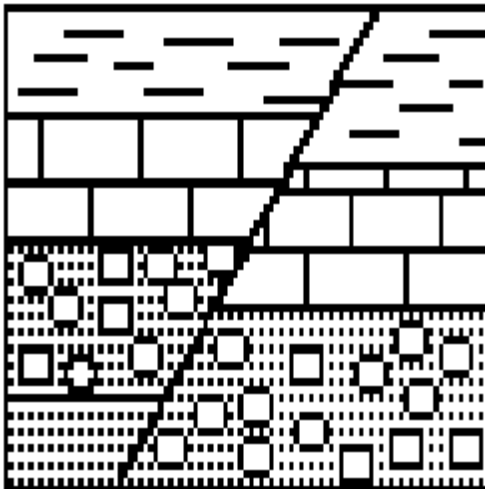
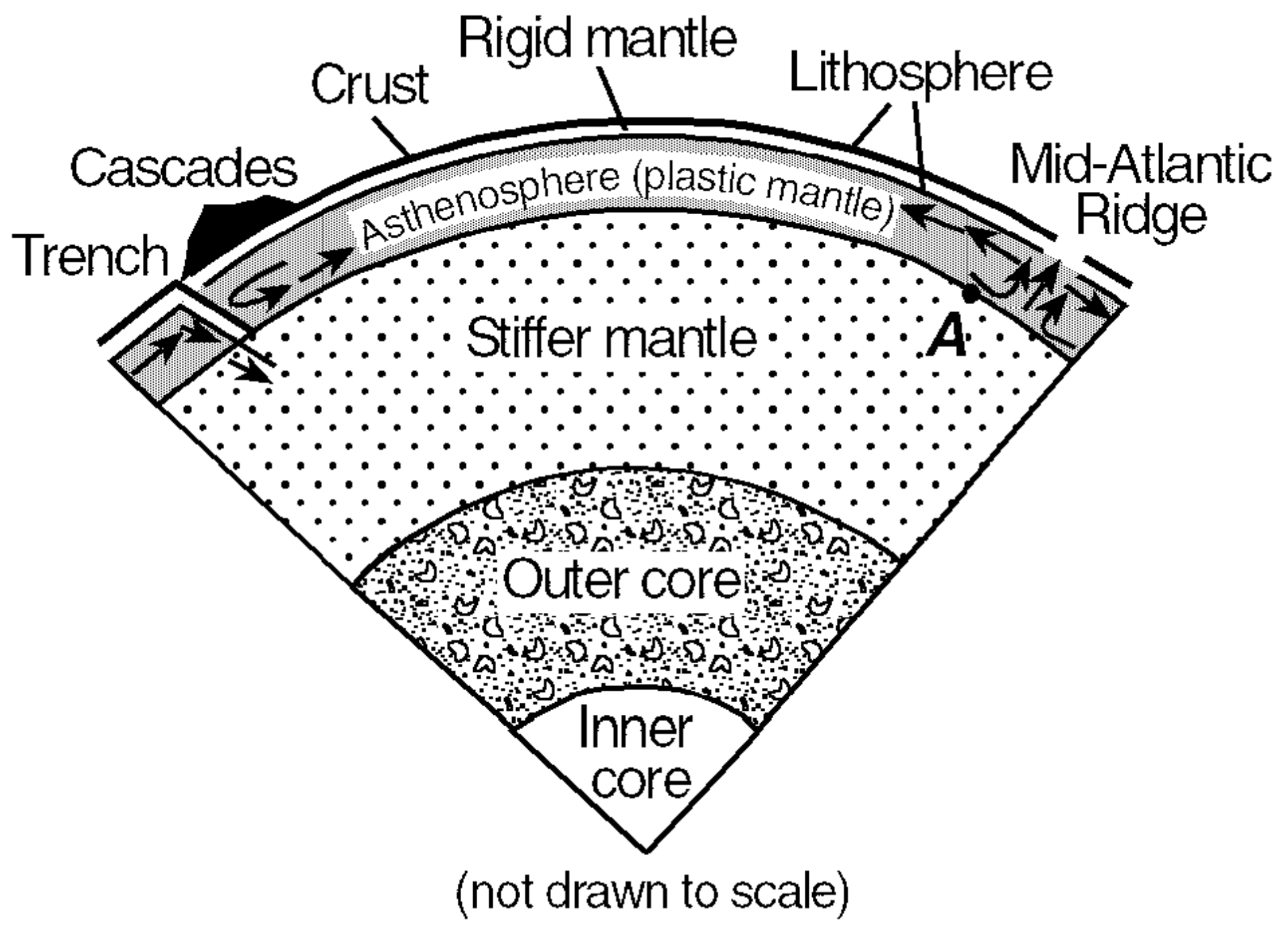
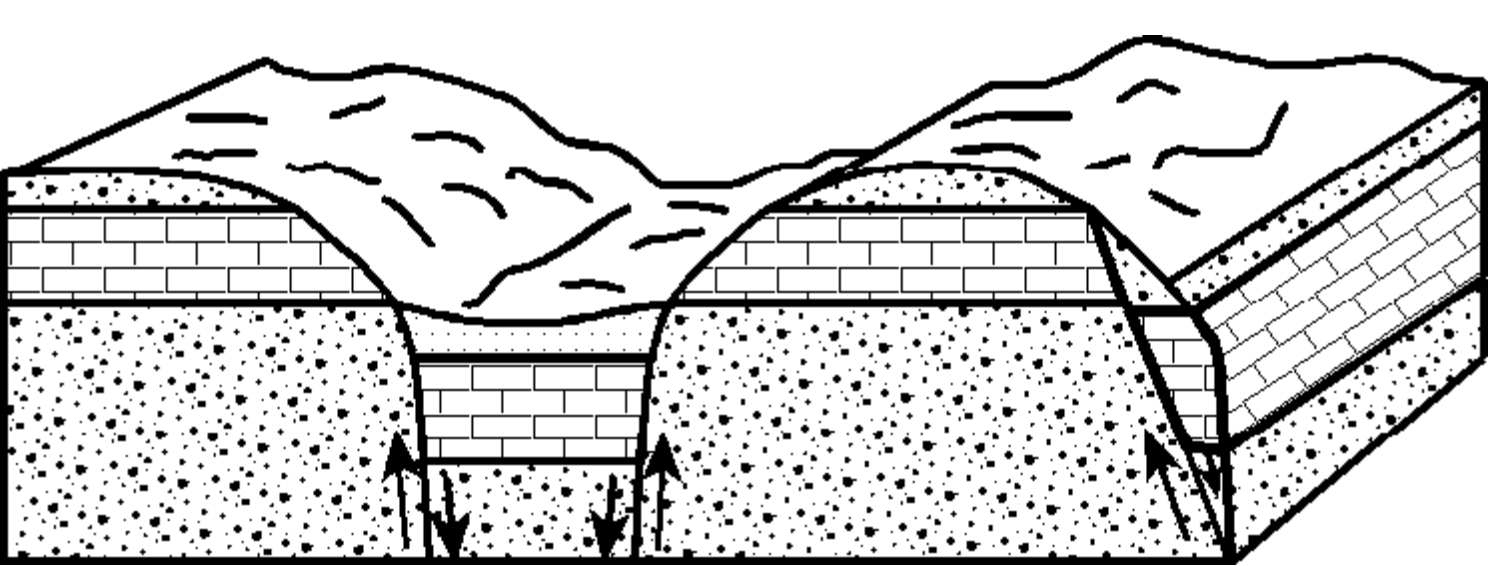
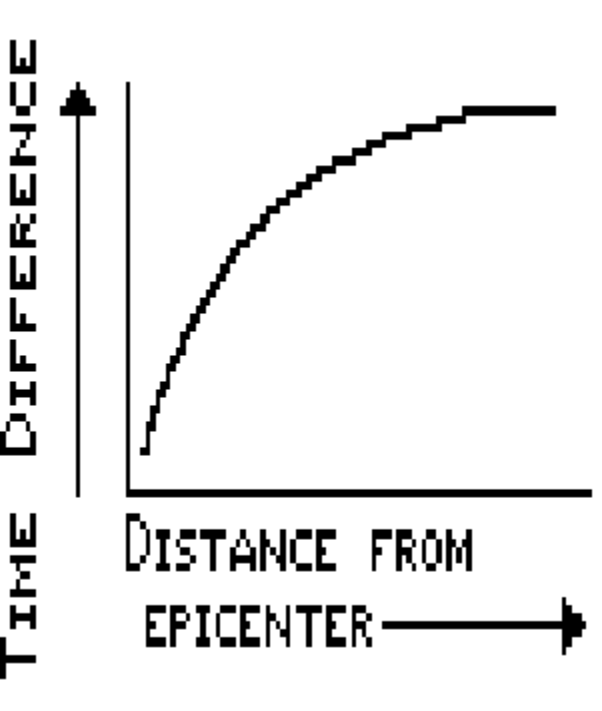
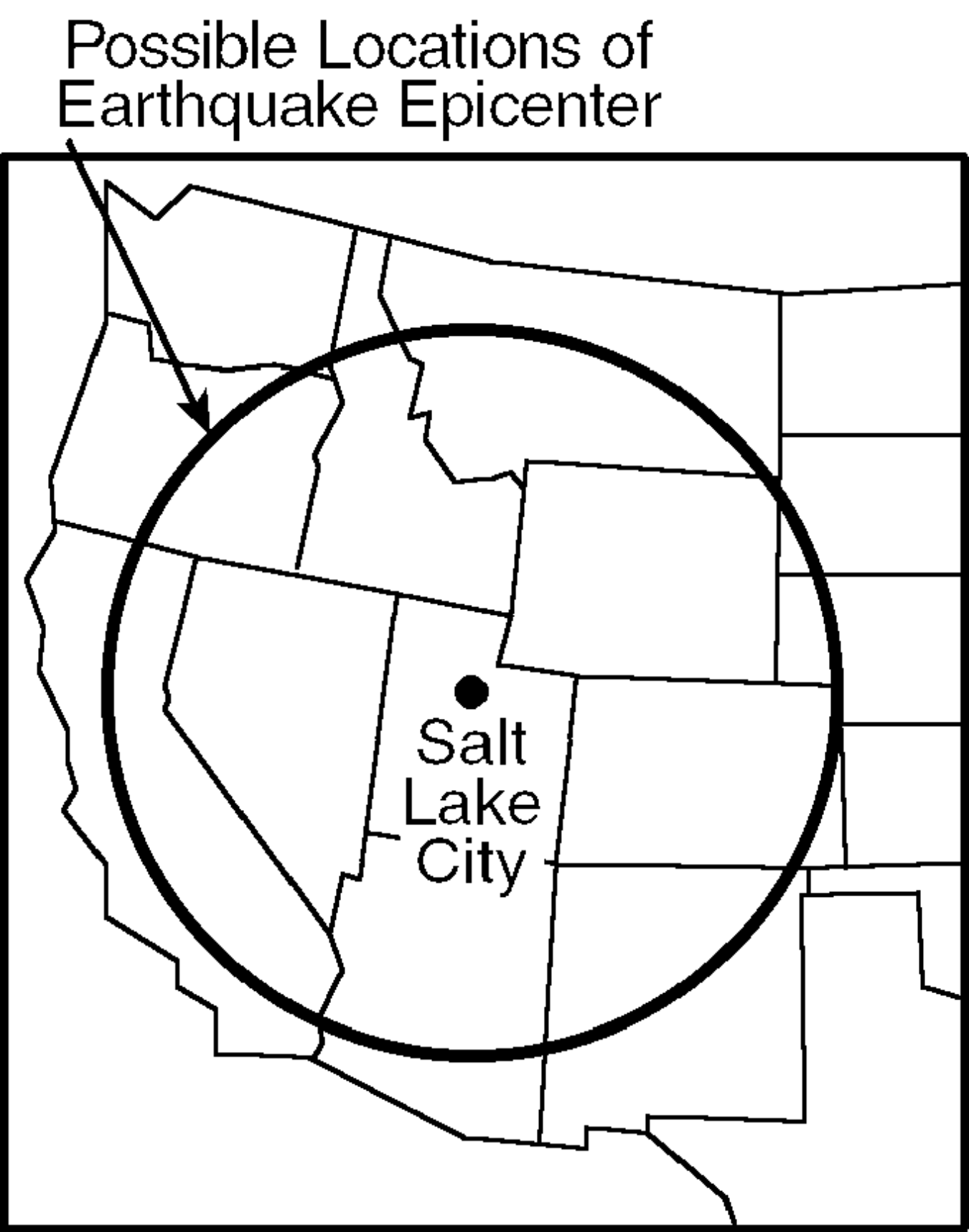
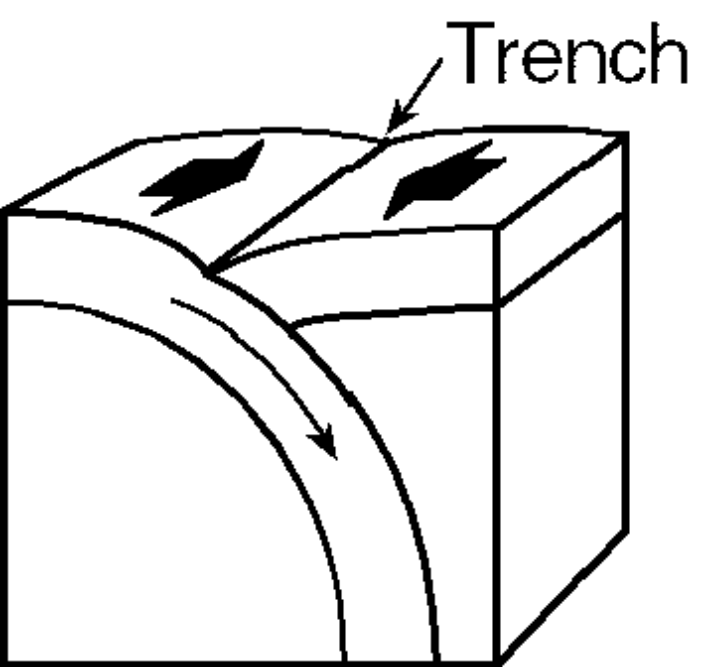



Rigid mantle
Crust
Lithosphere
Cascades
Asthenosphere (plastic mantle)
Mid-Atlantic Ridge
Trench
Stiffer mantle
A
Outer core
Inner core
(not drawn to scale)



