Dana Thome
August 2013

The Formation of the Isthmus of Panama

Disciplinary Core Idea

ESS2.B: Plate Tectonics and Large Scale System Interaction

The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountains chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth.

Essential Question: How does land form?

Students will understand that changes in Earth's landscape take place slowly, over time.
Students will understand that plate tectonics can cause the creation of some landforms.
Students will understand that theories can change as new information is discovered.

Students will know that:

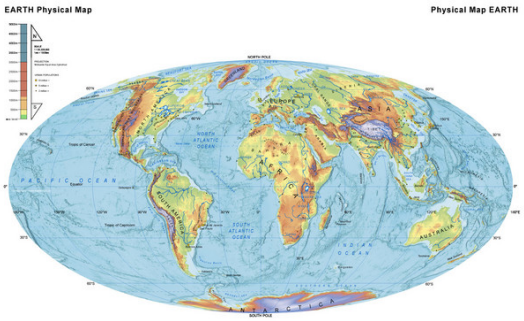
- movements of the Earth's plates takes place very slowly. (ESS1.C K-2)
- it took millions of years for the isthmus of Panama to form. (ESS1.C K-2)
- Panama is part of the "Ring of Fire." (volcanoes)
- the movement of plates pushed the ocean floor up above sea level, creating islands. (uplift)
- over millions of years, sand, fine soil and mud eroded from South America and filled in the gaps between land masses. (sedimentation)
- theories and ideas change as new evidence is discovered

Students will be able to:

- use maps to help locate the different land and water features near and around Panama. (ESS2.B)
- Interpret information presented visually (RI4.7)
- draw evidence from informational text to support analysis, reflection and research (W.4.9)

Engage

Students will be given physical maps of the world and be asked to make observations. The teacher will guide the discussion to the identification of some commonly identified land and water forms such as ocean, lake, mountain, river and isthmus.



Students will conduct a mini inquiry lesson in which they are given 15 minutes and a pile of books, maps and other resources, to find as many land and water forms as they can.

Teacher will chart student's findings then highlight these 12:
Ocean, Sea, Gulf, Bay, Lake, River, Mountain, Plain, Island, Peninsula, Plateau, Isthmus

Explore

Pose the question: As you were trying to find different landforms, did anyone find any clues or information that explained how any of the landforms were created? Elicit ideas from students about how land takes shape. Chart their ideas.

Show the following video (about 5 minutes):
http://app.discoveryeducation.com/search?Ntt=plate+tectonics&N=18341&N=4294949582

Talk about answers to questions student may have heard. Do any new questions emerge? Chart questions.

The following activity is a modification of this lesson:
http://plcmets.pbworks.com/w/page/17241337/Plate%20Tectonics%20Lesson%20Plan

Materials for each student:

- three graham crackers (plates)
- honey (asthenosphere)
- three 5-inch round plate (core)
- 1 beaker of water

Forming a new sea floor: At a divergent boundary plates pull apart from each other exposing magma at mid-ocean ridges forming new sea floor. (Plates move away from each other.)

1. Give each student a paper plate.
2. Pour honey in the center of the *plate (to represent the asthenosphere or mantle).*
3. Break 1 graham cracker so that you now have 2 pieces of graham cracker (plates).
4. Place the tectonic plates (graham crackers) close to each other on top of the asthenosphere (honey).
5. Slowly move the tectonic plates (graham crackers) away from each other, exposing the magma of the asthenosphere (honey).

Whole group discussion: What landforms may have been created when the plates move apart?

Creating Mountains or Volcanoes: At convergent boundaries mountains can form if two continental crusts come together however, if a continental and oceanic crust collide, a subduction zone will form causing volcanism. (Plates collide.)

1. Give each student a paper plate.
2. Pour honey in the center of the plate (to represent the asthenosphere mantle).
3. Break 1 graham cracker so that you have 2 pieces of graham cracker (plates).
4. Dip half of each graham cracker in a beaker of water.
5. Place tectonic plates (graham crackers) close to each other on top of the asthenosphere
6. Slowly move both tectonic plates (crackers) in the same direction until they buckle, forming what appears to be a small mountain.

