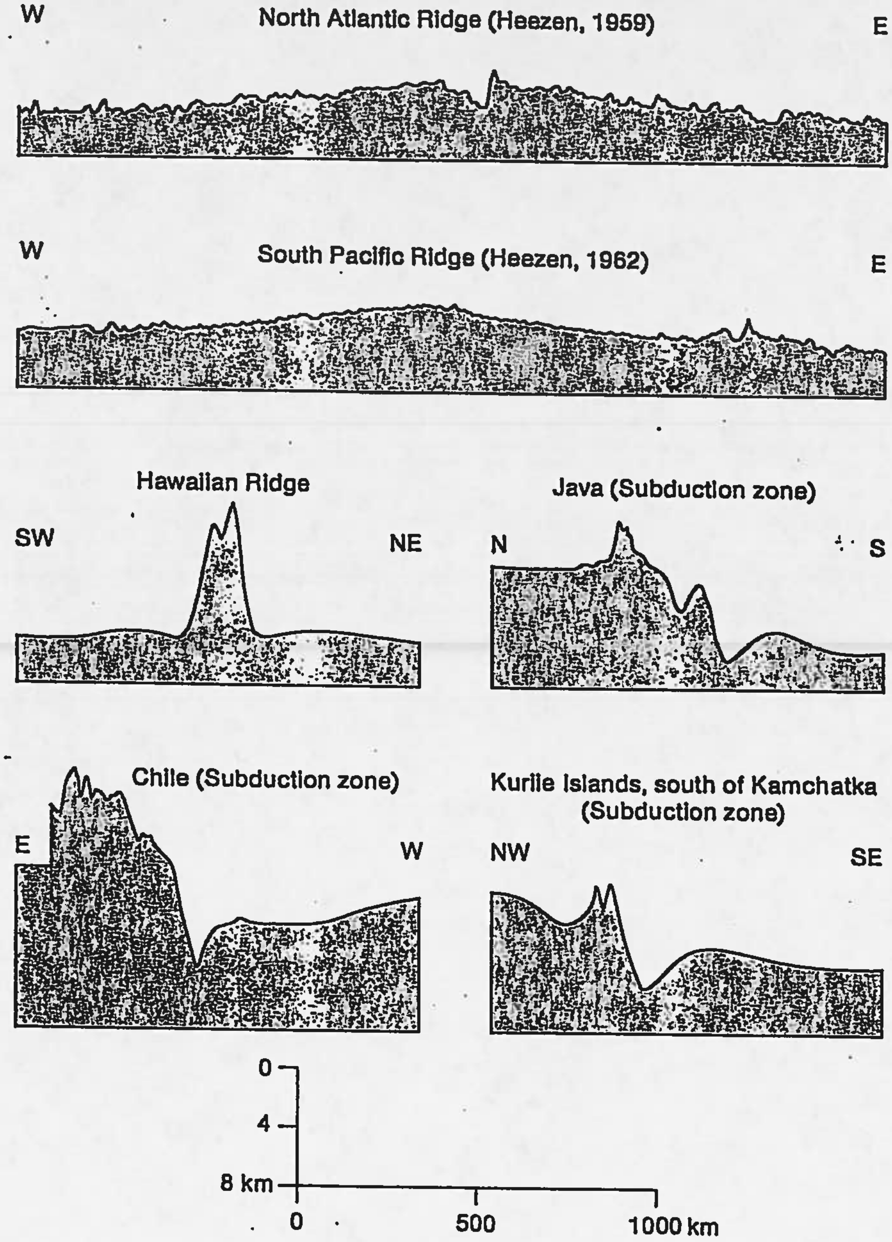


49 Comparison of topographic profiles

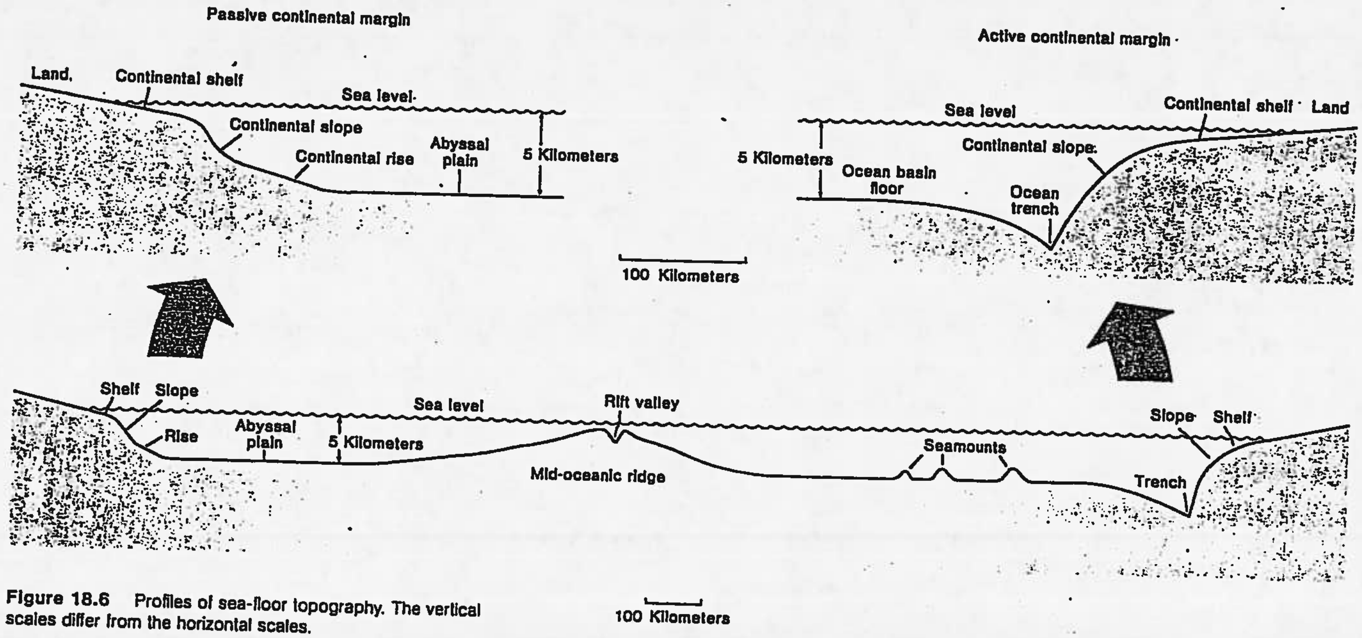
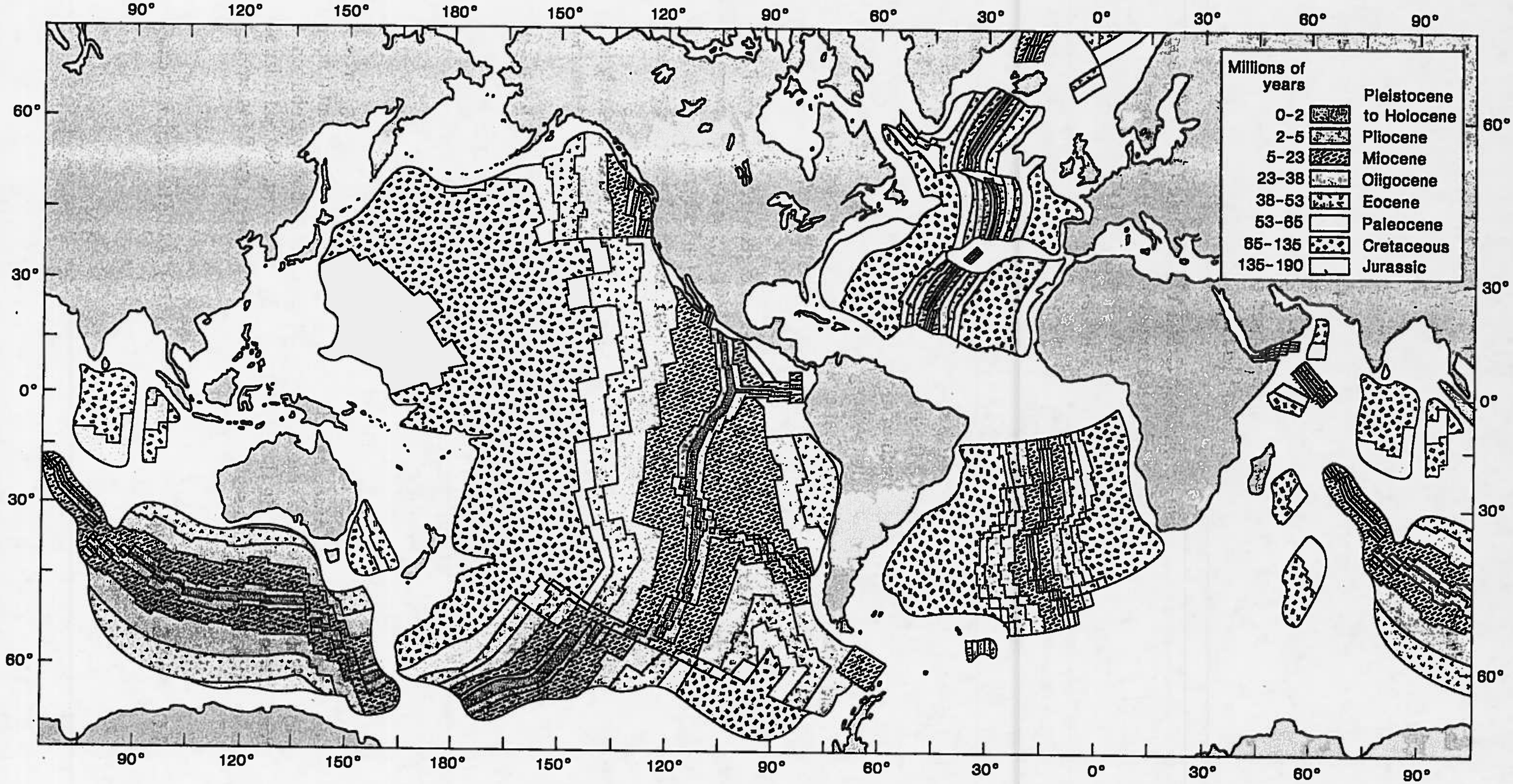


Figure 18.6 Profiles of sea-floor topography. The vertical scales differ from the horizontal scales.

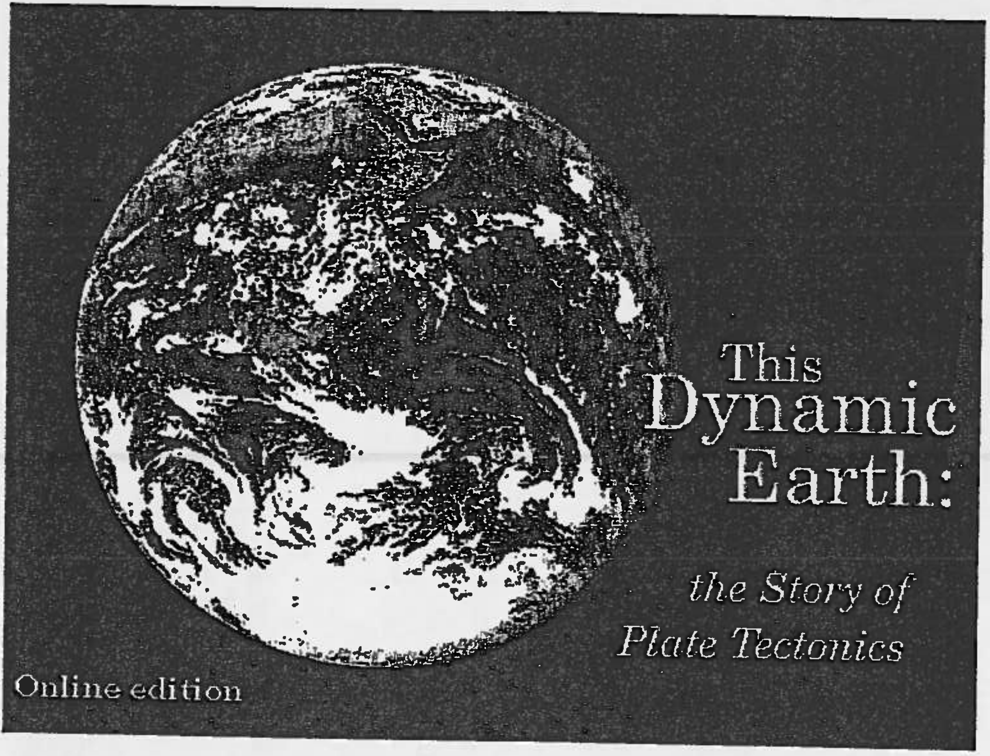
25 Age of Sea Floor
Figure 19.23

From a map by W. C. Pitman III, R. L. Larson, and E. M. Herron, 1974, Geological Society of America.



Charles C. Plummer and David McGeary, *Physical Geology*, 3d ed., © 1985, Wm. C. Brown Publishers

USGS

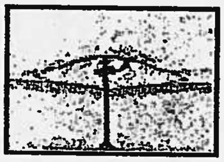


View of the planet Earth from the *Apollo* spacecraft. The Red Sea, which separates Saudi Arabia from the continent of Africa, is clearly visible at the top. (Photograph courtesy of NASA.)

