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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, recommending two 45-minute class periods for this module; (8) summary questions (with answers); (9) extension activities; and (10) list of references. In these activities on microcontinental tectonics, students duplicate the rotation of some microcontinents, determine the original location of microclimates by studying their paleomagnetism (declination and inclination), and find out why Baja, California will someday be a microcontinent like Madagascar and New Zealand. (Author/JN)

CRUSTAL EVOLUTION EDUCATION PROJECT

When A Piece Of A Continent Breaks Off

TEACHER'S GUIDE

Catalog No. 34W1031

For use with Student Investigation 34W1131
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

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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When A Piece Of A Continent Breaks Off

INTRODUCTION

In this module the students will duplicate the rotation of some microcontinents, figure out the original location of some microcontinents by using paleomagnetism, and find out where Baja California is going.

What happens when a piece of a continent breaks off from the larger landmass? This is what you will find out in this module

Sometimes, pieces of continents break off from the larger landmass Madagascar and New Zealand are two examples of this. Look at a world globe and see if you can figure out what continent each one was once a part of. Write your answers in the spaces below.

Madagascar — Africa
New Zealand— Australia

Landmasses like Madagascar and New Zealand are called **microcontinents.** Put your thumb and forefinger together, then slowly move them apart. This is the way Baja California is now moving away from North America (Find Baja California on the globe) Some day it will be a microcontinent like Madagascar and New Zealand.

PREREQUISITE STUDENT BACKGROUND

In order to complete this activity satisfactorily, the students should have some understanding of declination, inclination, and paleomagnetism.

OBJECTIVES

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

1. Describe what happens to microcontinents caught between two crustal plates that are moving in opposite directions.

2. Tell where a microcontinent came from by studying its paleomagnetism (declination and inclination).

MATERIALS

One jar lid, between 10 and 12 cm in diameter
Two boards or strips of wood, each about 30 cm in length
Scissors
Paste
String
World globes

There should be one set consisting of a jar lid, wood, scissors, paste and globe for each group. However, one or two large globes will do for the whole class if a number of small ones are not available. Cut strings to equal the distance from the middle of Baja California to 51° N. latitude, 66° W. longitude on your globe(s).

SUGGESTED APPROACH

Basically, this activity should be carried out by the students as independent inquiry. Some class discussion is encouraged to reach a satisfactory conclusion. An extension activity is available for those students who want to go further, or proceed at a faster pace than the rest of the class.

PROCEDURE

In this activity, the students will cut out a map of part of Oregon and Washington, paste it on a jar lid, and rotate it to see how this microcontinent turned between two crustal plates.

Key words: paleomagnetic direction, microcontinent, declination, inclination, paleomagnetism

Time required: two 45-minute periods

Materials: scissors, paste, 1 jar lid, 2 pieces of wood (or rulers)

When a piece of a continent breaks off, it can get caught between two crustal plates that are moving past each other in opposite directions. What do you think would happen to it then? In this activity you will find out.

The map in Figure 1 shows the age (in millions of years) and **paleomagnetic direction** (the direction that was magnetic north when the rocks were formed) of rocks at three places in Oregon. It also shows the direction in which you would expect magnetic north to have been for these and other rocks in the area that formed at the same time.

Cut out the part of Oregon and Washington that is encircled by the curved line in Figure 1. Paste this piece on a jar lid.

