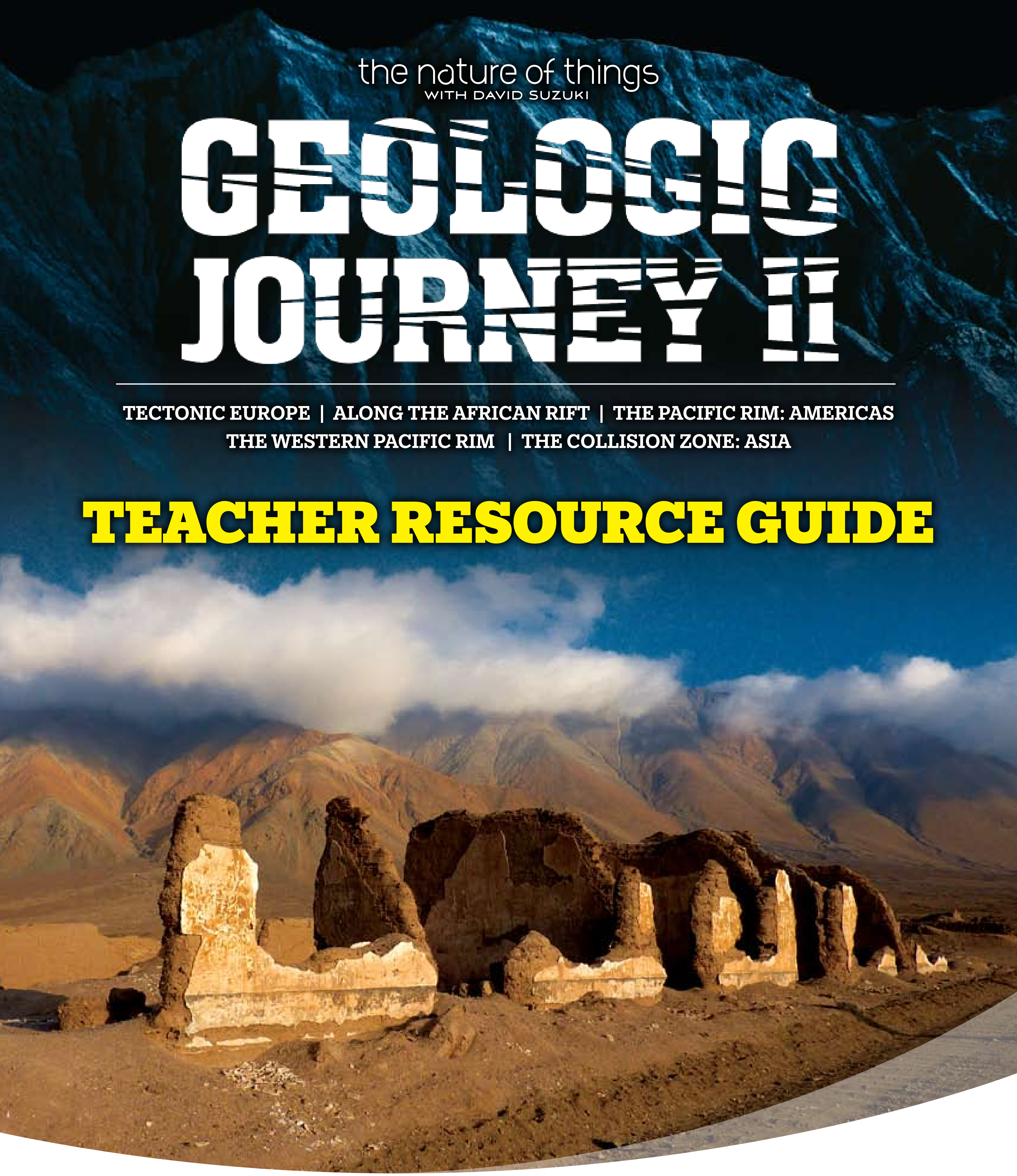
the nature of things
WITH DAVID SUZUKI

GEOLOGIC JOURNEY II

TECTONIC EUROPE | ALONG THE AFRICAN RIFT | THE PACIFIC RIM: AMERICAS
THE WESTERN PACIFIC RIM | THE COLLISION ZONE: ASIA

TEACHER RESOURCE GUIDE



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GEOLOGIC JOURNEY II

Teacher Resource Guide

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TEACHER RESOURCE GUIDE

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GEOLOGIC JOURNEY II

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USING THE *GEOLOGIC JOURNEY II* TEACHER RESOURCE GUIDE

Geologic Journey II will change the way you look at the world. In each episode, Earth's mysterious geologic processes are explored to help us understand and explain the geologic forces that shape our world—and our lives. This five-part documentary series will reveal the Earth's magnificent power and its breathtaking beauty. The series takes us to some of our planet's most dangerous and dynamic places and helps explain how they got that way. From some of the highest mountaintops to the lowest salt plains, and from the centre of violent volcanoes to the deep trenches beneath the ocean floor, *Geologic Journey II* travels with some of the world's most outstanding geologists as they decipher the mysteries of Earth's evolution. Using remarkable aerial photography and exquisite graphics, *Geologic Journey II* gives students of geology, science, environmental studies and geography a connection to their surroundings like never before.

Each of the five episodes focuses on a different area of the world:
• Tectonic Europe • Along the African Rift • The Pacific Rim: Americas
• The Western Pacific Rim • The Collision Zone: Asia

The Teacher Resource Guide serves a dual purpose: to provide the teacher with direction and a focus for each of the episodes and to provide students with opportunities to utilize the vast array of visual resources available to supplement their studies in this area. The guide explores the individuality and nuances of each episode, explains the geologic features experienced by Dr. Nick Eyles of the University of Toronto Scarborough as he visits these exotic locales with help from local geologic experts, and extends students' knowledge through writing, reflecting, discussing and explaining their findings.

Each episode has a different focus in terms of both the lesson plans and the student activities. This provides the teacher with a wide variety of approaches from which to choose. The writers have provided a consistent format to each of the activities, but within those activities, the lesson plans, approaches to teaching and learning, suggestions for extensions to the lessons and assessment ideas all differ. Teachers will be introduced to a variety of teaching and learning approaches that have universality and can be applied to other episodes of *Geologic Journey II*—or in other teaching settings.

Each episode has three activities based on a portion or an overview of the video.

The episodes of *Geologic Journey II* are supported by an excellent website, at www.cbc.ca/geologic2, which offers a number of opportunities to expand students' interests but still remain grounded in the video series. The website includes a glossary of terms and an opportunity for individuals (even students!) to add their photos to the photo gallery. For example, there is a series of four photographs that dramatically illustrate the size and scope of Chuquicamata, a feature of Episode 3: "The Pacific Rim: Americas."

There is also a connection to the University of Toronto Scarborough blog on the *Geologic Journey* website. Here students can get an inside view of the university where *Geologic Journey II* host, Professor Nick Eyles, holds his day job. Professor Eyles and his colleagues share some of their research adventures from around the world and closer to home.

Each *Geologic Journey II* DVD is divided into "chapters" that can be accessed from the main menu of each disc. For teachers and students using digital files of the episodes, the "start" time code and narration cue will assist in locating the segments of the video.

EPISODE	CHAPTER	CHAPTER TITLE	TIME	NARRATION CUE
1: Tectonic Europe	**1**	Vik, Southern Iceland	1:00	A lonely, empty research hut
	2	Edinburgh, Scotland	23:05	The Scottish capital of Edinburgh is a geological city if there ever was one.
	3	Hadrian's Wall, Northern England	30:00	The British Isles are in the middle . . .
	4	Swiss Alps	37:06	The Alps touch six countries in Europe
	5	Italian Alps	48:01	It's amazingly warm compared to the north side of the Grand St. Bernard tunnel . . .
2: Along the African Rift	**1**	Ol Njorowa Gorge, Kenya	00:03	The Great Rift Valley
	2	Afar Triangle, Ethiopia	07:53	How do continents split and how do new oceans form?
	3	Erta Alé, Ethiopia	15:31	But seeing the process with eyes instead . . .
	4	Aswan and Luxor, Egypt	26:15	From Ethiopia, Nick follows the Nile . . .
	5	Petra, Jordan	34:07	Nick says goodbye to Egypt and travels along the Red Sea coast . . .
	6	Dead Sea and Masada, Israel	40:14	From Petra, Nick goes north into the land of Canaan . . .
	7	Mediterranean Sea, Israel	49:13	Nick's journey ends on the coast of the Mediterranean Sea
3: The Pacific Rim: Americas	**1**	Icy Bay, Alaska, U.S.	00:00	
	2	Anchorage, Alaska, U.S.	08:25	Turnagain Arm, near Anchorage, illustrates both . . .
	3	San Francisco, California, U.S.	17:22	Running south along the rim . . .
	4	Atacama Desert, Chile	26:54	Leaving California, Nick heads south to one of the most earthquake-prone . . .
	5	Chaitén Volcano, Chile	43:36	Further south, in Patagonia, the climate . . .

4: The Western Pacific Rim	**1**	White Island, New Zealand	00:05	Deep below boiling mud
	2	Tarawera, New Zealand	07:11	White Island is one of a chain of volcanoes that includes the notorious . . .
	3	Wellington, New Zealand	13:32	Dramatic as they are, volcanoes are not the only threat . . .
	4	Fukuroi, Japan	18:30	Travelling northwest, Eyles' journey . . .
	5	Mount Fuji, Japan	24:49	Japan must face the potential threat of volcanoes . . .
	6	Motosu City, Japan	32:16	The quiet village of Motosu City exposes the workings of a killer fault . . .
	7	*Chikyu Hakken*, research ship	35:03	Here in the Nankai trough . . .
	8	Unzen, Japan	38:06	Volcanoes have a mystical allure . . .
	9	Southern Alps, New Zealand	44:43	On our last stop on our journey around the Western Rim of the Pacific . . .
5: The Collision Zone: Asia	**1**	The Himalayas	1:00	I've always wanted to see the Himalyas . . .
	2	Kathmandu, Nepal	22:15	Eight tributaries flow through the Kathmandu Valley . . .
	3	Calcutta, (Kolkata), India	28:17	Here are some facts about the Ganges River . . .
	4	Yogyakarta, (Java) Indonesia	35:04	Yogyakarta is the cultural heart of Java . . .
	5	Mount Merapi, (Java) Indonesia	45:46	This is the debris that was left behind by Merapi's 2006 eruption . . .

Organization of the Activities

Each unit begins with an introduction that will explain the general direction of the episode and/or the student activities. Each activity follows the same pattern:

Curriculum Expectations

The curriculum expectations dealt with in this Teacher Resource Guide came from a number of sources. The "Pan-Canadian Protocol for Collaboration on School Curriculum" outlines the science expectations for curriculum developers in the provinces and territories. In addition, there are curriculum expectations that are generally found in environmental studies, Earth science and geography curricula throughout the country. Although the courses are not necessarily standard across Canada, the expectations appear in different contexts on a fairly regular basis. The emphasis of the expectations is in the following areas:

- Geologic evidence of change in the environment
- Major areas of tectonic activity in the world
- The application of science and technology to life through current issues from a variety of perspectives
- Careers in science and technology
- The relationships between science/technology and societal needs

Pre-viewing Activities

The days of showing a video without adequate preparation are long gone. Today, much of the depth in videos such as *Geologic Journey II* can be explored, analyzed and evaluated with the identification of issues, questions to be explored, gathering background information and formulating hypotheses before watching the video. Teachers are encouraged to make full use of these pre-viewing activities.

Teacher Preparation and Materials Required

In addition to the video itself, many of the activities use additional materials to gather data, elicit student understanding and analyze relationships. Wherever possible, access to these materials has been provided—including some reproducible documents—within this Teacher Resource Guide.

Background Information

On occasion, the information presented in the video is at a fairly high level. Experienced teachers may not need the information included in this section; however, some background material is presented to provide essential information for teachers who may not be completely comfortable with specific areas of the content.

Before Beginning – Students

In some cases, it is recommended that students have a level of comfort with the topic or area before beginning; this information is provided for teacher and student direction.

Lesson Plan

The lesson plan is presented in student terms. Often, the activity is divided into segments for even easier use by the teacher.

Questions often lead the student through activation/engagement, exploration and acquisition of new knowledge especially through the video, and applying and extending their new knowledge base.

The questions in the lesson plan have a common numbering system using, in order, the episode number, activity number and question number. For example, question 4.2.3 would be the third question in the second activity of the fourth episode.

Extension Suggestion(s)

Similar in concept to the pre-viewing activities, the "post" activities are suggestions that the teacher can use to take the content of the video even further—areas of research, reviewing, reflecting and evaluating—for a deeper understanding of the video in a global context.

Assessment Suggestion(s)

Assessment is an individual teacher's responsibility; however, the writers have provided a series of assessment suggestions around which the classroom teacher can develop ways of measuring student understanding of the content and concepts presented in *Geologic Journey II.*

Websites

Throughout the lesson plans, a variety of websites have been identified by the authors to supplement the magnificent videos associated with *Geologic Journey II*. These websites have been chosen because they have excellent resources for the students—and they have a history of stability in terms of their availability. For certain, websites will change; however, the sites identified have had a great deal of consistency over the past 10 years.

Access to computers in classrooms varies tremendously across the country. As a result, teachers should modify the lesson plans to accommodate individual situations.

YOUR CAREER ON THE ROCKS!

Curriculum Expectations

• Identify and describe related science- and technology-based careers.

Activity Overview

In this activity, students investigate careers and academic programs in Earth science and the related field of environmental science.

Teacher Preparation and Materials Required

Students will require access to the following websites to complete this activity:
• University of Toronto Scarborough blog at www.cbc.ca/geologic2/blog/
• University of Toronto Scarborough blog entry at www.cbc.ca/geologic2/blog/fieldtrip.html
• Earth Sciences Canada website at www.earthsciencescanada.com

The following resources can also be referenced for this activity:
• The David Suzuki-Nick Eyles interview that follows Episode 1: "Tectonic Europe" on the DVD.
• ECO (Environmental Careers Organization) Canada website at www.eco.ca/occupationalprofiles/envirostream.aspx
• EnviroEmployment: Canadian Council for Human Resources website at www.cchrei.ca/_student/ee/

Access to Career Cruising, either through your school or at a local library, would also be useful.

Lesson Plan

Part 1

Geologists play an important role in ensuring that humans can live in and adapt to diverse tectonic environments. They study earthquakes, tsunamis, landslides, volcanic eruptions and other hazardous natural phenomena, and may advise authorities on earthquake risk, produce maps that identify potential lava flow paths or assist in planning to mitigate the effects of debris flows.

They also have an important role in contributing to the growing field of environmental science. Understanding how our physical Earth interacts with biology—or life forms—to shape ecosystems is fundamental to knowing how life is sustained on planet Earth. Scientists around the world are studying how human activity and natural processes work together to affect the future of life on Earth.

Use the information on the UTSC blog (www.cbc.ca/geologic2/blog/) to identify the careers in Earth science that are associated with geology.

How does the blog help students to understand the role of geology in the Earth- and environmental science areas?

What career possibilities are identified in the blog?

What educational background is required for each of these careers?

How could such a career be important, not only for an individual, but for planet Earth?

What type of careers in Earth science or environmental science could make important contributions to the quality of life of people living in specific regions of the world investigated in *Geologic Journey II*?

Part 2

Read Professor Nick Eyles's profile, below. Is there anything about his career that you find surprising?

View the following video, where Professor Eyles describes one of the classes he teaches: www.cbc.ca/geologic2/blog/fieldtrip.html.

What has changed for geologists over the last 20 years?

If you could take Professor Eyles on a field trip to your favourite outdoor area, what would you want him to explain or investigate with you?

Identify a local area of interest from a geographical or geological perspective. If you had the opportunity to take Professor Eyles to this area on a field trip, what questions would you have for him regarding the features of the area?

Profile

Nick Eyles is Professor of Geology at the University of Toronto Scarborough (UTSC). He's interested in "glacial sedimentology" and has spent many years studying modern glaciers.

He started his career in Great Britain at the universities of Leicester, Newcastle upon Tyne and East Anglia and moved to Canada to work at Memorial University in Newfoundland. He's been in Toronto since 1981, when he was awarded a prestigious NSERC University Research Fellowship.

Fieldwork is essential to geology. Professor Eyles has conducted geological fieldwork from the Arctic to the Antarctic, including work with the Ocean Drilling Program onboard the drillship *Resolution*. Recent sabbaticals have taken him to Brazil and Australia.

An author of more than 150 scientific papers on ice-age geology and environmental geology, Professor Eyles has also edited books on glacial geology and urban geology (*Environmental Geology of Urban Areas*) published by the Geological Association of Canada.

Professor Eyles has also written the popular "Rocks" series published by Fitzhenry and Whiteside, including titles such as *Toronto Rocks* (1998 with L. Clinton), *Ontario Rocks* (2002), *Canada Rocks: The Geologic Journey* (2007 with Andrew Miall) (*Toronto Star:* Science Book of the Year), *Canadian Shield: The Rocks that Made Canada (2010)* and *Road Rocks: Geological Wonders of Ontario* (2011).

When not looking at rocks in the field or writing about their history, Professor Eyles is an avid adventure motorcyclist (with a BMW 1200GS) and hockey player.

Part 3

On the Earth Sciences Canada website (www.earthsciencescanada.com), click on "Earth Science Careers." On the interactive map that appears, click on "What Can I Be?" Go to the A-Z list of jobs, and to demonstrate understanding of the issues associated with living on a dynamic planet:

- identify the careers in Earth science that relate to helping humans live safely in diverse tectonic environments
- choose one relevant career in Earth science and explain why you chose that career for more detailed research

- research that career and develop a one-page paper on the importance of, the requirements for and the benefits of such a career

Extension Suggestions

1. Investigate the career path of a geology professor who teaches at university in your province. What elements are similar to those of Professor Eyles? What elements are different?

2. Re-evaluate the course choices (where applicable) that you have already taken and those you are planning to take in your secondary school years as a pre-requisite to academic programs involving Earth sciences and environmental science. Identify one high school course that will be of particular significance in gaining admission to such a course in university.

3. You have just graduated from high school, and your chosen career is environmental science and/or geology. Your application to university involves both marks and a written report on your expectations for the course and an indication of how your background (education, experience) would suit you to such a course. Write a one-page article to respond to these two areas.

Assessment Suggestion

Assess the research paper identified in Part 3 using the following criteria:

- Knowledge and understanding of the facts, terms, principles and theories
- The inquiry skills as reflected in the organization, analysis and interpretation of the information
- The communications skills as reflected in the presentation of information and analysis
- The application/synthesis/conclusion, which should illustrate the clarity and logic of the research

GEOLOGIC JOURNEY II

EPISODE 1: TECTONIC EUROPE

UNIT OVERVIEW

In the first episode of this series, we traverse the Eurasian plate across Europe—from Iceland where new land is formed, to the Alps, where old land is destroyed. In between, viewers witness the twisted, gorgeous landscapes of Earth's surface under pressure—places where scientists first came up with the very study of geology itself, where geology became the science that changed the world. Viewers trek with University of Toronto Scarborough geologist Nick Eyles and his guides through volcanoes, glaciers, crags, mountains, rolling hills and broken cliffs that reveal the tectonic story of Earth.

In Activity 1 students explore the relationships between Earth processes and humans. Students document and characterize the risks and difficulties as well as the benefits associated with living in the geologically distinct regions of tectonic Europe. They then group these human impacts into categories to make connections with the specific geological processes operating in the various locations. A final step is to transfer this understanding to their own (and their community's) relationship with the part of the Earth on which they live.

In Activity 2 students delve into the changing perspectives on the age of the Earth, identify the different types of evidence used by Earth scientists to determine relative ages of rocks, including unconformities, folding, superposition, inclusions and fossil succession, and model/reconstruct these approaches to demonstrate their understanding.

The unit concludes with Activity 3 in which the types of plate margins in tectonic Europe are assessed using evidence of the nature of plate motion and extend to considering evidence for motion within the continental "mosaic." Based on rates of plate motion discussed in Episode 1 students turn back the clock and produce a series of generalized paleogeographic reconstructions for different times in Earth history.

EPISODE	CHAPTER	CHAPTER TITLE	TIME	NARRATION CUE
1: Tectonic Europe	1	Vik, Southern Iceland	1:00	A lonely, empty research hut
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	3	Hadrian's Wall, Northern England	30:00	The British Isles are in the middle . . .
	4	Swiss Alps	37:06	The Alps touch six countries in Europe
	5	Italian Alps	48:01	It's amazingly warm compared to the north side of the Grand St. Bernard tunnel . . .

EPISODE 1: TECTONIC EUROPE

ACTIVITY 1.1 • EARTH SCIENCE, SOCIETY AND THE ENVIRONMENT

Curriculum Expectations

- Analyze the relationship between geology and life on Earth.
- Increase awareness of the applications of science and technology to life by examining current issues from various perspectives.

Activity Overview

Students explore the connections between humans and Earth's tectonic forces and identify the risks, hazards, benefits and influences on society and culture of living near plate boundaries. They relate the societal influences to geological processes associated with a tectonic setting. Students examine their own relationship with place and the dynamic planet.

Pre-viewing Activity

Review the three types of boundaries associated with plate tectonics: convergent, divergent and transform.

In small groups, hypothesize on the role of active geologic activity on humans living in the area—their livelihood, culture and activities. Most students will identify negative effects; it is important to speculate on possible positive effects as well. Alert students to observe the ways in which people are impacted by geology and tectonics while watching Episode 1, chapters 1, 4 and 5.

Teacher Preparation and Materials Required

This activity is based on *Geologic Journey* Teacher Resource Guide pages 2 – 3, available at www.cbc.ca/geologic/teacher.html. Students actively engage in demonstrating the nature of plate motion at the divergent and convergent margins of tectonic Europe and physically locate related geologic features such as volcanism, geothermal activity, earthquakes and mountain building on the plate models.

Teachers will need either traditional diagrams of the geologic processes associated with plate margins or the materials to construct models to illustrate these (highly recommended). The model construction process is outlined in Part 1 below.

The materials for each group include:

- 3 blue thin camping foamies approximately 1.4 x 0.5 m (representing ocean crust)
- 2 large pieces of mattress foam approximately 50 x 80 cm and 10 cm thick (representing the continental plates)
- 6 cut-out arrows

Name labels for the plates

Several cut-out Xs (to represent earthquakes), plasticene (for making small volcanoes), cotton wool (to represent geothermal areas), 6 partly cooked and cooled lasagna noodles (ocean floor sedimentary layers)

Background Information

As David Suzuki commented, “Geologic changes have shaped the world as we know it.” Geology affects humans in many ways, from the rocks, sediments and soils on which we live and grow our food to the resources that we extract from the Earth. These resources range from oil, gas, uranium and coal for energy to the enormous variety of rocks and minerals that are the backbone of our industrialized society. However, the development of these resources from within the Earth should be placed in context with the notion of living in “places in the world that are poised to explode: hotspots that radiate unimaginable energy . . .” or where “geologic forces shape the world and our lives,” as Nick Eyles notes.

Geologic forces like tectonics and their effects such as volcanoes, earthquakes, and mountain building have an amazing impact on the people and societies that exist where they occur. From Iceland at one edge of Europe to the Alps at the other, geology can—and does—play an integral part of people’s lives, shaping their culture and how they interact with their environment.

