DOCUMENT RESUME

ED 216 935 SE 038 139

AUTHOR	Stoever, Edward, C., Jr.
TITLE	Drifting Continents and Magnetic Fields. Crustal Evolution Education Project. Teacher's Guide [and] Student Investigation.
INSTITUTION	National Association of Geology Teachers.
SPONS AGENCY	National Science Foundation, Washington, D.C.
REPORT NO	CEEP-MOD-OH12-1-5; ISBN-0-89873-008-2; ISBN-0-89873-009-0
PUB DATE	79
GRANT	SED-75-20151; SED-77-08539; SED-78-25104
NOTE	30p.
AVAILABLE FROM	Ward's Natural Science Establishment, Inc., P.O. Box 1712, Rochester, NY 14603 (or P.O. Box 1749, Monterey, CA 93940.)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	*Earth Science; Geographic Location; Geology; Instructional Materials; *Science Activities; *Science Course Improvement Projects; Science Curriculum; Science Education; Science Instruction; Secondary Education; *Secondary School Science; Teaching Guides; Teaching Methods
IDENTIFIERS	Continental Drift; *Crustal Evolution Education Project; National Science Foundation; *Plate Tectonics

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 three 45-minute class periods for this module; (8) summary questions (with answers); (9) extension activities; and (10) list of references. Objectives include explaining magnetic dip, using magnetic dip preserved in rocks to determine latitude of India at certain times in the past and its present rate of movement, and identify collision of India and Asia as the cause of the Himalayas. Familiarity with continental drift, paleomagnetism, latitude/longitude, and measuring angles with a protractor are prerequisites for understanding the teacher demonstration and completing the activities. (Author/JN)

CEEP™

CRUSTAL EVOLUTION EDUCATION PROJECT

Drifting Continents And Magnetic Fields

Drifting Continents And Magnetic Fields

TEACHER'S GUIDE

Catalog No. 34W1005

For use with Student Investigation 34W1105
Class time: three 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 [illegible] 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, [illegible] teachers, and scientists. Prior to [illegible] the materials were field tested by [illegible] teachers and over 12,000 students. [illegible] research is a breaking [illegible] 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 [illegible] learn more about the living earth [illegible] 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 [illegible] intended only for the [illegible] 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 [illegible] letters instead of the number [illegible] used in the Student Investigation.

[illegible] some modules, maps, rulers and other [illegible] materials are needed, and in [illegible] method of presentation. Read over the module before [illegible] class and refer to the list of MATERIALS in the module.

Each module is individual and self-contained in [illegible], but some are divided into two or more [illegible]. The recommended length [illegible] for each module is indicated. Some modules [illegible] knowledge of some aspects [illegible] this is [illegible] in the Teacher's Guide.

The material was prepared with the support of National Science Foundation Grant Nos. SED 75-20151, SED 77-08539 and SED 78-25104. However, any opinions, findings, conclusions or recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of NSF.

In order to comply with U.S. Public Law 94-86, every school district in the U.S.A. using these materials agrees to make them available for inspection by parents or guardians of children engaged in educational programs or projects of the school district.

Drifting Continents And Magnetic Fields

INTRODUCTION

Geophysicists have been able to plot the path of India, from its breakup with Antarctica, across the equator to its present position; using the apparent magnetic dip preserved in the rocks of India. In this module, students use paleomagnetic dating in the same way those geophysicists did, to determine the position of India at various times in the past. They also learn that the collision of India with Asia is the probable cause of the extensive earthquake activity in Tibet and southern China.

Scientists have determined that at one time India was a part of Antarctica It broke off from Antarctica and for 200 million years drifted northward, isolated from any other landmass Finally it collided with Asia, resulting in the uplift of the Himalaya Mountains Perhaps you have heard about the earthquakes in that part of the world. These earthquakes are the result of this collision process of one continent with another They tell us that it is still going on.

PREREQUISITE STUDENT BACKGROUND

Students should be familiar with continental drift and paleomagnetism. They should be able to locate places on a world map using latitude and longitude. They should also be able to measure angles with a protractor.

OBJECTIVES

After you have completed these activities, you should be able to

1. Explain what is meant by magnetic dip
2. Use the magnetic dip preserved in rocks to determine the latitude of India at certain times in the past, and its rate of movement
3. Identify the collision of India and Asia as the cause of the Himalayas

MATERIALS

One set of each of the following is needed for demonstration purposes:

Overhead projector

Transparency of the upper half of Worksheet 1

Iron filings and a bar magnet of a size that will fit the transparency

A transparent lid or dish to support the transparency above the magnet

Transparent protractor, ruler and a marker pen

At least one dip needle and a compass. If more are available, then students can determine the answers to Question 1 themselves.

One or more atlases

Each student should have a protractor, ruler, pencil and eraser

BACKGROUND INFORMATION

The difference in the magnetic dips of the rocks found in India is not the only evidence used by scientists to trace the northward movement of India. The magnetic anomalies of the Indian Ocean floor provide the major support. Students should realize that the information they deal with in this activity is simplified to make it readily understandable.

In the introduction of the student guide, students are told that the Himalaya Mountains and the earthquakes in southern China are the result of the collision of two continents. It is the movement of oceanic crust into a subduction zone along the southern margin of Asia that caused the collision. The two continents were drawn together by this movement. The continental crust of India, however, was too low in density to be drawn down into the subduction zone. Instead, it is colliding with the continental crust of Asia. In this way a great thickness of continental crust occurs at the zone of collision. This greater-than-normal thickness of lower density continental rock may be largely responsible for the height of the Himalayas. There seems to be a shortening of crust caused by this collision. As the crust shatters, it slides along the resulting faults in a general compression of the continental crusts of India and Asia. These movements result in the many shallow focus earthquakes occurring in Tibet. See Figure A.

The Alps are another zone where two continents have collided and produced mountains. The Alps are older than the Himalayas and resulted when Africa collided with Europe. A second period of collision may be occurring now. Africa seems to be moving into Europe. As a result, the Mediterranean Sea is closing. Millions of years from now another mountain range, parallel to the Alps, may be formed by this collision.

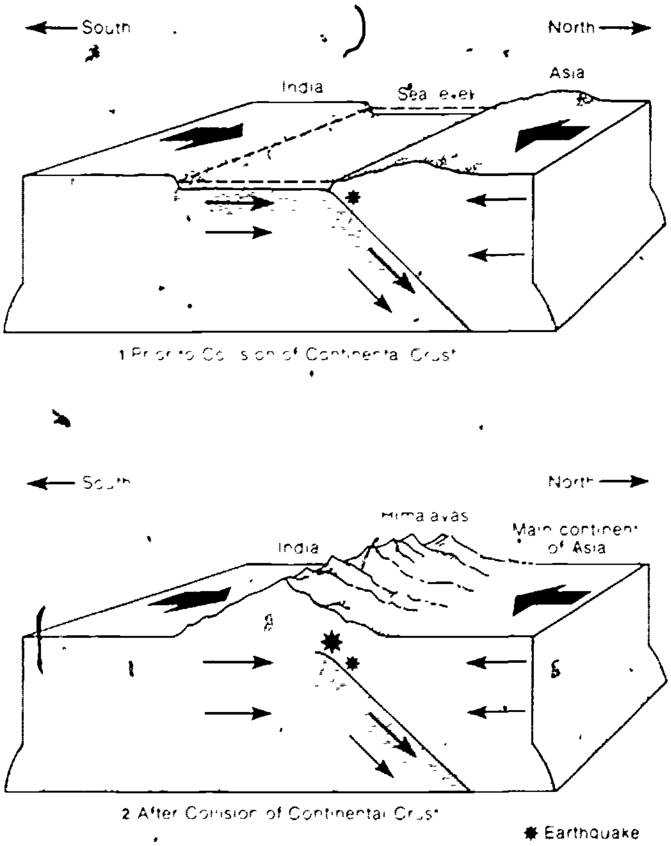


Figure A. Schematic representation of the collision of India and Asia, which produced the Himalayas and has resulted in continuing shallow earthquake activity.

SUGGESTED APPROACH

PART A of the module is a teacher demonstration. Students, however, should respond to the questions in the Student Investigation and on Worksheet 1 during and immediately after the demonstration. The remainder of the activity can be done in an individualized setting or in small groups with the demonstration as background. You should conduct a post-laboratory discussion at the end of the module using the SUMMARY QUESTIONS as a guide. This discussion could also include information relating to the EXTENSION.

PROCEDURE

PART A. What is magnetic dip?

In this part of the activity you conduct a demonstration and class discussion to review basic concepts concerning the earth's magnetic field and how it can be measured at various places on the surface.

Key words: dip needle, magnetic dip, horizon line

Time required: one to two 45-minute periods

Materials: protractor, ruler and pencil

The earth is surrounded by a magnetic field, which is strongest near the north and south magnetic poles It can't be seen However, anyone who has used a magnetic compass has observed it. The compass allows one to "tell directions" (north, south, east, or west). Telling directions is using only one part of the magnetic field—the horizontal part Since the field is three-dimensional, there is another part at right angles to the horizontal part. We will call this the vertical part To observe the vertical part of the field, you use a **dip needle.** It is similar to an ordinary compass except that the needle is allowed to rotate vertically instead of horizontally The angle formed by the dip needle and the horizon is known as the **magnetic dip.**

Demonstrate a dip needle and a compass. You may have to go outside the building to avoid magnetic materials. Have students use a compass to determine the orientation of the building, or some other feature, with reference to magnetic north. Then you can briefly discuss the three-dimensional nature of the magnetic field and introduce the dip needle as a compass in the vertical plane. Then have them determine the vertical component of the field at your school's location.