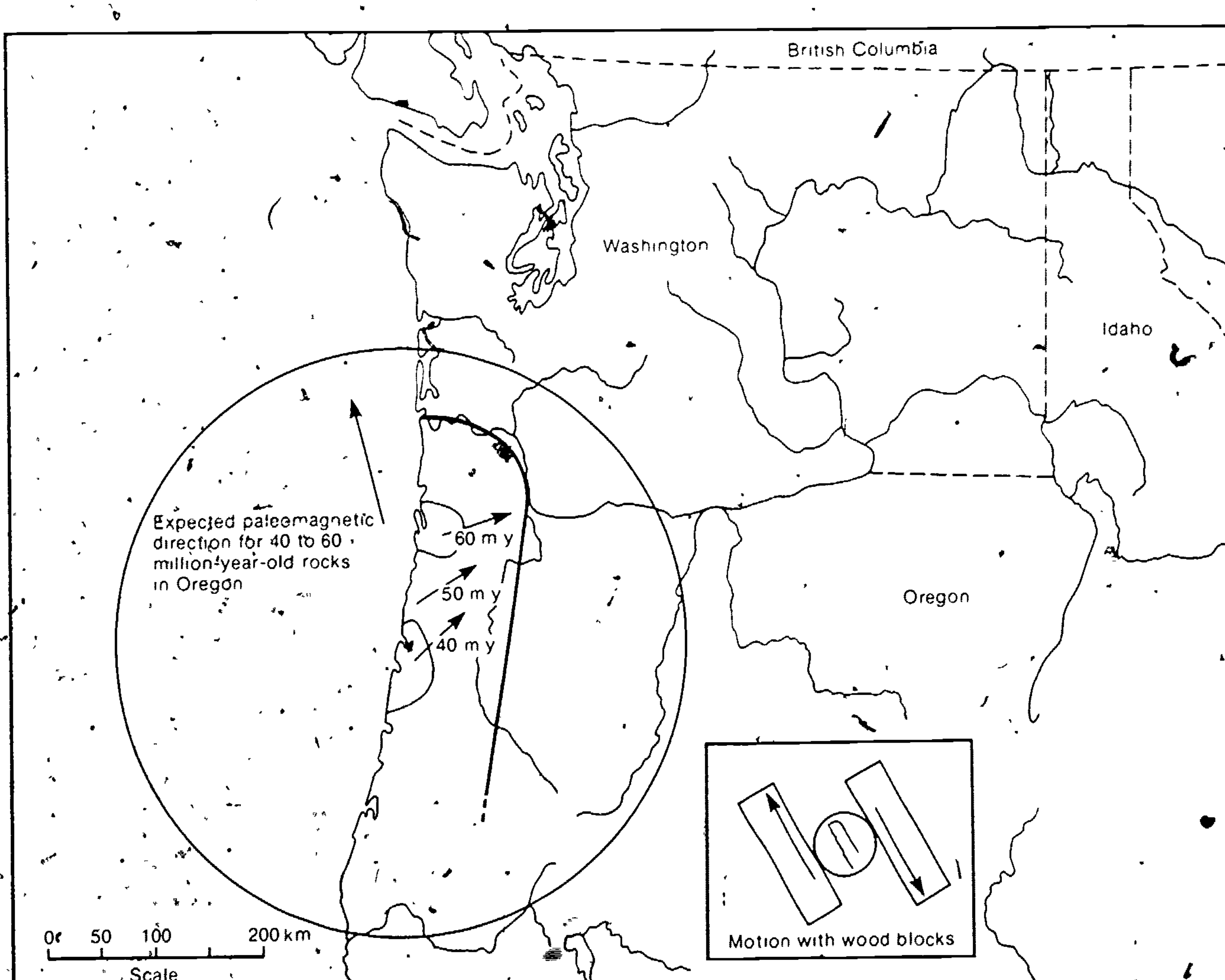

Figure 1. Map of the Pacific Northwest.