LESSON PLAN

Part 1 – Reconstructing Plate Boundaries Using Foamies

1.1.1 Identify the nature of plate motion at the three types of plate boundaries: divergent, convergent and transform.

1.1.2 Reconstruct the divergent boundary (e.g., Iceland) using two blue foamies. Place the arrows to indicate directions of plate motion.

1.1.3 Add a cardboard representation of Iceland and labels (North American Plate, Eurasian Plate). Then place any of the relevant props on the parts of the model where you think the phenomena they represent occur.

1.1.4 Reconstruct the convergent boundary to represent the formation of the Alps by closing the ancient Tethys Ocean (see www.cbc.ca/geologic2/glossary.html) between Europe and Africa. You will use a blue foamie for Tethys, with some lasagna noodles lying flat on top at the edges, to represent the sediments built up on the ocean plate. Place the arrows to indicate directions of motion on both the ocean and continental parts of the model and label each plate (Tethys Ocean, African Plate, Eurasian Plate).

1.1.5 Now make the continental plates collide. What happens to the ocean plate? What happens to the sedimentary layers (noodles)?

The ocean plate subducts beneath both the northern and southern continental blocks. The sedimentary layers (noodles) are light and so get pushed up onto the mattress foam continents to make mountains.

1.1.6 Next place any other props (earthquakes, volcanoes) on the model that you think are part of the convergent model.

1.1.7 In small groups, discuss the likely distribution of volcanic activity, geothermal activity, earthquakes, and mountain building associated with both types of boundaries.

Part 2 – Risks and Hazards

1.1.8 In pairs, complete a chart like the one below based on observations from chapters 1, 4 and 5 of the video.

CATEGORY	RISKS	HAZARDS
Transportation		
Energy		
Agriculture		
Natural Hazards (e.g., conditions associated with volcanic eruptions)		
Recreation		
Health		
Culture (music, stories, legends)		

1.1.9 Evaluate the role of gelogic activity, especially tectonics, on the lives of humans living in areas such as Iceland and the Alps.

1.1.10 What aspects of how humans live in both of these areas are NOT affected by geology and tectonics?

1.1.11 Stephen Johnston comments on how the Alps have shaped human history, and Nick Eyles described how Icelandic culture and mythology relate to geology—e.g., the basalt columns that legend states were made out of petrified trolls. Choose one image from the video and create a legend around how the landscape came to be or how humans relate to it. If possible, relate the legend to the history and culture of the region.

Extension Suggestions

1. Research the tectonic setting of the place where you live. Do you live near a plate boundary? If so, what type? If not, research the tectonic history of the region: is it an old tectonic margin now located in the interior of a plate (like Scotland)? Go to www.scotese.com/earth.htm to see reconstructions of how the continents and oceans have changed and moved over time through Earth history. These reconstructions aptly illustrate Nick Eyles's comment that "there's nowhere on the Earth's surface that's stable; everything is moving."

2. Use your understanding of the influence of tectonics on humans in the Eurasian Plate context to infer what kinds of influences, both positive and negative, tectonism (or geology) exerts on your local community or region.

3. As a class arrange two debates—one each for Iceland and the Alps—where students present the case for and against living in the two locations. Integrate the geological settings into the arguments.

4. Identify examples in Episode 1 of how humans have found ways to overcome some of the difficulties associated with the effects of geologic processes.

5. Do you think that in the future humans will be able to live totally independently of natural geologic and tectonic processes? Explain.

Assessment Suggestion

1. Have students choose either Iceland or the Alps and develop a promotional brochure for the local chamber of commerce, real estate magazine or tourism agency to encourage visits to or living in the region. The brochure should provide a context for the region by including a description of the geology, the resulting natural environment and the risks and benefits that people would encounter (either as visitors or permanent residents). Emphasis should be placed on an understanding of how geologic processes may influence the quality of life and how the community has implemented procedures to mitigate the risks of visiting/living in the area.

ACTIVITY 1.2 • UNDERSTANDING GEOLOGICAL TIME AND EARTH HISTORY

Curriculum Expectations

- Evaluate the significance of contributions, including Canadian contributions, to our understanding of geological time and of changes in Earth systems with time.
- Explain the different types of evidence used to determine the age of the Earth and how this has influenced our understanding of the age of the planet.
- Explain that scientific knowledge is subject to change as new evidence becomes apparent and as laws and theories are tested and subsequently revised, reinforced, rejected or replaced.

Activity Overview

Students document the evolution of approaches to understanding geological time as described in "Tectonic Europe" and understand the changing perspectives on the age of the Earth derived from these approaches. Students identify the different types of evidence, or "tools" used by Earth scientists to determine relative ages of rocks, including unconformities, folding, superposition, inclusions, and fossil succession, and model/reconstruct these approaches to demonstrate their understanding.

Pre-viewing Activity

The plaque in Greyfriars churchyard in Edinburgh notes that James Hutton (1728 – 1787) was the father of modern geology. As a class, or in groups, research the life of James Hutton, finding out who he was, what he did and what he discovered. To put the life of Hutton in perspective, identify other important discoveries being made in science, and by whom, around the same time.

Discuss in small groups or as a class the following questions:

- How old is Earth?
- How was it formed?
- Was Earth formed by a single event that happened catastrophically or by many different events and processes taking place over a long period of time?

Teacher Preparation and Materials Required

This activity focuses on chapters 2 and 3 of the video, highlighting the concepts of age of the Earth and how we determine Earth's history through the relative age dating of rocks. (Note: The teacher will need to be sensitive to students' perceptions, based on religious beliefs of how the Earth formed and its age, if they are in conflict with scientific understanding based on geological evidence.)

EPISODE 1: TECTONIC EUROPE

Materials required for each student or group:

Sandwich-making ingredients (e.g., several slices of bread, mustard in plastic bottles, ketchup, cheese slices, tomato slices, lettuce, pickles, lunch meats, etc.) (Note: The sandwich models can be eaten, but this will require some direction in terms of sound food hygiene practices while doing the activity.)

Sketch paper and coloured pencils or markers, or a digital camera

Appendix 1.2.1 – Concept Map Outline

Background Information

The way humans have viewed Earth's age and history has changed dramatically over time. David Suzuki notes that at the end of the 18th century, man was prominent in the story of the world. The common belief at that time was that "it [Earth] was young and made for him by God." Then, "the new science of geology emerged, secularizing our understanding of the Earth, taking man out of the centre of the story and replacing him with science." Suzuki remarks that the "first geologists turned up a tale in the rocks that no one ever imagined could exist."

This episode explores evidence in the rocks and helps us to learn how geologists decipher the relative ages of rocks around the world.

LESSON PLAN

Part 1 – The Age of the Earth

1.2.1 While viewing chapters 2 and 3 of the video, list the different interpretations of the age of the Earth that you encounter.

1.2.2 Using several copies of Appendix 1.2.1, make a concept map for each age interpretation, including in each:
• who the proponents were
• what were the ages/timeframes that they proposed
• what was the evidence for their ideas
• what did they believe were the process(es) or mechanism(s) for how the Earth formed

Include in the concept map any quotes or additional information that you think are important.

1.2.3 Research the following terms: *uniformitarianism* and *catastrophism* or *Neptunism* and write a short paragraph to indicate the key ideas that explain each one.

1.2.4 Imagine you have been asked to present a case for a "very old" Earth to an 18th century group of thinkers and philosophers. Consider the comment in the video about Hutton (and others who make progress in science) that they "see things that other people have seen, but they see it differently." Prepare a short presentation to make a case for a very old Earth. Include your own ideas as well as the evidence that you have discovered.

Part 2 – Unravelling Earth History: The Relative Ages of Rocks

1.2.5 What do we mean by relative age?

1.2.6 Think about all of the rock sections you saw in chapters 2 and 3, and identify the difficulties that geologists might have in fitting them all together and then sorting the evidence from each section into a history or sequence of events.

1.2.7 What approaches, or tools, mentioned in the video help geologists decipher the order or sequence of events, or relative ages of rocks?

1.2.8 Itemize your observations about the tools in the chart on the next page.

1.2.9 Research the remaining tools shown on the chart (those not marked with an asterisk) to understand how they are used to tell the relative ages of rock layers.

Tools for Relative Age Dating	Location in Scotland or England (as identified in the episode)	How is this tool used to determine relative age?
Unconformities *		
Fossils or faunal succession*		
Included fragments *		
Superposition		
Original horizontality		
Cross-cutting relations		
Other		

1.2.10 Some age-dating tools can be modelled using sandwich-making ingredients. For example, for the superposition tool, lay a few pieces of bread down one on top of the other. The bread at the bottom is oldest (you had to put it down first). This is exactly how the relative ages of rocks are determined in an undisturbed pile of sedimentary layers—the bottom layers must be oldest as they were laid down before the others. In small groups model how each of the relative-age-dating tools from 1.2.8 work to reveal the sequences of events in rock sections. Photograph or sketch each model as you make it.

1.2.11 Make a sandwich model for the unconformity at Siccar Point that Nick Eyles travelled to by boat and write the geological history of this rock section. Now you can eat your models. Have a great lunch!

Part 3 – Who's Who in Canadian Geology?

1.2.12 We know that James Hutton is considered the father of modern geology. Who would be considered the father of Canadian geology? Research important individuals in early Canadian geology (such as Sir William Logan, Alice Wilson, Helen Belyea or George Dawson) and write a brief report about his/her contributions to this important science.

Extension Suggestions

1. Using the information gathered (either as sketches or photographs) from 1.2.10, develop a how-to guidebook or manual for relative age dating. Annotate each sketch to show how the tools would be used by a geologist.

2 Try to construct a single sandwich model that incorporates all of the relative-age-dating tools.

3. Consider what other kinds of foods would be good models to explain the principles of relative age dating and/or the formation of different rock types. Plan a menu based on these ideas and host a "geological food" event.

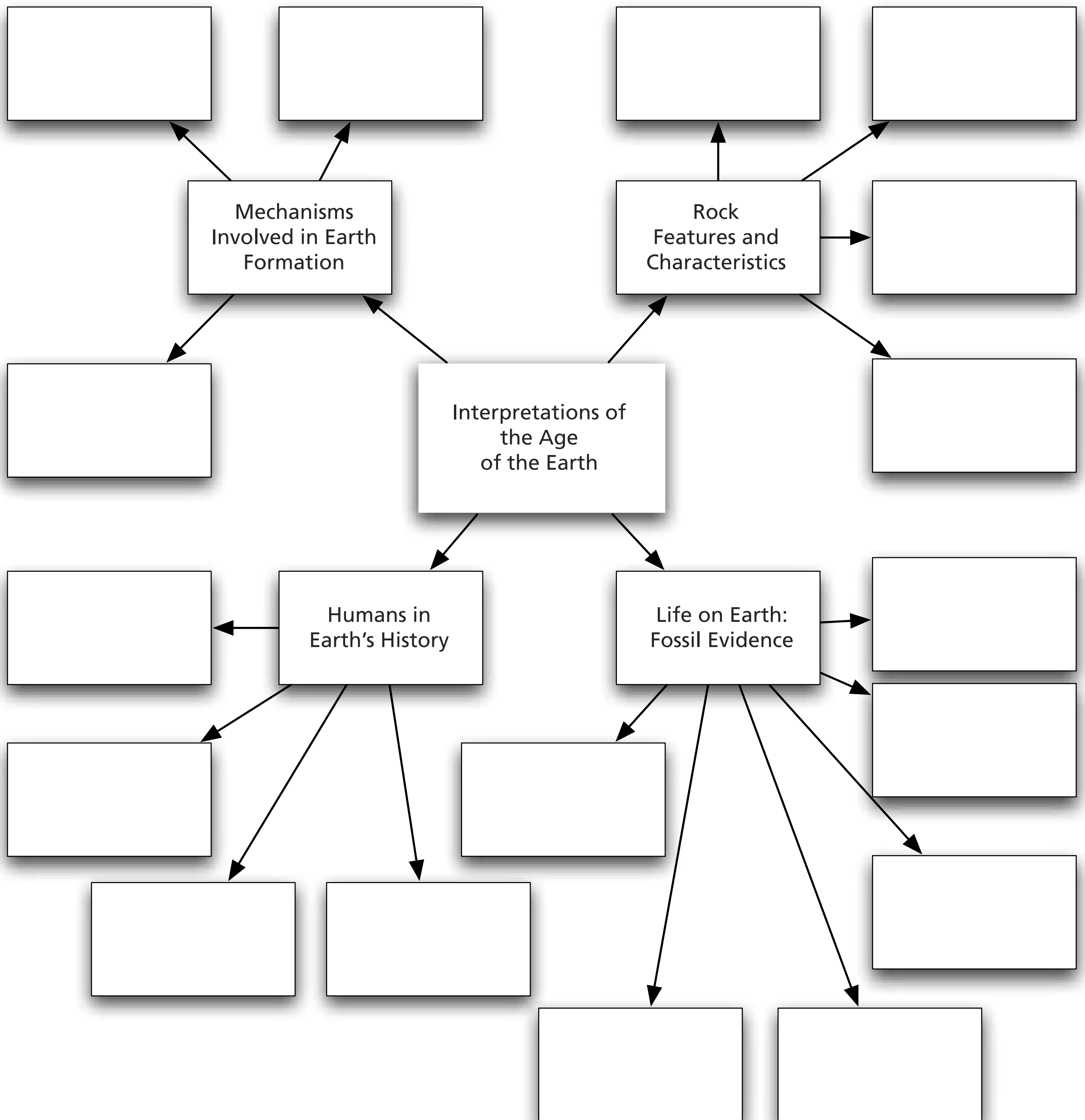
EPISODE 1: TECTONIC EUROPE

Assessment Suggestions

1. Students choose an image from the episode, from your local area, or from the *Geologic Journey II* website (www.cbc.ca/geologic2/photos.html) and apply their knowledge of relative-age-dating tools to determine the history of the rock layers shown (e.g., the order in which different layers formed and the sequence of events resulting in the complete section) in the image.

2. What other major scientific discoveries have changed some fundamental ways that humans had (or have) of looking at the world and their importance in it? Some examples might be evolution or our understanding of the solar system. Outline what life would be like for us if discoveries such as these had never been made. What are some of the implications of these scientific discoveries?

Appendix 1.2.1 – Concept Map Outline



ACTIVITY 1.3 • RECONSTRUCTING MOBILE EARTH

Curriculum Expectations

- Demonstrate an understanding of the processes at work within Earth and on its surface and the role of these processes in shaping Earth's surface.
- Describe the types of boundaries (convergent, divergent) between lithospheric plates and explain the types of internal Earth processes occurring at each.

Activity Overview

Students explore the types of plate margins highlighted in this episode. After reviewing the Supercontinent Cycle and the Wilson Cycle, students examine the "mosaic" of Europe and identify the ancient oceans that opened and closed to bring together its diverse parts. Using rates of plate motion, students calculate how long an ocean opening and closing might take and reconstruct the history of Europe through two different phases of ocean formation and destruction.

An understanding of the Wilson Cycle is integral to this activity, so if students are unfamiliar with it, completing the pre-viewing activities is recommended.

Pre-viewing Activities

1. Cycles are a key part of Earth's long and dynamic history. Two types of cycles are particularly important for understanding how the forces of tectonics impact and change our continents and oceans. Using an Internet search engine, research the Supercontinent Cycle and answer the following questions.
   - What was the most recent supercontinent?
   - What other supercontinents are thought to have existed in Earth's past?
   - Determine the ages of all of the supercontinents you have identified.
   - How long does the supercontinent cycle take?
   - What types of plate boundaries are suggested by the existence of supercontinents?
2. In small groups, hypothesize how geologists use specific kinds of evidence to support the theory that supercontinents existed in the past. Present your hypothesis to the class.

3. Alfred Wegener was the first to propose the existence of supercontinents in the past. He put forward many different lines of evidence for his supercontinent, Pangaea. Research the evidence for Pangaea and present it either as a PowerPoint presentation or as a poster.

4. Research the Wilson Cycle and answer the following:
   - Describe the opening phase of the Wilson Cycle. Give examples of places today that are at each of the different steps in the opening phase of the cycle.

A website with the basics on the Wilson Cycle an be found at http://csmres.jmu.edu/geollab/Fichter/Wilson/wilsonsimp.html.

- Describe the steps in the closing phase of the Wilson Cycle.
- Identify locations worldwide that are at each stage of the Wilson Cycle.
- What geological processes are happening at the locations identified above?
- Where does ocean crust form? (We see this in action in Chapter 1 of the video.)
    - What happens to the ocean crust when ocean basins close?
    - Why do oceans close?
    - Is all ocean crust the same?
    - How old is the oldest ocean crust in today's oceans?

5. Using Activity 1.1 review the types of plate margins and use the foamies (see below) to reconstruct a complete Wilson Cycle. Identify each type of plate margin in all the stages of the Wilson Cycle.

6. View chapters 1, 4 and 5 of the video and ask students to make note of any ages mentioned for locations or parts of Europe as well as any rates of plate motion.

Teacher Preparation and Materials Required

This lesson plan could be the basis for a culminating activity on this topic. It requires that students have viewed the complete episode. As students review the video, ask them to make note of any ages mentioned for locations or parts of Europe, as well as any rates of plate motion.

Appendix 1.3.1 – Outline Map of the World for each student

Scissors

Access to the Internet

Materials as for Activity 1.1:

- 3 thin blue camping foamies approximately 1.4 x 0.5 m (representing ocean crust)
- 2 large pieces of mattress foam approximately 50 x 80 cm and 10 cm thick (representing the continental plates)
- Cut-out arrows

Background Information

Geologically, Europe is a complex mosaic of plate fragments that have collected together as ancient oceans opened at divergent plate boundaries and closed at convergent plate boundaries. As David Suzuki notes "plates have their own system of movement, they come together . . . they break apart."
In this activity we explore how the Eurasian plate is moving today and look back into its past to reconstruct some very different patterns of plate motion. Students identify where ancient oceans used to exist before they closed and brought together the diverse pieces that now make up tectonic Europe. Everything is not always as it seems!

EPISODE 1: TECTONIC EUROPE

LESSON PLAN

Part 1 – Oceans in Europe: Opening and Closing

1.3.1 View the complete Episode 1 video and note the geological ages mentioned for specific places or regions in this episode on the appropriate places on the outine map (e.g., Nick Eyles notes that Scotland and England were sutured together at Hadrian's Wall 400 million years ago). Identify both the ages of rocks and timing of collisions.

1.3.2 Review the stages of the Wilson Cycle from the pre-viewing activity. If there is a suture or collision such as the one that formed the Alps, this signifies the closing of an ocean. What are the two ancient oceans mentioned in the episode (one in the United Kingdom and one in the Alps)? What is the modern-day ocean associated with Europe? Label and mark on your map (Appendix 1.3.1) the traces or locations of the ancient oceans.

1.3.3 Use an Internet search engine to determine the timeframe during which the two ancient oceans existed. A good place to start is www.scotese.com. Which of the ancient oceans is the oldest?

1.3.4 Starting with the oldest ocean (Iapetus), cut the Appendix 1.3.1 map at the ocean suture location and pull apart the sides to signify opening the ocean. Note which side of the ocean Scotland is on. Which side is England on? What other parts of the world were separated by this ancient ocean? (Appendix 4.1.2 – Continental Collision Model will help with this.)

1.3.5 Determine the width of a typical ocean at the full ocean stage of the Wilson Cycle. Using the map scale, open the ocean to its full extent. Close the ocean again to simulate the rest of the Wilson Cycle for this ocean. Imagine being at the suture at the time of collision. What would the landscape have looked like? Do you think it would have looked just like it does now? Why not? Based on this simulation, identify the plate associated originally with Scotland.

1.3.6 Repeat the process for the more recent ocean that opened and closed to form the Alps. In this reconstruction, identify the plate associated with Italy and the Matterhorn. Where are the sedimentary layers that were deposited in this ancient ocean? What could have happened to the ocean that was between Africa and Europe during the process of ocean closing? What "conclusive evidence" did Stephen Johnston identify as evidence of the existence of a former ocean?

1.3.7 Why are the Alps so much higher than the landscape around Hadrian's Wall, even though both formed in the same way (i.e., as a result of a Wilson Cycle)?

1.3.8 What are the implications of this "multicultural" geological background for Europe? Do oceans always form in the same places? Is it likely that at some time in the future parts of the Eurasian plate will be separated again by a new ocean?

1.3.9 What stage of the Wilson Cycle has the present ocean associated with Europe reached?

Part 2 – How long does it take to open and close an ocean?

1.3.10 Both sides of the mid-ocean ridge or diverging plate margin move apart at approximately the same rate. As David Suzuki notes "it's like two conveyor belts moving in opposite directions pushing the plates apart." What are the rates of plate motion identified in this episode with respect to Iceland? Review your response to 1.3.5. Calculate a timeframe for the opening, as well as the closing, of the two ancient oceans. How many millions of years would each entire Wilson Cycle take?

Extension Suggestions

1. Use a world map or globe to determine the current average width of the Atlantic Ocean. Based on Part 2 above, at what stage of the Wilson Cycle is the Atlantic Ocean? When would you expect it to begin to close? In approximately how many million years in the future will the Atlantic Ocean be fully closed?

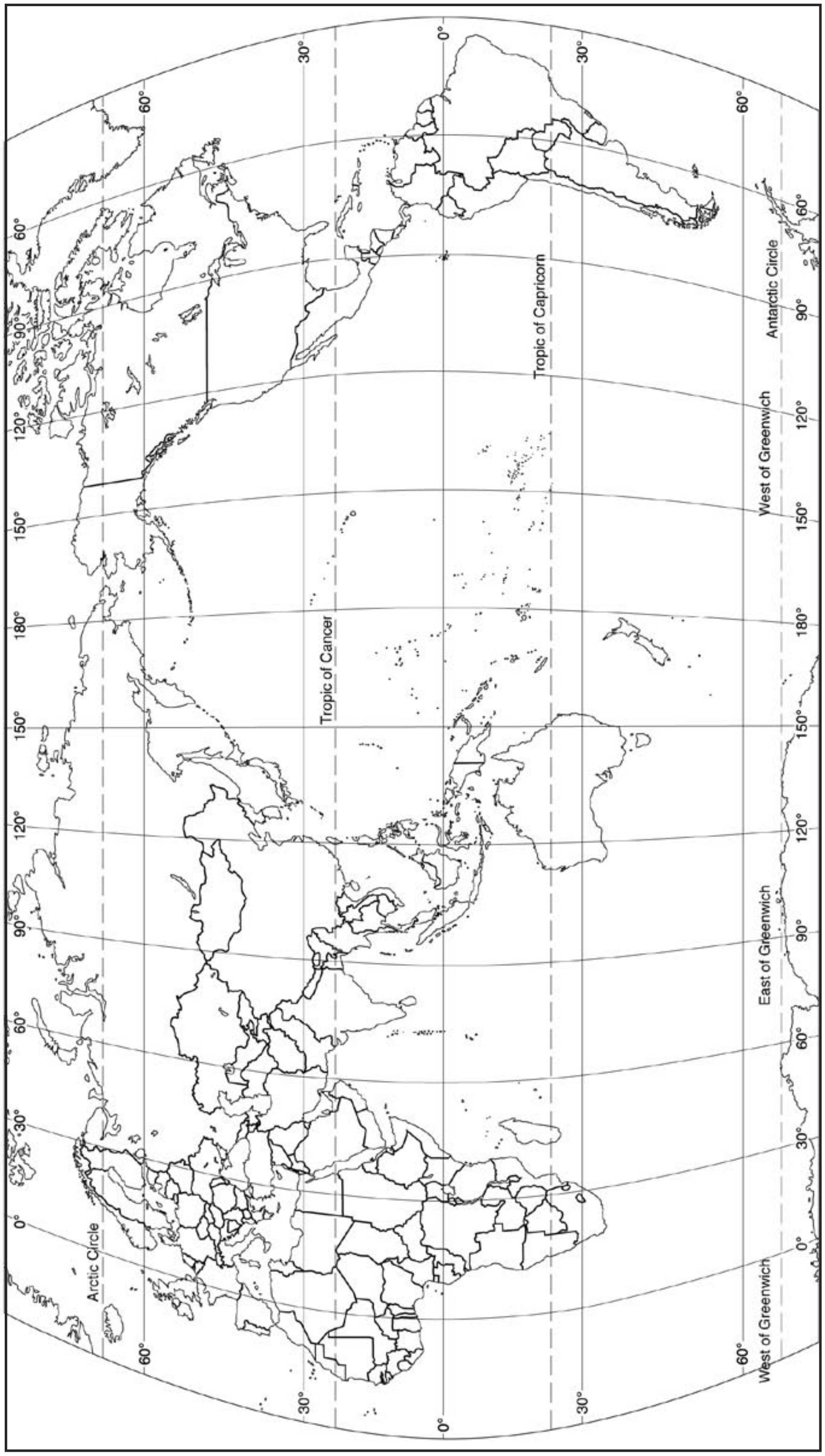
2. When an ocean closes, does the volcanic activity at the mid-ocean ridge stop? Predict for how long Iceland will continue to experience its characteristic volcanic activity.