Whole group discussion: What landforms may have been created when the plates collide?

Causing an Earthquake: At a transform boundary rigid plates forcefully slide past each other causing earthquakes to occur. (Plates slide past each other.)

1. Give each student the third paper plate.
2. Pour honey in the center of the plate to represent the asthenosphere or plastic like mantle.
3. Break 1 graham cracker into 2 pieces.
4. Place tectonic plates (graham crackers) in close proximity to each other on top of the asthenosphere (honey).
5. Forcefully slide the plates (graham crackers) past each other.

Whole group discussion: What landforms may be created when there is an earthquake?

If time permits or you think student can attend, this video is a good summary. This video clip is about 15 minutes long.
http://app.discoveryeducation.com/search?Ntt=plate+tectonics&N=18341&N=4294949582

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Explain: The Formation of the Isthmus of Panama

Have students look at the world map. Draw their attention to Panama. Ask:

> What kind of landform is this? How might it have been formed?
> We are going to explore 2 different ideas that scientist have had.

Activity #1A: **Land Ho! The Isthmus Forms**! Adapted from *Jason XV: Rainforest at the Crossroads* ©2003 JASON Foundation for Education

In this lesson, students will explore what scientists have believed to be the geologic processes that formed the Isthmus of Panama. Students will compare a series of three maps that show land and water changes over time.

Materials:
Copies of Master B (The Isthmus of Panama),
blue and brown colored pencils

Procedure:

1. Assign each student a time period (15 million years ago, 7 million years ago or 3 million years ago).
2. The 15 million years ago group will color all areas A on their map brown to represent land. They will color the rest of the map, including areas B and C blue, to represent ocean.
3. The 7 million years ago group will color areas A and B brown. They will color the rest of the map, including C blue.
4. The 3 million years ago group will color areas A, B and C brown. They will color the rest of the map blue.
5. On the back of the map have students record 3 observations about their map.
6. Form groups of 3 students, one from each time period.
7. Have students put their maps in chronological order.
8. Ask students to make observations about their maps and how they have changed.
9. After small groups have had time to discuss, bring students back and talk about what they are noticing. Help them make connections to the video and graham cracker activity. Chart these ideas. You will need them later.

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Activity #1B: The Geological History of the Isthmus of Panama

Materials:

Copies of **The Geological History of the Isthmus of Panama** (page 26 Master A)
Colored pencils or highlighters
Copies of Questions

Procedure:

1. Assign color coding and or symbols for note taking. For example:
   If you are **unsure** of what a word means**, underline it in yellow** or write a W in the margin.
   If you learned something amazing, **underline in red** or write an L in the margin.
   If you do not understand part of the text, **underline in green** or put a question mark in the margin.
   If there is something you want to make sure to remember, **underline in purple** or put a star in the margin.

1. Students should read the article and take notes. Encourage them to read more than once. (Accommodate students as necessary.)

2. After students have read individually, have them talk in small groups about their notes.

3. Bring students together to talk about what they've read. Highlight important information such as how slowly plates actually move, the three different processes that may have formed the isthmus, etc.

4. Give students questions. Have them work through the text to answer the questions. Format however you like.

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Reading: The Geologic History of the Isthmus of Panama

1. The authors of the article say that to understand the geology of Panama, you have to know a little about "plate tectonics." How do the authors explain what "plate tectonics" means.

2. Thinking about the activities we've done so far, what else can you add to their explanation?

3. Did the formation of the Isthmus happen quickly or slowly? Cite evidence from the text to back up your response.

4. What three processes did the authors of the article believe were involved in the formation of the Isthmus of Panama?

5. Use the information in the text to describe how each of the following processes occurs:

   a. Volcanic eruptions:

   b. Uplift:

   c. Sedimentation:

Evaluate

6. Take a look at the three maps we made. Use the visual information from the maps and what you learned from the article to write a summary of how some scientists think the Isthmus of Panama was formed.

