

Chapter 2: A Tropical Alberta

Practice, page 331

1. After the death of an animal, burial is seldom immediate. The remains usually become food for scavengers, who may carry away body parts to some other location. If burial does happen, the process of decomposition may then inhibit the preservation process—by the time remains become part of a sedimentary rock layer, parts may be missing or seriously disfigured by scavengers or decomposers. After millions of years encased in sedimentary rock, the fossil must become exposed through erosion but not become subject to the effects of erosion itself. Finally, the exposed fossil remains must be discovered as a significant find by someone, who then passes this information on so the fossil can be recovered by a trained paleontologist. Clearly, there are many opportunities for fossil evidence to become incomplete.
2. Coal, oil, and natural gas do not represent the preserved remains of ancient life. In the case of oil and natural gas, the process of chemical change has dramatically altered the original individual organisms into a completely different form.

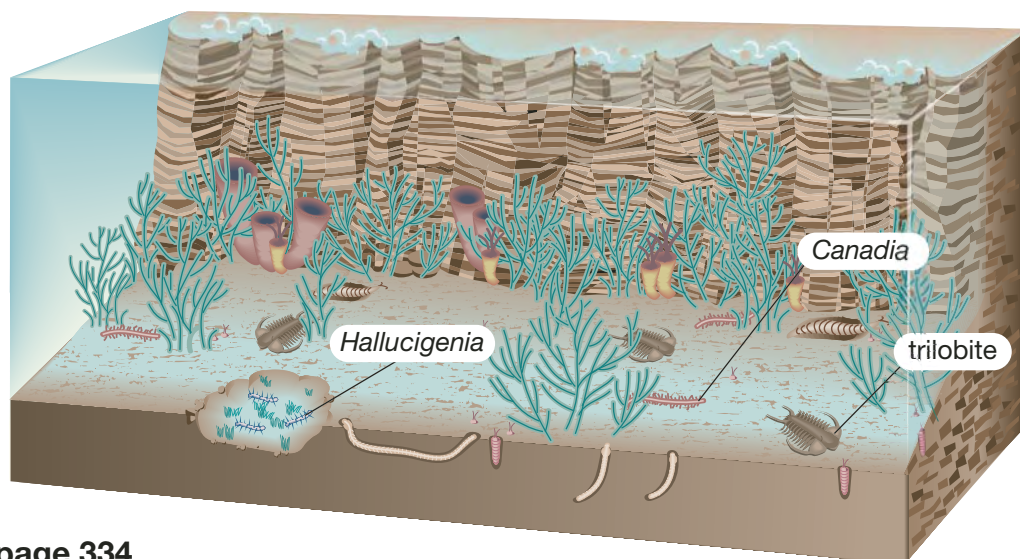
Practice, page 331

3. If comparisons to modern species are valid, then the two stalks—or small tentacles—are structures similar to sensory organs, which respond to chemical information or light from the environment.
4. If it is similar to modern bristle worms, *Canadia* was likely an animal that lived along the bottom of the sea floor. If it used its feathery, gill-like structures for locomotion, then it could have been free-swimming.
5. The food source for *Canadia* would be very difficult to determine from this fossil evidence. Since no parts like shells have ever been found, *Canadia* could have been a filter feeder, ingesting tiny particles of organic material from near the sea floor's bottom.
6. This is the principle of uniformitarianism.

Practice, page 333

7. The artist's conception of the underwater ecosystem that was home to the Burgess Shale fossils is a hypothetical interpretation because it not only shows the activities of these ancient organisms, but it also suggests some of the possible predator/prey relationships among the organisms.

8. The trilobites, *Canadia*, and *Hallucigenia* are all swimming along the bottom.



Practice, page 334

9. a. The source of the fine silt and clay that formed the Burgess Shale was the eroding Precambrian rock that formed much of the North American continent.
- b. The extremely small size of these particles meant that they could fit in the tiniest openings and pores of the ancient organisms that they would eventually help to fossilize. The minute details of delicate structures could be preserved by a tight encasement of fine mud.
10. If the explanation of the underwater mud avalanche is correct, then haphazard fossil positions make sense. Since an avalanche is a sudden, unpredictable, and disorderly event, it follows that the fossils should be preserved in a way that reflects the violence of this process.

2.1 Questions, page 335

Knowledge

1. a. Shale is a sedimentary rock formed through geological processes from fine particles of silt and clay.
- b. Trace fossils include the burrows, footprints, root channels, excavations, and droppings of ancient plants and animals.
- c. Preservation is the act of keeping something away from injury, destruction, or decay. This is why preservation is a key step in fossilization.
- d. The Cambrian Period, which is the first period of the Paleozoic Era, spans a time interval from 590 million years ago to 500 million years ago.
- e. The Paleozoic Era, which followed the Precambrian Era, is a time interval from 590 million years ago to 250 million years ago.