3. David Suzuki comments that "geologists are really storytellers. They gather their material by clambering over rocks." Write a "geological" bedtime story based on any chapter of Episode 1: "Tectonic Europe" that appeals to you. Share your story with the class or a younger student or sibling.

Assessment Suggestion

In earlier times in Earth history, when the planet had much more internal heat, plates moved considerably faster than they do now. Students draw a series of sketches to illustrate the stages of the Wilson Cycle using a maximum width of 5 000 km for the full or mature ocean basin stage. Then, instead of our current plate motion rates of several cm/year, calculate the duration of each stage of the Wilson Cycle based on an average rate of plate motion of 100 cm per year.

Appendix 1.3.1 – Outline Map of the World



Source: Pearson School Atlas Teacher's Guide, by Robert Morrow
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GEOLOGIC JOURNEY II

EPISODE 2: ALONG THE AFRICAN RIFT

UNIT OVERVIEW

Episode 2: "Along the African Rift" takes us on a remarkable journey across a landscape that has a history of giving birth; whether it is to the evolutionary steps of early modern humans, the cradle of the first human civilizations, the fiery furnace of the hottest place on the planet or the splitting apart of a continent to give rise to a new ocean, this is a place where "things have occurred that have not happened anywhere else." In the words of University of Toronto Scarborough geologist Nick Eyles, as he gazed into the molten crater of Dellol atop the Ethiopian volcano Erta Alé, "it is amazing to see this, not just as a scientist, but as a human being."

Along the way, we visit the Afar region of northern Ethiopia to climb a large, flat shield volcano that the local residents call the "smoking mountain," traverse west to the highlands that feed the cataracts of the Nile River, marvel at the ability of Egyptian culture to grasp the geology of their homeland to assemble the foundations of a great civilization, and then walk along the steep-sided canyon of red sandstone that leads us to the ancient merchant city of Petra.

This episode has three distinct geological and cultural themes:

1. The interconnectedness of human evolution with the geology and climate characteristics of the East African Rift Valley (chapters 1 to 3 of the video).
2. The separation of the African Plate from the Arabian and Sinai plates that allowed for the emplacement of the Nile Valley that then led to the emergence of one of humanity's high cultures (Chapter 4).
3. The Dead Sea Rift Valley, a transform fault that connects to the Red Sea and constitutes one of the most seismically active areas of the Middle East. Geologists use clues from both the rocks and stone structures that were built long ago to map out—at times right to the day of the week—when major seismic events occurred in the region (chapters 5 to 7).

EPISODE	CHAPTER	CHAPTER TITLE	TIME	NARRATION CUE
2: Along the African Rift	1	Ol Njorowa Gorge, Kenya	00:03	The Great Rift Valley
	2	Afar Triangle, Ethiopia	07:53	How do continents split and how do new oceans form?
	3	Erta Alé, Ethiopia	15:31	But seeing the process with eyes instead . . .
	4	Aswan and Luxor, Egypt	26:15	From Ethiopia, Nick follows the Nile . . .
	5	Petra, Jordan	34:07	Nick says goodbye to Egypt and travels along the Red Sea coast . . .
	6	Dead Sea and Masada, Israel	40:14	From Petra, Nick goes north into the land of Canaan . . .
	7	Mediterranean Sea, Israel	49:13	Nick's journey ends on the coast of the Mediterranean Sea

EPISODE 2: ALONG THE AFRICAN RIFT

ACTIVITY 2.1 • THE AFAR TRIANGLE: WHERE VOLCANOES, EARLY HUMANS AND A YOUNG OCEAN MEET

Vocabulary Checklist
Wilson Cycle, triple junction, divergent plate boundary, mantle plume, archaebacteria, hydrothermal fluid

Curriculum Expectations

- Analyze, with reference to geological records, the relationships among climate, geology and life on Earth, and evaluate contributions to our understanding of changes in Earth systems over geological time.
- Describe geological evidence that suggests life forms, climate, continental positions and Earth's crust have changed over time.
- Select and use appropriate numerical, symbolic, graphical and linguistic modes of representation to communicate ideas, project plans or results.

The Afar region of northern Ethiopia is where tectonic forces act at a "triple junction"—an area of the Earth's crust that is breaking apart along three major weaknesses. Where the Red Sea, the Gulf of Aden and the northern extremity of the East African Rift Valley meet is the epicentre of this triple junction—and the opening up of the beginnings of a substantial ocean basin.

Chapters 1 to 3 of Episode 2: "Along the African Rift" focus on the unique relationships among the emergence of modern humans, the comings and goings of large inland waterways as climate cycles occur, and the immense geologic forces that have been tearing apart eastern Africa for the past 30 million years. German geologist Martin Trauth has uncovered a connection between this "first industrial revolution" and people's adaptation to the cycles of climate from dry to wet.

Did you know . . .
The summit of the Erta Alé shield volcano in northern Ethiopia is one of only four places on Earth where one can directly view molten rock bubbling up to the surface as a lava lake. The "smoking mountain" as it is called in the local language is one of the hottest places on our planet.

Atop Erta Alé, northern Ethiopia's "smoking mountain," one of only four active lava lakes on Earth, the cauldron mimics plate tectonics in miniature. As the lava surface cools, a thin dark crust is formed that is almost immediately rifted apart by hot, upwelling molten material from below.

Activity Overview

This activity is an "eco-tourism" development project. In groups of three or four, students design a brochure, create a multimedia infomercial or prepare an oral/video presentation that outlines the characteristics of the Afar Triangle region. Links will be made to the geology, people and places that are seen in chapters 1, 2 and 3 of the video. Students should be able to identify and describe the plates that influence the tectonic forces around the Horn of Africa and the associated physical landscapes as well as the relationships among types of plate boundaries (convergent, divergent, transform), type of volcanism at each boundary and the notion of a "triple junction."

Background Information

Prior to viewing the video, teachers should review the basics of plate tectonics using maps available in atlases or use online sources at the introductory level.

EPISODE 2: ALONG THE AFRICAN RIFT

The *Geologic Journey II* website, www.cbc.ca/geologic2/videos.html has a brief video clip entitled "Birthplace of Humanity" that introduces the connection between the geology of the Afar region and human evolution.

The *Geologic Journey II* website also has a glossary (www.cbc.ca/geologic2/glossary.html) that provides short descriptions of a variety of geological phenomena connected to plate tectonic activity.

Students should have some geographic familiarity with key locations associated with chapters 1, 2 and 3 of Episode 2: "Along the African Rift." The following locales are featured: East African Rift Valley, Afar Depression, Erta Alé volcano, Danakil Desert, African Plate, Somali Plate, village of Al Abdullah.

Pre-viewing Activity

Teachers can activate/engage students' prior knowledge in a variety of ways prior to viewing the video. Create a class list of "essential questions" students need to consider as they develop their eco-tourism package or information resource.

In the first step of the project (question 2.1.1), students update this list with new/revised "essential questions" following the viewing of chapters 1, 2 and 3 of the video. To focus on the development of these questions, teachers can ask students to watch for:

- Evidence to support the labelling of the Afar Triangle of Ethiopia as "the cradle of humanity"
- How the Afar Triangle affirms the notion of a supercontinent—an idea developed by J. Tuzo Wilson, a Canadian geoscientist
- The geological history of the Danakil Desert, which has promoted the development of salt slabs at the surface that are suitable for mining
- The clues that relate hyperthermophile life forms found in the Danakil Depression to the origin of life on Earth
- Opportunities for visitors who use the eco-tourism package to view a "window into the Earth's mantle" (on Erta Alé)

Teacher Preparation and Materials Required

This activity draws from chapters 1, 2 and 3 of the episode.

Also recommended as students build their ecotourism project:

- YouTube (for video footage of Danakil Desert)
- Google Earth (for locations and satellite imagery)
- Flikr (for Creative Commons licensed images from the Afar region, see www.flickr.com/photos/43349236@N04)
- Ocean floor imagery from CBC's *One Ocean* series – Episode 1, Chapter 1 and Episode 3, Chapter 1

LESSON PLAN

Part 1 – Understanding the Afar Region and Its Eco-tourism Potential

2.1.1 View chapters 1, 2 and 3 of the video and revisit your "essential questions" list that was developed in class. Update the list with new or revised "essential questions" for your eco-tourism development project based on information you have learned from the video.

2.1.2 You want to generate enthusiasm to encourage visitors to come to a place that receives very few tourists each year. The video states that "this is the very cradle of the human species" and "there are things that have happened here that have not occurred anywhere else on Earth." To develop this unique experience, identify some of these "things" and the key locations to be visited for your eco-adventure plan in the Afar region of northern Ethiopia.

2.1.3 If Martin Trauth was available to guide tours of the Rift Valley, what links would you expect him to emphasize among climate change, geology and the emergence of early humans from this area? Include several of these links in your presentation.

2.1.4 About two million years ago, early humans in this region fashioned stone tools that have been found preserved in the diatomite sediments. Nick Eyles says that, "these tools represent the first industrial revolution." What is diatomite, and where does it come from? Would you agree with Nick Eyles that simple stone tools were a "revolutionary" way to use geology for a human purpose? Provide rationale for your position.

2.1.5 From an eco-adventure tourism perspective, this region has many great stories to be revealed (e.g., its plate-tectonic setting, the Wilson Cycle unfolding before our eyes). What should be emphasized in terms of attracting eco-adventure tourism to this area?

Part 2 – Extreme Environments, a Birthplace for Life and the Salt of the Earth

2.1.6 Part of your eco-adventure involves traversing the hot, arid Danakil Desert of Ethiopia. You plan to visit the village of Alé Abdullah, where merchants load slabs of salt onto camels to sell in the markets. How does the existence of large salt flats in the region link to climatic cycles in this region's geological past? What effects might climate change have had on the people who live in this area?

2.1.7 The Dellol crater in the Danakil Desert has average temperatures that are the hottest on Earth. The Earth's crust here is very thin, allowing groundwater to be super-heated by magma below the surface of the salt deposits. What happens as a result of this heating of water? Research the concept of a hydrothermal fluid and include this information in your presentation.

2.1.8 At Dellol crater, mats of bacteria co-exist with hot brines that bubble up to the surface in a colourful landscape like none other. These organisms are known as extremophiles. How might these organisms be a "window on the earliest life forms to inhabit planet Earth"?

Part 3 – Lava Lakes and the Volcanoes from Mars

The next stop on your eco-adventure involves the long and perilous trek to the top of Ethiopia's shield volcano, Erta Alé. There, the eco-tourists hope to glimpse through the steam and mist the volcanic cauldron of its summit caldera and the lava lakes there.

2.1.9 Based on what you have seen and heard in Chapter 3 of the video, determine your route to the 613-metre summit of Erta Alé volcano. It is known as a shield volcano, and there are similar ones on the surface of Mars. As a group, conduct an inquiry to compare the sizes of shield volcanoes on Earth and on Mars—height, size and the existence of calderas.

2.1.10 Geologist Nick Eyles states that the lava pools at the summit of Mt. Erta Alé "mimic plate tectonics on a small scale, with crust rifting apart as hot magma comes up from beneath. It is like a window into Earth's mantle." How can you use your presentation (brochure, video, infomercial) to make connections among the big ideas of plate tectonics (e.g., new crust forming at a divergent boundary, existence of shield volcanoes) with what people will witness when they look down into these lava pools?

Extension Suggestions

1. Extreme environments provide an unusually rich environment for life where we might expect no life at all. CBC's *One Ocean* series (Episode 1: "Birth of an Ocean," Chapter 2: Oasis of the Deep) provides imagery of the extreme sea-floor environment that illustrates an alternative instance of hydrothermal fluid activity (and bizarre life forms) quite different from what was observed in "Along the African Rift." What can you conclude about the ability of life on Earth to adapt to challenging environments?

2. Chapters 1, 2 and 3 of Episode 2: "Along the African Rift" briefly introduce the idea that large supercontinents come and go (assemble and then break up) on our planet in a cycle that is about 500 million years in length. The Afar Triangle area is splitting open along three weaknesses in Earth's crust as a part of the current Wilson Cycle. What might this region's landmasses look like as the next supercontinent assembles? Compare your ideas with those on the PALEOMAP Project website maintained by Richard Scotese. See www.scotese.com/sfsanim.htm and check out the development of the Afar region over the past 250 million years—and into the next 250 million!

3. The *Geologic Journey II* website has a collection of geologic images submitted by viewers from around the world. The collection is located at www.cbc.ca/geologic2/photos.html.

Use these photographs to develop a potential "geologic safari" to areas of the world that have sparked your interest based on the quality and "interest level" of the photographs.

Assessment Suggestion

The GEOLOR online resource provides a virtual tour of the entire length of the East African Rift Valley. While Episode 2: "Along the African Rift" focuses on the Afar region where three crustal plates are pulling apart, there is much more to this rift valley, which extends all the way to Mozambique in southern Africa. Explore www.geolor.com/East_African_Rift_Valley_geolor.htm and see volcanoes such as Ol Doinyo Lengai ("the mountain of God") in Tanzania.

Groups of students can select one of the links and report what geological science they have found there through the preparation of a "digital safari" that can be presented to the class.

The teacher can collaborate with students in determining what the actual components of the final product will contain. The following points may help guide the process of developing a rubric for assessing the project:

- Outline the connections between the local geology and the history of the peoples who live (or once lived) in the tour area.
- Pose a set of research questions that could guide "citizen science-action research" while on the eco-adventure; this helps to focus the narrative to enrich the tour participants' experiences.
- What challenges will be faced in traversing the region? How can we prepare for these?

Compare the infomercial, brochure or video you have produced to what one tour company has put together as an itinerary for this trip at www.volcanodiscovery.com/en/ethiopia/erta_ale_danakil/expedition.html . Have they captured the evidence for the relationships among life forms, climate, plate tectonic movements and the volcanic activity of northeastern Ethiopia?

ACTIVITY 2.2 • BIRTH OF THE NILE AND THE RISE OF A STONE CULTURE IN EGYPT

Curriculum Expectations

- Analyze and describe examples where scientific understanding was enhanced or revised as a result of the invention of a new technology (describe how stonemasons in ancient cultures made use of the properties of rocks/minerals in order to demonstrate cultural priorities).
- Describe the historical evolution of extraction of, and the use of, several resources obtained from the lithosphere.

At the beginning of Episode 2: "Along the African Rift" we discover that the emergence of the western Ethiopian highlands was due to the convergence of tectonic forces acting near the Afar Triangle. These forces provided a watershed for what would become one of the most important rivers in human history. As geologist Nick Eyles makes his way along the river, we find that the Nile allowed for efficient transport of various types of stone that represent some of the oldest known uses of geologic resources as building materials. The most prized for carving monuments (obelisks) to the gods and the great pharaohs were the red and black granites of the high Aswan region in southern Egypt. A red sandstone from specific quarries where large flat surfaces could be cleaved off the rock face (geologists call these cleavage planes) was also valued. This particular stone, derived from sediments that were once washed into a now-forgotten sea, was also ideal for carving the hieroglyphs ("priests' writings") that we associate with Egyptian culture.

These early peoples created the first detailed geologic maps of their stone quarries and sent out large field parties to search for minerals (e.g., lapis lazuli, a bright blue ornamental mineral). All this was directed toward building monuments that connected them to an afterlife.

Activity Overview

This activity takes the form of an inquiry activity. Teachers may find it useful to guide students in developing the "big ideas" as a first step in the inquiry process. Students are encouraged to explore the context of "what new impressions do you have of Egyptian culture now that you can link it directly to the geology of this part of the world?" This can represent the basis for an "essential question" that can guide a whole collaborative effort among students to uncover those "big ideas."

Pre-viewing Activity

Teachers can activate or engage students' prior knowledge in a variety of ways to develop a series of "essential questions" to guide the inquiry. This can be done by posing some questions in advance and then revisiting these questions after viewing the video. These might include:

- What we see around us today is considered a continuation of the Industrial Revolution, which began over 200 years ago. Some say that ancient Egypt's use of stone for building was also a sort of "industrial revolution." Why might this be the case?
- Chapter 4 of Episode 2 makes the claim that the Egyptian civilization represents the "oldest known use of stone anywhere in the world for building." What types of evidence should we be looking for to support this claim? (This is an excellent activation for student inquiry, particularly for students who enjoy doing some "digging"—after all, that's what geologists like to do.)
- Hypothesize the links among ancient cultures, how the people in those cultures live their lives, and the geology that is around them.

Teacher Preparation and Materials Required

This activity draws from Chapter 4 of the video. Teachers may also want to make copies of Appendix 1.2.1 – Concept Map and Appendix 2.2.1 – Your RAFT and use the criteria suggested in Appendix 2.2.2 – Assessment Criteria for a Presentation: Suggested Areas to develop a personalized rubric for assessment of a presentation.

Background Information

Prior to viewing Chapter 4 of Episode 2, teachers can review the fundamentals of effective inquiry learning. Samples and descriptions of inquiry-based, problem-based or project-based learning can be found online at: "Teacher Tip" – http://eduscapes.com/tap/topic43.htm and "Teachnology" – www.teach-nology.com/currenttrends/inquiry/.

A framework that teachers may find a good starting point for inquiry was developed by Smarter Science (www.smarterscience.youthscience.ca) to help elementary science and technology curriculum and the secondary science curriculum come alive for students with classroom activities that reflect the investigative, creative and social nature of science. An effective framework for teaching science will actively engage students, incorporate literacy and numeracy learning and develop thinking skills, problem-solving skills and independent learners. Smarter Science is a framework, not a program; it is a means for teaching students how to do science, but does not dictate what to teach. It results in learners that are engaged in the process of science and more than willing to create, innovate, and explore the science curriculum.

LESSON PLAN

Part 1 – The Activating/Engaging Phase of the Inquiry

In this part of the inquiry, the intention is to link your prior knowledge with what has just been seen in Chapter 4 of the video. We will be exploring some of the ideas that were brought to us about things such as the geologic origin of the Nile River, and how Egyptian stonemasons used the very nature of the rocks in order to get just what was needed for building, carving and celebrating their rich culture.

In a small-group setting, we can begin the inquiry process:

1. Brainstorm some questions that come to mind after having viewed Chapter 4 of the video.
2. Think about a role that each of you would like to play in the research (for instance, photojournalist, stonemason, architect, geological engineer, Egyptian priest, map maker, etc.). Later on, we will put those roles together into a research team.

Part 2 – The Acquisition/Exploration Phase of the Inquiry

Begin to arrange your ideas from the questions developed in Part 1 of the inquiry using a copy of Appendix 1.2.1 – Concept Map. For example, using the following essential question as a sample might generate additional questions to guide the development of your concept map: "How might we account for ancient Egypt's use of stone as a form of 'industrial revolution'?"

- Do you have a number of different rock types listed on your map? Can we create some categories out of these?
- Does it make sense to put certain ideas under the heading of "architecture" as opposed to "technology use"?
- Is there a larger idea that can link, or capture more fully, these points you have made?

At this stage, it is important for you and your research team to begin the process of locating information from various sources based on what came from your concept map and "big idea" questions.

Keep thinking about the role that you want to play in terms of your contribution to the research team. In Part 3 of the activity you can arrange your responsibilities and generate some new knowledge.

Part 3 – The Application Phase of the Inquiry

In this part, we want to get a clearer picture of where we are with our inquiry into the geology of Egypt and its connections to that country's history and culture. We also want to share and celebrate our new geologic thinking. As a group, some of the new understandings we have developed may include:

- New understandings about the interdependence of Earth systems that support human communities, and the realities of geologic events that can be hazardous
- Awareness of the consequences of human actions on the geologic environment (e.g., sustainable use of resources, planning for scarcity, location of population centres)

Your research team can develop a plan for a final task that shows your learning. This can be done through a performance, a demonstration, a multimedia presentation or some sort of product. It can be developed with individual contributions within your small groups and then presented to the whole class.

The evaluation criteria for work quality should be developed by students and teacher together. Some suggested criteria for the development of a rubric based on the final product could be based on the example in Appendix 2.2.2 – Assessment Criteria for a Presentation: Suggested Areas.

Assessment Suggestion

The following points may help guide the process of developing a rubric for assessing the inquiry project:

- Outline the connections between the local geology and the history of the Egyptian people who live (or once lived) in the area that you have examined with your research team.
- Consider doing a "gallery walk" with the group presentations and discuss what elements of each made for a powerful message. Listen carefully as students talk about what they have discovered. Listen too for how students feel connected to their own work. What could have been changed? What might be added to enhance the final product(s) of the inquiry?
- If students need guidance on how to effectively assess their own work and accomplishments, the following phrases can be useful in getting that process underway:
    - I found out this really interesting thing about . . .
    - We were really confused about . . .
    - One thing I would have liked to have done, but did not have time for was . . .
    - A remaining question I have is . . .
    - I am still struggling with the following geological ideas . . .

Appendix 2.2.1 – Your RAFT

The RAFT process—an acronym for "role," "audience," "format" and "topic"—can help students see an overview of an entire project. This example will provide a model. Here is what your RAFT might look like—with a few gaps left for you to consider filling in:

RAFT IDEAS: GEOLOGY AND ANCIENT EGYPT			
Role	**Audience**	**Format**	**Topic**
Photojournalist	Tour operators, advertising agencies	Photo essay	Landscape along the Nile River
Stonemason	Fellow stonemasons, building architects		
Geological Engineer			What are the mechanics of getting carved stone out of the quarries?
Temple Priest	The people of ancient Egypt who used their crops to pay taxes to the temple		What are the latest data for the flooding periods along the Nile River?
Mapmaker	Field parties who search for rocks and minerals		Where are the best locations to get the rock types needed for buildings, obelisks, religious carvings, etc.?
Tour Guide	Visitors to Egypt	Multimedia presentation, pamphlet, advertising campaign	

Appendix 2.2.2 – Assessment Criteria for a Presentation: Suggested Areas

The following can provide the basis for assessment.