If your students are familiar with the idea of vectors, you should discuss the magnetic field as a vector quantity having both magnitude and direction. There are two angles of interest: *declination* and *inclination*. Declination is the angle of deviation from the geographic north. Inclination is the angle that the dip needle makes with the horizontal plane. In the activity this is called magnetic dip. See Figure B.

Although you may want to discuss declination (or the difference between true north—geographic north—and magnetic north) with your students, this distinction is not essential for understanding the basic OBJECTIVES of this module. In fact, it may confuse students since later in the activity they are told that over geologic time, geographic north and magnetic north can be assumed to be essentially the same.

1. Your teacher has shown you a compass and a dip needle. Which would you use to measure the horizontal part of the earth's magnetic field? <u>compass</u> Determine the direction, with a compass, to some object in your room or school yard.

Object ____________________

Direction ____________________

What instrument would you use to measure the vertical part of the earth's magnetic field? <u>dip needle</u>

In this activity you will be using the magnetic dip recorded in rocks. When molten rocks reach the surface of the earth and begin to cool, certain minerals within the rocks are magnetized parallel with the magnetic field of the earth These rocks will then have a weak magnetic field themselves. The positions of samples of the rocks are recorded before they are collected Scientists can then measure the horizontal and vertical parts of the magnetic fields of these rocks. This will tell them about the magnetic field in the area at the time the rocks cooled

This explanation of the paleomagnetism of rocks is highly simplified. The rocks become magnetized as they crystallize. When the Curie temperature is reached (about 500° C), this magnetism will become permanent. If later the rock is heated above the Curie point, it will lose its permanent magnetism. It will acquire a new field when the temperature falls back down through the Curie point again. Therefore, the scientist must know the temperature history of the rock.

Because of crustal disturbances, many rocks are not found in their original positions. Magnetic data from them can still be used, however, if the scientists are able to make corrections on the positions. The original positions can often be determined from bedding planes and other characteristics of the rocks.

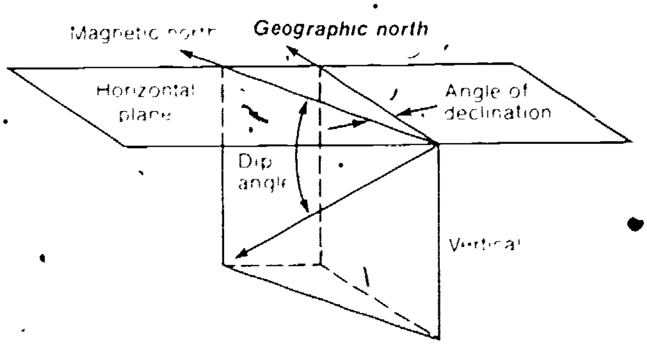


Figure B. The earth's magnetic field can be measured vertically and horizontally.

Set up the demonstration as follows:

1. Place the bar magnet on the overhead projector and cover it with the transparent lid or dish.
2. Scatter the iron filings on the transparent lid over the bar magnet.
3. Place the transparency of the diagram of the earth's magnetic field (Worksheet 1) over the iron filings so that its north and south poles coincide with those of the bar magnet. Be careful not to disturb the iron filings.

Try out the demonstration at least a day or two ahead. Be sure the magnet and the diagram are of the correct size so that the iron filings will follow closely the lines of magnetic force on the diagram. You may have to redo the diagram to make them fit correctly. This is an important step in that it allows students to "see" the earth's magnetic field as modeled by the field of the magnet. The student can then relate the demonstration to orientation of the dip in diagrams representing rocks taken from various places on the earth's crust. If students don't understand this, then the remaining part of the module will have little meaning for them.

2. After you observe your teacher's demonstration, label the north and south poles on the diagram on Worksheet 1

3. Notice that a horizon line has been drawn at location C. A **horizon line** is a straight line touching the circle but not intersecting it. Draw in the horizon line at the other four locations To make a horizon line, first draw a straight line from the center of the circle to the point on the circle through which the horizon line must pass (This line is the *radius* of the circle.) Then draw a line 90° (perpendicular) to the radius at the point on the circle. This is the horizon line for that point. Measure the angle of dip of the magnetic field at each location. It will be the angle formed by a line of magnetic force and the horizon. Note that the radius and dip angle for C are already shown.

A <u>90°</u> B <u>60°</u> C <u>35°</u> D <u>60°</u> E <u>5°</u>

4. Worksheet 1 has drawings of rocks collected at each of the five locations Draw arrows on the rock drawings showing the direction of dip recorded by the magnetic minerals in these rocks. The rocks are all samples from recent lava flows.

5. Where on the earth is the dip the greatest? <u>at the poles</u> the least? <u>at the equator</u>

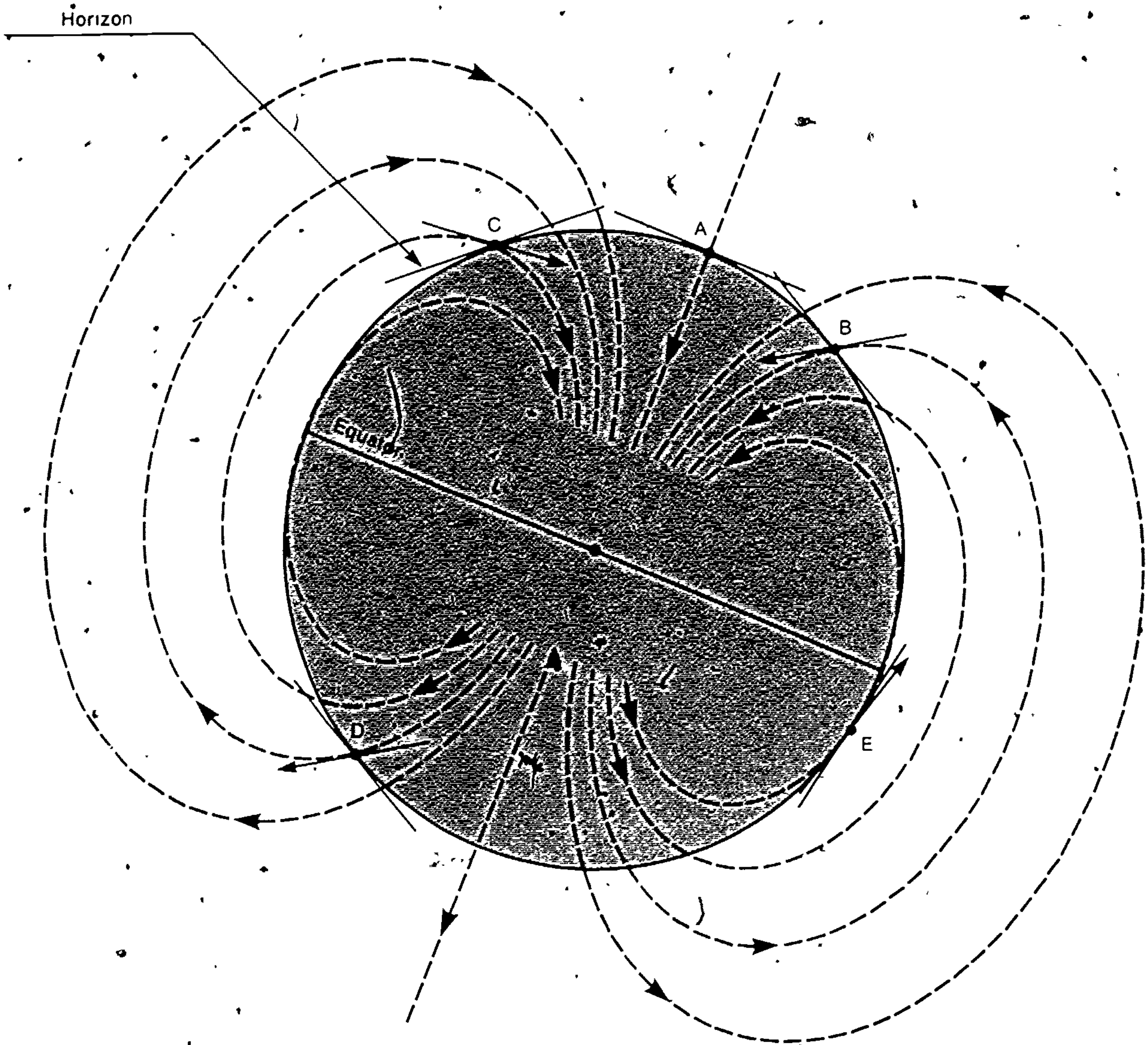
6. Samples A, B, and C are from the northern hemisphere. What is the relationship between dip and distance from the north magnetic pole?

