search for gold—or any other mineral.

3.3.7 Refer to a physical map of the Canadian Shield that indicates mining activity (e.g., *The Pearson School Atlas,* p.20). Record the location of gold mines and copper mines on the map of the Canadian Shield developed earlier in this section. Describe any pattern you see for the location of each of the types of mines. What clues are there on your map that would suggest a new area to search for gold? Explain/support your choice.

3.3.8 The search for gold in this chapter makes use of a variety of clues that are embedded in the landscape. One of these clues is revealed in Image 3.4. Explain how the "ultmate clue, a vein of white quartz" in the rock is significant to the search. Identify two other clues that were mentioned in the video, select the one that you believe to be the most significant and be prepared to support your choice to the class.

Extension Activity

3.3.9 Research a Canadian mining company and prepare a summary of their business. Use the Internet and also write to the company to obtain your information. The summary should include where they are located in Canada, what minerals they focus on, the background of the company, and the challenges they face in this industry, now and for the immediate future.

Suggestions for Assessment

Concept map and the map analysis activities can be assessed for process or evaluated based on the supporting points provided in the explanations.

Keywords

meteorites, Sudbury Basin, Archaean Shield, impact crater, melt sheet, core samples

Introduction

The Canadian Shield near Sudbury, Ontario, was hit by a meteorite about 1.8 billion years ago; it helped mould the geology of the Sudbury Basin. The impact created a unique environment where several mineral resources were formed, creating a lucrative site for resource extraction in Canada. Geologist John Spray explores this area of the Canadian Shield, and later in the chapter travels to the impact crater area at Manicouagan in Quebec to investigate whether this more recent meteor impact zone has the same potential for resource wealth as the Sudbury Basin.

Curriculum Objectives

- explain the economic importance of certain geological formations (e.g., Sudbury Basin)
- analyze the roles of natural features and processes in providing economic resources for society
- explain the different points of view on a geographic issue that are, or might be, held by various stakeholders (e.g., individuals, business organizations, governments, special interest groups)

Materials Required

- *Geologic Journey: The Canadian Shield* video
- Image 3.5 – Space View of Manicouagan
- Image 3.6 – Core Samples
- The Earth Impact Database – http://unb.ca/passc/ImpactDatabase

Student Activities

3.4.1 Develop a list of the various stakeholders that might be interested in a proposed mining development associated with mineral deposits (using the Manicouagan deposit as an example).

3.4.2 Several mining towns in the past have declined due to the dependency on a single industry. Sudbury has been able to avoid this sort of decline by expanding its economic base. Do you think the future mining centre of Manicouagan will be able to replicate Sudbury's success, and if so, how would you advise this community to proceed?

View Chapter 4 of the video and respond to the following questions.

3.4.3 What is the Archaean Shield?

3.4.4 Explain how nickel-bearing minerals formed as a result of meteorite impacts.

3.4.5 Why is it logical to presume that there would be mineral wealth located at other impact sites on the Canadian Shield?

3.4.6 The impact crater at Manicouagan is described as a mere youngster. What implications does this have from a mining perspective? Use The Earth Impact Database to compare the ages of the impact events for the Canadian Shield area. If the age of the impact crater is a significant factor in the ability to successfully mine the area, which areas on the Canadian Shield have a better chance of yielding successful mines than Manicouagan?

3.4.7 Explain the value of the core samples to the exploration of the Canadian Shield.

3.4.8 Using small groups (the number will vary based on the number of students in the class; if the class is particularly large, consider having two sets of five groups), assign students to the following roles representing a variety of interest groups related to the development of mineral resources in the Shield:

- Mining company executive
- Politician
- Environmentalist
- Local citizen
- Native person

Each interest group will be responsible for developing a position, from their point of view, about the development of a new mining complex at Manicouagan with the potential for huge economic benefits. The development may have positive as well as negative effects; it is important to separate facts from opinions and to recognize bias in articles used for research. Each of the interest groups meets with their research and develops a common position for the group—then records that position.

The impact crater at Sudbury is estimated at 1.85 billion years old, and is almost 200 km across.

Reorganize the student groups so that the new groupings have a representative from each of the interest groups. The groups are now made up of representatives of the different roles. Students share their perspective with others who may have a different perspective on the issue and make notes about the "other sides" of the issue.

Restructure the original interest groups and debrief the positions of the other groups.

Try this! On The Earth Impact Database locate the stereo pair of the Manicouagan impact crater for a three-dimensional view of the site in Quebec.

Post on chart paper a revised position on the proposed development to enhance the group's position and, at the same time, acknowledge the presence of other opinions.

Students write their name on the chart paper that has the position about development that they are personally most comfortable with.

Debrief the activity by examining their choices and the rationale for the choices.

Extension Activities

3.4.9 Plan a school field trip (or virtual field trip) to Science North and Dynamic Earth in Sudbury, Ontario. Make use of the Web sites http://sciencenorth.on.ca and http://dynamicearth.ca/dynamic-earth.html. In your field trip, outline the areas you wish students to visit, how long the visit will last, what information should be gathered, and, most importantly, what they would do in advance of the visit and what they would produce to illustrate the value they received from the visit.

3.4.10 In small groups, plan and deliver a lesson to a lower grade about the mining industry in the Canadian Shield.

Suggestions for Assessment

Students can be assessed for participation in the group role-play activity. Evaluation of the groups can be based on their written responses and their ability to support their positions in the large-group discussion.

5

CHAPTER 5

Diamonds: The New Resource

Keywords

melt sheet, Slave Craton, showings, indicator minerals, kimberlite

Introduction

The Slave Craton is an old and stable part of the continent. It is part of the area “where time began, the very place where the North American continent was conceived.”

It is significant to this chapter because the Craton has undergone much erosion by the elements of water, wind, and ice; of particular importance is the recent glacial activity. Due to this erosion, and other geologic activity, diamonds have been brought to the surface of the Earth. The diamonds are transported from the interior to the surface through kimberlite pipes. The low-tech approach to mineral exploration is also shared in this chapter. Using maps and assessment reports, clues may be found that may lead to the discovery of diamonds.

Curriculum Objectives

- understand the role of erosional agents in shaping physical features
- identify the educational requirements, job descriptions, current opportunities, and future prospects for selected careers that require geographic knowledge and skills
- evaluate the role of technology in changing relationships between humans and the environment

Materials Required

- *Geologic Journey: The Canadian Shield* video

The Ekati Mine is North America’s first mine to produce diamonds. It is located in the area of the central Slave Craton.

Student Activities

3.5.1 The marketing of diamonds as the ultimate symbol of love has been very successful over the years. What are some of the slogans used by diamond merchants? Do you believe that other gemstones—such as rubies or emeralds—will ever replace diamonds in this role? Why are Canadian diamonds more attractive to consumers than diamonds from Africa? Do you think Canadian diamonds will make a significant space for themselves in the global diamond market? Offer comments to support your point of view.

View Chapter 5 of the video and respond to the following questions.

3.5.2 Explain how the events of the most recent Pleistocene Glaciation of the past two million years have been significant in helping with the discovery of diamonds, possibly formed as early as three billion years ago.

3.5.3 Offer one advantage and one disadvantage to taking a low-tech approach to prospecting.

3.5.4 What is the significance of a kimberlite pipe?

3.5.5 Diamonds are often found in sediments. How can that be explained, given that diamonds were formed in kimberlite pipes?

3.5.6 Prospector Walter Humphries notes that “the chance of … finding a mine in [t]his lifetime is pretty remote.” Why is this the case?

3.5.7 Write an opinion-based article supporting or refuting the notion that the Canadian Shield be designated as a protected area. Following discussion and evaluation, articles can be submitted to local or national media for consideration.

3.5.8 Prepare a “T Chart.” On one side, list the different employment opportunities related to mining found on the Canadian Shield. In the second column, suggest the importance of a sound knowledge of Earth sciences/geography as a basis for employment in this area.

3.5.9 In this chapter the Canadian Shield has been referred to as a “national icon.” Research the notion that the Shield is indeed a “national icon,” viewing the notion from different perspectives (e.g., the geologic perspective, the economic perspective, the human perspective, or the environmental perspective), or from a different perspective that you can identify and articulate to the teacher.

3.5.10 Conduct a debate on the Canadian Shield as a “national icon.” Students take a stance of “agree,” “disagree,” or “undecided” and move to an area of the classroom where others of a similar position are located. Students in the “undecided” area should be reminded that they will have to take a position on the issue later in the debate. Following debate on the issue, the “undecided area” is off-limits and students then re-examine their position on the issue and move to the appropriate area of the class—agree or disagree—where others of a similar position are located.

Extension Activity

3.5.11 Prepare a visual presentation for a school open house, or as a department promotion that shows the changes in geotechnology over the past century and focuses on the discipline of geography and earth sciences as a vital, current field of study.

Suggestions for Assessment

Students may have their opinion-based articles evaluated based on criteria established by the teacher.

Responses offered in the debate can be assessed for quality and depth of thought.

4: The Appalachians

Introduction

This episode of *Geologic Journey* explores the geology and major geologic events that have created the Appalachian Mountains. The episode focuses on the tectonic forces that developed these mountains over 300 million years ago, the economic and environmental legacy of the area, and the importance of this area as a source of scientific data supporting theories of the Earth's geological evolution.

The episode on the Appalachians is divided into five chapters:

- Chapter 1: Coal: Getting It Out of the Ground — 12:00 minutes
- Chapter 2: Colliding Plates, Making Mountains — 3:30 minutes
- Chapter 3: New Technologies, New Theories — 8:15 minutes
- Chapter 4: Want to Be an Earth Scientist? — 10:15 minutes
- Chapter 5: Earthquake Hazard — 11:00 minutes

The episode can be viewed in its entirety (44 minutes), or can be divided into the five chapters indicated. The viewing questions are associated with each of the activities but could be consolidated into a series of questions covering the entire episode. Suggested responses to the viewing questions can be found in the Answer Key on the Web site at www.cbc.ca/geologic/teacher.html.

Keywords

anthracite, bituminous, lignite, folding, drift mining, strip mining

Introduction

The activity begins by having students develop some background on coal in the Appalachian region. The focus then moves to the changing methods of mining coal in the anthracite region of Pennsylvania over the past century and how these methods have impacted the miners and the environment of the region.