Knowledge and Understanding – content and variety of relevant images or objects, labels and texts to illustrate an understanding of events and issues

Thinking and Inquiry – a selection and organization of images and objects to offer insight into the topic or theme

Application – an arrangement of images and objects to show logical connections between people and events and the creation of new connections and questions for the viewer

Communication – a clear message or theme that provides visual impact; titles, labels and sources of information/credits clearly indicated

ACTIVITY 2.3 • THE DEAD SEA RIFT AND CLUES TO ANCIENT EARTHQUAKES

Curriculum Expectations

- Identify individual or collective actions that work to preserve valuable geological sites.
- Analyze technological developments that have increased our knowledge of geological processes and structures and how this knowledge assists in monitoring and managing these.
- Describe the types of boundaries (convergent, divergent, transform) among lithospheric plates and explain the types of internal Earth processes occurring at each.

Did you know . . .
The steep-walled canyon that takes us into Petra was carved out by running water—a perpetual stream that created a habitable oasis in the canyon. It appears the Nabataeans could control their water supply by damming the stream during periods of flash flooding—what was called the Musa. But this area of the world is now a hot, dry desert of windblown sand. The Middle East was once a cooler and wetter environment than it is today, and the narrow canyons were carved by the action of rivers that found their way through natural geological fractures in the red sandstones that characterize this area.

Chapters 5, 6 and 7 of Episode 2: “Along the African Rift,” explore the relationship between large seismic events and the rise and fall of civilizations in the history of this region—with a particular emphasis on the modern-day Middle East. This journey involves a remarkable sequence of landscape types starting with the enigmatic red sandstone canyon and continuing to the ancient mercantile city of Petra. This “city of stone” (hence its Greek name “petra” meaning “stone,” and in Arabic, Al-Batrã’) was the major centre of Nabataean culture and was founded in the 6th century BCE. The deep canyon that approaches Petra is part of a long series of similar deep-cut, abandoned river channels that link the Dead Sea to the north with the Gulf of Aqaba to the south. The city was abandoned in about 500 CE.

An Israeli geophysicist, Dr. Shmuel Marco from Tel Aviv University, studies historical earthquakes from clues he can glean from the ruins of ancient cities and bands of sedimentary material in the cliff faces. In a stunning bit of reasoning from fallen stone columns and metal coins that were found at certain sites in the region, he and his co-workers have determined that a massive magnitude 7.5 earthquake struck the entire Middle East on what we would call May 19, 363 CE.

Many geological events have disrupted entire cultures in this part of the world—especially the great earthquake of 1202, which is thought to be the largest quake in the last 3 000 years to strike the Dead Sea rift valley.

Activity Overview

This activity focuses on the relationships that develop between geology, culture and the development of civilization. Students use an online application hosted by the United States Geological Survey (USGS) to examine current tectonic and earthquake activity in the Middle East. Making the connection between the present geological activity in the crust of this region and the experiences of past civilizations can demonstrate that—on human lifetime scales—very little has changed in the last 4 000 years. However, on a geological timescale, a great deal can take place over millions of years. Specifically, the area featured in chapters 5, 6 and 7 involve what geoscientists call a transform boundary, where two plates (the Sinai and Arabian plates) are sliding past one another, creating a network of faults in the crust.

Pre-viewing Activities

Teachers can activate or engage students' prior knowledge by reviewing what they may already know about the region. Most recognize the importance of the region historically as one having some of the world's oldest and most diverse cultures. The region has been at a crossroads of religion, science, architecture and civilization for centuries. Now they can add the connections between these areas and the geology of the region.

Students should review the basic geography of the area and become familiar with the locations they will experience in the video: Petra, Dead Sea, Masada, Hippos, Jordan River, Gulf of Aqaba, Red Sea and the Sinai Peninsula.

Teacher Preparation and Materials Required

This activity draws from chapters 5, 6 and 7 of Episode 2: "Along the African Rift."

Teachers will find a world map or globe and the following online sources helpful:

- This Dynamic Planet, hosted by the USGS, is available online at http://mineralsciences.si.edu/tdpmap/. Clicking on the interactive map feature at http://nhb-arcims.si.edu/ThisDynamicPlanet/index.html allows you to zoom in on a region of Earth and examine the tectonic activity there for the last one million years.
- Earthquake Hazards Program of the USGS maintains a website that provides real-time plotting of earthquake activity worldwide at http://neic.usgs.gov/neis/qed/ for current seismic activity (especially for this region); connections can be made with the tectonic plate motions.
- Global Tectonic Activity Map (available online at http://denali.gsfc.nasa.gov/dtam/gtam/
- At the UNESCO website (http://whc.unesco.org) students can conduct a search—complete with an interactive map—to find heritage sites of their choice. Through that search, they can find the page devoted to the city of Petra. **Teacher Tip:** If you have an ESL orientation to your classroom the URL to be located is http://whc.unesco.org/en/list/326/. The contents of each UNESCO page devoted to a site are available in six languages: English, French, Arabic, Mandarin, Russian and Spanish.

LESSON PLAN

Part 1 – What is a World Heritage site?

The United Nations Education, Scientific and Cultural Organization (UNESCO) has a program that designates places around the world that have "outstanding universal value to humanity . . . to be protected for future generations to appreciate and enjoy." The city of Petra in southwestern Jordan is a World Heritage site.

Using the UNESCO website (http://whc.unesco.org), students can use the zoom feature in the "Maps" tab and take themselves to the Interactive Map page and then go on a virtual tour to a scale where the local geology becomes woven into the structures that were built by human activity over centuries.

2.3.1 How is the work of establishing a UNESCO site accomplished?

2.3.2 Can you think of a geological site in Canada that has been identified by UNESCO as a "natural" World Heritage site? If not, conduct a search at http://whc.unesco.org/en/list/ to identify such sites.

2.3.3 How has the preservation of Petra as a World Heritage site supported the objective in this activity of identifying "individual or collective actions that work to preserve valuable geological sites"?

2.3.4 Based on your viewing of chapters 5, 6 and 7 of the video, how did the ancient cultures that have occupied Petra make effective use of the elements of the local geology for their own purposes? As well as natural resources such as water and building stone, consider other aspects such as architecture, art forms and the design of dwellings.

Part 2 – New Technology and the Dead Sea Rift

Nick Eyles takes us on a tour along the transform fault that lies between the Sinai/Israeli Plate to the west and the Arabian Plate to the east. Some of the most notable historical names are associated with this area, including Sea of Galilee, Jordan River, Dead Sea, Wadi Qumran, Gulf of Aqaba and the Red Sea.

As a class or in small groups access the This Dynamic Planet geologic map found at http://nhb-arcims.si.edu/ThisDynamicPlanet/index.html. With the assistance of a world map or globe in the classroom, locate the area of the Middle East that is featured in this episode. Zoom in so that portions of east Africa, Saudi Arabia and the Middle East are all visible onscreen. The scale on your screen should read "2 000 km" or "1 000 km," depending on what level of zoom you want.

By clicking on the "Layers" tab, toggle on the Earthquakes, pre-1900 Notable Earthquakes and Plate Tectonics features. Close this menu so you can now see just the map with all its features and the large Legend in the right corner of the screen.

In small groups, describe the tectonic activity of this region based on the map. Divide the areas of focus—Volcanoes, Earthquakes, Plate Boundaries—based on the legend on the map.

2.3.5 What type of tectonic plate boundaries are found in this region? Note: the transform (sliding) boundaries are drawn in black on this map, not in white as the Legend indicates.

2.3.6 Locate the white arrows that indicate the direction of moving plates. In what two directions is the lithosphere moving in this part of the world?

2.3.7 Are the earthquakes "shallow" or "deep" in the crust here? Is this earthquake depth connected in any way to the type of plate boundary?

Through online sources, locate information about the following two places: Masada and Hippos (Sussita). You may also want use Google Earth to locate these places and then "fly in" from Earth orbit to see them up close; the video states that each location was devastated by a large earthquake.

2.3.8 The ancient ruins of Hippos were destroyed in a large earthquake that occurred in 1202. What current earthquake research featured in the video (with geophysicist Shmuel Marco from Tel Aviv University) made use of the ruins as a way to understand the timing and force of the earthquake?

2.3.9 How does our answer to 2.3.8 connect to the objective of this activity to "analyze technological developments that have increased our knowledge of geological processes and structures and how this knowledge assists in monitoring and managing these processes"?

Extension Suggestion

Real-time Earthquake Monitoring

Teachers may suggest that groups of students engage in an ongoing earthquake-monitoring program that takes place over the course of the school year. The class can be subdivided geologically by assigning particular lithospheric plates to each group.

A large wall map (available at the This Dynamic Planet website at http://mineralsciences.si.edu/tdpmap/ or from a local geological survey office) can be placed on a classroom wall that has a cork backing. Each week, short reports of recent earthquake activity as determined from the USGS earthquake hazards site—http://neic.usgs.gov/neis/qed/—can be delivered to the class by students. Pushpins of various colours can be used to indicate the magnitude of the plotted earthquakes.

At the end of the term, a summative presentation can be made by student groups to summarize for the class the distribution of earthquakes around the world. Comparisons with established maps of worldwide seismicity can allow for a correlation to be made with student data.

Assessment Suggestions

1. The summative presentation can be assessed using some of the following criteria, developed into an appropriate rubric: knowledge and understanding, thinking and inquiry skills illustrated, evidence of written/graphic/oral communications skills and the application of knowledge—drawing conclusions, making predictions and illustrating connections.

2. In addition, the group work aspect of the process can be assessed using criteria such as communication of the written work (before and after interaction), oral communication with peers in the group setting and the application of skills and concepts related to the group's achievements.

EPISODE 3: THE PACIFIC RIM: AMERICAS

UNIT OVERVIEW

The tectonic story of this unit starts with a visit to southern Alaska. Here, the fastest-growing mountains on the planet are a result of the Yakutat Block, or micro-plate, being carried and pushed by the Pacific Plate into Alaska. During the last 200 million years, the process of tectonic accretion has attached landmass to western North America, including areas of British Columbia and Alaska. One of the consequences of this tectonic force was the most powerful earthquake recorded in North America, near Anchorage in 1964. The Pacific Plate's collision with the North American Plate has also created an extensive mountain system. The combination of the uplifting of these massive fold mountains and the forces of glaciation working to tear them down has created some of the most spectacular vistas in the world.

California is home to one of the planet's mega geologic features—the infamous San Andreas Fault, which is visible from space. This geologic icon is only one of many fractures that underlie large urban coastal centres such as Seattle, San Francisco and Los Angeles. Chapter 3 of this episode focuses on the seismic history and threat to the city of San Francisco. Lying between the San Andreas Fault to the west and the Hayward Fault to the east, the city is described as sitting on a "seismic subway system." Severe earthquakes hit this area in 1906 and 1989.

Chile is also no stranger to massive earthquakes. Here the Nazca Plate is being forced under South America, pushing up the Chilean coastline like a giant wedge. The sinking Nazca Plate has resulted in huge impacts to the Atacama Desert and the vast Andean mountain chain. The geologic activity has been responsible for the creation of vast supplies of many different minerals that have had significant economic benefits for the people of Chile.

The Lascar and Chaitén volcanoes are among the most active and most dangerous in Chile—a country with the highest concentration of active volcanoes of any country in the world.

EPISODE	CHAPTER	CHAPTER TITLE	TIME	NARRATION CUE
3: The Pacific Rim: Americas	1	Icy Bay, Alaska, U.S.	00:00	
	2	Anchorage, Alaska, U.S.	08:25	Turnagain Arm, near Anchorage, illustrates both . . .
	3	San Francisco, California, U.S.	17:22	Running south along the rim . . .
	4	Atacama Desert, Chile	26:54	Leaving California, Nick heads south to one of the most earthquake-prone . . .
	5	Chaitén Volcano, Chile	43:36	Further south, in Patagonia, the climate . . .

ACTIVITY 3.1 • ALASKA: TECTONIC SHOWPLACE

Curriculum Expectations
- Demonstrate an understanding of the processes at work within Earth and on its surface and the role of these processes in shaping Earth's surface.
- Investigate geological evidence of major changes that have occurred during Earth's history and the processes that have contributed to these changes.
- State a prediction and a hypothesis based on available evidence and background information.

Activity Overview
Students demonstrate and reinforce their understanding of events related to tectonic collision in this region of Alaska. The use of information organizers allows students to demonstrate a holistic view of tectonic forces and their subsequent impacts on the physical elements of the region and its people.

Pre-viewing Activity
Prior to viewing the video, teachers should review the basics of plate tectonics, using maps available in current atlases or on basic websites. Using search phrases such as "images of plate tectonics" or "videos of plate tectonics" will generate some excellent sites—some academic, some free and some commercial.

Review with the students:
- the plates that influence the tectonic forces around the western edge of North America
- the trenches associated with these plates
- the physical landscapes associated with the tectonic forces of the region

Teacher Preparation and Materials Required
View chapters 1 and 2 of the video and note the different types of plate boundaries that are mentioned and described, as well as their subsequent impacts on landscapes.

Copies of Appendix 3.1.1 – Multi-consequence Web Diagram

Background Information
The Yakutat micro-plate (sometimes called the Yakutat terrane), is slowly colliding with the North American Plate. It is actually riding atop the Pacific Plate, which sinks under the North American Plate in southern Alaska. This is called subduction. See Appendix 4.1.2 – Continental Collision Model.
The Yakutat micro-plate is slowly moving in a northwesterly direction at a convergence rate of approximately 40+ mm per year—the highest rate in the world and twice as fast as the current movement of India into Southern Asia

(where the Himalayas are being created). As the plate converges and presses into the continental landmass, the result is the fast growth of the mountains in the St. Elias and Chugach ranges. The Yakutat Plate is responsible for the creation of Mt. McKinley (or Denali), the highest peak in North America at 6 194 m. This collision is also responsible for many earthquakes extending far into the interior of Alaska. The Yakutat micro-plate has a major fault to its east—the Queen Charlotte-Fairweather Fault. This is a right-moving strike-slip fault (looking from the Yakutat plate across the fault, objects move to the right).

Students should know the basics related to the types of plate boundaries and their impacts on adjacent landscapes and the types of faults associated with the different types of plate movement (normal fault, reverse fault, strike-slip or transverse fault, thrust fault, horst and graben faults). Students should also be familiar with terms such as *orogeny*, *continental collision*, *subduction* and the basics associated with alpine glaciation.

While viewing chapters 1 and 2 of the video, students should gather evidence to support the statement “the Yakutat region of southern Alaska is one of ‘the most dangerous places on Earth.’”

GEOLOGIC JOURNEY II

EPISODE 3: THE PACIFIC RIM: AMERICAS

LESSON PLAN

View chapters 1 and 2 of the video. You will gather evidence from the video and then string together a timeline of events.

3.1.1 The Yakutat region of southern Alaska is described as being one of “the most dangerous places on Earth.” Write a summary paragraph to support whether you agree or disagree with this statement, using evidence gathered to support your position.

3.1.2 Explain why the Yakutat micro-plate, although relatively small, is so powerful.

3.1.3 Glaciation has been described as having the “last say” in shaping the southern Alaska region. What features of glaciation are prominent in these chapters of the episode?

3.1.4 There are many uplifted layers of rock along the shoreline of the southern Alaskan coast. Using the term *isostatic rebound* (or *uplift*) explain how this may have happened.

3.1.5 Why is it possible to find many different types of rock around the shores of southern Alaska?

3.1.6 Describe the process of accretion and how this may have altered the shape of Alaska and British Columbia over the past 200 million years.

3.1.7 Many earthquakes have occurred in this region’s past. What evidence do geologists have to estimate when these events occurred?

3.1.8 A new scientific discipline is called paleoseismology. How may this science be used to help predict future earthquake risks?

3.1.9 Working in pairs, and using the information in the box below, string the facts together in proper sequence to “tell the story” that describes the patterns of the physical landscape in southern Alaska. Arrange the terms from earliest to most recent occurrence and “connect” any that fit logically together. Justify your order and be prepared to share your decisions with other groups.

moraine deposition
isostatic rebound
micro-plate
shoreline terracing
glaciation
land depression
land accretion
earthquakes
subsidence
collision
folding
global warming

Did you know . . .
- Three of the largest six earthquakes ever were in Alaska.
- Over 1 000 earthquakes are recorded in Alaska every month!
- Alaska has 11 per cent of all the world's recorded earthquakes.

Source: "Are you prepared for the next Earthquake in Alaska," (www.aeic.alaska.edu/html_docs/nextbigeq.html)

3.1.10 A massive earthquake occurred in southern Alaska in 1964. Using Appendix 3.1.1, develop a multi-consequence web diagram. In the centre shape (cause), profile the date, location, size and cause of the earthquake. Using the boxes that surround the centre box, identify the types of damage. For example, boxes may be used to describe land subsidence, the subsequent tsunami or liquefaction of the soil. Add boxes if needed. Research this earthquake for additional information and add to your diagram. A good starting point is the Alaska Earthquake Information Center, www.aeic.alaska.edu/quakes/Alaska_1964_earthquake.html.

3.1.11 How would you describe the damage caused by the earthquake of 1964? Write a conclusion based on the information you have collected and organized.

3.1.12 Earthquakes with a magnitude over 7.0 on the Richter scale are devastating. Alaska experiences one of these, on average, every year! Earthquakes with a magnitude of 8.0 are 10 times more powerful than a 7.0. Use the information below to develop a timeline graph from 1900 to the present to show earthquakes that have been centred on Alaska with a magnitude over 8.0.

1900 – 8.3	1903 – 8.3	1904 – 8.3	1904 – 8.3
1938 – 8.2	1946 – 8.1	1957 – 9.1	1958 – 8.3
1964 – 9.2	1965 – 8.7	1986 – 8.0	

(Source: National Geophysical Data Center: www.ngdc.noaa.gov)

3.1.13 Describe the pattern developed and suggest when the next earthquake of this magnitude might occur.

Extension Suggestions

1. Draw a diagram or develop a model to illustrate a strike-slip fault based on the southeastern Alaska region where the Queen Charlotte-Fairweather Fault borders the eastern edge of the Yakutat micro-plate. Show arrows for the movement of the plates.

2. Imagine you are walking down the main street of Anchorage on March 27, 1964. It is 5:36 p.m. local time, and the second largest earthquake ever recorded—magnitude 9.2—hits. You are interviewed by a local paper as to what you saw and experienced. Describe the information you give to the newspaper. You may wish to research this earthquake for more detail of what happened. A good starting point is the Alaska Earthquake Information Center at www.aeic.alaska.edu/quakes/Alaska_1964_earthquake.html.

3. Research websites devoted to preparation for earthquakes. A useful document is www.aeic.alaska.edu/html_docs/pdf_files/eqprepare.pdf published by the Alaska Earthquake Information Center. Create a one-page illustrated document for use in Alaskan schools that will help

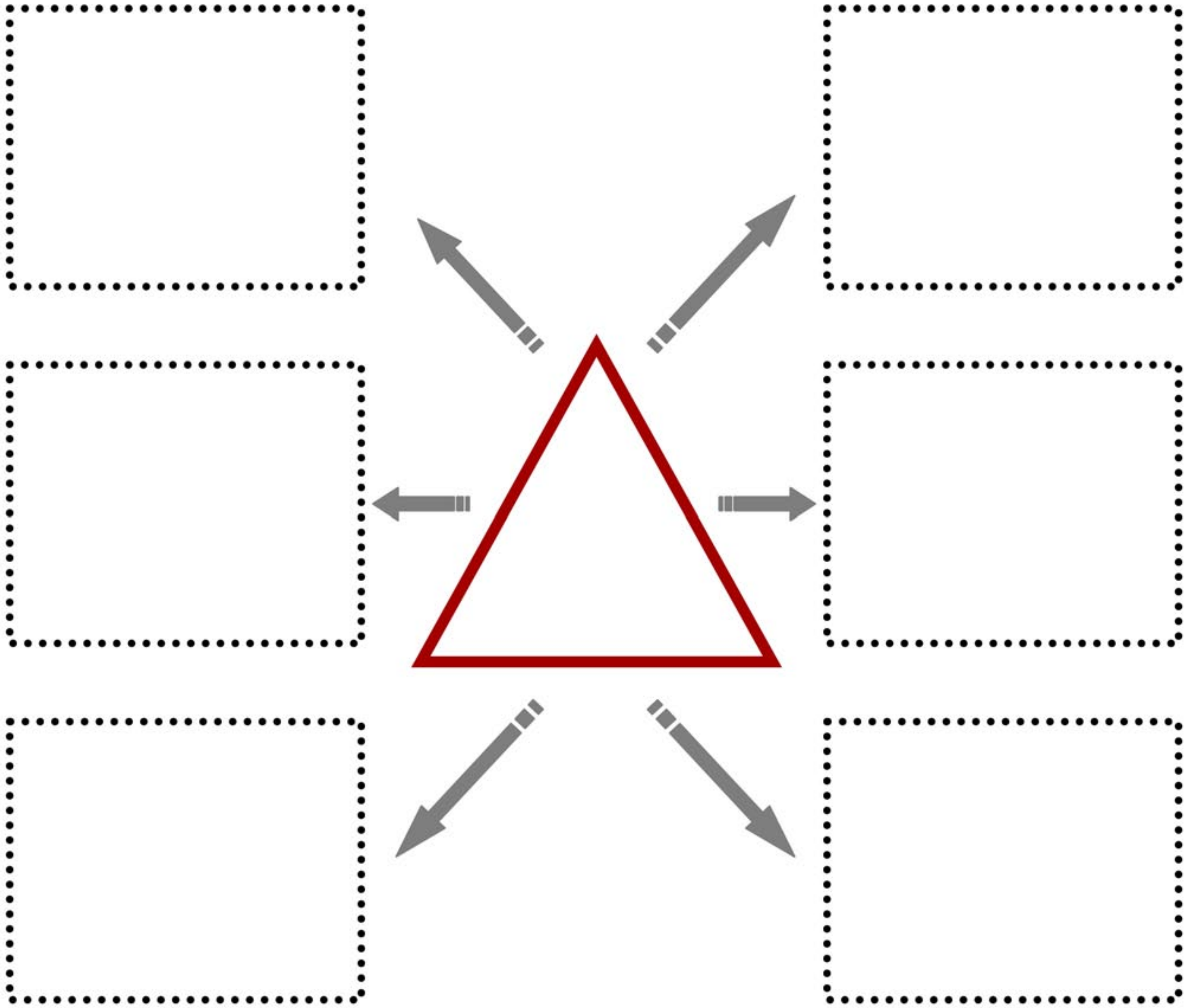
students in the event of another major earthquake. Your document should catch the interest of the students and provide useful safety information.

4. Although Alaska has had very powerful earthquakes, because it has fewer large centres of population, they have resulted in fewer deaths than other more populated places in the world. However, tectonic movements here have caused death and destruction in places thousands of kilometres away. The cause? Tsunamis. Tsunamis are large ocean waves caused by earthquakes. They are the result of sudden shifts in ground level beneath an ocean or landslides of rock material falling into an ocean. In the 1964 earthquake, 106 Alaskans died in the local tsunami, but these waves killed a further 16 people as far away as Oregon and California. Research three other tsunamis that have originated in this region, including the largest-ever-recorded tsunami, in 1958. What caused these tsunamis? How far did they travel? What were their impacts in other places?