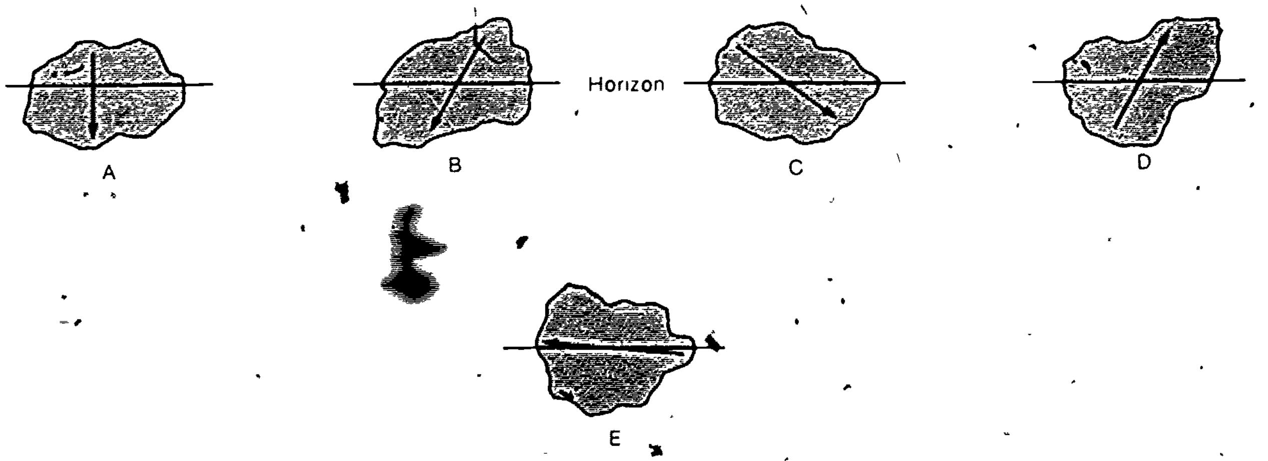
Dip becomes greater closer to the north magnetic pole.

7. Samples D and E are from the southern hemisphere. What happens to the dip in the southern hemisphere?

It is reversed. The north-seeking needle will point up rather than down.

Be certain that students understand the relationship of dip to latitude and position north or south of the equator. This understanding is essential for PART B.





8

Answer Sheet 1 (PART A)

PROCEDURE

PART B: What does magnetic dip tell about India?

In this part of the activity, students study evidence from magnetic dip recorded in certain rocks. This record has led geophysicists to believe that India has drifted northward to collide with Asia. Students learn that changes in the rate of movement can be determined and that the collision accounts for the Himalaya Mountains and the extensive geological activity in that area.

Key words: radiometric dating, paleolatitude

Time required: one 45-minute period

Materials: protractor, ruler and pencil, atlas

Geophysicists find that the ancient magnetic dip may be different in rocks of different ages on the same continent. This is particularly true of India.

Figure 1 shows drawings of six rocks. Each rock is from a different formation in India. Samples B and D are from lava flows. The others are sedimentary rocks that contain particles of iron. Iron particles will often act like tiny magnetic compasses as sediments are being deposited. They align themselves with the magnetic field of the earth. Sedimentary rocks and igneous rocks, then, can provide a record of the earth's magnetic field.

Note that the age of each rock is given in years. Geologists can determine how long ago an igneous rock crystallized by a method known as **radiometric dating**. They can also determine the approximate time of deposition of sediments at a site where igneous rocks have cut across the sedimentary rocks.

Figure 1 is based upon data from C.T. Klootwijk, 1976. It has been translated from the form used by paleomagnetists into the form used in this activity to make it more understandable to students.

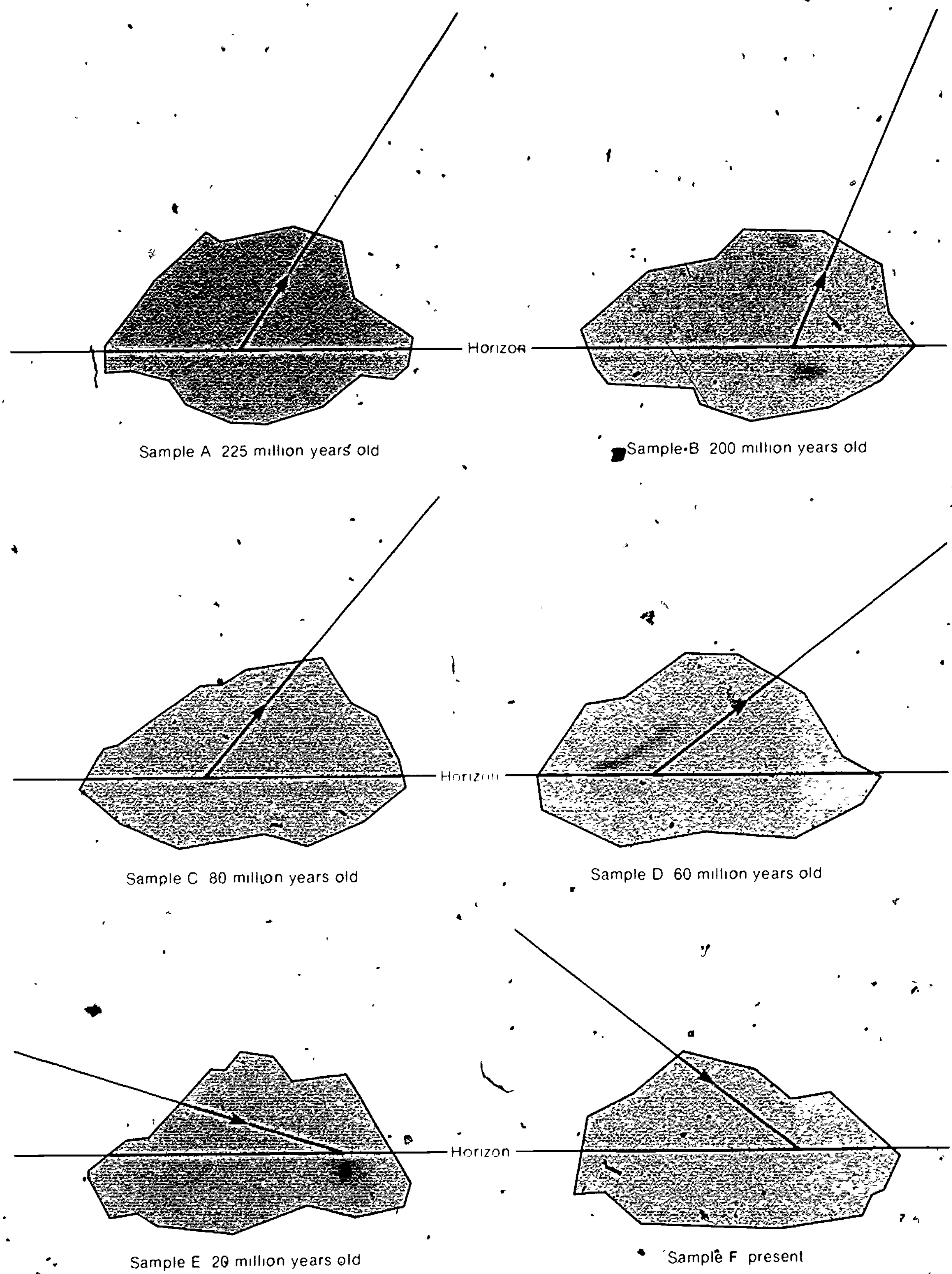


Figure 1. The direction of magnetic dip is diagramed on these rock samples from India

The direction of magnetic dip is indicated by the arrow on each sample.

1. Use the protractor to measure the angle of magnetic dip for each sample and place your results in the proper column of the Data Sheet on Worksheet 2.

What could cause the magnetic dip of the rocks found in India to change during the last 225 million years? There are three possibilities:

a. The north magnetic pole has moved.
b. India has moved.
c. Both the north magnetic pole and India have moved

Most scientists now believe that the magnetic poles have always remained relatively close to the earth's geographic poles and that the geographic poles have always remained in an area near their present positions. Therefore, a and c are not acceptable explanations, and the only possible explanation is that India has moved.

Since the magnetic and geographic poles are close together, you can assume for this activity that they are indeed the same. Therefore, the angle of magnetic dip can give you latitude and distance from a geographic pole if you use this graph (Figure 2).

2. Using Figure 2, determine the **paleolatitude** (ancient latitude) for each of your samples from India. Record this on your Data Sheet on Worksheet 2.

Paleolatitude is found by using the angle of magnetic dip the students recorded from Figure 1. For example, rock C has a 49° dip. Using Figure 2, look for 49° on the bottom scale labeled "Angle of magnetic dip." Go up from that point to the curved line. From that point on the curve read across to the scale of latitude to find the "paleolatitude." For rock C it is approximately 30°S. latitude (note position of arrow).

3. Plot the paleolatitude and age of each sample on the graph on Worksheet 2.

4. From the graph you have just plotted, determine the average rate of movement of India during the last 200 million years in cm/year.