Curriculum Objectives

- investigate the impacts of changing resource-extraction technologies on human beings and the natural environment
- describe the geological processes that produce valuable mineral resources such as coal

Materials Required

- *Geologic Journey: The Appalachians* video
- Figure 4.1 – Types of Coal
- Figure 4.2 – Distribution of Pennsylvania Coal
- Figure 4.3 – Cross-section of the Geology of Pennsylvania

Student Activities

4.1.1 Survey the class to determine the sources of energy used to heat their homes and water and to cook their food. Summarize the results in chart form.

4.1.2 Compare these results with a historical view of sources of energy that were available 50 to 100 years ago when natural gas, oil, and solar heating were not as prevalent as they are today. Summarize these results. (Hopefully coal will appear in the list).

4.1.3 Explore the reasons for shifting from such energy sources as wood and coal to natural gas, oil, solar, and electrical energy (e.g., lower cost, cleaner burning, easier to regulate burning, and less storage space needed).

4.1.4 Suggest how energy sources might change in the future.

4.1.5 Identify the differences among the types of coal shown in the following chart.

Figure 4.1 – Types of Coal

Coal Type	Carbon Content	Hardness	Heating Value (kJ/kg)	Major Uses
Anthracite	85-95%	Hardest	35 000 +	Water Purification, Home Heating
Bituminous	45-85%	Medium Hard	25 000 to 35 000	Electricity Generation, Iron and Steel Making
Sub Bituminous	35-45%	Medium Soft	20 000 to 30 000	Electricity Generation
Lignite	25-35%	Soft	10 000 to 20 000	Electricity Generation

4.1.6 Suggest reasons for the choice of anthracite to heat homes in the past.

Study the map and cross-section below and answer the questions that follow. The map shows the areas of Pennsylvania where different types of coal are found. The diagram shows a cross-section of the geology of Pennsylvania.

Figure 4.2 – Distribution of Pennsylvania Coals

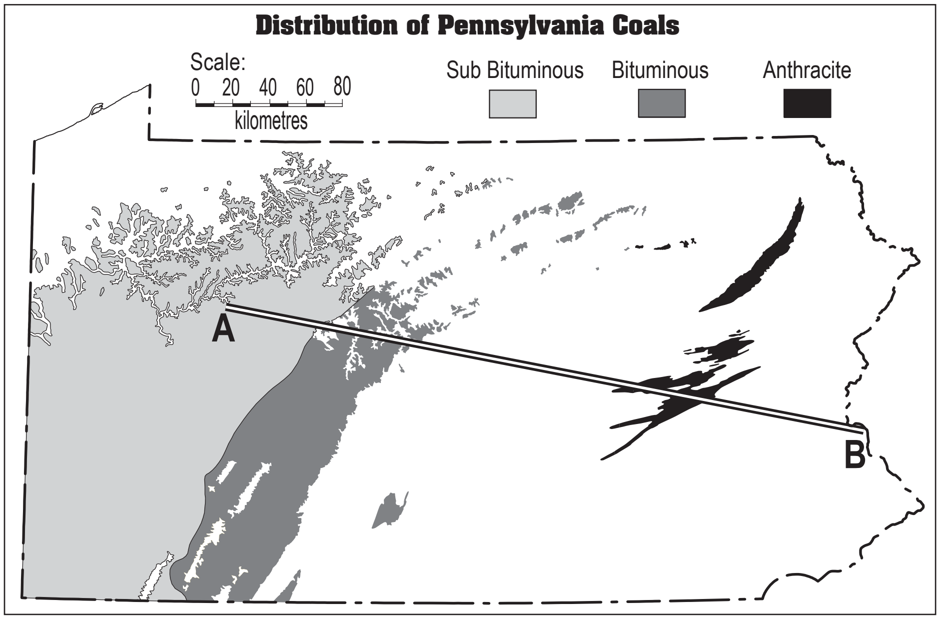
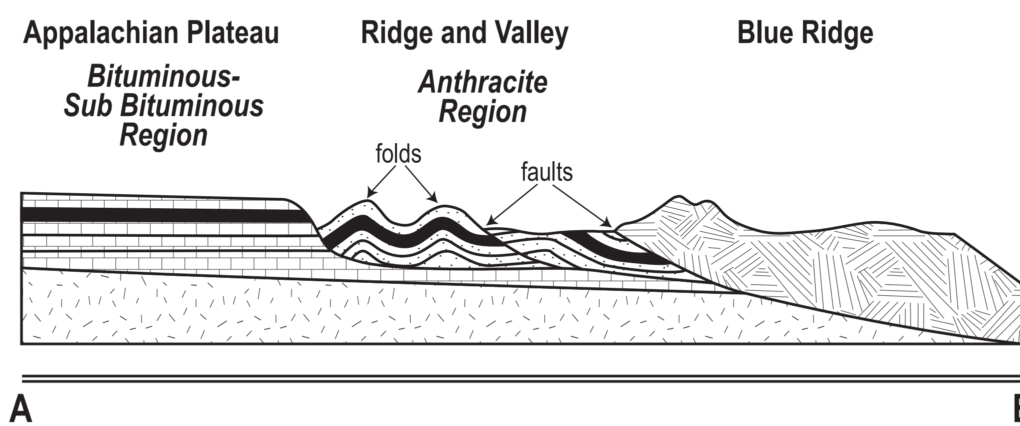


Figure 4.3 – Cross-section of Appalachian Landforms



4.1.7 Identify the three types of coal occurring in Pennsylvania.

4.1.8 Describe the differences in the cross-section and coal deposits in the Anthracite Region compared with the Bituminous and Sub Bituminous regions.

4.1.9 What might account for the fact that the hardest coal, anthracite, only occurs in eastern Pennsylvania?

4.1.10 In which area would it be more difficult to mine coal? Suggest reasons for this difficulty.

4.1.11 View Chapter 1 of the video and complete the following organizer on differences in coal mining from the early 20th century to the early 21st century.

Time Period	Type of Mine	Number of Miners	Human Risks	Environmental Risks
Early 20th Century				
Early 21st Century				

4.1.12 What explains the change in mining methods and mining employment by the beginning of the 21st century?

4.1.13 Explain how you decided on the level of human and environmental risks based on what was shown in the video.

4.1.14 In small groups, debate the notion that changes in mining methods have been justifiable based on human and environmental grounds.

4.1.15 Conduct research to identify areas of the world where mining—especially coal mining—is still very dangerous.

Suggestions for Assessment

Peer assessment or evaluation might be used for the completed organizer and the explanations for the changes and the student estimation of the level of human and environmental risks associated with each type of mining.

Teacher evaluation would be more appropriate for the answer to the inquiry question.

Web Links

Web sites with information on coal include:

- http://en.wikipedia.org/wiki/Coal
- http://en.wikipedia.org/wiki/Anthracite
- www.rocksandminerals.com/coal.htm
- www.worldcoal.org
- www.teachcoal.org/aboutcoal/index.html
- www.rocksandminerals.com/coal.htm
- http://en.wikipedia.org/wiki/List_of_disasters

The Appalachians

2

CHAPTER 2

Colliding Plates, Making Mountains

Keywords

tectonic plate, plate boundary, collision boundary, Pangaea

Introduction

This activity requires prior knowledge and understanding of the basics associated with plate tectonics theory and familiarity with the terms *tectonic plate, continental and oceanic crust, plate boundary*, and *Pangaea*. The chapter examines the processes and physical features that occur when two plates carrying continental rocks collide with one another. Students then apply the theory to the actual formation of the Appalachians, using maps, and then add a more detailed look at one aspect of the creation of the Appalachians outlined in the video.

Teachers should use the first 3½ minutes of Chapter 1 of the video and the complete Chapter 2.

Curriculum Objectives

- explain the relationship between plates, tectonic activities—including earthquakes—and mountain building
- describe the differences between oceanic and continental rocks and explain the processes at work along plate boundaries

Materials Required

- *Geologic Journey: The Appalachians* video
- Figure 4.4 – Continental Collision Model
- The three-map series (Figures 4.5, 4.6, and 4.7) showing the formation of the Appalachian System
- Figure 4.8 – Geologic Timeline

Student Activities

View the first 3½ minutes of Chapter 1 of the video, where continents are shown drifting together and apart.

4.2.1 What is depicted in this short clip?

4.2.2 Hypothesize what would happen when two continents bump into, or collide with, each other.

4.2.3 What real-life examples could simulate the same type of activity?

4.2.4 Examine the diagram set Continental Collision Model (Figure 4.4) and use words to describe what has happened over the sequence of the three diagrams.

4.2.5 Explain how these diagrams could be applied to the development of a mountain system today.

4.2.6 Using an atlas with relief and physical features, draw a simple sketch that outlines and labels the two continents that are colliding, includes arrows to show the movement of the two continents, and uses lines to show the pattern of mountains that are a result of this collision.

4.2.7 Using the maps showing the formation of the Appalachians (Figures 4.5 to 4.7) and the Geologic Timeline (Figure 4.8), mark the two dates shown on Figures 4.5 and 4.7 and label the events shown by all three maps in the spaces provided on the Geologic Timeline.

4.2.8 Based on Figures 4.5 to 4.7, write a description of what happened to form the Appalachian Mountains of North America.

4.2.9 What other parts of the world have remains of the same mountain-building event, based on Figure 4.6?

4.2.10 Based on Figure 4.7, what happened after the formation of the Appalachian Mountains? How many years passed before this event began to occur?