Applying Concepts

- 2. a.** The process of fossilization can be described as follows:

life → death → burial → preservation → discovery → recovery

- b. The Burgess Shale fossils are unique because the fossilization process involved the rapid death of these organisms from a mud avalanche. This avalanche also assured immediate burial, so the remains were safe from predators. The mud, surrounded by deep deoxygenated water that limited the decay process, provided an excellent storage medium that resulted in the superb preservation of these fossils.
3. Trace fossils, such as burrows, are not found in the Burgess Shale fossils because the underwater mud avalanche would have either collapsed or filled in these traces of Cambrian life.
- | | |
|--|--|
| <p>4. Cambrian Explosion = 20 million a</p> <p>$= 20 \times 10^6 \text{ a}$</p> <p>$= 2.0 \times 10^7 \text{ a}$</p> | <p>Earth's History = 4.5 billion a</p> <p>$= 4.5 \times 10^9 \text{ a}$</p> |
|--|--|

$$\begin{aligned}\text{Percentage for Cambrian Explosion} &= \frac{(2.0 \times 10^7 \text{ a})}{(4.5 \times 10^9 \text{ a})} \times 100\% \\ &= 0.44\%\end{aligned}$$

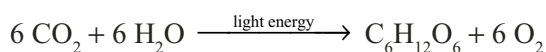
The percentage of Earth's history that corresponds to the Cambrian Explosion is about 0.44%.

5.
 - a. In Chapter 1 you learned that cyanobacteria left trace fossil evidence in the form of stromatolites. Despite the microscopic size of these creatures, the fact that they were the dominant form of life on Earth for two billion years meant that they were still able to have a huge impact on the planet. Collectively, they are largely responsible for Earth's oxygen-rich atmosphere. Banded iron formations are further evidence of the cyanobacteria effects.
 - b. The exchange of oxygen between the atmosphere and the water takes place at the boundary between the water and the atmosphere. Wave action, especially at the triple boundary between air, water, and land, would further ensure that the water was oxygenated. The shallow-water ecosystems would also be home to the cyanobacteria and to the stromatolites that they created, so the oxygen being released at that moment would be in close proximity to the other life forms.
 - c. Deep water is, by definition, far away from the surface and usually distant from shore. It follows that all the arguments that tend to indicate shallow water is oxygen-rich indicate deep water is oxygen-deficient. Since oxygen is key for the work of bacteria responsible for biological decay, the deep water would reduce the rate of decay for Burgess Shale fossils.

Practice, page 337

11. The Ordovician Period started 500 million years ago and lasted until 440 million years ago, so this time interval spans 60 million years.

12. a. The process where plants produce oxygen as a by-product is called photosynthesis. The following equation describes this process:



- b. Ozone absorbs ultraviolet radiation high in the atmosphere to prevent much radiation from contacting organisms living on Earth's surface. Without the protective effects of the ozone layer, early amphibians would have been subjected to the harmful effects of this radiation, and this would greatly reduce the time they could spend out of the water.

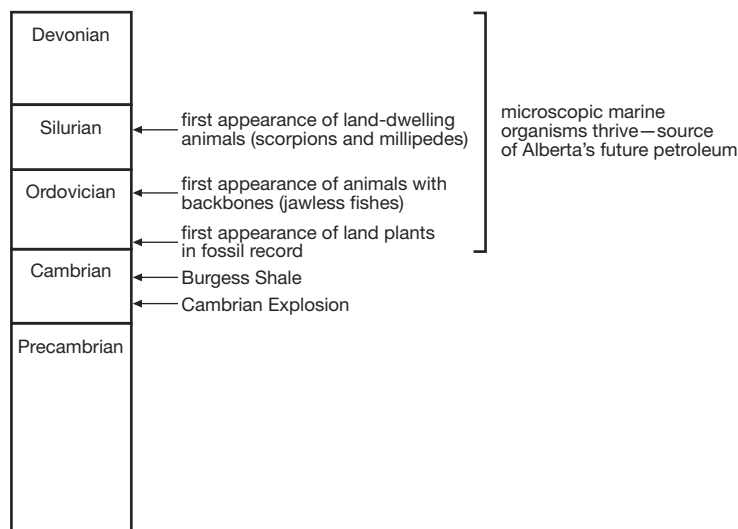
Practice, page 338

13. Alberta's warm tropical sea was the home of microscopic marine organisms. For tens of millions of years, the dead remains of these creatures created a thick bed of organic ooze on the sea floor. The action of bacteria is thought to have removed most of the oxygen and nitrogen, leaving carbon and hydrogen as the building blocks of petroleum. It took another 380 million years of constant heat and pressure to convert this material to liquid form and to force it into the porous remains of fossilized reefs.
14. Although the tropical waters surrounding the Bahamas may have a rich supply of microscopic marine life that forms an organic ooze on the bed of its tropical waters, one important element in the creation of petroleum is missing. The missing element is 380 million years of heat and pressure to convert this material into petroleum.

