Motivate

INTERACTIVE CHALKBOARD PowerPoint® Presentations

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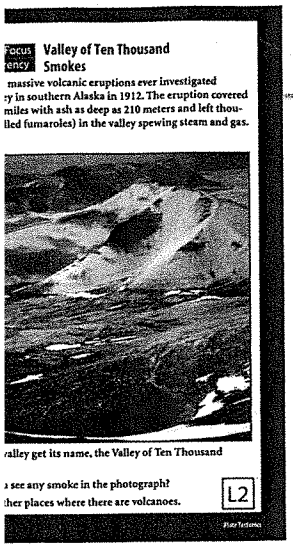
L1



Focus Valley of Ten Thousand Smokes
massive volcanic eruptions ever investigated
y in southern Alaska in 1912. The eruption covered
miles with ash as deep as 210 meters and left thou-
lled fumaroles) in the valley spewing steam and gas.

valley get its name, the Valley of Ten Thousand

see any smoke in the photograph?
her places where there are volcanoes.

L2

Plate Tectonics

o Prior Knowledge

quakes Ask if anyone has experienced an earthquake. have these students explain happened. If no one has, in that earthquakes cause round to shake, often cause reat damage. Tell students earthquakes often happen se of the movement of

section 3

* P. 280 — 285 → Cornell Notes

Theory of Plate Tectonics

as you read

What You'll Learn

- **Compare and contrast** different types of plate boundaries.
- **Explain** how heat inside Earth causes plate tectonics.
- **Recognize** features caused by plate tectonics.

Why It's Important

Plate tectonics explains how many of Earth's features form.

Review Vocabulary

converge: to come together
diverge: to move apart
transform: to convert or change

New Vocabulary

- plate tectonics
- plate
- lithosphere
- asthenosphere
- convection current

Plate Tectonics

The idea of seafloor spreading showed that more than just continents were moving, as Wegener had thought. It was now clear to scientists that sections of the seafloor and continents move in relation to one another.

Plate Movements In the 1960s, scientists developed a new theory that combined continental drift and seafloor spreading. According to the theory of **plate tectonics,** Earth's crust and part of the upper mantle are broken into sections. These sections, called **plates,** move on a plasticlike layer of the mantle. The plates can be thought of as rafts that float and move on this layer.

Composition of Earth's Plates Plates are made of the crust and a part of the upper mantle, as shown in **Figure 8.** These two parts combined are the **lithosphere** (LIH thuh sfihr). This rigid layer is about 100 km thick and generally is less dense than material underneath. The plasticlike layer below the lithosphere is called the **asthenosphere** (as THE nuh sfihr). The rigid plates of the lithosphere float and move around on the asthenosphere.

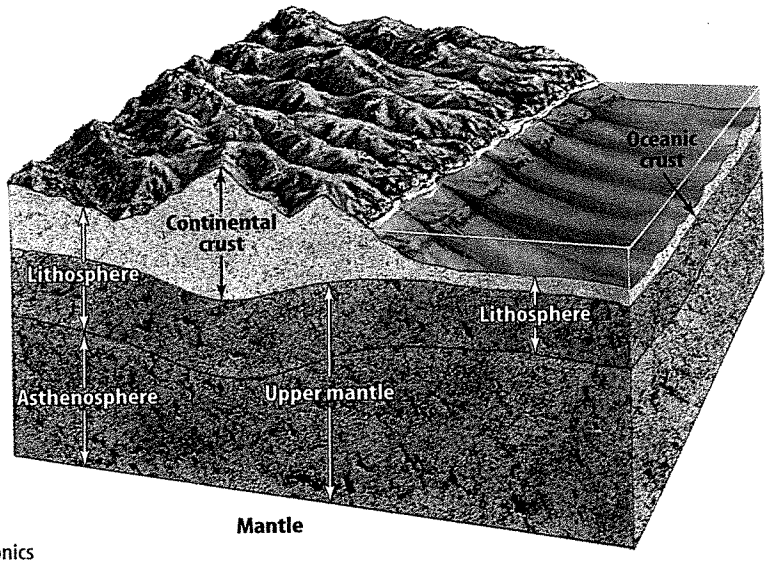


Figure 8 Plates of the lithosphere are composed of oceanic crust, continental crust, and rigid upper mantle.