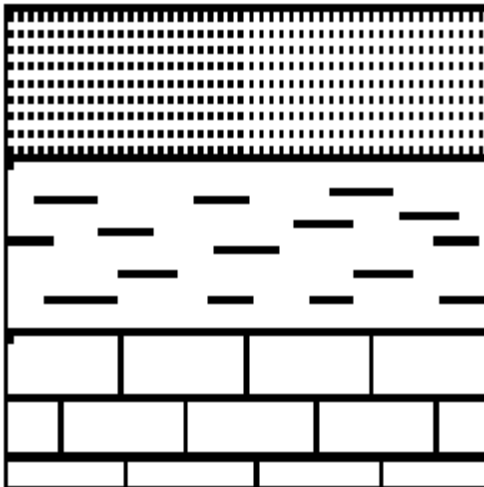

TIME DIFFERENCE
DISTANCE FROM EPICENTER

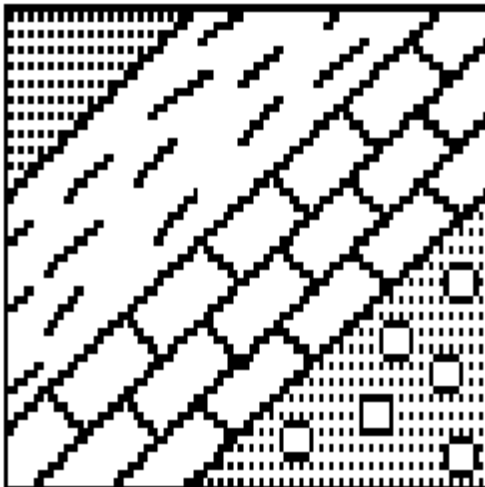

Possible Locations of
Earthquake Epicenter
Salt
Lake
City

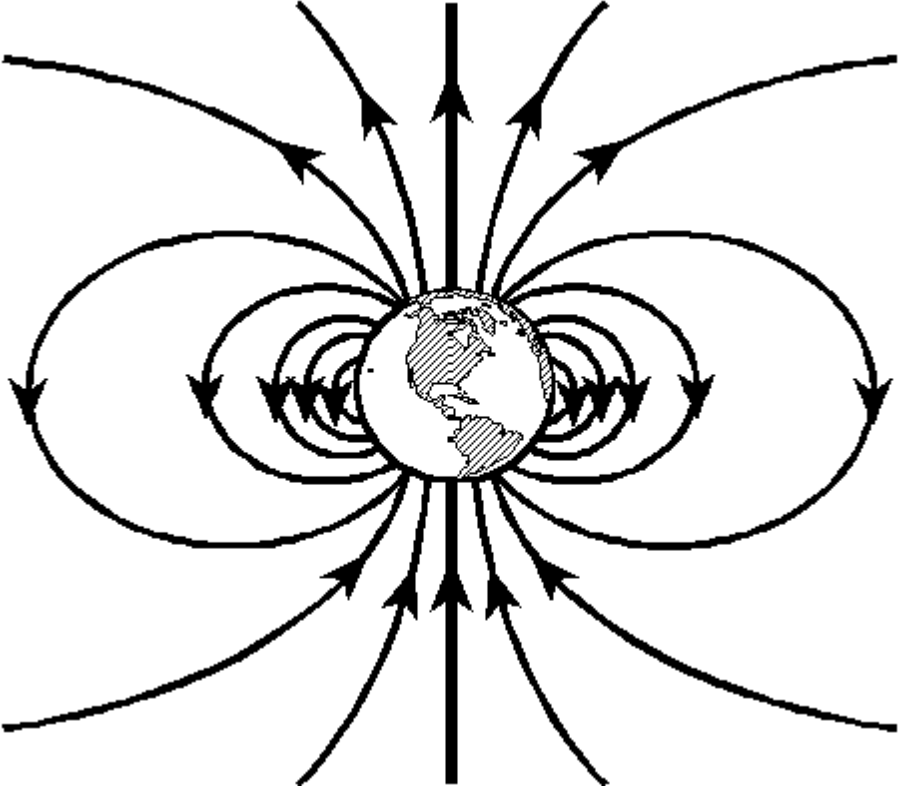

Trench


North America
PACIFIC OCEAN
South America
Peru-Chile Trench

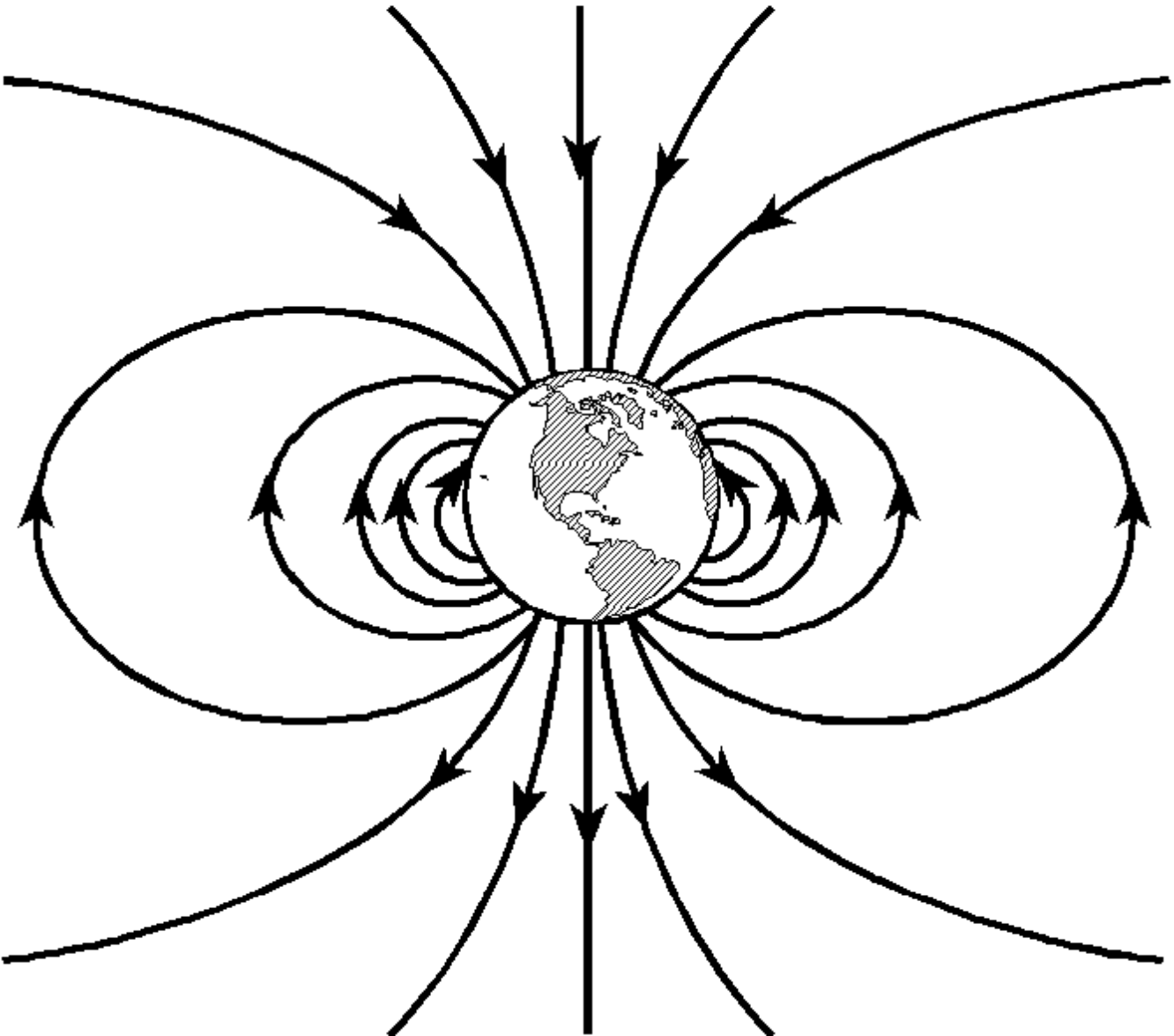

MID ATLANTIC RIDGE
SHORELINE OF SOUTH AMERICA
SHORELINE OF AFRICA

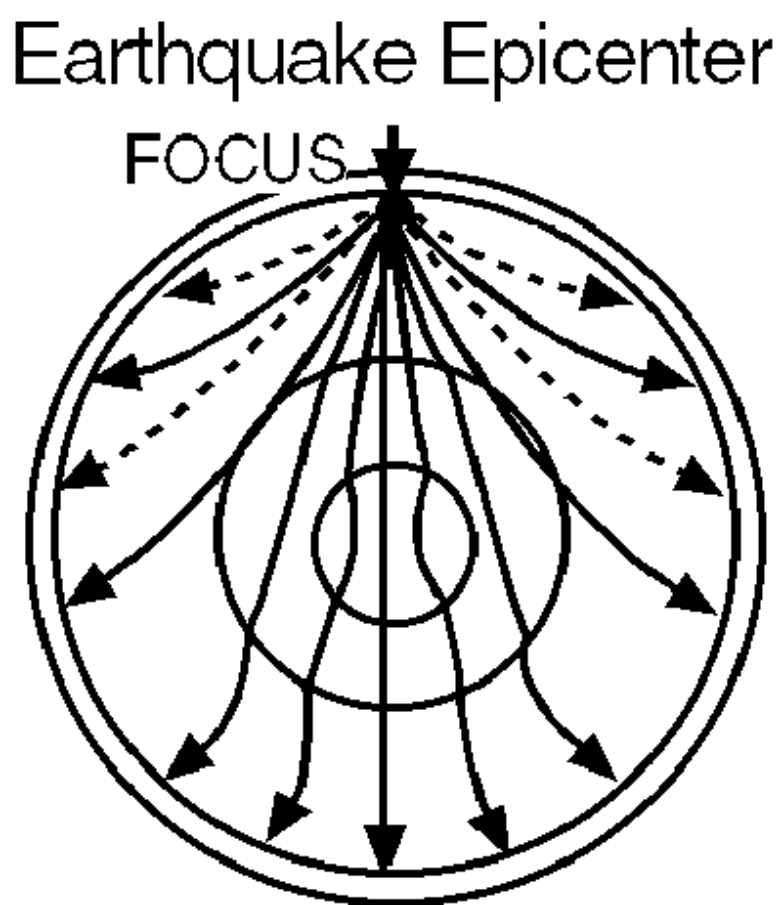


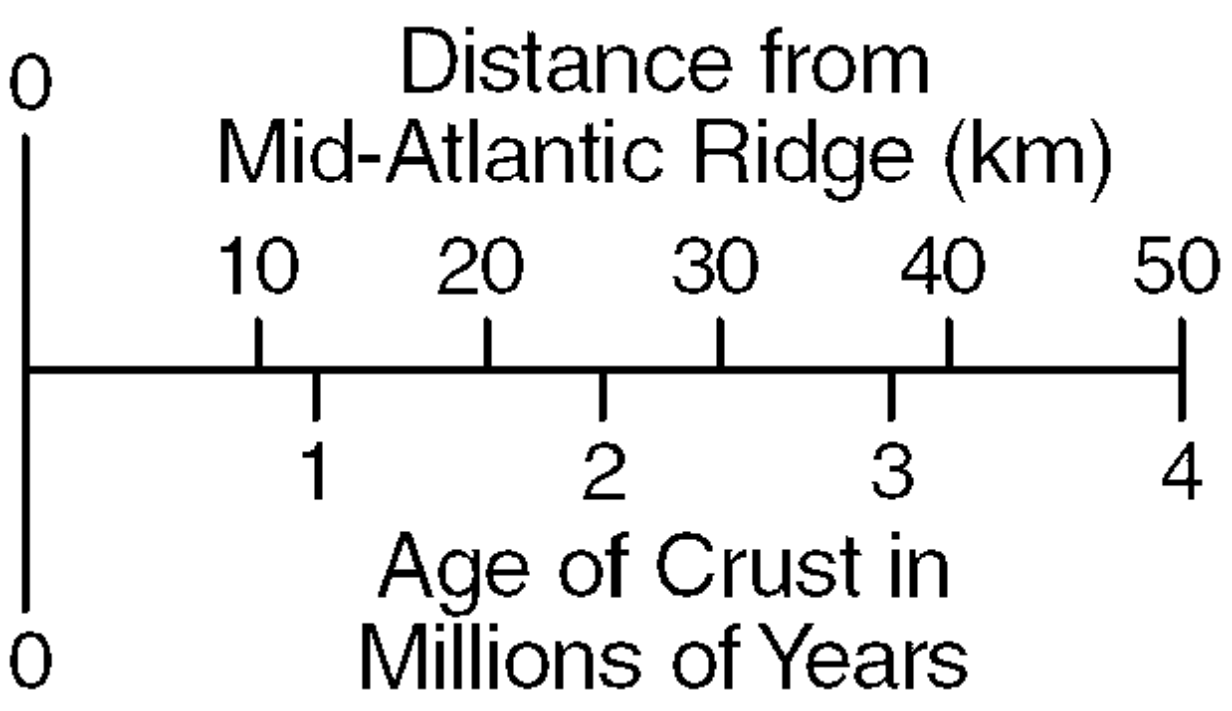




Earth's Normal Magnetic Field

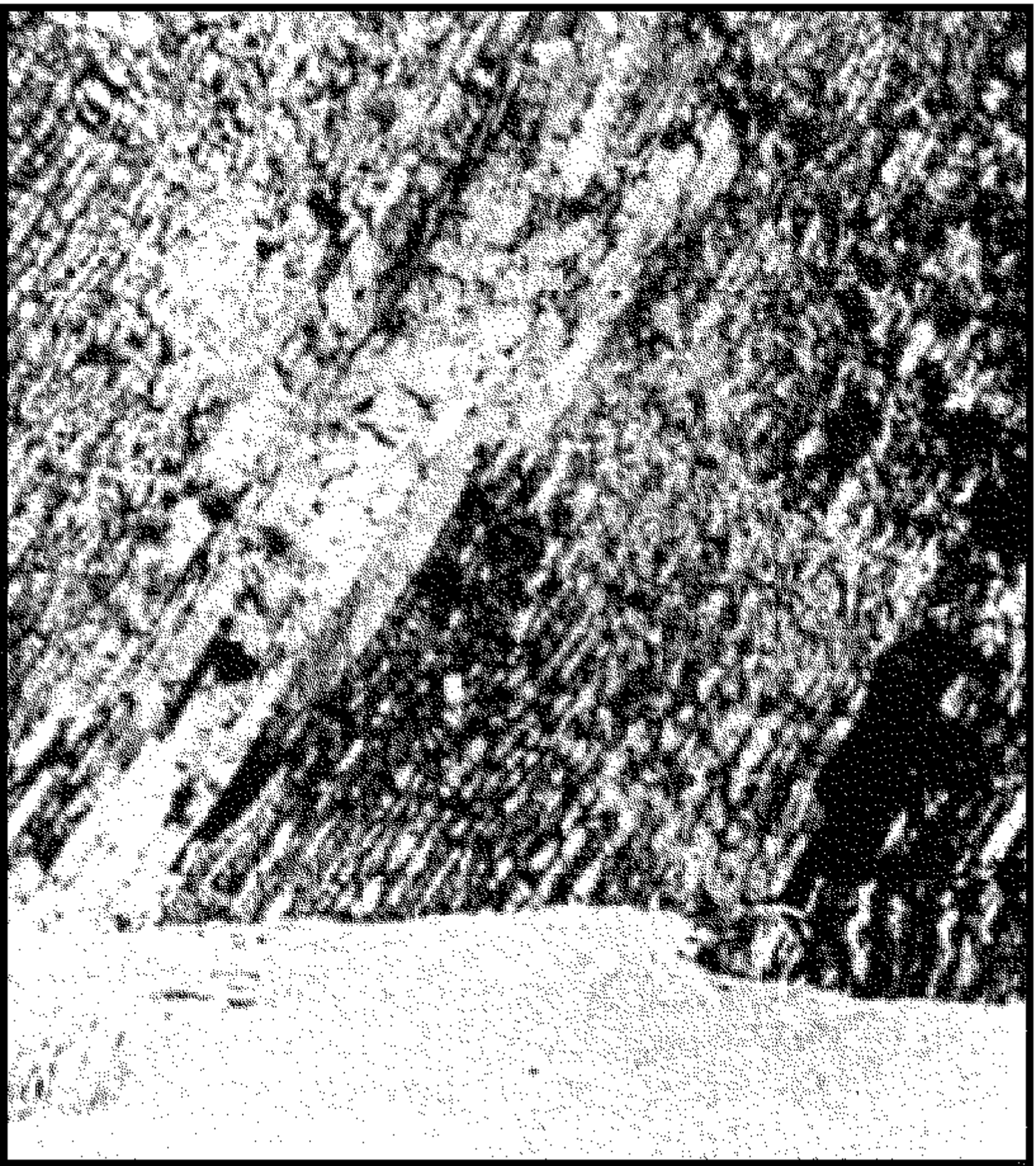


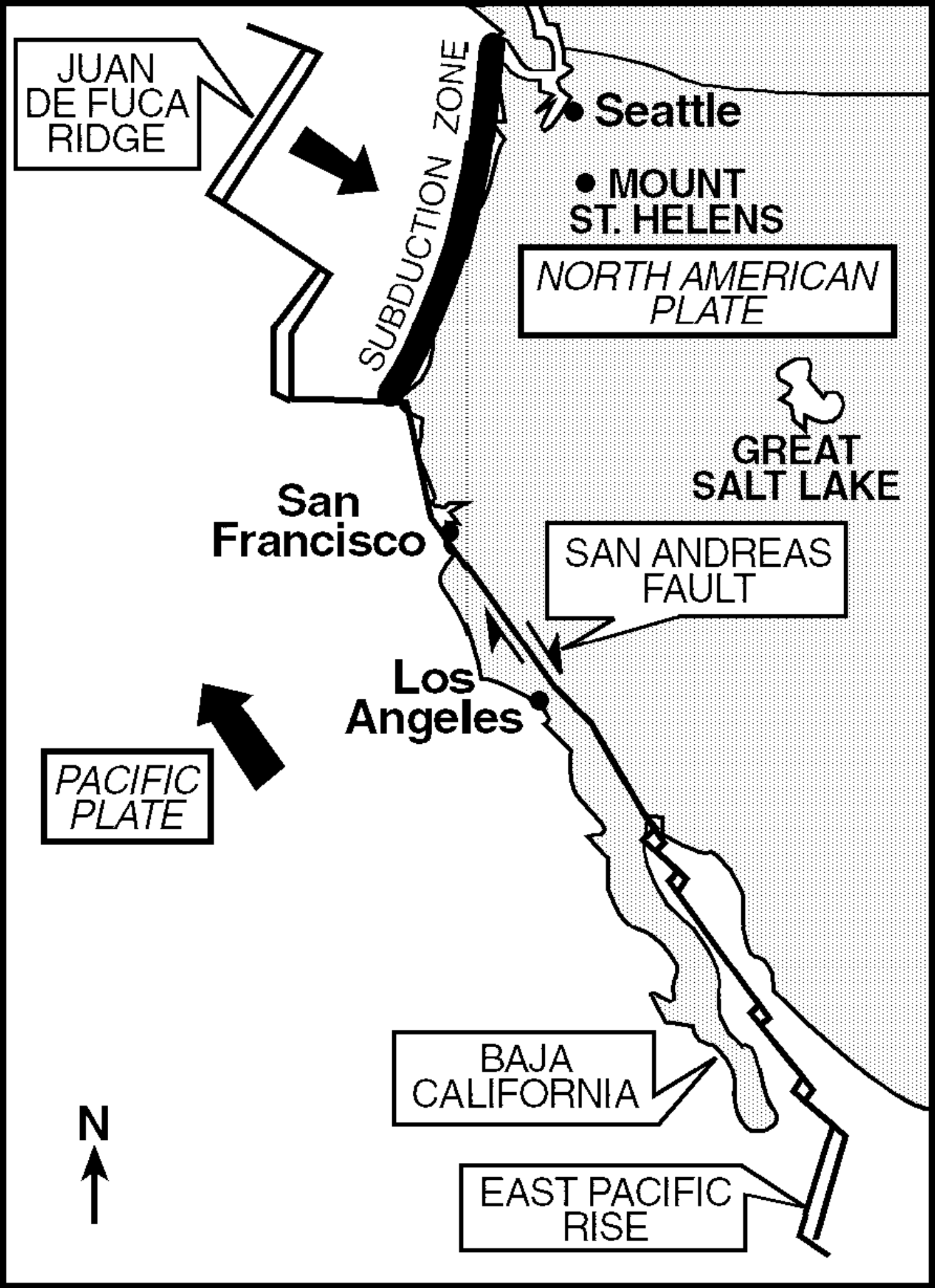

Earthquake Epicenter
FOCUS

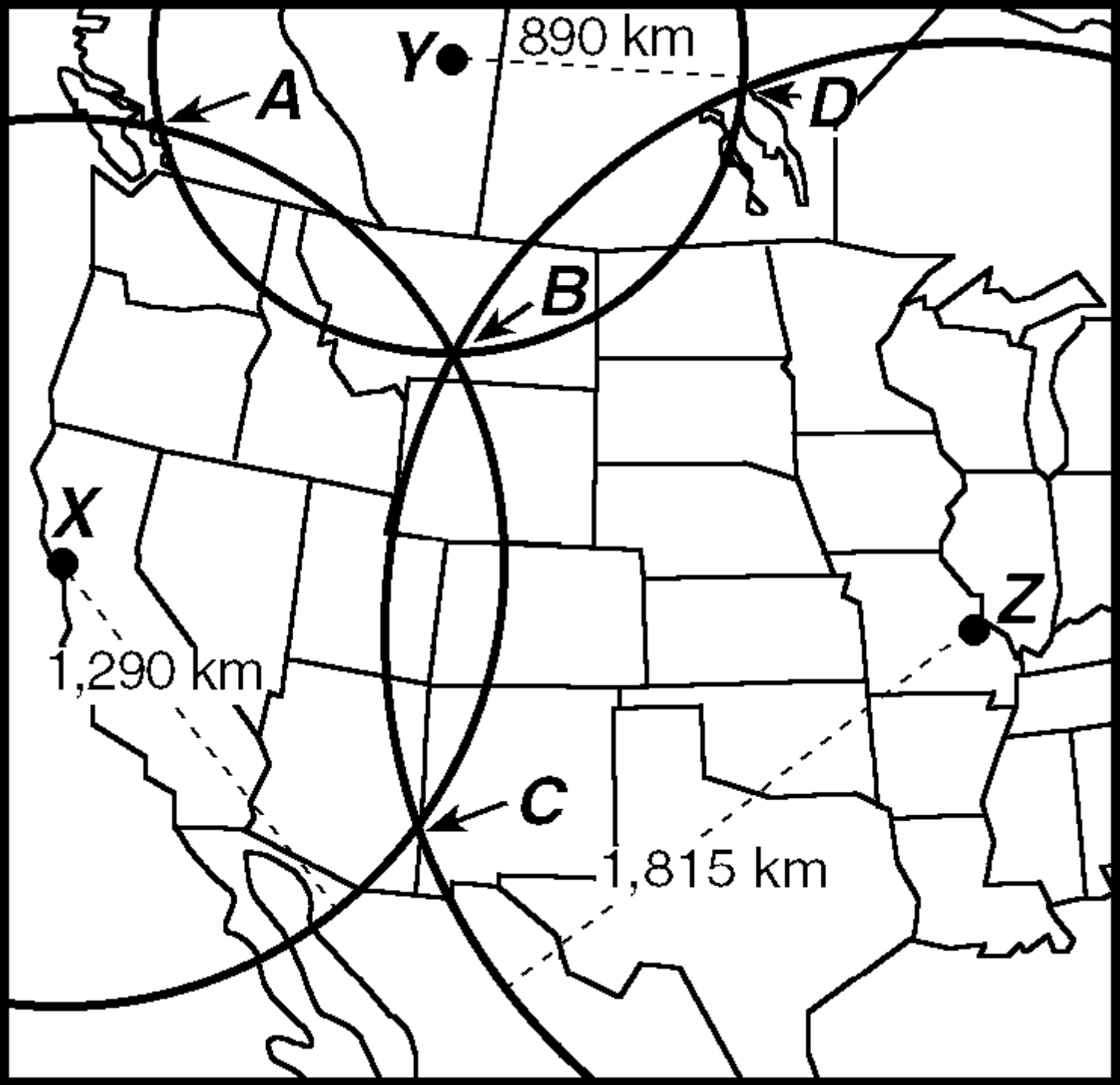

0
Distance from
Mid-Atlantic Ridge (km)
10
20
30
40
50
1
2
3
4
Age of Crust in
Millions of Years
0

DATA TABLE

Seismic Station	P - wave Travel Time
A	8 min 20 sec
B	0 min 31 sec
C	12 min 18 sec
D	3 min 20 sec




JUAN DE FUCA RIDGE
SUBDUCTION ZONE
Seattle
MOUNT ST. HELENS
NORTH AMERICAN PLATE
GREAT SALT LAKE
San Francisco
SAN ANDREAS FAULT
Los Angeles
PACIFIC PLATE
BAJA CALIFORNIA
EAST PACIFIC RISE
N