Approximately 3.2 cm/year

5. Has India always moved at the same rate of speed during the last 200 million years?

No

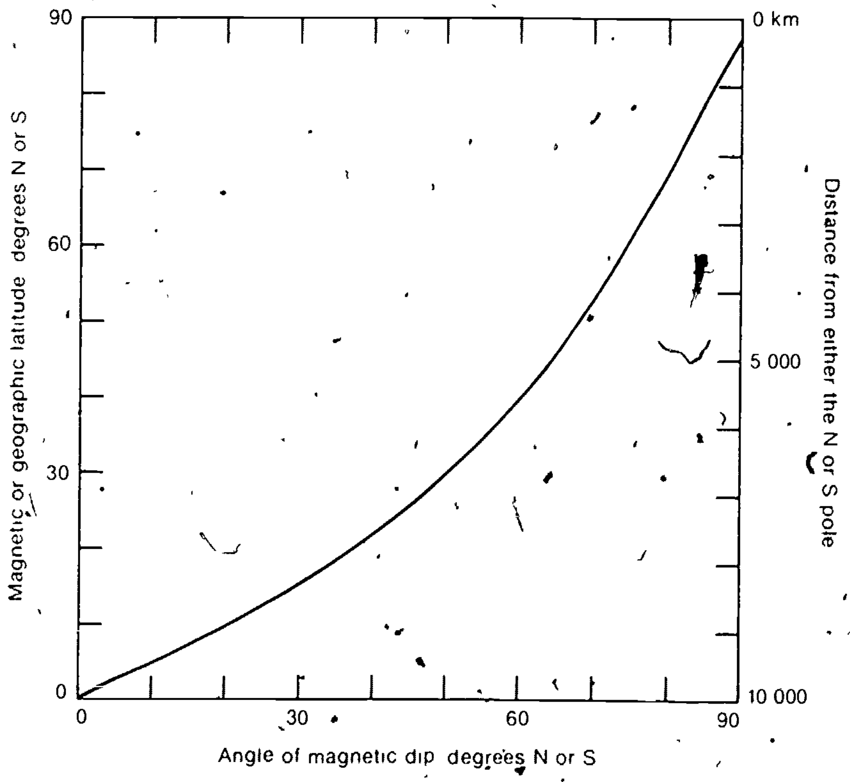
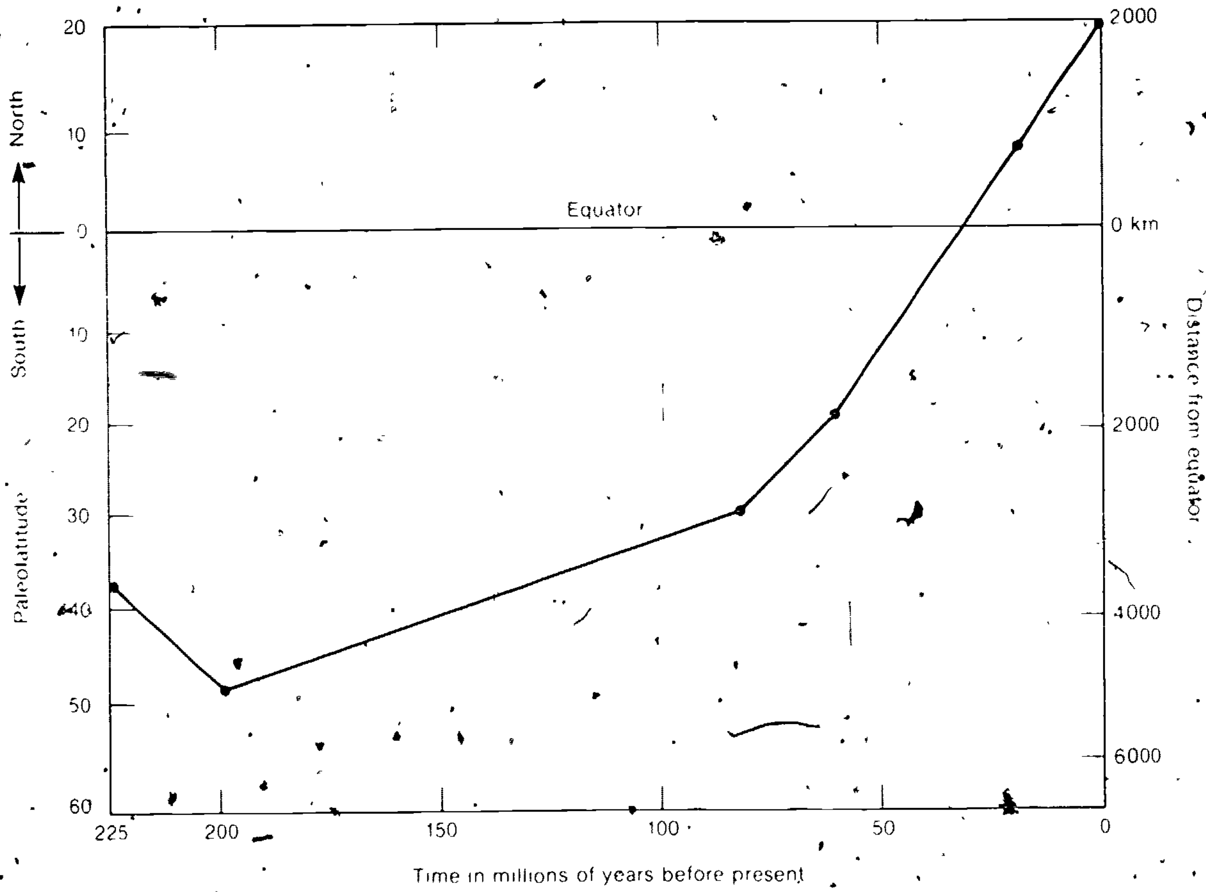


Figure 2. Graph showing relationship between distance from magnetic poles and angle of magnetic dip.

Data Sheet

Rock Sample	A	B	C	D	E	F
Age of Sample	225m y	200m y	80m y	60m y	20m y	Present
Angle of Dip	56	66	49	37	17	37
Paleolatitude	37°S	48°S	30°S	19°S	8°N	20°N

Graph



Answer Sheet 2 (PART B)

REFERENCES

Klootwijk, C T , 1976, The drift of the Indian subcontinent, an interpretation of recent paleomagnetic data. *Geologische Rundschau*, v. 65, no. 3, p. 885-909.

Mead, D.F., 1976, How the Chinese predict earthquakes. *Science Digest*, v 79, no. 3 (Mar.), p. 57-61.

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

Shaw, E., 1977, Can animals anticipate earthquakes? *Natural History*, v 86, no 9 (Nov), p. 14.

China's quake forecasting: 50-50. *Science News*, 1977, v. 112, no. 9 (Aug.), p. 133-134.

6. Mark the position of India for the various dates of your samples on the map on Worksheet 3.

Scientists have discovered that India has not had very much east-west movement in its past. Therefore, the path that you have plotted is probably pretty close to that actually taken by India.

The Himalayas are thought to be an area where two continents are actually in the process of colliding. What would you expect some of the effects of such a collision to be? Use an atlas to answer the next two questions.

7. Where is the highest elevation in the world?

Mt. Everest in the Himalayas

8. Locate the Tibetan Plateau What are some typical elevations?

Mountains rise to 25,000 feet. Valley floors are at about 20,000 feet.

9. What might cause the elevations you found for the answers to the last two questions?

The collision of two continents causes the high elevations. You may want to discuss the mechanisms of this collision as described briefly in BACKGROUND INFORMATION.

To answer the next question, compare Figure 3 with your atlas.

If a copy of either the *World Seismicity Map* (1974, U.S. Geological Survey) of *Terrestrial Heat Flow Data Map* (1976, World Data Center A for Solid Earth Geophysics, Boulder, Colorado) is available, it may be used in place of Figure 3.

10. Near what topographic features do most of the earthquakes in southeast Asia seem to occur?

In or near the Tibetan Plateau, in the Himalaya Mountains, and in the mountains of Pakistan.

How can you explain their occurrence?

The collision of India and Asia can also account for the many earthquakes that occur in southeast Asia. Again, you may want to discuss the mechanisms as described in BACKGROUND INFORMATION.

SUMMARY QUESTIONS

1. Describe the movements of India for the past 225 million years

India has moved from the southern hemisphere to its present position. It was once part of Antarctica. After its separation, it remained isolated until its collision with Asia.

2. What types of evidence are used to determine the movement of India?

In this activity, only the evidence from magnetic dip has been used to demonstrate the movement of the Indian continent. Other evidence, however, is also used by scientists, including magnetic anomaly patterns observed in the ocean floor, the correlation of rocks by using fossils and radiometric dates, and the types of fossils found in rocks of different ages.

3. What is magnetic dip?

This is the record of the inclination of the earth's magnetic field preserved in a rock, at the time and in the geographic location, where the rock formed.

4. What types of geological features and activity may result where continents collide?

Mountain ranges will be produced in the collision of continents. Where this collision is still active, as in Tibet, there may also be earthquake activity.