Section 3 Resource Manager

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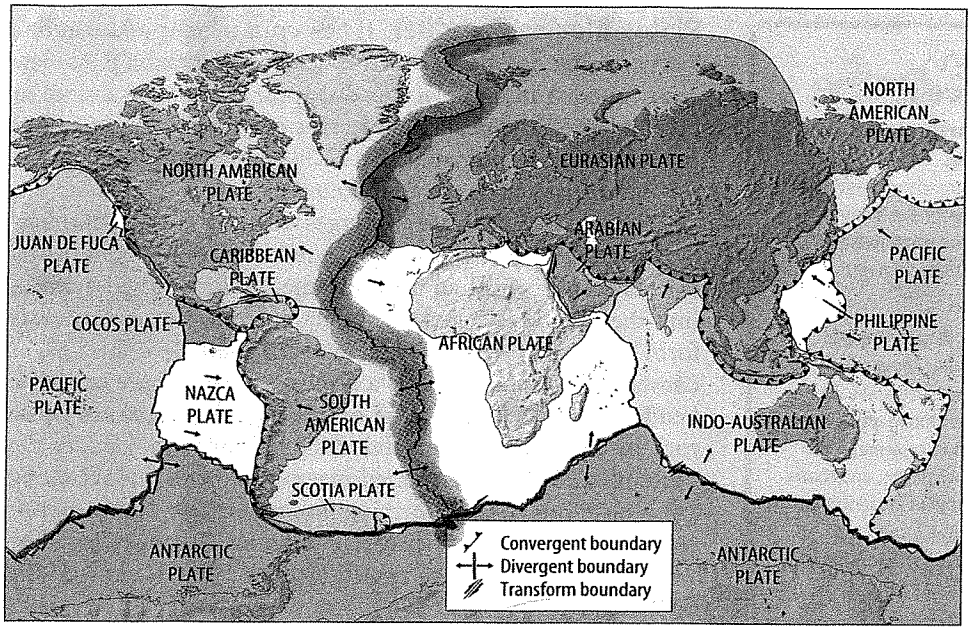


Plate Boundaries

When plates move, they can interact in several ways. They can move toward each other and converge, or collide. They also can pull apart or slide alongside one another. When the plates interact, the result of their movement is seen at the plate boundaries, as in **Figure 9.**

Reading Check *What are the general ways that plates interact?*

Movement along any plate boundary means that changes must happen at other boundaries. What is happening to the Atlantic Ocean floor between the North American and African Plates? Compare this with what is happening along the western margin of South America.

Plates Moving Apart The boundary between two plates that are moving apart is called a divergent boundary. You learned about divergent boundaries when you read about seafloor spreading. In the Atlantic Ocean, the North American Plate is moving away from the Eurasian and the African Plates, as shown in **Figure 9.** That divergent boundary is called the Mid-Atlantic Ridge. The Great Rift Valley in eastern Africa might become a divergent plate boundary. There, a valley has formed where a continental plate is being pulled apart. **Figure 10** shows a side view of what a rift valley might look like and illustrates how the hot material rises up where plates separate.

Figure 9 This diagram shows the major plates of the lithosphere, their direction of movement, and the type of boundary between them.
Analyze and Conclude *Based on what is shown in this figure, what is happening where the Nazca Plate meets the Pacific Plate?*

Science Journal

Theory Development Many scientists contributed ideas that led to plate tectonics theory. Have students select one from A.L. Du Toit, S.K. Runcorn, Bruce Heezen, Arthur Holmes, J. Tuzo Wilson, Jack Oliver, Lynn R. Sykes, Fred Vine, D.H. Matthews, and L.W. Morley and write a one-page report in their Science Journals about his contributions. L2 P

2 Teach

Quick Demo

Continental Movement

Materials globe or map

Estimated Time 10 minutes

Procedure Obtain a globe make a map on which you move continent pieces fro child's puzzle map. Use globe or map to demonst continental movement.

Caption Answer

Figure 9 These plates are moving a from each other.

Reading Check

Answer Plates can collide, pull a or move past one another.

Fun Fact

The Indian Plate, which collided with Asia to form the Himalaya, continues to move at a rate of almost 5 cm per year. This massiv plate is moving twice as fast as yo fingernails grow!