Y
890 km
A
D
B
X
Z
1,290 km
C
1,815 km

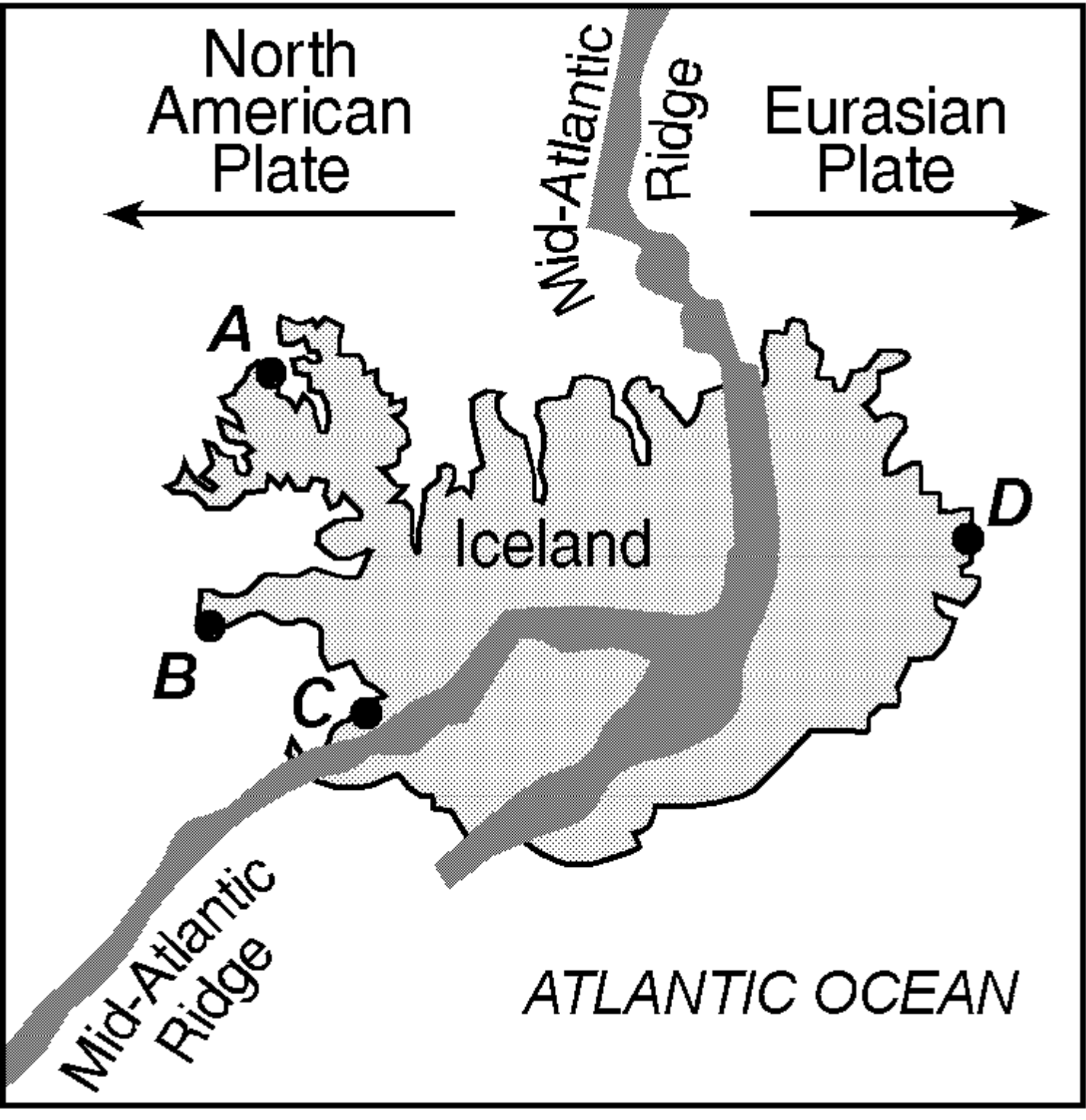
P-Wave

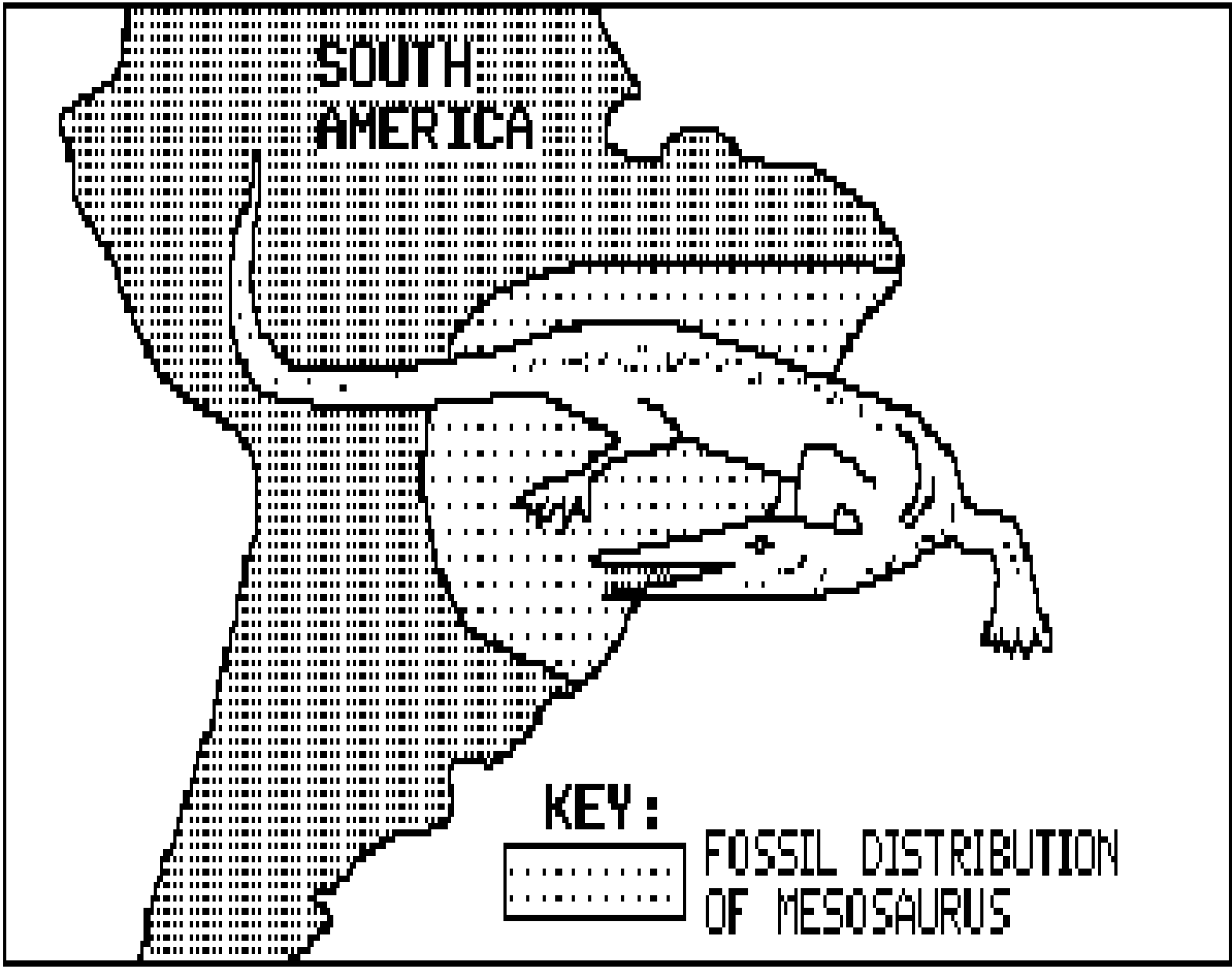
S-Wave

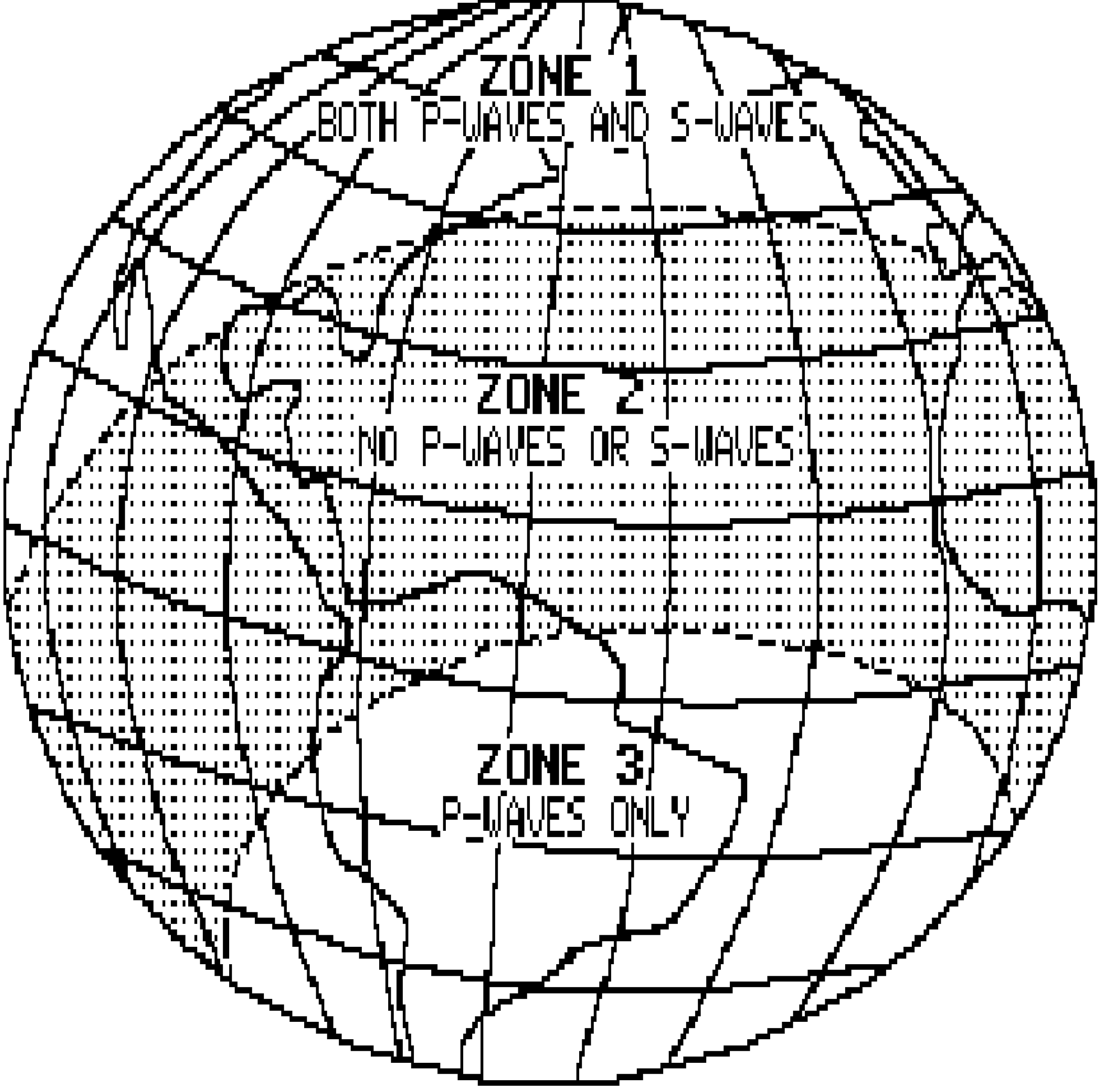
11:10 AM

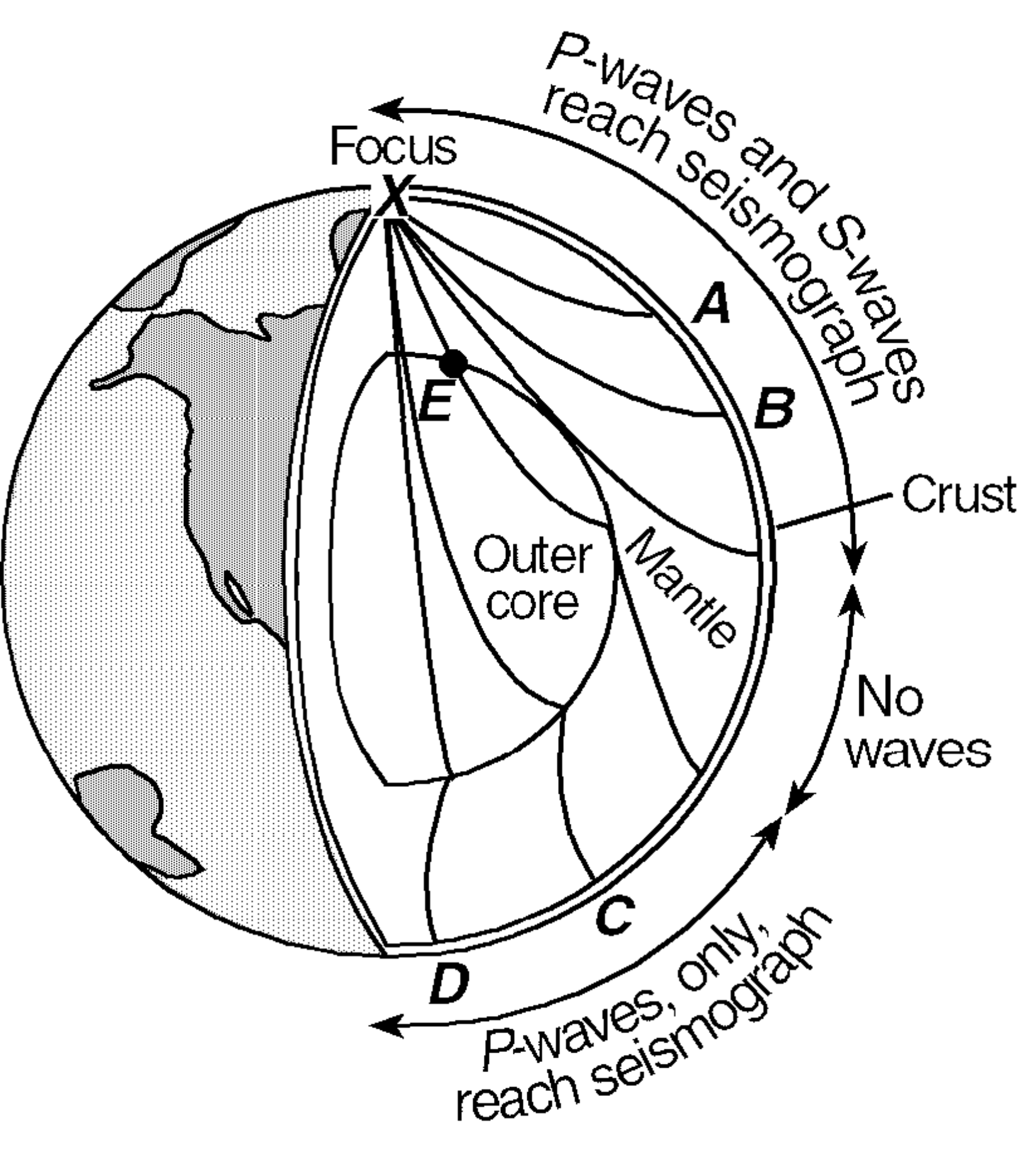
11:15 AM

11:20 AM

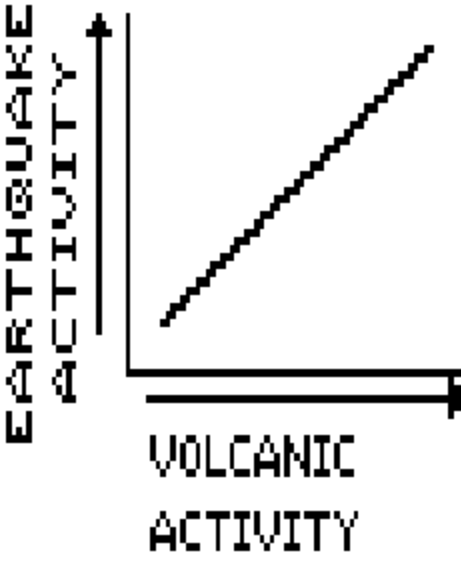

North American Plate
Mid-Atlantic Ridge
Eurasian Plate
A
Iceland
D
B
C
Mid-Atlantic Ridge
ATLANTIC OCEAN

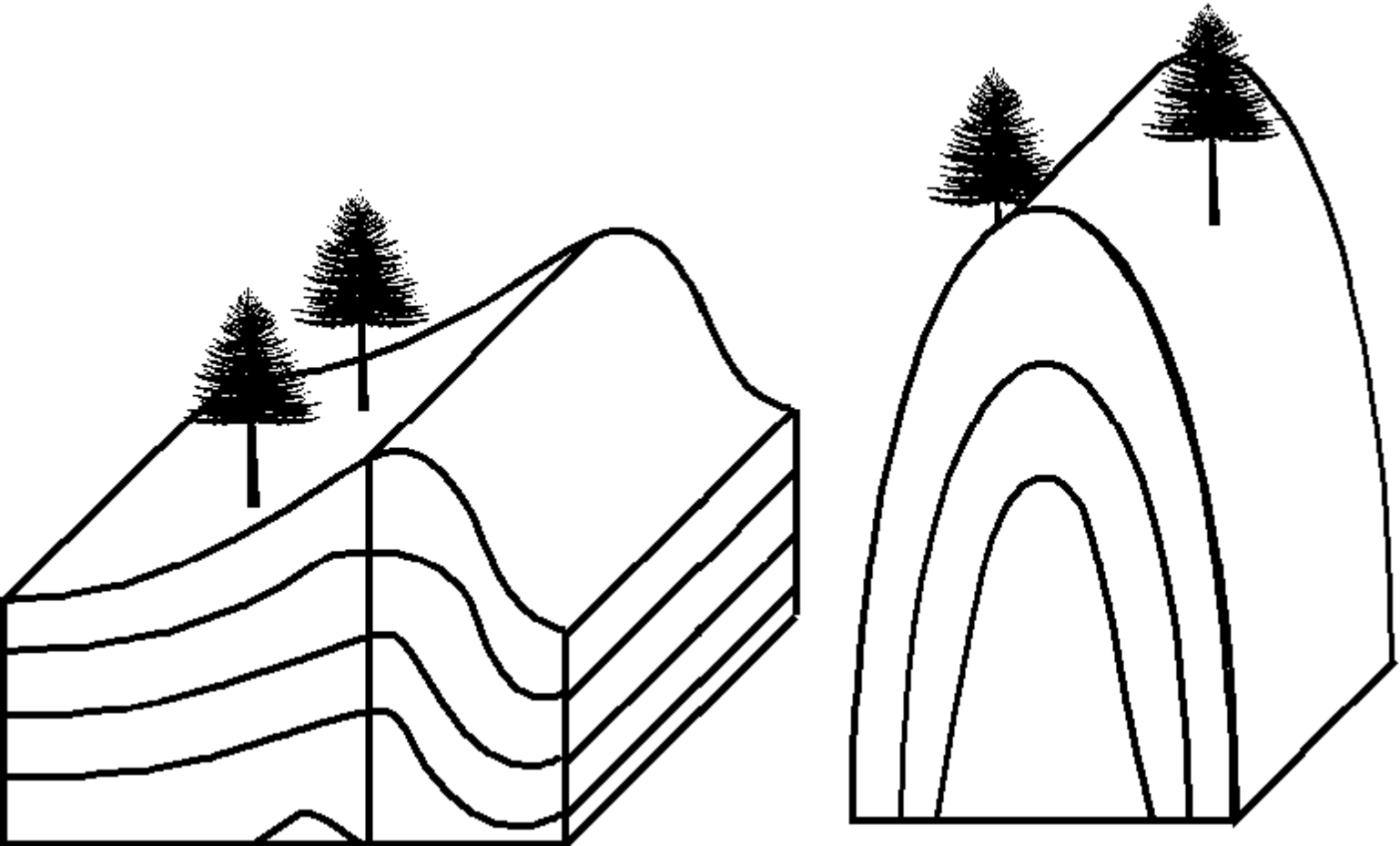

SOUTH
AMERICA
KEY:
FOSSIL DISTRIBUTION
OF MESOSAURUS

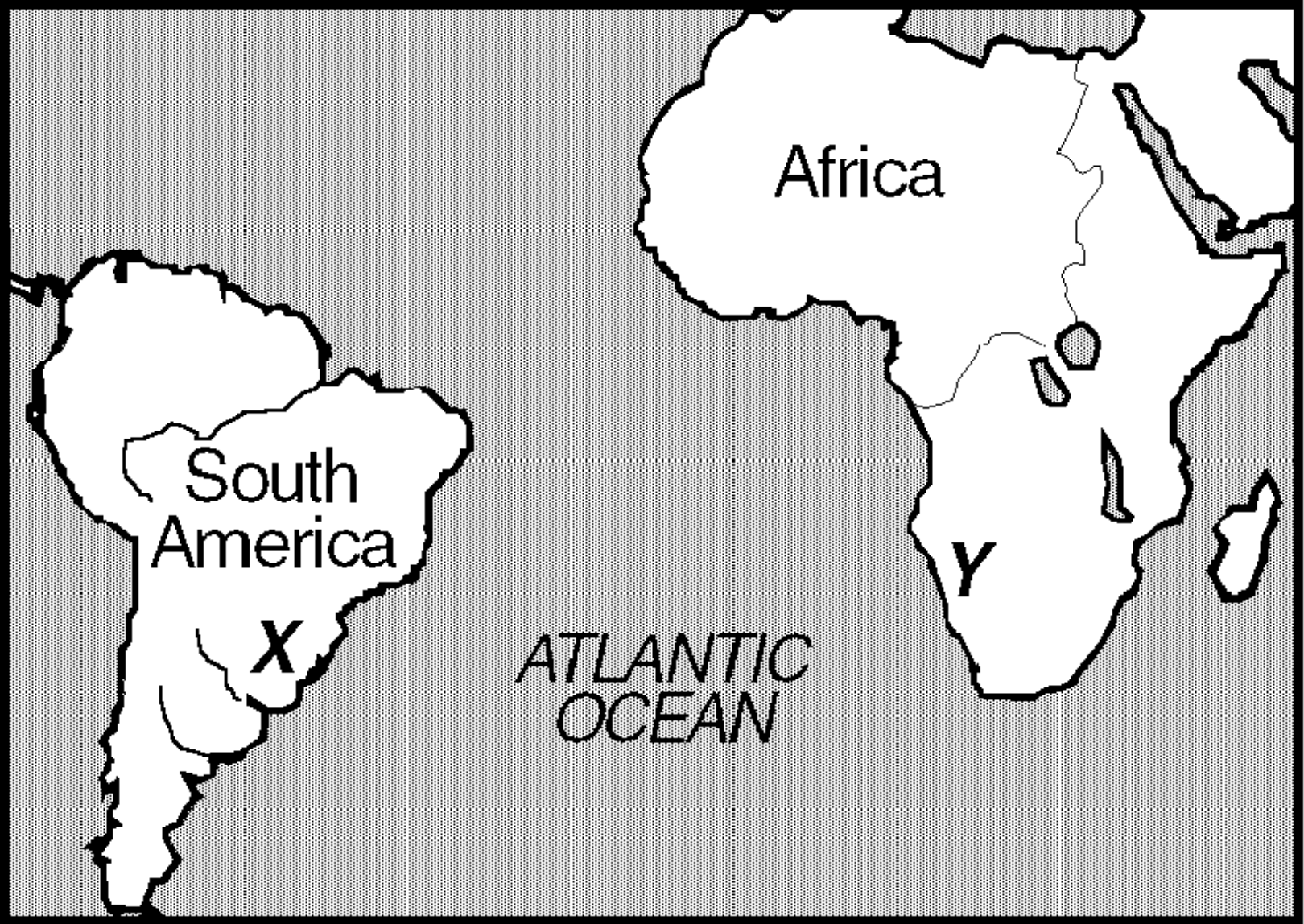

ZONE 1
BOTH P-WAVES AND S-WAVES
ZONE 2
NO P-WAVES OR S-WAVES
ZONE 3
P-WAVES ONLY


P-waves and S-waves reach seismograph
Focus
X
A
B
E
Crust
Outer core
Mantle
No waves
C
D
P-waves, only, reach seismograph