Figure 4.4 – Continental Collision Model

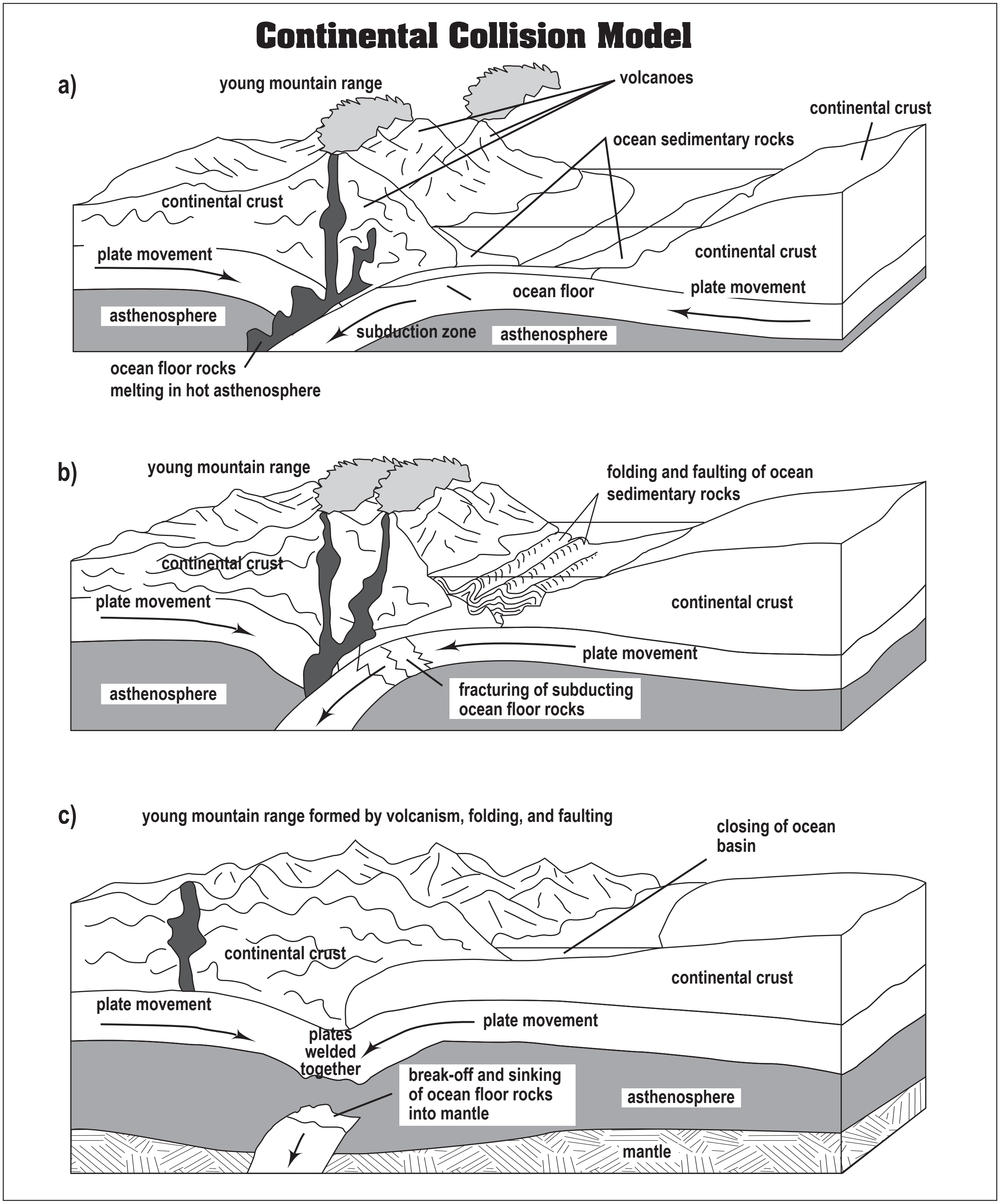


Figure 4.5 – Collision of Africa, Laurentia (North America), and Baltica (Northern Europe)

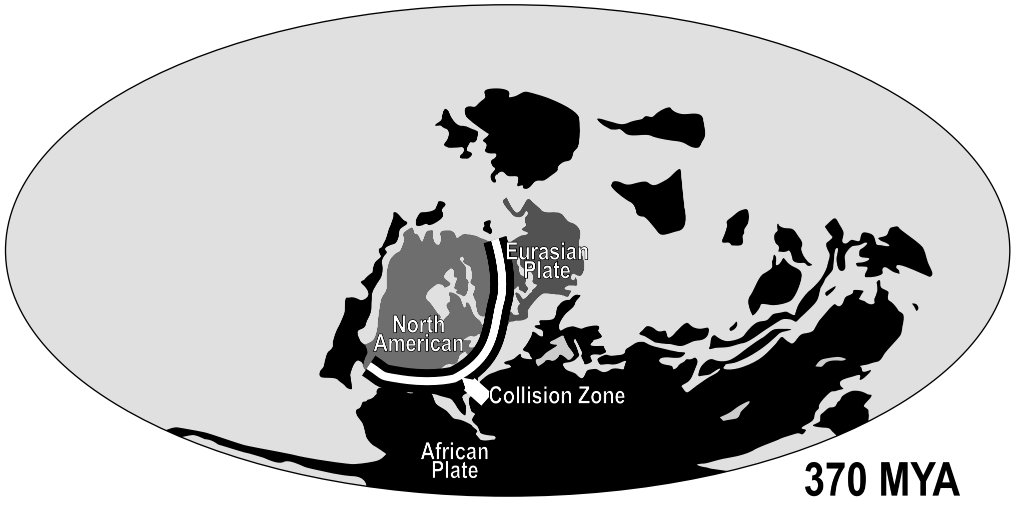


Figure 4.6 – Collision Zone: Forming Mountains

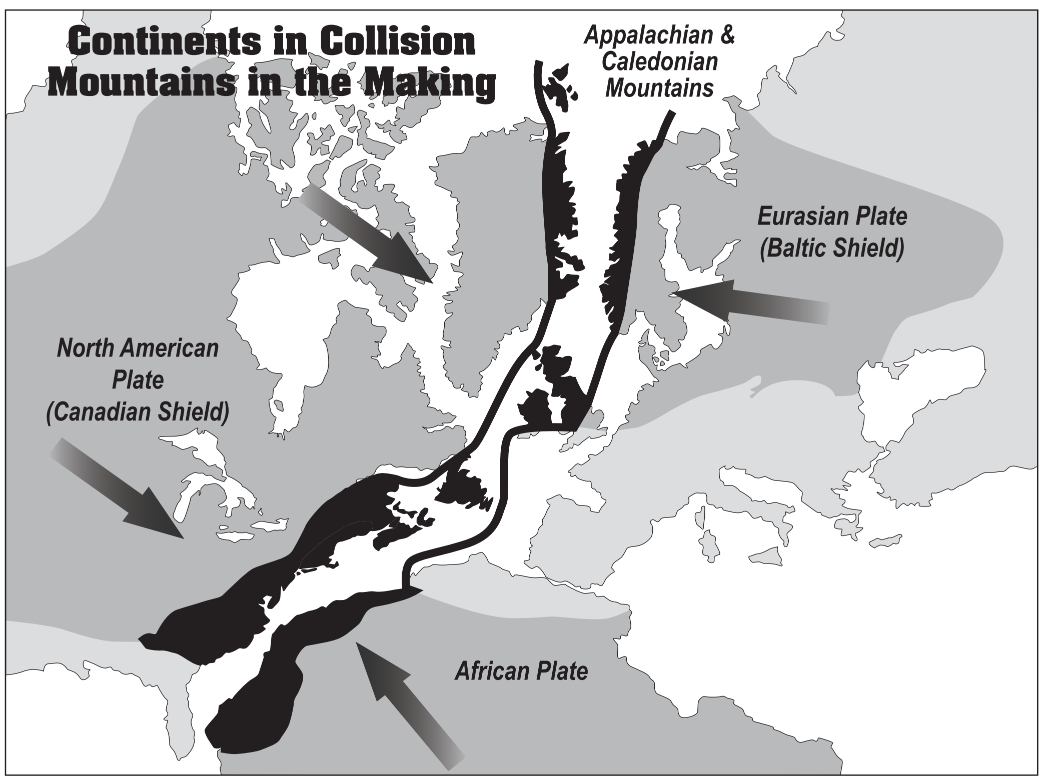


Figure 4.7 – The Breakup of Pangaea

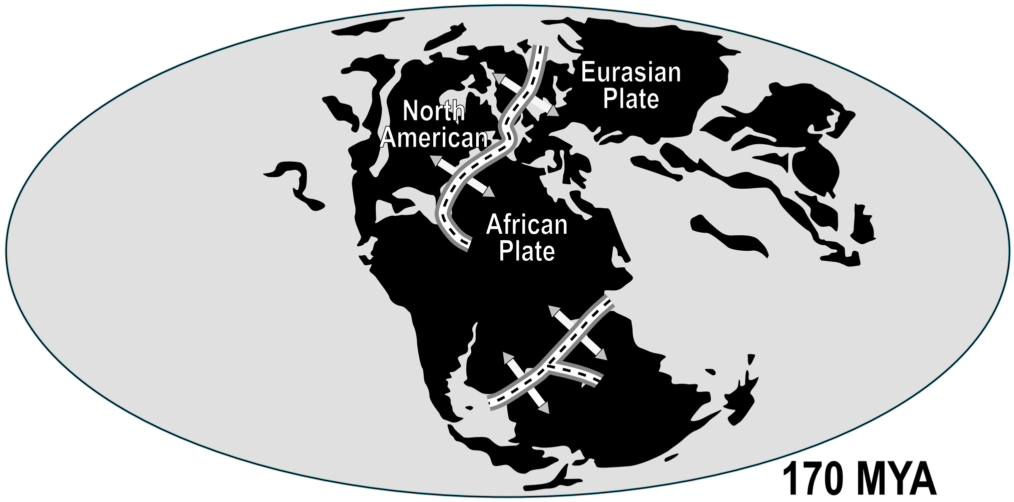
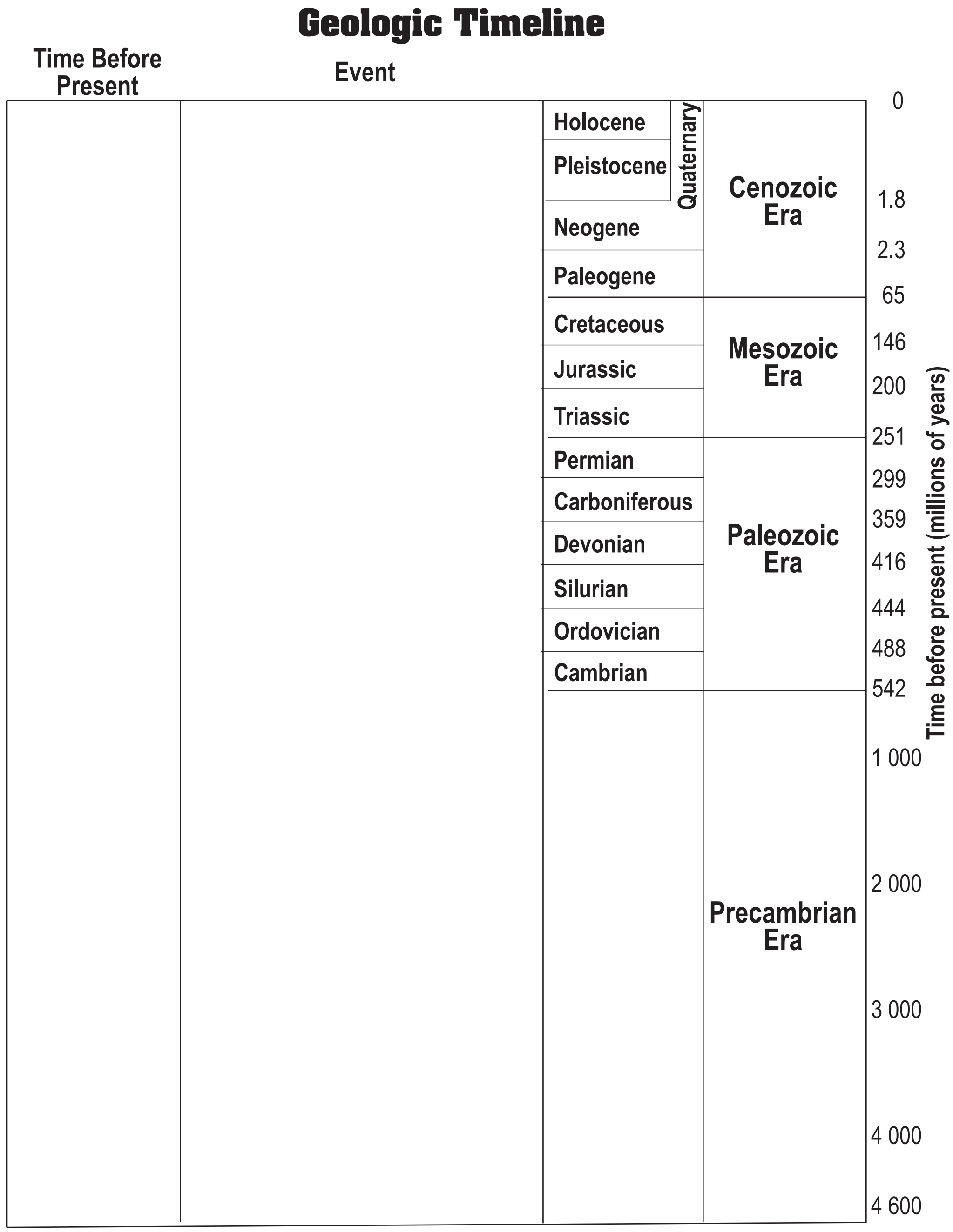


