CEEP™

CRUSTAL
EVOLUTION
EDUCATION
PROJECT

Spreading Sea Floors And Fractured Ridges

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TEACHER'S GUIDE

Catalog No. 34W1025

For use with Student Investigation 34W1125
Class time: two 45-minute periods

Developed by
THE NATIONAL ASSOCIATION OF GEOLOGY TEACHERS

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NAGT Crustal Evolution Education Project

Edward C. Stoever, Jr., Project Director

Welcome to the exciting world of current research into the composition, history and processes of the earth's crust and the application of this knowledge to man's activities. The earth sciences are currently experiencing a dramatic revolution in our understanding of the way in which the earth works. CEEP modules are designed to bring into the classroom the methods and results of these continuing investigations. The Crustal Evolution Education Project began work in 1974 under the auspices of the National Association of Geology Teachers. CEEP materials have been developed by teams of science educators, classroom teachers, and scientists. Prior to publication, the materials were field tested by more than 200 teachers and over 12,000 students.

Current crustal evolution research is a breaking story that students are living through today. Teachers and students alike have a unique opportunity through CEEP modules to share in the unfolding of these educationally important and exciting advances. CEEP modules are designed to provide students with appealing firsthand investigative experiences with concepts which are at or close to the frontiers of scientific inquiry into plate tectonics. Furthermore, the CEEP modules are designed to be used by teachers with little or no previous background in the modern theories of sea-floor spreading, continental drift and plate tectonics.

We know that you will enjoy using CEEP modules in your classroom. Read on, and be prepared to experience a renewed enthusiasm for teaching as you learn more about the living earth in this and other CEEP modules.

About CEEP Modules...

Most CEEP modules consist of two booklets: a Teacher's Guide and a Student Investigation. The Teacher's Guide contains all the information and illustrations in the Student Investigation, plus sections printed in color, intended only for the teacher, as well as answers to the questions that are included in the Student Investigation.
In some modules, there are illustrations that appear only in the Teacher's Guide, and these are designated by figure letters instead of the number sequence used in the Student Investigation.

For some modules, maps, rulers and other common classroom materials are needed, and in varying quantities according to the method of presentation. Read over the module before scheduling its use in class and refer to the list of MATERIALS in the module.

Each module is individual and self-contained in content, but some are divided into two or more parts for convenience. The recommended length of time for each module is indicated. Some modules require prerequisite knowledge of some aspects of basic earth science; this is noted in the Teacher's Guide.

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Spreading Sea Floors And Fractured Ridges

INTRODUCTION

When scientists first mapped the mid-ocean ridge in the Atlantic Ocean, it seemed like a fairly regular mountain range except for being mostly underwater. Then in 1953, Marie Tharp, a geologist at Lamont Geological Observatory, discovered that the Mid-Atlantic Ridge was split down the middle. Further mapping showed an even more curious thing—the ridge isn't a continuous line of mountains! At many places, the ridge line is broken by offsets called **fracture zones.** Fracture zones are long faults in the ocean crust. Many fracture zones are shown on the wall map, *Atlantic Ocean Floor,* that is used with this activity.

You know that earthquakes occur along active faults on the continents. Are there also earthquakes along the fracture zones?

PREREQUISITE STUDENT BACKGROUND

Students should know about the different types of faults and the relative movement of blocks of the earth's crust in each type of fault. They should also be aware of the relationship between faulting and earthquakes. This activity also presumes that students know about the topography of mid-ocean ridges and that they understand the concept of sea-floor spreading.

OBJECTIVES

After you have completed this activity, you should be able to:

1. Tell how the geography of the mid-ocean mountains is different on either side of a fracture zone.

2. Draw a diagram to show the relation between sea-floor spreading direction and direction of rock movement on both sides of a fracture zone.

3. Explain why earthquakes may occur along only part of a fracture zone.

MATERIALS

Wall map, *Atlantic Ocean Floor,* National Geographic Society, Educational Services, Department 79, Washington, D.C. 20036—at least two copies per class.

World Seismicity Map, United States Geological Survey, 1200 S. Eads Street, Arlington, Va. 22202—at least two copies per class.

Sea-floor spreading device (including cardboard base and paper Worksheet)—one for each team of two students, plus one for yourself.

These devices must be constructed in advance as follows:

1. Prepare sheets of stiff cardboard at least 22 x 27 cm in size—one sheet for each pair of students. Corrugated cardboard from old shipping cartons is adequate. See Figure A 1.