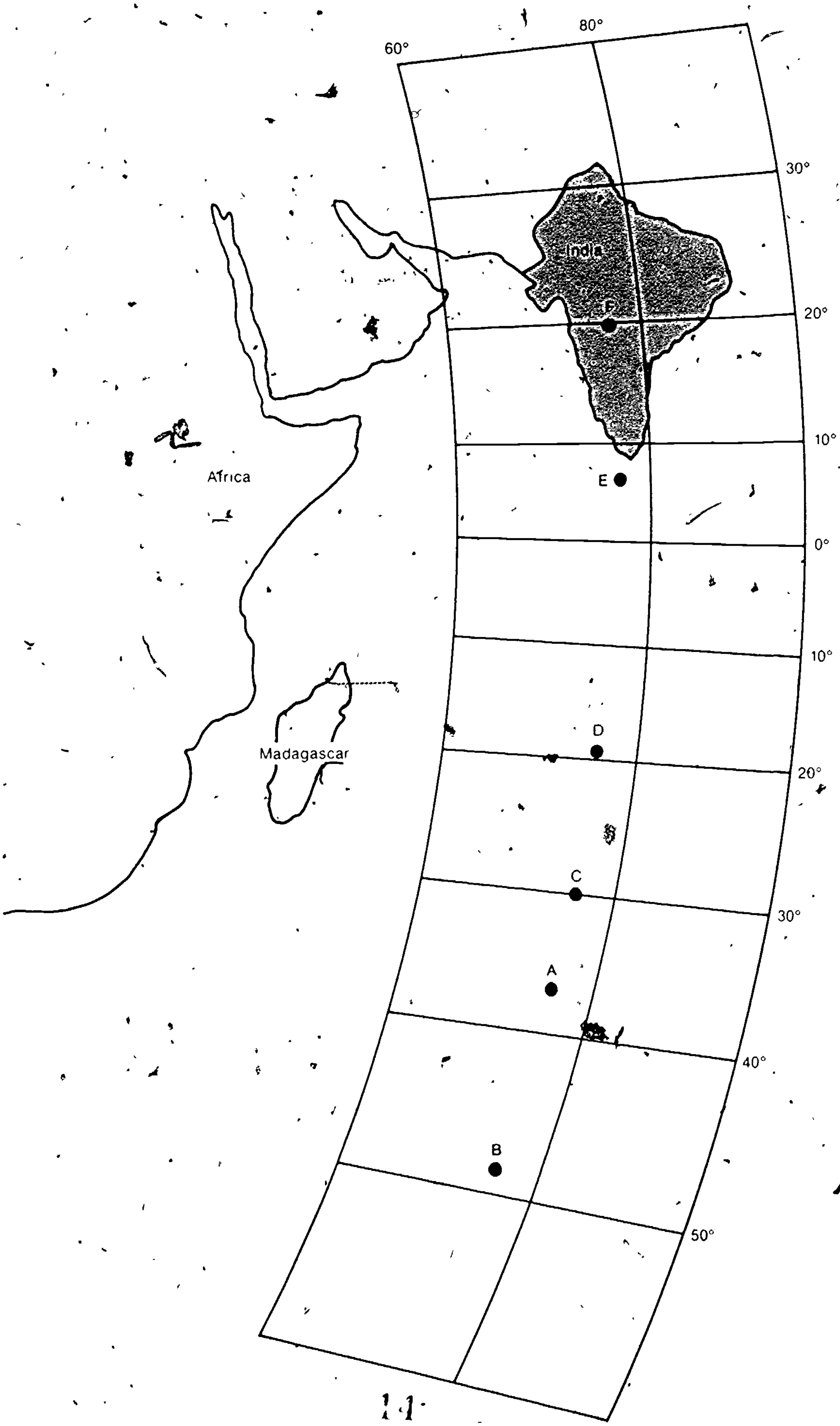
EXTENSIONS

Some devastating earthquakes have occurred in China recently. See if you can find news stories of these earthquakes in your library. What effects did they have upon people? Where were they located? Can they be explained by the collision of the two plates?

The most severe earthquakes in China have occurred far from the mountains. They cannot be readily explained by the collision of the two continents.

Chinese scientists have been recording the occurrence of earthquakes for thousands of years Recently they have been attempting to predict earthquakes. Can you locate information on their efforts to predict earthquakes? What types of methods are they using? How successful have they been?

The articles by Mead and Shaw, and the one in Science News, discuss the work of Chinese seismologists who have been attempting to predict earthquakes. You might refer your students to these articles. It also would add interest to present some of this information in your post-laboratory discussion of the activities in this module.



11

Answer Sheet 3 (PART B)

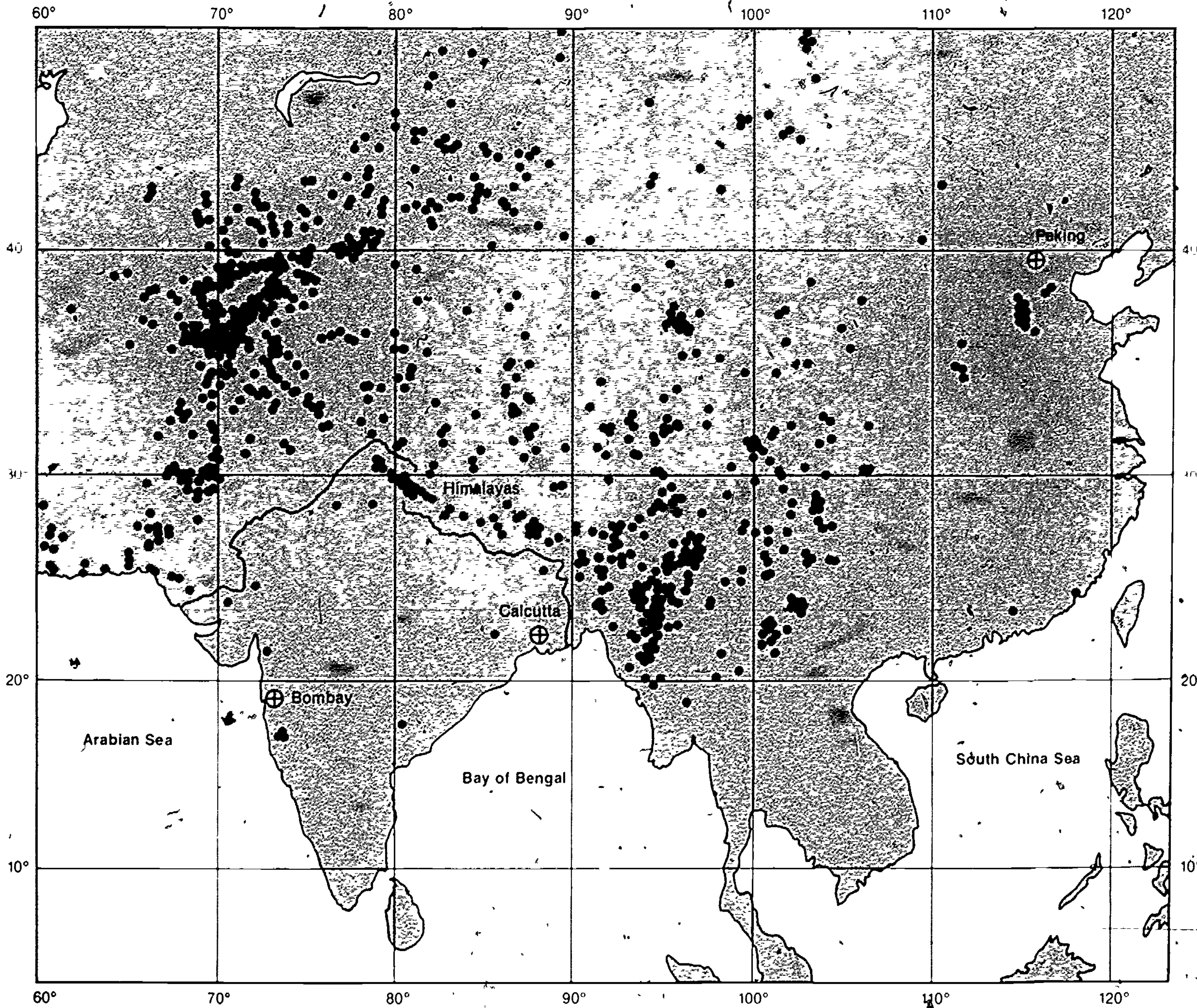


Figure 3 Epicenters of earthquakes on mainland of southeast Asia, 1961 through 1973.
(Based on *Terrestrial Heat Flow Data Map*, 1976, World Data Center A for Solid Earth Geophysics, Boulder, Colorado.)

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

Ward's Natural Science Establishment, Inc.
P.O. Box 1712, Rochester, New York 14603 • P.O. Box 1749, Monterey, California 93940

CEEP MODULE NO. OH12 1-5
ISBN: 0-89873-006-2

Printed in U.S.A

CRUSTAL EVOLUTION EDUCATION PROJECT

NAME DATE

Student Investigation
Catalog No. 34W1105

Drifting Continents And Magnetic Fields

INTRODUCTION

Scientists have determined that at one time India was a part of Antarctica It broke off from Antarctica and for 200 million years drifted northward. isolated from any other landmass Finally it collided with Asia, resulting in the uplift of the Himalaya Mountains Perhaps you have heard about the earthquakes in that part of the world. These earthquakes are the result of this collision process of one continent with another They tell us that it is still going on

OBJECTIVES

After you have completed these activities, you should be able to

1. Explain what is meant by magnetic dip
2. Use the magnetic dip preserved in rocks to determine the latitude of India at certain times in the past. and its rate of movement
3. Identify the collision of India and Asia as the cause of the Himalayas

PROCEDURE

PART A What is magnetic dip?

Materials protractor, ruler and pencil

The earth is surrounded by a magnetic field, which is strongest near the north and south magnetic poles. It can't be seen. However, anyone who has used a magnetic compass has observed it. The compass allows one to "tell directions" (north, south, east, or west) Telling directions is using only one part of the magnetic field—the horizontal part. Since the field is three-dimensional, there is another part at right angles to the horizontal part. We will call this the vertical part To observe the vertical part of the field, you use a **dip needle.** It is similar to an ordinary compass except that the needle is allowed to rotate vertically instead of horizontally. The angle formed by the dip needle and the horizon is known as the **magnetic dip.**

1. Your teacher has shown you a compass and a dip needle. Which would you use to measure the horizontal part of the earth's magnetic field? ________ Determine the direction, with a compass, to some object in your room or school yard.

Object ____________________

Direction ____________________

What instrument would you use to measure the vertical part of the earth's magnetic field? ________

In this activity you will be using the magnetic dip recorded in rocks. When molten rocks reach the surface of the earth and begin to cool, certain minerals within the rocks are magnetized parallel with the magnetic field of the earth. These rocks will then have a weak magnetic field themselves. The positions of samples of the rocks are recorded before they are collected. Scientists can then measure the horizontal and vertical parts of the magnetic fields of these rocks. This will tell them about the magnetic field in the area at the time the rocks cooled.