Figure 4.8 – Geologic Timeline



View Chapter 2 of the video and answer the following questions.

4.2.11 Describe the present-day mountains in Shenandoah National Park and compare their current description with what they looked like when originally formed.

4.2.12 What event was responsible for the formation of these mountains?

4.2.13 What evidence can be seen in the rocks today that prove that such an event occurred hundreds of millions of years ago?

Extension Activities

Students with access to the Internet could visit sites such as the following to gain a more detailed look at plate movements over geologic time. Each of these sites contains either a series of maps showing the Earth's continents at various times in the past or animated movies of plate movement.

- The Paleomap Project at www.scotese.com/earth.htm
- This Dynamic Earth: The Story of Plate Tectonics at http://pubs.usgs.gov/gip/dynamic/dynamic.html
- Geology: Plate Tectonics at www.ucmp.berkeley.edu/geology/tectonics.html
- Geologic Evolution of North America at http://jan.ucc.nau.edu/~rcb7/nam.html
- Paleographic Views of Earth History at http://jan.ucc.nau.edu/~rcb7/globaltext2.html

4.2.14 Describe the movement of plates that currently occupy specific locations on the surface of the Earth (e.g., Laurentia) and where they were located at different times (millions of years ago) in the past. Students can also investigate some of the unanswered questions related to plate tectonics.

The theory of the cycles of closing and opening oceans is known as the Wilson Cycle and is named after J. Tuzo Wilson, a world-famous Canadian geophysicist who was a major contributor to the theory of plate tectonics.

4.2.15 Research the important role of Canadians in the development of the theories related to plate tectonics for an independent study or research paper. For example, as J. Tuzo Wilson stated in 1968, "The Earth, instead of appearing as an inert statue, is a living, mobile thing." Explain why this theory is still in vogue 40 years later.

Suggestions for Assessment

Teachers may choose to have students hand in their Geologic Timelines and their written answers to the questions.

The Appalachians

3

CHAPTER 3

New Technologies, New Theories

Keywords

hypothesis, theory, GPS measuring equipment, radiocarbon dating, laser technology, isotopic data, zircons

Introduction

This chapter focuses on the relationship between the new technologies that have become available to earth scientists in their attempts to unravel the past history of the Earth over billions of years of time and the development and testing of old theories and/or new hypotheses.

Curriculum Objective

- understand the steps involved in the proposing, testing, and verification or refutation of hypotheses in the earth sciences

Materials Required

- *Geologic Journey: The Appalachians* video

Student Activities

4.3.1 Individually, and then in groups, develop a definition for the terms *hypothesis* and *theory*. Share the definitions with the class and come to a class consensus on what these two terms mean. Suggest why hypotheses and theories are important elements in a geologist's professional career.

4.3.2 Create a full-page organizer, based on the following example.

Case Study/ Researcher	Hypothesis	Technology in Use	Facts Collected Using Technology	Result of Hypothesis Testing
Montmorency Falls – Stephane Mazzotti				
New Madrid – Martitia Tuttle				
North Carolina/ Newfoundland – James Hibbard				

While viewing Chapter 3 of the video, complete the organizer.

In column 2, describe the hypothesis that each of the earth scientists is attempting to prove.

In column 3, describe one important type of technology being used in their quest for facts to test their hypothesis.

In column 4, list the data/facts they were able to collect using this technology.

In column 5, explain whether these facts helped to prove their hypothesis.

The theory of plate tectonics was one of the great revolutions in science and added greatly to our understanding of the processes that formed the world we see today. It emerged as a result of many new technologies that were developed during and after the Second World War to aid in the exploration of the seabed and its features.

4.3.3 If enough facts were assembled to prove a hypothesis, what name is now applied?

4.3.4 If the case studies presented in the program are typical, what can we expect to happen to present-day theories as new technological devices become available for use by earth scientists in the future? Explain your prediction.

Suggestions for Assessment

Teachers may choose to assess students on their ability to gather the appropriate information from the video to complete the organizer with accuracy and insight and to apply their understandings to give a well-argued answer to the inquiry question.

Want to Be an Earth Scientist?

Keywords

earth scientist

Introduction

The activities associated with this chapter of the video ask students to reflect on the knowledge and skills as well as the personality traits possessed by the individual earth scientists featured in the video, and the knowledge and skills that have helped them to become successful researchers. This information is used to examine career opportunities and interests in areas related to the earth sciences.

Curriculum Objectives

- identify careers and the knowledge, skills, and personal characteristics needed to carry out field and laboratory research in the earth sciences
- research job descriptions, current opportunities, and future prospects for careers in the earth sciences

Materials Required

- *Geologic Journey: The Appalachians* video

Because of its great size, geological complexity, and large variety and size of mineral resources, Canada offers many career opportunities for earth-science graduates.

Student Activities

4.4.1 As a pre-viewing activity, describe what two **personality traits** would be essential for anyone interested in becoming, or working as, a scientist, especially one that deals with the Earth and all of its complexities. In a large-group discussion, share ideas and compile a list of the traits mentioned and the number of times each is suggested. Repeat this process to identify some of the **knowledge and skills** that would be essential for carrying out the job of an earth scientist. Develop a summary list of these and the number of times each was listed.

4.4.2 In small groups, choose several personality traits as well as knowledge and skills from the lists generated and divide these among the members of the group. Each individual will focus on one personality trait and one knowledge/skill base and will write a brief note to indicate whether the traits (personality and knowledge/skills) they chose were demonstrated by the individuals shown in the two case studies in Chapter 4 of the video on the New Madrid area (Martitia Tuttle) and North Carolina/Newfoundland areas (James Hibbard).

Within the group, share findings; then each group will indicate very briefly whether the traits they researched were validated or invalidated. Where different groups disagree over the same trait, discuss and try to reach a consensus.

Based on these discussions, revise the list by underlining traits verified, removing traits that were not verified, and adding any additional traits that were suggested by the program but were not included in the original list after a general class discussion.

Apply what you have learned in this activity, other activities in this video series, and other exposure to career opportunities in this course, to answer the following questions.

4.4.3 How does this process represent a simplified version of the scientific method of proposing and testing a hypothesis?

4.4.4 Based on what you have learned from viewing some or all of the programs in this series, or in your previous work in this subject, would you consider pursuing a career in the earth sciences? Give reasons for your response, in some detail.

Suggestions for Assessment

Teachers may choose to assess the level and effectiveness of student participation in the group exercise and their answers to the two application questions.

5

CHAPTER 5

Earthquake Hazard

Keywords

earthquake, fault, rebound, earthquake hazard, earthquake magnitude

Introduction

This chapter asks students to assess the hazard level of earthquakes in the central and eastern regions with those of other regions of Canada and the United States. As part of their assessment, students are asked to comment on whether the level of concern suggested in the chapter is appropriate or exaggerated and to explain their position.

Curriculum Objective

- describe and explain the relationship between mountain building, faulting, plate tectonics, and earthquake activity

Materials Required

- *Geologic Journey: The Appalachians* video
- Figure 4.9 – Earthquake Epicentres
- Figure 4.10 – Seismic Risk

Student Activities

4.5.1 In small groups, and before viewing the video, identify areas where you think earthquakes are frequent, severe, and destructive to human beings and their activities.

4.5.2 What is the risk of experiencing earthquakes in your local area and the magnitude of any earthquakes that might occur there? Share each group's findings with the rest of the class and try to establish a consensus on the earthquake risk in your local area. From travel, general knowledge, or previous residence in other parts of Canada, establish a consensus on the earthquake risk in other parts of the country.

View Chapter 5 of the video.

4.5.3 What does the term *rebound* mean when used by geologists or earth scientists? Suggest how such rebound would cause earthquakes.

4.5.4 What is the size, or magnitude, of such earthquakes, according to the commentary in the video?

4.5.5 Earthquakes are related to what geologic features?

4.5.6 What is the name of one of these features found within southern Quebec and visible at Montmorency Falls?

4.5.7 Briefly describe how Martitia Tuttle is trying to predict the frequency of earthquakes in the New Madrid area of the central United States. Based on her research, how frequent are the massive quakes that occur in this region?