Assessment Suggestion

Create a rubric for the assessment of students' Appendix 3.1.1 – Multi-consequence Web Diagram results. Criteria may include: quality of profile content, types of damage, detail of damage, and quality of conclusion(s) reached.

Appendix 3.1.1 – Multi-consequence Web Diagram



ACTIVITY 3.2 • THE SAN ANDREAS FAULT: THREAT TO CITIES

Curriculum Expectations

- Analyze technological developments that have increased our knowledge of geological processes and structures and how this knowledge assists in monitoring and managing these processes and structures.
- State a prediction and a hypothesis based on available evidence and background information.
- Identify and describe science- and technology-based careers.

Activity Overview

San Francisco is surrounded by a complex network of faults, each with the potential to be devastating to the city and its surrounding population.
Part 1 of the activity is a review of the types of faults, including the important transform fault that passes through much of California. How these faults may cause damage is supported by a review of the extent and damage of the 1906 and 1989 earthquakes, using a comparison organizer. Through use of historical data, students hypothesize the potential threat to this region in the future.

Part 2 of the activity involves a role-play simulation to experience the complexity of planning for an earthquake. By simulating roles, students learn that planning involves many people, groups and perspectives on the issue. Following presentations of their action plans, students review and evaluate the planning-for-an-earthquake process by writing a local editorial on the quality of preparation by their simulated city.

Extensions offer opportunities for students to examine Earthquake Action Plans (EAPs) in significant North American West Coast cities such as San Francisco, Vancouver and Anchorage.

Pre-viewing Activities

1. Review the region's plate pattern by referring to a global plate tectonics map that shows some detail for the North American region.

2. Review the location and type of faults prominent around the San Francisco Bay region.

3. Look at a map of population centres in the vicinity of the San Andreas Fault system; determine which major centres of population would be at risk from tectonic activity in this region.

EPISODE 3: THE PACIFIC RIM: AMERICAS

Teacher Preparation and Materials Required

Since students will be focusing on the two earthquakes of 1906 and 1989 the teacher should be prepared to pause the video at critical pieces of information, or split the class into those who collect information for 1906 and those for 1989. A copy of Appendix 3.2.1 – Comparison Organizer: The Great Earthquakes of 1906 and 1989 will help the students to focus on the information to be collected from the video.

Name tags for the roles in the simulation activity are required.

Teachers and students may wish to access the following websites for detailed information about earthquakes and their effects along the west coast of North America.

- Southern California Earthquake Center – www.shakeout.org
- Red Cross – www.redcross.org/www-files/Documents/pdf/Preparedness/checklists/Earthquake.pdf
- Bay Area Governments – http://quake.abag.ca.gov
- USGS - Putting Down Roots in Earthquake Country http://pubs.usgs.gov/gip/2005/15/
- City of South San Francisco – www.ssf.net/index.aspx?NID=427
- BC Earthquake Information – www.pep.bc.ca/hazard_preparedness/prepare_now/prepare.html
- City of Vancouver - http://vancouver.ca/emerg/prepyourself/earthquaketips.html
- Los Angeles Fire Department – http://lafd.org/eqbook.pdf

Background Information

The San Andreas Fault is one of the planet's mega-cracks. This fault is one of many fractures that underlie large urban coastal centres such as Seattle, San Francisco and Los Angeles. Much of the video focuses on the seismic history and threat to the city of San Francisco. Lying between the San Andreas Fault to the west and the Hayward Fault to the east, the city is described as sitting on a "seismic subway system." Severe earthquakes hit this area in 1906 and 1989. On April 18, 1906, 3 000 people died when an earthquake ripped through the heavily populated region of San Francisco. The entire city shook and crumbled when a 477 km stretch of the San Andreas Fault shifted in association with a magnitude 7.8 earthquake. Parts of San Francisco and California were offset several metres.

The San Andreas Fault is often described as being both a transform fault and a strike-slip fault. A transform fault runs along a plate boundary. A strike-slip fault is nearly vertical, with movement horizontally. The land west of the fault on the Pacific Plate is moving slowly to the northwest, while the land east of the fault is moving southwest at a rate of approximately 35 mm annually.

LESSON PLAN

Part 1 – The Danger

Review the region's plate pattern by referring to a global plate tectonics map that shows some detail for the North American region.

Review the map of the faults that are prominent around the San Francisco Bay region in Chapter 4 of the video. Alternately, there is a general map of the faults affecting California at http://pubs.usgs.gov/gip/earthq3/where.html and a more detailed map of the San Francisco area at http://earthquake.usgs.gov/earthquakes/recenteqscanv/FaultMaps/San_Francisco.html.

3.2.1 How long is the San Andreas Fault?

3.2.2 The San Andreas Fault is an example of a transform or strike-slip fault. Describe how this can be damaging.

3.2.3 Strike-slip faults are described as being "dextral" or "sinistral." Research the different meanings. Which term best applies to the San Andreas Fault?

3.2.4 Using maps of California and tectonic plate locations, identify the major cities that are vulnerable to the San Andreas Fault. Confirm your response using http://geology.com/san-andreas-fault/.

3.2.5 The city of San Francisco is said to lie above a "seismic subway system." What are the main faults, and which one is considered to be the most dangerous in the immediate future?

3.2.6 Two significant earthquakes hit San Francisco in recent times—in 1906 and 1989. Based on information in the episode together with further research, complete Appendix 3.2.1 – Comparison Organizer: The Great Earthquakes of 1906 and 1989, which compares these events.

3.2.7 Based on the video, the frequency of major earthquakes in California and your summary, hypothesize the likelihood of another major earthquake hitting the San Francisco Bay region. A good starting point for research is the National Geophysical Data Center website at www.ngdc.noaa.gov/hazard/earthqk.shtml.

Part 2 – Simulation: Planning for the "Big One"

Earthquakes are a reality for people living near the faults in California, especially in the San Francisco Bay area, and there is extensive planning for these pending disasters. You will experience the complexity of the actual planning process for an earthquake. You will be part of a planning group for a simulated city about the same size as San Francisco (800 000 people). The city is heavily dependent on trade to and from its port. The people there live with the danger and reality of nearby tectonic faults, which have resulted in a number of large, damaging earthquakes in the past—the most recent being in 1911 and 1975. Both caused extensive damage, thousands were injured and over 200 deaths were reported in 1911 and 30 deaths in 1975.

EPISODE 3: THE PACIFIC RIM: AMERICAS

Did you know . . .
Along the San Andreas Fault, the Pacific Plate is moving northwestward (relative to the North American Plate) at the same speed as the growth of a fingernail.

During the 1906 earthquake, the plate moved several metres in some locations.

The San Andreas Fault has moved about 560 km during the past 15-20 million years.

Your Earthquake Action Planning Committee (a group of six) has the task to prepare the community for an earthquake-related disaster. For the purpose of the simulation, the fault system to be used is exactly like that in the San Francisco region. The six people in your committee each have a specific role including:

- Director of Schools, responsible for the safety of students in the educational system in the region
- Chief of Police, responsible for law and order
- Health-care chairperson, with responsibility to minimize fatalities and injuries
- Media representative (television, radio, online) to co-ordinate communications before and after the earthquake
- Fire Chief, responsible for the control of fire damage associated with earthquakes and structural damage
- Mayor, political control of the meetings of the committee and the overall co-ordination of and responsibility for the community response

Name tags should be prepared for each of the roles.

Each committee will send its representatives to a specialized group of experts. For example, all the mayors will meet together, all the chiefs of police, and so on. At this meeting, this group should discuss what they should do to help the city prepare that will minimize harm to its population and damage to its structures.

As a collection of like-minded individuals, this specialized group will establish their roles, what they will need to bring to the table of their committees and therefore what research has to take place to provide a factual background for the role, plus any recommendations coming from the group. For example, the mayors need to discuss their leadership role on the committee, the initiatives they need to start to prepare for an earthquake, the types of emergency plans that exist elsewhere and their powers in a state of emergency.

Return to your Earthquake Action Planning (EAP) committees.

Introduce yourselves. Do not forget your name tag. Each member of the committee will report briefly (five minutes) on what needs to happen now in preparation for a future earthquake.

3.2.8 List 10 critical decisions that should be part of the community preparation for a future destructive earthquake.

3.2.9 List 10 important actions that must take place during an earthquake. Try to place these in order of importance (this is called “rank ordering”).

3.2.10 List five actions that need to be taken AFTER the earthquake.
Action plans will be displayed, and representatives will explain the main features. The committees will collectively learn from the other plans and improve their own planning document.

3.2.11 Individual review: Assume you are now a member of the local media. Write an editorial about the quality of the Earthquake Action Plan that was created for your city. State your opinion about the plan, its merits and problems and suggest ways it could be improved.

Extension Suggestions

1. Research and review earthquake preparation plans in significant urban North American centres such as San Francisco, Los Angeles, Seattle, Vancouver, Anchorage.

2. Discuss and research possible careers in earthquake understanding and possible careers associated with planning for such natural disasters.

Assessment Suggestions

A rubric based on individual and/or group participation in the action planning can be developed using the following criteria:

Individual

- Individual self-assessment, including role contribution
- Information gathered
- Quality of media report

Group

- Level of group co-operation
- Group outcome
- Quality of action plan presentation

Appendix 3.2.1 – Comparison Organizer: The Great Earthquakes of 1906 and 1989

	1906	1989
Date		
Location of epicentre		
Location relative to the major fault lines		
Magnitude		
Cause of building damage		
Amount of building damage		
Human costs (fatalities, injuries, number of people left homeless)		
Similarities between the two earthquakes		
Differences between the two earthquakes		
Similarities and differences may or may not be significant. Identify key similarities and differences that are significant and therefore important in dealing with future earthquakes.		

ACTIVITY 3.3 • A CHILEAN REALITY: BENEFITS AND DANGERS OF TECTONICS

Curriculum Expectations

- Identify major areas of tectonic activity in the world by plotting the location of major recorded earthquakes and active volcanoes on a map and distinguish the areas by type of tectonic activity.
- Explain the different types of evidence used to determine the age of the Earth and how this has influenced our understanding of the age of the planet.
- Demonstrate an understanding of the processes at work within Earth and on its surface and the role of these processes in shaping Earth's surface.
- Explain that science and technology are developed to meet societal needs and expand human capability.

Activity Overview

This activity is based on the tectonic forces at work along the west coast of South America, focusing on the long, narrow country of Chile. The activity involves: a review of the tectonic activity in this area and a media presentation on volcanoes or earthquakes. This area has been undergoing subduction and the creation of subsequent landforms as a result of the collision of the Nazca Plate and the South American Plate. The region has a place in the early discovery of tectonic processes from Charles Darwin's observations in 1834-35. The landforms and mineral wealth are explored together with the threat of earthquakes and tsunamis to the low-lying coastal areas in Chile.

The Atacama Desert is explored for its geological gems: landforms, mineral wealth, evidence of climate change and nearby volcanoes. The indigenous people—the Atacameño—demonstrate resilience when faced with natural challenges, which we see even today. Finally we witness the threat and destructiveness of two of Chile's most dangerous volcanoes: Lascar and Chaitén.

In Part 2 of the activity, the class is divided into four groups. Under the leadership of an "executive producer," the groups create a media presentation on one of the volcanoes or one of the serious earthquakes experienced in Chile.

Extensions offer opportunities to use map work to explore the distribution of earthquakes and volcanoes in Chile and to explore the costs and benefits of such a volatile environment.

EPISODE 3: THE PACIFIC RIM: AMERICAS

Pre-viewing Activities

1. Review the region's tectonic plate pattern.
2. Review the characteristics of the Chilean environment.
3. Review a population distribution map of Chile and relate it to the physical geography of the country.

Teacher Preparation and Materials Required

View chapters 4 and 5 of the video and visit the following websites:

- geology.com: Volcanoes and Volcanic Eruptions – http://geology.com/volcanoes/
- Extreme Science – www.extremescience.com
- Global Volcanism Program – www.volcano.si.edu/world/
- This Dynamic Planet – http://nhb-arcims.si.edu/ThisDynamicPlanet/index.html
- NASA Earth Observatory – http://earthobservatory.nasa.gov/NaturalHazards/
- Chile Earthquake Information USGS – http://earthquake.usgs.gov/earthquakes/world/index.php?regionID=8
- National Geophysical Data Center – www.ngdc.noaa.gov/hazard/hazards.shtml

The media assignment will require video and audio equipment.

Background Information

The northern coast of Chile is one of the world's most active and dangerous seismic regions. In 1960 the world's most powerful earthquake ever recorded (Valdivia, 1960, 9.5 on the Richter Scale) sent a 25-metre-high tsunami racing across the Pacific Ocean. Here the Nazca Plate is being forced under South America, pushing up the Chilean coastline like a giant wedge. The sinking Nazca Plate has resulted in huge impacts to the Atacama Desert and the vast Andes mountain chain. The upheaval of landmasses over time has raised the level of the coastline, and further inland dried up vast inland waters, creating huge salt deposits in salt lakes, or solars. The sinking, melting magma of the Nazca Plate has produced large amounts of minerals and resulting economic wealth. The export of these minerals is the foundation of Chile's economy. This region is home to the world's largest copper mine, Chuquicamata.

The video demonstrates what it is like to live in the shadows of some of the most active and dangerous volcanoes in Chile—the Lascar and Chaitén volcanoes. Chaitén is a volcanic caldera located in southern Chile. Considered dormant for the past 9 000 years, the volcano began to show signs of activity in 2008. Because of the sudden movement within the massive structure, geologists feared that the volcano could give rise to a pyroclastic flow, which often results from explosive volcanic activity. The Chilean government evacuated nearly 4 000 people from nearby towns. When Chaitén finally erupted on May 2, 2008, ash clouds flew 17 km into the sky and covered several towns. The Chaitén volcano is a part of the larger volcanic arc of the Pacific Rim that includes several hundred active volcanoes from Chile to Colombia.

EPISODE 3: THE PACIFIC RIM: AMERICAS

LESSON PLAN

Did you know . . .
The northern part of the Nazca Plate dips beneath the South American Plate at quite a shallow angle—called flat slab subduction. As a result, there are more earthquakes here. In the south it dips more steeply, resulting in more dangerous volcanoes from the rapidly melting rock.

Part 1 – Observing, Gathering Data and Analyzing the Video

3.3.1 View chapters 4 and 5 of the video and summarize the information learned under the following headings:

- Chile's Physical Geography
- Darwin's Observations
- The Atacama Desert
- Lascar and Chaitén Volcanoes

Share this information with a partner and amend your individual lists of information.

3.3.2 What physical characteristics of Chile have created dangerous conditions for most of its population and particularly cities such as Antofagasta and Calama?

3.3.3 Research the size and movement of the Nazca Plate. Explain, using a diagram, how this has become the main threat to the Chilean coast as well as influencing the development of volcanoes far inland.

3.3.4 What physical evidence was discovered by Charles Darwin in 1834-35 to explain tectonic uplift along the Chilean coastline? How may this have shaped his view of a changing world landscape?

3.3.5 Describe the topography of the Atacama Desert.

3.3.6 What minerals have developed as a result of the tectonic forces present in this area?

3.3.7 The Chuquicamata copper mine is the largest open pit mine in the world. Describe its dimensions using terms of some of your local community landmarks and distances between them.

3.3.8 The landscape of the Atacama Desert in such places as the Valle de la Luna (Valley of the Moon) appears "pummeled." What does this mean and what has caused this appearance?

3.3.9 What evidence is there that there have been significant climate changes in this Atacama region?

3.3.10 How have the Atacameño peoples adapted to the climate changes of the past 10 000 years?

3.3.11 Lascar volcano is one of the most dangerous in northern Chile. How did andesite and rhyolite rock particles make Lascar dangerous when it erupted in April 1993?

3.3.12 In May 2008, the 4 000 residents of Chaitén, in Chile's Patagonia region, were evacuated. Why was the Chaitén volcano (10 km away) so destructive, and why is it still dangerous today?

3.3.13 Based on the information in the video, make a case for either abandoning or maintaining the town of Chaitén.

Part 2 – Case Study Analysis: Media Presentations

3.3.14 In this activity, you will be a member of a media reporting team. Your team will be responsible for reporting a catastrophic event that has taken place in Chile—either a devastating earthquake or a major volcanic eruption. You will be given an opportunity to research information about the natural disaster. Your task is to present a media report. Each group should appoint an executive producer who is in charge of the media presentation and who will assign roles based on a group discussion. You will be assigned to cover one of these events:

- The eruption of the Chaitén volcano in May 2008
- The eruption of the Lascar volcano in April 2006 (first erupted in 1993)
- The earthquake on February 27, 2010, affecting Maule, Concepción, Talcahuano
- The earthquake on May 22, 1960, affecting Puerto Montt and Valdivia

The media report must contain the following elements:

- A live television news report. This will take the form of a docudrama or skit in which you actually report from the scene of the disaster. Assume you are a CBC journalist who has been hurriedly dispatched to the disaster scene. What are you going to tell the viewing audience? What have you seen? What have you learned about the disastrous event? Make it interesting for the viewer who is hearing and seeing about the event for the first time.
- A map showing the location of the disaster
- A graphic that can be used either on television, in a newspaper/magazine or online, etc. This will provide information to the viewer/reader about the cause of the disaster.
- A list of websites that the viewer can visit for more information
- An interview (which may be put into the TV report) with a local scientist about the disaster. A seismologist may give the bigger picture (historical perspective) and detail (the type of volcano or earthquake).
- An opportunity for the audience (the rest of the class) to ask questions of the scientist (or any other official) regarding the disaster to simulate e-mails or Tweets. The teacher may hand out slips of paper on which the student audience can write questions. These can be submitted to the executive producer of the media presentation who selects questions to be asked.
- A newspaper headline and editorial in which an opinion is expressed about the disaster (Were people ready? How good was the response?)
- A bulletin-board display of your materials used and presented

At the end of each media presentation, student groups will visit the bulletin boards completed by other groups, read the information presented in display format and ask questions of researchers, designers and authors of the presentation.

Extension Suggestions

1. Plot volcanoes in Chile, including type and level of activity to reinforce the concept of tectonic impacts along the Andes Mountain chain. Historic earthquake events will also be plotted. Use symbols to represent the size and level of activity of volcanoes and centres of earthquake events. References for this information include:
   • www.volcano.si.edu/world/region.cfm?rnum=15
   • www.volcanolive.com/chile.html (volcanoes)
   • www.ngdc.noaa.gov/hazard/hazards.shtml (earthquakes)

2. Plot Chile's major centres of population. Summarize the vulnerability of the Chilean population to such natural disasters.

3. People on the west coast of the Americas live with constant danger from earthquakes and volcanic eruptions. However, the tectonic processes of subduction have also brought—especially in Chile—economic benefits from the vast mineral deposits, along with other benefits such as tourism to areas of mountains and volcanoes. Identify the costs and the benefits of living in such a seismic region.

4. Some people in Canada already live in an area with a history of earthquakes. Identify some of these areas. If you do not live in one of these areas, how would you feel about moving to an area with a larger amount of seismic and/or volcanic activity?

Assessment Suggestion

Beside each bulletin-board display, students can provide "graffiti"—a positive comment based on questions such as "What I liked about this . . ." and "The neatest thing I learned was . . ."

Each student may write reflections about what they learned most from the content, the media presentations and the collaborative working conditions.

GEOLOGIC JOURNEY II

EPISODE 4: THE WESTERN PACIFIC RIM

UNIT OVERVIEW

In Episode 4: "The Western Pacific Rim," the geologic journey starts in New Zealand then travels to Japan before returning to New Zealand's South Island. New Zealand's series of mountainous islands is subject to constant change from the forces of plate tectonics and erosion. As the Pacific Plate subducts under the Australian Plate it "fuels" the active Taupo chain of volcanoes, which includes White Island and Mt. Tarawera—and is the source of many Maori legends. New Zealanders also face the threat of earthquakes as plates grind past each other along the North Island fault system, which continues south along the Alpine Fault. The capital city of Wellington sits on top of this active fault.

Japan is one of the most tectonically volatile regions along the Pacific Ring of Fire. Located above four intersecting plates, Japan knows it will face another "big one"—but the question of timing remains a mystery. The episode investigates emergency preparations for earthquakes, the festivals associated with volcanism and earthquakes, and deep-sea research into plate movements.

Returning to New Zealand, Episode 4 deals with both tectonics and glacial erosion on the South Island, which have create a landscape that attracts millions of visitors and has been the scenic background for the movie series *The Lord of the Rings.*

"The Western Pacific Rim" illustrates what life is like living on the edge of major tectonic plates, where stunning landscapes are combined with the realities of people living in an environment susceptible to significant tectonic events.

EPISODE	CHAPTER	CHAPTER TITLE	TIME	NARRATION CUE
4: The Western Pacific Rim	1	White Island, New Zealand	00:05	Deep below boiling mud
	2	Tarawera, New Zealand	07:11	White Island is one of a chain of volcanoes that includes the notorious . . .
	3	Wellington, New Zealand	13:32	Dramatic as they are, volcanoes are not the only threat . . .
	4	Fukuroi, Japan	18:30	Travelling northwest, Eyles' journey . . .
	5	Mount Fuji, Japan	24:49	Japan must face the potential threat of volcanoes . . .
	6	Motosu City, Japan	32:16	The quiet village of Motosu City exposes the workings of a killer fault . . .
	7	*Chikyu Hakken*, research ship	35:03	Here in the Nankai trough . . .
	8	Unzen, Japan	38:06	Volcanoes have a mystical allure . . .
	9	Southern Alps, New Zealand	44:43	On our last stop on our journey around the Western Rim of the Pacific . . .

ACTIVITY 4.1 • MORE THAN MEETS THE EYE: THE REALITY OF NEW ZEALAND'S LANDSCAPE

Curriculum Expectations

- List and describe the evidence that supports the theory of plate tectonics such as the location of volcanoes and earthquakes.
- Demonstrate an understanding of the processes at work within Earth and on its surface and the role of these processes in shaping Earth's surface.

Vocabulary
Visit the Glossary on the *Geologic Journey II* website at www.cbc.ca/geologic2/glossary.html for the following: erosion, plate tectonics, subduction, glaciers, erosion, lahar, pyroclastic flow, caldera, stratovolcano, faults, lithosphere, deposition, greywacke, tephra.

Activity Overview

Students develop an overview of how selected locations in New Zealand are shaped by tectonic forces and then apply the concepts linked to plate tectonics through map analysis, building a visual flowchart and creating a travel advertisement. Using a variety of images and information sources, students will understand how tectonic forces shape New Zealand's picturesque landscapes as well as the potential dangers that this volatile region presents to humans.

Pre-viewing Activity

New Zealand's stunning landscapes are contrasted with the reality of their formation and the unpredictability of their possible change. Have students view images of the picturesque landscapes either in travel advertisements or the *Lord of the Rings* movie trilology to generate observations about the features seen in the images. Then, students may hypothesize how the landscape was formed and how it may change in the future. Students can share their answers with a partner and record additional information from the exchange.

Teacher Preparation and Materials Required

View chapters 1, 2, 3 and 9 of Episode 4: "The Western Pacific Rim" before sharing with the class.