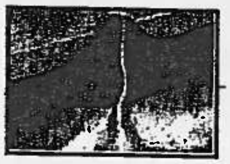
Preface

Historical perspective

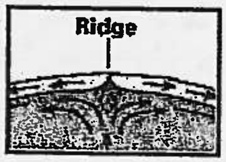
Developing the theory



Understanding plate motions



"Hotspots": Mantle thermal plumes



Some unanswered questions

Plate tectonics and people

Endnotes

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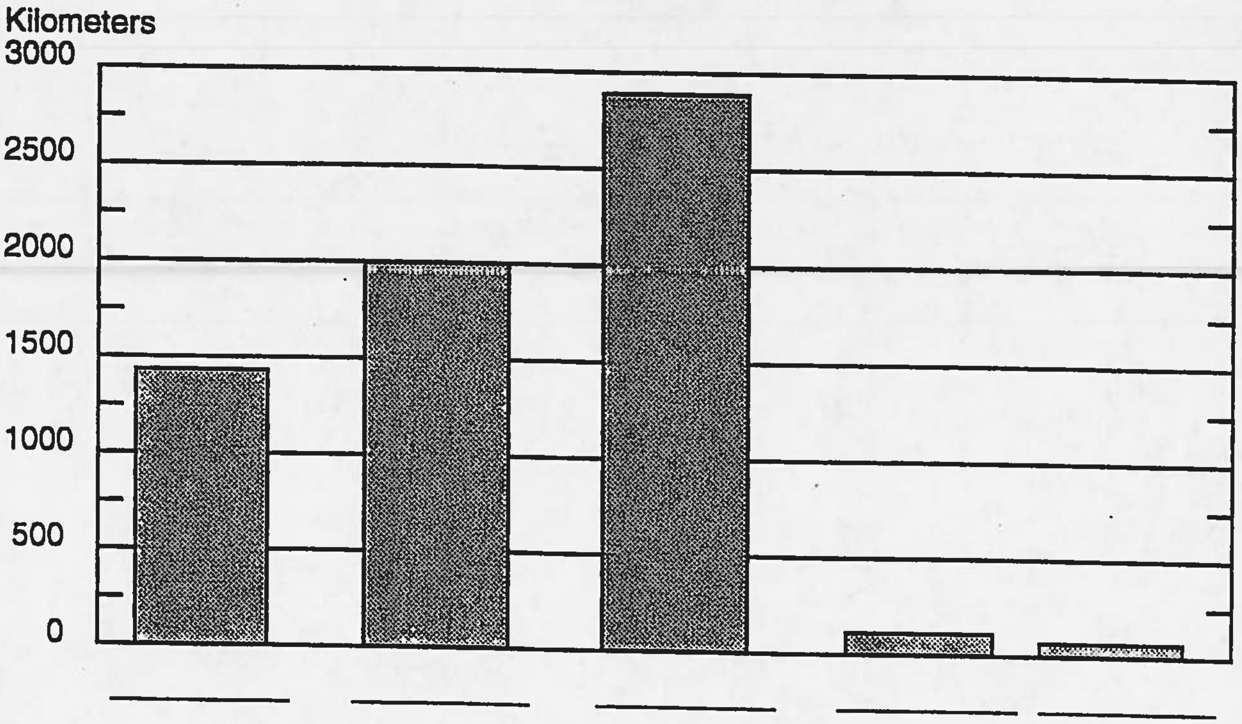
Activity 1.11 Graph of the Earth's Layers

Name: ______________



1. Lable each bar with the appropriate layer:

Mantle
Outer core
Crust
Inner core
Lithosphere

3. How thick is each layer?

Inner core ______________

Outer core ______________

Mantle ______________

Lithosphere ______________

Crust ______________

2. Using the bar graph, put the correct thickness in each blank.

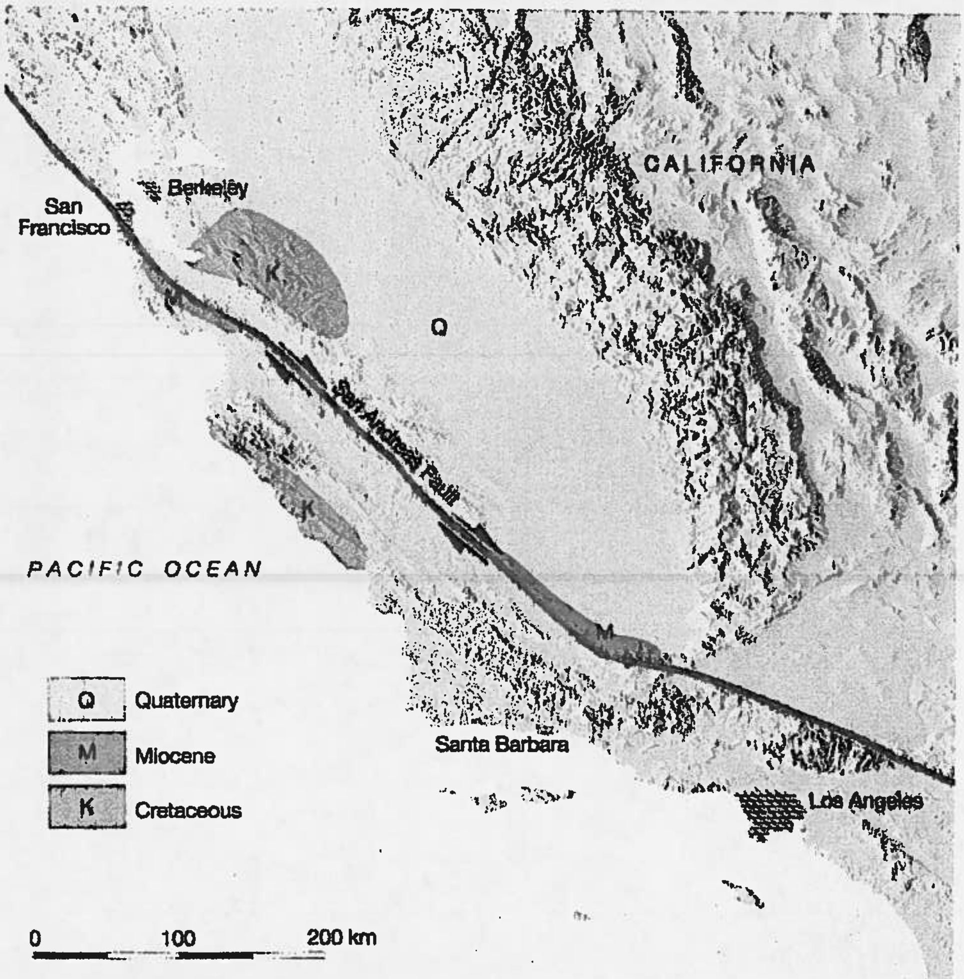
40 km
100 km
1,400 km
2,000 km
2,900 km

4. Answer the questions.

Which layer of the Earth is the thickest? ______________

Which layer of the Earth is the thinnest? ______________

Modified from Earthquakes-NSTA/FEMA

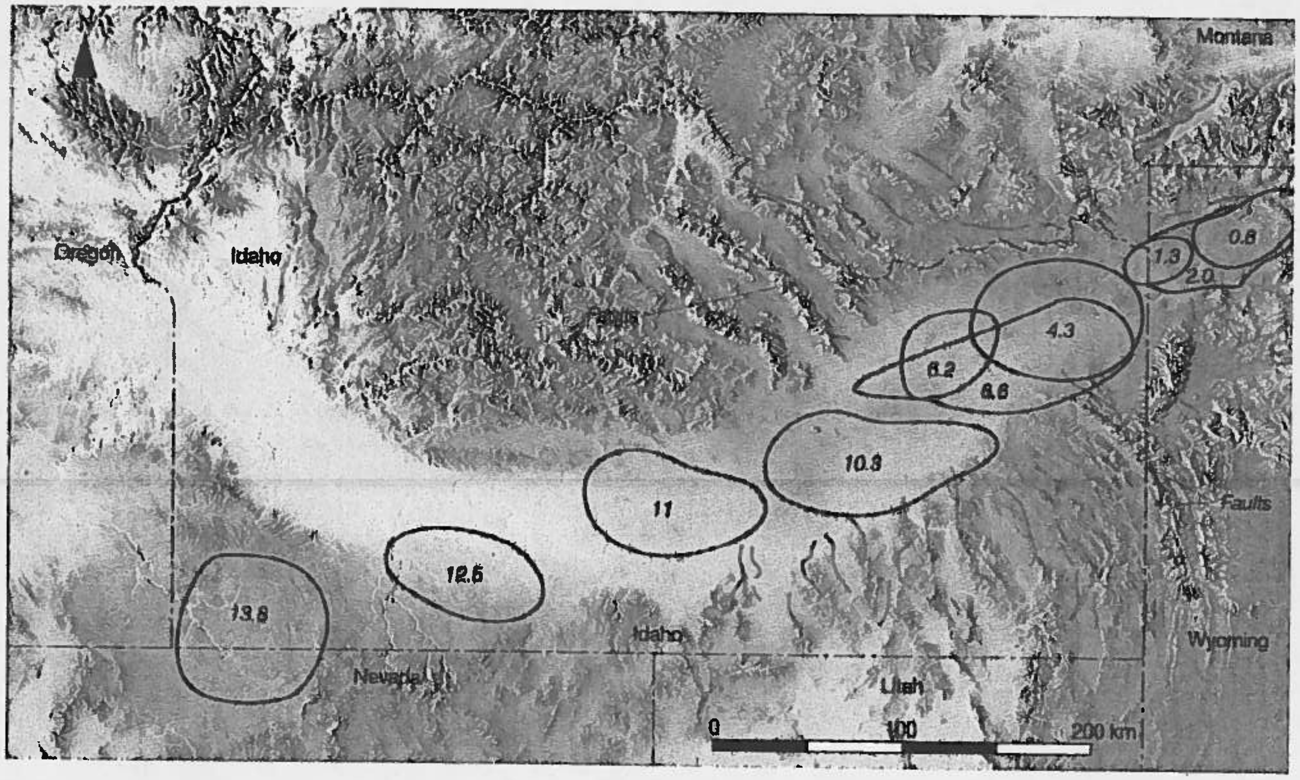


Generalized geologic map of southern California. Half-arrows indicate relative motions along the San Andreas Fault. The fault is also a boundary between two of Earth's lithospheric plates. The relative motion of the Pacific Plate (under the Pacific Ocean) is northwest. The North American Plate is located east of the fault and is moving relatively southeast. The two bodies of Miocene rocks (about 15 million years old) located along either side of the San Andreas Fault were one body of rock that has been separated by motions along the fault.

a. You can estimate the average annual rate of movement along the San Andreas Fault by measuring how much the Miocene rocks have been offset by the fault, and by assuming that these rocks began separating soon after they formed. What is the average annual rate of fault movement in centimeters per year (cm/yr)?

b. The average yearly rate of movement on the San Andreas Fault is very small. Does this mean that the residents of southern California have nothing to worry about from this fault? Explain.

c. An average movement of about 5 m (16 ft) along the San Andreas Fault was associated with the devastating 1906 San Francisco earthquake that killed people and destroyed property. Assuming that all displacement along the fault was produced by Earth motions of this magnitude, how often must such earthquakes have occurred in order to account for the total displacement?



This figure shows the distribution of circular areas that were centers of crustal faulting and buckling when they were located over the Yellowstone hot spot. The numbers indicate the ages of deformation, as determined by Mark Anders (by dating tilted layers of ash and basalt that accumulated on the deformed areas).

a. What direction is the North American plate moving, according to Anders' data? Explain your reasoning.

b. What was the average rate in centimeters per year (cm/yr) that the North American plate has moved over the past 11 million years?

WHAT ON EARTH IS PLATE TECTONICS?

The Earth is covered by a thin skin of solid crust and uppermost mantle called the lithosphere. The lithosphere is broken up into interconnected slabs that geologists call plates. Plate tectonics is the theory that describes how these plates move about and interact with each other at their boundaries.

1) There are two basic types of lithosphere, CONTINENTAL and OCEANIC. Continental lithosphere is made of relatively light-weight minerals, so it has a low density. Oceanic lithosphere is more dense than continental lithosphere because it is composed of heavier minerals. A single plate may be partly oceanic and partly continental lithosphere.

2) Beneath the lithospheric plates lies a layer of very dense, semi-molten rock called the ASTHENOSPHERE. Plates are less dense than the asthenosphere beneath them. This means that the plates are truly floating on top of the asthenosphere.

3) Deep within the asthenosphere the pressure and temperature are so high that the rock softens and partially melts. This softened, dense rock can flow very slowly (think of Silly Putty). Where temperature instabilities exist near the core/mantle boundary, slowly moving CONVECTION CURRENTS may form within the semi-fluid asthenosphere.

4) Convection currents bring hot material from deeper within the mantle up toward the surface.

5) Convection currents diverge where they approach the surface. The diverging currents exert a weak tension or "pull" on the plate above it. Tension and high heat flow weakens the floating, solid plate, causing it to break apart. The two sides then move away from each other in opposite directions, forming a DIVERGENT PLATE BOUNDARY.

6) The 'gap' between these diverging plates fills with molten rock from below. Sea water cools the molten rock, which quickly solidifies, forming new oceanic lithosphere. This continuous process builds a chain of volcanoes and rift valleys called a MID-OCEAN RIDGE or SPREADING RIDGE.

7) Little by little, as new molten rock is extruded at the mid-ocean ridge, the newly created oceanic plate moves away from the ridge where it was created.

8) As distance from the hot spreading ridge increases, the oceanic plate cools down. The colder the oceanic plate gets, the denser ("heavier") it gets. Eventually the edge of the plate that is farthest from the spreading ridge cools so much that it becomes more dense than the asthenosphere beneath it.

9) As you know, denser materials sink, and that's exactly what happens to the oceanic plate—it starts to sink into the asthenosphere! Where one plate sinks beneath another a SUBDUCTION ZONE forms.

