PLATE TECTONICS

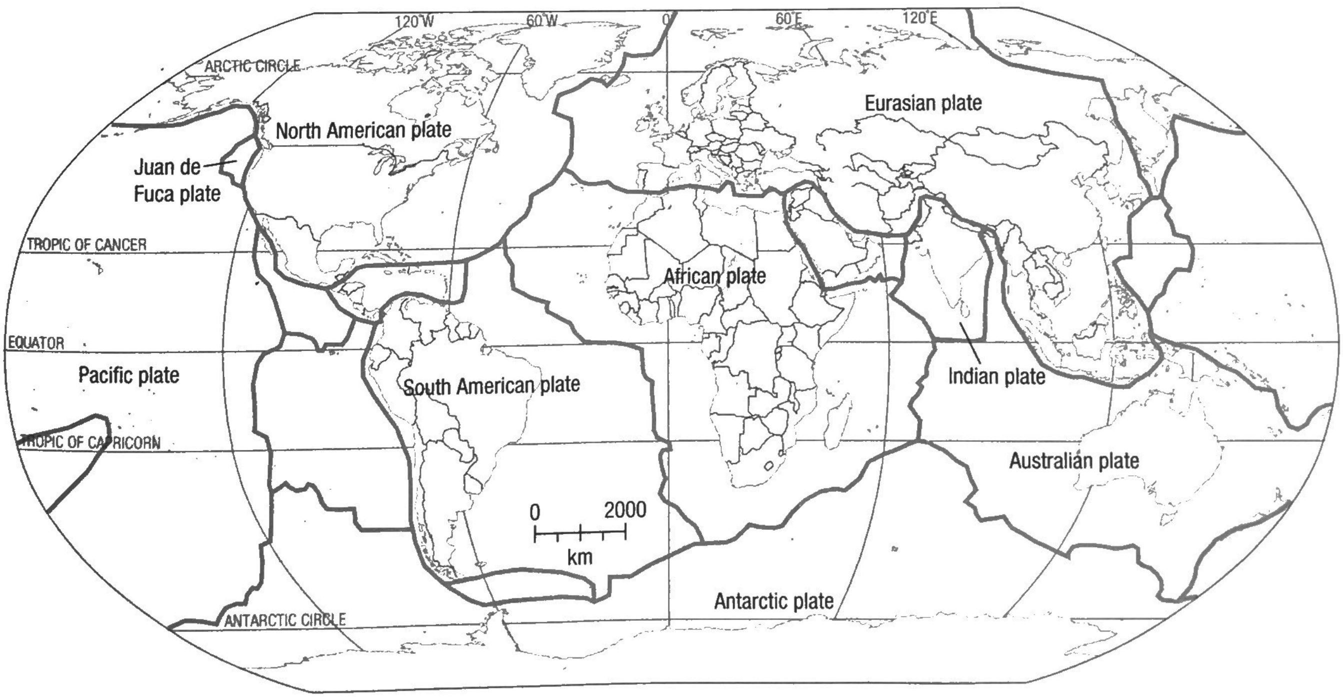
The theory of **plate tectonics** is one of the most important theories ever to result from scientific research. It explains why we have high mountain ranges, majestic plains, and the deepest parts of the ocean. Here is how it works. Earth's crust may seem solid and unyielding—we live on it and build massive buildings and other structures on it. But the theory of plate tectonics tells us that the crust is actually floating on molten rocks inside Earth. Furthermore, the crust is not a single piece. It is made of dozens of pieces called *plates*. There are seven major plates, eight secondary plates, and more than 60 minor plates (Figure 2–5). A good way to imagine the plates is to picture the cracked shell of a hard-boiled egg, with the cracks being the plate boundaries.