2.2 Questions, page 342

Knowledge

1.
 - a. Petroleum is the liquid hydrocarbon formed from millions of years of geological processes acting on the remains of ancient microscopic marine organisms.
 - b. A reef is a submerged ridge of rock, sand, or coral that rises to the water's surface.
 - c. A petroleum trap is a large quantity of petroleum confined between layers of impermeable rock.
 - d. Seismic waves are waves that travel through Earth as a result of explosions or earthquakes.
2. The Geological Time Scale should look similar to this one.



Applying Concepts

3. a. The rank of materials from slowest to fastest is as follows: crude oil, shale, sandstone, and limestone.
- b. The strongest reflection would come from crude oil and limestone—the materials with the greatest differences in density.
- c. The weakest reflection would come from the materials with the least difference in density—shale and sandstone.

Practice, page 344

15. a. A crustal plate is a large piece of continental crust or oceanic crust that floats and slowly moves atop the asthenosphere.
 - b. Plate tectonics is the theory that the lithosphere consists of crustal plates that slowly move across Earth's mantle and interact at the plate boundaries.
 - c. A seismic wave is a wave that travels through Earth as a result of explosions or earthquakes.
16. Urban areas have a greater population density and a higher concentration of buildings than do rural areas. As geologists often say, "Earthquakes don't kill people, buildings do." Most deaths from earthquakes are caused by buildings falling on people.

Practice, pages 348 and 349

17. a. Wave I: $\Delta d = 200 \text{ km}$
 $\Delta t = 20 \text{ s}$
 $v = ?$

$$v = \frac{\Delta d}{\Delta t}$$

$$= \frac{200 \text{ km}}{20 \text{ s}}$$

$$= 10 \text{ km/s}$$

The speed of wave I is 10 km/s.

Wave II: $\Delta d = 100 \text{ km}$
 $\Delta t = 20 \text{ s}$
 $v = ?$

$$v = \frac{\Delta d}{\Delta t}$$

$$= \frac{100 \text{ km}}{20 \text{ s}}$$

$$= 5.0 \text{ km/s}$$

The speed of wave II is 5.0 km/s.

Wave III: $\Delta d = 66 \text{ km}$
 $\Delta t = 20 \text{ s}$
 $v = ?$

$$v = \frac{\Delta d}{\Delta t}$$

$$= \frac{66 \text{ km}}{20 \text{ s}}$$

$$= 3.3 \text{ km/s}$$

The speed of wave III is 3.3 km/s.

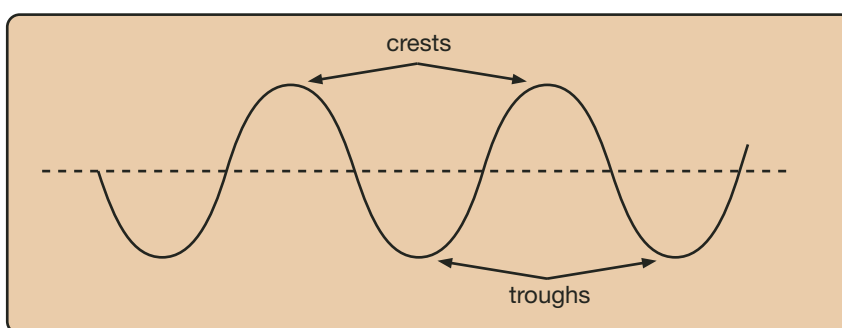
- b. Wave I had the fastest speed, so it must be a P-wave. Wave III had the slowest speed, so it must be a surface wave. Using the process of elimination, wave II must be an S-wave.
- c. Wave III is more likely to damage buildings because this wave has a larger amplitude than the other two, indicating that it is transferring more energy. Wave III also has the longest duration of any of the waves, so it will shake the buildings for a longer time period.