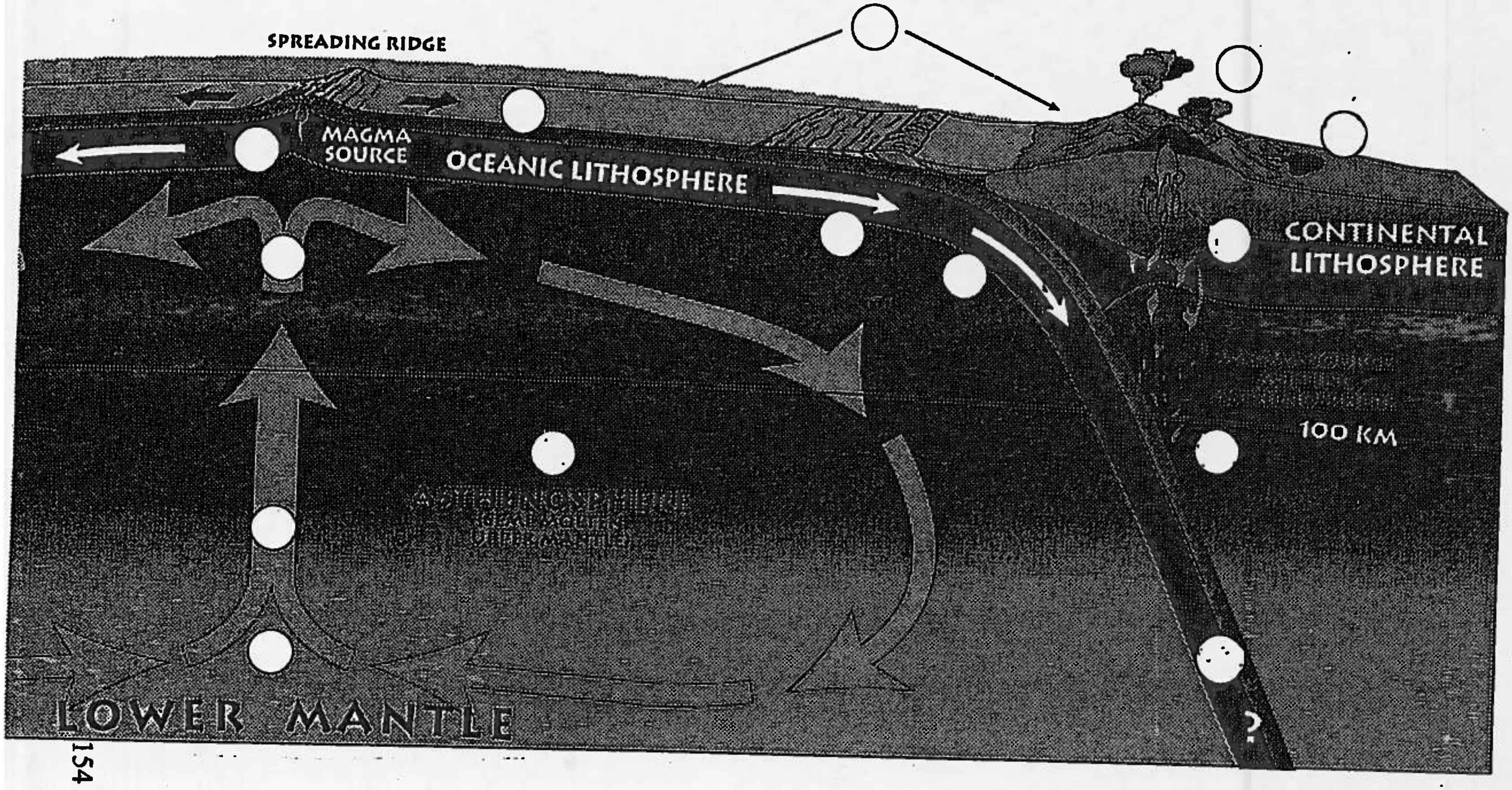
10) The sinking leading edge of the oceanic plate actually 'pulls' the rest of the plate behind it—evidence suggests this is the main driving force of SUBDUCTION. Geologists are not sure how deep the oceanic plate sinks before it melts, but we do know that it remains solid far beyond depths of 100 km beneath the Earth's surface.

11) Subduction zones are one type of CONVERGENT PLATE BOUNDARY, the type of plate boundary that forms where two plates converge. Notice that although the cool oceanic plate is sinking, the buoyant continental plate floats like a cork on top of the more dense asthenosphere.

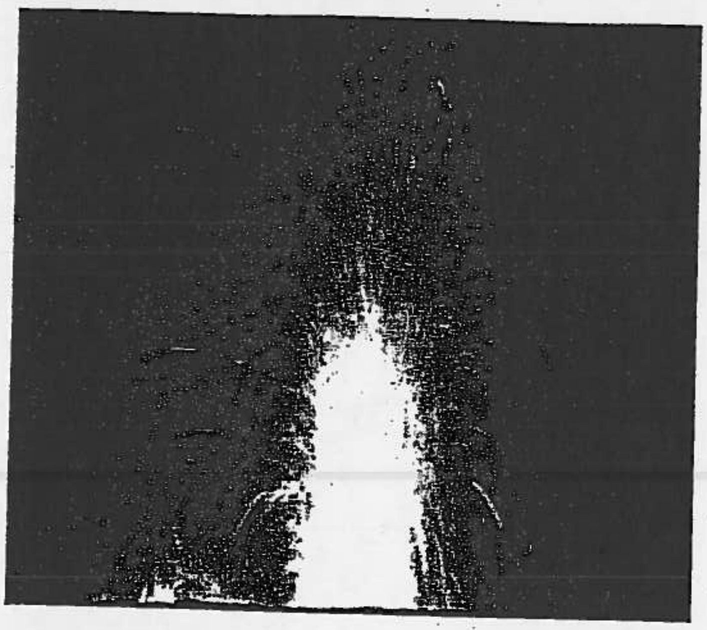
12) When the subducting oceanic plate sinks more than 100 kilometers below the Earth's surface, huge temperature and pressure increases cause water and other volatile gasses trapped in the minerals of sinking plate to be released. These gasses work their way upward, MELTING THE MANTLE above the subducting plate.

13) The newly generated molten mantle is less dense than the surrounding rock, so it rises toward the surface. On its way upward, dense minerals solidify from the magma and are left behind, making the magma increasing less dense as it approaches the Earth's surface. Most of the molten rock cools and solidifies in magma chambers far below the Earth's surface. Large INTRUSIVE rock bodies that form the backbones of great mountain ranges such as the Sierra Nevada form by this process.

14) Some molten rock may break through the Earth's surface, instantly releasing the huge pressure built up in the gas-rich magma chambers below. Gasses, lava and ash explode out from the surface breach. Over time, layer upon layer of erupting lava and ash build volcanic mountain ranges above the simmering cauldrons of crystals and magma below.



A Teacher's Guide to the Geology of Hawaii Volcanoes National Park



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This guide is designed for teachers, other educators, and anyone interested in volcanoes. It provides background information on numerous topics and includes teaching suggestions and activities. Although the guide focuses on Hawaiian volcanoes, similar processes and features are observed at volcanoes around the world.

When a lava cools and solidifies, the magnetic domains within the iron minerals contained in the lava align in the direction of Earth's magnetic field. The solidified lava thus preserves a record of Earth's magnetic field at the time the ks were formed. As early as 1906 scintists recognized that the poles of the magnetic field preserved in some rocks were oriented in the opposite direction from the poles evident in other specimens, as if Earth's north and south magnetic poles had switched places.

Subsequent studies showed that these magnetic reversals do, indeed, occur, and that the magnetic poles have been reversed many times during the geologic past. The effect of these reversals has been to create periods of "normal" magnetism (periods in which the polarity matched the present position of the north and south magnetic poles), and periods when the magnetic field was reversed.

To test the plate tectonics theory, scientists proposed that, if new oceanic crust is created at the oceanic ridges by the extrusion of lava, then the rocks on the ocean floor adjacent to the ridges should preserve a record of the periods of normal and reversed magnetism. If we measure the strength of Earth's gnetic field across the ridge, a series of anomalies, or differences, should occur. Where rocks solidified during periods of "normal" magnetism, higher values should be found because induced magnetism adds to the present strength of the magnetic field. Lower values should be found in rocks solidified during reversed magnetism, because the polarity of these rocks reduces the local effect of Earth's present magnetic field.

If we were to map the magnetic anomalies across the oceanic ridge, alternating bands of high and low magnetism should appear on both sides of the ridge, one side being the mirror image of the other. Such a pattern would provide strong evidence for sea-floor spreading and the theory of plate tectonics.

The map on the right is of a portion of the Atlantic Ocean and the magnetic measurements made by a research vessel as it crossed the ridge on four traverses. When the curve on a traverse ove zero, the strength of the magnetic field is greater than normal (it adds to the strength of the present magnetic field). Where the curve drops below zero, the strength of the magnetic field is less than normal because the paleomagnetism in the rocks has a reverse polarity and thus reduces the present strength of the magnetic field.

The objective of this exercise is to determine the zones of normal and reverse polarity along each track of the research vessel and to correlate the zones along this part of the Mid-Atlantic Ridge.

a. On curve A, note the points where the magnetic curve intersects the line of zero field strength. To emphasize the negative anomalies (areas below the zero line of the curve), shade them gray with a soft pencil. The first two adjacent to the ridge crest are done to illustrate. Do the same for curves B, C, and D.

b. On curve A, color the positive magnetic anomalies as follows: youngest = red, next youngest = orange, next youngest = light green, and next youngest = dark green. Do the same for curves B, C, and D.

c. The Mid-Atlantic Ridge is offset by numerous fracture zones. We have generalized this segmentation of the ridge by showing only a few major fracture zones between each traverse. The next step is to interpolate the patterns of magnetic anomalies between each traverse. This can be done by projecting the crest of the ridge perpendicular to the fracture zone and then extending each positive anomaly from the measured curve up to the fracture zone. This creates bands of magnetic anomalies offset by fracture zones.

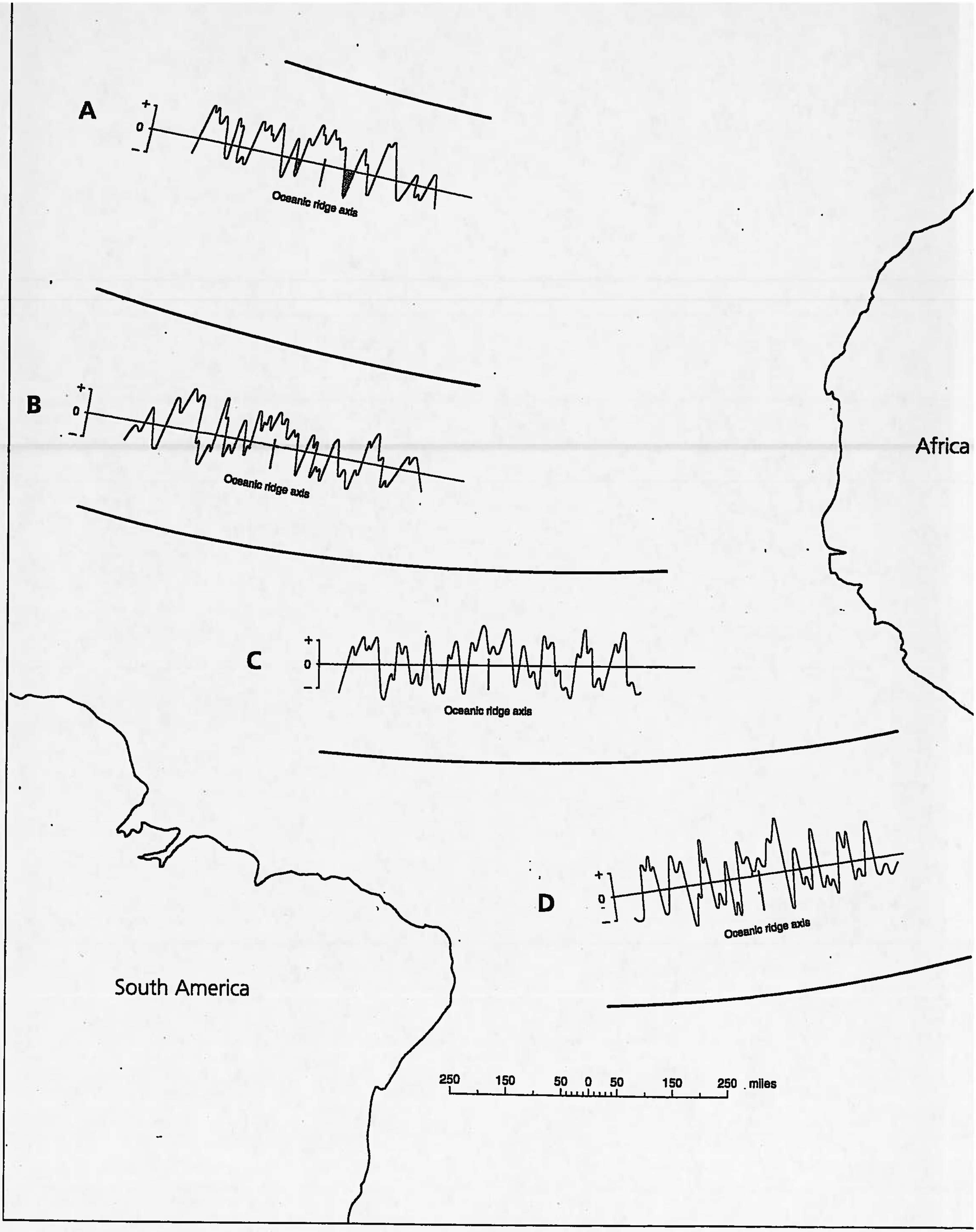
d. Color all positive anomalies red, orange, light green, and dark green, as you did on the measured curves.

e. Describe, briefly, the patterns of the magnetic anomalies shown on the map that you have constructed. Do the patterns cross or parallel the oceanic ridge? Are the patterns on either side of the ridge similar or different?

anomalies on the sea floor supports the theory of plate tectonics.

g. Refer to the geomagnetic time scale in your textbook and determine the age of each band on the map.

h. Calculate the average rate of spreading of the floor of the Atlantic Ocean during the last 3 million years. (Use the map scale and the time duration of the rock units determined from the geomagnetic time scale in your text.)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0
–
Oceanic ridge axis
B
+
0
–
Oceanic ridge axis
Africa
C
+
0
–
Oceanic ridge axis
D
+
0
–
Oceanic ridge axis
South America
250 150 50 0 50 150 250 miles