Copies of Appendix 4.1.1 – Flowchart Template and Appendix 4.1.2 – Continental Collision Model.

Use Appendix 4.1.2 to explain how volcanoes (like White Island) form at plate boundaries, how plates move when subducting and how fold mountains (like the Southern Alps) are created.

For the pre-viewing activity, selected scenery shots from either *The Lord of the Rings: The Two Towers* or *The Return of the King* can be used.

The activity uses several websites as sources of information.
USGS/Smithsonian website – http://mineralsciences.si.edu/tdpmap/ is central to the activity.

Other websites may be used for support:
- Global Volcanism Program – www.volcano.si.edu/world/find_regions.cfm
- USGS Earthquake Program – http://earthquake.usgs.gov/earthquakes/
- GeoNet (New Zealand focused) – www.geonet.org.nz
- GNS Science (go to the "Learning" tab) – www.gns.cri.nz
- Google Maps and Earth – www.google.com/earth/index.html

Background Information – Teacher

New Zealand's series of mountainous islands in the vast Pacific Ocean, initially formed as the Earth's crust folded, is subject to constant change from the forces of plate tectonics and erosion. The location of New Zealand on the Pacific Ring of Fire has not only created a stunning landscape but also leaves the people and the environment susceptible to significant tectonic events as the Pacific and Australian plates collide.

To the east of the North Island, the Hikurangi Trough marks the collision area where the Pacific Plate subducts under the Australian Plate and fuels the Taupo chain of volcanoes, which includes White Island and Mt. Tarawera. The plates then grind past each other along the North Island fault system—which includes the active Wellington fault—and continues south along the Alpine Fault.

At the tip of the South Island, the Australian Plate subducts below the Pacific Plate, resulting in the uplift of sandstone and mudstone referred to as *greywacke*. Heat and pressure at the plate boundaries can result in melting of the rock and concentration of minerals as recrystalization occurs. Because of this process, the metamorphosed rock can contain valuable mineral deposits. The landscape of the South Island is further shaped by glacial erosion. It is therefore an excellent example of building (tectonics) and wearing away (erosion).

Background Information – Student

Imagine living on the edge—of plate boundaries that is! The collision of two major plates—the Pacific and the Australian—has resulted in stunning landscapes worthy of Hollywood movies. But New Zealanders, situated in such a collision zone, face the reality of significant physical harm and destruction of property when a major earthquake or volcanic eruption occurs.

So how does this happen? The lithosphere, divided like a cracked eggshell, "floats" on top of the constantly circulating magma. This configuration is known as plate tectonics. The collision of slabs, or the pieces of the eggshell, may result in the rock folding or uplifting, subducting or pushing one under the other, or pushing and sliding against each other. Mountain building, earthquakes and volcanoes are all possible outcomes. New Zealand's location along the edge or boundary of two major plates within the Pacific Ring of Fire makes tectonic events inevitable.

LESSON PLAN

View chapters 1, 2, 3 and 9 of the video.

4.1.1 In chart form, for each of the following locations—White Island, Tawawera, Wellington and the Southern Alps—answer the five "Ws."

- Where is it located?
- What happened?
- When did it happen?
- Why did it happen?
- Who may have impacted on the situation?*

You may need to refer to Google Maps or Google Earth and additional researched information to complete your chart.

* Although there may be little in terms of "who" involved in this example, it is important to keep thinking about this fifth "W" for other situations in geology and environmental science examples.

4.1.2 The following questions can be answered using the video and the USGS Smithsonian website at http://mineralsciences.si.edu/tdpmap/ (click on the Interactive Map link). In the "Layers" tab make sure all the features are checked "on." Use the zoom in/out tool as well as the legend.

- Is your local region in Canada situated on a plate boundary?
- Why is the Pacific Ring of Fire one of the most tectonically active places on the planet?
- Why is New Zealand considered part of this "ring"?
- Which tectonic plates collide in New Zealand? In which direction are these plates moving?
- What features and events occur in New Zealand as a result of this plate movement?
- How has plate movement resulted in the Taupo Volcanic Zone where White Island is located? Explain using diagrams in your written answer.
- Why is the location of the capital city of Wellington a concern to both geologists and to many of the people who live in the city?
- Why are the Southern Alps a popular destination for tourism and skiing?

4.1.3 Select two locations featured in the New Zealand chapters of the video. Using information from the video as well as related websites, complete Appendix 4.1.1 – Flowchart Template to illustrate the formation of New Zealand's landscape. For each selected location, record visuals (e.g., sketches, diagrams, image downloads, graphic designs) into the appropriate boxes to show:

- how the landscape looks today
- how the landscape was formed
- what the landscape might look like hundreds of years from now

Beneath your images explain the forces responsible for building or shaping this landscape.

4.1.4 As an adventure travel guide, create an advertisement to promote New Zealand's landscape. Your potential customers/travellers are looking for a

Did you know . . .
New Zealand's population of just over four million is concentrated mostly in cities spread throughout its two main islands—North and South. Wellington is the world's most southerly capital city but is built on shaky ground—about 30 km above the boundary zone between the between the Australian and Pacific plates.

Did you know . . .
The New Zealand GeoNet project, a collaboration between the Earthquake Commission and GNS Science, records light to moderate earthquakes (4.0 - 4.9 magnitude causing minor damage) daily, strong earthquakes (6.0 - 6.9 magnitude causing major damage in urban areas) at least two times per year, and a major earthquake (7.0 - 7.9 magnitude causing serious damage and casualties) once every three years.

unique experience across the North and South Islands including: mountain treks, visiting volcano and earthquake locations, viewing mud pools and learning about Maori fire-gods legends. Use visuals and brief explanations to highlight this country as a must-see destination.

4.1.5 Volcanic eruptions may produce a number of hazards such as ash clouds, pyroclastic flows, lava and toxic gases. These negative outcomes from a volcano's destructive force can alter the landscape and be harmful to humans. However, there are some benefits that volcanoes can produce. Read the following statements and explain why each is considered to be a benefit of a volcanic eruption. You may need to research additional information to support your explanation.

- "Volcanoes can build new land."
- "Volcanic materials have created some of the most fertile soils on Earth."
- "Valuable metallic mineral deposits such as gold, copper and zinc are found in volcanoes worldwide."
- "Volcanoes and their surrounding environment provide adventure tourism and recreation opportunities."
- "Geothermal energy can be harnessed from the steam generated by magma-heated groundwater."
- "Ash clouds from large volcanic eruptions can lessen the effects of global warming by reducing the amount of sunlight heating the Earth."

Rank each statement on a scale from 1 (least beneficial) to 10 (most beneficial). Compare your rankings with those of a classmate.

Summarize your findings as to whether the benefits from volcanic eruptions outweigh the risks.

Extension Suggestions

1. In Chapter 1 of the video the White Island eruptions are compared to the 1981 Mount St. Helens (United States) eruption. As a class or individually, research how "sideways" vents in these eruptions made each so dangerous and how it shaped the landscape. Further explore what each of these landscapes looks like post-eruption and how they are used by humans today.

2. New Zealand's second largest city, Christchurch, located on the South Island, was rocked in 2010 by significant earthquakes. Individually or in small groups, students can orally and/or in writing provide a brief news report about this series of events and the dangers earthquakes pose to urban areas.

Assessment Suggestions

1. Assessment of the student's answers to the five "Ws"(when, where, what, why, who) and the map analysis can be used to determine the student's level of comprehension of concepts linked to plate tectonics and related tectonic events.

   The teacher may choose to discuss the answers for one or two questions as an exemplar for students prior to the submission of student work.

2. Assessment of the visual flowchart and travel advertisement can be used to evaluate how well students can apply their knowledge of plate tectonics. Criteria may include (but not be limited to): appropriate use of selected images, well-supported written explanations, effective use of visuals and researched information.

3. Assessment of the benefits of volcanic eruptions can be used to determine the student's ability to make decisions based on the quality of their researched information and to justify their responses using specific examples and/or explanations.

4. Assessment of the visual flowchart and travel advertisement can be used to evaluate how well students can apply concepts to appropriate situations.

Appendix 4.1.1 – Flowchart Template

Location: ____

Look like today?	→	**How formed?**	→	**Look like in the future?**

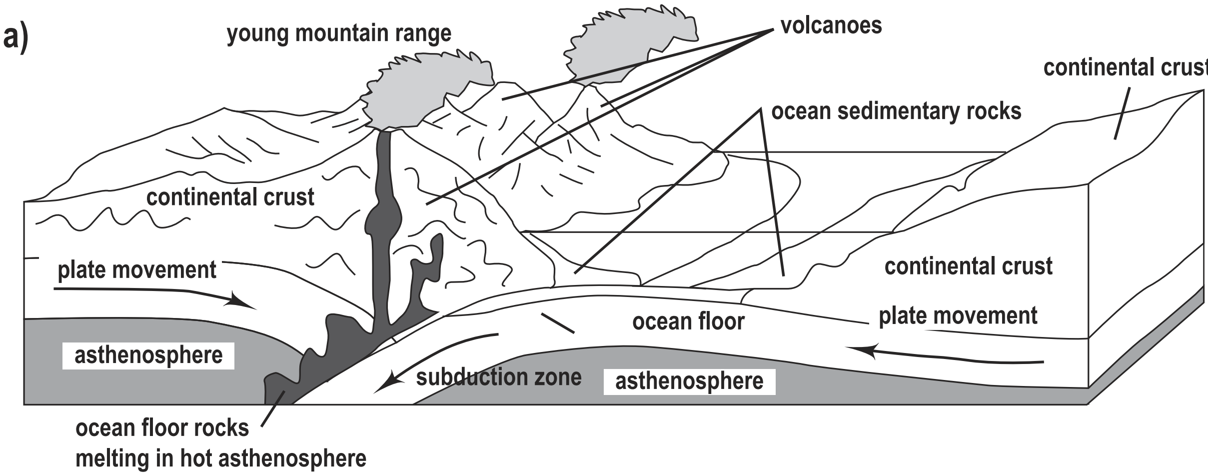
Explanation:

Explanation:

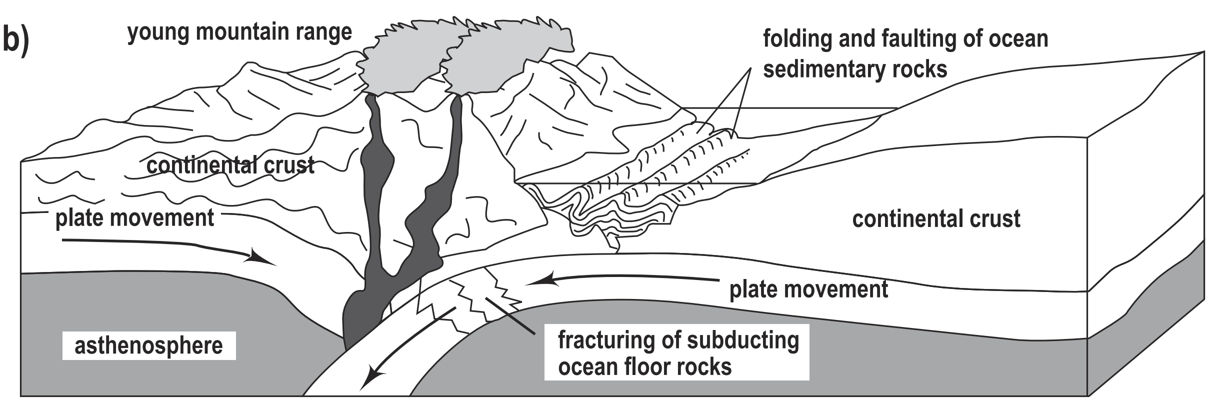
Explanation:

Appendix 4.1.2—Continental Collision Model

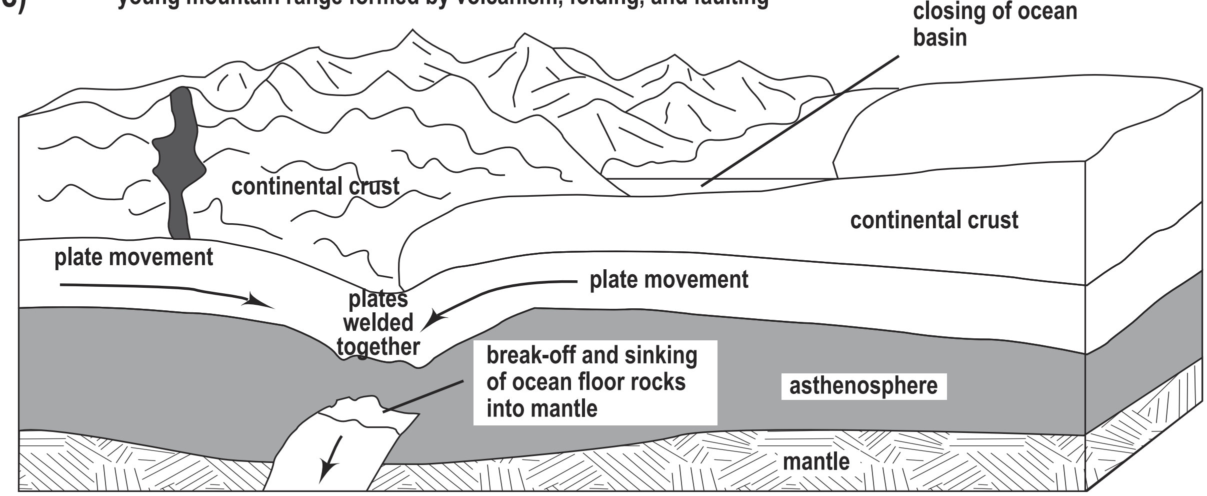
a)



b)



c)



ACTIVITY 4.2 • JAPAN: LEARNING FROM THE PAST, PREPARING FOR TOMORROW

Curriculum Expectations

- Examine technologies that enable us to increase our knowledge and understanding of Earth's structure and have improved the ability of scientists to monitor and predict changes in the lithosphere.
- Evaluate the impact of natural systems on people and their activities.

Activity Overview

The activity begins with an overview of selected earthquakes and volcanoes in Japan and how these devastating tectonic events impact the landscape and the residents. Students apply and evaluate their knowledge of plate tectonics, subduction zones and the consequences of earthquakes and volcanoes through graphic organizers, map analysis, role play and the development of an action plan. Students gain a greater understanding of how tectonic forces shape Japan's landscapes, influence the actions and attitudes of its citizens and the role that science and technology play in predicting when the next big earthquake and/or volcanic eruption will occur.

Pre-viewing Activity

Located on the Pacific Ring of Fire, Japan has faced many devastating tectonic events. The Great Kanto earthquake of 1923 and the eruptions of Mount Unzen in the early 1990s are but two examples from the last century. Living on top of the intersection of four major tectonic plates—Eurasian, North American, Pacific and Philippine—Japan's citizens know that a major earthquake or volcanic eruption will happen in the future.

Working in small groups, provide students with the following scenario:
You have arrived in Tokyo, a densely populated capital city of 13 million situated above the intersection of three major tectonic plates. While touring Tokyo the ground starts to shake. What would you do in the event of an earthquake if you were:

- in a hotel room
- in a shopping mall
- on a hiking excursion along Tokyo Bay
- riding a train

Students should come to consensus regarding their responses and share common directions with other groups.

Teachers may review the first 16 pages of the manual on survival published by Metropolitan Tokyo at www.seikatubunka.metro.tokyo.jp/index3files/survivalmanual.pdf.

EPISODE 4: THE WESTERN PACIFIC RIM

Teacher Preparation and Materials Required

View chapters 4 to 8 of the video before sharing with the class.

Copies of Apendix 4.2.1 – Tectonic Events Organizer

A political and physical map of Japan may be helpful.

There are a great number of online resources about this area, including detailed information about Japan's plate boundaries and plate movements. Some excellent sites include the following:

- GLGArcs: Japan in a subduction zone – www.glgarcs.net/intro/subduction.html
- City of Fujiyoshida Fire Festival Information – www.city.fujiyoshida.yamanashi.jp/div/english/html/firefest.html
- Interactive Plate Tectonics map (select the following map layers: volcano, earthquakes, plate boundaries and zoom in to Japan) – http://nhb-arcims.si.edu/ThisDynamicPlanet/index.html
- Career information for volcanologists and geologists – http://vulcan.wr.usgs.gov/Outreach/StudyVolcanoes/career_planning.html
- General career search site – www.careerplanner.com/Default.cfm
- Information and images about the *Chikyu* drillship – www.ship-technology.com/projects/chikyu/ and http://news.bbc.co.uk/2/hi/8071021.stm

Background Information – Teacher

Japan's tectonic volatility and devastation are showcased through well-known eruptions and earthquakes such as Mount Fuji, Mount Unzen and Great Kanto. The westward-moving Pacific Plate subducts below the North American Plate along the northern Kuril and Japan trenches. The Pacific Plate also subducts underneath the Philippine Plate along the Izu-Bonin Trench near central Japan. The Philippine Plate subducts below the Eurasian Plate along the Nanaki Trough in south-central Japan and the Rykyu Trench in southwestern Japan.

With more than 75 active volcanoes, Japan has had many documented explosive eruptions. Mount Fuji, a stratovolcano famous for its conical shape, last erupted in 1707; celebrations to appease the fire goddess of Mount Fuji are held annually.

Mount Unzen erupted in 1792; the landslides and associated tsunami killed 15 000 people. Recent eruptions caused pyroclastic flows that raced down the slope at speeds of 100 to 200 km/hour. Early-warning systems and evacuation plans have been established, and dikes have been constructed to channel lahar flows into sediment basins.

The *Chikyu* drillship stationed off the coast of Japan above the Nankai Trough is involved in a project called the NanTroSEIZE to study plate movements and predict earthquakes. This expedition is intended to drill two boreholes in the Earth's crust to monitor and study the mechanisms that cause earthquakes. Research labs analyze crust samples. The ship uses GPS systems to control the drilling activities. The *Chikyu* presently drills 2 – 4 km below the surface, but its next phase aims for a drilling capacity of over 10 km. It is possible that this drilling might even reach the mantle.

Did you know . . .
Researchers have found that the boundary areas of the three intersecting plates underneath Tokyo are closer to the surface than previously thought. The plate boundaries range from only 4 to 26 km from the surface (prior estimates were 20 to 40 km). Tokyo may be more susceptible to the effects of an earthquake as stronger ground motion is likely when a quake occurs closer to the surface (source: *National Geographic,* 2005).

Did you know . . .
Chikyu in Japanese means "Earth," an appropriate name for a ship with a 100 m drilling rig attached to it—the tallest in the world—that is used to bore holes into the Earth's crust to gather information about the mechanisms that cause earthquakes.

LESSON PLAN

View chapters 4 to 8 of the video. Complete Appendix 4.2.1 – Tectonic Events Organizer.

4.2.1 Use the video and these websites to respond to the following questions: http://earthquake.usgs.gov/earthquakes/world/japan/density.php and http://vulcan.wr.usgs.gov/Volcanoes/Japan/Maps/map_japan_volcanoes.html.

- Why is Japan such a tectonically volatile region? Explain using the theory of plate tectonics.
- Which region in Japan experiences the greatest number of earthquakes?
- What is the cause of Tokyo's moderate earthquake risk? Why might this level of risk be of concern to Tokyo?
- Do you agree or disagree with the statement: "Volcanoes in Japan are some of the most active and explosive in the world." Support your stance.
- Where in Japan would you predict the next big earthquake and volcanic event to occur? Explain why for each prediction.

4.2.2 Imagine that you are an exchange student living in Japan. Create a mock Facebook profile page to highlight what life is like under the threat of a major earthquake or volcanic eruption. Share in hard copy or post to your course website (check with your teacher first). Allow at least three "friends" (a.k.a. classmates) to comment on your profile.

Your profile page should include:
- Background Information: List the following: name of city/town where you live in Japan, population, landscape description (physical and human features).
- Work: Outline the main industries or sources of employment for the location.
- Photo(s): Include at least one photo showing how the landscape was shaped by a tectonic event. You can include additional landscape photos. Do not include a personal photo.
- Likes and Interests: List various recreation and/or tourism activities in your location.
- Something About Me: Use this section to explain past or present tectonic events in the location you have chosen. Explain tectonic events (past and/or present) that have occurred in your location, outline earthquake/volcano emergency and safety preparation plans and include your personal thoughts on the benefits and concerns about living in this location.

4.2.3 As part of a CBC team of journalists, you have been asked to report on how Japan can learn from its past tectonic events to prepare for tomorrow. Select and research one of the following careers: geologist, volcanologist, seismologist, research scientist. A good starting point is the UTSC blog on the *Geologic Journey II* website at www.cbc.ca/geologic2/blog/. Additional information can be found at www.earthsciencescanada.com – Earth Science Careers. Gather information about the causes and consequences of Japan's tectonic events outlined in the video. Communicate your findings in a one-or two-page report using the following subtopics: career overview, where tectonic events occurred, how tectonic events occurred, impacts of tectonic events (human and physical) and the role of technology in learning about tectonic events. Meet with your team to share your reports and to develop a three- to five-point action plan that the Japanese government can use in future earthquake and volcano safety planning.

Extension Suggestions

1. September 1 is Japan's National Disaster Prevention Day and is used for earthquake and fire drills. Working in small groups and using Appendix 4.2.2 – Importance of Disaster Prevention Mind Map, research and record information relating to the topic "Importance of disaster prevention in Japan."

2. Research the ongoing activities of the drillship *Chikyu*. Draw an annotated diagram to illustrate a cross-section of the drillship and its exploratory drilling through the sea floor. Your annotation should include a response to the following statement: "If the Nankai Trough technology captures a seismic event in action, it could revolutionize earthquake science."

Assessment Suggestions

1. Formal teacher assessment of students' answers to the organizer in Appendix 4.2.1, the analysis of Japan's volcano and earthquake density maps and the mock Facebook page can be used to determine students' level of comprehension of plate tectonics, subduction zones and the impacts of earthquake and volcanic events on the landscape and human populations. Student organizer answers should contain specific and accurate information from the video that is placed under the appropriate organizer headings. Student map analysis answers should demonstrate a link between their observations and the concept of plate tectonics. The mock Facebook profiles should demonstrate students' ability to apply the concepts and gathered information to a scenario.

