DO YOU KNOW?

if plate tectonic movements continue without change, in 50 million years there will be no Mediterranean Sea; Spain, French Britain and the islands of Great Britain will be united; the Cantabric Sea will disappear; Australia and Indonesia will form one continent; and the Atlantic and the Indian Oceans will grow. Meanwhile, the Pacific Ocean will decrease in size. In the geologic time scale 50 million years is a short time. In the human time scale it is a time frame very difficult to visualize!

2.4 FORCES STRONG ENOUGH TO MOVE PLATES

Excitement among earth scientist grew as the plate tectonic theory developed in the late 1960s. The mechanism that causes the plates to move, however, is still not known. This section presents ideas about forces strong enough to move pieces of the earth's crust. Think about these questions as you read:

a. How could convection currents move plates?

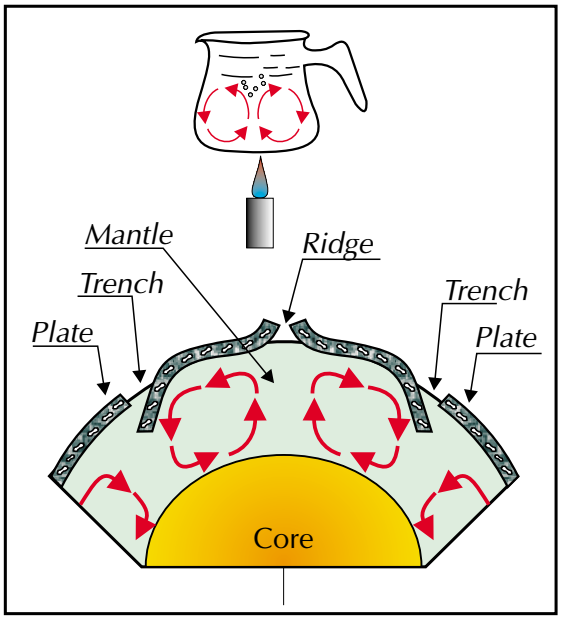
b. How might plumes cause plate movement?

c. What are hot spots?

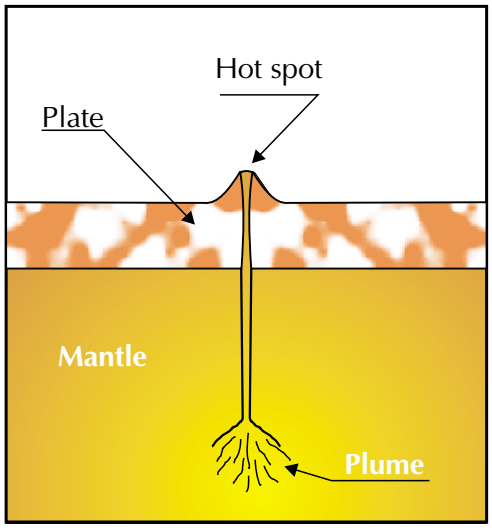
• ONE POSSIBILITY-CONVECTION CURRENTS

Convection currents transfer heat through liquids or gases. The diagram of the coffee pot shows two convection currents in water. Note that the water nearest the flame rises. When it cools near the surface, it sinks.

Some scientists have suggested that convection currents flowing in the mantle may cause the plates to move. Because of the great heat in the mantle, parts of the mantle may flow like a very thick liquid. Compare the diagram of the coffee pot to the diagram of the mantle. A plate might move above a huge convection current like an object riding along on a giant conveyor belt.



Convection currents.



Hot spots origin.

• PLUMES IN THE MANTLE

A plume, pictured on the left, is a narrow, jetlike flow of hot material from a great depth in the mantle. Plumes at spreading boundaries might cause plates to move by adding material to the edges of plates. The added material may push the plates apart.

Scientists do not know whether the force driving the plates is due to convection currents, plumes, a combination of the two, or other unknown factors.