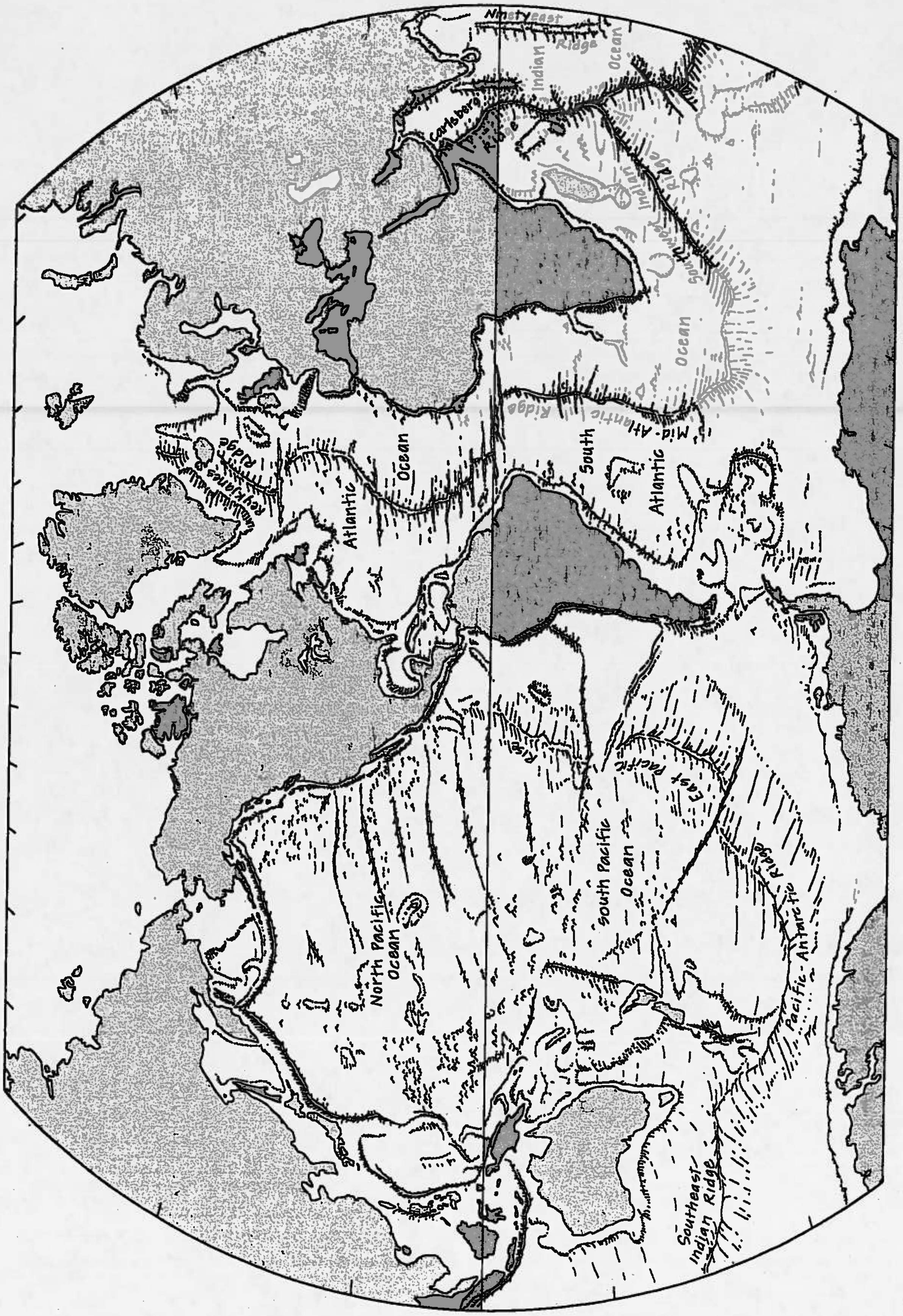
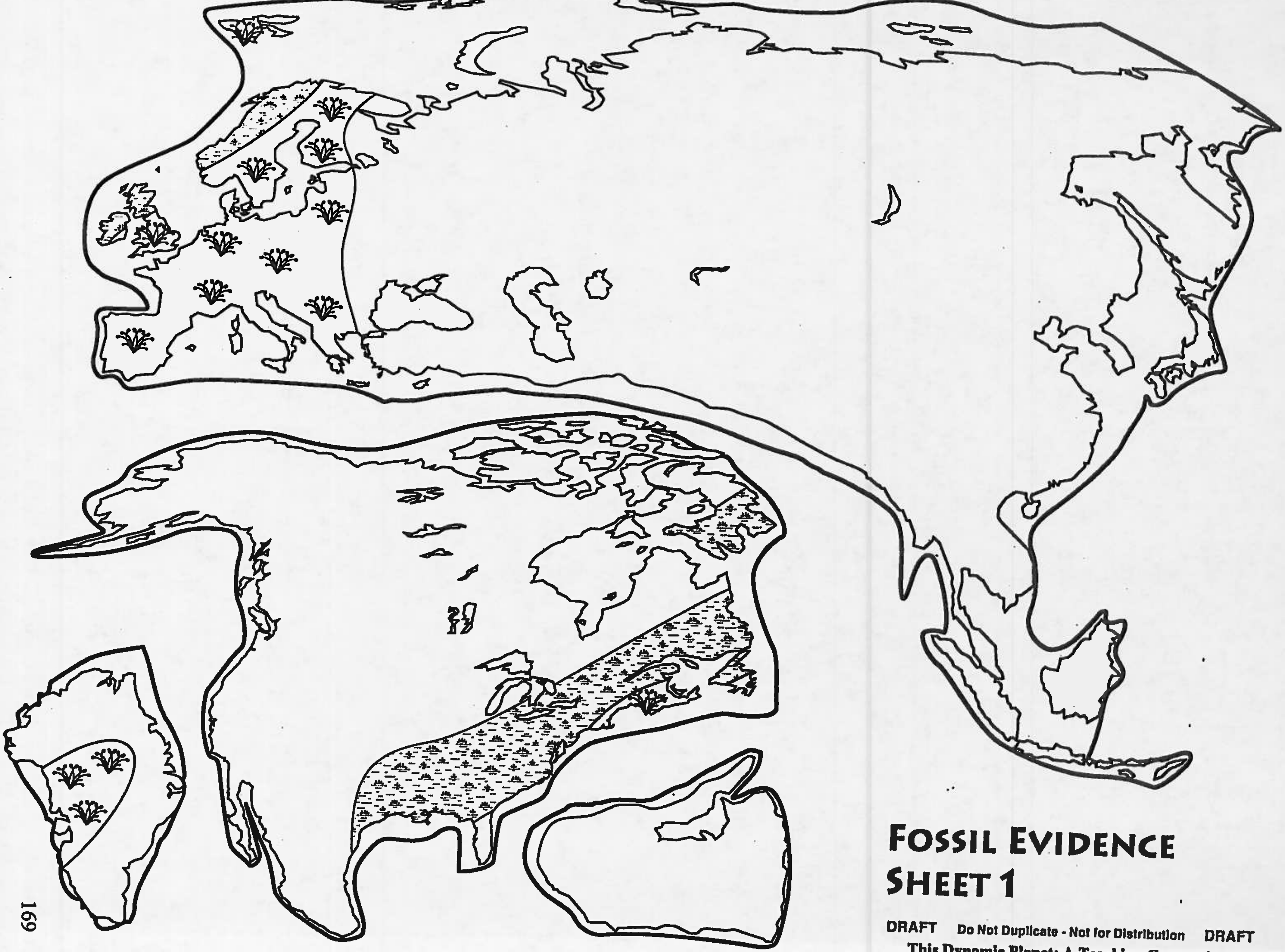


Figure 18.1
Global map of the ocean basins.

PLATE TECTONICS TIMELINE

Earth Date No.	Person/Event	This Dynamic Page
240? 1 & 4	The Greeks know that the Earth is spherical and Eratosthenes measures the circumference of the Earth.	
early 1500s greatly.	Ocean soundings (by dropping a hand line) reveal ocean depth varies 14	
1519-22	Magellan's expedition is first to circumnavigate the world.	
1540s	Archbishop Ussher develops the idea that all changes on Earth were sudden and due to catastrophes (Catastrophism).	3
1596	Abraham Ortelius says that the Americas were "torn away from Europe and Africa...by earthquakes and floods".	5
1785	James Hutton develops the Principle of Uniformitarianism—"the present is the key to the past".	3
1855	Deep sea line soundings by Matthew Maury begin to measure ocean depth, which reveal the first evidence of undersea mid-Atlantic mountains.	14
1858	Antonio Snider-Pellegrini made two maps showing how the South American and African continents fit together and then separated.	3
1890	Edward Suess suggested that at one time southern hemisphere continents were joined as one massive continent which he called Gondwanaland. His evidence for this was the location of common fossils.	
late 1800s	Survey ships laying trans-Atlantic telegraph cable confirm undersea mountains in mid-ocean.	14
1906 & 1920	Scientists discover that rocks show magnetic poles have reversed through geologic time	17
1912	Alfred Wegener publishes articles that support a *Continental Drift Theory*.	5
1914-18	During WWI, the use of sonar equipment, which records the time it takes for sound waves from a ship to bounce back to the ship from the ocean floor, supports Maury's earlier work.	14
1915	Alfred Wegener publishes book entitled *The Origin of Continents and Oceans*. The ideas in this book were refined in 1914 from his 1912 articles. This was done while healing from injuries received during WWI.	9
1920s	Data from German research vessel *Meteor* shows existence of a central valley along the top of the Mid-Atlantic Ridge.	11
1928	Arthur Holmes suggested that convection currents in the mantle as the driving force of continental drift. He had no evidence to support his theory.	

1929-30	Wegener's 4th edition of his 1915 book is published containing the . significant observation that shallower oceans were geologically younger. Wegener dies while on a meteorological expedition in Greenland.	11 10
1947	U.S. vessel *Atlantis* discovers sediment layer on Atlantic Ocean floor is much thinner than anticipated.	14
1950s 29	Ocean exploration expands. A great mountain range is discovered that 15- virtually encircles the Earth.	
1961	Cox, Doell and Darymple use potassium-argon dating technique to date continental rocks to determine their magnetic orientation.	20
1962	Harry Hess publishes *History of Ocean Basins* which outlines how seafloor spreading works. He suggests the sea floor separates at the mid-ocean ridges and new seafloor is created by upwelling of the mantle.	23
1966 Hess'	Vine, Matthew and Morly compare data gathered in 1961 with the magnetic 20striping found on the ocean floor and see a definite pattern to prove theory.	
mid-1960s	Because of 1963 treaty to ban above ground nuclear testing, the Worldwide 29 Standardized Seismograph Network allows scientists to precisely map concentrated zones of earthquake activity.	
1968	*Glomar Challenger* collects age-dated core samples along Mid-Atlantic Ridge that further proves the seafloor spreading hypothesis.	21
1970s	Plate tectonic theory begins to be accepted.	
1975	U.S. submersible *Alvin* makes first human observation of seafloor spreading.	28
1977	Hot springs and unusual sea life found along Galapagos Rift spreading ridge.	25
1979	RISE expedition is first ever to observe high temperature vents called *black smokers.*	25
1991	Discovery of remains of polar dinosaurs found in Australia providing further evidence that the continents have not always been in their present positions.	12
1999	Mars Global Surveyor finds evidence of magnetic reversals on Mars	



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SHEET 1

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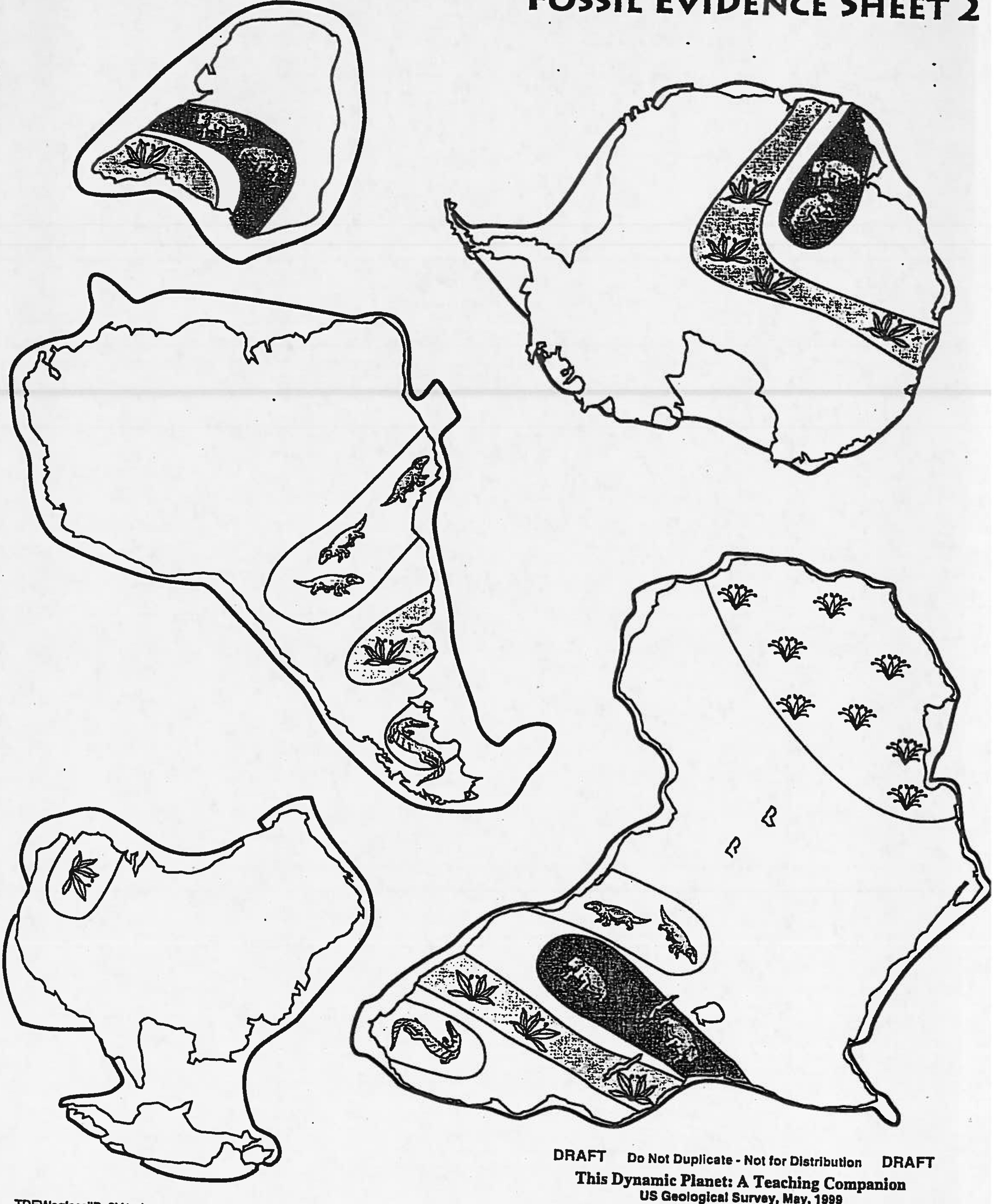
This Dynamic Planet: A Teaching Companion