2. After you observe your teacher's demonstration, label the north and south poles on the diagram on Worksheet 1.

3. Notice that a horizon line has been drawn at location C. A **horizon line** is a straight line touching the circle but not intersecting it. Draw in the horizon line at the other four locations. To make a horizon line, first draw a straight line from the center of the circle to the point on the circle through which the horizon line must pass. (This line is the *radius* of the circle.) Then draw a line 90° (perpendicular) to the radius at the point on the circle. This is the horizon line for that point. Measure the angle of dip of the magnetic field at each location. It will be the angle formed by a line of magnetic force and the horizon. Note that the radius and dip angle for C are already shown.

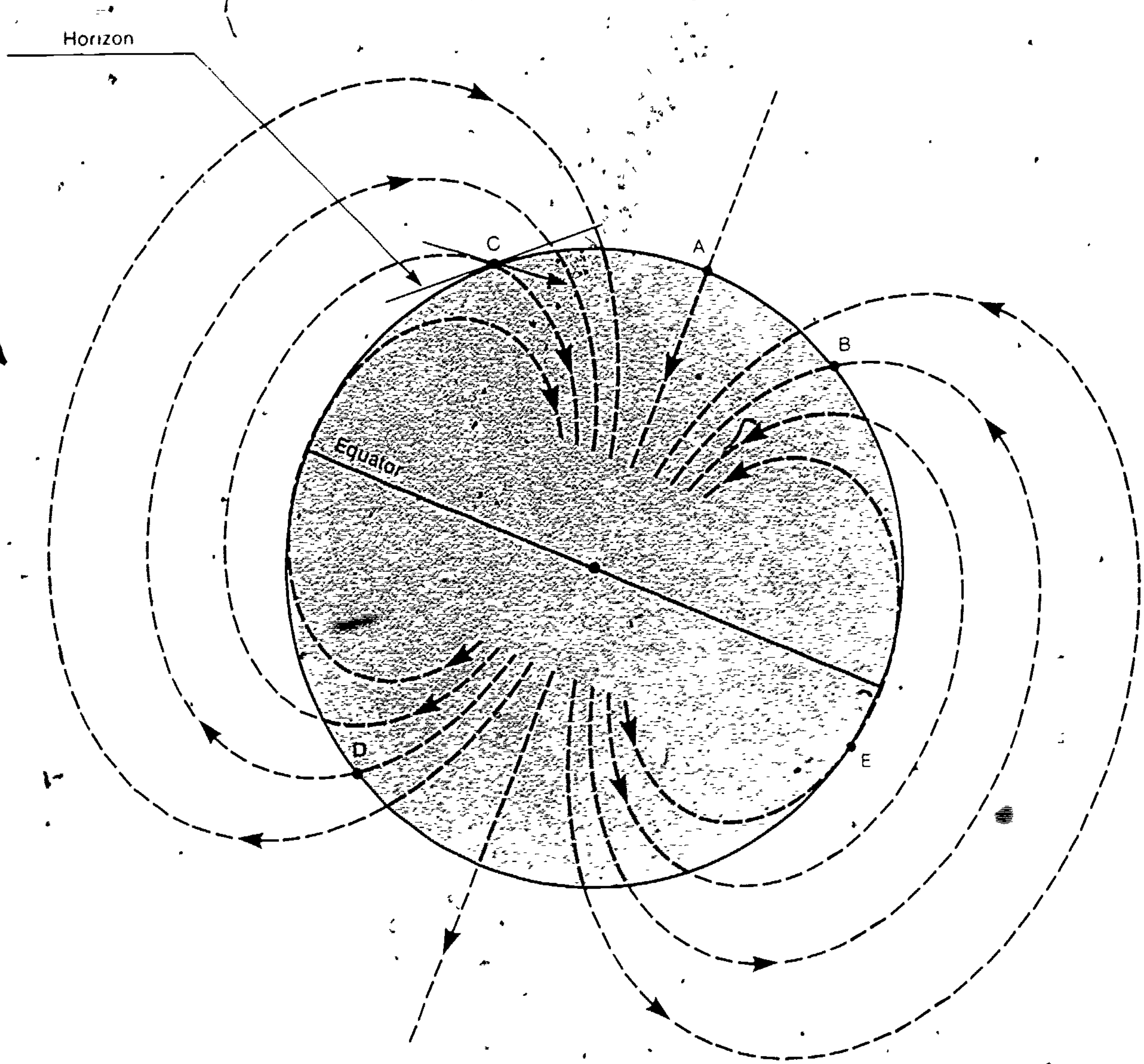
A ____ B ____ C ____ D ____ E ____

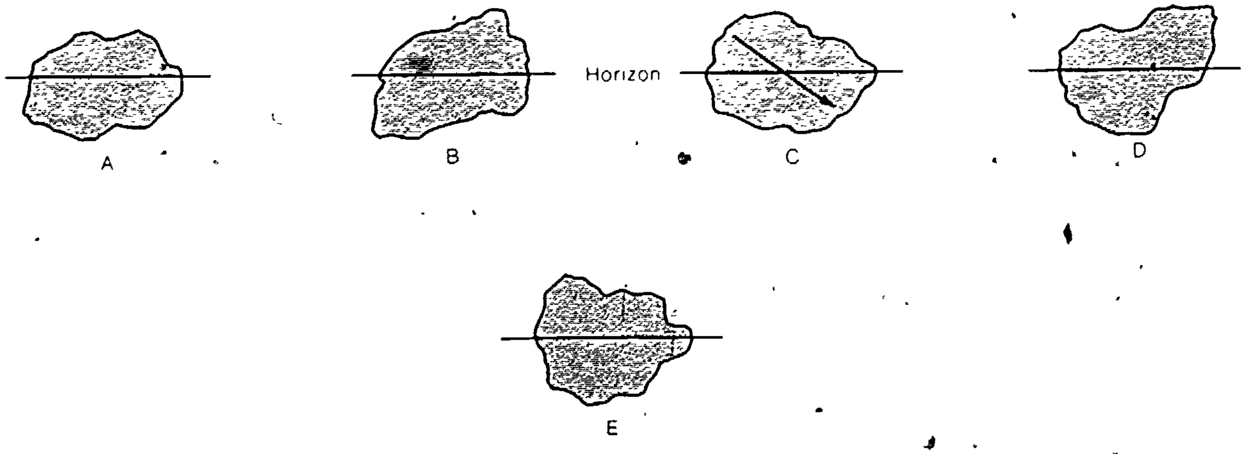
4. Worksheet 1 has drawings of rocks collected at each of the five locations. Draw arrows on the rock drawings showing the direction of dip recorded by the magnetic minerals in these rocks. The rocks are all samples from recent lava flows.

5. Where on the earth is the dip the greatest? ____________ the least? ____________

6. Samples A, B, and C are from the northern hemisphere. What is the relationship between dip and distance from the north magnetic pole?

7. Samples D and E are from the southern hemisphere. What happens to the dip in the southern hemisphere?





Worksheet 1 (PART A)

PROCEDURE

PART B What does magnetic dip tell about India?

Materials protractor, ruler and pencil, atlas

Geophysicists find that the ancient magnetic dip may be different in rocks of different ages on the same continent This is particularly true of India.

Figure 1 shows drawings of six rocks Each rock is from a different formation in India. Samples B and D are from lava flows. The others are sedimentary rocks that contain particles of iron Iron particles will often act like tiny magnetic compasses as sediments are being deposited They align themselves with the magnetic field of the earth. Sedimentary rocks and igneous rocks, then, can provide a record of the earth's magnetic field

Note that the age of each rock is given in years Geologists can determine how long ago an igneous rock crystallized by a method known as **radiometric dating.** They can also determine the approximate time of deposition of sediments at a site where igneous rocks have cut across the sedimentary rocks

The direction of magnetic dip is indicated by the arrow on each sample.

1. Use the protractor to measure the angle of magnetic dip for each sample and place your results in the proper column of the Data Sheet on Worksheet 2