• INVESTIGATING HOT SPOTS

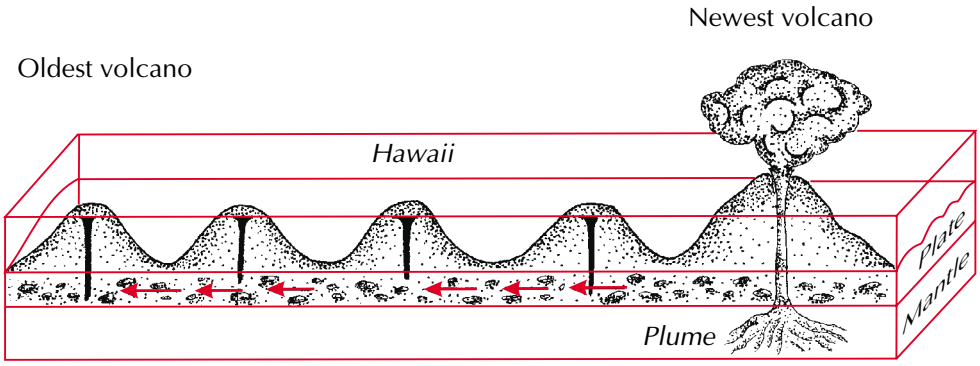
Volcanoes appear where magma from plumes reaches the earth's surface. Places with a great deal of volcanic activity are called **hot spots**. Hot spots are found over plumes in the mantle. Some plumes are located beneath plate boundaries. Earth scientists believe, however, that plumes also occur away from plate

boundaries. For example, hot spots that occur in the middle of a plate are caused by plumes away from plate boundaries.

Hot spots in the middle of the Pacific plate formed the Hawaiian Islands. These volcano-islands are actually huge mountains rising from the ocean floor. Notice in the diagram that the erupting volcano is directly over the plume.

During the past 80 million years, the Pacific plate has been moving to the northwest. The volcanoes move with the plate, but the plume in the mantle does not move. Volcanoes that move away from the plume leave their source of magma. They are inactive.

As the inactive volcanoes move along, new, active volcanoes appear above the plume. Because the plate moves to the northwest, new volcanoes appear to the southeast.



Hawaiian Island origin from a hot spot.

DO YOU KNOW?

Although most hot spots are found in the ocean, some hot spots are on continents. Hot spots on land might by areas where continents are starting to split.

A) REPORT

Someday it wil be possible to forecast earthquakes

TO LUBRICATE THE EARTH

By Isaac Asimov

Once in a while the earth shakes. At the planetary scale it is a very trivial phenomenon, just a short and small shake. At the human scale, by contrast, it is huge; the only natural phenomenon that can kill thousands of people and produce enormous damage in less than 5 minutes.

This shaking is what we call an earthquake.

On January 24, 1556 there was an earthquake in Shensi province, China. This earthquake was reported to have caused 830,000 deaths, the highest death toll to date for this type of disaster. Another earthquake, on December 30, 1703, killed 200,000 people in Tokyo, and on October 11, 1757, 300,000 people died in Calcutta.

On December 1, 1775, Lisbon in Portugal was destroyed by an earthquake and the subsequent tsunami. Sixty thousand people died.

The earthquake's destiny is, with time, to be more and more destructive, because of the simple reason that there are more people over the earth and the works of the human beings are more complex, expensive and numerous.

Let's think, for instance, of the 1906 earthquake that destroyed San Francisco city, killing 700 people, leaving 750,000 people homeless, and producing damage of $ 500 million. If there were such an earthquake today, it is probable that many more people would die, many more would be made homeless, and damage to property would be many times greater.

What can be done? Is it possible to forecast earthquake so that at least people can be evacuated in time?

Perhaps it is possible. There are certain preliminary phenomena which, it seems, foretell a seismic movement: ground uplift or slight cracks in rocks, which cause changes in water lever in wells, or in the electric and magnetic properties of the ground.

People are indiferent to some of the preliminary earthquakes, but animals, who live closer to nature can detect them and show sings of concern. Horses rear and run away, dogs howl and fishes start to jump. Animals which normally stay hidden in holes, like serpents and rats, suddenly come into the open; and the chimpanzees at the zoo are disturbed and spend more time on the ground.

In China, where earthquakes are much common and harmful than in many other countries, people have been asked to pay attention to any uncommon behaviour in animals, any abnormal noise in the ground, any change in the level of water wells or abnormal cracks in paint on walls.

The Chinese say they have forecast some earthquakes and saved many lives in the earthquake of February 4, 1975, in the northeast part of the country. But another earthquake in July 27, 1976 was not forecast and a city was leveled.

Evacuation of a city is a big problem and could cause as much disturbance as the disturbance produced by the earthquake itself. Moreover, even if the population is evacuated there is the risk of people losing their property.

Is it possible to both forecast and delay earthquakes?.

Perhaps. The earth's crust is composed of several huge plates that grind against each other when they move. The junction where the plates join (faults) are irregular and uneven, so friction is huge. Rocks on both sides of the fault slide between them. When they jam, pressure is stored up, until finally, when the stress is great enough the faults yields and a sudden movement is produced. Then the process starts again.