Science Words

Use Have students look up words *diverge* and *converge* use each word in a sentence. discuss how these mean- relate to plate boundaries. e answers: Two paths diverge at a the road; traffic will converge in nter of the intersection. Plates con- or come together, at some bound- and diverge, or move apart, at

Applying Science

wers

, most fit together when conti- ital shelves are included.

continental shelves are the edges ontinents. Present-day coastlines ult from sea-level changes.

Science Online

Topic: Earthquakes and Volcanoes

Visit earth.msscience.com for Web links to recent news or magazine articles about earthquakes and volcanic activity related to plate tectonics.

Activity Prepare a group demonstration about recent volcanic and earthquake events. Divide tasks among group members. Find and copy maps, diagrams, photographs, and charts to highlight your presentation. Emphasize the locations of events and the relationship to plate tectonics.

Plates Moving Together If new crust is being added at one location, why doesn't Earth's surface keep expanding? As new crust is added in one place, it disappears below the surface at another. The disappearance of crust can occur when seafloor cools, becomes denser, and sinks. This occurs where two plates move together at a convergent boundary.

When an oceanic plate converges with a less dense continental plate, the denser oceanic plate sinks under the continental plate. The area where an oceanic plate subducts, or goes down, into the mantle is called a subduction zone. Some volcanoes form above subduction zones. **Figure 10** shows how this type of convergent boundary creates a deep-sea trench where one plate bends and sinks beneath the other. High temperatures cause rock to melt around the subducting slab as it goes under the other plate. The newly formed magma is forced upward along these plate boundaries, forming volcanoes. The Andes mountain range of South America contains many volcanoes. They were formed at the convergent boundary of the Nazca and the South American Plates.

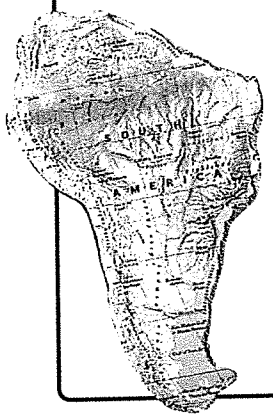
Applying Science

How well do the continents fit together?

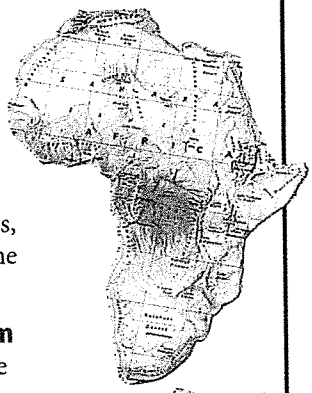
Recall the Launch Lab you performed at the beginning of this chapter. While you were trying to fit pieces of a cut-up photograph together, what clues did you use?

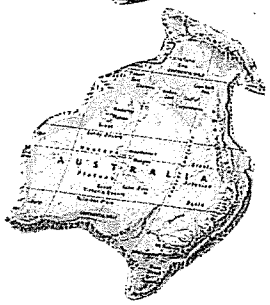
Identifying the Problem

Take a copy of a map of the world and cut out each continent. Lay them on a tabletop and try to fit them together, using techniques you used in the Launch Lab. You will find that the pieces of your Earth puzzle—the continents—do not fit together well. Yet, several of the areas on some continents fit together extremely well.



Take out another world map—one that shows the continental shelves as well as the continents. Copy it and cut out the continents, this time including the continental shelves.





Solving the Problem

1. Does including the continental shelves solve the problem of fitting the continents together?
2. Why should continental shelves be included with maps of the continents?

LAB DEMONSTRATION

urpose to demonstrate compression orces that can form folded mountains

aterials two slabs of clay (5 cm thick and bout 30 cm long), wax paper

reparation Place the clay slabs on wax aper to make them easier to slide.

Procedure Lay the two clay pieces flat on a table. Have students predict what will happen when they are forced together. Push the two pieces together.

Expected Outcome Students will see folds and breaks form as the pieces of clay are pushed together.