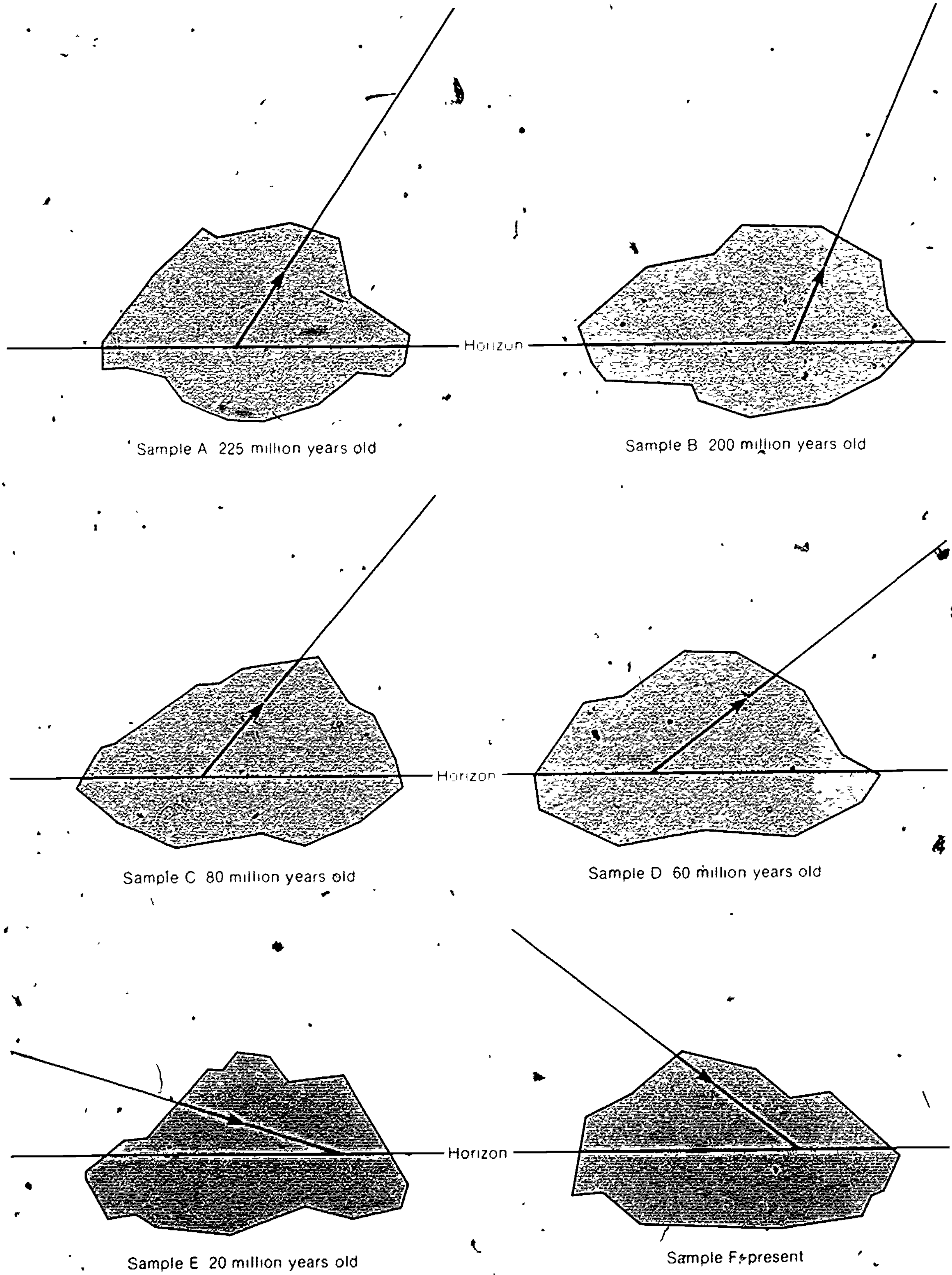


Figure 1. The direction of magnetic dip is diagramed on these rock samples from India.

What could cause the magnetic dip of the rocks found in India to change during the last 225 million years? There are three possibilities

a. The north magnetic pole has moved

b India has moved.

c. Both the north magnetic pole and India have moved

Most scientists now believe that the magnetic poles have always remained relatively close to the earth's geographic poles and that the geographic poles have always remained in an area near their present positions. Therefore, a and c are not acceptable explanations, and the only possible explanation is that India has moved

Since the magnetic and geographic poles are close together, you can assume for this activity that they are indeed the same. Therefore, the angle of magnetic dip can give you latitude and distance from a geographic pole if you use this graph (Figure 2)

2. Using Figure 2, determine the **paleolatitude** (ancient latitude) for each of your samples from India. Record this on your Data Sheet on Worksheet 2

3. Plot the paleolatitude and age of each sample on the graph on Worksheet 2

4. From the graph you have just plotted, determine the average rate of movement of India during the last 200 million years in cm/year.

5. Has India always moved at the same rate of speed during the last 200 million years?

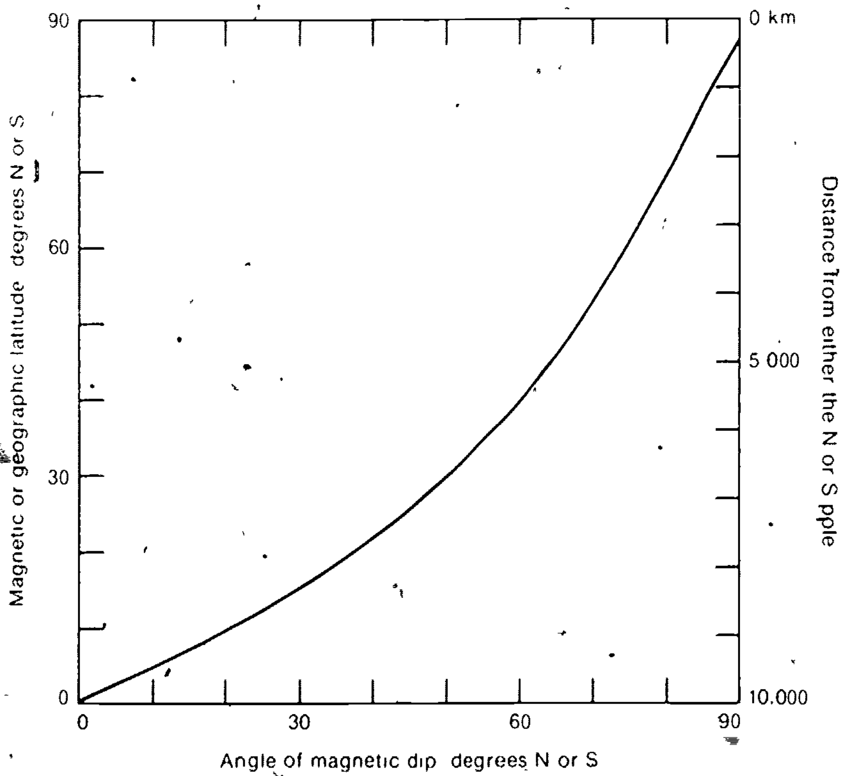
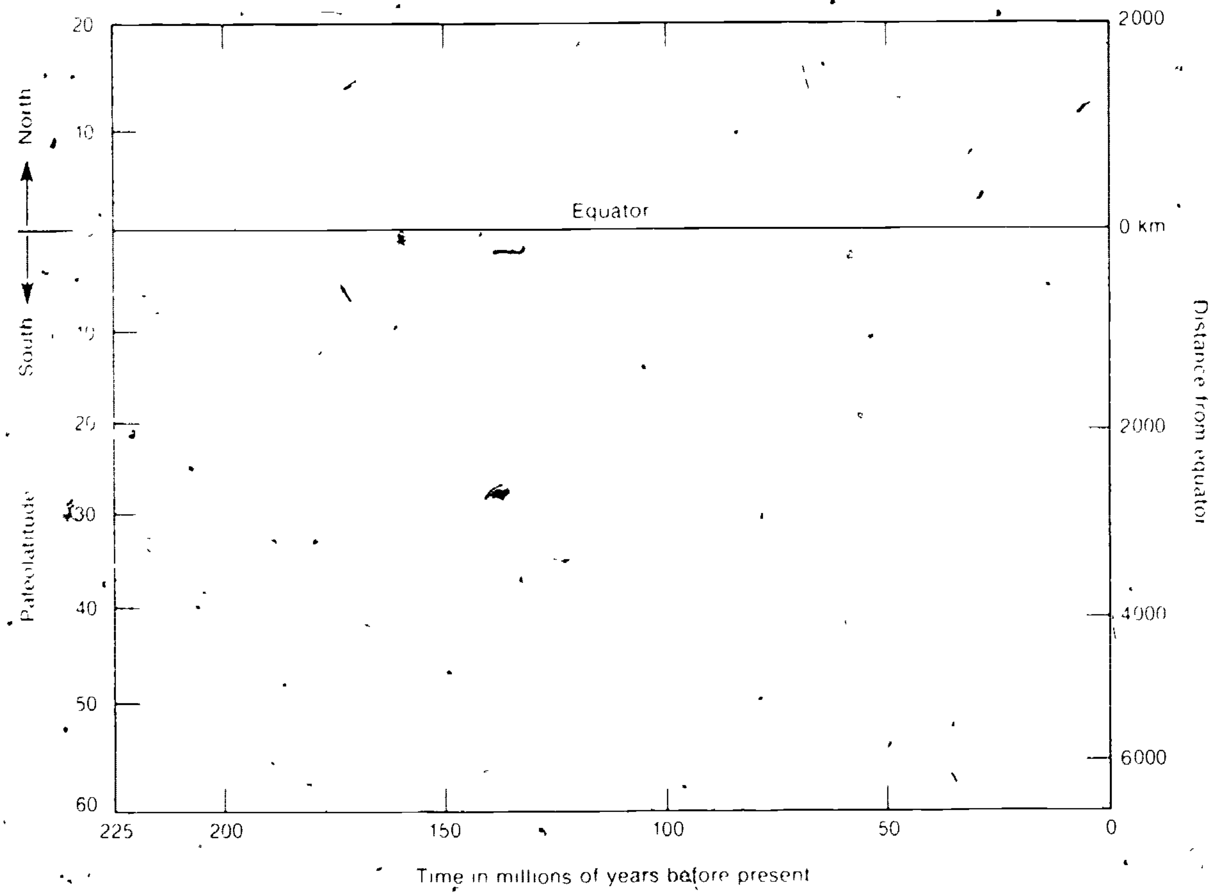


Figure 2. Graph showing relationship between distance from magnetic poles and angle of magnetic dip

Data Sheet

Rock Sample	A	B	C	D	E	F
Age of Sample	225m y	200m y	80m y.	60m y	20m y	Present
Angle of Dip						
Paleolatitude						

Graph



Worksheet 2 (Part B)

6. Mark the position of India for the various dates of your samples on the map on Worksheet 3.

Scientists have discovered that India has not had very much east-west movement in its past. Therefore, the path that you have plotted is probably pretty close to that actually taken by India

The Himalayas are thought to be an area where two continents are actually in the process of colliding What would you expect some of the effects of such a collision to be? Use an atlas to answer the next two questions

7. Where is the highest elevation in the world?

8. Locate the Tibetan Plateau. What are some typical elevations?

9. What might cause the elevations you found for the answers to the last two questions?

To answer the next question, compare Figure 3 with your atlas

10. Near what topographic features do most of the earthquakes in southeast Asia seem to occur?

How can you explain their occurrence?