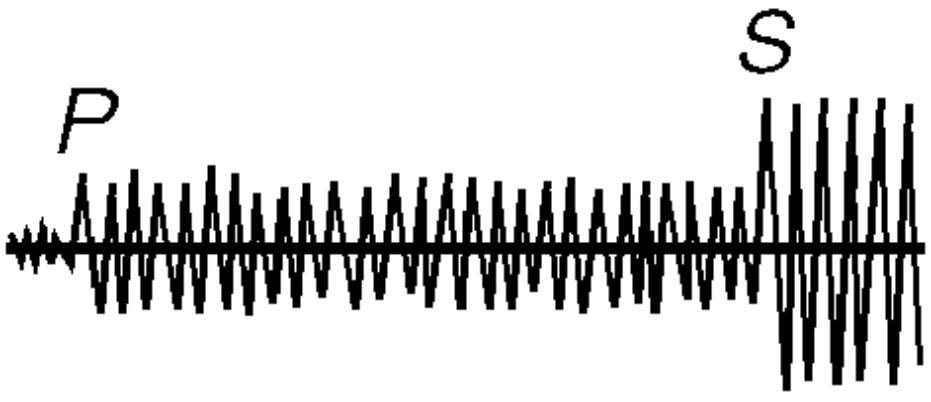
STATION	TRAVEL-TIME DIFFERENCE
A	4 min 32 sec
B	3 min 52 sec
C	3 min 10 sec
D	4 min 17 sec