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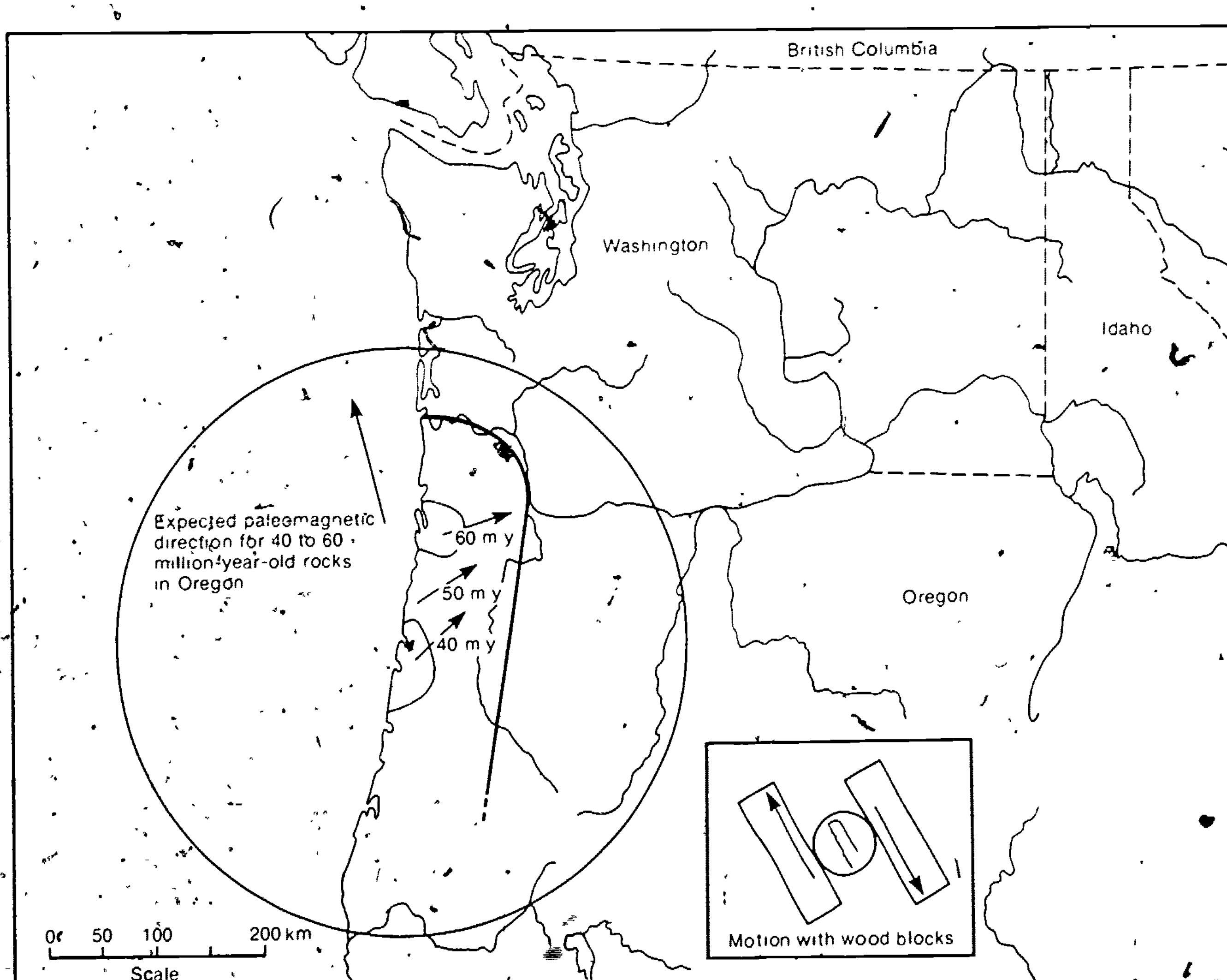

Figure 1. Map of the Pacific Northwest.

Put something like a pencil or pen on the opposite side of your desk to represent the north magnetic pole 40 to 60 million years ago. Now place the jar lid on the desk in front of you. Point the 60 m.y. arrow to your imaginary north magnetic pole. Put two pieces of wood on opposite sides of the jar lid, as shown in the diagram in the lower right-hand corner of the map, and move the wooden pieces in the directions that the arrows point.

If the students do this correctly, the jar lid should turn in a clockwise direction.

1. In what direction does the jar lid and its piece of map turn, clockwise or counterclockwise?

clockwise

2. What do you have to do to get the 50 m.y. arrow to point to your north magnetic pole?

Turn clockwise from 60 m.y. to 50 m.y.

3. What do you have to do to get the 40 m.y. arrow to point to your north magnetic pole?

Keep on turning clockwise from 50 m.y. to 40 m.y.

4. In what direction have these three places in Oregon moved in comparison with most of Oregon and Washington?

They have all turned clockwise.

5. How can you explain this?

The 60 m.y. rocks were formed on a microcontinent that turned a little between two plates moving in opposite directions past each other. Then the 50 m.y. rocks were formed and turned a little more with the 60 m.y. rocks. Later the same thing happened to the 40 m.y. rocks.

