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ABSTRACT

Crustal Evolution Education Project (CEEP) modules were designed to: (1) provide students with the methods and results of continuing investigations into the composition, history, and processes of the earth's crust and the application of this knowledge to man's activities and (2) to be used by teachers with little or no previous background in the modern theories of sea-floor spreading, continental drift, and plate tectonics. Each module consists of two booklets: a teacher's guide and student investigation. The teacher's guide contains all of the information present in the student investigation booklet as well as: (1) a general introduction; (2) prerequisite student background; (3) objectives; (4) list of required materials; (5) background information; (6) suggested approach; (7) procedure, including number of 45-minute class periods required; (8) summary questions (with answers); (9) extension activities; and (10) list of references. Two class periods are suggested to complete the activity in this module in which students sketch a labeled cross-section showing stages in the collision of two plates containing continental masses, identify a mountain range resulting from continental collision, identify lithospheric plates on which continents are colliding, and list three kinds of evidence that some modern continental masses are in collision. (Author/JN)

CEEP™

CRUSTAL EVOLUTION EDUCATION PROJECT

What Happens When Continents Collide?

TEACHER'S GUIDE

Catalog No: 34W1030

For use with Student Investigation 34W1130
Class time: two 45-minute periods

Developed by
THE NATIONAL ASSOCIATION OF GEOLOGY TEACHERS

Produced and Distributed by
Ward's Natural Science Establishment, Inc. Rochester, NY • Monterey, CA

What Happens When Continents Collide?

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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What Happens When Continents Collide?

INTRODUCTION

The theory of plate tectonics states that earth's crustal plates have always been in motion. Plates that are separating from each other allow lava to well up from the mantle to rise to the ocean floor. As the lava cools, new ocean crust forms at the mid-ocean mountain range to fill the gap left by the separating plates (See Figure 1.) Where plates are moving toward each other, there is a problem—the ocean lithosphere must be destroyed. This happens when the ocean lithosphere of one plate sinks downward under the opposing plate. This downward motion of a plate is called subduction. An ocean trench marks the place where one plate is subducting under another. (See Figure 2.)

However, if the subducting plate is carrying a part of a continent, the situation becomes more complex. Continental crust has a lower density than ocean crust. Scientists think that because of the density difference between the two types of crust, the continental crust cannot be subducted. Near the border of the continent are abyssal plain and continental margin sediments. These, too, have low density. How will the sediments and continental rocks on one plate behave as they are drawn together with continental rocks of another plate? Has this happened in the past? Is it happening today?

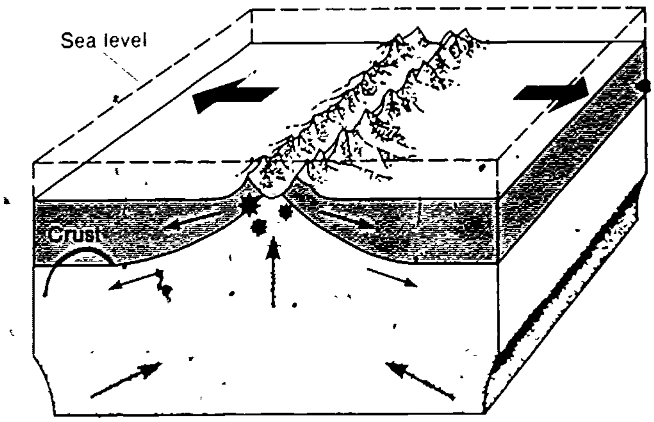

Figure 1 Magma rises into mid-ocean ridge. At the same time, plates move apart from each