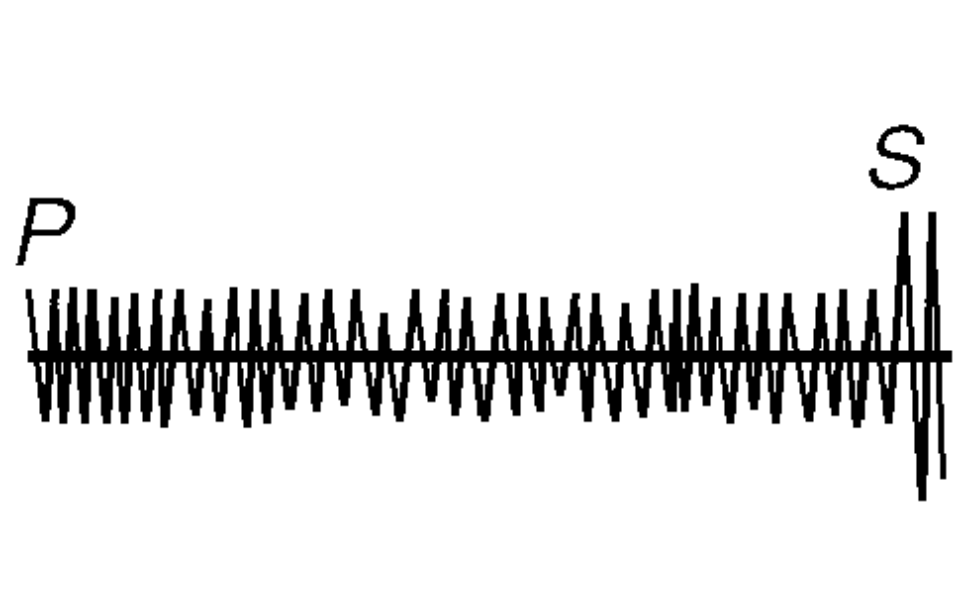

EARTHQUAKE ACTIVITY
VOLCANIC ACTIVITY

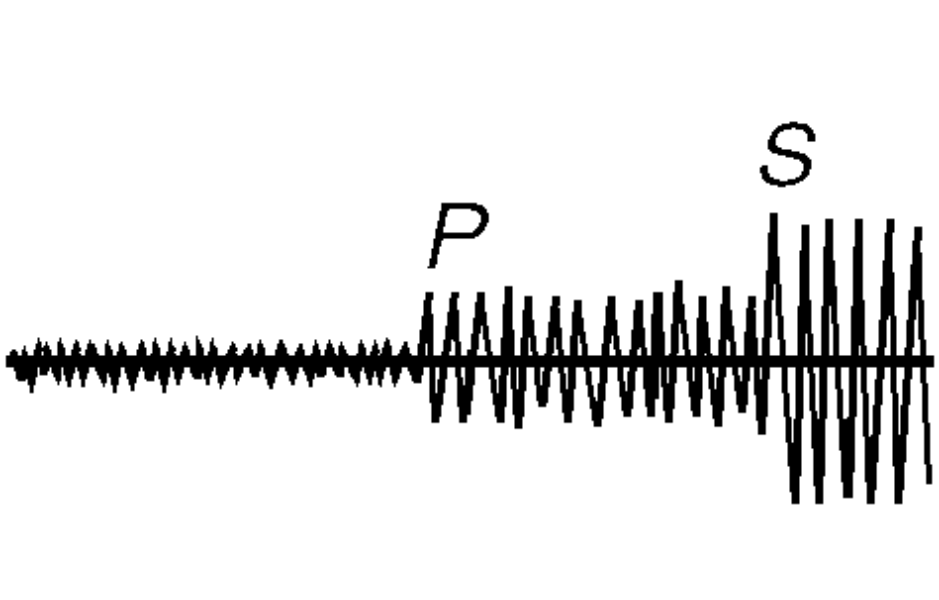


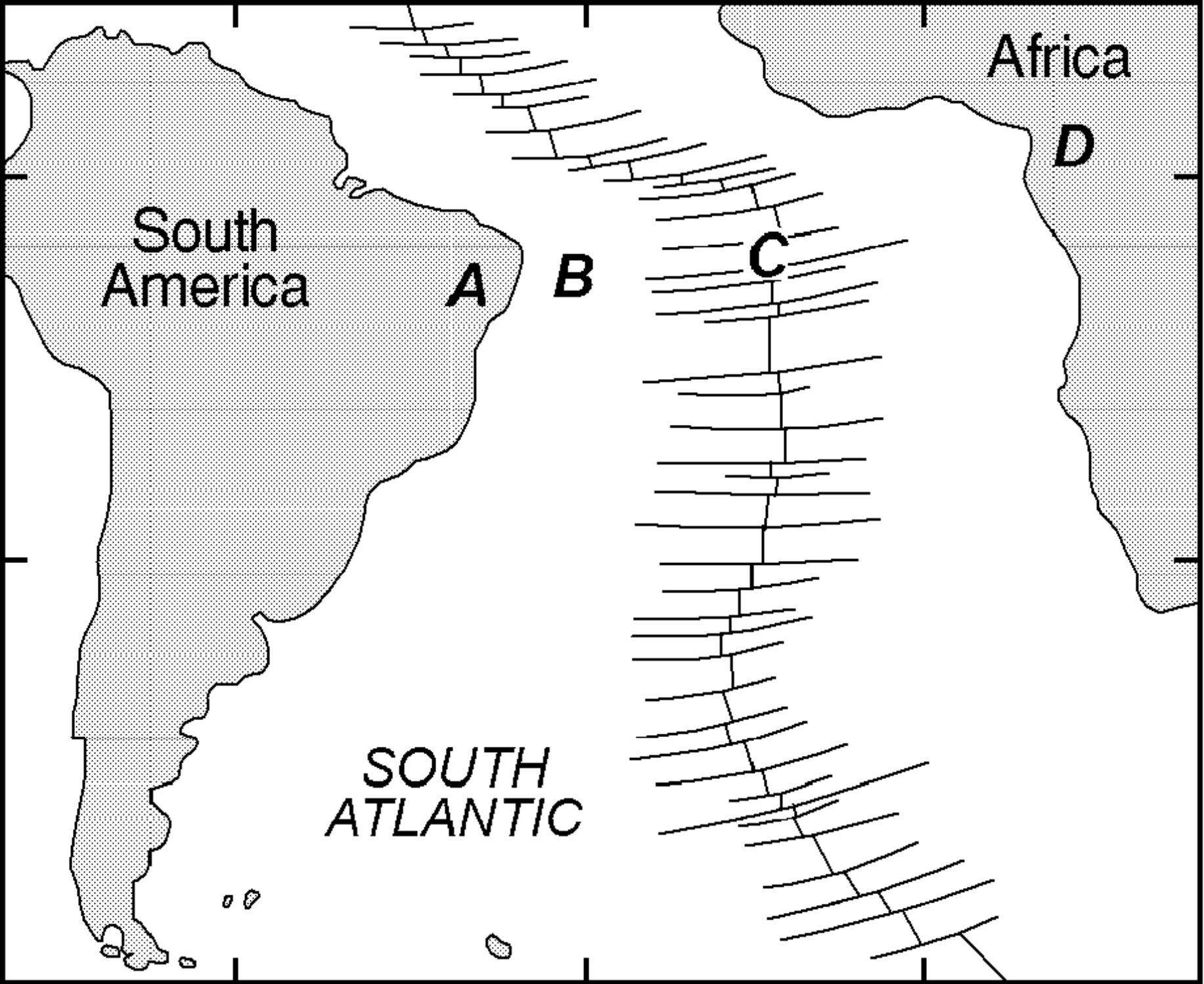

Africa
South America
X
Y
ATLANTIC OCEAN

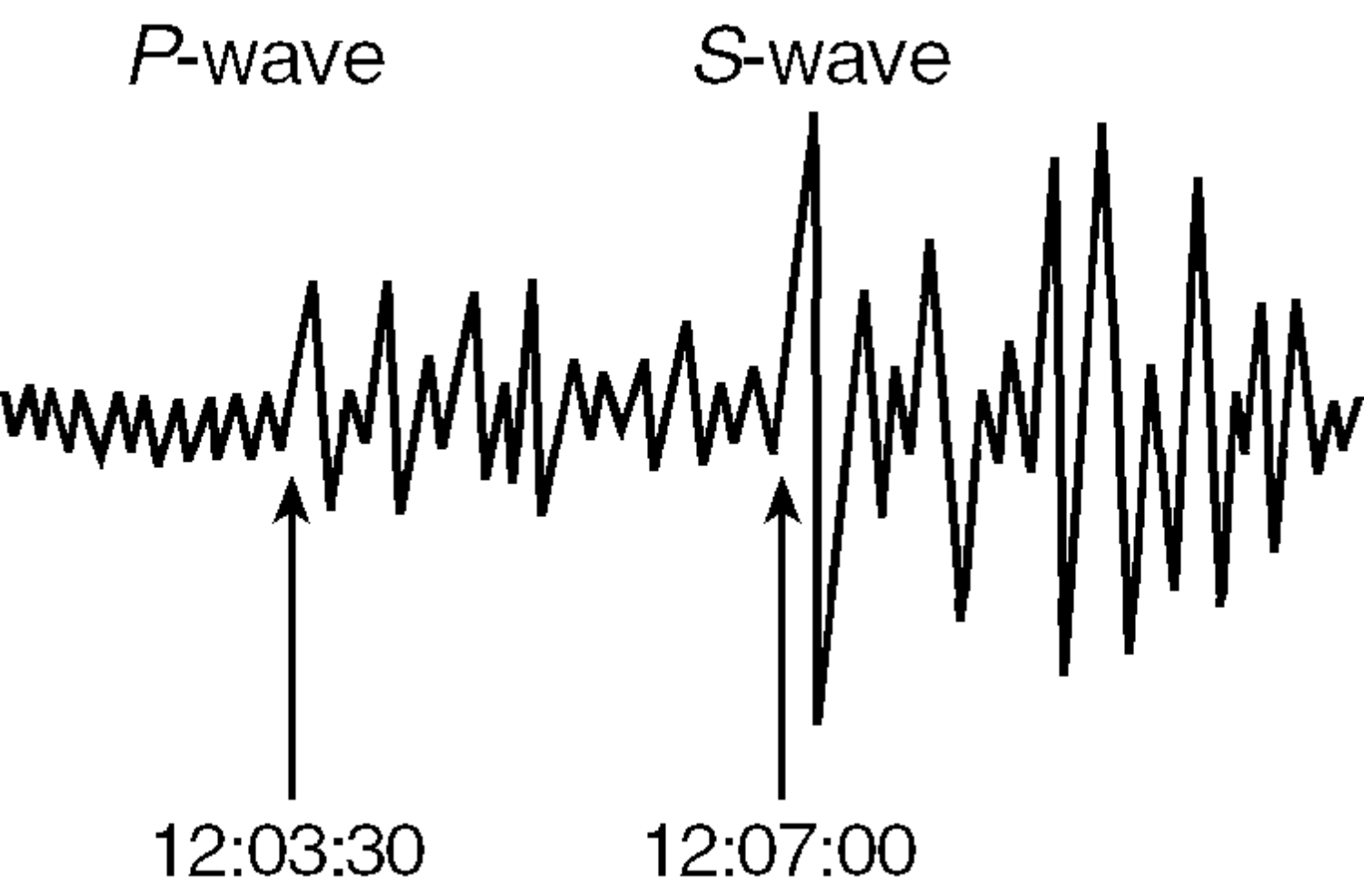

S
P

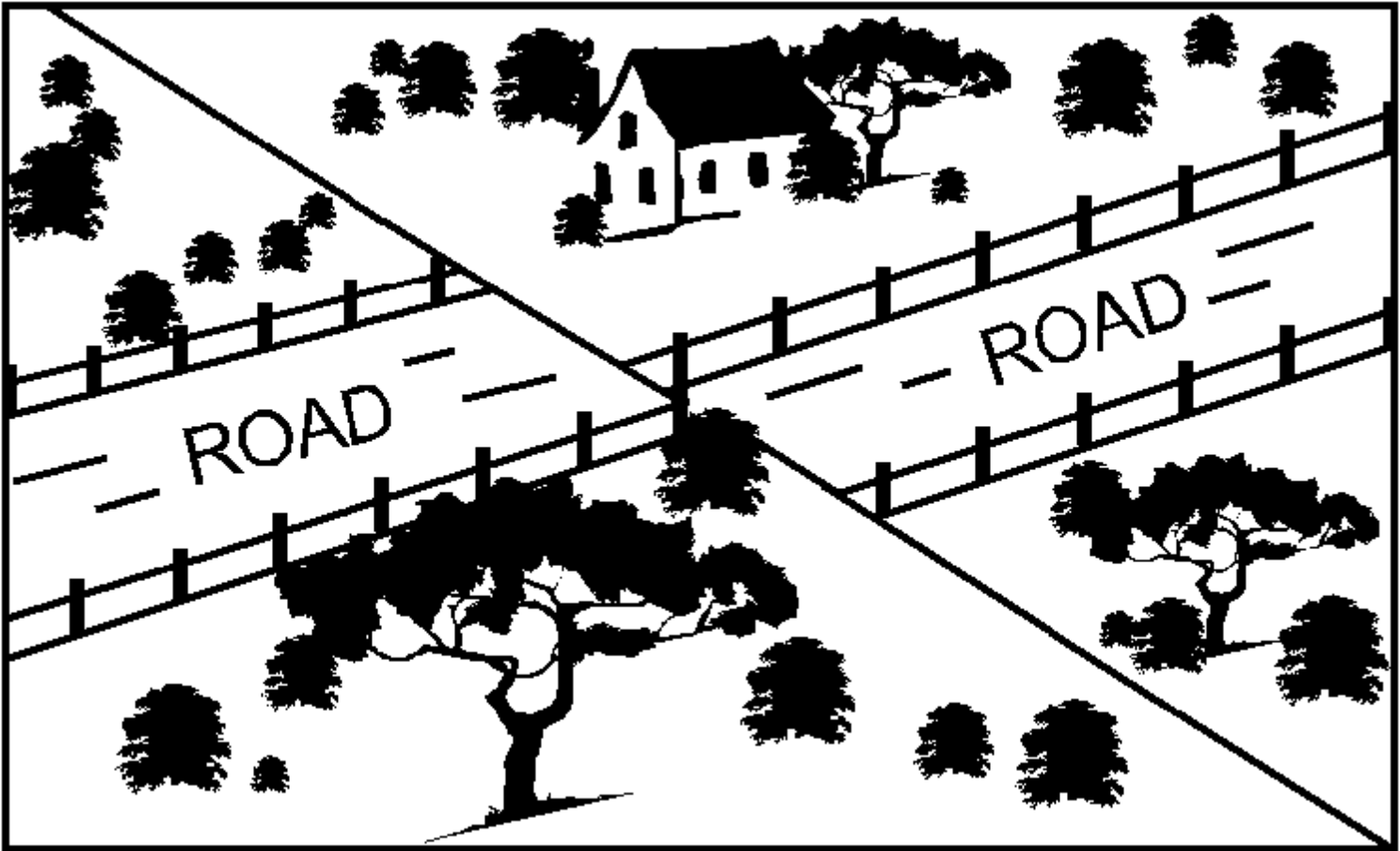

P
S

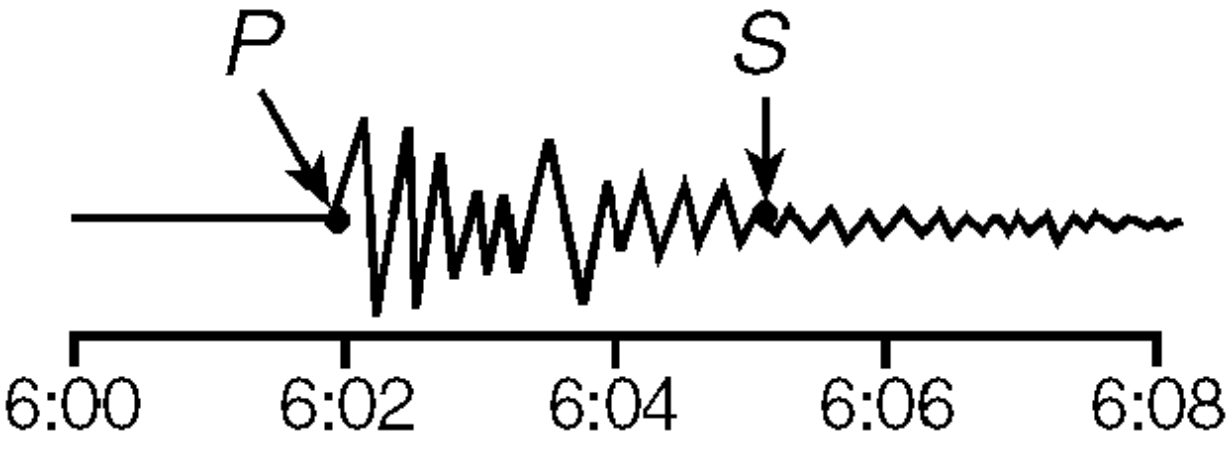

P
S

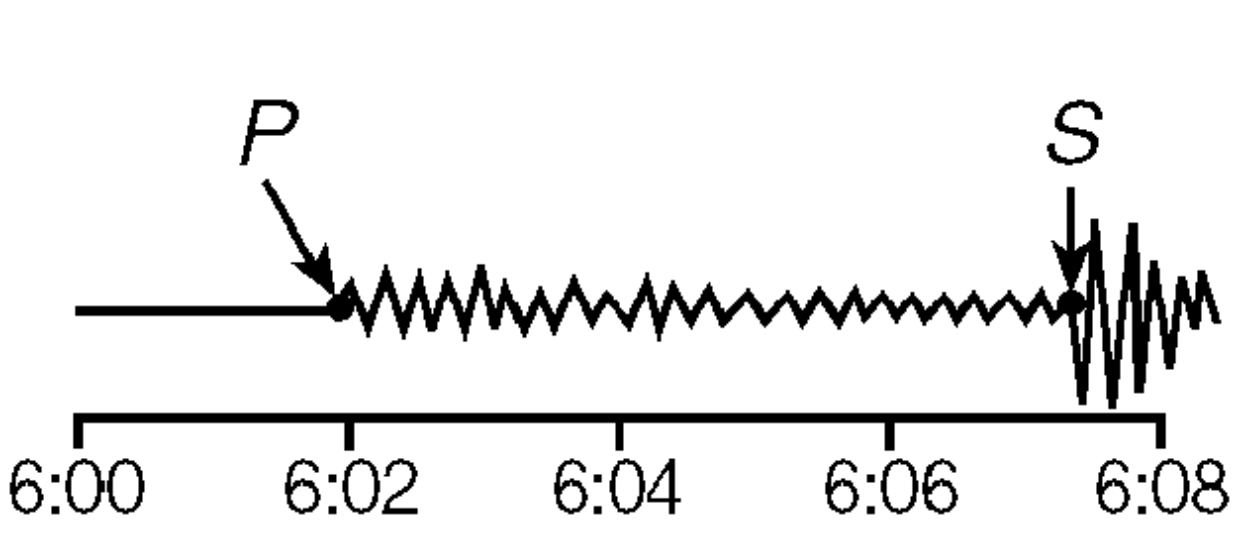

P
S

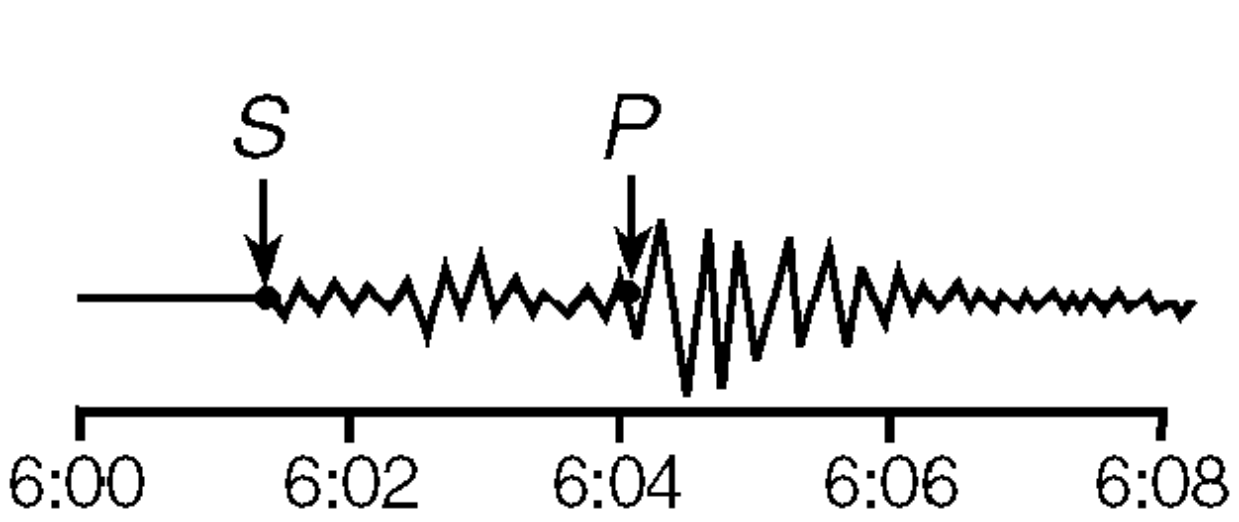

Africa
D
South
America
A
B
C
SOUTH
ATLANTIC

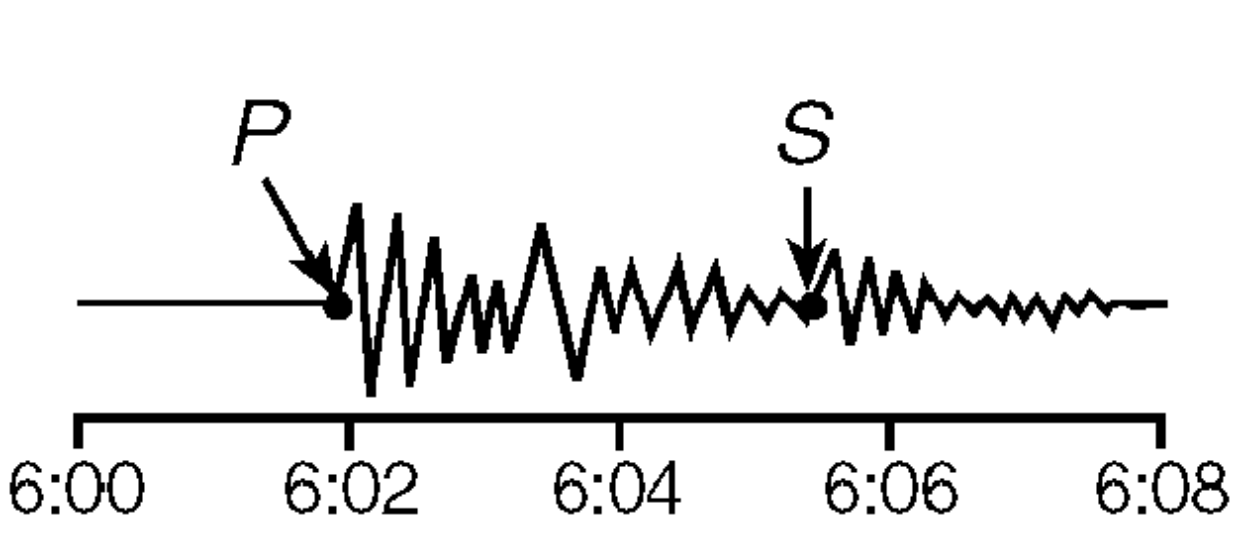

P-wave
S-wave
12:03:30
12:07:00


ROAD
ROAD

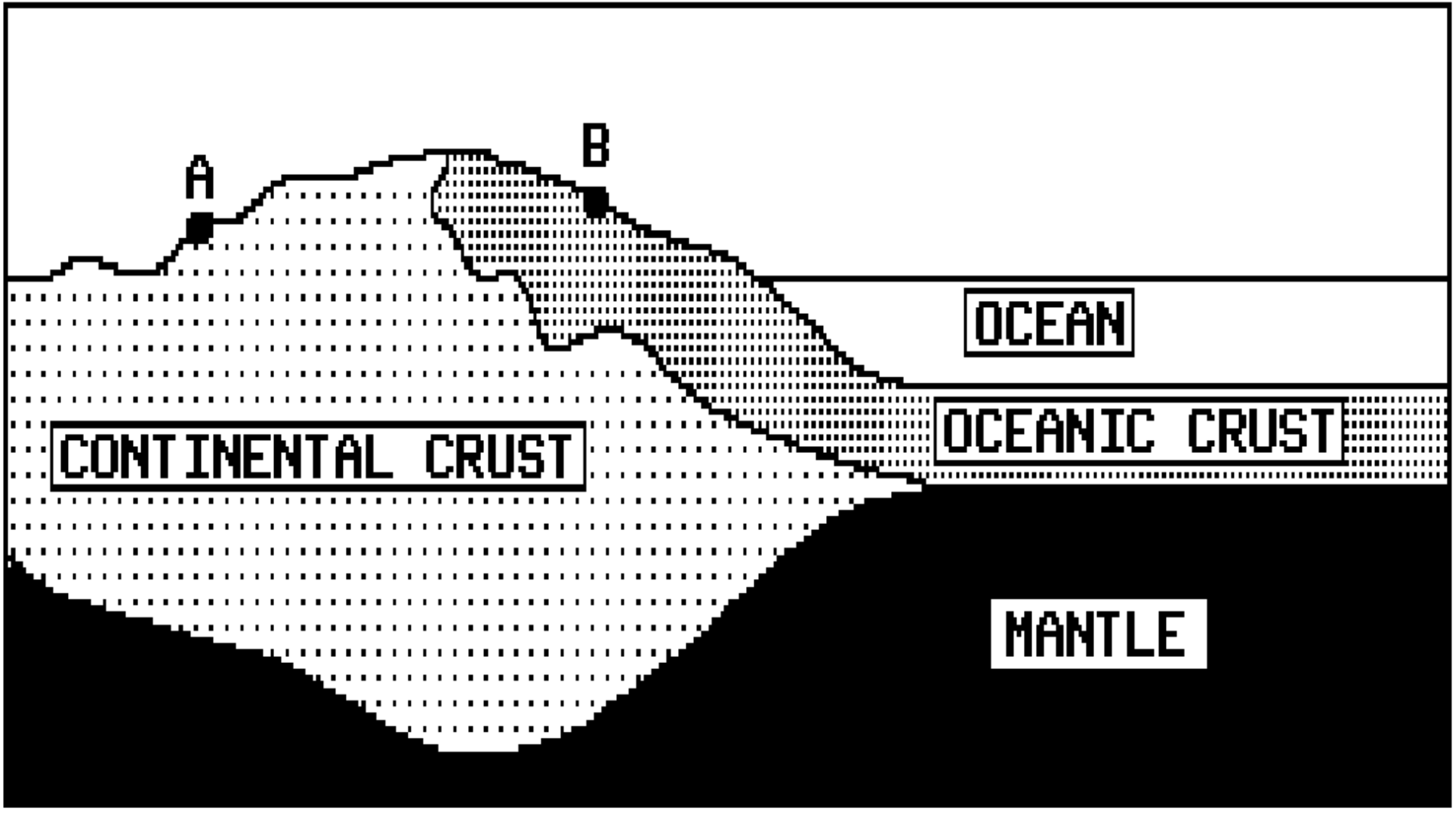

P
S
6:00
6:02
6:04
6:06
6:08

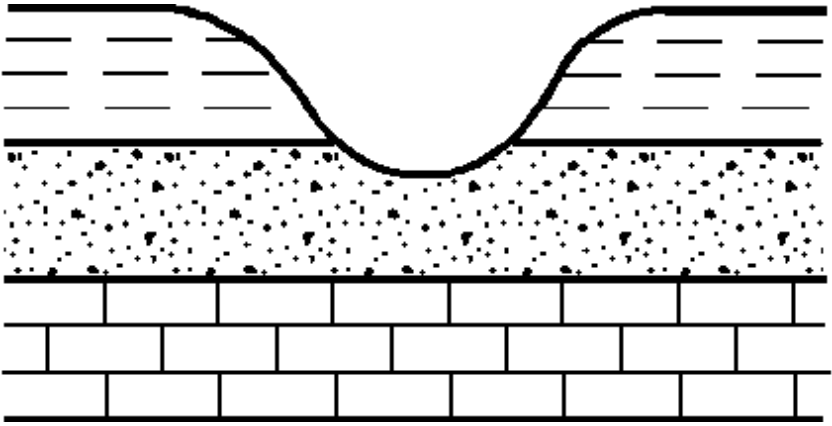

P
S
6:00
6:02
6:04
6:06
6:08

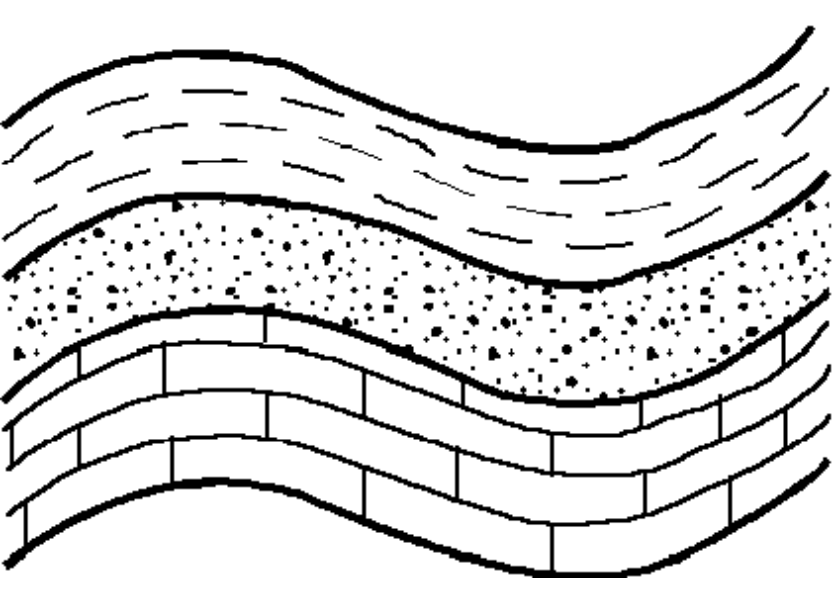

S
P
6:00
6:02
6:04
6:06
6:08

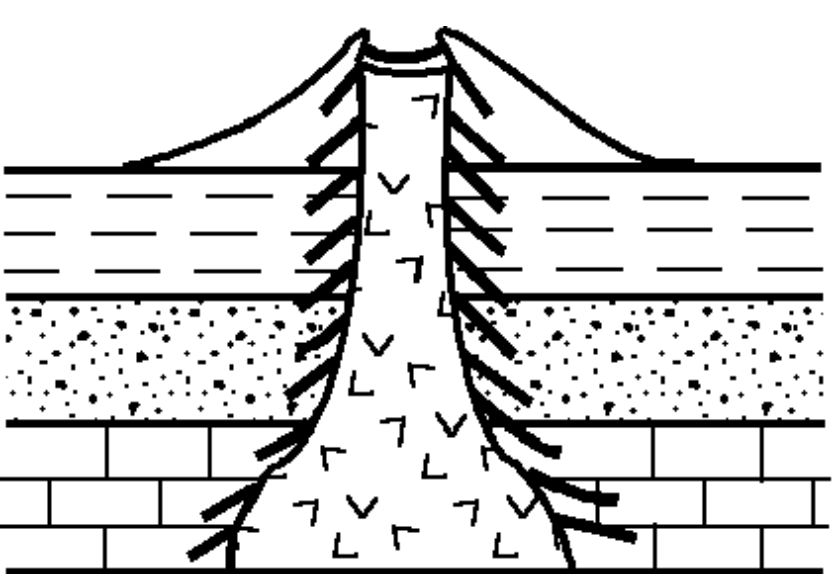

P
S
6:00
6:02
6:04
6:06
6:08

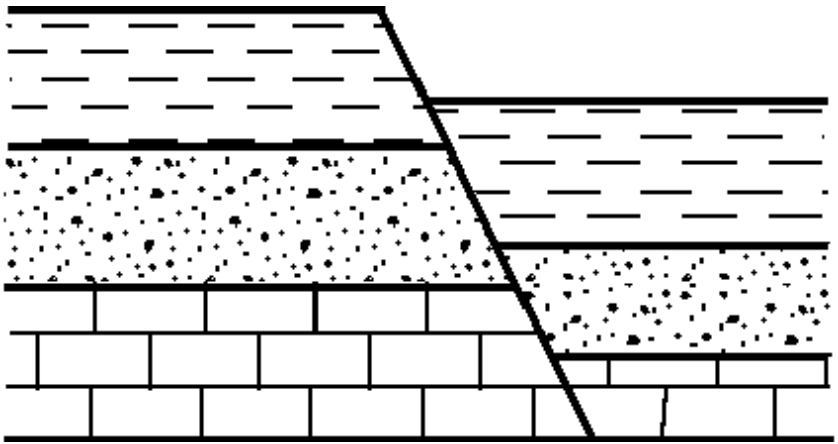
Station	Arrival Time of *P*-Wave	Arrival Time of *S*-Wave	Difference in Arrival Times of *P* and *S*-Waves	Distance to Epicenter
A	6:02:00 p.m.	6:07:30 p.m.	5 min 30 sec	—km
B	—p.m.	6:11:20 p.m.	7 min 20 sec	5,700 km