2. Place the Worksheet from a Student Investigation (see Figure A 2) on a sheet of the cardboard. Use it as a guide to cut two slits in the cardboard. These slits, about 2 mm wide and 9 cm long, should each be cut under the Worksheet between the large dots shown. After cutting the slits with a sharp knife, you can make them the proper width simply by passing a table knife through the slits. Use the same Worksheet to prepare all of the sheets of cardboard. Print MAR along the edge of the cardboard at the outside end of each slit (Figure A 1).

3. Prepare all of the Worksheets as follows: First, place a short piece of masking tape at each end of each Worksheet in the spaces indicated. Second, slit all sheets down through the center solid line but *do not* cut through the masking tape at the ends of each Worksheet. See Figure A 2. Then, trim off the excess paper around the perimeter of each Worksheet.

4. Place one Worksheet on each piece of cardboard. Holding several index cards together as a "pusher", push down in succession on the words "PUSH HERE" between each pair of the dashed lines on the Worksheet. As you push, each pair of the dashed lines should move toward each other and meet. Repeat this procedure for each Worksheet. See Figure 1.

Students who investigate suggestion 2, EXTENSIONS, will use the National Geographic maps, *Arctic Ocean Floor, Indian Ocean Floor,* or *Pacific Ocean Floor.* These maps are available from the National Geographic Society at the address given above. Order at least one of each map per class.

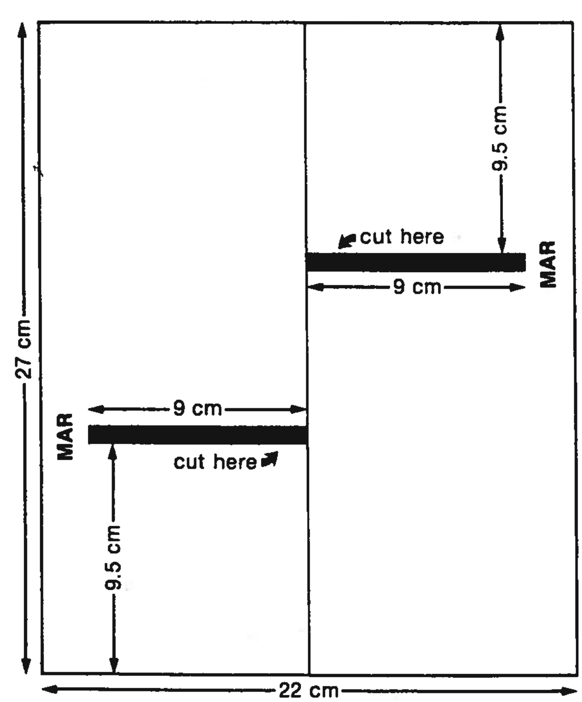


Figure A 1. Cardboard base of sea-floor spreading device.

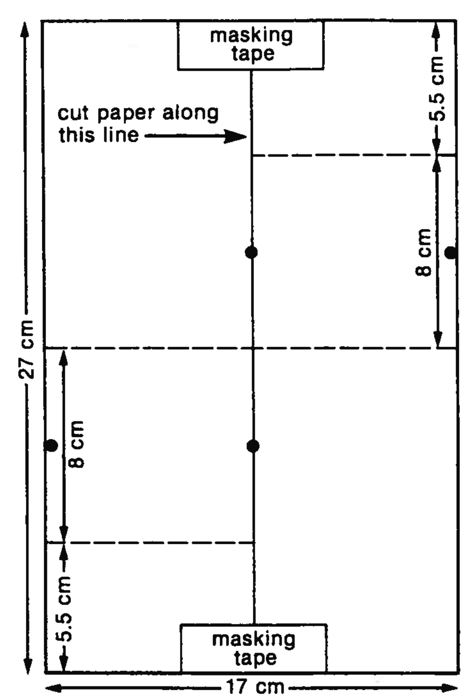


Figure A 2. Worksheet for sea-floor spreading device, from Student Investigation.

BACKGROUND INFORMATION

Beginning in the early 1950s, large fracture zones in the sea floor were first discovered in the eastern Pacific Ocean. In general, fracture zones are long, narrow faults in the earth's crust. They cut across and trend at right angles to mid-ocean ridges. Fracture zones disappear close to the continents. At first it appeared that only the Pacific Ocean had fracture zones, and that it had only a few large ones. However, oceanographers now know that fracture zones are common in all ocean basins. Some scientists think many of them may continue through the continental crust. This seems especially likely in the region of California and adjacent states, where the continental crust may overlie a portion of the mid-ocean mountains of the northern Pacific Ocean. Large fracture zones, such as the Mendocino and Murray, may intersect the hidden mid-ocean mountain range.