The next great quake forecast by earth scientists for Canada is expected to be offshore from Vancouver Island. It is possible that such a quake will produce a tsunami as well as cause destruction on a large scale throughout southwestern British Columbia and the state of Washington in the United States.

4.5.8 What impressions of earthquake hazards do you have from the comments in this chapter of the video?

Use the maps of earthquake epicentres (Figure 4.9) and seismic risk (Figure 4.10) and complete the following.

4.5.9 Locate your local community on each of the two maps and describe the relative number, and hazard level, of earthquakes in your area.

4.5.10 How does the number, magnitude, and hazard of earthquakes in your local area compare with other parts of Canada (the highest and lowest areas, for example).

4.5.11 Comment on whether the level of concern expressed in the video about earthquakes in eastern Canada/North America is appropriate or exaggerated. Explain your position, using evidence from the video and Figures 4.9 and 4.10.

Suggestions for Assessment

Have students submit their written answers to the last question, where they are asked to comment on the level of concern regarding earthquake hazards and to explain their position, for teacher evaluation.

Figure 4.9 – Earthquake Epicentres

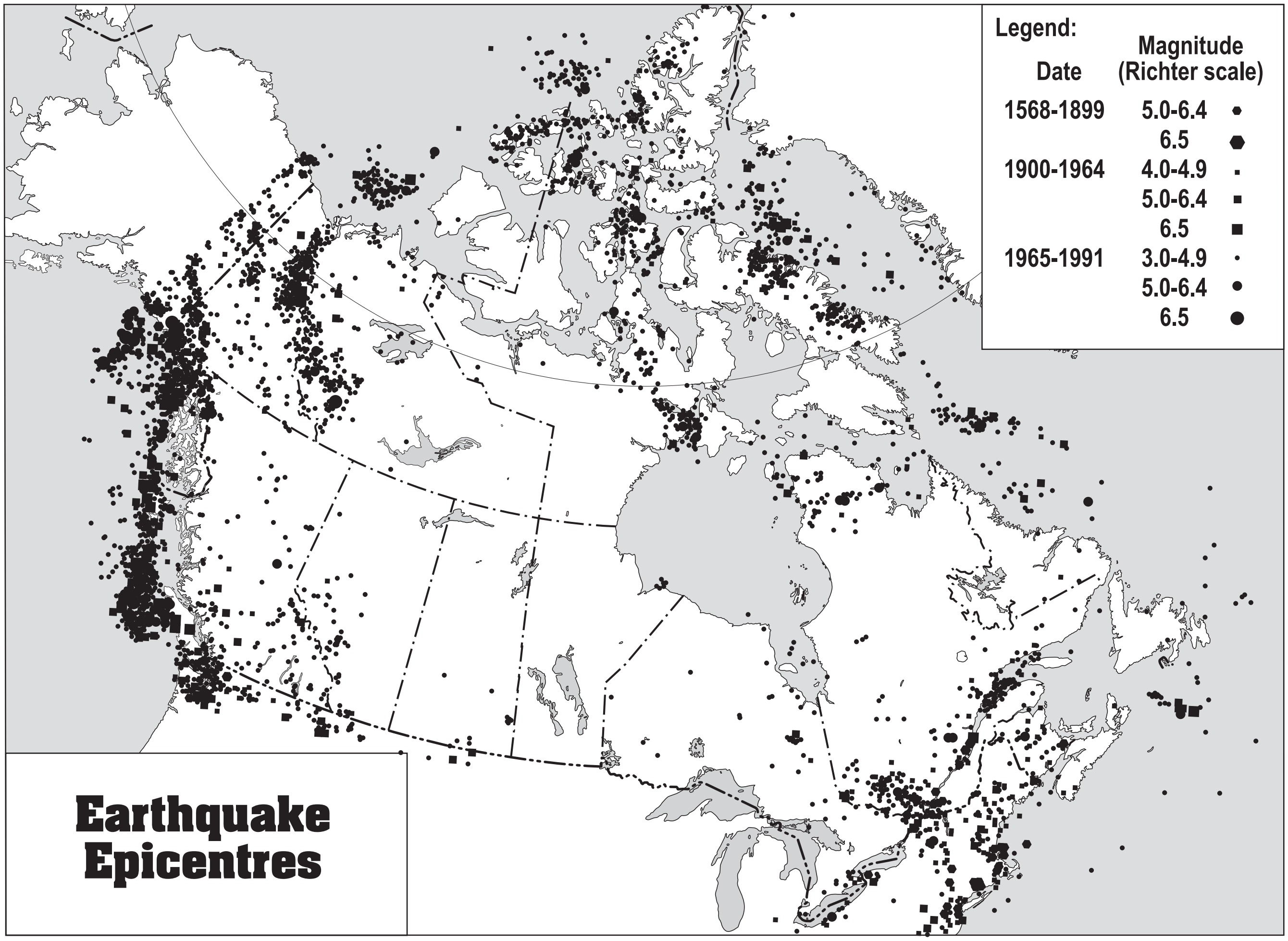
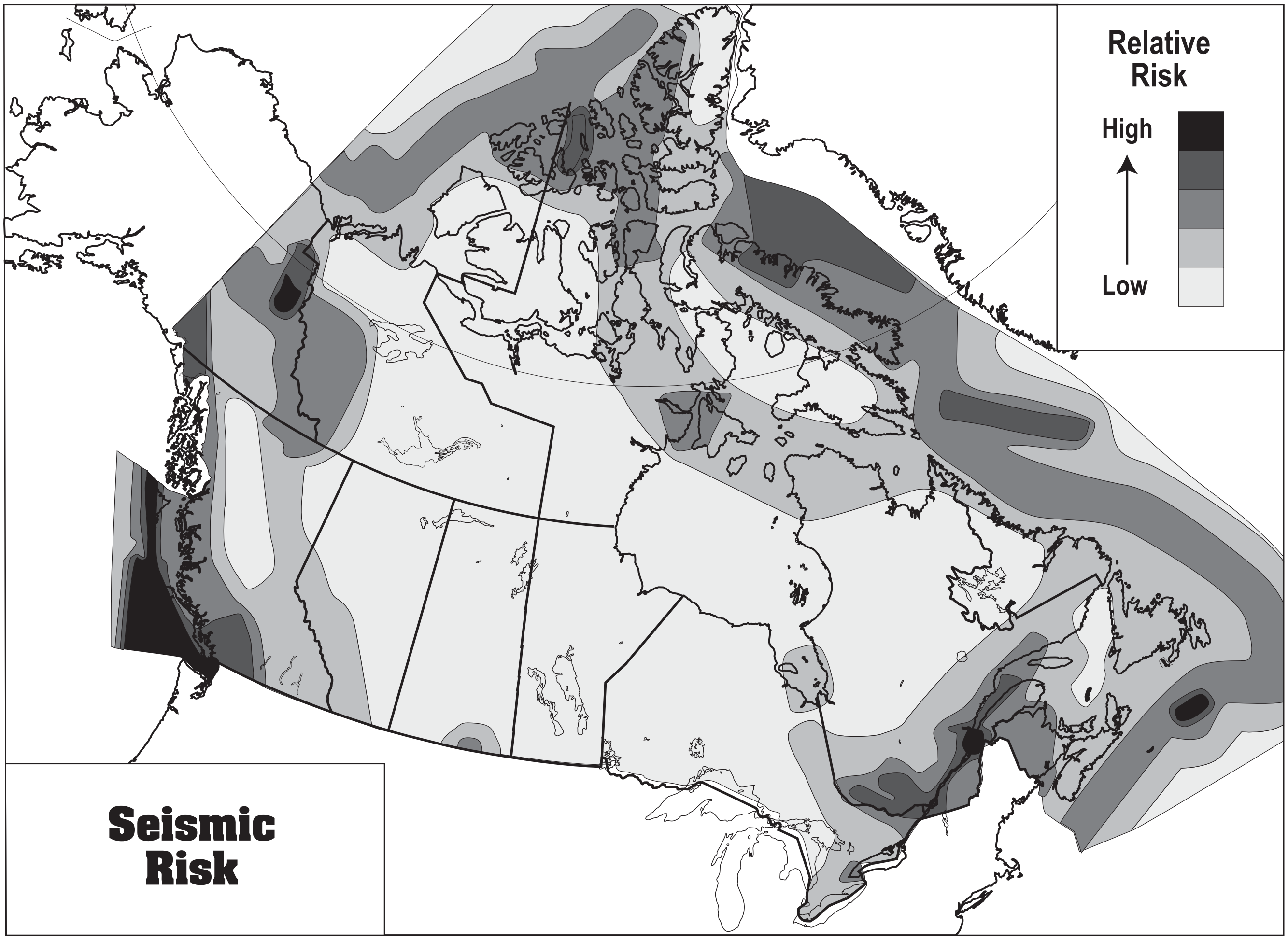


Figure 4.10 – Seismic Risk



5: The Atlantic Coast

Introduction

Geologic Journey: The Atlantic Coast details the dramatic story of tectonic upheaval and how these forces shaped the geological evolution of eastern North America. Along the way, we learn how a radical new theory of the Earth helped explain the unusual geology of eastern Canada.

We explore the Tablelands in Gros Morne National Park with its majestic barren slopes in the Long Range Mountains of Newfoundland and Labrador. Here, a piece of ancient ocean floor has been left stranded along the margin of a continent in a process called obduction, and we learn how the emerging theory of plate tectonics allowed geologists to develop a better understanding of this phenomenon.

We linger along Newfoundland's rugged Avalon coastline, where thousands of fossils are graphic evidence of how North America and Africa were once bound together. We then travel to Morocco to search for clues to understand what climatic or ecological factors were at work to precipitate one of the most significant episodes of mass extinction recorded in the geologic record. We uncover evidence that at about 400 million years ago what is now Nova Scotia was nestled up against northwestern Africa, close to modern-day Morocco. Jessica Whiteside and Paul Olsen search for evidence of dramatic climate swings in the red rocks at their feet. The answer ultimately may rest with the relationship between the global carbon cycle and its effects on Earth's atmosphere.

We meet Eldon George, rock and fossil collector, who has dedicated his life to passing on the thrill of discovery to visitors at his rock shop at Parrsboro Beach in Nova Scotia. He has a fine collection of fossils of small early crocodiles and mammal-like reptiles. Unfortunately, over half of the species that existed at the end of the Triassic were eliminated by a mass extinction event. The preserved fossils, found in the red rock of Parrsboro Beach, were among those species able to survive the "super greenhouse" temperatures of the Early Jurassic world.