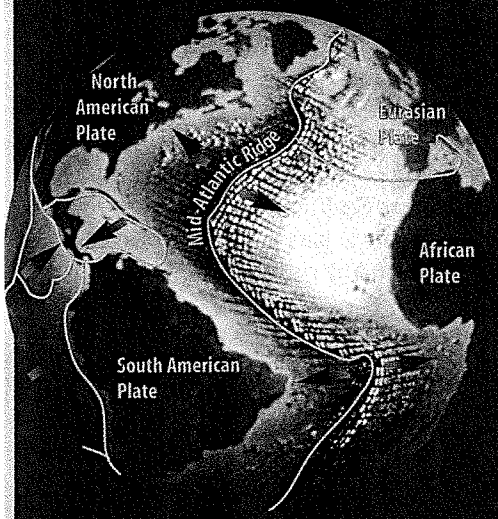
Assessment

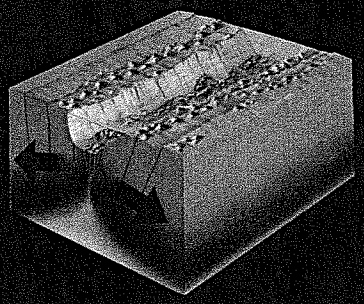
What landforms are the folds in the clay analogous to on Earth's surface? folded mountains

NATIONAL GEOGRAPHIC VISUALIZING PLATE BOUNDARIES

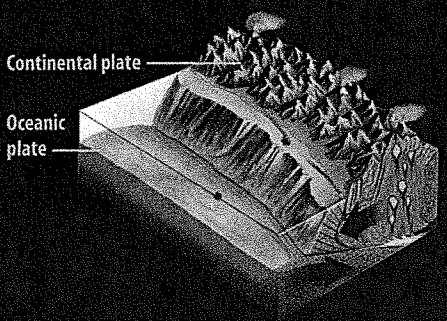
Figure 10

By diverging at some boundaries and converging at others, Earth's plates are continually—but gradually—reshaping the landscape around you. The Mid-Atlantic Ridge, for example, was formed when the North and South American Plates pulled apart from the Eurasian and African Plates (see globe). Some features that occur along plate boundaries—rift valleys, volcanoes, and mountain ranges—are shown on the right and below.

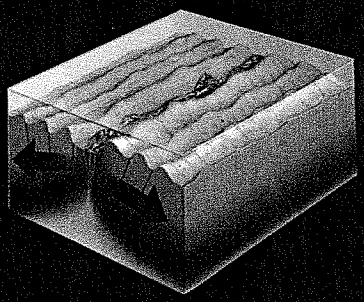




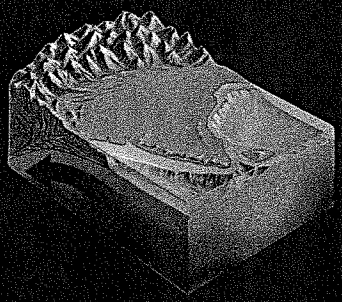
A RIFT VALLEY When continental plates pull apart, they can form rift valleys. The African continent is separating now along the East African Rift Valley.



SUBDUCTION Where oceanic and continental plates collide, the oceanic plate plunges beneath the less dense continental plate. As the plate descends, molten rock (yellow) forms and rises toward the surface, creating volcanoes.



SEAFLOOR SPREADING A mid-ocean ridge, like the Mid-Atlantic Ridge, forms where oceanic plates continue to separate. As rising magma (yellow) cools, it forms new oceanic crust.



CONTINENTAL COLLISION Where two continental plates collide, they push up the crust to form mountain ranges such as the Himalaya.

NATIONAL GEOGRAPHIC

Visualizing Plate Boundaries

Have students examine tl pictures and read the captior Then ask the following que tions.

How would you predict tl size of the Atlantic Ocean w change over the next 100 milli years? Why? The Atlantic Ocean v become larger because sea-floor spre ing is occurring along the Mid-Atlan Ridge.

The Andes mountains a found along the west coast South America. How did tl mountain chain form? The pl boundary along the west coast of So America is a convergent boundary, wh results in the formation of mounta and volcanoes.

Activity

Surtsey Have small grou research the history of Surtsey small island in the Nor Atlantic Ocean. Ask them draw a map of the island's loc tion and write a summary of h the island formed, describing t type of plate boundary and t volcanic activity involved. L2

ELL COOP LEARN IS
Interpersonal

IDENTIFYING isconceptions

ıtion of Earth Because stu-
ts feel as though they are
ıding perfectly still on
th's surface, they often for-
that they are moving in
:ral ways at the same time.
ınind students that, as they
n class, Earth is rotating at
m/s, speeding around the
at 29.8 km/s, and the tec-
c plate on which they sit is
ing around on Earth's
tic-like mantle.

sual Learning

re 11 Have students study
photograph of the San
reas Fault and then describe
ence that shows the plates
:ither side of the fault are
ing. Students should see that
ns and other features that cross the
ıre offset because of movement.

tion Answer

e 11 The western side (Pacific
of the fault is moving faster than
stern side (North American Plate).