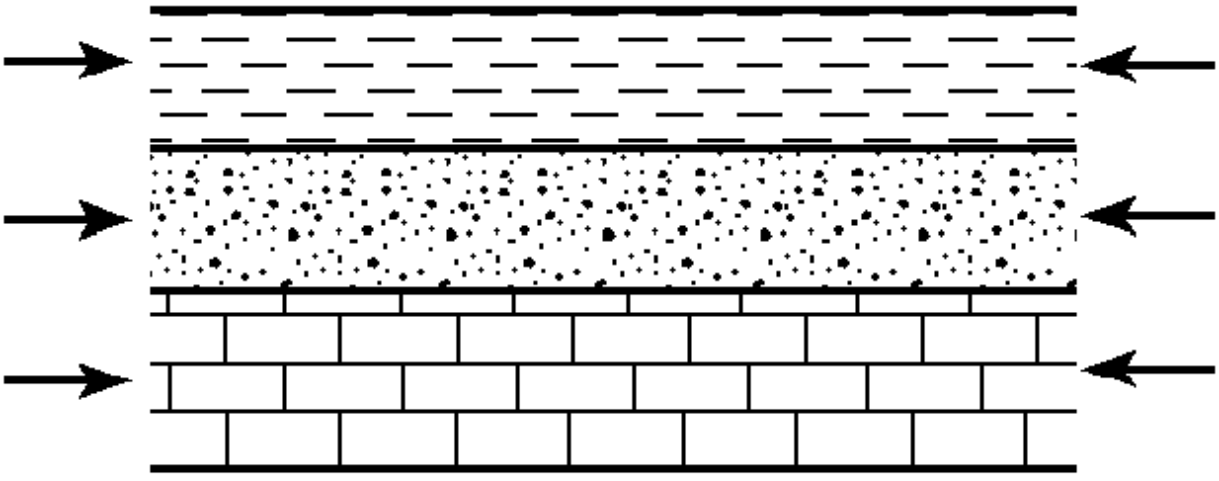

A
B
OCEAN
CONTINENTAL CRUST
OCEANIC CRUST
MANTLE

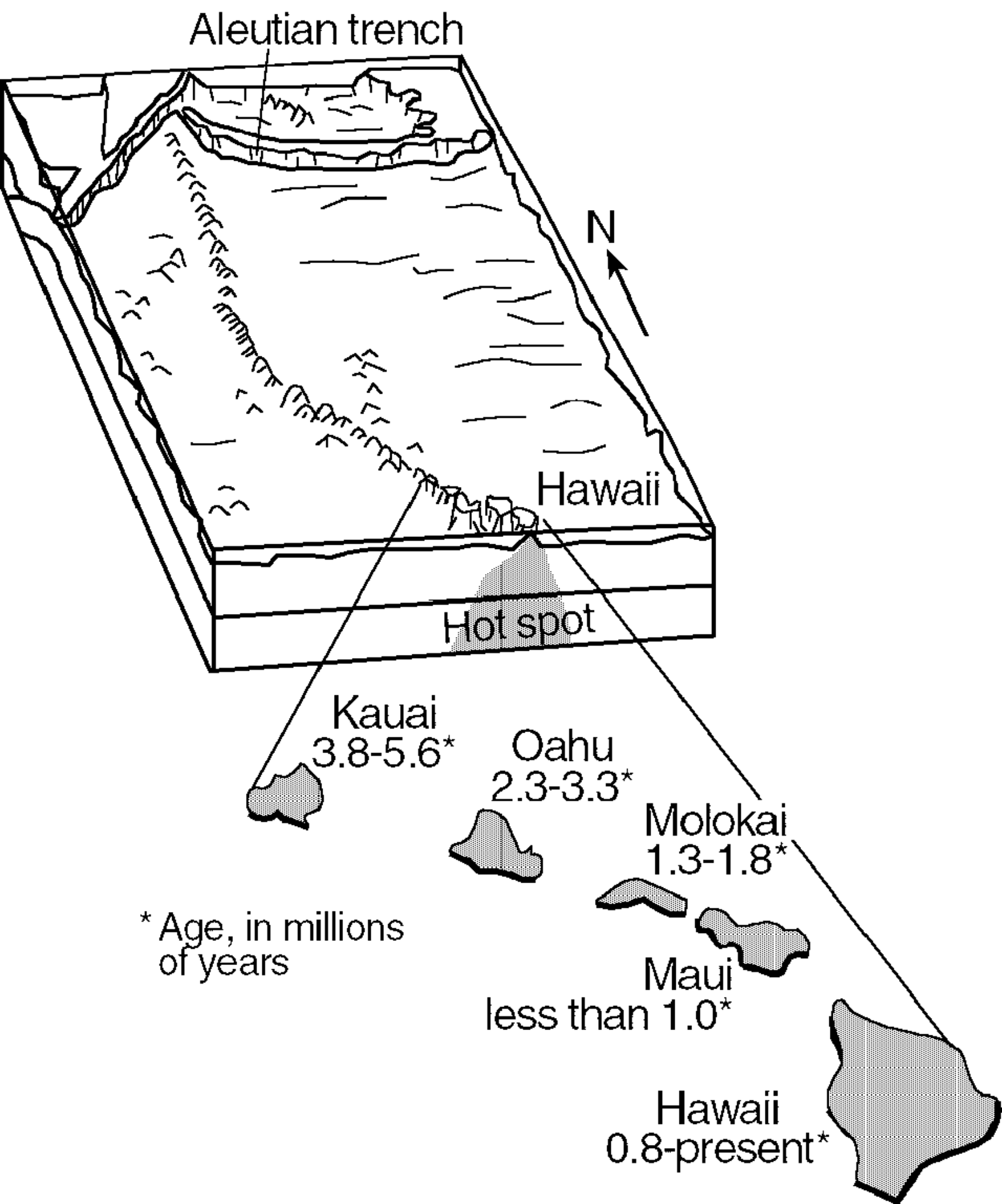


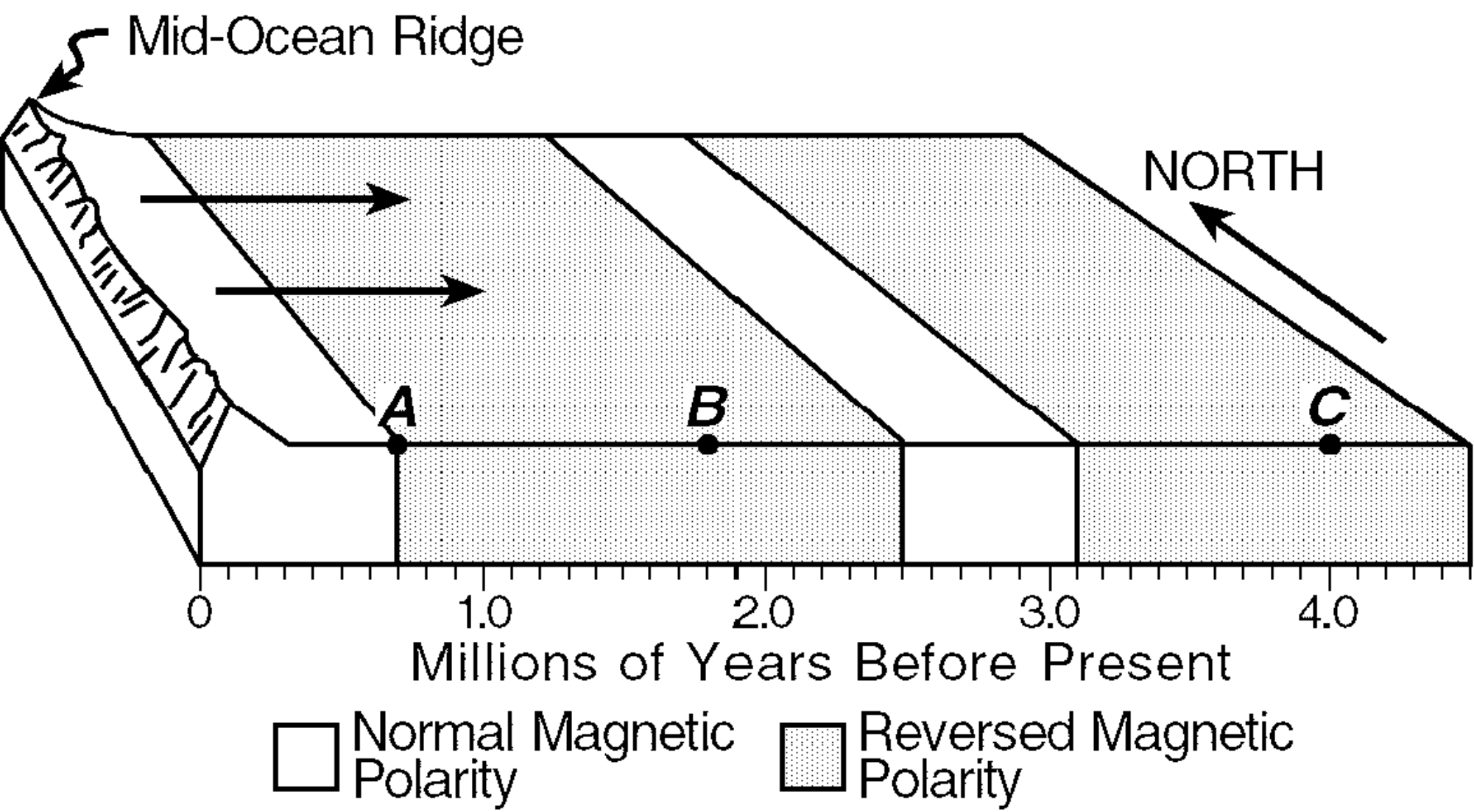






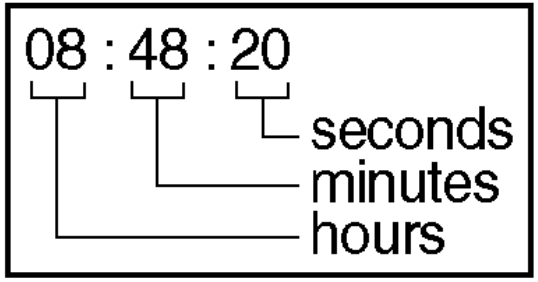


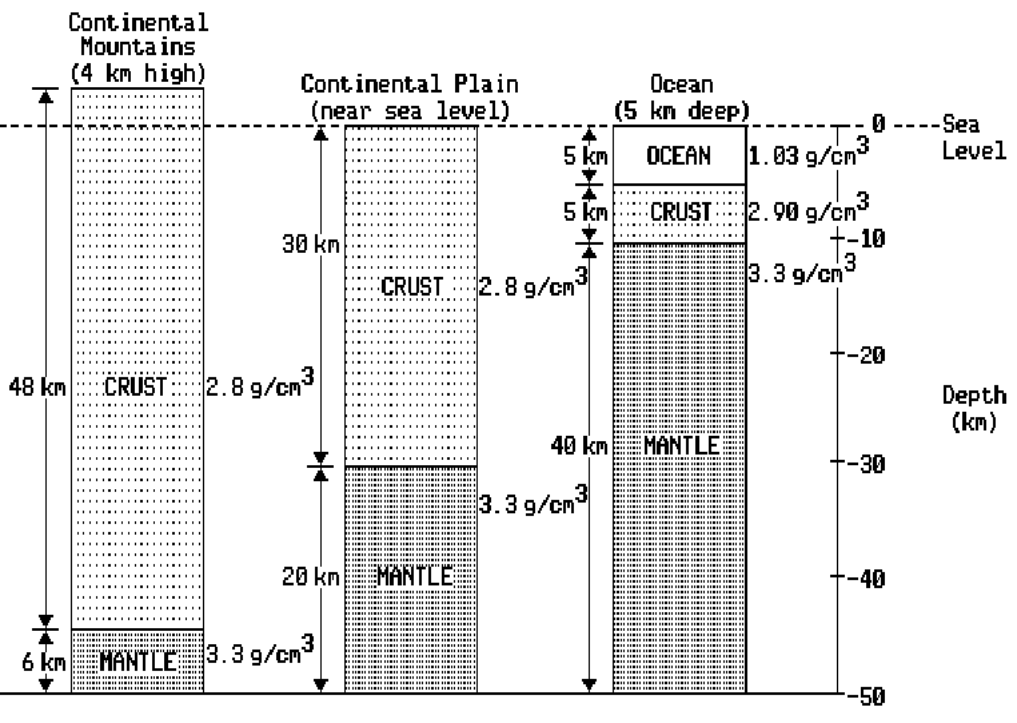

Aleutian trench
N
Hawaii
Hot spot
Kauai
3.8-5.6*
Oahu
2.3-3.3*
Molokai
1.3-1.8*
* Age, in millions
of years
Maui
less than 1.0*
Hawaii
0.8-present*

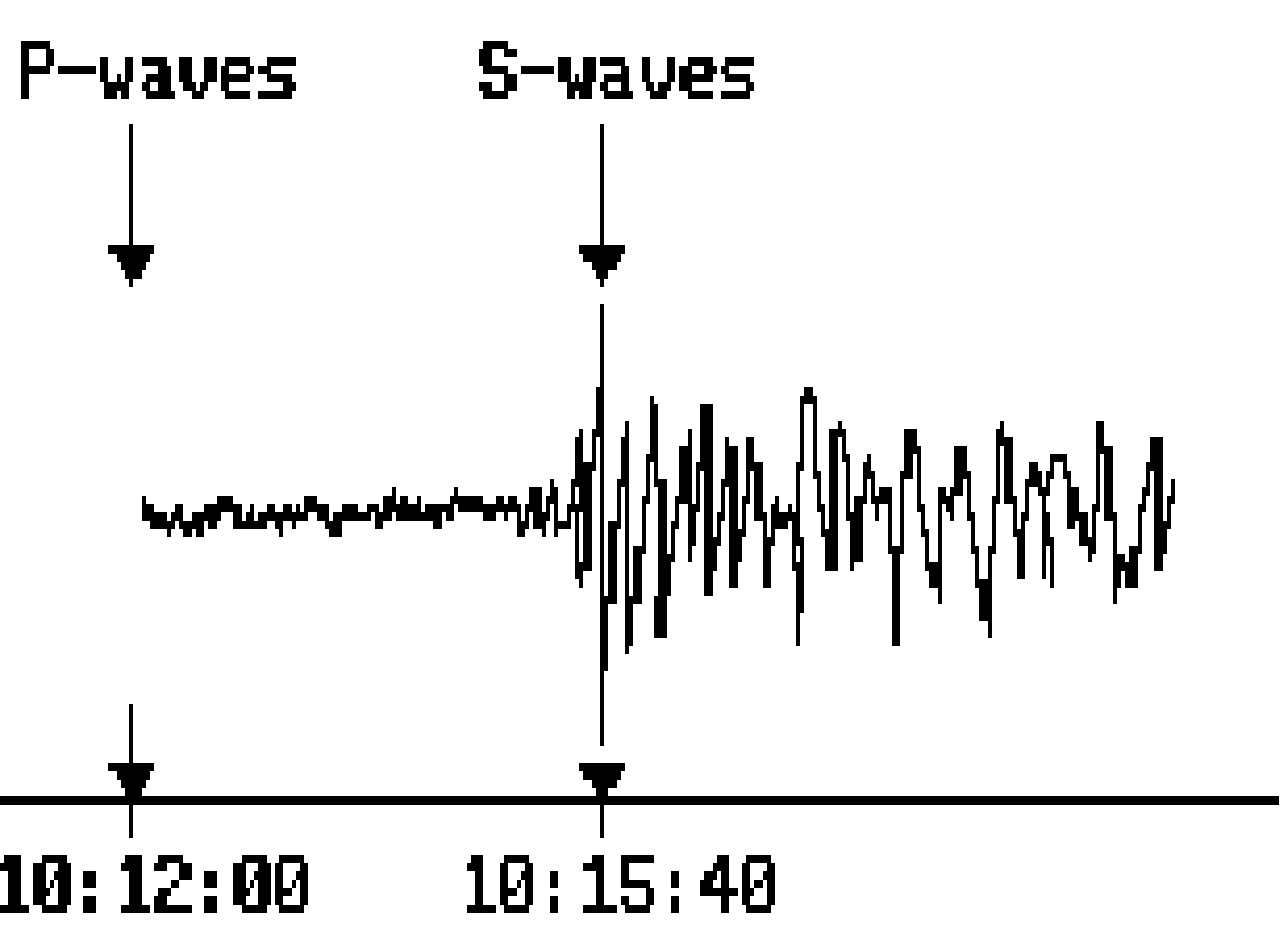

Mid-Ocean Ridge
NORTH
A
B
C
0
1.0
2.0
3.0
4.0
Millions of Years Before Present
Normal Magnetic Polarity
Reversed Magnetic Polarity

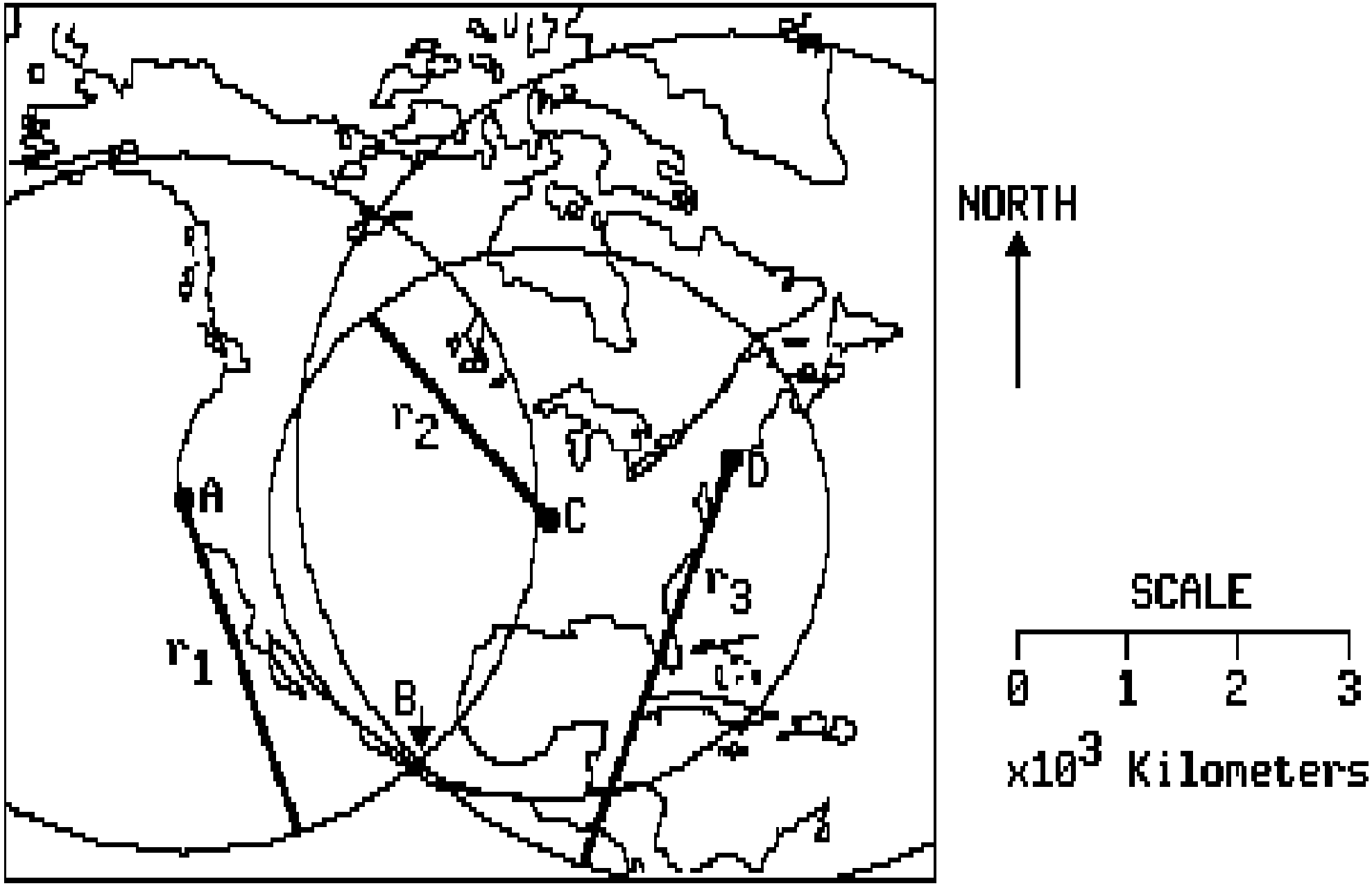
Seismic Station	*P*-Wave Arrival Time	*S*-Wave Arrival Time	Difference in Arrival Times	Distance to Epicenter
A	08:48:20	No *S*-waves arrived		
B	08:42:00		00:04:40	
C	08:39:20		00:02:40	
D	08:45:40			6,200 km

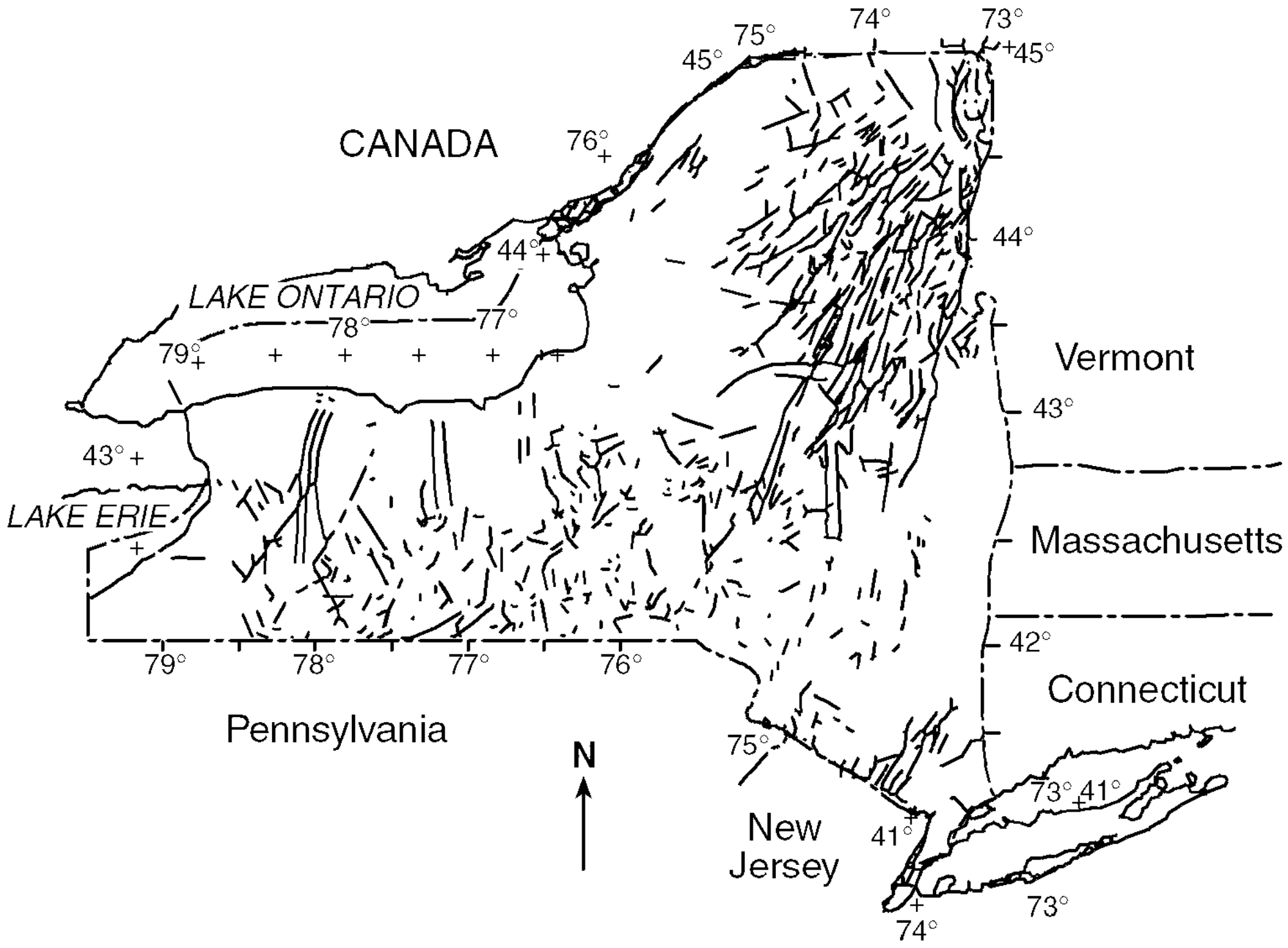
KEY:




Continental Mountains (4 km high)
Continental Plain (near sea level)
Ocean (5 km deep)
0
Sea Level
-10
-20
-30
-40
-50
Depth (km)
48 km
CRUST
2.8 g/cm3
6 km
MANTLE
3.3 g/cm3
30 km
CRUST
2.8 g/cm3
20 km
MANTLE
3.3 g/cm3
5 km
OCEAN
1.03 g/cm3
5 km
CRUST
2.90 g/cm3
40 km
MANTLE
3.3 g/cm3