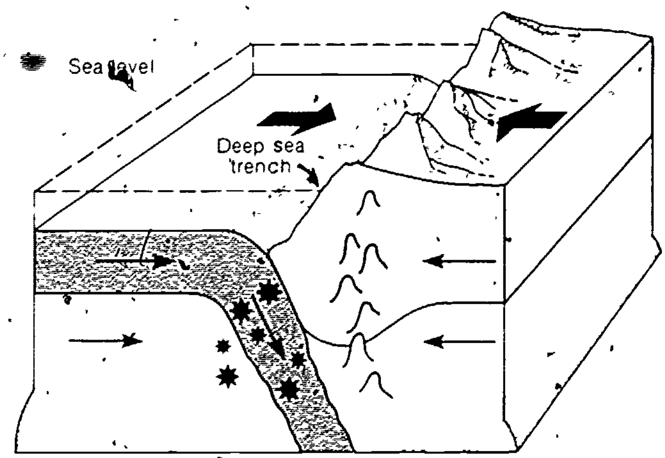

Figure 2 One crustal plate subducting under another

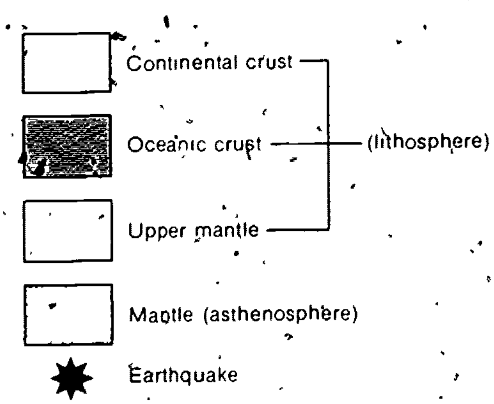

Illustration key

BACKGROUND INFORMATION

The Eurasian Plate was formed by the collision of separate European and Asian plates. The Ural Mountains are the result of this collision about 250 million years ago. India was once part of the southern supercontinent called Gondwanaland. When Gondwanaland split apart, India began a counterclockwise rotation and northward migration. The collision of the Indian and Eurasian plates began about 40 to 60 million years ago. It has caused fold mountain formations and thickening of the continental crust in the area stretching from Afghanistan to southeastern China. Recent earthquakes in the Himalayan mountain region and to the north show that the collision process is still active. However, the earthquake pattern is possibly not related exclusively to the collision process. Research on this aspect of plate tectonics is continuing.

SUGGESTED APPROACH

Students can perform this activity individually if provided with a pre-assembled continental collision device. Alternatively, two students could easily assemble the paper strip of the continental collision device and do the activity in one lab period. In this case, for safety reasons, provide students with cardboard in which the subduction slit has already been cut and widened. Students can tape the stationary block of furring strip to the cardboard base.

If more than one class is to use the device, then ask each student or team to carefully disassemble the device when finished with it.

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If more than one class is to use the device, then ask each student or team to carefully disassemble the device when finished with it.

PROCEDURE

In this activity students learn to simulate the collision of continental lithosphere resulting from plate motions.

Key words: none

Time required: two 45-minute periods

Material: one continental collision device

1. Figure 3 shows the continental collision device On Figure 3 label the wooden furring strips "continental crust." Label the slit "marginal trench " Label the paper strip "oceanic crust and lithosphere " Label the colored napkin "oceanic sediments" and the white napkin "continental margin sediments "

2. Use one hand to grasp the end of the strip of paper that extends through the slit in the cardboard of the continental collision device. Slowly pull the strip of paper downward. Try to pull evenly so the paper strip doesn't shift from side to side Stop pulling when the moving block has traveled as far as it will go.