The movement of Earth's plates has shaped Canada in many ways. For example, the mountain chains on the east and west coasts grew as a result of plates colliding. The movement of plates has also played a role in the formation of Canada's fossil fuels. Oil, gas, and coal formed when Canada's land mass was located in a warmer, tropical climate. Where will Canada be located in the next few hundred million years? Time—and data on plate direction and speed—will tell.

plate tectonics the theory that Earth's outer shell is made up of individual plates that move, causing earthquakes, volcanoes, mountains, and the formation and destruction of areas of the crust

go online

Find out more about mid-ocean ridges and see new crust forming at a mid-ocean ridge (2:53 minutes).



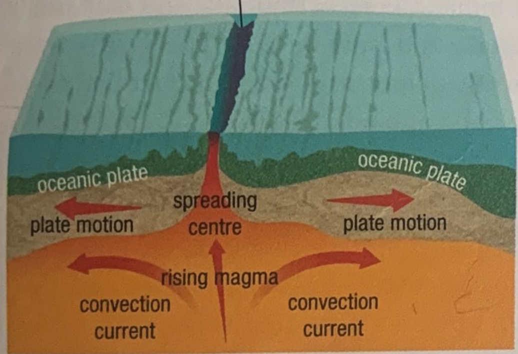
▲ **Figure 2–5 Earth's major tectonic plates.** This map names the seven major plates. The minor plates are shown, but not named, except for the Juan de Fuca and Indian plates.

Types of Plate Movement

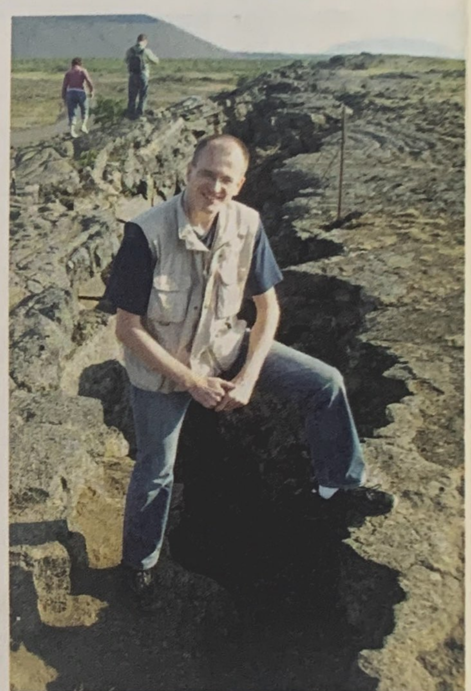
Plates are not joined to each other—they are only touching. They move because the molten rock below them moves. There are three possible directions of movement.

mid-ocean ridge a feature created by the spreading of the sea floor where two plates are diverging. The best-known example runs through the Atlantic Ocean from north to south.

- **Divergent:** This occurs when two plates move apart (Figure 2–6). Most commonly this happens along a **mid-ocean ridge**, although it does happen on land too (Figure 2–7). When this happens, both plates get larger. New areas of Earth's crust are constantly being created in that way along 70 000 kilometres of mid-ocean ridges. Most of the world's volcanoes occur along divergent plate boundaries.



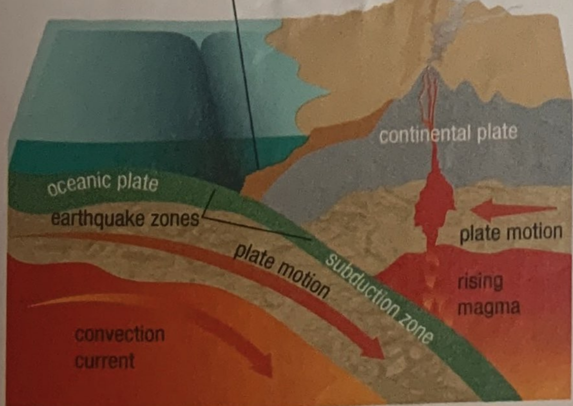
◀ **Figure 2–6** Divergent plates: oceanic plate ⟵ ⟶ oceanic plate



▲ **Figure 2–7** This man in Iceland is standing with one foot on the Eurasian plate and the other on the North American plate. The gap is increasing at slightly less than one centimetre per year.