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Engage: What?! Another Theory about the Formation of the Isthmus

Background information for the teacher:

The original article is here:
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0002791

A summary of the findings is here:
http://news.ufl.edu/2008/07/29/plate-tectonics/

http://wanderinggaia.files.wordpress.com/2010/03/united-plates-of-america-the-making-of-a-new-world-08-june-2011-new-scientist.pdf

Elaborate:

Materials:

Copies of the following articles
Colored pencils or highlighters
Sentence strips and markers

STRI News / These are one page press releases with relatively simple summaries. Create five groups, one for each article.

United Plates of America June 20, 2011
http://www.stri.si.edu/english/about_stri/headline_news/news/article.php?id=1327

Jaramillo Proposes New Theory on the Age of the Isthmus of Panama June 27, 2011
http://www.stri.si.edu/english/about_stri/headline_news/news/article.php?id=1330

STRI Rocks Oct. 22, 2012
http://www.stri.si.edu/english/about_stri/headline_news/news/article.php?id=1574

Panama Canal Paleontology Project April 30, 2013
http://www.stri.si.edu/english/about_stri/headline_news/news/article.php?id=1656

Panama Debate Highlighted in Science Magazine July 22, 2013
http://www.stri.si.edu/english/about_stri/headline_news/news/article.php?id=1695

Procedure:

1. Assign color coding and or symbols for note taking. For example:
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   If you do not understand part of the text, **underline in green** or put a question mark in the margin.
   If there is something you want to make sure to remember, **underline in purple** or put a star in the margin.

2. Students should read the article and take notes. Encourage them to read more than once. (Accommodate students as necessary.)

3. After students have read individually, have them talk in their groups about their notes. **What is the big idea in each article?**

4. Give each group a couple of sentence strips and have them find in the article one sentence or phrase that sums up the big idea. They should write it on their sentence strip and post on a wall in the classroom.

5. After each big idea is posted, discuss with the class what is happening: ***New theories are emerging about the age of the isthmus and how it was formed.***

Explore and Elaborate

Materials:

Copies of Central American Peninsula Maps A and B

Colored copies of **The Geological History of the Isthmus of Panama** (page 26 Master A) from previous lesson.

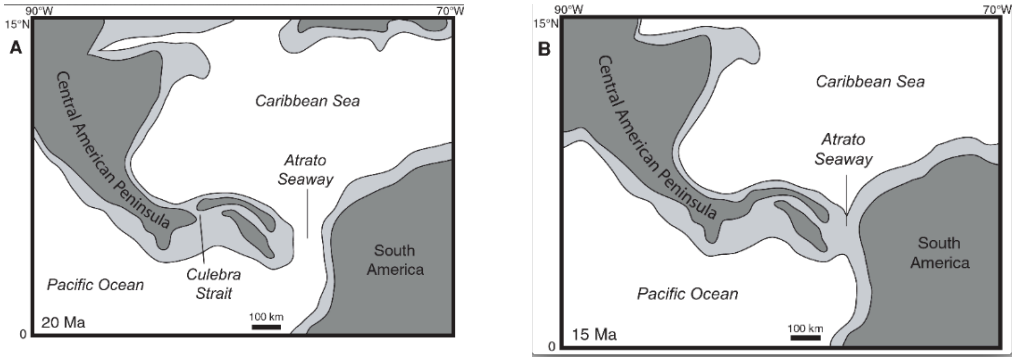


Figure A: 20 million years ago
Figure B: 15 million years ago

Figure 11. Paleogeographic reconstructions of Central America for (A) 20 Ma and (B) 15 Ma. *Light gray represents the outline of tectonic plates containing continental or volcanic-arc crust. Dark gray represents subaerial land. Base maps for the reconstructions were derived from the ODSN Plate Tectonic Reconstruction Service (http://www.odsn.de/odsn/services/paleomap/paleomap.html). The location of subaerial land is based on this study and the distribution of Cretaceous to Tertiary continental and volcanic terranes as derived from Case and Holcombe [70].*
doi:10.1371/journal.pone.0002791.g011