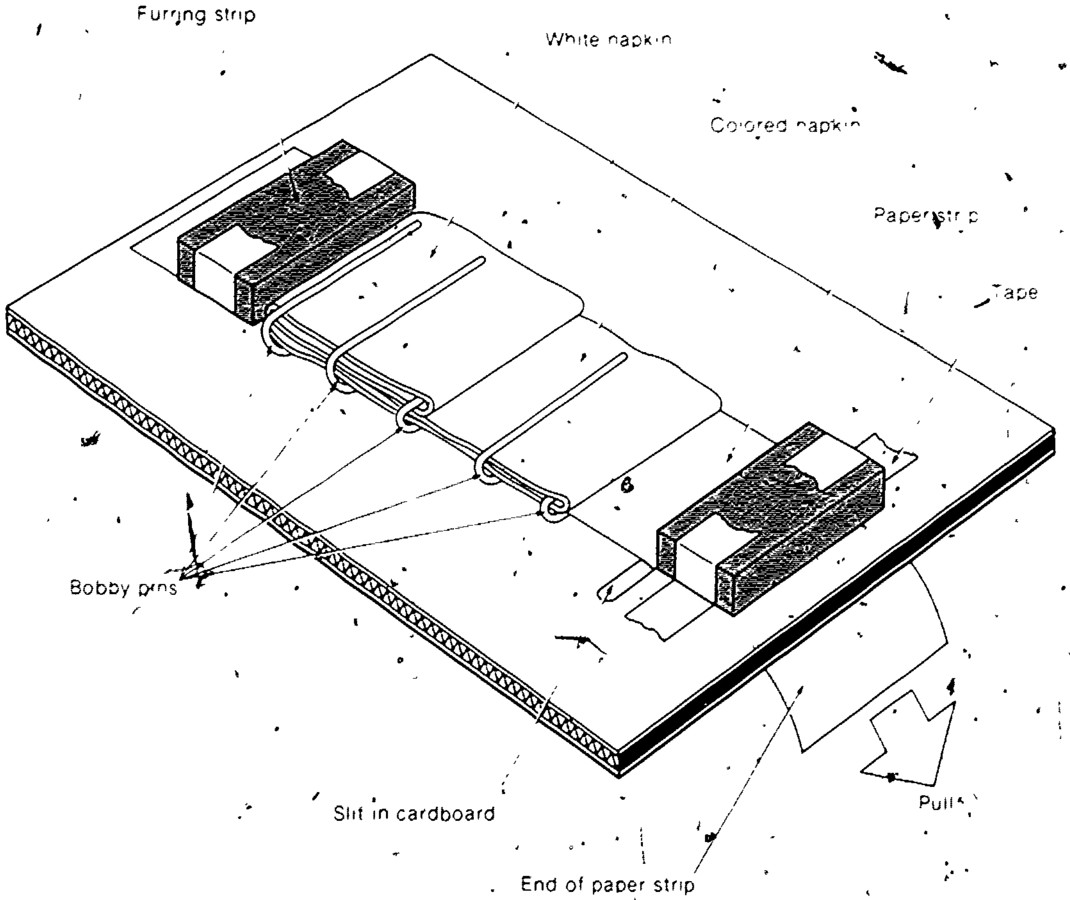

Figure 3. Continental collision device ready for use

In the space below, write sentences that tell what happened to the simulated ocean sediments and continental margin sediments.

At first, the ocean sediments moved toward the stationary continent without being disturbed. Then, the sediments hit against the stationary continent and began to form into fold mountains. After that, the continental margin sediments began to form into fold mountains.

In the space below, sketch a cross-section of the model to show the final arrangement of continental blocks and sediments. Label the type of mountains formed by the motion of simulated sediments between the two continental blocks. On your diagram make asterisks (*) to show where earthquakes might occur during a combined subduction and collision process on the real earth.

Student sketches will not be as detailed as example shown below, but the crumpled condition of the napkins should be apparent in their diagrams.

3. In the space below, tell what might happen if the simulated continental blocks were made of clay instead of wood.

The blocks would also change shape through folding and faulting because of the collision.

4. Study the topography of the Indian Plate and adjacent countries of the Eurasian Plate on the physical map of the ocean floor. In the space below, describe how the topography of that area is similar to that simulated on your continental collision device.

The Indian landmass is relatively flat except for the northern region. There, the Himalaya Mountains have been formed by the collision of India with Asia.

5. Pull the moving block and paper strip back to their original positions. Slide the bobby pins along the paper strip to return the napkins to their original positions.

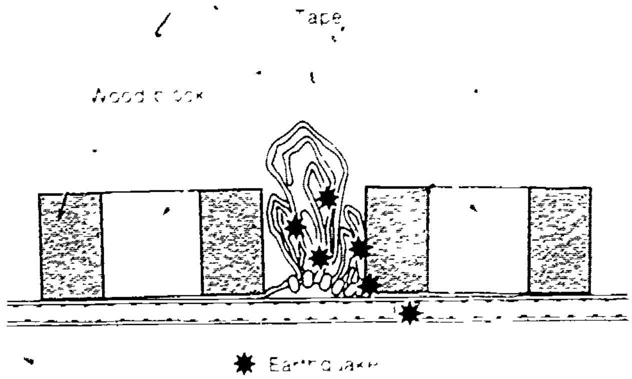

Figure A. Side view of continental collision device after pulling strip of paper.

SUMMARY QUESTIONS

1. How does the theory of plate tectonics explain continental collisions?

When a lithospheric plate carrying a continent is subducted under another plate with a continent near its edge, then the two continents may eventually collide.

2. What happens to ocean and continental margin sediments lying between the moving continental blocks?

Such sediments are compressed to form fold mountains. (Faults usually occur also, but they cannot be simulated by the continental collision device.)

3. Based on results from the continental collision simulation, describe three kinds of evidence that might prove two continental masses were moving together:

a earthquakes (where?)—

Along the borders of the two continents and along the subducting oceanic lithosphere.

b sedimentary rocks (where in relation to continental masses? What kind?)—

Folded sedimentary rocks between the two continental masses should show evidence of ocean sediments and continental margin sediments.

c kind of topography—

Fold mountains.

EXTENSION

Refer to a diagram that shows how the continents were joined to form the supercontinent Pangaea Now study the physiographic diagram of the ocean floor to see where mountains might have formed when these continents first came together to form Pangaea List the names of these mountains.