In 1965, J. Tuzo Wilson, a Canadian geophysicist, combined information on earthquake and sea-floor spreading to show that active faulting was likely to occur in only a portion of a fracture zone: the portion lying between offset ridges of the mid-ocean mountain range (Figure B). This part of a fracture zone is called a transform fault.

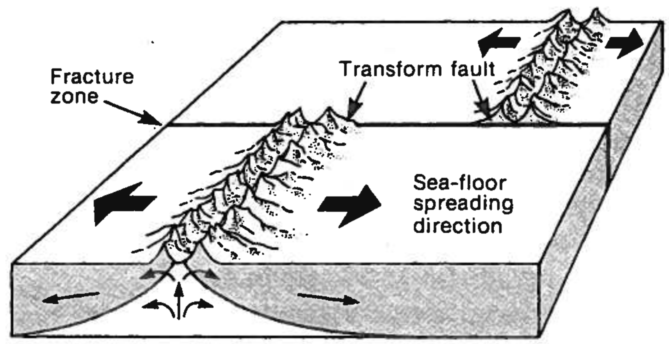


Figure B. A mid-ocean ridge offset along a fracture zone.

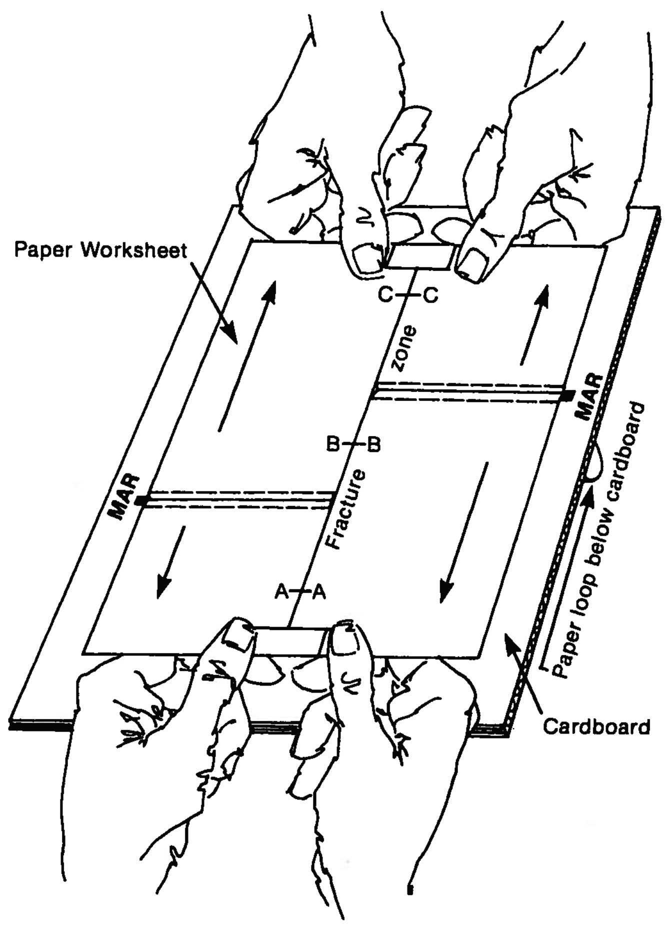


Figure 1. Sea-floor spreading device, labeled as indicated in the instructions. Note the manner in which the device is to be operated, with movement indicated by the arrows.

SUGGESTED APPROACH

The students should be grouped in pairs, preferably with partners facing each other across the lab table, when they begin to use the sea-floor spreading device. If this arrangement is not possible, then students can sit in adjacent seats, facing each other.

As the students begin to make sketches based on use of the two wall maps, there will be a fair amount of movement around the room. Make sure there is easy passage to wall maps which should be in widely separated locations in the classroom. This will avoid traffic jams and overcrowding. This activity will be completed faster if students continue to work as two-person teams for the entire lab period. Therefore, you might choose to collect only one set of answers and sketches from each team.

PROCEDURE

In this activity students use a simple manipulative device which simulates motion on the transform fault portion of fracture zones.

Key words: fracture zone, transform fault

Time required: two 45-minute periods

Materials: pencils, wall maps, *Atlantic Ocean Floor* and *World Seismicity Map,* sea-floor spreading device for each team of two students.

1. Study the sea-floor spreading device at your lab station. The central long slit running lengthwise along the paper Worksheet represents a fracture zone. The sections of Mid-Atlantic Ridge (labeled MAR on the cardboard) are offset by this fracture zone. Label the central slit "fracture zone".