Some geologists call Alaska the "garbage dump" of the Pacific. This is because part of the Pacific crustal plate is moving toward Alaska, and any piece of broken-off continent that is in the eastern Pacific may end up in Alaska.

Here the students try to locate the original position of a piece of Alaska, using the paleomagnetic declination and inclination of the drifting rocks.

You have learned already that the **declination** is the direction a compass needle points, compared with the direction of the north geographic pole The **inclination** is the magnetic needle's dip or angle from the horizontal. The inclination of a magnetic needle is downward if the needle is north of the equator, upward if the needle is south of the equator The **paleomagnetism** in a rock shows the position of the magnetic field of the earth at the time the rock was formed Using this information, you can figure out from where parts of Alaska came.

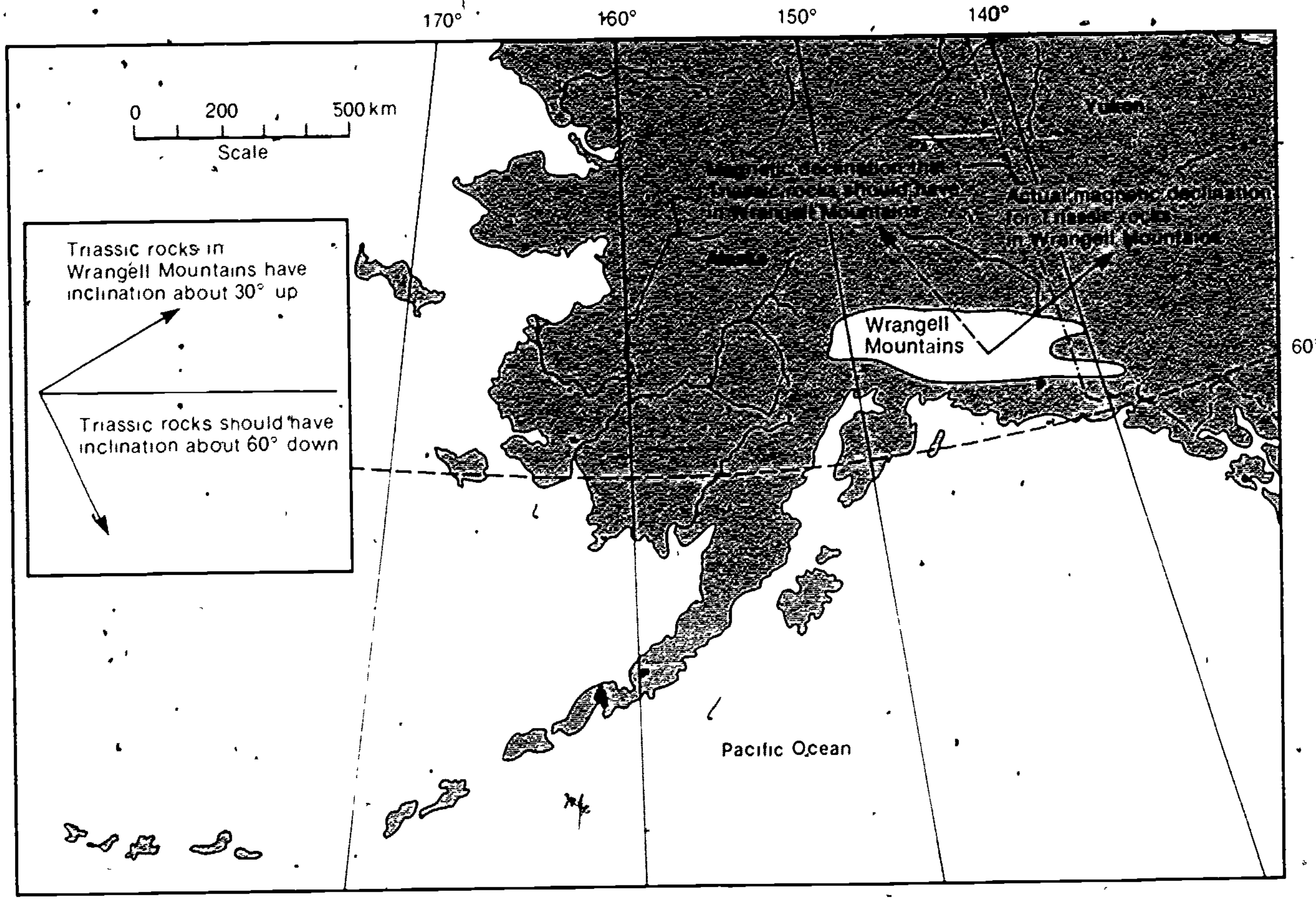

Figure 2 Map of Wrangell Mountains region in Alaska

Look at Figure 2. Find the outline of the Wrangell Mountains The inclination for the Triassic rocks is 30° above the horizontal. Because of the location of Alaska, the inclination should be 60° below the horizontal.

6. Was the Wrangell Mountains microcontinent located north or south of the equator during the Triassic?

Because the inclination for the Triassic rocks is 30° above the horizontal, the Wrangell Mountains microcontinent was located south of the equator during the Triassic.

Again look at the outline of the Wrangell Mountains in Figure 2. The solid arrow shows the declination of the Triassic rocks in the Wrangell Mountains. The dotted arrow shows the declination that the Triassic rocks should have in Alaska. You can see that these rocks have rotated 90° compared with the expected declination of Triassic rocks in Alaska. Using a map of the world, swing this area around in an imaginary counterclockwise arc just below the equator until the solid arrow points in the same direction as the dotted arrow.

7. Where are the Wrangell Mountains now? See if you can come up with an answer with which everyone agrees

The Wrangell Mountains microcontinent ends up approximately in the region of present-day Peru. This may be overdoing it a bit, since everything else was moving at the same time, but it does indicate the principle.

When you have all agreed where this microcontinent was located during the Triassic, try to figure out how (in ways other than paleomagnetism) Triassic rocks in the Wrangell Mountains might differ from Triassic rocks in the rest of Alaska