Procedure:

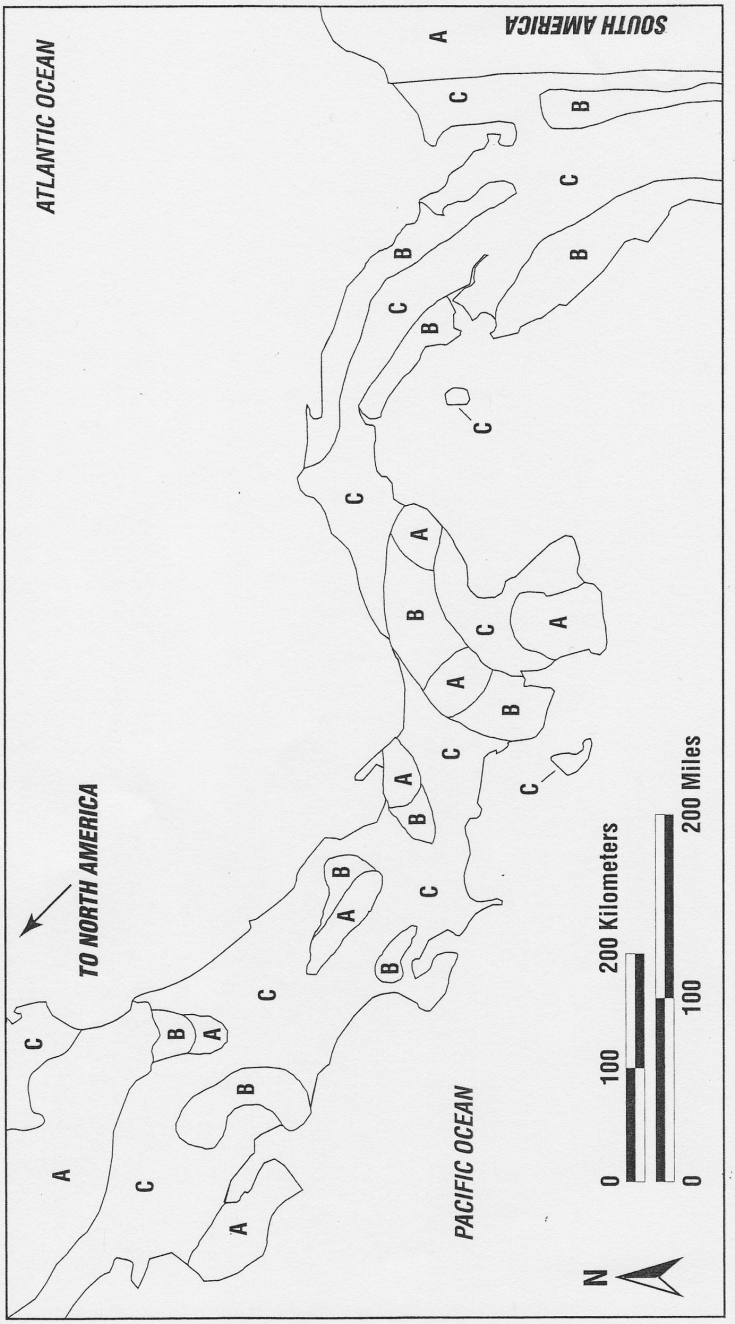
1. Have students compare the two different sets of maps. Discuss the differences and similarities of the visual maps.
2. Elicit questions from students. What questions do they have? Chart these questions.
3. Ask students to consider how we could find answers to these particular questions.
4. Give students time to try finding answers to their questions.