2. a. On your sea-floor spreading device draw a short line across the fracture zone below the lower section of the Mid-Atlantic Ridge. Label both ends of the line "A". (See Figure 1.)

b. Make a similar line between the two sections of the Mid-Atlantic Ridge. Label both ends of the line "B".

c. Make a similar line above the upper section of the Mid-Atlantic Ridge. Label both ends of the line "C".

3. Work with a partner who will face you on the other side of your lab table. Both of you should grasp the Worksheet as shown in Figure 1. Now, both of you should pull your ends of the Worksheet slowly toward yourselves at the same time. CAUTION—stop pulling before the paper loops pull out of the cardboard!

When you perform the pulling motion on the sea-floor spreading device, you are simulating the real motion of the sea floor.

As you both pull on the Worksheet, look to see if the two parts of the Mid-Atlantic Ridge are moving. Also, look to see which parts of the fracture zone are moving past each other and which are not. If necessary, push the paper loops back down through the cardboard and repeat the procedure.

4. In the space below, make a sketch to show the parts of the Mid-Atlantic Ridge and final position of the lines A-A, B-B, and C-C. Draw arrows on both sides of the fracture zone to show the direction of rock movement on each side of the fracture zone.

The students' sketches should look like Figure C.

5. Did the two parts of the Mid-Atlantic Ridge change positions? __No__

Based on your sketch, write a sentence below that describes where the paper is moving in opposite directions on either side of the fracture zone. This portion of a fracture zone is called a **transform fault.**

The paper is moving in opposite directions on both sides of the fracture zone only between the two sections of the Mid-Atlantic Ridge.

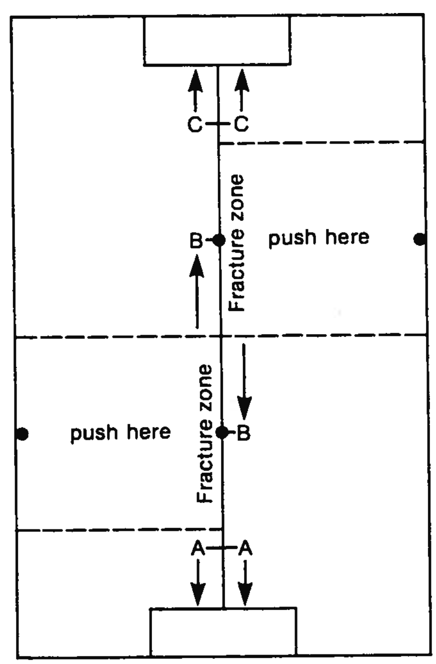


Figure C. Final position of sea-floor spreading device marked with arrows to show movement directions on both sides of a fracture zone.

The sea-floor spreading device was designed to represent rocks moving past each other on both sides of the transform fault. Earthquakes occur on any fault where rocks move past each other. Therefore, a map of earthquake epicenters should show places where earthquakes occur along transform faults in the sea floor.

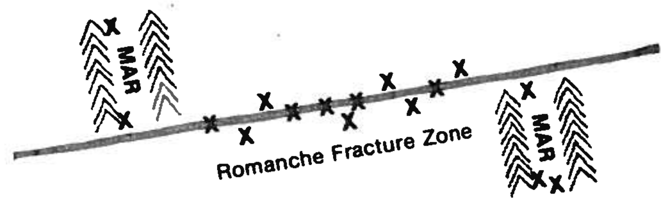
6. Assume that the paper Worksheet represents the Romanche Fracture Zone (in the North Atlantic Ocean) and sections of the Mid-Atlantic Ridge. Find the Romanche Fracture Zone on the *National Geographic* map of the Atlantic Ocean. Write the approximate latitude and longitude of the center of the Romanche Fracture Zone here.

0° (equator) latitude

20° W. longitude

7. Make a sketch of the Mid-Atlantic Ridge and Romanche Fracture Zone in the space below. Label all parts of the diagram. Take your sketch to the *World Seismicity Map* posted in your classroom. Find the Romanche Fracture Zone on the seismicity map. Mark a line of x's on your sketch to show where earthquakes have occurred along the Romanche Fracture Zone. In the space beneath your sketch, write a sentence that tells where such earthquakes occur.

The students' sketches should look something like this:



Earthquakes along the Romanche Fracture Zone occur only between the sections of Mid-Atlantic Ridge. Some students may also correctly locate earthquakes along the Mid-Atlantic Ridge.

You have now discovered the transform fault portion of a real fracture zone. Many other fracture zones contain transform faults. They are indicated by an earthquake pattern similar to the one found along the Romanche Fracture Zone.