FOSSIL EVIDENCE SHEET 2



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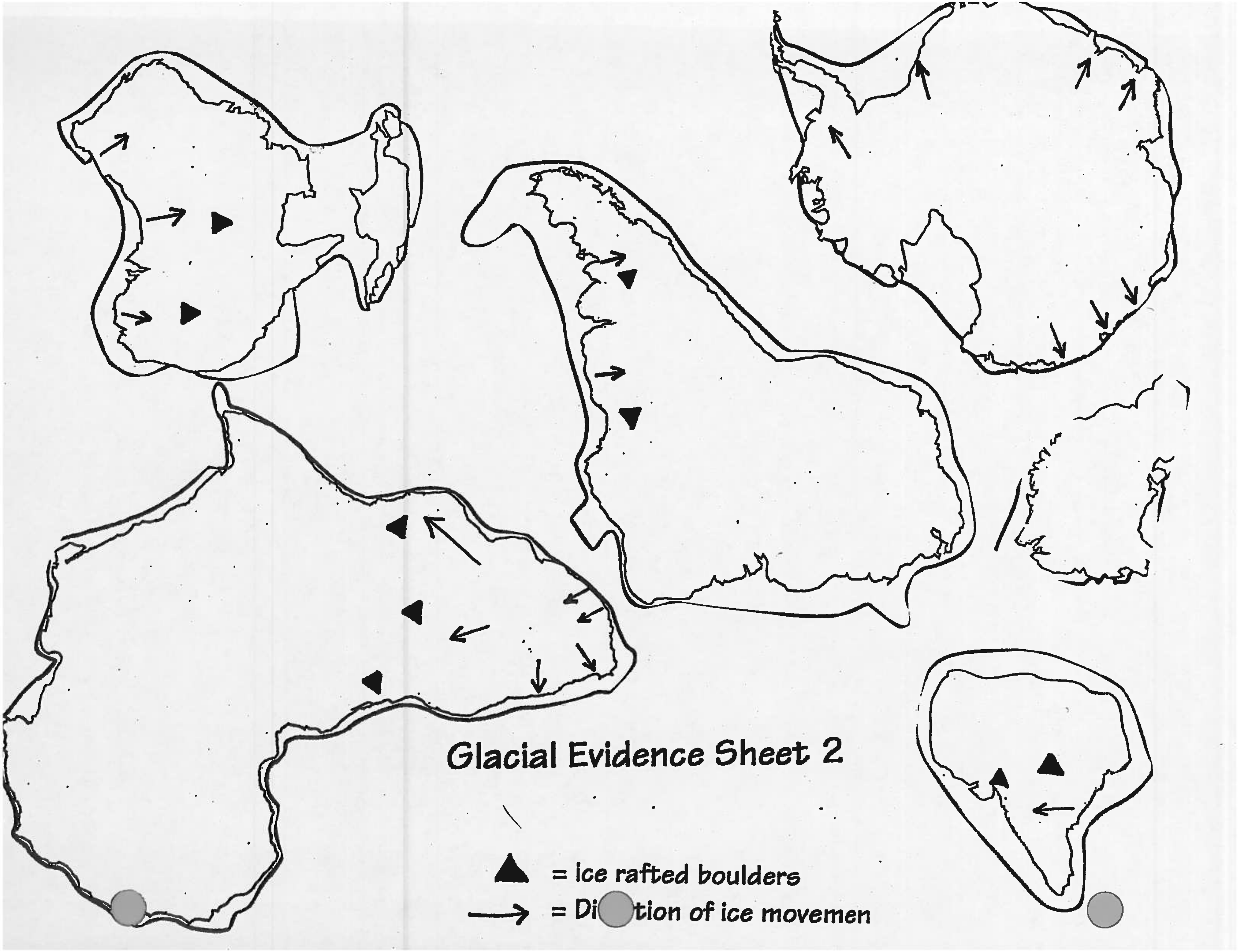
This Dynamic Planet: A Teaching Companion

US Geological Survey, May, 1999

For updates see <http://geology.wr.usgs.gov/docs/tdp/info.html>

Wegener's Key to continent positions about 250 million years ago.

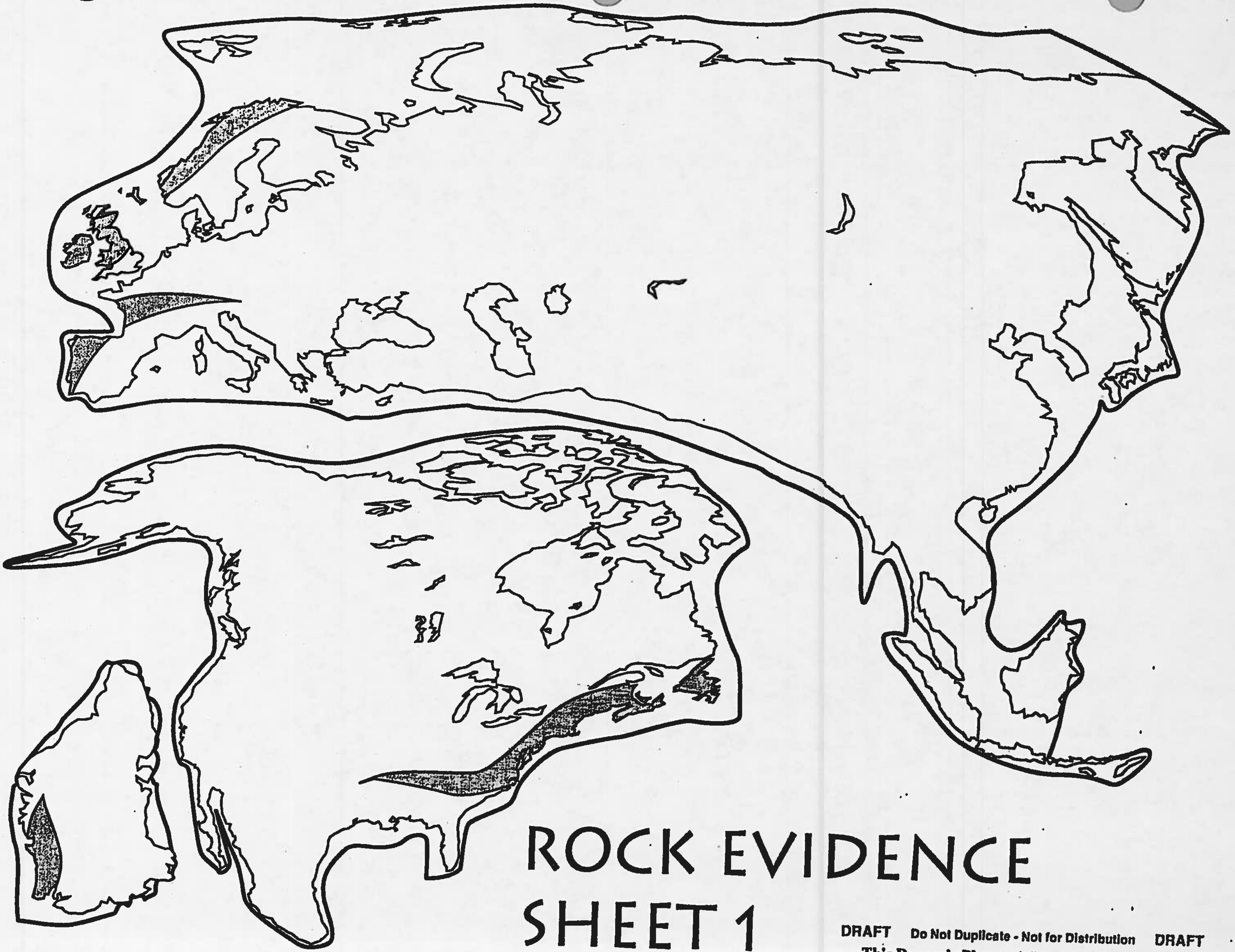

U/A



Glacial Evidence Sheet 2

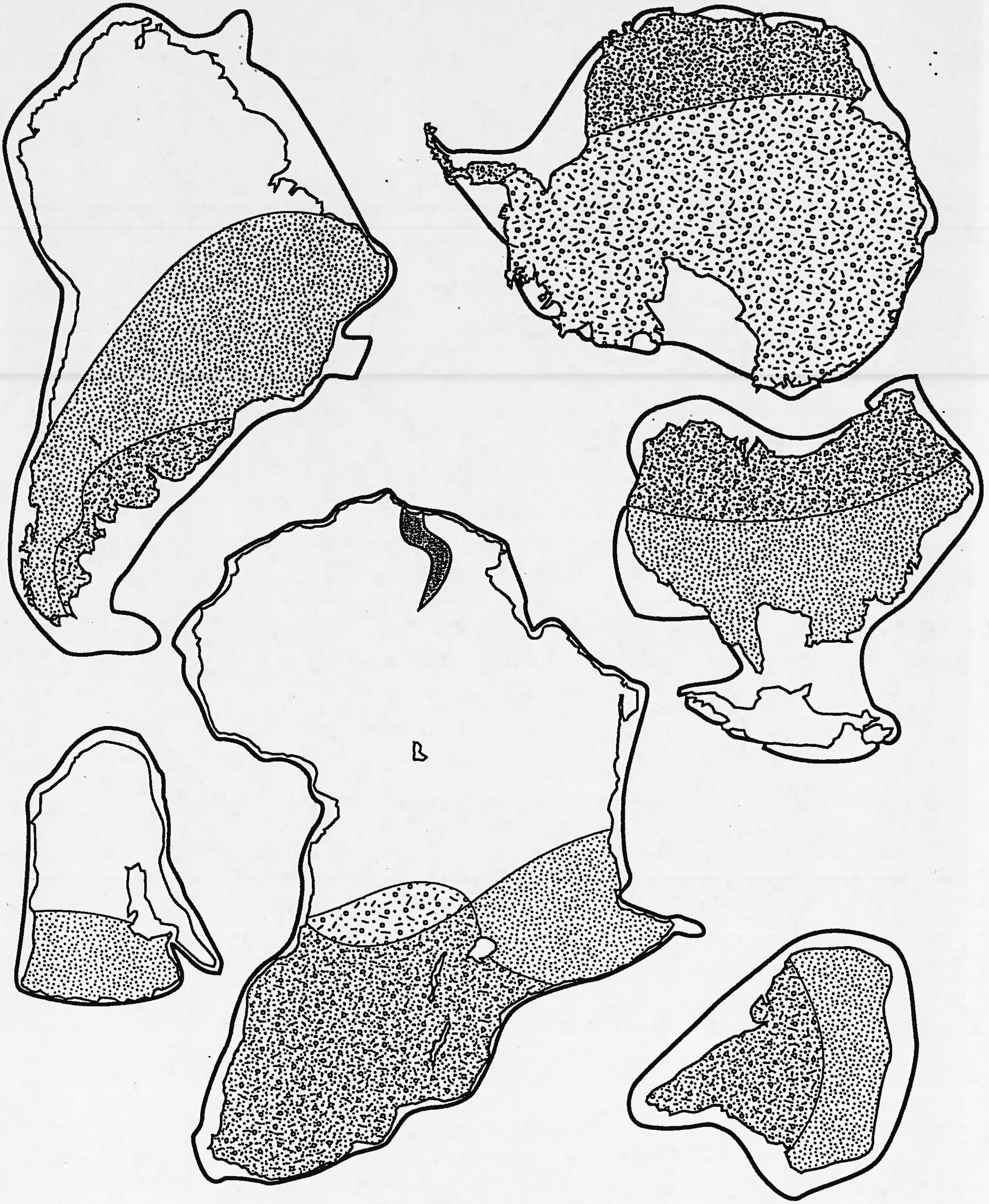
▲ = ice rafted boulders

→ = Di tion of ice movemen

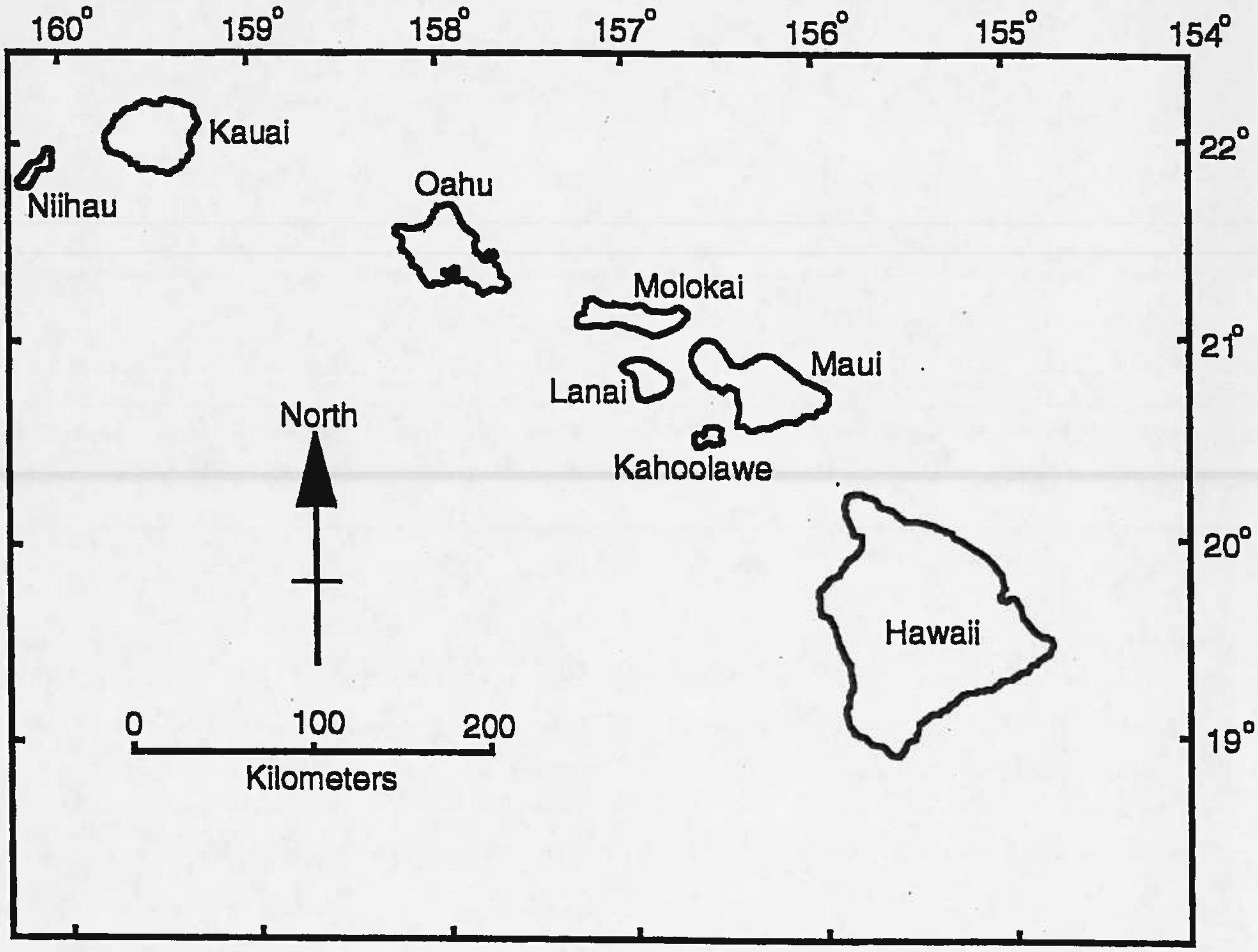


ROCK EVIDENCE
SHEET 1

ROCK EVIDENCE SHEET 2



Activity 2.3 The Rate of Plate Motion



Directions:
Use the map and the following information to determine the rate of motion of the Pacific Plate over the Hawaiian hot spot.
The volcano that formed the Island of Niihau is 4.89 million years old.