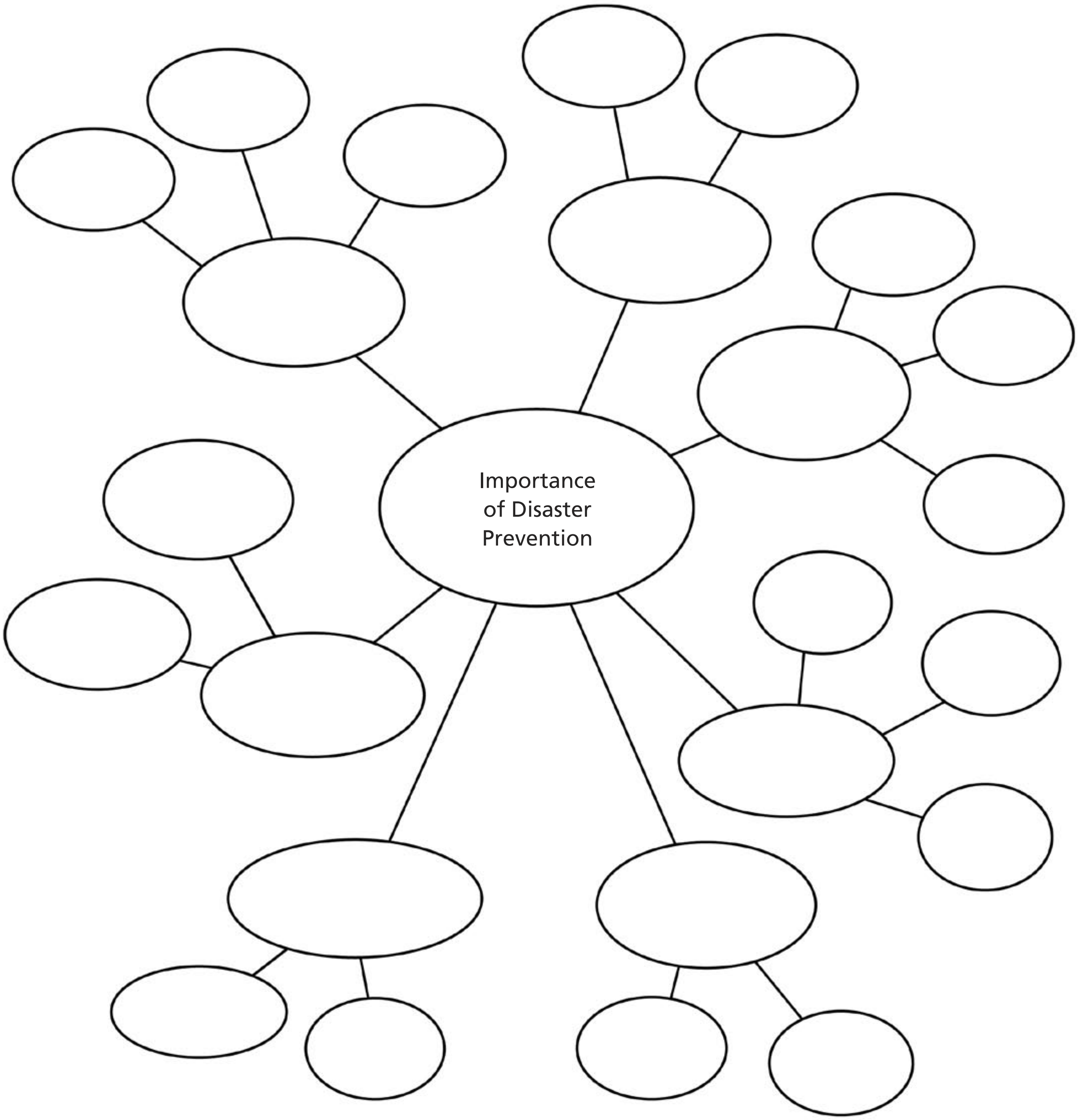
2. Formal teacher assessment of the annotated diagram and statement response can be used to evaluate how well students can utilize their research and communication skills to demonstrate the relationship between the role of technology and science in earthquake prediction. Assessment criteria may include (but not be limited to): accuracy of diagram, concise explanation of diagram components/functions and a well-supported written explanation.

3. Formal teacher assessment of the career report and action plan can be used to determine students' ability to evaluate and draw conclusions from their knowledge of plate tectonics, researched material and specific tectonic events in Japan. The report and action plan should be accurate, concise and linked to their selected career.

Appendix 4.2.1 – Tectonic Events Organizer

LOCATION	TECTONIC EVENT(S)	WHEN?	WHY?	IMPACTS ON LANDSCAPE	IMPACTS ON HUMANS
Fukurio					
Fujiyoshida					
Interior of Japan (Motosu)					
Shimabara Peninsula (east of Nagaski)					

Appendix 4.2.2 – Importance of Disaster Prevention Mind Map



ACTIVITY 4.3 • NEW ZEALAND AND JAPAN: A TECTONIC TOUR

Curriculum Expectations

- Identify major areas of tectonic activity in the world by plotting the location of major recorded earthquakes and active volcanoes on a map and distinguish the areas by type of tectonic activity.
- Demonstrate an understanding of the processes at work within Earth and on its surface and the role of these processes in shaping Earth's surface.

Activity Overview

In this activity students use their knowledge and understanding gained from prior activities to complete the lessons. Activity 4.3 begins with a KWL chart to recap information from the video. The lesson plan begins with an organizer comparing the landforms of New Zealand and Japan, followed by a mapping exercise to illustrate where these features are located. A travel presentation and statement response component will allow students to analyze the role that plate tectonics has in the formation and shaping of New Zealand and Japan's landscapes and how these landscapes have become tourist attractions.

Pre-viewing Activity

Before viewing Episode 4: "The Western Pacific Rim," divide students into two groups—the first group to focus on how tectonic forces impact New Zealand's landscape and its people and the second group to focus on how tectonic forces impact Japan's landscape and its people. Use Appendix 4.3.1 – KWL (Know . . . Want to Know . . . Learned) Chart. Students will complete the first two columns PRIOR to viewing the video and the third column AFTER viewing the video.

Teacher Preparation and Materials Required

This activity can be used as a "culmination" for the unit, whereby students use their knowledge and understanding gained from activities 4.1 and 4.2. Alternatively, Activity 4.3 can be used on its own. Viewing the complete episode is required for this activity. The video can be viewed by the class for the first time or used to recap information and concepts covered in activities 4.1 and 4.2.

A computer lab with Internet access may be helpful for a number of lesson tasks.

Copies of Appendix 4.3.1 – KWL (Know . . . Want to Know . . . Learned) Chart and Appendix 4.3.2 – Venn Diagram: Tectonic Forces of New Zealand and Japan can be made ahead of time.

Students may wish to copy the Venn diagram outline onto chart paper.

Students should also have access to a map outline of the western portion of the Pacific Rim from New Zealand to Japan; a good one can be found at: http://er.jsc.nasa.gov/SEH/Mission_geography/Map_index.pdf.

Additional Web-based resources include:

- Satellite photos of volcanoes – http://earthobservatory.nasa.gov (Images of the Day)
- Interactive Plate Tectonics map – http://nhb-arcims.si.edu/ThisDynamicPlanet/index.html (select the following map layers: volcano, earthquakes, plate boundaries, and zoom in to Japan)
- Japan National Tourism Organization – www.jnto.go.jp
- New Zealand Tourism Guide – www.tourism.net.nz
- White Island Volcano, New Zealand – www.wi.co.nz
- New Zealand's National Parks and Tourism – www.newzealand.com/travel/destinations/national-parks/national-parks-home.cfm

Background Information – Teacher

The location of New Zealand and Japan on the western edge of the Pacific Ring of Fire results in an environment susceptible to significant tectonic events as the plates collide. These tectonic forces have also formed and shaped stunning landscapes, many of which have become tourist attractions—especially for adventure tourists who are looking for unique, rugged and, at times, risky travel experiences. For example, Japan's Mt. Fuji attracts millions of visitors annually to view its famous conical shape and to celebrate the cultural and spiritual significance of the Mt. Fuji fire goddess. Similarly, New Zealand's Tongariro National Park, located on the North Island, is known for its duel World Heritage status featuring unique volcanic landscape and Maori culture.

The tourism industry has become one of the fastest-growing economic sectors in the world. Even in the wake of the recent global recessionary trends, the rate of growth of this economic sector is projected to increase. For 2010, the Government of Japan estimates that over seven million international tourists visited the country, and for New Zealand, the government estimates that over 2.5 million visitors arrived. The United Nations World Tourism Organization estimates that by 2020 International tourist arrivals are expected to reach 1.6 billion.

EPISODE 4: THE WESTERN PACIFIC RIM

LESSON PLAN

Did you know . . .
A Venn diagram is a type of graphic organizer—in this case where information unique to Japan and New Zealand is recorded in each outer oval, and the centre overlapping oval contains information that is shared between these two countries.

Situated on the western edge of the Pacific Ring of Fire, New Zealand and Japan lie above the intersection of major subducting plates, which results in earthquakes and volcanoes. These tectonic forces also create unique landscapes, many of which have become tourist attractions—especially for adventure tourists. Can you picture yourself as one of the millions of tourists who visit New Zealand and Japan each year to view these stunning yet ever-changing landscapes?

4.3.1 How do the landscapes of New Zealand and Japan compare? Working in small groups, answer the following questions and record your information in the appropriate sections of Appendix 4.3.2 – Venn Diagram: Tectonic Forces of New Zealand and Japan. Use specific examples of locations and tectonic events from Episode 4: "The Western Pacific Rim" in your answer. Your group may choose to record your Venn diagram on a piece of chart paper. Post your completed copy in the classroom and examine the information presented by other groups.

How have tectonic forces shaped New Zealand's landscape? What are the resulting features? How have tectonic forces shaped Japan's landscape? What are the resulting features?

4.3.2 Create your own "Shake 'n' Bake" map for New Zealand and Japan that shows where their tectonic events and features are located. Use this link for a base map of the western Pacific Rim: http://er.jsc.nasa.gov/SEH/Mission_geography/Map_index.pdf. Label the items listed below for Japan and New Zealand. Remember to include a title for your map as well as a detailed legend. Hard copy or online maps and atlases will help ensure the accuracy of your labels. A good starting place is the Interactive Plate Tectonics Map at http://nhb-arcims.si.edu/ThisDynamicPlanet/index.html (select the following map layers: volcano, earthquakes, plate boundaries, and zoom in to Japan and New Zealand).

- Pacific Ring of Fire
- Tectonic plates, type of boundaries, direction of plate movement
- Tectonic events examined in Episode 4: "The Western Pacific Rim." For each of these tectonic event labels, attach a text box. In the text box indicate when it occurred, why it occurred, what are the resulting features, and how do they impact the people.
- Additional landscape features (e.g., hot springs, mud pools, glaciers)

4.3.3 As a well-known travel writer you have been hired by CBC's *Geologic Journey II* producers to visit the tectonic landscapes of New Zealand and Japan. Your task is to investigate and present to an editorial team some sample locations in New Zealand and in Japan that you think will satisfy the adventure tourism requests of your audience.

- How have plate tectonics formed and shaped the landscapes in your selected locations?
- What can the adventure traveller see and do in these locations?
- What dangers or risks do these locations pose to the traveller and the residents?
- Choose a presentation format—blog, webpage, poster display, oral report, travel article, photo/video display—and share your presentation with the editorial team (your classmates). Presentations need to include detailed and accurate information as well as relevant photos/images/diagrams.

4.3.4 Read the following five statements from the video and answer the questions following based on these statements.

- "To the people and countries around the Pacific Rim, the threat (of volcanoes and earthquakes) is constant and the (tectonic) forces revered."
- "We live on a restless and fractious planet."
- "Tectonic forces that continually reshape our planet can destroy—but they can also create.
- "So often around the Pacific Rim there is a deadly rhythm at play as plates lock, buckle and break."
- "In geology, it is the landscape that tells the story of the forces beneath your feet."

Explain in your own words the meaning of each statement. Use information from the video as well as previous lessons and activities to support your answers.

Share your answers with a partner and record any new thoughts or interpretations.

Discuss your responses to these statements with a small group.

Select one of the statements you think best highlights the power of tectonic forces shown in the episode and write a reflection outlining your rationale.

Extension Suggestions

1. Mud pools and geysers are iconic landscape features of New Zealand's North Island, while Japan's hot springs are a popular destination for locals and visitors alike. Research how tectonic forces create mud pools, geysers and hot springs, where these features are found in New Zealand and Japan, and why these features are so popular with tourists.

2. Have you personally travelled to either New Zealand or Japan? Have you visited any of the other areas you have seen in the *Geologic Journey II* episodes? Do you have photos of their landscapes? If so, submit your photos to the *Geologic Journey II* website at www.cbc.ca/geologic2/ and click on the "Your Photo" tab. Include your photo and a brief description of the features of the location.

Even if you have not visited some of these locations, visit the photo galley on the website to see how individuals have captured the geology of places they have visited.

3. On February 22, 2011, a 6.3 magnitude earthquake struck Christchurch, New Zealand (South Island). Research the “hard facts” on his devastating earthquake: casualties and data figures on the extent of the damage. Identify the plates and faults involved and the type of movement that caused the earthquake. Explain why a 6.3 magnitude earthquake had such a deadly effect. Relate the earthquake to the information you have learned from Episode 4: “The Western Pacific Rim.”

Assessment Suggestions

1. Informal assessment of students’ answers to the KWL Chart (Appendix 4.3.1) can be used to check student comprehension of topics and events from the video and their understanding of key concepts such as plate tectonics from the video and/or from prior activities.

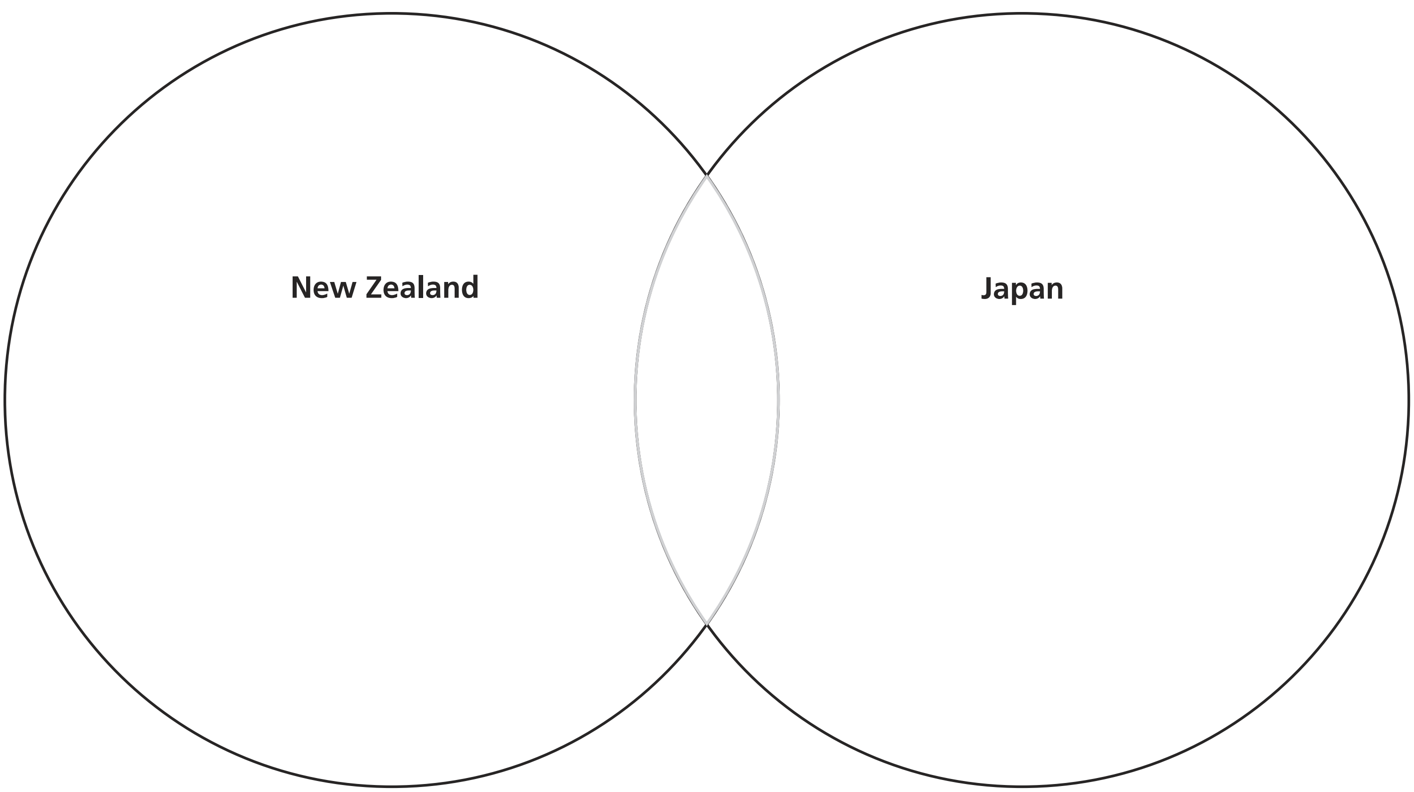
2. Formal teacher assessment of students’ answers to the Venn diagram (Appendix 4.3.2) and the “Shake n’ Bake” map can be used to determine the students’ level of comprehension of plate tectonics, subduction zones and the impacts of earthquake and volcanic events on the landscape and human populations. Student organizer answers should contain specific and accurate information from the video that are placed under the appropriate headings. Student maps should be accurately labelled, and the information boxes should demonstrate an understanding of the impacts of plate tectonics.

3. Formal teacher assessment of the travel presentation and statement reflection can be used to evaluate how well students can utilize their research and communication skills to demonstrate the relationship between the functions of plate tectonics and the formation and alteration of different landscapes. Assessment criteria for the travel presentation may include (but not be limited to): accuracy of information, use of specific and detailed information, variety of relevant images and effective communication of information.

Appendix 4.3.1 – KWL (Know . . . Want to Know . . . Learned) Chart

KNOW What do I already know about the impacts that tectonic forces have on New Zealand's/Japan's landscape and people?	WANT TO KNOW What questions do I have about the impacts that tectonic forces have on New Zealand's/Japan's landscape and people?	LEARNED What have I learned about the impacts that tectonic forces have on New Zealand's/Japan's landscape and people?

Appendix 4.3.2 – Venn Diagram: Tectonic Forces of New Zealand and Japan



EPISODE 5: THE COLLISION ZONE: ASIA

UNIT OVERVIEW

The central concept of this episode is that the Earth works as a machine—even a recycling machine—using the old to build the new. The three sections of the episode emphasize three "big ideas":

- the rise and fall of the Himalayas, an area in constant transition in a land of earthquakes and erosion
- the role of water in the geology of Asia, especially as a carrier of sediment from the mountain to the sea
- the role of the volcanoes of the Indonesian island arc in the creation of new land and, ultimately, the next supercontinent

Activity 1 provides students with an opportunity to examine concepts like crustal shortening as a creator of mountains, and the role of earthquakes, landslides and glaciers in bringing them down. A section on fossil evidence is included, as well as one on the impact of the geological processes on human activity in the area.

In Activity 2, the focus is on the Ganges and its tributaries. The activity includes a map exercise to delineate the trip that sediment makes on its way to the Bay of Bengal. This section also deals with earthquakes in Kathmandu and the surrounding area and the role of water in religion.

In Activity 3, students focus on the role of volcanoes in an island arc—the processing plant where sediments get recycled into new land and the evidence that indicates that volcanic activity in Indonesia will make the area the centre of the next supercontinent. Because Mount Merapi in Indonesia erupted on October 26, 2010, this is a timely section and an opportunity to look at volcanoes in some detail. The Pacific Ring of Fire, island arcs, and the special place of Java in volcanic activity are all explored. The area's vulnerability to earthquakes and tsunamis is also noteworthy. Pyroclastic flows and lahars are investigated, and students are asked to research and describe the process by which the next supercontinent will be formed.

EPISODE	CHAPTER	CHAPTER TITLE	TIME	NARRATION CUE
5: The Collision Zone: Asia	1	The Himalayas	1:00	I've always wanted to see the Himalyas . . .
	2	Kathmandu, Nepal	22:15	Eight tributaries flow through the Kathmandu Valley . . .
	3	Calcutta, (Kolkata), India	28:17	Here are some facts about the Ganges River . . .
	4	Yogyakarta, (Java) Indonesia	35:04	Yogyakarta is the cultural heart of Java . . .
	5	Mount Merapi, (Java) Indonesia	45:46	This is the debris that was left behind by Merapi's 2006 eruption . . .

EPISODE 5: THE COLLISION ZONE: ASIA

ACTIVITY 5.1 • HIMALAYAS: CREATION AND DESTRUCTION

Curriculum Expectations

- Investigate geological evidence of major changes that have occurred during Earth's history and of the various processes that have contributed to these changes.
- Demonstrate an understanding of how changes to Earth's surface have been recorded and preserved throughout geological time and how they contribute to our knowledge of Earth history.
- Investigate various types of preserved geological evidence of major changes that have taken place in Earth history.

Activity Overview

The activity provides students with the ability to describe the processes that created and will ultimately destroy the Himalayas. They examine and evaluate the role of fossil evidence in explaining these processes. Finally, they compare the stories told by geology and the local religious tradition in interpreting the geological history of the region.

Pre-viewing Activity

The processes explored in Chapter 1 of the video are easier to understand if students have some geographical knowledge of the area. Using a good classroom map, allow students to:

- locate the Himalayas, Nepal and the surrounding countries
- locate major sites in the video: Mustang, the Gandaki River, the Khumbu Ice Falls
- understand the direction in which sediment is being removed from the mountains, generally south toward the Ganges

Teacher Preparation and Materials Required

The teacher should preview Chapter 1 of the video, which will be the basis for this activity.

Students will need access to the *Geologic Journey II* website (www.cbc.ca/geologic2) and copies of Appendix 3.1.2 – Continental Collision Model and Appendix 1.3.1 – Outline Map of the World.

Students should have a general understanding of the geography of the area where the Asian and Indian plates have met. A basic map of the world's tectonic plates will be helpful. Many maps are available online using the search words "tectonic plates."

EPISODE 5: THE COLLISION ZONE: ASIA

LESSON PLAN

View Chapter 1 of the video.

5.1.1 Describe the key events in the continental collision that led to the creation of the Himalayas. Apply the information in the video to the diagrams found in Appendix 4.1.2 – Continental Collision Model.
[Optional – use the materials outlined in Episode 1, Activity 1 (pages 1-2 and 1-3) to construct a model to illustrate the development of the Himalayas. The materials required and the instructions from this activity can be applied directly to the development of this mountain system.]

5.1.2 List the key points described in the video that demonstrate that the Himalayas are indeed "a place in constant transition," "impermanent" and "ephemeral."

5.1.3 Rocks in the Kali Gandaki Gorge are cited as an excellent example of crustal shortening. Explain what the term *crustal shortening* means. Apply this concept to the model construction process identified in Episode 1, Activity1. How does an understanding of that process help us understand how the Himalayas were formed?

5.1.4 The Kumbhu Glacier is only one of the 12 000 to 15 000 glaciers in the Himalayas. The video describes it as "a machine that continually works toward change." With a partner, describe the glacier's work as a change agent, specifically identifying some of the processes and end products, both erosional and depositional, that are associated with glaciation.

5.1.5 The Kali Gandaki Gorge, historically an important trade route between Tibet and India, is also home to thousands of people. They continue to live there despite the constant threat of earthquakes and landslides. Suggest reasons why people would choose to live in such an environment.

5.1.6 In the Kali Gandaki Gorge, geology meets religion because the landscape is at the core of the beliefs of the Bön people of Mustang. Although scientists have explanations related to earthquakes and their causes, the Bön people have different beliefs. How does their religion explain earthquakes? In chart form, identify the ways in which the scientific and religious explanations differ.

5.1.7 At Muktinath, Nick Eyles and anthropologist Carroll Dunham observe that, in the Kali Gandaki Gorge, both geologists and religious traditionalists (in this case, both the Bön and the Hindus) are telling a story about the birth and death of the mountains. With a partner, choose to tell the story of the birth and death of the mountains from either a religious or geological perspective. Use the material in the video and on the website to tell "your side" of the story. Share your story with your partner and then, as a pair, share your stories with another pair of storytellers. Do the stories agree in their details?

5.1.8 After sharing your stories, still in groups of four, discuss the following: Do the stories told by geology and religious tradition both have a contribution to make to an understanding and appreciation of the life cycle of the Himalayas? Why or why not? Summarize the key elements of your discussion in chart form.