SUMMARY QUESTIONS

1. What is a fracture zone?

A fracture zone is a fault separating two blocks of ocean crust which are in motion with respect to each other along only a limited part of the fault.

2. Which part of a fracture zone is a transform fault?

The transform fault occurs only on the part between offset mid-ocean ridge segments.

3. Did sea-floor spreading change the position of the Mid-Atlantic Ridge sections in your model? **No**

4. Define the term "transform fault".

A transform fault is the part of a fracture zone where relative movement of the sea floor is taking place.

5. Why are earthquakes only along the transform fault part of a fracture zone?

Earthquakes occur only on the transform fault part of a fracture zone because that is the only part of the fracture zone where the blocks of rock are moving past each other.

6. Make a sketch of two parts of the mid-ocean ridge that are cut by a fracture zone.

The students' sketches should look like the sketch they made of the Romanche Fracture Zone.

EXTENSIONS

1. Using the *Atlantic Ocean Floor* map and *World Seismicity Map,* locate other transform faults that are part of the fracture zones.

Students will find that earthquake zones do correspond with transform fault locations in the Atlantic. They also will note that the direction of offset of ridges by transform faults is, in some cases, just the opposite of the offset in the vicinity of the Romanche Fracture Zone which was examined in this activity.

2. Study maps of the Arctic, Pacific, or Indian Oceans, such as those found in the *National Geographic* series on the ocean floor. Describe the location (latitude, longitude) of major offsets in the mid-ocean ridge where it crosses a fracture zone. Do these locations correspond with earthquakes along the transform faults?

As in the first extension, students will find that earthquake zones correspond with transform fault locations throughout the world. Again, they will note that the direction of offset of ridges by transform faults is, in some places, just the opposite of the offset in the vicinity of the Romanche Fracture Zone which was examined in this activity.

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NAGT Crustal Evolution Education Project Modules

CEEP Modules are listed here in alphabetical order. Each Module is designed for use in the number of class periods indicated. For suggested sequences of CEEP Modules to cover specific topics and for correlation of CEEP Modules to standard earth science textbooks, consult Ward's descriptive literature on CEEP. The Catalog Numbers shown here refer to the CLASS PACK of each Module consisting of a Teacher's Guide and 30 copies of the Student Investigation. See Ward's descriptive literature for alternate order quantities.

CEEP Module	Class Periods	CLASS PACK Catalog No.
• A Sea-floor Mystery: Mapping Polarity Reversals	3	34 W 1201
• Continents And Ocean Basins: Floaters And Sinkers	3-5	34 W 1202
• Crustal Movement: A Major Force In Evolution	2-3	34 W 1203
• Deep Sea Trenches And Radioactive Waste	1	34 W 1204
• Drifting Continents And Magnetic Fields	3	34 W 1205
• Drifting Continents And Wandering Poles	4	34 W 1206
• Earthquakes And Plate Boundaries	2	34 W 1207
• Fossils As Clues To Ancient Continents	2-3	34 W 1208
• Hot Spots In The Earth's Crust	3	34 W 1209
• How Do Continents Split Apart?	2	34 W 1210
• How Do Scientists Decide Which Is The Better Theory?	2	34 W 1211
• How Does Heat Flow Vary In The Ocean Floor?	2	34 W 1212
• How Fast Is The Ocean Floor Moving?	2-3	34 W 1213
• Iceland: The Case Of The Splitting Personality	3	34 W 1214
• Imaginary Continents: A Geological Puzzle	2	34 W 1215
• Introduction To Lithospheric Plate Boundaries	1-2	34 W 1216
• Lithospheric Plates And Ocean Basin Topography	2	34 W 1217
• Locating Active Plate Boundaries By Earthquake Data	2-3	34 W 1218
• Measuring Continental Drift: The Laser Ranging Experiment	2	34 W 1219
• Microfossils, Sediments And Sea-floor Spreading	4	34 W 1220
• Movement Of The Pacific Ocean Floor	2	34 W 1221
• Plate Boundaries And Earthquake Predictions	2	34 W 1222
• Plotting The Shape Of The Ocean Floor	2-3	34 W 1223
• Quake Estate (board game)	3	34 W 1224
• Spreading Sea Floors And Fractured Ridges	2	34 W 1225
• The Rise And Fall Of The Bering Land Bridge	2	34 W 1227
• Tropics In Antarctica?	2	34 W 1228
• Volcanoes: Where And Why?	2	34 W 1229
• What Happens When Continents Collide?	2	34 W 1230
• When A Piece Of A Continent Breaks Off	2	34 W 1231
• Which Way Is North?	3	34 W 1232
• Why Does Sea Level Change?	2-3	34 W 1233