If the Wrangell Mountains were near the equator and west of Central or South America during the Triassic, they should have rocks and fossils that show they were formed in a warm climate compared with the cold climate rock and fossil types of the rest of the Alaska Triassic rocks.

SUMMARY QUESTION

Find Corsica, Sardinia, Sicily, and Italy on a globe. If Africa is moving eastward compared with Europe, in what direction are these microcontinents turning (clockwise or counterclockwise)?

In this case, the microcontinents are turning in a counterclockwise direction.

EVALUATION

In addition to a written evaluation you can observe the students' participation and performance as a means of informal evaluation. Alternatively, you may wish to have them find out how fast Baja California will move (i.e., the rate at which the Pacific Plate is moving) if it will take 50 million years to reach Alaska along the path that they have shown it will follow.

EXTENSION

Materials: string, world globe

In the INTRODUCTION of this module, you read that Baja California was breaking off from North America. Where do you think it will eventually end up? To find out, place one end of a string on a world globe at Baja California. Place the other end at 51° N. latitude and 66° W. longitude. Keeping the 51°-66° end of the string pressed against the globe, swing the other end of the string up and around through the Pacific until it comes to land again. Where did the moving end of the string end up? Where will Baja California be some day?

If done correctly, the left-hand end of the string will swing up and around to Alaska. This is where Baja California will eventually end up. This will take about 50 million years.

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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

WARD'S

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MODULE NO. WA7 1-2
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CEEP

CRUSTAL EVOLUTION EDUCATION PROJECT

NAME DATE

Student Investigation

Catalog No 34W1131

When A Piece Of A Continent Breaks Off

INTRODUCTION

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Sometimes, pieces of continents break off from the larger landmass Madagascar and New Zealand are two examples of this. Look at a world globe and see if you can figure out what continent each one was once a part of. Write your answers in the spaces below:

Madagascar — __________

New Zealand— __________

Landmasses like Madagascar and New Zealand are called **microcontinents**. Put your thumb and forefinger together, then slowly move them apart. This is the way Baja California is now moving away from North America. (Find Baja California on the globe.) Some day it will be a microcontinent like Madagascar and New Zealand.