Each of these movements produces an earthquake. The more sudden and vast the displacement, the greater the magnitude of the earthquake. Naturally, if the jamming is small and the displacements are frequent, there will be many earthquakes, unable to produce damage. By contrast, if the jamming and the friction are huge and the stress is accumulated over decades, there will finally be a huge earthquake destroying everything in the area.

Is it possible to reduce the friction of the plates and ease the sliding?.

Imagine that we dig very deep wells along a fault and inject water. The liquid would slide among the rocks, lubricating their surface and favoring a gradual slide which would produce a series of small and harmless earthquakes. The dreadful killer earthquakes would never occur again.

B) CHAPTER SUMMARY

- Alfred Wegener proposed that the continents were once joined in a large continent called Pangaea.

- Wegener used rock layers, fossils, and changes of climate as evidence for continental drift.

- The mid-ocean ridge is a mountain chain 65,000 kilometers long in the oceans of the world.

- Magma rises from the mantle creating new ocean crust at the mid-ocean ridges.

- The plate tectonic theory states that the rigid outer part of the earth is broken into a number of pieces called plates. The plates move apart, collide, or slide past one another.

- The flow of material in the mantle by convection and/or plumes may cause plate movement.

- Hot spots are regions on the surface of the earth that lie directly over a plume.

C) QUESTIONS/PROBLEMS

1 . Compare Wegener's continental drift theory to the plate tectonic theory.

2. Imagine a reason, other than continental drift, for identical fossils in South America and Africa.

3. Why is sediment in the center of mid-ocean ridges either thin or absent?

4. What would happen to the crust if there were spreading boundaries but no colliding boundaries?

5. Using the chart on plate movement and trenches in this chapter, explain why so many earthquakes occur in the Philippine Islands.

6. What type of surface feature might occur on a plate where a convection current is sinking the mantle?

7. An active volcano is at the south end of a north-south chain of volcanoes that are no longer active. What direction is the plate moving?

8. List the continents that were part of Pangaea.

9. How would Wegener account for fossil ferns found in the rocks of Antarctica?

10. Describe the Mid-Atlantic Ridge.

11. Where is the youngest rock in a mid-ocean ridge?

12. Describe a segment of the earth called a plate.

13. What caused the trenches around the Pacific Ocean?

14. What is a convection current?

15. in what layer of the earth does a plume originate?

16. If you visit a hot spot, what would you expect to see?

D) CHAPTER TEST

A. Vocabulary. In the brackets of the left margin match the definition in Column I with the term it defines in Column II.

Column I	Column II
1. the name of Wegener's large continent	a. convection current
2. large underwater mountain chain that surrounds the earth	b. continental drift
3. a theory that the earth's surface is broken into many rigid pieces	c. hot spot
4. deepest section in the oceans where a plate is moving under another plate	d. mid-ocean ridge
5. hot material rises, spreads side-ways, and then sinks again	e.Pangaea
6. a theory that describes the formation of new crust	f. plume
7. region on the earth's surface that has great many volcanoes	g. plate tectonics
8. a jetlike flow of hot material from deep within the mantle	h. sea-floor spreading
9. theory that land masses move over the ocean floor	i. trench
	j. magma

B. Multiple Choice. in the brackets at the right choose and mark the letter that best completes the statement or answers the question.

1. Scientists disagreed with Wegener's idea because he could not explain: ( )

   a) similar fossils' in different continents
   b) forces necessary to move continents.
   c) identical rock formations.
   d) climate changes.

2. New ocean crust is produced at: ( )
   a) trenches
   b) mid-ocean ridges
   c) faults
   d) beaches

3. Old ocean crust is being destroyed at: ( )
   a) trenches
   b) ridges
   c) faults
   d) volcanoes

4. If many trenches surround a plate, the plate is probably: ( )
   a) getting larger
   b) getting smaller
   c) remaining the same size
   d) getting thicker

5. Fault boundaries occur where: ( )
   a) one plate sinks under another
   b) plates are no longer moving
   c) two plates are spreading apart
   d) two plates are sliding past one another

6. A possible cause of plate movements is: ( )
   a) convection in the mantle
   b) the earth's rotation
   c) the pull of the moon
   d) the pull of the sun

7. The Hawaiian Island chain was probably created as the Pacific plate passed over a:
   a) fault
   b) plume
   c) trench
   d) mid-ocean ridge

In the following question, mark the INCORRECT or not corresponding alternative.

8. The Mid-Atlantic Ridge ( )
   a) is where two plates collide.
   b) is composed of parallel ridges
   c) is part of the world underwater mountain chain.
   d) is where new crust forms.