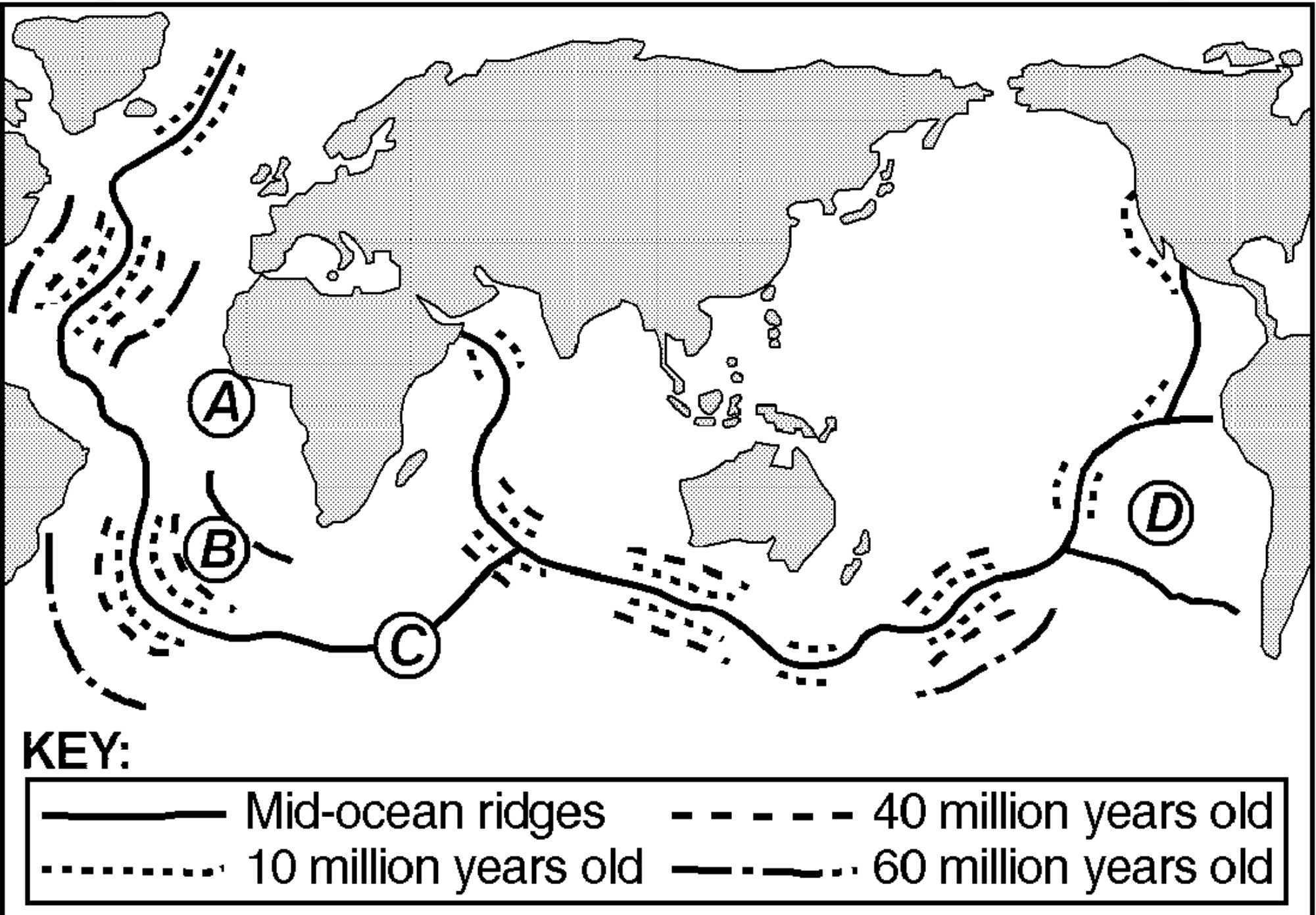

P-waves
S-waves
10:12:00
10:15:40

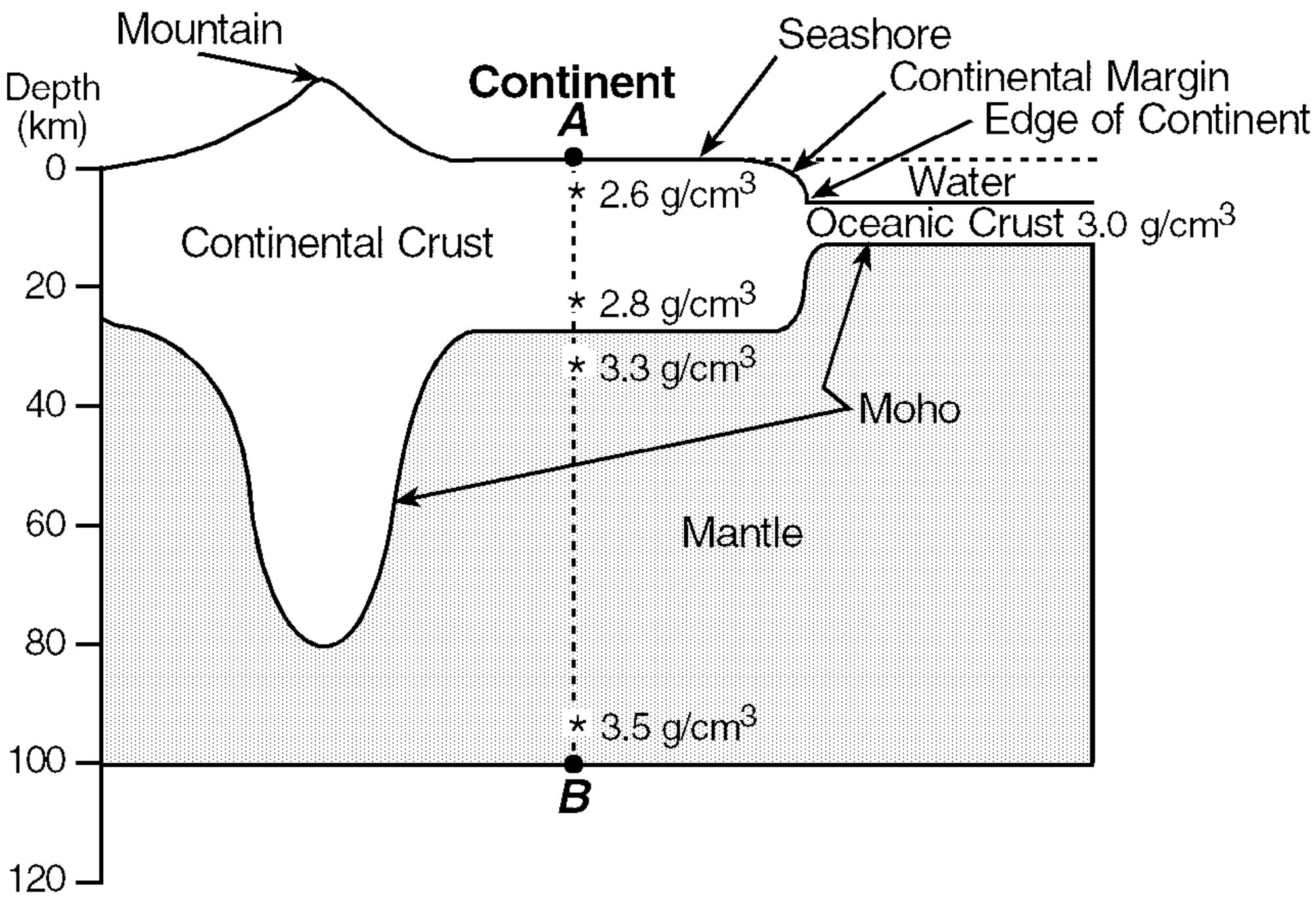

NORTH
SCALE
0 1 2 3
x10^3 Kilometers
A
B
C
D
r1
r2
r3


CANADA
LAKE ONTARIO
LAKE ERIE
Pennsylvania
New Jersey
Vermont
Massachusetts
Connecticut
N
45°
75°
74°
73°
76°
44°
78°
77°
79°
43°
42°
41°

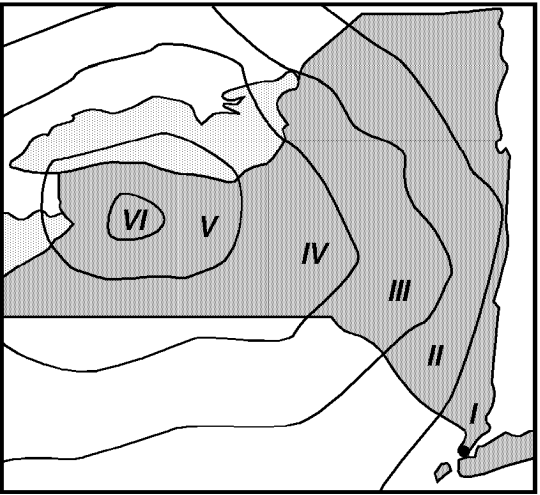

Pittsburgh
New York City
Louisville
New Orleans
0
400
800
1,200 km

Age of Rocks on the Sea Bottom Relative to Ridges




Mountain
Seashore
Continent
Continental Margin
Depth (km)
A
Edge of Continent
0
2.6 g/cm3
Water
Oceanic Crust 3.0 g/cm3
Continental Crust
20
2.8 g/cm3
3.3 g/cm3
40
Moho
60
Mantle
80
3.5 g/cm3
100
B
120

New York State



Modified Mercalli Scale

Intensity	Observed Effects
I	Usually only detected by intruments
II	Felt by a few persons at rest, especially on upper floors
III	Hanging objects swing; vibration like a passing truck; noticeable indoors
IV	Felt indoors by many, outdoors by few; a sensation like a heavy truck striking a building, parked automobiles rock
V	Felt by nearly all; sleepers awakened; liquids disturbed; unstable objects overturned, some dishes and windows broken
VI	Felt by all; many frightened and run outdoors; some heavy furniture moved; glassware broken; books fall off shelves; damage slight
VII	Difficult to stand; noticed in moving automobiles; damage to some masonry; weak chimneys broken at roofline
VIII	Partial collapse of masonry; chimneys, factory stacks, columns fall; heavy furniture overturned; frame houses moved on foundations

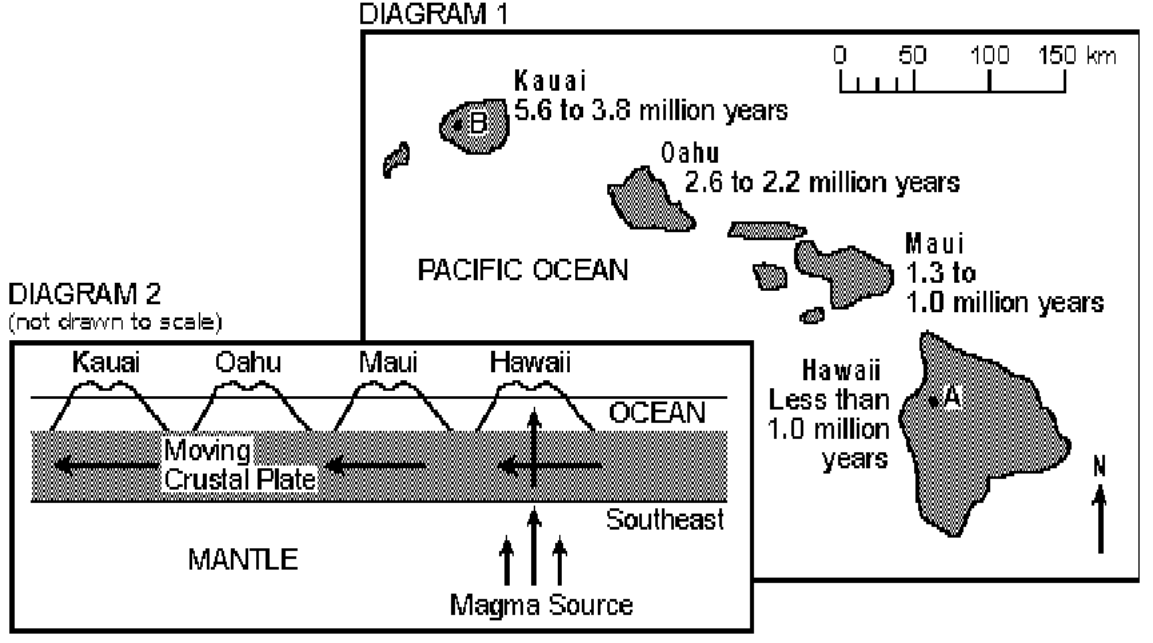
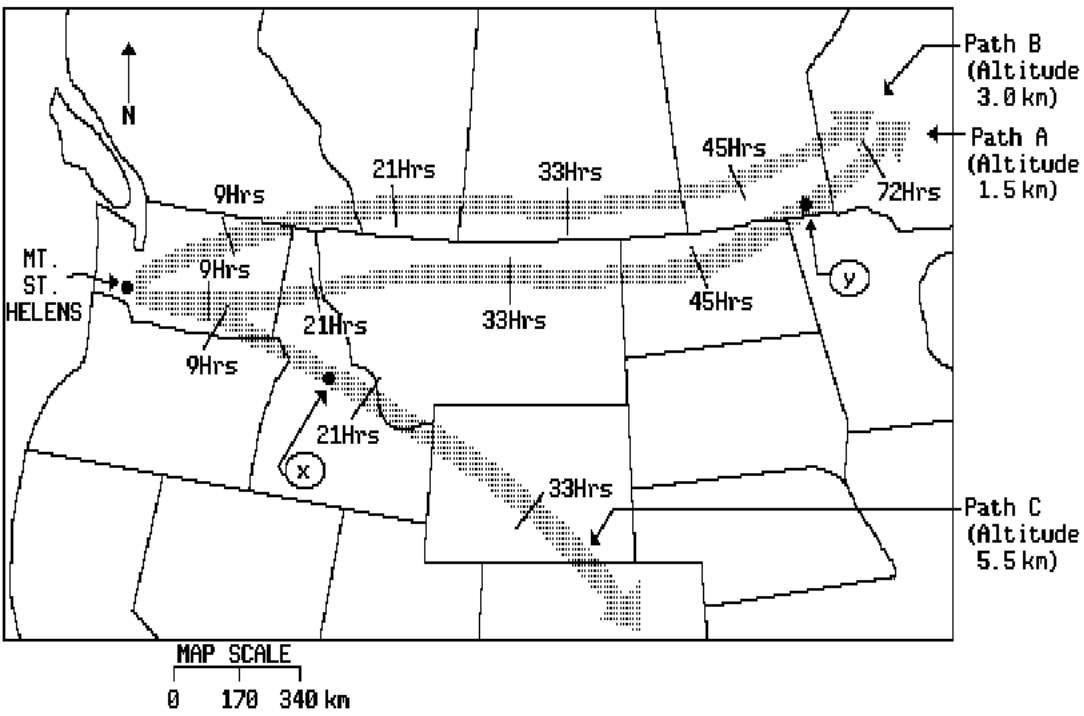
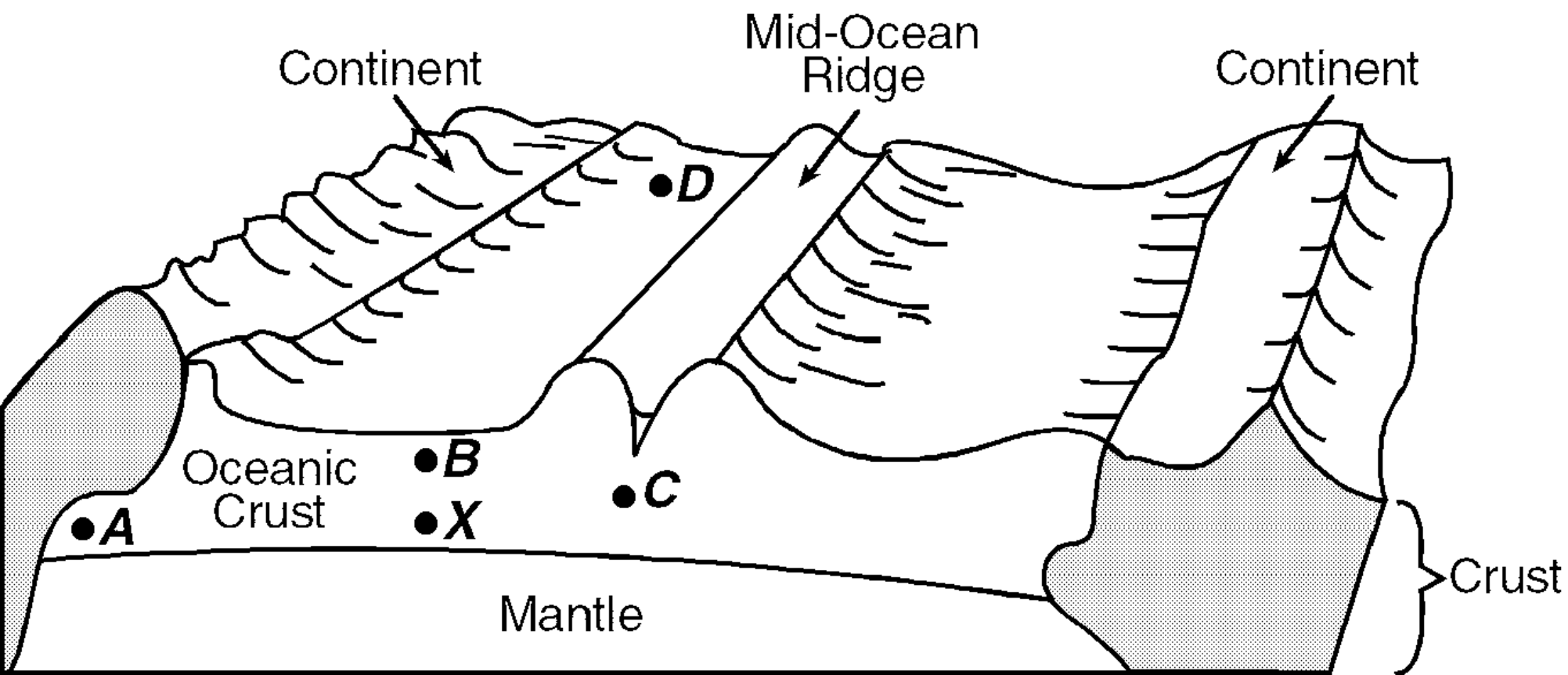
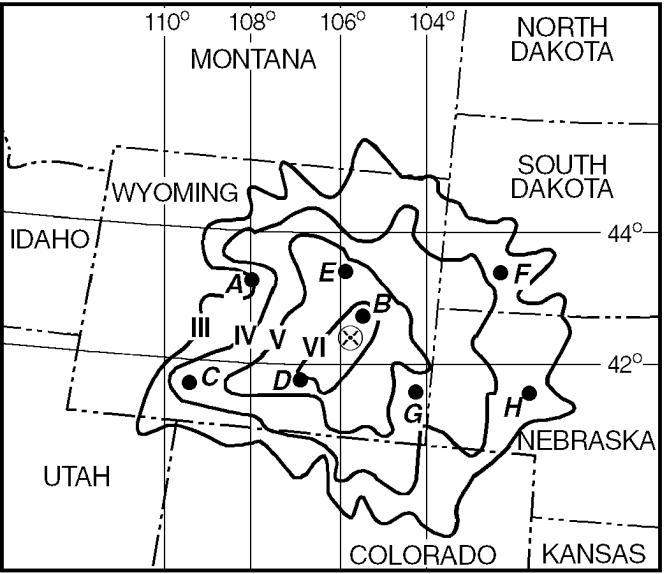


DIAGRAM 1
0 50 100 150 km
Kauai
5.6 to 3.8 million years
B
Oahu
2.6 to 2.2 million years
PACIFIC OCEAN
Maui
1.3 to
1.0 million years
Hawaii
Less than
1.0 million
years
A
N
DIAGRAM 2
(not drawn to scale)
Kauai
Oahu
Maui
Hawaii
OCEAN
Moving
Crustal Plate
Southeast
MANTLE
Magma Source


N
Path B
(Altitude
3.0 km)
Path A
(Altitude
1.5 km)
45Hrs
72Hrs
21Hrs
33Hrs
9Hrs
MT.
ST.
HELENS
9Hrs
45Hrs
21Hrs
33Hrs
9Hrs
y
21Hrs
x
33Hrs
Path C
(Altitude
5.5 km)
MAP SCALE
0 170 340 km