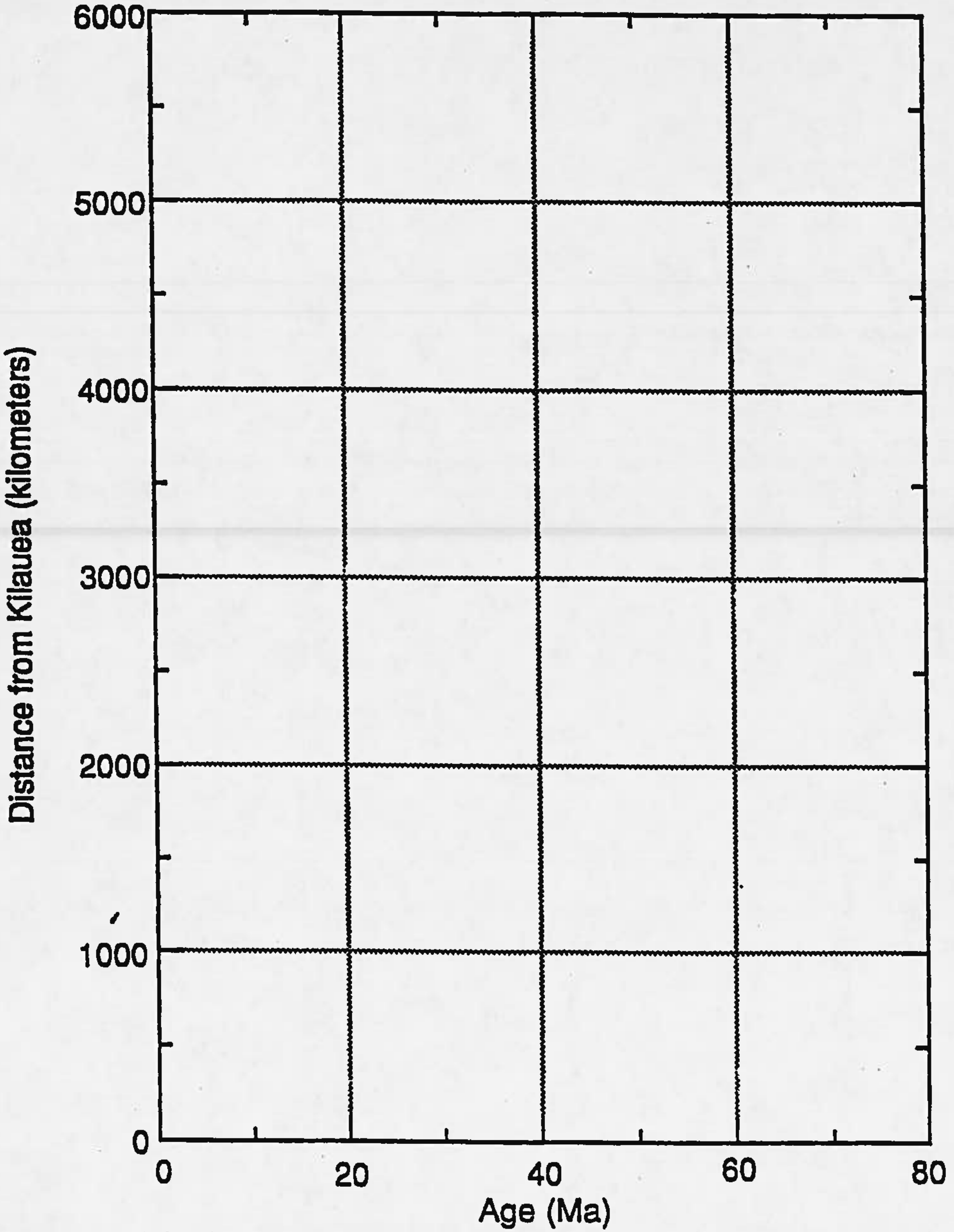
Step 1.
Rate is the distance traveled over a period of time. The distance traveled is equal to the distance from the present location of the hotspot (southeast Hawaii) to Niihau. Time is the age of the island.
Start by measuring the distance from southeast Hawaii to Niihau.
Use the scale on the map.

Step 2.
To determine the average rate of motion for the Pacific Plate, divide the distance to Niihau by the age of the island.

Step 3.
Note that your rate is in kilometers/million years (km/Ma). Convert your answer to centimeters per year (cm/yr).

Step 4.
How far will the plate move by the time you retire (50 years from now)?

Activity 2.6 Graphical Determination of the Rate of Plate Motion



The age of the islands and seamounts increases with distance away from Kilauea. This activity determines the average rate that the Pacific Plate has moved over the last 65 million years.

Seamount or Island	Distance (km)	Age (Ma)
Suiko	4,860	65
Koko	3,758	48
Midway	2,432	28
Necker	1,058	10
Kauai	519	5

Directions:
1. Plot the data on the graph.
2. Draw a best-fit line through the data points.
3. Determine the slope of the line. The slope is equal to the rate of plate motion.
4. Convert your answer from kilometers/million years to centimeters/year.
5. How far does the plate move in 50 years?

CONSTRUCTING A TOPOGRAPHIC PROFILE

Topographic maps present a view of the landscape as seen from directly above, an excellent perspective from which to examine global and regional relationships. This view is, however, unnatural to us, for we are accustomed to seeing hills and valleys from a horizontal perspective.

In detailed studies of landforms, it may be desirable to construct a profile, or cross section, through certain critical areas so that various features can be analyzed from a more natural viewpoint Such a profile can be constructed quickly and accurately along any straight line on a contour map, as illustrated in (A) below.

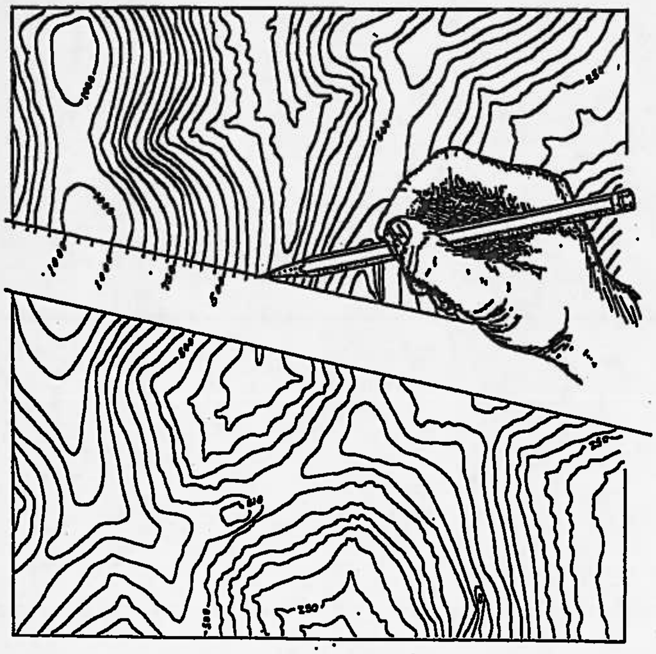
The procedure is as follows:

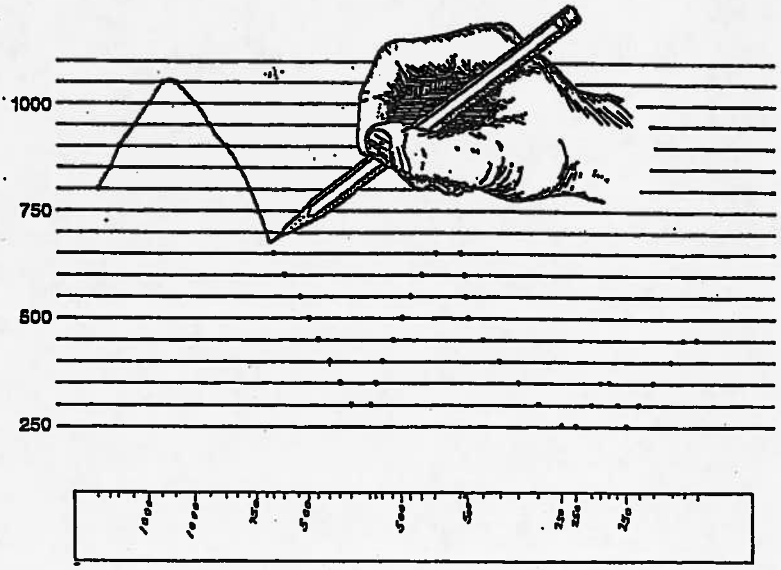
1. Lay a strip of paper along the line for which the profile is to be constructed.
2. Mark on the paper the exact place where each contour, stream, and hilltop crosses the profile line.
3. Label each mark with the elevation of the contour it represents. If contour lines are closely spaced, it is sufficient to label only the index contours.
4. Prepare a vertical scale (C) on the graph paper provided by labeling horizontal lines to correspond to the elevation of each index contour line.
5. Place the paper with the labeled marks at the bottom of the profile paper and project each contour onto the horizontal line of the same elevation.
6. Connect all of the points with a smooth line.

Obviously, the appearance of the profile will vary, depending on the spacing of the horizontal lines on the profile paper. If the vertical scale is the same as the horizontal scale, the profile will be nearly flat. For this reason, the vertical scale is usually exaggerated to show local relief.

STEP 1

Construct a profile along A-A' in diagram B using the graph paper provided in C.