OBJECTIVES

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

1. Describe what happens to microcontinents caught between two crustal plates that are moving in opposite directions.

2. Tell where a microcontinent came from by studying its paleomagnetism (declination and inclination).

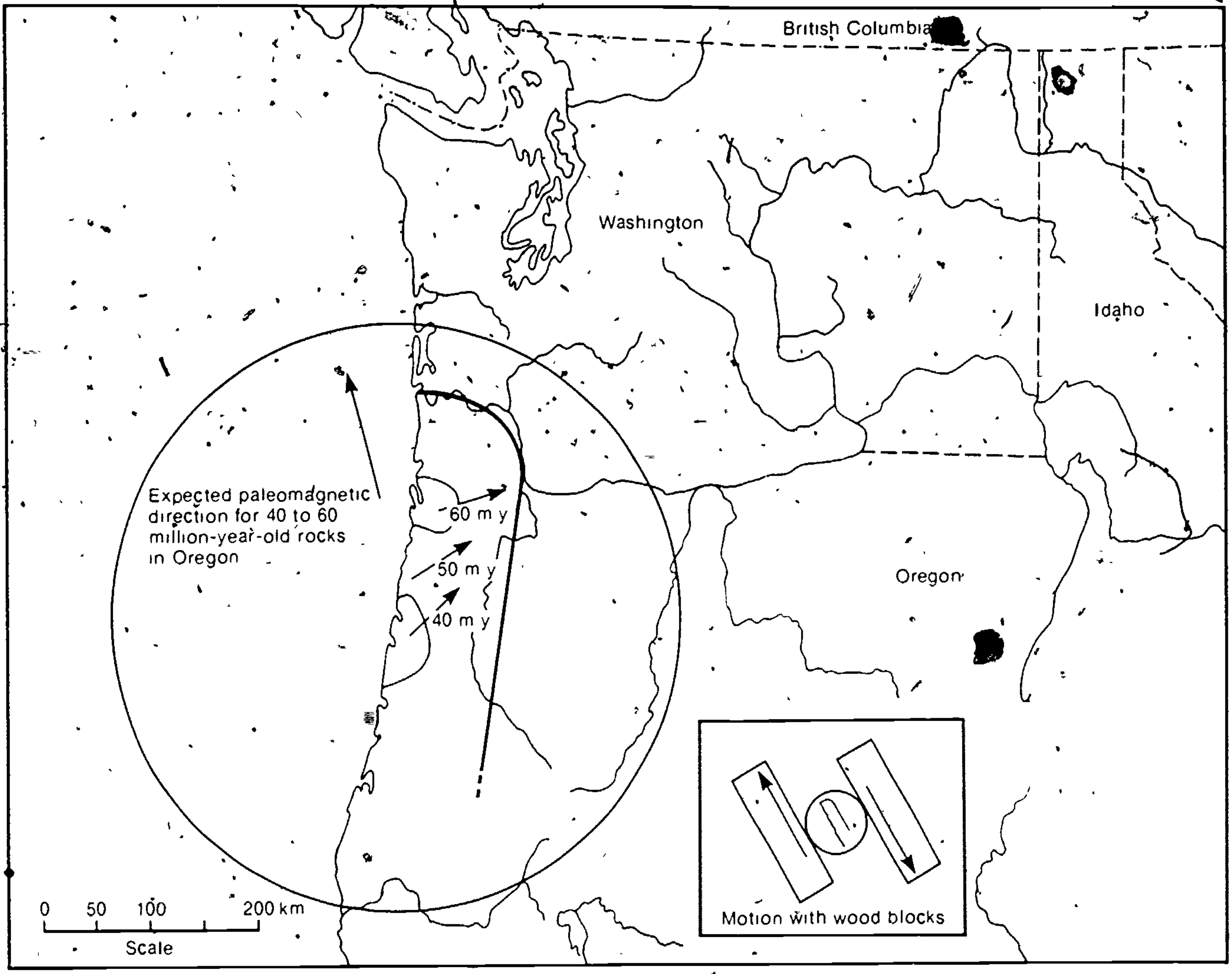

Figure 1. Map of the Pacific Northwest.