5.1.9 Describe how rivers like the Gandaki are part of the machine that works to level the Himalayas.

5.1.10 The ammonites found in the Himalayas are described as "index fossils" and are noted to be of great geological importance. What are index fossils? What do they tell us about the birth and age of the Himalayas? Supplement the material in the video with that available on the website at www.cbc.ca/geologic2/explore.html.

5.1.11 Ammonites are known locally in Nepal and India as saligrams, and to Hindus they are important religious symbols. Describe this importance.

Extension Suggestions

1. In 2007, an unfortunate error in a report from the Intergovernmental Panel on Climate Change suggested that the Himalayan glaciers would disappear by 2035. The error has been corrected—this clearly is not about to happen. But the error did draw scientific attention to the fact that research on the Himalayan glaciers is in its early stages. Scientists are not even sure how many glaciers there are—between 12 000 and 15 000 is the estimate. The study of these glaciers will be extremely important to geologists over the next several years.

   On March 2, 2010, www.nature.com published an online article titled "Settling the science on Himalayan glaciers." It is an excellent starting point to learn more about what we know and what we need to know about these glaciers. It is available at www.nature.com/climate/2010/1003/full/climate.2010.19.html.

2. Using material in the article, and from any other sources you wish to include, prepare a brief description of the status of Himalayan glacier studies today.

3. How does the status of the Himalayan glaciers compare with that of the glaciers in Alaska, the Andes, the Alps, or the continental glaciers of Antarctica?

4. Chapters 1 and 2 identify some of the hazards associated with living in areas of landslides and earthquakes in the Himalayas. Using Appendix 1.3.1 – Outline Map of the World identify other areas of the world that would be similar in terms of threats to humans. Rank order these locations using "least attractive for habitation" as the highest ranking. Share your responses with a partner and collaboratively develop a new list based on consensus of responses.

Assessment Suggestions

1. Teachers may assess the effectiveness of student participation in the group exercise (5.1.7) and the resulting chart (5.1.8). Criteria for assessment for the student participation component may include contributions made to the group decision, responsiveness to suggested change in student submission, ability to convince others when there is disagreement, oral communication with peers and willingness to suggest new ideas. The chart could be assessed using basic graphic organizer criteria such as title, knowledge and understanding of the facts and terms, visual communication of information and ideas and written communication of information and ideas.

2. Teachers may assign the following scenario to their students as a summative evaluative tool. The chart created in the group discussion can be used to assist in the development of the following program:

   As a geologist working with the government of Nepal, it is your responsibility to introduce an earthquake preparedness program to the Bön people.

   - How would you go about making the case for such a program while respecting the religious traditions of the Bön?
   - Prepare an outline of the speech you might give to the Bön to introduce the program indicating the main message you would like to convey.
   - How would you explain the region's vulnerability to the Bön?
   - What changes would you suggest the people make?
   - How might you relate your points to the beliefs outlined in the video?

Assessment criteria for the earthquake preparedness program could include the presentation of the facts and ideas, oral and/or visual communication skills and applicability of the preparedness program for the intended audience.

ACTIVITY 5.2 • WATER: GEOLOGICAL . . . ECOLOGICAL . . . RELIGIOUS

Curriculum Expectations

- Investigate geological evidence of major changes that have occurred during Earth's history and of the various processes that have contributed to these changes.
- Demonstrate an understanding of the processes at work within Earth and on its surface and the role of these processes in shaping Earth's surface.
- Describe the limitations of current knowledge in predicting earthquakes and the need for more accurate predictions.

Activity Overview

Students explore the role the waters from melting Himalayan glaciers and the sediments they carry have on the lives of the people of Nepal and surrounding countries. They follow the flow of some of this water from the mountains down the Ganges and its tributaries to the Bay of Bengal. The geological, ecological and religious importance of the Ganges will be highlighted. A stop along the way at Kathmandu explores that city's earthquake vulnerability. The episode concentrates on the Ganges—only one of the river systems carrying sediment away from the Himalayas. This activity broadens the student's perspective to include a wider picture of the extent of the geologic activity in this area.

Pre-viewing Activity

Chapters 1, 2 and 3 of the video explore the theme of water as a sacred symbol in Hindu religion. Before showing the video, ask students to describe the different ways that religions use water as part of religious ceremonies, or revere it as sacred. Make a list of the responses for further reference and as part of the Extension Activity.

Review the basic geography and geology of the area that students will be exploring in the activity. Locate and enter the two major centres in the episode—Kathmandu and Kolkata (Calcutta)—on Appendix 5.2.1 – Outline Map of the Indian Subcontinent and Southeast Asia.

Teacher Preparation and Materials Required

Review chapters 1, 2 and 3 of the video, which are the basis for this activity.

Episode 3: "The Pacific Rim: Americas" is also referenced in this activity. If students have not yet viewed Episode 3, they should do so before responding to question 5.2.12.

Students will need Appendix 5.2.1 – Outline Map of the Indian Subcontinent and Southeast Asia on which to plot the river systems draining south from the Himalayas.

Access to the Internet and especially to the map of the Ganges and its tributaries at www.mapsof.net will be of assistance.

Copies of *National Geographic* (April 2010), a special issue on water including the map of the “Third Pole” on pages 70-71 and the “World of Rivers” insert map, will be helpful.

LESSON PLAN

View chapters 1, 2 and 3 of the video.

Part 1 – Glacial Melt and Rivers Flowing from the Himalayas (Chapter 1)

5.2.1 According to geologists, the Himalayan glaciers are now melting more rapidly than they have in the recent past. Describe the impact of this trend on the river systems they feed and the people who live in close proximity to the rivers.

5.2.2 Identify problems created by the increase in sediment carried by these rivers.

5.2.3 Identify some of the ways attempts are made to manage these river systems. Suggest the problems and benefits associated with each management technique.

5.2.4 The video concentrates on one of the south-flowing rivers: the Ganges. How many tributaries flow through the Kathmandu Valley to feed the Ganges?

5.2.5 The Ganges is not the only river system drawing meltwater from the Himalayan glaciers. Plot the following major south-flowing river systems on your map: the Indus, the Irrawaddy, the Salween, the Mekong and the Brahmaputra-Jamuna. What countries are involved in the drainage basin systems from the Himalayas toward the south? What problems might be associated with the multinational scenario of these drainage basins?

5.2.6 If one or more of the countries listed in 5.2.5 were to attempt to alter the flow of one of these rivers to exploit the resource, how would this likely affect international relations?

5.2.7 Using information from *National Geographic* and www.mapsof.net/uploads/static-maps/river_ganges_and_tributaries.png, plot on your blank map the route of the Ganges and its tributaries.

5.2.8 Scientists confidently predict that flow from the Himalayan glaciers will decline precipitously during the next 100 years. What is likely to happen in the region as this flow decreases? Use a concept map to organize your response, using headings such as Ecological Effects, Social Effects and Political Effects as the first level of organization outward from the centre of the concept map, which can be labelled "Himalayan glaciers decline precipitously." See Appendix 1.2.1 – Concept Map Outline as an example.

Part 2 – Kathmandu and the Earthquake Threat (Chapter 2)

5.2.9 List some of the reasons why Kathmandu is especially prone to earthquake activity.

5.2.10 When was Kathmandu's last major earthquake? Describe how the city has changed since then.

5.2.11 GeoHazards International has helped the governments of Nepal and the Kathmandu region create a risk-management project aimed at starting a process to manage risks associated with earthquakes in the city and its valley. Based on what you have seen in the video, assess the effectiveness of the process to this particular point. Cite specific examples from the video to validate your opinion.

5.2.12 In the video, there are examples of how a developed nation responds to the threat of earthquake (specifically, the U.S. in San Francisco and Stanford University in California). Summarize those preparations and compare them with Kathmandu's current preparations. What measures might Kathmandu realistically borrow from the California example?

Part 3 – Down the Ganges to the Sea (Chapter 3)

5.2.13 One-sixth of India's population is dependent on the Ganges. How does the Himalayan sediment contribute to their sustenance? How might decreased glacier melt affect this population?

5.2.14 For Hindus, the Ganges is India's holiest river. The faithful view its waters as pure and untainted from its source in the Himalayas to the delta in the Bay of Bengal. How might science and religion have differing views regarding the "pure and untainted" nature of the Ganges? What are some of the major problems—and their sources—associated with the Ganges?

5.2.15 Describe some of the ways in which Hindus express their reverence for the Ganges.

5.2.16 Identify the source of drinking water for the residents of Kolkata (Calcutta). What are some of the implications of this source for the residents of Kolkata?

5.2.17 An increase in the rate of glacial melt in the Himalayas means more sediment will be carried by the Ganges. What are the major effects of the increase in sediment on the river system, especially at its mouth, the Ganges, or Sunderbonda, Delta?

5.2.18 The Ganges Delta is the world's largest river delta, but there are several other major deltas on rivers fed by the Himalayan glaciers. Locate these and mark them on your map. What other major world rivers also have extensive deltaic deposits?

5.2.19 Summarize the life cycle of Himalayan sediment from its beginnings before the origin of the mountain range to its deposit in the Bay of Bengal.

Extension Suggestions

1. In the video, water is portrayed as playing a significant role in the Hindu religion. In the pre-viewing activity, students have noted that water is sacred not only to Hindus, but to many other religions as well. Investigate the role of sacred waters, either in history or in the modern

world, using specific rivers such as the Nile, Tigris, Euphrates or Jordan. Alternately, water and its sacred role can be explored in specific religions such as Buddhism, Christianity, Islam, Judaism, Shinto and Zoroastrianism. Students prepare a short paper on one river or one religion, outlining the core beliefs involved.

2. Consider how a people's strong belief in sacred waters might be harnessed for a campaign in water conservation and/or river remediation.

3. In 5.2.13, the decrease in the meltwater from the Himalayan glaciers and the implications of this for the people downstream were identified. Research to determine similar situations in North America (e.g., in the Missouri-Mississippi system or the Columbia system).

4. In 5.2.18, some of the other major river deltas of the world were identified. Research to determine how ONE of these deltas has been affected by water flow and sedimentation in recent years and how this trend is expected to be maintained or changed in the near future.

5. The delta of the Ganges is also prone to the vagaries of weather—typhoons (hurricanes) in particular. Research to find out the details associated with one of the most deadly typhoons in history: Typhoon Bhola in 1970. In your research, indicate the origin of the typhoon, its physical characteristics, the damage in the Ganges Delta and why typhoons are particularly damaging to delta areas.

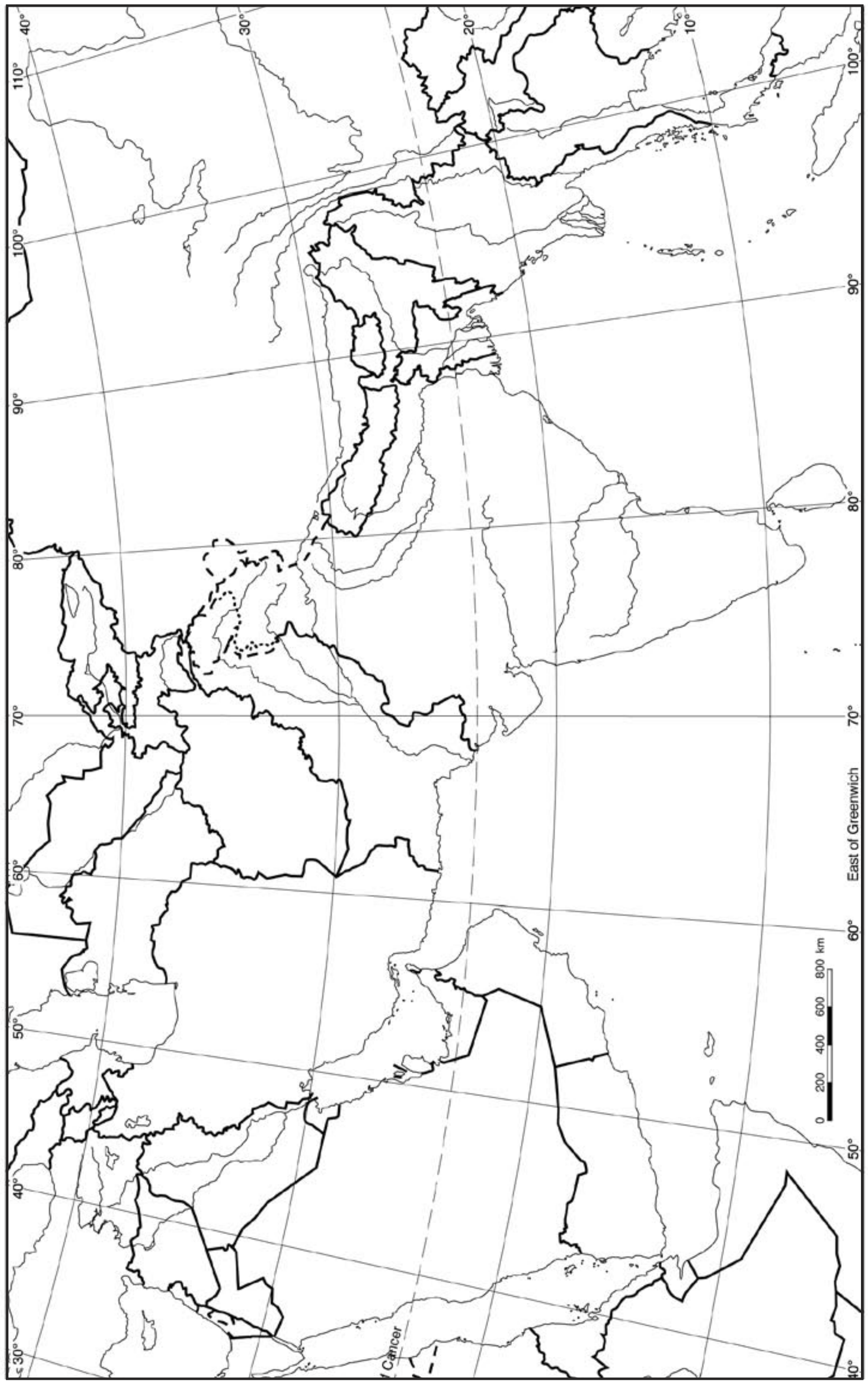
Assessment Suggestions

1. Teachers may assess students' ability to fully summarize the role of Himalayan sediment in the creation and destruction of the mountain range. A rubric for the assessment could involve criteria such as the logic/application of knowledge, quantity of information to support the opinion, communication skills through written work and critical thinking skills.

2. Teachers may assess students' understanding of the earthquake threat in Kathmandu and their recommendations of steps to reduce the city's vulnerability. Criteria for the assessment may include knowledge and understanding of the problem and suggested solutions, the quantity and quality of the solutions to the problem, and the application (logical predictions and conclusions) and the effectiveness of the communication.

3. Teachers may have students hand in their completed maps of the glacier-fed river systems and their answers to questions 5.2.7 and 5.2.8.

Appendix 5.2.1 – Outline Map of the Indian Subcontinent and Southeast Asia



Pearson School Atlas Teacher's Guide, by Robert Morrow

ACTIVITY 5.3 • FIERY FURNACE, NEW CONTINENT

Curriculum Expectations

- Demonstrate an understanding of the processes at work within Earth and on its surface and the role of these processes in shaping Earth's surface.
- Analyze technological developments that have increased our knowledge of geological processes and structures and how this knowledge assists in monitoring and managing these processes and structures.

Activity Overview

Chapters 4 and 5 of the video concentrate on Indonesian volcanic activity, highlighting Merapi on Java, one of the most regularly active volcanoes in the world. The lesson plan mirrors this focus but also highlights the ways in which science has learned to monitor and predict eruptions with a view toward minimizing human injuries and fatalities. In this activity students learn how Himalayan sediment completes its journey from the Bay of Bengal to become the volcanoes of Indonesia. Students explore the process by which this sediment becomes the magma thrown up by those volcanoes. They examine the way in which volcanic activity is monitored by scientists, and witness the tremendous destructive power of Merapi. Finally, they consider the evidence that scientists believe will lead to the creation of a new supercontinent over the next 200 million years.

Pre-viewing Activity

Students' pre-knowledge about this area of the world and its significance in terms of plate tectonics and volcanism may vary. It is suggested that a review of the following terms will provide a basic understanding of the material covered in the lesson plan: *Pacific Rim of Fire, Java (Sunda) Trench,* and *island arc*. A good educational atlas or maps should be used to locate these areas and describe the associated terms.

The focus of this activity is on Indonesia. Use a classroom map to pinpoint the location of this island nation and its geographical relationship to the Ganges Delta. Most educational atlases will identify the location of the volcanoes in this region. An alternate is the U.S. Geological Survey map of the major volcanoes of Indonesia with eruptions since 1900, which can be found at http://vulcan.wr.usgs.gov/Volcanoes/Indonesia/Maps/map_indonesia_volcanoes.html. Similar maps can be utilized to explain the significance of this area as a centre of volcanic activity—why the video refers to it as a fiery furnace.

Teacher Preparation and Materials Required

The teacher should review chapters 4 and 5 of the video, which are the basis for this activity.

There are a number of excellent websites associated with volcanism. Students should be encouraged to access these sites (as identified in the activities).

Students will need chart paper and markers for Activity 5.3.10.

Because many photographers were in the area covering the earthquake and tsunami, the 2010 Merapi eruptions were particularly well photographed. Many striking photographs, with commentary, are available on the Montserrat volcano website created by Bob Thompson of the Department of Earth Sciences, University of Durham, at www.montserratvolcano.org/Merapi.htm. With the commentary they provide a valuable overview of the course and fury of the event. CAUTION SHOULD BE USED IN VIEWING THE PHOTOGRAPHS. The second part of the page contains several graphic photographs of individuals and animals killed during the eruptions.

LESSON PLAN

View chapters 4 and 5 of the video.

Part 1 – A Tectonic Bullseye

5.3.1 What are the three major islands of Indonesia where much of the area's volcanic activity takes place?

5.3.2 On the *Geologic Journey II* website (www.cbc.ca/geologic2), the tectonic map of the region is described as resembling a giant bullseye. What recent tectonic events in the program support this description?

5.3.3 Describe the role of the tectonic plates in the Java (Sunda) Trench that is responsible for the area's tectonic volatility. Use Appendix 4.1.2 – Continental Collision Model to assist in your description.

5.3.4 Describe how the meeting of those plates, combined with Himalayan sediment, is responsible for producing the Indonesian volcanoes.

Part 2 – The Eruption of Merapi

5.3.5 In the video, Merapi is described as both a "good guy" and a "bad guy." What are the positive aspects of life in this zone of regular volcanic activity?

5.3.6 On average, how often does Merapi erupt?

5.3.7 Nick Eyles describes the magma on Merapi as "stiff"—in other words, of very high viscosity. How does the high viscosity of magma affect the formation and eruption patterns of volcanoes ?

5.3.8 How are fumeroles associated with volcanic activity? How would you describe the visual image of a fumerole? How are fumeroles formed? What factors determine how long fumeroles exist before becoming "extinct"?

5.3.9 What signs do caretakers monitor monthly to predict the timing of volcanic eruptions?

5.3.10 Modern technology has made it possible for scientists to have considerable success in predicting when volcanoes are likely to erupt. In 2010, the area around Merapi was under evacuation well before the first pyroclastic flow. Far more people were killed when they returned to the area while Merapi was still highly active.

UNAVCO, Inc. provides satellite-based global navigation services to geoscience research and associated organizations. The acronym is derived from "University NAVSTAR Consortium"—NAVSTAR being the forerunner of GPS. The UNAVCO website (www.unavco.org) includes a PowerPoint presentation titled "The Science of Prediction: Monitoring Volcanic Activity." The presentation (with many examples from the 1980 Mount St. Helens eruption, which created a massive pyroclastic flow) describes the ways in which volcanic activity is currently monitored.

In small groups, use the information in this presentation (which you may wish to supplement with additional research) to prepare a chart that:
- describes the five signs of volcanic processes that are monitored
- lists the main tools used to monitor each sign
- describes the observations that indicate that volcanic activity is increasing

5.3.11 Pyroclastic flows make Merapi an especially dangerous volcano. Describe the causes, make-up and behaviour of pyroclastic flows.

5.2.12 The 2010 Merapi eruptions were especially brutal (perhaps the largest since 1870), lasted for over a month and killed more than 300 people. Most of those killed were refugees who returned to the area despite advice to the contrary and clear warnings that the volcano remained active. Consider yourself to be a person living near Merapi. You have been told to evacuate and do so . . . but sometime later, you decide that you must return to your home and farm. What rationale could you provide for making this decision?

5.3.13 Students in schools around the world regularly participate in fire drills. In some places, including the west coast of the United States, students also participate in "lahar drills." What are lahars? How do they develop? What measures are used to control them?

Part 3 – The Next Supercontinent

5.2.14 How often are supercontinents formed?

5.2.15 When did Pangea, the last supercontinent, break up?

5.2.16 While geologists agree that in about 200 million years Earth will be home to one supercontinent, not all agree on what it will look like. The model in Episode 5: "The Collision Zone: Asia" is that of Pangea Proxima—what Christopher Scotese of the University of Texas thinks will happen. On October 20, 2007, an article titled "Pangaea, the comeback," by Caroline Williams and Ted Nield, appeared in *New Scientist*. It is available to readers on the Australian Academy of Science NOVA website (www.science.org.au/nova/newscientist/104ns_011.htm). The article discusses some of the competing theories of a vision of the next supercontinent and expectations for life in such an environment. Using information from the article, describe the births of Novopangaea, Amasia and Pangaea Proxima, three competing predictions of how the next supercontinent will develop. What expectations of tectonic activity account for the differences in those predictions?

Extension Suggestions

1. Using the *New Scientist* article "Pangaea, the comeback" as a starting point, research . . . and predict . . . what life is expected to be like on the next supercontinent.

2. Volcanic lightning is a fascinating but little-studied phenomenon that accompanies many eruptions. Research the current scientific

understanding of volcanic lightning and why some scientists argue it may account for the origin of life on Earth.

Assessment Suggestions

1. Teachers may assess the students' ability to describe the complete process of continent building from the dismantling of the Himalayas to the volcanic birth of the new continent. A rubric for a report might include the elements of knowledge and understanding of the topic, the thinking and inquiry skills indicated, the format and content of the written and visual communication (if any) and application-making, conclusions, predictions and connections.

2. Teachers may choose to have the students hand in their descriptions of the births of Novopangaea, Amasia and Pangaea Proxima.

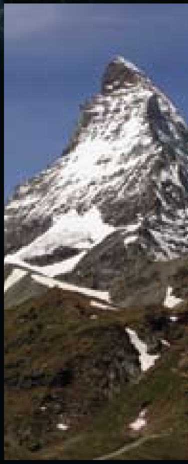
3. Teachers may choose to evaluate the group work on the charts on monitoring volcanic activity. A rubric for co-operative group work might include the following criteria: communication of material for the group, oral communication with peers in the group setting and the application of concepts and skills related to the group setting.

the nature of things
WITH DAVID SUZUKI

GEOLOGIC JOURNEY II

TECTONIC EUROPE | ALONG THE AFRICAN RIFT | THE PACIFIC RIM: AMERICAS
THE WESTERN PACIFIC RIM | THE COLLISION ZONE: ASIA





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