- **Convergent:** Two plates move toward each other. There are two types of convergence, depending on the kinds of plates that are colliding.
  1. *Continental plate meets oceanic plate:* The rocks that make up deep-ocean plates are denser than those that make up continental plates. As a result, a heavier oceanic plate slides underneath a continental plate (Figure 2–8). This process is called **subduction**. Note that existing crust is "recycled" by subduction. The crust being melted here balances the new crust forming at a divergent plate boundary.

subduction the process in which one plate slides underneath another. The subducted plate moves into Earth's interior and is "recycled" (it melts).



◀ **Figure 2–8** Convergent plates I: oceanic plate ⟶⟵ continental plate

go online

Mount St. Helens in Washington state, not far from the Canadian border, is a volcano caused by subduction along a plate boundary. You can learn more about its 1980 eruption through the words of the scientists who observed it (7 minutes).

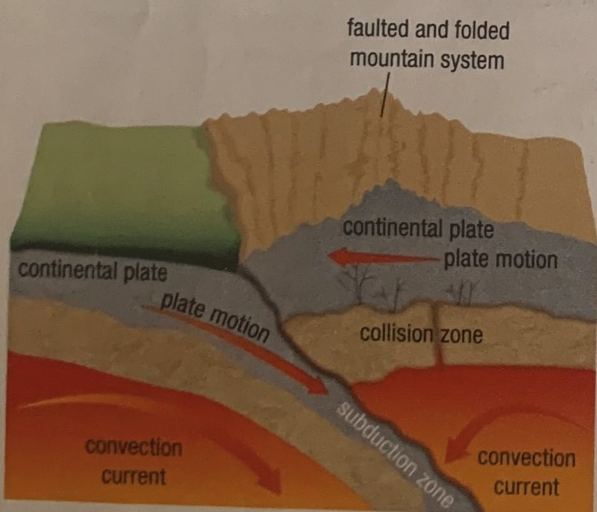
go online

Find out more about plate boundaries in a National Geographic video (6 minutes).

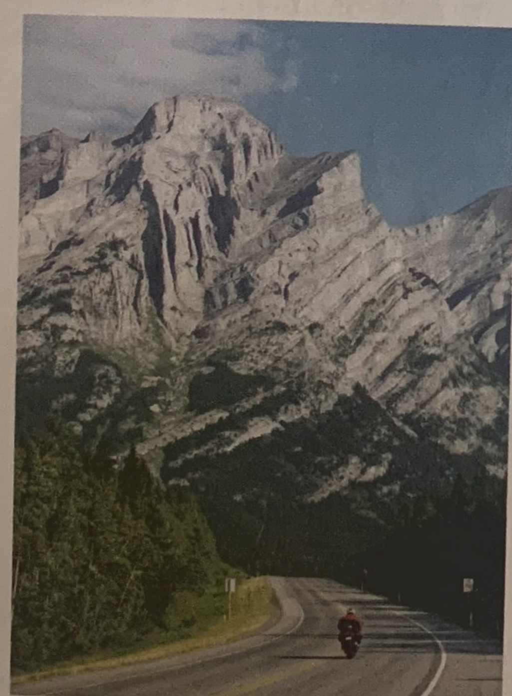
Subduction can happen fairly smoothly when the oceanic plate moves slowly and continuously under the continental plate. As it does, there are many small earthquakes that cause no damage, and might not even be felt by people. However, in some places, the plates do not move. They push against one another and tension builds up for centuries. Eventually this tension is released in only a few seconds. The result can be a catastrophic 8.0 to 9.0+ quake. This is the situation that concerns officials in British Columbia, since they know the plates there have been locked since 1700.