This episode of Geologic Journey is divided into three chapters:

- Chapter 1: Tales from the Ocean Floor 16:00 minutes
- Chapter 2: Experiment in the Precambrian Oceans 11:30 minutes
- Chapter 3: Mass Extinction . . . and Something New Out of Africa 17:30 minutes

The episode can be viewed in its entirety (44 minutes), or can be divided into the three chapters indicated. The viewing questions are associated with each of the chapters, but could be consolidated into a series of questions covering the entire episode. Suggested responses to the viewing questions can be found in the Answer Key on the Web site at www.cbc.ca/geologic/teacher.html.

The Atlantic Coast

Tales from the Origin Floor

Keywords

crust, mantle, collision tectonics, ophiolite, Gros Morne National Park, J. Tuzo Wilson, supercontinent cycle, UNESCO, tourism

Introduction

Geologic Journey: The Atlantic Coast relates the story of how tectonic upheaval has shaped the geological evolution of eastern North America. We learn how a piece of ancient ocean floor has been stranded along the margin of a continent in a process called obduction. The theory of plate tectonics helps us to understand this phenomenon, where the oceanic crust there has been tipped up on its side.

As one of Canada's legendary geoscientists, J. Tuzo Wilson was drawn to the disciplines of both geology and physics in the newly emerging discipline of geophysics. In 1966, Wilson proposed that the geological evidence indicated that the Atlantic Ocean of today was not the only opening of this ocean basin.

The existence of chromite in 460 million-year-old sedimentary rocks at Lobster Cove pointed to older rocks that had been eroded, resulting in this heavy mineral found in the younger rocks.

Curriculum Objectives

- explain how scientific knowledge evolves as new evidence comes to light and as laws and theories are tested and subsequently restricted, revised, or replaced
- propose courses of action on social issues related to science and technology
- identify individual or collective actions that work to preserve valuable geological sites
- describe the importance of peer review in the development of scientific knowledge
- identify and discuss the importance of the main ideas of a scientific theory such as plate tectonics

Materials Required

- *Geologic Journey: The Atlantic Coast* video
- Figure 5.1 – In the News … Geological Article Review Checklist
- Figure 5.2 – Concept Map: Geology of the Tablelands, Gros Morne National Park, Newfoundland
- Figure 5.3 – K-W-L Chart
- Images 5.1 to 5.4 – Tablelands in Gros Morne National Park

Geoscientists call fragments of upper mantle and lower crust that have been thrust up and stranded on the edges of continents ophiolites, a reference to the greenish, mottled "snake-like" appearance of these magnesium-rich rocks. Further information on ophiolites and their importance to plate tectonics can be found online at: http://en.wikipedia.org/wiki/Ophiolite.

Student Activities

5.1.1 Students develop a K-W-L (three-column) chart (Figure 5.3 on page 5-6) to illustrate what they "already know" (K), "want to know" (W) and "what they learn" (L) from the video. The first two columns (K and W) should be filled in prior to showing the video.

The K-W-L charts can be used in a variety of ways. One method is to have pairs of students share their information, then have the pairs join to form a group of four, and then have the groups of four post results for the whole class. This can be done in different ways. Students can share the K and W information before viewing the video and then complete the L column after the video, or the three columns can be shared following the watching of this segment of the video.

View Chapter 1 of the video and respond to the following questions.

5.1.2 What characteristics of the Tablelands of western Newfoundland make this an interesting area to visit … or study?

5.1.3 Geologist Robert Stevens identified a particular mineral within the sedimentary rocks of Lobster Cove that was "unusual." What was this mineral, and what important questions did it raise about the neighbouring rocks?

5.1.4 Robert Stevens made a bold new hypothesis about the origin of the barren, magnesium- and chromium-rich rocks of the Tablelands. Describe briefly his new idea, and how it compared with earlier theories of the origin of these rocks. Hiking the trails of Gross Morne allows visitors to "walk from the seafloor down to the Earth's upper mantle." Explain how this is possible.

5.1.5 Geologists call these slices of ancient ocean crust that have been preserved on land as “ophiolites” or “serpent-like rocks.” Find a Web site that deals with ophiolites and sketch out a simple diagram of the kind of geologic setting in which ophiolites form.

5.1.6 Using a plate tectonic map of the Earth today, hypothesize the future location of new areas of ophiolites. The This Dynamic Planet Web site provides a Web-based version of a world map of global tectonics at http://mineralsciences.si.edu/tdpmap/.

5.1.7 In small groups, create a concept map to summarize the key concepts introduced in this chapter using the blank concept-mapping template. Roles may be assigned within the small groups: discussion leader, recorder, presenter, facilitator.

Use the information gathered to develop a complete concept map. Figure 5.2, on page 5-5, provides a sample template that can be used with students.

5.1.8 Write an article for a local newspaper, school newspaper, or class Web site, using the “In the News…” Geological Article Review Checklist (Figure 5.1, page 5-4). The article could begin, for instance, with the headline “Geologists Find Piece of Ocean Floor Stranded in a National Park.”

5.1.9 View the four images of the Tablelands in western Newfoundland (Images 5.1 to 5.4). (Full-colour copies of all the images referenced in this guide are available online at www.cbc.ca/geologic/teacher.html.)

Using a collection of images from various sources, including the four noted above, create a visual presentation about the geology of Gros Morne National Park that could be used to promote tourism in this area. As a component of this activity, consult existing travel and tourism material available on Web sites such as Gros Morne Adventures – Newfoundland Adventure Tourism available online at www.grosmorneadventures.com/activities.html.

Figure 5.1 – "In the News…" Geological Article Review Checklist

"In the News…" Geological Article Review Checklist

Date ___________________ Field Reporter: _________________________

Title of Article: ____

In my science writing piece, did I:

1. ☐ say what I wanted to say clearly?
2. ☐ choose precise, informative wording so that others will understand?
3. ☐ arrange paragraph details in logical or interesting ways?
4. ☐ write well-formed sentences that maintain interest?
5. ☐ write with a variety of sentence patterns?
6. ☐ have a main idea and supporting details in each paragraph?
7. ☐ have a clear beginning, middle, and ending to my story?
8. ☐ make the people and events realistic and interesting?
9. ☐ avoid unnecessary words or complicated terminology that did not include an explanation?
10. ☐ provide the important geological ideas that frame the story?

Figure 5.2 – Concept Map – Geology of the Tablelands, Gros Morne National Park, Newfoundland

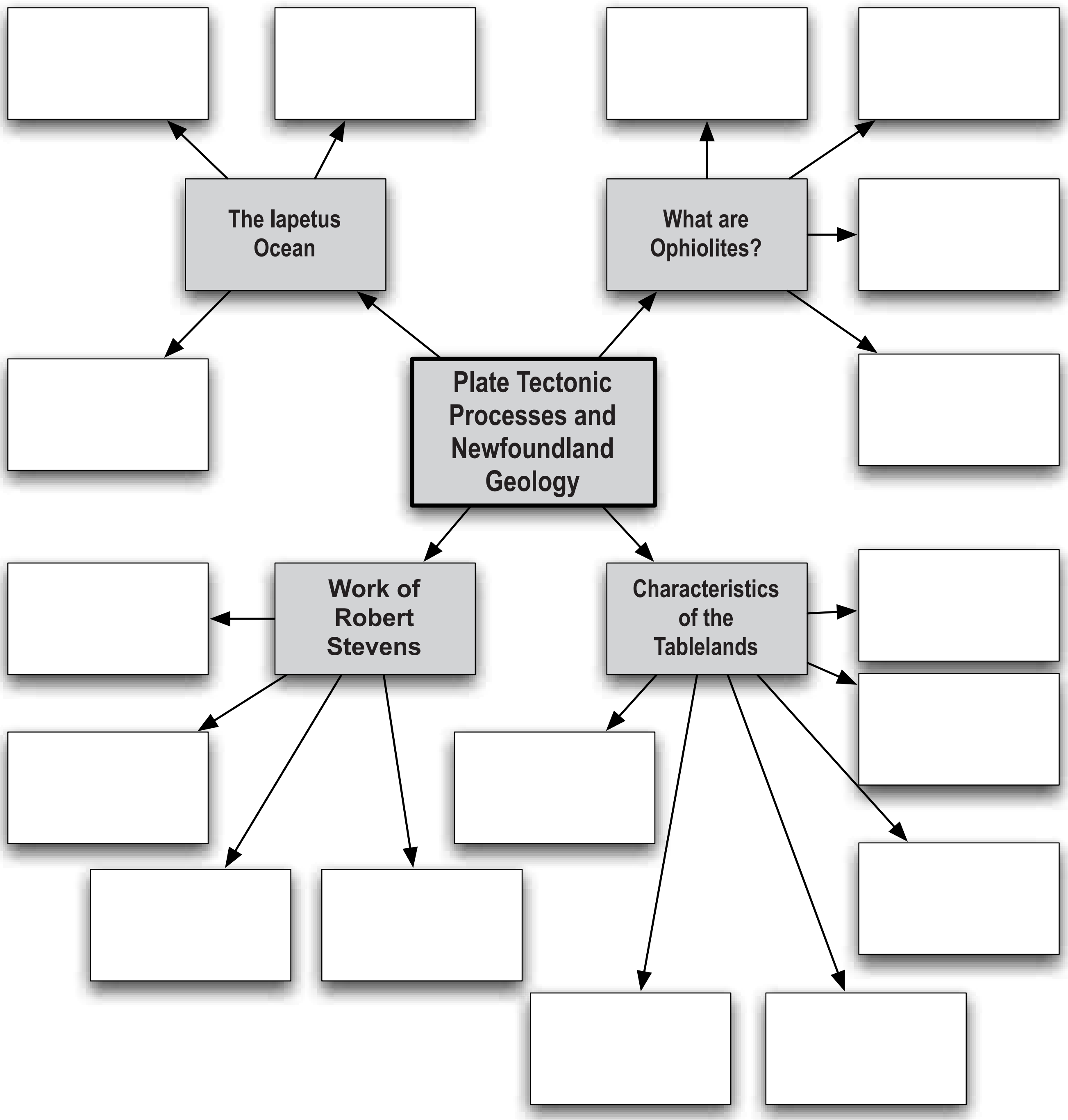


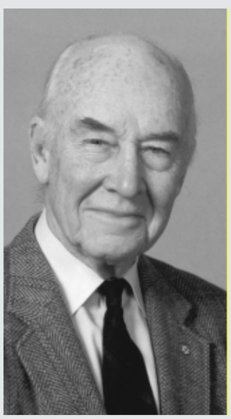
Figure 5.3 – K-W-L (Know … Want to Know … Learned) Chart

The Tablelands – Gros Morne National Park, Newfoundland

KNOW *What do I already know about the theory of plate tectonics?*	**WANT TO KNOW** *What questions do I have about the geology and history of this area?*	**LEARNED** *What have I learned about the Tablelands, plate tectonics, and ophiolites?*
Where I looked for information:	Resources I found useful:	

(K-W-L adapted from Donna Ogle, College of Education, National-Louis University, Evanston, IL)

The Canadian geophysicist J. Tuzo Wilson had the rare ability of being able to attach himself to particular geological ideas as they emerged. Wilson was progressively an advocate of a variety of theories of the evolution of the Earth's surface, including an Earth of fixed continents and ocean basins, a contracting Earth, an expanding Earth, Wegener-style continental drift, and then the new synthesis of plate tectonics.