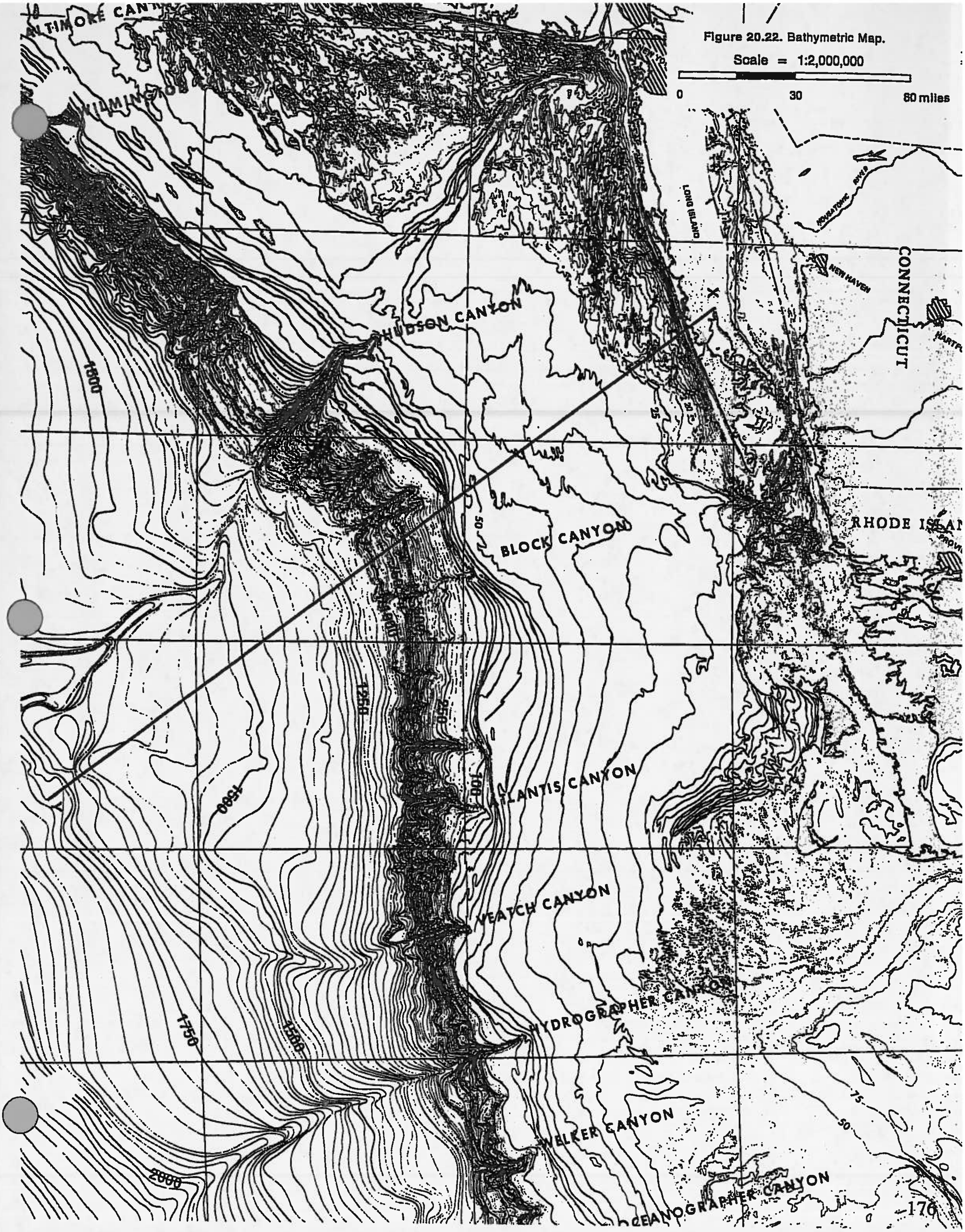
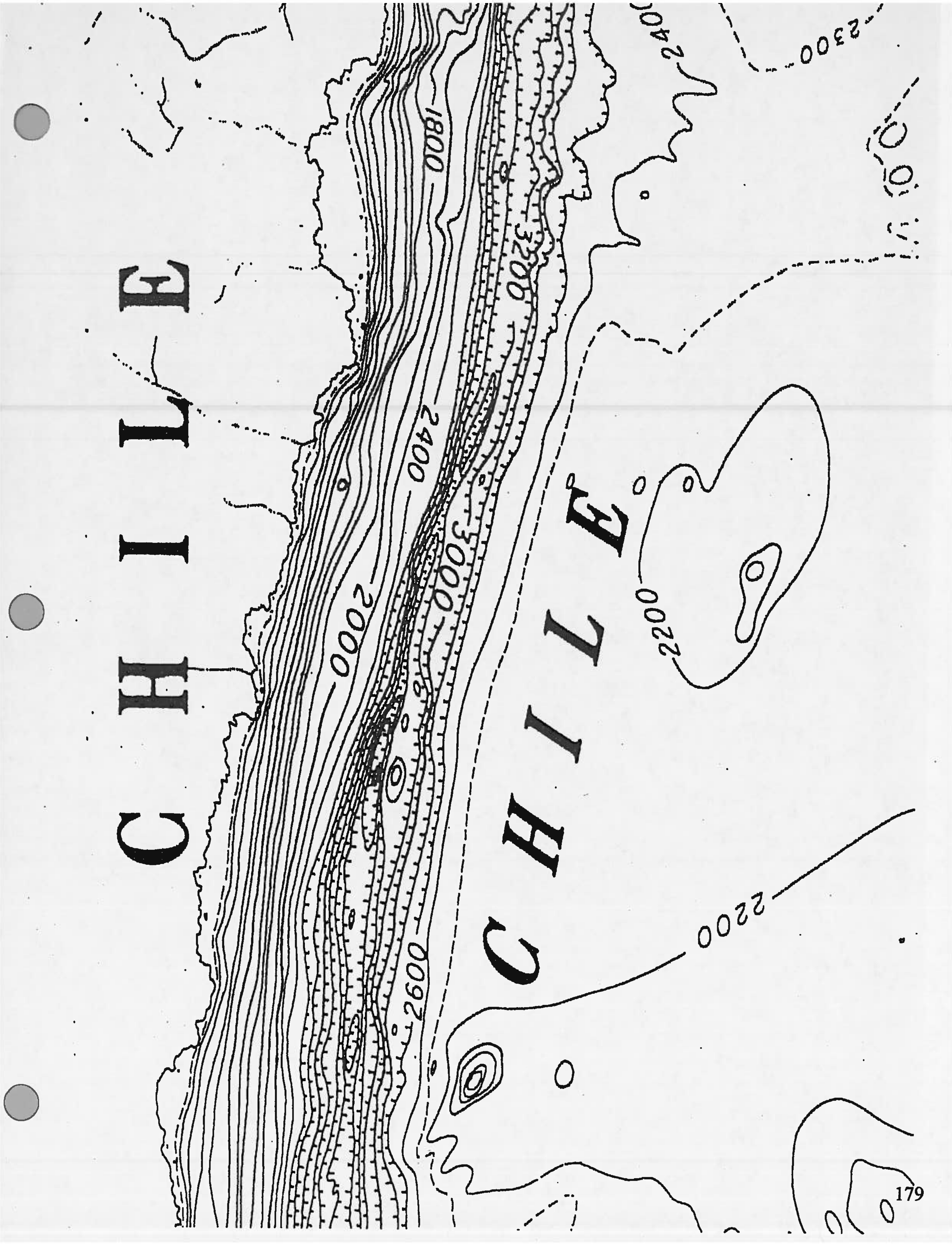


Figure 20.22. Bathymetric Map.

Scale = 1:2,000,000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East Pacific Rise

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Meters Feet

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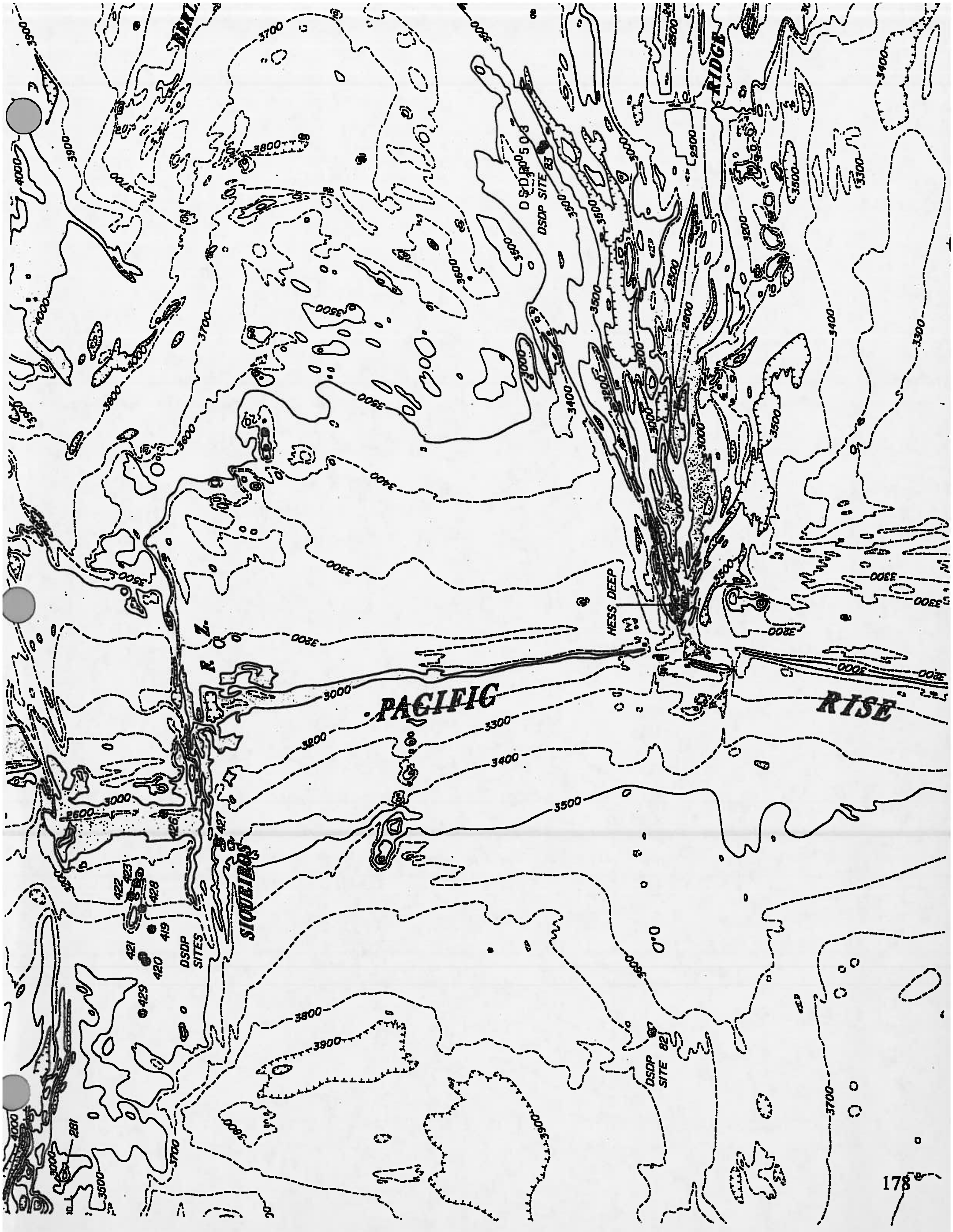
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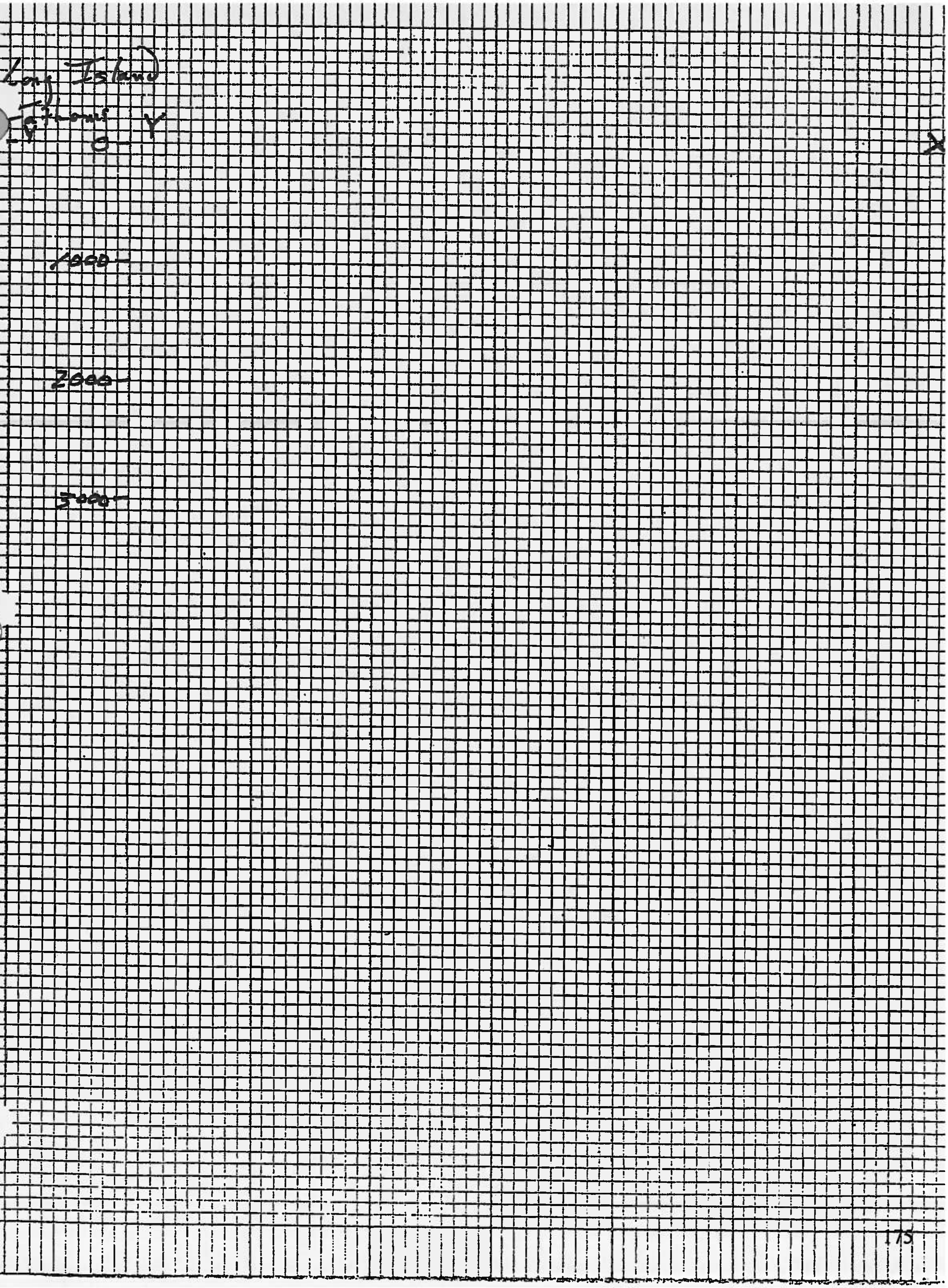
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2,000

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Plate 1A. Bathymetry
The Eastern Pacific Ocean and Hawaii
Vol. N of The Geology of North America (GNA-N)

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ROCK STARS

J. Tuzo Wilson

Derek York, Physics Department, University of Toronto

Tuzo Wilson lived for ideas, and those he created were weird and wonderful. Many were wrong, but some were marvelously right. And, until his death in 1993, he never stopped creating ideas.

The Early Years

He was the first child, born on October 24, 1908, in Ottawa, to the former Henrietta Tuzo and John Armistead Wilson. His mother's name, Tuzo, came from her father's distant Angevin Huguenot ancestors, who landed in Virginia in the seventeenth century. Henrietta was a remarkable and adventurous woman who loved mountaineering. Mount Tuzo in western Canada was named after her because she and Christian Bohre were the first to scale its peak. She had met her future husband, John Wilson, while attending the camp of the Alpine Club of Canada near Banff in Alberta. John, a Scottish engineer, was to play an important role in the development of civil aviation in Canada. Thus, a love of the outdoor life and world travel was instilled in their son, John Tuzo Wilson.

When Tuzo was 17, he had the good fortune to become field assistant to the famous Everest mountaineer Noell Odell who, recalled Tuzo, "showed me the wonders of field geology." Tuzo enrolled in physics at the University of Toronto, but he soon switched to a double major in physics and geology, and in 1930, he considered himself to be Canada's first-ever graduate in geophysics.

A scholarship then took Tuzo to Cambridge University, ostensibly for graduate work in geophysics. However, he quickly found that the university had no clearly organized department, and, after being baffled by Harold Jeffreys' high-powered mathematical lectures, he decided to take an assortment of lectures in geology and physics that appealed to him, and he completed a second B.A. degree.

This was followed by a stint at the Geological Survey of Canada (GSC), where Tuzo worked on Sudbury rocks with the GSC's director, W.H. Collins. Collins, presumably responding to Tuzo's tremendous drive and ability, recommended that he take a Ph.D. in geology at a leading university in the United States. Tuzo was accepted at Harvard and MIT but chose to enroll at Princeton because "it offered the most money, and because Professor R.M. Field said that he hoped to start teaching geophysics there." At Princeton, Tuzo met future giants Harry Hess, Maurice Ewing (visiting from Lehigh), and George Woollard, but Field "failed to bring anyone to Princeton to teach us geophysics." So the young Canadian completed his Ph.D. at Princeton by carrying out geological mapping in the Beartooth Mountains under the nominal supervision of Professor Taylor Thom. During this thesis work, he made the first recorded climb of Mount Hague, shining as his mother had in the mountains.