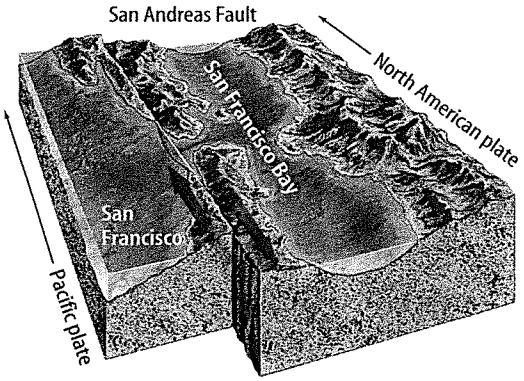
Where Plates Collide A subduction zone also can form where two oceanic plates converge. In this case, the colder, older, denser oceanic plate bends and sinks down into the mantle. The Mariana Islands in the western Pacific are a chain of volcanic islands formed where two oceanic plates collide.

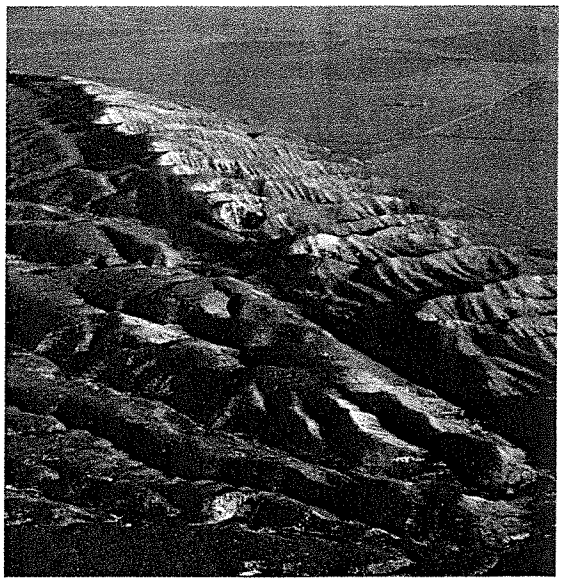
Usually, no subduction occurs when two continental plates collide, as shown in **Figure 10.** Because both of these plates are less dense than the material in the asthenosphere, the two plates collide and crumple up, forming mountain ranges. Earthquakes are common at these convergent boundaries. However, volcanoes do not form because there is no, or little, subduction. The Himalaya in Asia are forming where the Indo-Australian Plate collides with the Eurasian Plate.

Where Plates Slide Past Each Other The third type of plate boundary is called a transform boundary. Transform boundaries occur where two plates slide past one another. They move in opposite directions or in the same direction at different rates. When one plate slips past another suddenly, earthquakes occur. The Pacific Plate is sliding past the North American Plate, forming the famous San Andreas Fault in California, as seen in **Figure 11.** The San Andreas Fault is part of a transform plate boundary. It has been the site of many earthquakes.

Figure 11 The San Andreas Fault in California occurs along the transform plate boundary where the Pacific Plate is sliding past the North American Plate.

Overall, the two plates are moving in roughly the same direction. **Explain** *Why, then, do the red arrows show movement in opposite directions?*





This photograph shows an aerial view of the San Andreas Fault.

Curriculum Connection

Mathematics The deepest point on Earth's surface is the bottom of the Mariana Trench, 11.2 km below sea level. Have students find Earth's highest point. Mt. Everest is 8.8 km above sea level. After students determine which is bigger, have them draw a scale diagram showing Mt. Everest in the trench. Their drawings should show how many kilometers Mt. Everest's top would be below sea level. 2.4 km

Causes of Plate Tectonics

Many new discoveries have been made about Earth's crust since Wegener's day, but one question still remains. What causes the plates to move? Scientists now think they have a good idea. They think that plates move by the same basic process that occurs when you heat soup.