J. Tuzo Wilson

Photo Credit: http://gsahist.org/gsat/gt01sep24_25.pdf

Web Links

- Rock Stars – J. Tuzo Wilson
  http://gsahist.org/gsat/gt01sep24_25.pdf – an excellent synopsis of Wilson's career
- This Dynamic Earth – the Story of Plate Tectonics
  http://pubs.usgs.gov/gip/dynamic/dynamic.html – an excellent video that provides an introductory-level treatment of the key ideas and principles of the theory of plate tectonics
- Ophiolites
  http://volcano.und.nodak.edu/vwdocs/vw_hyperexchange/ophiolites.html – this site provides a virtual field trip to some of the world's better examples of ophiolites
- Gros Morne Adventures – Newfoundland Adventure Tourism
  www.grosmorneadventures.com/activities.html

The Atlantic Coast

2

CHAPTER 2

Experiment in the Precambrian Oceans

Keywords:

Ediacaran fauna, Precambrian, Newfoundland, Mistaken Point, Avalon Peninsula, volcanic islands, "snowball" Earth, metazoan life, extinction, Iapetus Ocean (proto-Atlantic), African continent

Introduction

Geologic Journey: The Atlantic Coast looks at the rugged coastline of Newfoundland, where thousands of fossils are graphic evidence of how North America and Africa were once bound together. Along Newfoundland's Avalon coastline the discovery of a bizarre-looking collection of animals helped solve a problem that once baffled Darwin.

The importance of the Precambrian soft-bodied organisms whose impressions litter the bedding planes of the Mistaken Point area cannot be overstated. Canada has the good fortune of being host to one of the rarest preserved ecosystems known in the world, and there are no organisms living today that remotely resemble these creatures in terms of body arrangement. Their unique and unexpected forms have left paleontologists and paleoecologists scratching their heads over determining just how they lived and how they captured food from the water column. The Ediacarans existed for about 30 million years and then rather rapidly vanished—perhaps within the jaws of new organisms that were Earth's first marine predators.

Curriculum Objectives

- describe why the fossil forms found at Mistaken Point in Newfoundland can be considered "a dead-end experiment in the history of life on Earth"
- appreciate why surprise observations made by a student doing unrelated field work can be important to opening up an entirely new field of research
- identify individual or collective actions that work to preserve valuable ecological sites
- describe the geological evidence that suggests that seemingly successful life forms can be vulnerable to sudden catastrophes, climatic changes, continental positions, or simply the passage of time
- connect the evolution of life on Earth to constantly changing geological environments over immense spans of time

Materials Required

- *Geologic Journey: The Atlantic Coast* video
- Images 5.5 – 5.10 – The Mistaken Point Ediacaran-age fossils
- Figure 5.4 – Concept Map: Mistaken Point

Student Activities

5.2.1 Use one of the following statements to generate discussion in a "think-pair-share" format. Students initially react personally to the question (agree, disagree), then discuss their views, attempting to reach consensus. Each pair then joins another pair, repeating the process.

"Most of us spend too much time on the last 24 hours of life and too little on the last 600 million years."

"You could be the most highly adaptable marine organism on planet Earth, but if the pond dries up, a volcanic ash layer buries you, or the ocean freezes over . . . you're dead!"

5.2.2 View the images of the Mistaken Point Ediacaran-age fossils (Images 5.5. to 5.10). (The images are available online at www.cbc.ca/geologic/teacher.html.)

Working in small groups, students provide reflections on their impressions of these unique life forms. Questions to respond to could take the form of:

- "What really surprised me about these fossils was . . ."
- "What I found intriguing about these as life forms was . . ."
- "I would like to know more about . . ."

Concept maps help students create a visual representation of the relationships among concepts and allow teachers to assess the manner in which students are processing and organizing new information.

View Chapter 2 of the video and respond to the following questions.

5.2.3 Why is the presence of the Ediacaran animal assemblage at Mistaken Point in Newfoundland such a significant one in unlocking the secrets of early life on Earth?

5.2.4 What gave you the impression that this area was one of special geologic significance?

5.2.5 Guy Narbonne describes these unique Precambrian-age fossils as “the diamonds of the fossil world.” What do you think he meant by this statement?

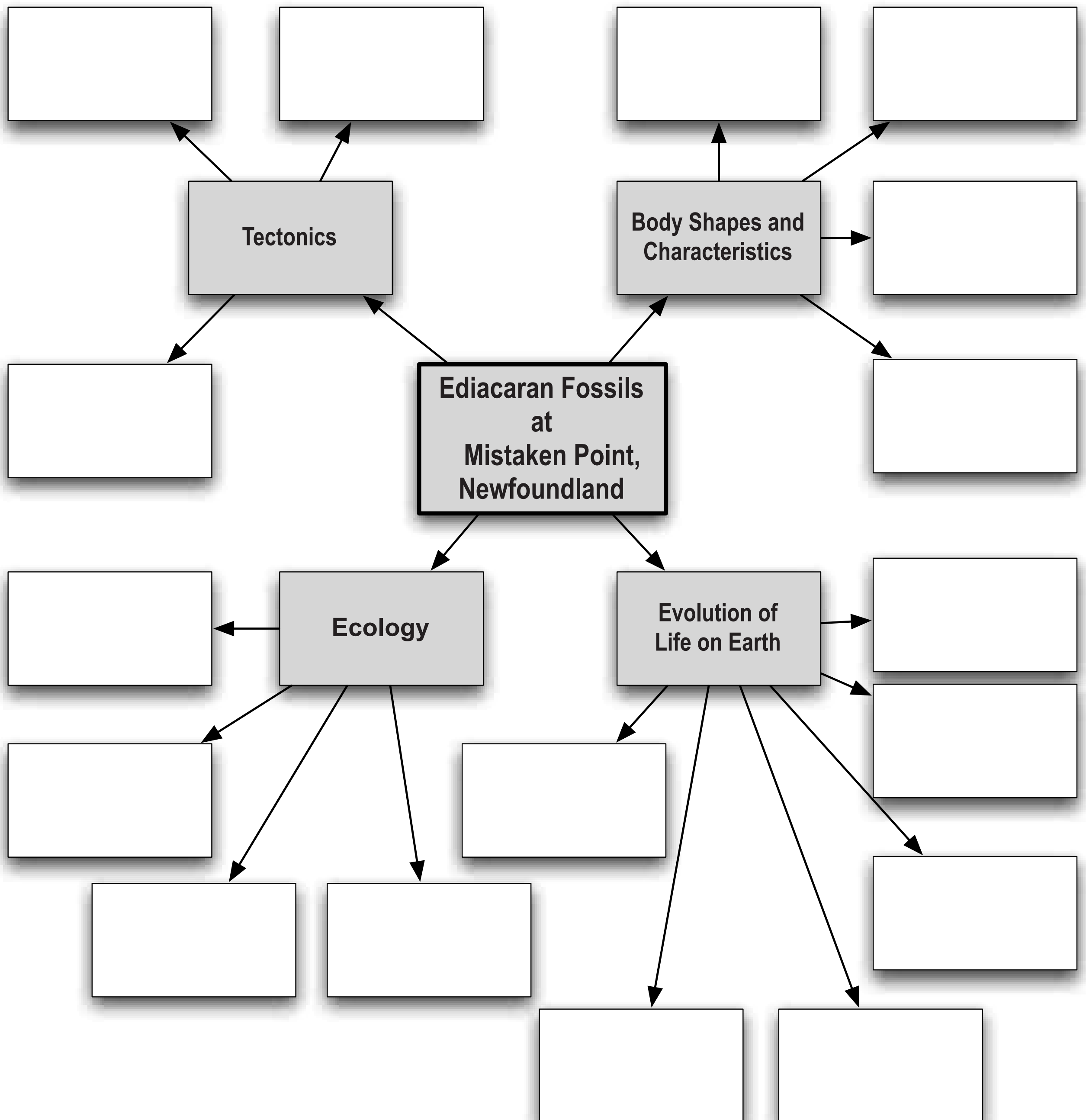
5.2.6 Describe the ecological environment of these 600-million-year-old creatures. What role did volcanic ash play in the preservation of their remains?

5.2.7 What important role has the Ward family of Portugal Cove South played in the preservation of the Mistaken Point Ecological Reserve?

5.2.8 Modern humans have been walking this planet for about 500 000 years. Can we be considered an “experiment” in the history of life on Earth?

5.2.9 Create a concept map of the key ideas introduced in this chapter of the video. Use the concept map to write a short essay, storyboard for a video production, or multimedia presentation on the nature of early life on Earth. Figure 5.4, on page 5-10, provides a sample template.

Figure 5.4 – Concept Map – Mistaken Point



Extension Activities

"Ask the Geologist" Webquest

Access the *Geologic Journey* Web site at www.cbc.ca/geologic/mts_eyles.html to view interviews of six Canadian geoscientists associated with this production. (All scientist interviews are also available on the *Geologic Journey* educational DVDs and VHSs.)

5.2.10 Develop a comparative chart to illustrate your impressions of these contributors to Canadian geology using the following as a guide.

- What scientific background does this individual have?
- What sort of work in geosciences interests them?
- What are the most interesting parts of the Canadian geology story for them?
- How has their work influenced the thinking about how planet Earth works?

Did You Know…..

The fossil assemblage at Mistaken Point was first discovered by a young geology student from India—Shiva Misra—in the summer of 1967. He was working on a Master's degree in geology and was mapping the rocks of the Cape Race area in southeastern Newfoundland when he came upon these fossils quite accidentally. You can access more information about this discovery online at: Discovery of Ediacaran Fossils in Southeastern Newfoundland at http://members.rediff.com/mistakenpoint/.