Evaluate

1. Which theory do you believe?

Have students write a defense of the theory they agree with. Their paper should include at least three pieces of evidence, cited from text that supports their argument. They should also include an explanation of how the peninsula was formed according to the theory they are defending.

The Isthmus of Panama

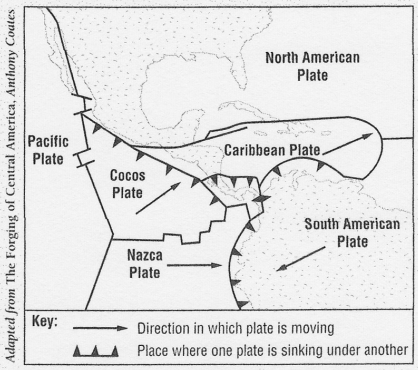


Adapted from The Forging of Central America, *Anthony Coates*

Master B

The Geologic History of the Isthmus of Panama

Introduction to Earth Plate Movement



Adapted from The Forging of Central America, *Anthony Coates*

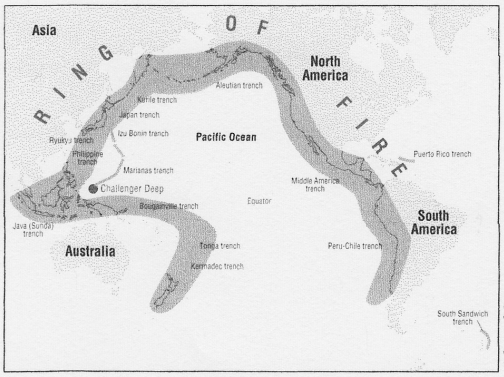
The current location of tectonic plates near Panama.

To understand the geology of Panama, you should know something about the theory of plate tectonics. This theory explains that mountain building, earthquakes, and volcanoes result from the movement of "plates." These are large sections of the Earth's crust. For example, the North American plate includes most of the continent of North America and the crust under the western half of the Atlantic. Most of the Earth's plates are moving slowly (about an inch or two per year). The movements of Earth's plates caused the Isthmus of Panama to form over time and they continue to cause geologic change in the area.