Convection Inside Earth Soup that is cooking in a pan on the stove contains currents caused by an unequal distribution of heat in the pan. Hot, less dense soup is forced upward by the surrounding, cooler, denser soup. As the hot soup reaches the surface, it cools and sinks back down into the pan. This entire cycle of heating, rising, cooling, and sinking is called a **convection current.** A version of this same process, occurring in the mantle, is thought to be the force behind plate tectonics. Scientists suggest that differences in density cause hot, plasticlike rock to be forced upward toward the surface.

Moving Mantle Material Wegener wasn't able to come up with an explanation for why plates move. Today, researchers who study the movement of heat in Earth's interior have proposed several possible explanations. All of the hypotheses use convection in one way or another. It is, therefore, the transfer of heat inside Earth that provides the energy to move plates and causes many of Earth's surface features. One hypothesis is shown in **Figure 12.** It relates plate motion directly to the movement of convection currents. According to this hypothesis, convection currents cause the movements of plates.

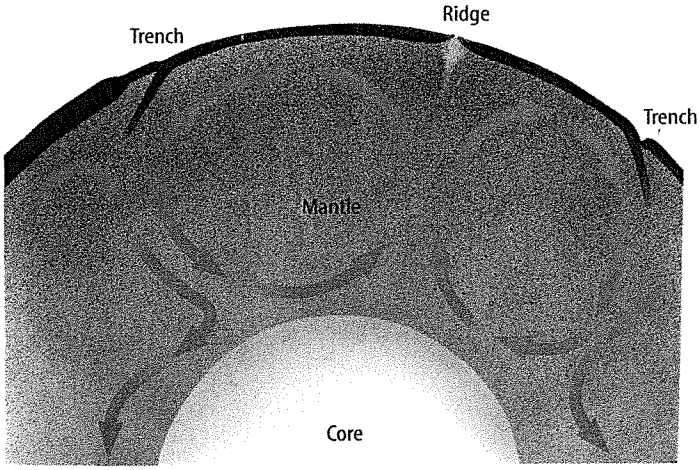


Figure 12 In one hypothesis, convection currents occur throughout the mantle. Such convection currents (see arrows) are the driving force of plate tectonics.

Mini LAB

Modeling Convection Currents

Procedure

1. Pour water into a clear, colorless casserole dish until it is 5 cm from the top.
2. Center the dish on a **hot plate** and heat it. **WARNING:** *Wear thermal mitts to protect your hands.*
3. Add a few drops of **food coloring** to the water above the center of the hot plate.
4. Looking from the side of the dish, observe what happens in the water.
5. Illustrate your observations in your **Science Journal.**

Analysis

1. Determine whether any currents form in the water.
2. Infer what causes the currents to form.

Mini LAB

Purpose Students model ar observe currents. L2 ELL [**Visual-Spatial**

Materials clear glass cassero dish, water, hot plate, food cc oring, thermal mitts

Teaching Strategy Have studen note any movement in tl water.

Safety Precautions Students mu wear thermal mitts. Be sure tl dish is stove-top safe.

Analysis

1. Some students will observe currents; others won't.
2. The transfer of thermal energy fro the burner to the dish warms the water near the bottom of the dish The cooler, denser water at the to of the dish sinks, displacing the warmer, less dense water, which then moves toward the top of the dish. As the warmer water cools, i becomes denser and sinks to start the cycle again.

Assessment

Process Direct students to a informative labels to the dra ings they made of their obser tions. The labels should numbered and in sequen explaining the steps in the fc mation and movement of co vection currents. Use **Perfc mance Assessment in t Science Classroom,** p. 127.

Active Reading

Write-Draw-Discuss This strategy encourages students to actively participate in reading and lectures, assimilating content creatively. Have students write about an idea, clarify it, then make an illustration or drawing. Ask students to share responses with the class and display several examples. Have students Write-Draw-Discuss about the causes of plate tectonics.

Cultural Diversity

Hawaiian Terms The Hawaiian Islands are volcanoes that formed as a result of magma rising through a "hot spot" in the middle of a plate. Some volcanic rocks have names that were made common in Hawaii. *Pahoehoe* (pa-hoe-ee-hoe-ee), from the Hawaiian word meaning "rope," forms in linear ridges. *Aa* (ah-ah) forms with sharp, jagged surfaces.