5.2.11 "Wonderful Life" in Canada's Rocks

In the early 20th century, the head of the Smithsonian Museum in Washington, D.C., Charles D. Walcott—along with his wife—happened across a collection of fossils in Cambrian-age limestones and shales while on a trail ride using packhorses. This occurred high in the Canadian Rockies in what is now Yoho National Park, near the town of Trail, British Columbia. Walcott collected kilograms of samples that he took back to the Smithsonian. After being catalogued there, they sat in storage for 75 years, until opened by a young British paleontology student named Simon Conway-Morris. On opening the first drawer, he exclaimed "My God . . . there is a whole life's work here!"

Within a few years, we had knowledge of a completely bizarre new ecosystem from the past, and these creatures of the "Burgess Shale" had become famous around the world as a collection of life forms that had never been seen before—or since.

Interested students can conduct online research using keywords such as "Burgess Shale fossils," or "Cambrian explosion of life," or "Charles D. Walcott" in order to discover more about this remarkable collection of Canadian fossils and the people who were involved in unravelling their nature.

The book *Wonderful Life – The Burgess Shale and the Nature of History,* by the late Harvard palaeontologist Stephen J. Gould, is an excellent source of background on the animals of the Burgess Shale. It was a bestseller and is still available in most major bookstores.

CBC's *The Nature of Things* produced an excellent documentary about this topic. *Burgess Shale: Impressions of Life* is available on VHS or DVD from CBC Learning (www.cbclearning.ca).

Web Links

- The Discovery: Discovery of Ediacaran Fossils in Southeastern Newfoundland http://members.rediff.com/mistakenpoint/ – a comprehensive teacher background site that provides access to the key scientific papers published at the time of the discovery of the fossil assemblage at Mistaken Point
- Ediacara Biota: Ancestors of Modern Life or Evolutionary Dead End? http://geol.queensu.ca/museum/exhibits/ediac/ediac.html – information about the Ediacaran fauna, named after the Ediacara Hills of the Flinders Range in south-central Australia
- Past Lives: Chronicles of Canadian Paleontology – An Ediacaran Pompeii http://gsc.nrcan.gc.ca/paleochron/06_e.php – the nature and ecology of the Mistaken Point fossil assemblage, raises the analogy of the death of these organisms as being similar to that of the people of Pompeii

Suggestions for Assessment

Virtual Field Trip Reports: A "Jigsaw" Activity

Using a "jigsaw" methodology, students will prepare a virtual field-trip report based on the following scenario:

Each group will "virtually" organize a return field trip to the Ediacaran fossil area of the Avalon Peninsula or a different locality in Canada that may have some geological connection to this area. Each group will outline the purpose and objectives for the trip and the methods to be used. A set of research questions should also be developed in order to focus the field trip's science. "Expert" groups could include photographer, artist, researcher, field-note specialist, image collector, and more.

The following can be used as a guide for the virtual field trip report.

- Purpose of field trip and science objectives
- What tasks will I perform?
- What did I find out about the location?
- Where did I get my expert advice?
- What work needs to be done?
- What challenges and difficulties did I encounter?

The Atlantic Coast

3

CHAPTER 3

Mass Extinction . . . and Something New Out of Africa

Keywords

Triassic-Jurassic boundary, tectonics, paleoclimates, dinosaurs, Nova Scotia, Pangaea, Africa, Wilson Cycle, tourism, mass extinction

Introduction

In this chapter of *The Atlantic Coast*, we search for clues to understand what climatic or ecological factors were at work to precipitate one of the five most significant episodes of mass extinction recorded in the geologic record. Over half of all species living at the end of the Triassic (about 200 million years ago) were eliminated by a mass extinction event. The "survivors" that repopulated parts of planet Earth are represented in the red sedimentary rocks of Parrsboro Beach.

Much earlier, about 400 million years ago, what is now Nova Scotia was nestled up against northwestern Africa, close to modern-day Morocco. In the foothills of Morocco's Atlas Mountains, paleoecologists Jessica Whiteside and Paul Olsen search for evidence of dramatic climate swings among the fossilized animal and plant remains found in these red rocks.

Curriculum Objectives

- explain how scientific knowledge evolves as new evidence comes to light and as laws and theories are tested and subsequently restricted, revised, or replaced (e.g., explain how fossil data contributed to the theory of the evolution of species)
- propose courses of action on social issues related to science and technology, taking into account an array of perspectives, including that of sustainability
- identify individual or collective actions that work to preserve valuable geological sites

Materials Required

- *Geologic Journey: The Atlantic Coast* video
- Images 5.11 – 5.15

Student Activities

5.3.1 Brainstorm with students about how they could find information and locate it on the shelves in the school or public library if the topic was related to geology.

5.3.2 Create a comparative chart to illustrate the similarities and differences in looking up information on the Internet versus performing that task in a library.

5.3.3 Predict the kind of results of a search on *mass extinctions* that using the Internet as the database will provide.

5.3.4 Develop a list of criteria that are important in establishing the usefulness of a Web site for use in science-related searches.

View this chapter of the video and respond to the following questions.

5.3.5 Describe three characteristics of the Parrsboro Beach area of the Bay of Fundy coastline in Nova Scotia that attracted your interest.

5.3.6 Not all important discoveries are made by professional scientists. Describe the contributions of Eldon George, rock hound and fossil hunter.

5.3.7 Why are the bone beds at Parrsboro such a rich treasure of vertebrate fossils?

5.3.8 A connection is made between the break-up of the supercontinent Pangaea, the mass extinction event at the end of the Triassic Period 210 million years ago, and increased volcanic activity along the margins of Africa and North America. How are all of these ideas related?

"I'm looking for the fingerprint of the carbon isotopes as they're recorded in these fossils." – Jessica Whiteside. What does Dr. Whiteside mean by this statement?

You may have to conduct some further research on how isotopes of carbon are used to draw conclusions about Earth's climates in the past.

5.3.9 Dr. Whiteside describes humanity today as both a "super predator" and "a geological force." What do you think she means by those descriptions of our species?

For an excellent place to start for teachers looking for particular types of Webquest templates see http://webquest.sdsu.edu/designpatterns/all.htm. Select a student-friendly, basic search engine and demonstrate how to best to use it with guided practice.

The research work of Dr. Jessica Whiteside featured in this chapter has a focus on major patterns and controls of ecosystem evolution, the evolution of key innovations in organisms, and also how great environmental catastrophes can be read in the geologic record from hidden chemical clues.

5.3.10 Following the viewing of this chapter of *The Atlantic Coast,* create a list of keywords to search for Web sites that deal with the instances of mass extinctions in Earth's history.

Extension Activities

5.3.11 The following activity will help you to develop an understanding of the Internet as a source for valid, reliable information. The Webquest is to search out information to inform about the variety, number, geologic age, and characteristics of great "mass extinction" episodes. You will learn how to develop information literacy skills, use both primary and secondary sources, bookmark key Web sites for later viewing, and use online materials to support such activities as multimedia presentations.

There are connections between the bone beds of Parrsboro Beach where the survivors of the mass extinction event are to be found, and across the Atlantic, where we have similar age rocks in Morocco. These hold clues as to whether or not it was volcanism that caused the demise of Earth's climatic stability and led to widespread extinction of species. What does the Internet have to offer that will keep us informed on the debate over just what caused the mass extinction event at the end of the Triassic?

A Web page creation tool is available at http://eduscapes.com/sessions/travel/create.htm#2a.

Potential search engines at your disposal can be found at http://lorien.ncl.ac.uk/ming/Resources/searcheng/search.htm

Read and investigate more information on using the Internet effectively with students at www.edu.gov.mb.ca/k12/tech/lict/let_me_try/g7/internet_literacy.doc.

5.3.12 Jessica Whiteside conjectures that humanity may have become a "geological force" that could be instigating history's sixth great mass extinction of species by virtue of our population growth, destruction of habitat, and the burning of colossal amounts of fossil fuels. Use this conjecture as the basis for a debate on the topic.

5.3.13 Paul Olsen of Columbia University, a leading expert on the Triassic-Jurassic boundary, has found preserved in the rocks that enclose the Minas Basin the bones and footprints of the victims and survivors of the end-of-Triassic cataclysm. Conduct research to determine how these fossils offer scientists opportunities to discover what caused the extinction and perhaps to determine the future fate of Earth's inhabitants.

5.3.14 View images of the landscapes near Parrsboro Beach in Nova Scotia and in the foothills of the Atlas Mountains in Morocco (Images 5.11 – 5.15). (Full-colour copies of all the images referenced in this guide are available online at www.cbc.ca/geologic/teacher.html.)

Using copies of the images on the Web site and cueing up the video at two or three appropriate points, create a presentation about the geology and fossil organisms seen in this chapter. Organize the presentation along the lines of an informal scientific meeting, with small groups of students each taking on particular segments of the oral presentation.

Web Links

- Fossils of Nova Scotia – the Parrsboro Fossil Site
  http://museum.gov.ns.ca/fossils/sites/parrs/index.htm
- Geologically Significant Sites in Nova Scotia
  www.bayoffundy.com/44geositesNS.aspx
- Geological Formation of the Bay of Fundy
  www.bayoffundy.com/geologicalformation.aspx
- Mass Extinction at the End of the Triassic
  www.mineralogie.uni-wuerzburg.de/palbot/evolution/trjextinction.html
- Teaching Documents about Mass Extinction Events
  www.mineralogie.uni-wuerzburg.de/palbot/teach/extinctionteach.html

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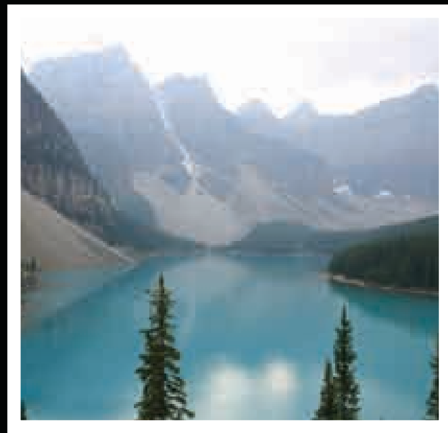


THE GREAT LAKES • THE ROCKIES • THE CANADIAN SHIELD
THE APPALACHIANS • THE ATLANTIC COAST

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