18. The only wave that could travel to the other side of the planet would be a P-wave because S-waves cannot travel through the liquid outer core, and surface waves have a short range. The wave that corresponds to a P-wave is number I because it travels with the highest speed.

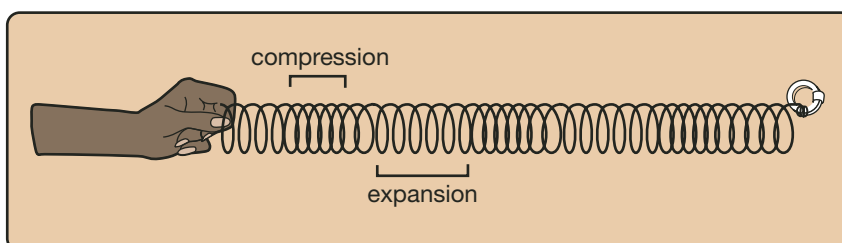
2.3 Questions, page 351

Knowledge

1. An S-wave is a transverse wave with crests and troughs.



A P-wave is a longitudinal wave with compressions and expansions.

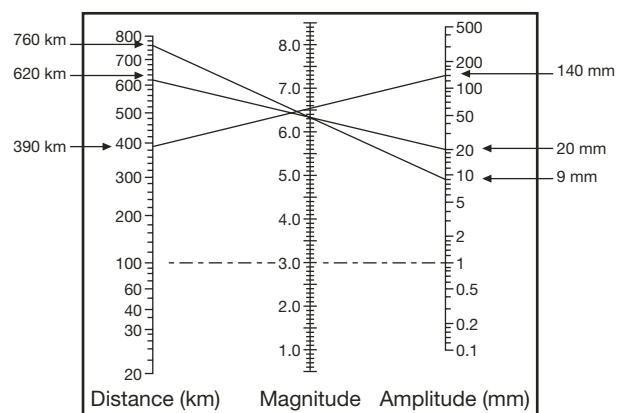


- 2. The seismic wave that produces the most damage in an earthquake is the surface wave.
- 3. The waves actually start from the focus, which is many kilometres below Earth's surface in the crust. The epicentre is the point on Earth's surface directly above the focus.

Applying Concepts

- 4. The epicentre of this earthquake is about 20 km west of the Queen Charlotte Islands.

5. As shown in this chart—a nomogram—the Richter magnitude of this earthquake is 6.4 or 6.5.



6. Bella Coola is much closer to the earthquake than Vancouver is. When the S-waves have travelled to Bella Coola, the energy is concentrated in a smaller volume of rock compared to when these same waves reach Vancouver. More energy is available to move the ground at Bella Coola than there is at Vancouver. Since the amplitude of the S-wave is an indicator of the energy transferred, the seismic wave has a larger amplitude in Bella Coola than it does in Vancouver.
7. a. Canada's largest earthquake recorded by a seismograph occurred on August 22, 1949. It took place west of the Queen Charlotte Islands.
- b. The Richter magnitude for this earthquake was 8.1.
- c. The earthquake happened on the Queen Charlotte Fault, which separates the North American Plate from the Pacific Plate. In this system, the Pacific Plate is being forced in a northwesterly direction that runs parallel to the fault. The fault itself is thought to be a crack in Earth's crust that runs vertically, straight down into the planet. When the stress between these plates becomes greater than the breaking strength of the rock, the Pacific Plate suddenly slides to the northwest, relative to the North American Plate. Geologists think there is little vertical motion here because one plate suddenly slides past the other.
- d. You probably reported that you identified key words and inserted these key words into a favourite search engine. If you found the required information in a reasonably short time, you likely used focused search words. As an example, using *earthquake* and *Queen Charlotte Islands* would be an efficient combination of key words. Similarly, if you used *Canada's largest earthquake* as the input into the search engine, results would be obtained fairly quickly. A less-effective combination would be *earthquakes* and *Canada*, which is not specific enough to produce results in a reasonable amount of time. In general, the most likely area of improvement is to add more specific entries into the search engine. These entries should reflect the main focus of the original question.

Practice, page 356

19. No, it is not a coincidence that a mass extinction occurred at the same time the Paleozoic Era ended and the Mesozoic Era began. The Geological Time Scale was assembled using index fossils. When one set of index fossils suddenly disappeared and another set suddenly appeared, it was decided that such events corresponded to a boundary between two eras.
20. Trilobites are excellent index fossils because they emerged in the fossil record in the Cambrian Period at the start of the Paleozoic Era, and they became extinct in the Permian Period at the end of the Paleozoic Era. In other words, trilobites only existed during the Paleozoic Era.