Students will discover that such mountain ranges as the Atlas of North Africa, the Alps of southern Europe and the Appalachians of the eastern United States are the results of early continental collisions.

REFERENCES

Matthews, S.W , 1973, This changing earth *National Geographic,* v. 143, no. 1 (Jan.), p. 1-37.

Molnar, P and Tapponier, P., 1977, The collision between India and Eurasia. *Scientific American,* v. 236, no. 4 (Apr.), p 30-41.

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

WARD'S

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MODULE NO. RY3 6-2
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CRUSTAL EVOLUTION EDUCATION PROJECT

NAME DATE

Student Investigation

Catalog No 34W1130

What Happens When Continents Collide?

INTRODUCTION

The theory of plate tectonics states that earth's crustal plates have always been in motion. Plates that are separating from each other allow lava to well up from the mantle to rise to the ocean floor As the lava cools, new ocean crust forms at the mid-ocean mountain range to fill the gap left by the separating plates (See Figure 1) Where plates are moving toward each other, there is a problem—the ocean lithosphere must be destroyed This happens when the ocean litho-sphere of one plate sinks downward under the opposing plate This downward motion of a plate is called subduction An ocean trench marks the place where one plate is subducting under another (See Figure 2)

However, if the subducting plate is carrying a part of a continent, the situation becomes more complex Continental crust has a lower density than ocean crust. Scientists think that because of the density difference between the two types of crust, the continental crust cannot be subducted. Near the border of the continent are abyssal plain and continental margin sediments These, too, have low density How will the sediments and continental rocks on one plate behave as they are drawn together with continental rocks of another plate? Has this happened in the past? Is it happening today?

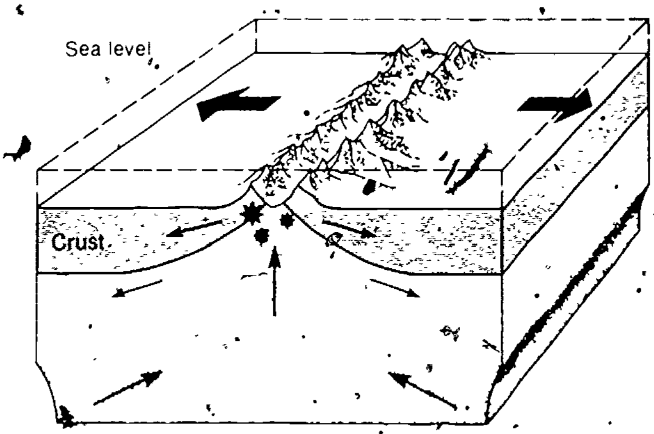

Figure 1 Magma rises upward into mid-ocean ridge Plates move apart from each other

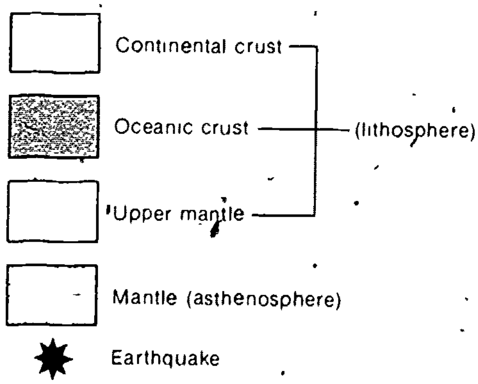

Illustration key

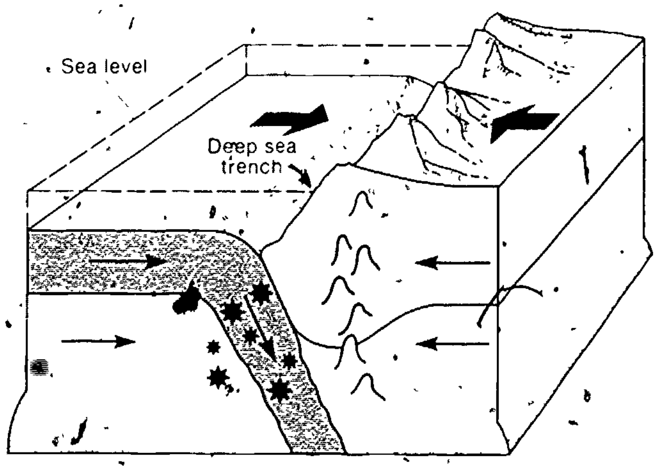

Figure 2 One crustal plate subducting under another.