Most of history's most devastating earthquakes (often accompanied by tsunamis) are of this type. These include the 1700 earthquake off the BC coast (estimated intensity 8.7 to 9.2), the 1964 Alaska earthquake (9.2), the 2004 Indian Ocean earthquake and tsunami (9.0), and the 2011 Japan earthquake and tsunami (9.0). The destructiveness of these mega-quakes is sadly demonstrated by the fact that the Indian Ocean earthquake and tsunamis killed over 275 000 people in 11 countries. People were killed by the tsunami as far away as Africa, nearly 5000 kilometres from the centre of the quake.

2. *Continental plate meets continental plate* (Figure 2–9): When two continental plates run into each other, massive layers of rock are folded, broken, and forced upward by the immense pressures of the collision (Figure 2–10). This process created many of the world's most important mountain ranges. The Himalayas (including Mount Everest, the world's tallest mountain) began forming when the Indian secondary plate collided with the Eurasian plate. This process started about 55 million years ago and continues today as Mount Everest rises higher and higher above sea level.

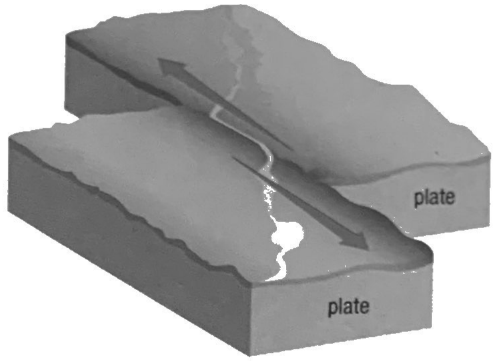


▲ **Figure 2–9** Convergent plates 2: continental plate →← continental plate



◀ **Figure 2–10** These rocks were created in horizontal layers at the bottom of the ocean. You can still see the layers, but they are no longer flat. The incredible power of plates colliding folded them into this shape in Canada's Rocky Mountains.

- **Transform:** Along a transform plate boundary (also called a conservative boundary), plates are made neither larger nor smaller. In these locations, plates move in roughly parallel, but opposite, directions (Figure 2–11). As with subduction, this process often happens fairly smoothly, with many small earthquakes but no catastrophic damage. But sometimes, again like in subduction zones, the plates lock up for many years until an enormous release of energy occurs, resulting in a damaging earthquake. These quakes tend to be much less severe than the worst ones along subduction zones. Major quakes at transform boundaries are generally in the intensity range of 5.5 to 7.5.



▲ **Figure 2–11** Plates move along a transform plate boundary in opposite directions. The 2010 Haiti earthquake was a magnitude 7.0 quake along a transform boundary.

APPLY IT!

1. **a)** What is happening to the size of the Atlantic Ocean? How do you know?

   b) Something about a map of the Atlantic Ocean helped early geologists consider the possibility that the continents were moving. What was this?

2. **a)** What does *subduction* mean?

   b) We know that the North American plate and the Juan de Fuca plate are converging, but which one is subducting under the other? How do you know?

   c) What will eventually happen to the plate that is subducting?

3. **a)** With your classmates, answer this question without doing research. You know that students in British Columbia are taught how to react to an earthquake if they are at school. Assume that you are the BC government official in charge of earthquake preparedness. What additional preparations should people make to minimize the impact of a major earthquake and tsunami? Note: Nothing can be done to stop an earthquake and tsunami from happening.

   b) Now go online to see how well you did in being prepared for an earthquake.

4. ■ **Geographic Perspective** Debate this question: Government should spend tax dollars on reinforcing buildings, roads, and bridges instead of building tourist facilities (e.g., for the Olympics).

5. The first person to observe that the shapes of Africa and the Americas fit together well was the famous geographer and mapmaker Abraham Ortellius in 1596. In spite of his early insight, the theory of plate tectonics was not generally accepted until the second half of the 20th century. Imagine you are someone writing a newspaper column in 1900 about the idea of continental drift. Why would you have been unwilling to support the ideas of Ortellius?