PROCEDURE

Materials. scissors, paste, 1 jar lid, 2 pieces of wood.

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1. In what direction does the jar lid and its piece of map turn, clockwise or counterclockwise?

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4. In what direction have these three places in Oregon moved in comparison with most of Oregon and Washington?

5. How can you explain this?

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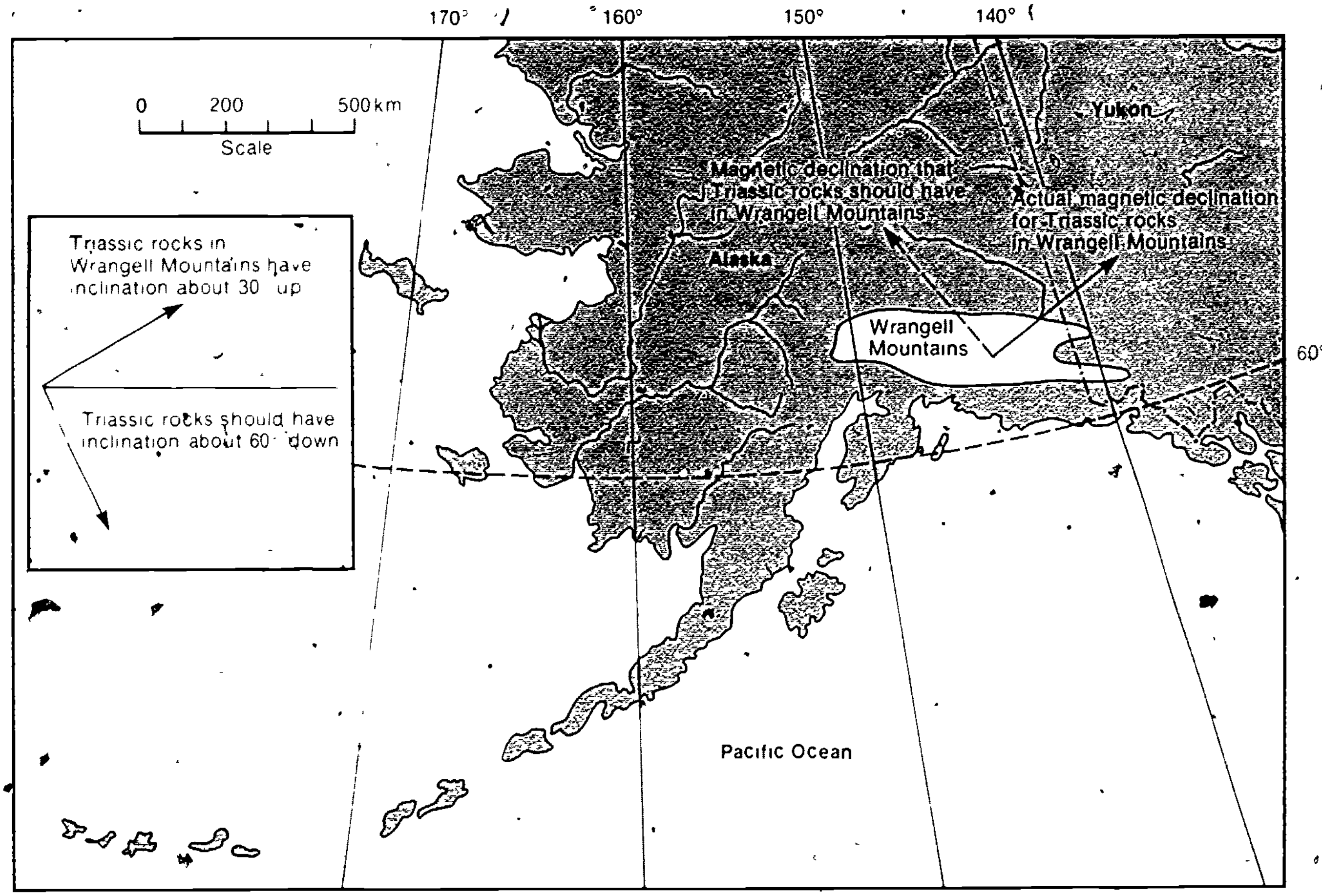

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