With the outbreak of World War II, Tuzo left the job he'd had at the GSC since graduating from Princeton and joined the Canadian Army as an engineer. He spent four years overseas before returning to Canada as a colonel and director of operational research. In this capacity, he organized Exercise Musk Ox, which he described in 1982 as "the first and still the most extensive motorized expedition ever to cross the Canadian Arctic."

Following his demobilization, Tuzo was appointed professor of geophysics at the University of Toronto in 1946. In the next 14 years, he built a considerable reputation, clarifying the structures of the Canadian Shield with the help of the newly flowering field of geochronology. Here, he applied ideas initially derived locally, perhaps, to Earth at large. He pointed out that the age divisions he could see in the Canadian Shield were probably features of all the major shields of Earth. He wrote about continental growth, and not merely for the North American continent. He adopted Jeffreys' theory of mountain building on a contracting Earth and rejected the idea of continental drift. By the late 1950s, Tuzo was famous but also controversial—something of a maverick and a promoter of ideas, some said, that made them uncomfortable. Not only that, the contraction hypothesis he promoted so strongly was turning out to be inadequate.

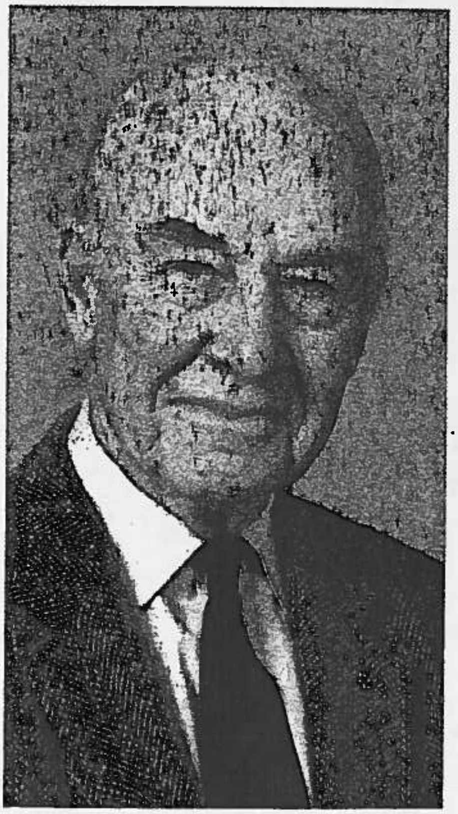
The Climactic Years

It was at the University of Toronto that Tuzo reacted brilliantly by admitting to himself that he was wrong about a contracting Earth and by wondering if Dietz, Hess, Irving, and others might be right about continental drift. And remarkably quickly, at an age (about 50) when very few scientists have come up with great ideas, Tuzo recognized that Earth was a highly mobile place. Years of global, large-scale thinking had prepared him to take geology forward in a dramatic fashion.

Tuzo's mind had a fascinating way of solving problems. Unlike most physicists, who find their solutions via mathematics, Tuzo solved problems almost entirely with visual images and then presented the solutions in extremely clear prose. He had a remarkable ability to look into the heart of extreme complexity and see simplicity itself. The nearest mind that I can think of to compare with Tuzo's was that of Michael Faraday who, instead of integrating differential equations to calculate the electric field, imagined a charged particle to be an octopus with tentacle-like lines of force reaching out into the space around it.

To solve the problem of the origin of the Hawaiian Islands, for example, Tuzo imagined someone lying on his back on the bottom of a shallow stream, blowing bubbles to the surface through a straw. The bursting bubbles were the Hawaiian Islands, and they lay in a line because they were swept along the surface by the moving stream. Thirty years later, leading geophysical theorists use supercomputers to solve horrendous equations that Tuzo "solved" in the visualizing region of his brain.

Tuzo's great paper describing this, "A Possible Origin of the Hawaiian Islands,"


J. Tuzo Wilson in his 80s.
Photo courtesy of Delroy Curling.

was rejected by the leading American geophysical journal in 1963 on the grounds that it was completely at variance with the latest seismic studies of the region. Undeterred, he sent it to the Canadian Journal of Physics, where it was immediately published because, I suspect, the editors didn't know what else to do with anything so devoid of mathematics.

His second great, yet simple, idea was that of transform faults. Again, Tuzo's approach was visual and non-numerical. And yet it was devastatingly definitive in what it predicted. It did not give us an equation, such as $E=mc^2$, or say that the magnetic field near a wire is proportional to the current flowing through it. Tuzo's transform fault concept said to earth scientists that they were living in a looking-glass world. For earthquakes occurring underwater and in the middles of oceans, he predicted that the rocks everybody believed had moved right to left during the earthquake had moved left to right, and vice versa. This was a wonderful geometric test for the existence of continental drift and plate tectonics. If the rocks moved as Tuzo said, continental drift was a racing certainty. If they didn't, Earth was a far more static place. Wilson capped his transform fault paper (1965) with a stunning synthesis of what we now know as plate tectonics.

In 1967, Lynn Sykes of the Lamont Geological Observatory examined the motion of rocks in 10 earthquakes on two mid-ocean ridges and found Tuzo's predictions were correct in every case. His announcement of this went a long way in convincing people that continental drift had not only occurred in the past 200 m.y., but was going on under our feet today, at the rate at which our toenails are growing.

Interestingly, in his very last paper, which appears not to have been published, he merges his beautiful Hawaiian plume idea with geophysical exploration. He gave the preprint to me in late 1992, just before I was to leave Toronto for six months. In his irrepressible style, Tuzo entitled it, "On Migrating Mountains and a Revolution in Earth Sciences."

Among many other ideas, he pointed out in the paper an association between bonanza gold deposits in the United States and rising plumes, which he claimed underlay the continent. The manuscript I have is incomplete, but in the very sentence where it halts is contained the quintessence of Tuzo Wilson: the word "ideas." Said he, "These great faults may or may not have plumes associated with them, but the *ideas* gained in Nevada suggest that even without plumes, large faults may provide channels bringing ores from far greater depths of origin than has been previously considered." He had stamped December 4, 1992, on the manuscript, and in his familiar script had written "Thanks, Derek! Tuzo. Nearly done now!" Four months later, I received in Capetown a message that on April 15, 1993, he had died of a heart attack.

Extraordinarily powerful—mentally and physically—to the end, Tuzo had in later years been happy and successful as principal of Erindale College at the University of Toronto, where he and his wife, Isabel, entertained thousands of students and visitors. After stepping down from this position, he was, at 65, appointed director-general of the internationally renowned Ontario Science Centre, a position in which he reveled, with his magnetic personality and gift for popularization.

Further Reading

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"Rock Stars" is produced by the GSA History of Geology Division. Editorial Committee: Michelle Aldrich, Robert Dott, Robert Ginsburg, Gerald Middleton (editor of this profile).

J. Tuzo Wilson in his early 60s, sailing his Chinese junk on Georgian Bay. Photo courtesy of Susan Wilson.

J. Tuzo Wilson in preparation for the International Geophysical Year in 1957, examining a gravimeter with Jack Jacobs and Ron Farquhar. Photo by MacLeod-Gilbert A. Milne & Co.

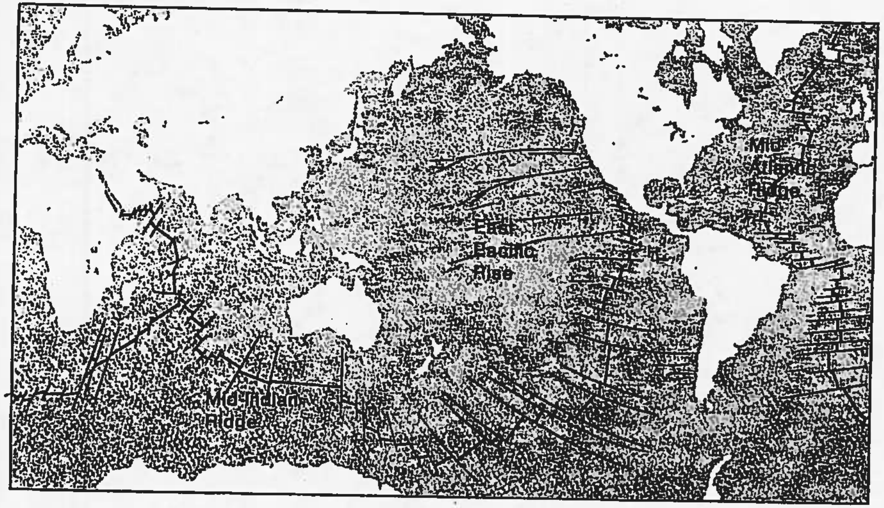

Figure 18.15 The mid-oceanic ridge, offset by fracture zones. Darker lines indicate the ridge crest; lighter lines show the fracture zones.

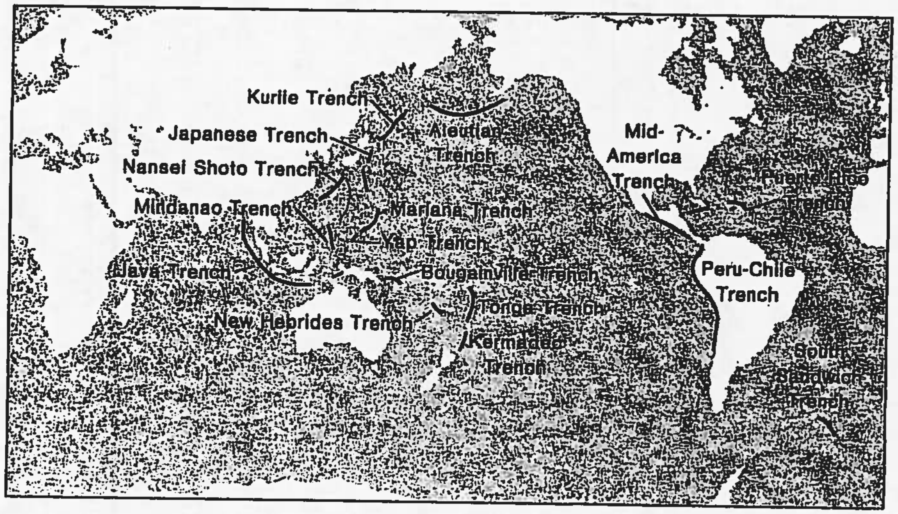

Figure 18.13 The distribution of oceanic trenches.

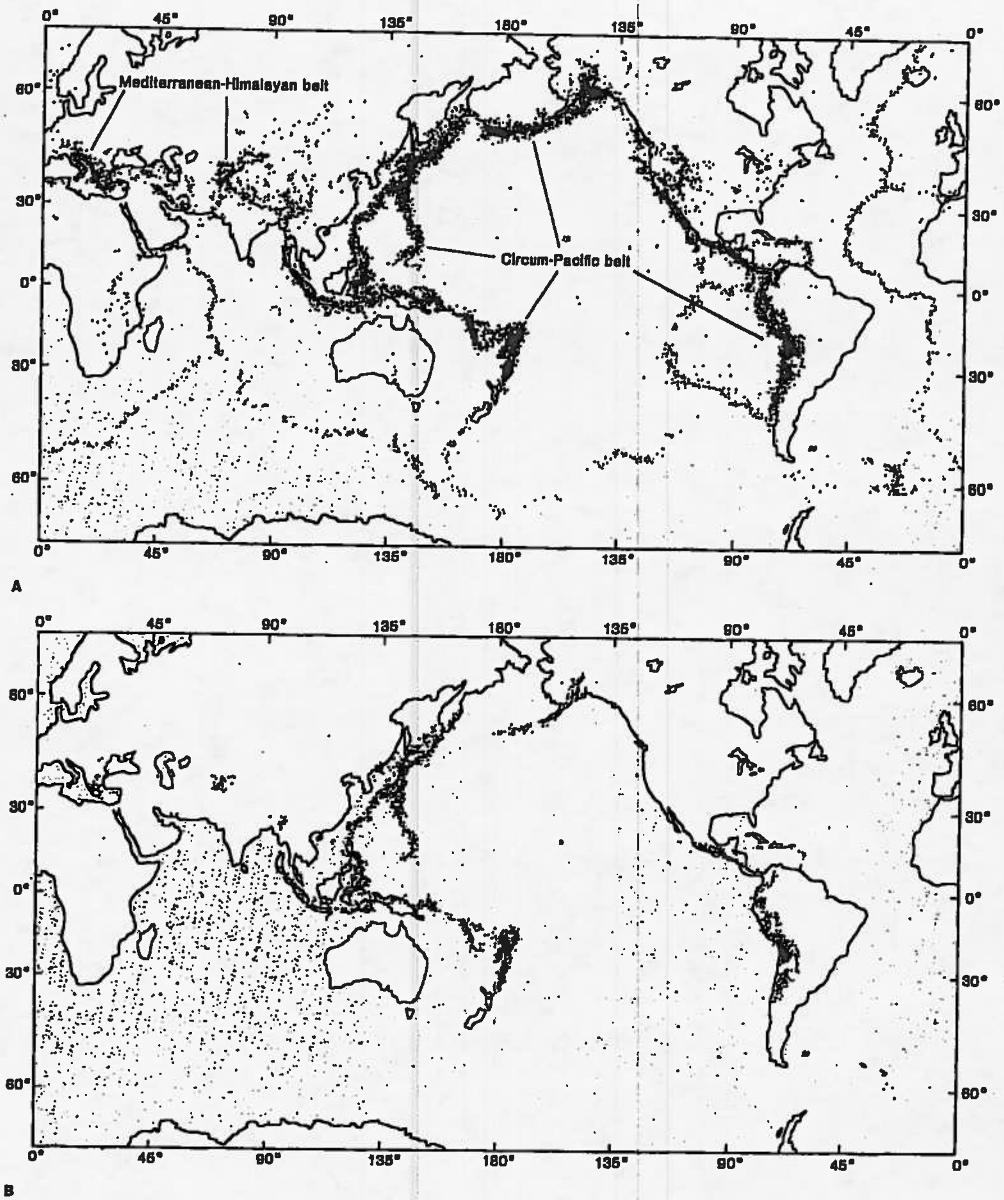

Figure 18.19 World distribution of earthquakes from 1961 to 1967. (*A*) Epicenters of quakes with depth of locus between 0 and 700 kilometers. (*B*) Epicenters of quakes with depth of locus between 100 and 700 kilometers.

From Barazangi and Dorman, *Bulletin of Seismological Society of America*, 1969