Formation of the Isthmus of Panama

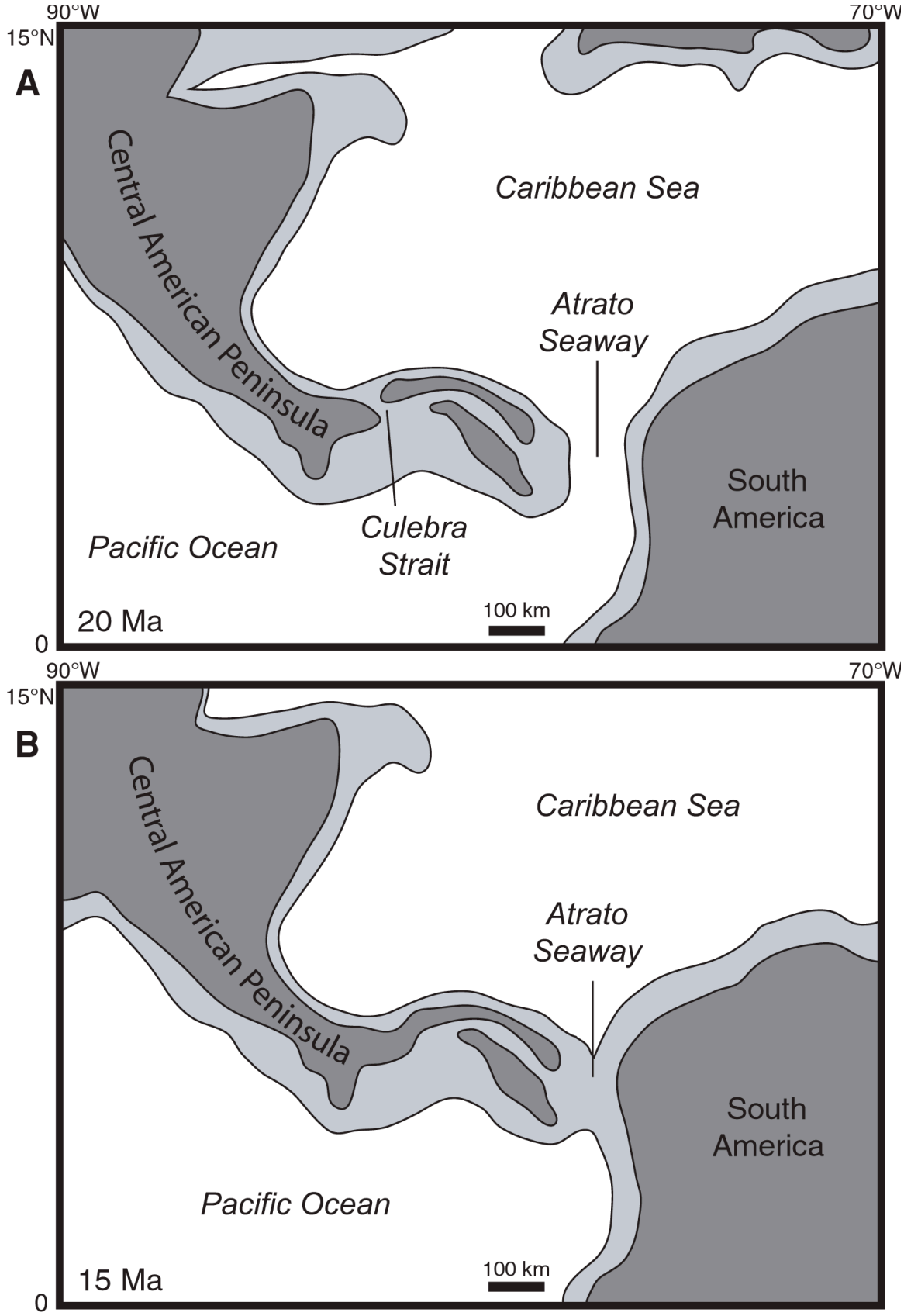
Much of the land that makes up the Isthmus of Panama was originally formed in the ocean. Over millions of years, these portions of the ocean floor rose above sea level. In this exercise, you will make maps that show what the isthmus looked like 15 million years ago, 7 million years ago, and 3 million years ago. First, you need to understand the processes involved. Here's the story:

- **Volcanic eruptions.** Panama is part of the Pacific Ocean's "Ring of Fire," the huge chain of volcanoes along the west coast of the Americas, Japan, and other areas (see the map to the right). These volcanoes are formed when various plates of the Pacific Ocean are thrust downward under neighboring plates, causing molten lava to erupt. In the Isthmus of Panama region, the Cocos Plate (see the map above) is being thrust under the Central American Plates. As a result, volcanoes began appearing in the area that is now the Isthmus of Panama about 15 million years ago. Over the next few million years, more and more volcanoes appeared, eventually forming a chain.
- **Uplift.** Tectonic plate movement caused the ocean floor to be pushed upward. As portions of the ocean floor rose above sea level, new islands were formed and continued to fill in the Isthmus of Panama. This process occurred slowly over millions of years.
- **Sedimentation.** Over millions of years, sediment (sand, fine soil, and mud) was deposited into the ocean. This process became very important about 6 to 3 million years ago, when massive amounts of sediment eroded from South America and from the islands that had already formed in the isthmus. Sediment was deposited into the ocean and filled gaps between the existing land masses.



Adapted from USGS map

Master A


90°W
70°W
15°N
A
Central American Peninsula
Caribbean Sea
Atrato Seaway
South America
Culebra Strait
Pacific Ocean
20 Ma
100 km
0
90°W
70°W
15°N
B
Central American Peninsula
Caribbean Sea
Atrato Seaway
South America
Pacific Ocean
15 Ma
100 km
0