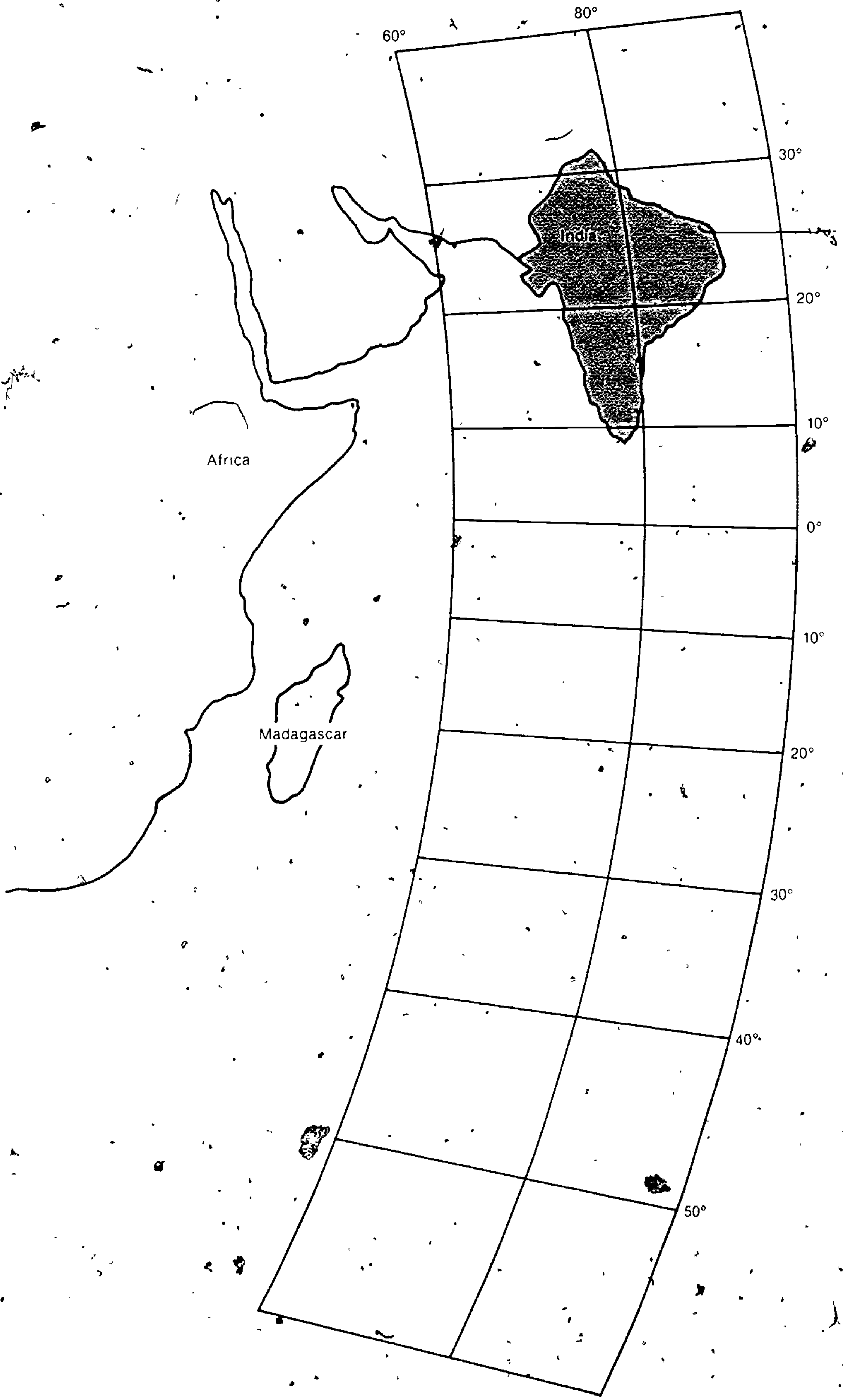
SUMMARY QUESTIONS

1. Describe the movements of India for the past 225 million years

2. What types of evidence are used to determine the movement of India?

3. What is magnetic dip?

4. What types of geological features and activity may result where continents collide?



Worksheet 3 (PART B)

EXTENSIONS

Some devastating earthquakes have occurred in China recently. See if you can find news stories of these earthquakes in your library. What effects did they have upon people? Where were they located? Can they be explained by the collision of the two plates?

Chinese scientists have been recording the occurrence of earthquakes for thousands of years Recently they have been attempting to predict earthquakes. Can you locate information on their efforts to predict earthquakes? What types of methods are they using? How successful have they been?

REFERENCES

Mead, D.F., 1976, How the Chinese predict earthquakes. *Science Digest*, v 79, no. 3 (Mar.), p. 57-61

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

China's quake forecasting: 50-50. *Science News*, 1977, v. 112, no 9 (Aug.), p. 133-134.

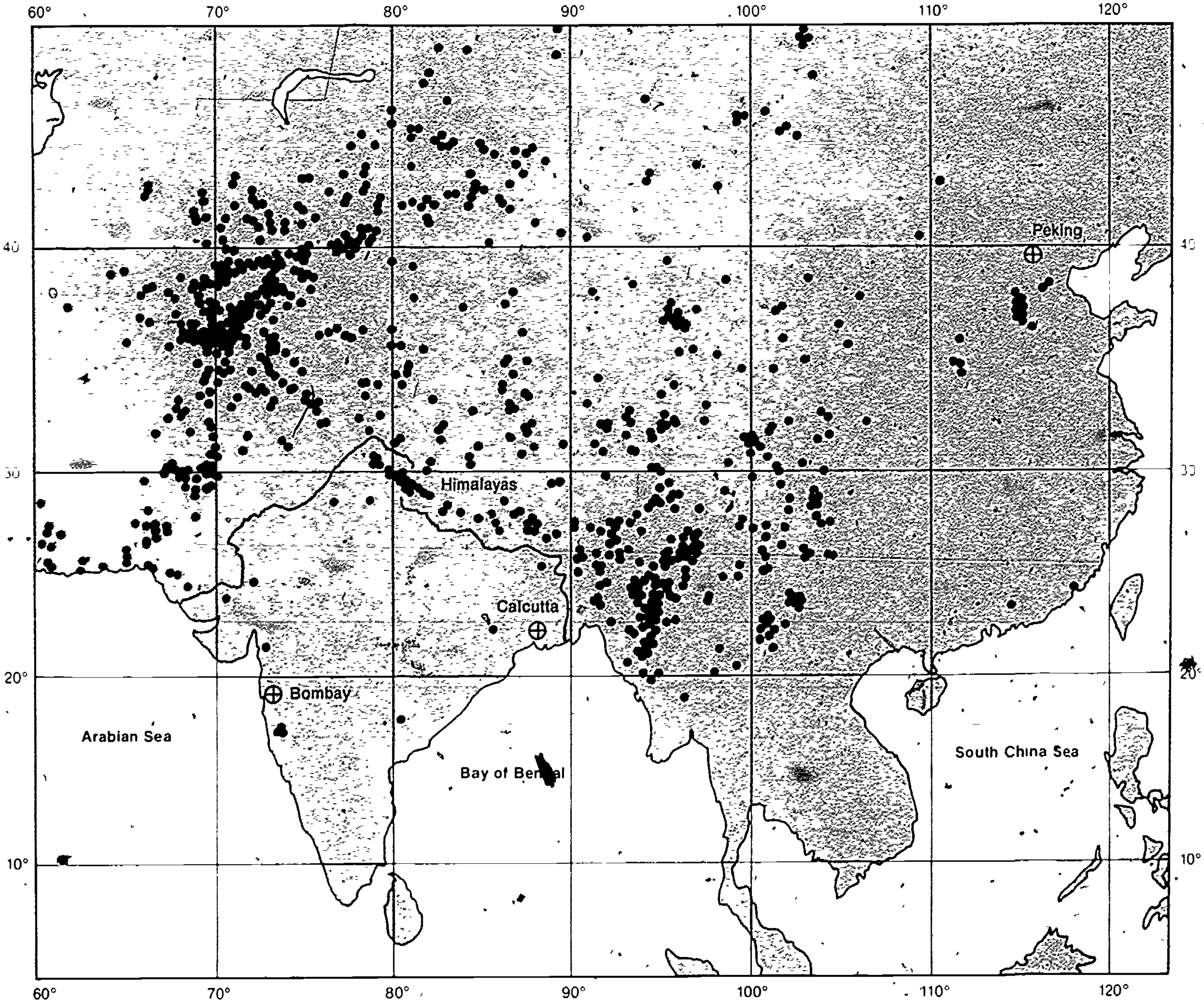


Figure 3 Epicenters of earthquakes on mainland of southeast Asia, 1961 through 1973
(Based on *Terrestrial Heat Flow Data Map*, 1976, World Data Center A for Solid Earth Geophysics, Boulder, Colorado)