21. Event A occurred at the end of the Cambrian Period, while event B took place at the end of the Ordovician Period. Event C happened at the end of the Devonian Period, with event D near the end of the Permian Period. The end of the Triassic Period was the time period for event E, while event F occurred at the end of the Cretaceous Period.

Practice, page 357

22. The Permian Extinction could have been caused by a period of glaciation, a reduction in coastline with Pangaea's formation, a deep impact from a comet or a large asteroid, or intense volcanic activity from what is present-day Siberia.
23. The deep impact of a comet or a large asteroid—as well as a period of intense volcanic activity—could have triggered a period of glaciation. In both cases, large amounts of dust, ash, and debris would have been thrown high into the atmosphere. This, in turn, would have prevented sunlight from reaching the surface and caused a worldwide drop in temperature.
24. a. In the case of events D and F, the graph shape is tall and narrow. This shape relates to the variable on the vertical axis because a large percentage of species became extinct. The narrowness relates to the variable on the horizontal axis because these events occurred in a relatively short time. Therefore, these mass extinctions were likely sudden events.
- b. The events that would cause a sudden change are the deep impact theory and the volcanic eruption theory. The formation of Pangaea would be a more slowly developing event, as would the initiation of a period of glaciation.

Practice, page 359

25. a. The effects of subduction are earthquakes and volcanic activity. Earthquakes occur as the sudden release of stored energy when one crustal plate moves relative to the other. The energy is stored after years of stress cause the rock in the region between the plates to bend, fold, and compress. When the breaking point of the rock is reached, huge chunks of Earth's crust suddenly move and the energy is released as seismic waves carry the energy to other parts of the crust.

The volcanic activity is caused by the crust of the subducted plate being pushed down into the mantle where the rock melts. This molten rock eventually makes its way to the surface in the form of volcanic activity.

- b. The principle of uniformitarianism is that geological processes at work today operate in fundamentally the same way that they did millions of years ago.
26. a. The main difference in the two models of subduction is the angle in which the oceanic crust is pulled under the continental crust. In the case of Mesozoic Alberta, the subduction angle is less steep—it dips at a shallower angle than the model for southern Alaska.
- b. Geologists suspect that the reason the volcanic activity occurred much farther inland in Mesozoic Alberta is due to the shallow subduction angle. At this angle, the oceanic crust has to travel much farther inland before it descends deep enough to melt in the asthenosphere. Since the melting occurs much farther inland, the resulting volcanic activity also occurs farther inland.

2.4 Questions, page 360

Knowledge

1. Volcanic activity occurs when two plates separate, as in the middle of the Atlantic Ocean, and when one plate subducts under another, as is the case in southern Alaska.
2. The Permian Extinction at the end of the Paleozoic Era could have been caused by a period of glaciation, by the reduction in coastline with the formation of Pangaea, by a deep impact from a comet or a large asteroid, or from intense volcanic activity in what is now present-day Siberia. Of these potential causes, the deep-impact and/or the volcano theories seem most probable according to the shape of the mass extinction graph—the shape of the graph for this extinction suggests a sudden event.
3. Dinosaurs were able to flourish because they took advantage of vacancies in the food chain caused by the mass extinction at the end of the Triassic Period. Dinosaurs thrived in the Jurassic and Cretaceous Periods that followed. The mass extinction that marked the end of the Cretaceous Period coincides with the disappearance of dinosaurs from the fossil record.

Applying Concepts

4. The Atlantic Ocean was formed as the North American Plate and the South American Plate began drifting to the west away from the African and Eurasian Plates. The Atlantic Ocean was formed due to a diverging plate boundary. The volcanic activity at this boundary added crust to the plates on both the east and west sides, causing the Atlantic Ocean to become wider.
5. Throughout most of the Paleozoic Era, current-day Alberta spent much of the time submerged under shallow tropical seas. During these times the sedimentary rock layers of shale and limestone were formed as horizontal strata. As the North American Plate drifted west after the break-up of Pangaea, geologists believe that a series of collisions began with arcs of volcanic islands. The plate that these islands rode was subducted under the North American Plate—this left the continental crust that comprised the islands to be welded onto the west coast of North America. During the last series of collisions in the late Cretaceous Period, the crust containing the parts of Alberta that were once seabeds were raised, folded, and twisted. Geologists think that the effects of millions of years of intense compression caused by the action of the tectonic plates created the intricate folds in the rock on the side of Mount Michener.
6. The Cretaceous/Tertiary Mass Extinction created an ideal opportunity for the rapid diversification of mammals because spaces in the food chain previously occupied by dinosaurs and other extinct species were now available.