OBJECTIVES

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

1. Sketch a labeled cross-section showing stages in the collision of two plates containing continental masses.

2. Identify at least one mountain range that has resulted from collision of continents.

3. Identify lithospheric plates on which continents are colliding

4. List at least three kinds of evidence that some modern continental masses are in collision

PROCEDURE

Material. one continental collision device

1. Figure 3 shows the continental collision device On Figure 3 label the wooden furring strips "continental crust" Label the slit "marginal trench" Label the paper strip "oceanic crust and lithosphere" Label the colored napkin "oceanic sediments" and the white napkin "continental margin sediments"

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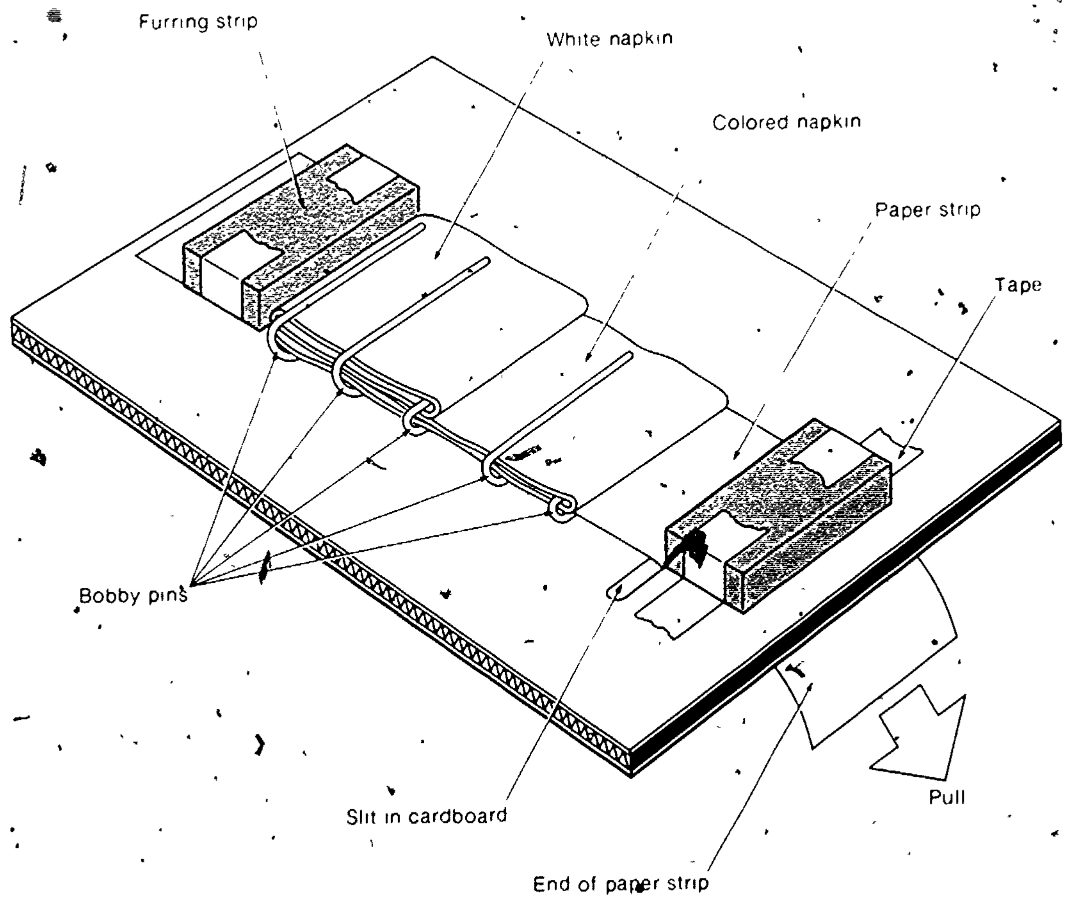

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5. Pull the moving block and paper strip back to their original positions. Slide the bobby pins along the paper strip to return the napkins to their original positions

SUMMARY QUESTIONS

1. How does the theory of plate tectonics explain continental collisions?

2. What happens to ocean and continental margin sediments lying between the moving continental blocks?

3. Based on results from the continental collision simulation, describe three kinds of evidence that might prove two continental masses were moving together

a earthquakes (where?)—

b sedimentary rocks (where in relation to continental masses? What kind?)—

c kind of topography—

EXTENSION

Refer to a diagram that shows how the continents were joined to form the supercontinent Pangaea. Now study the physiographic diagram of the ocean floor to see where mountains might have formed when these continents first came together to form Pangaea. List the names of these mountains.

REFERENCE

Molnar, P and Tapponier, P , 1977, The collision between India and Eurasia *Scientific American*, v 236, no 4 (Apr), p 30-41

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