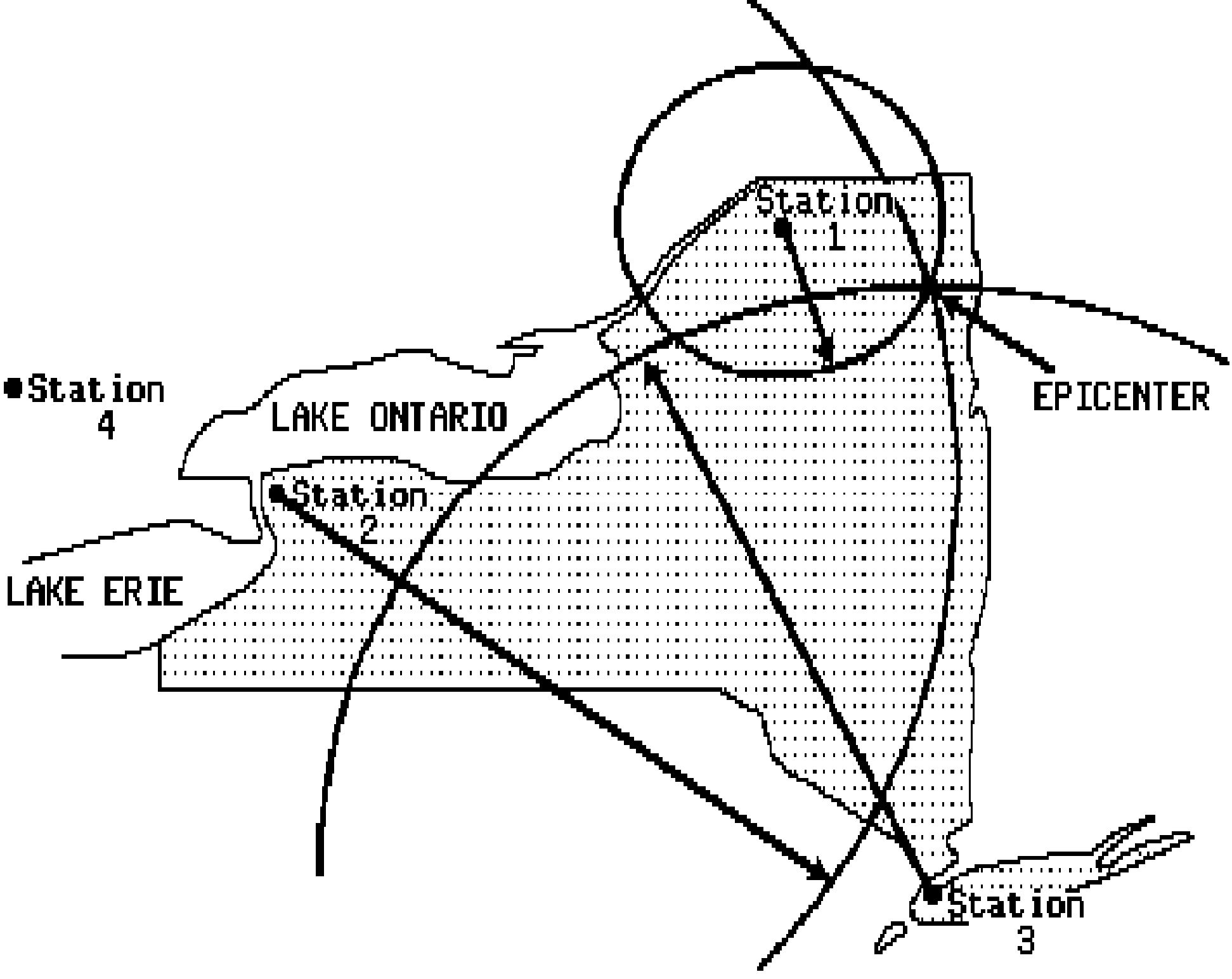

Continent
Mid-Ocean
Ridge
Continent
D
Oceanic
Crust
B
X
C
A
Mantle
Crust

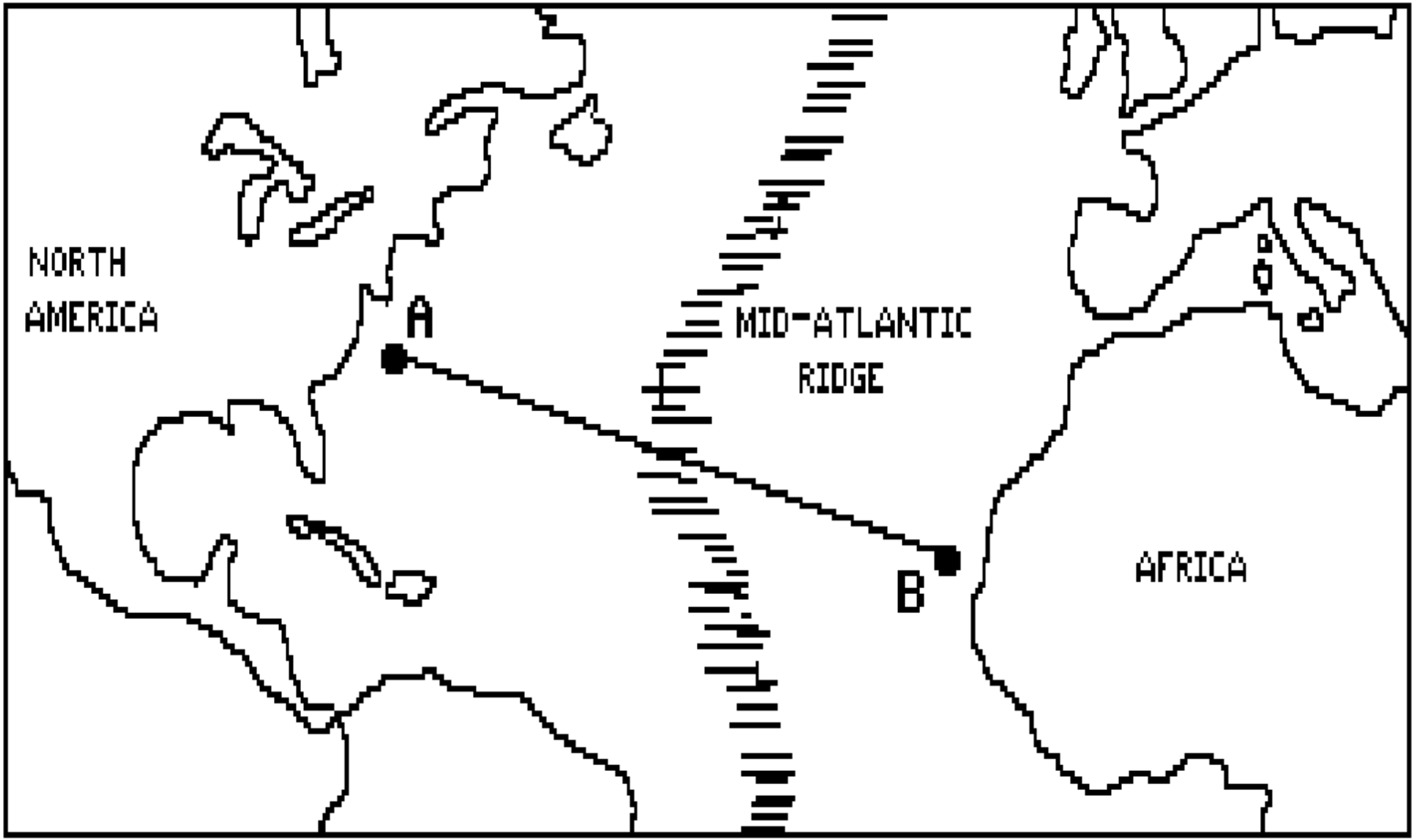
Isoseismal Map

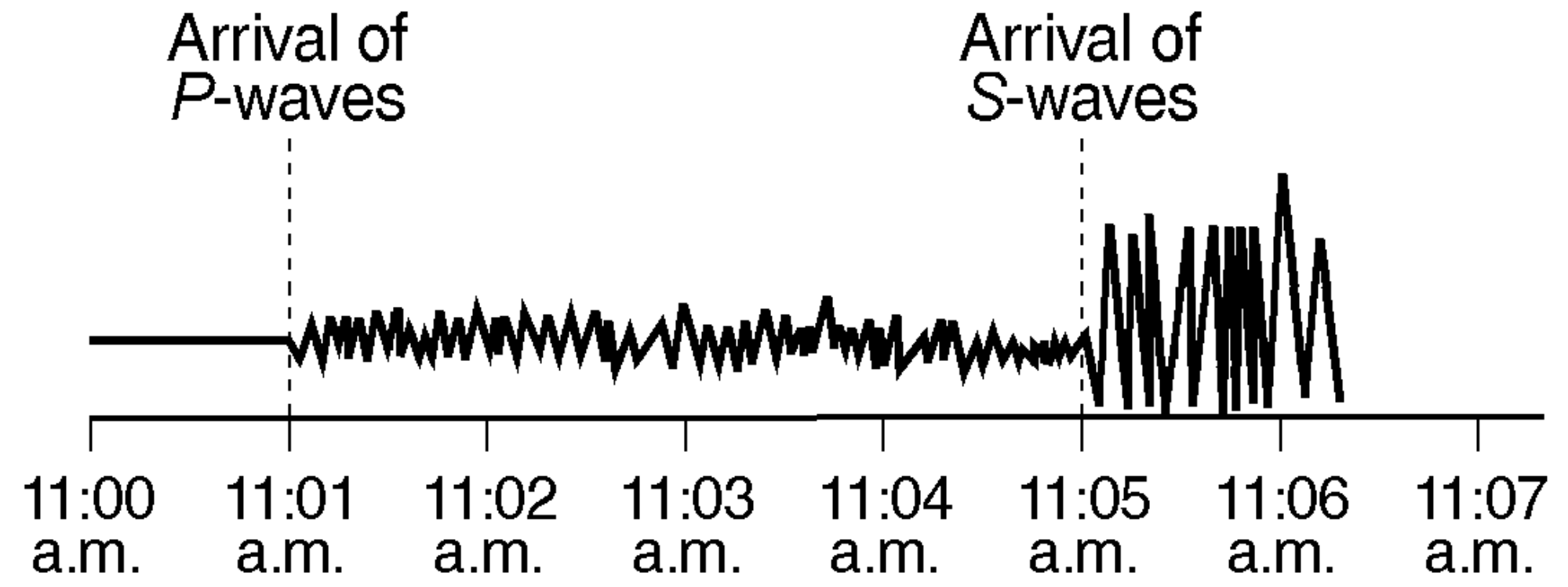


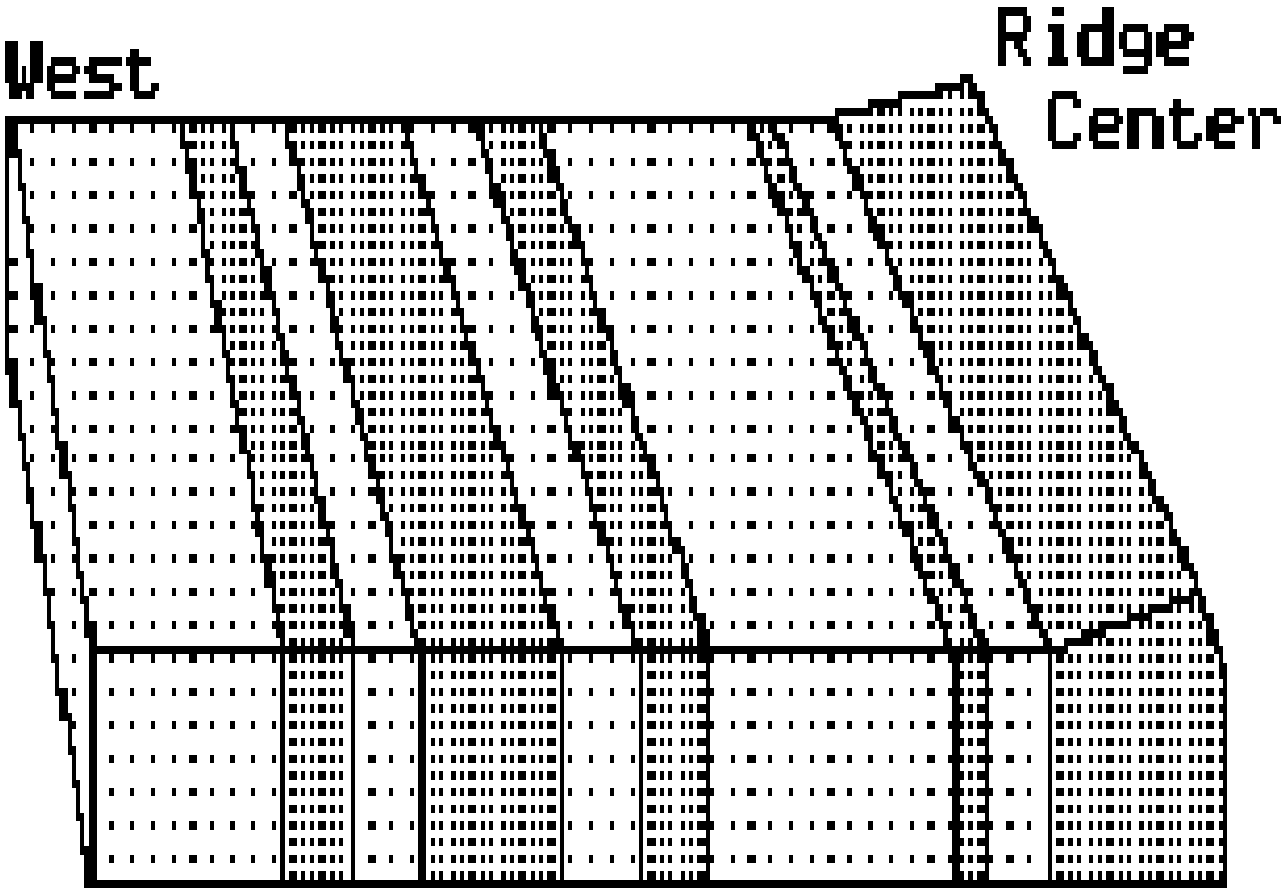
Modified Mercalli Intensity Scale

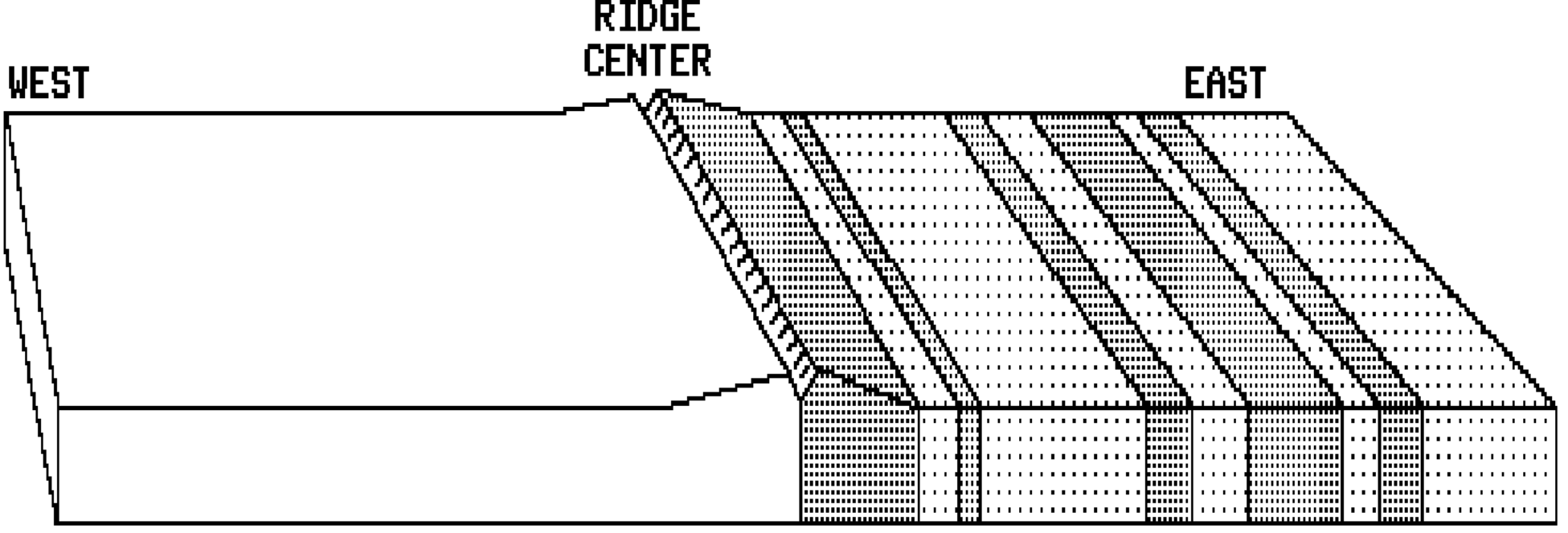
Intensity Level	Effect
I	Felt only by a few people
II	Felt indoors by a few people, especially on the upper floors of buildings.
III	Vibration like that of a passing heavy truck: heavy objects swing
IV	Dishes, windows, and doors rattle
V	Dishes and windows may break; felt by nearly everyone
VI	Felt by all; heavy furniture may move


Station
1
EPICENTER
Station
4
LAKE ONTARIO
Station
2
LAKE ERIE
Station
3


NORTH
AMERICA
A
MID-ATLANTIC
RIDGE
B
AFRICA


Arrival of
P-waves
Arrival of
S-waves
11:00
a.m.
11:01
a.m.
11:02
a.m.
11:03
a.m.
11:04
a.m.
11:05
a.m.
11:06
a.m.
11:07
a.m.


West
Ridge
Center



magnetic minerals in these rocks indicate magnetic north as it is today

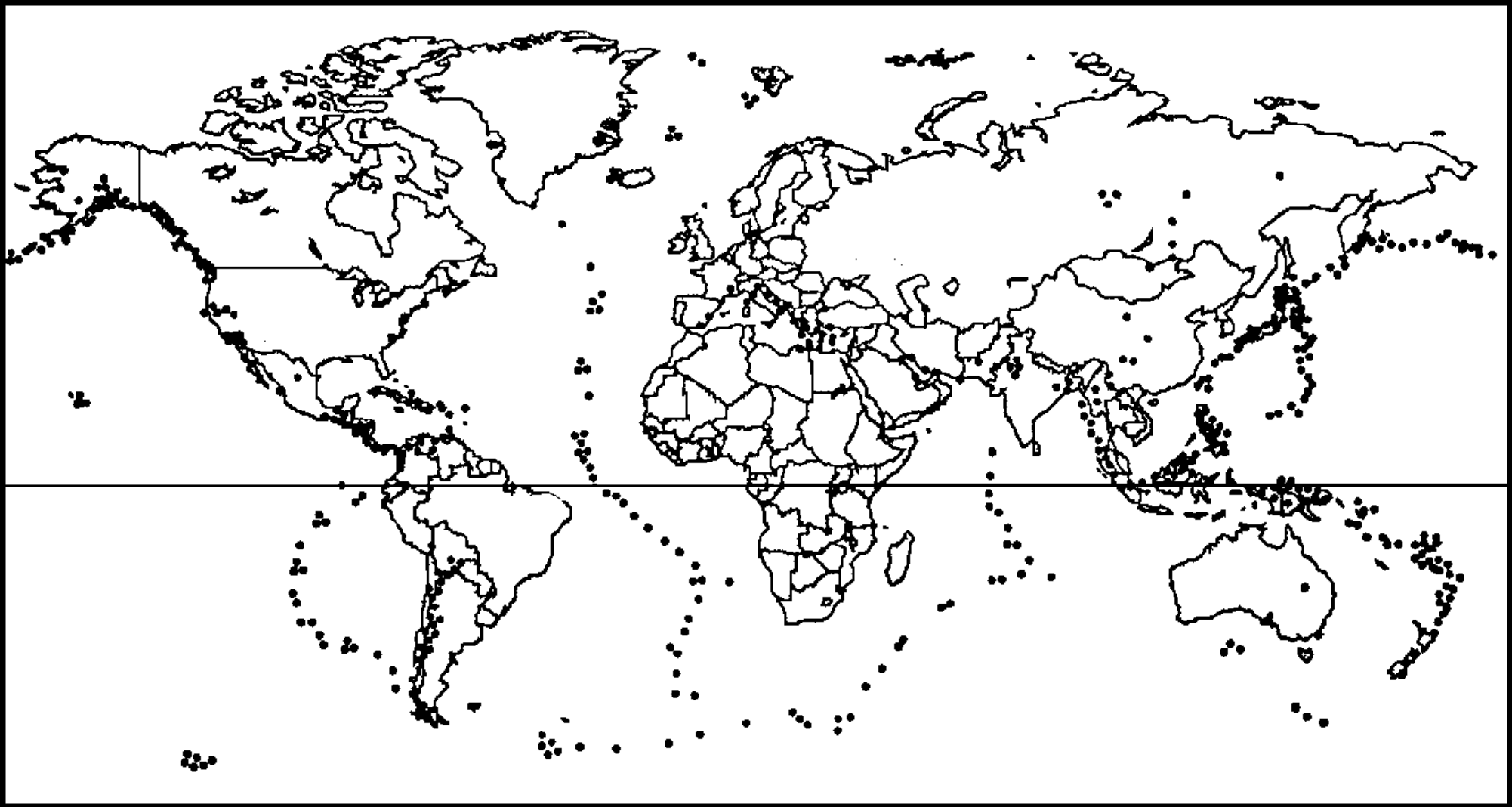
magnetic minerals in these rocks indicate magnetic north to be where magnetic south is today

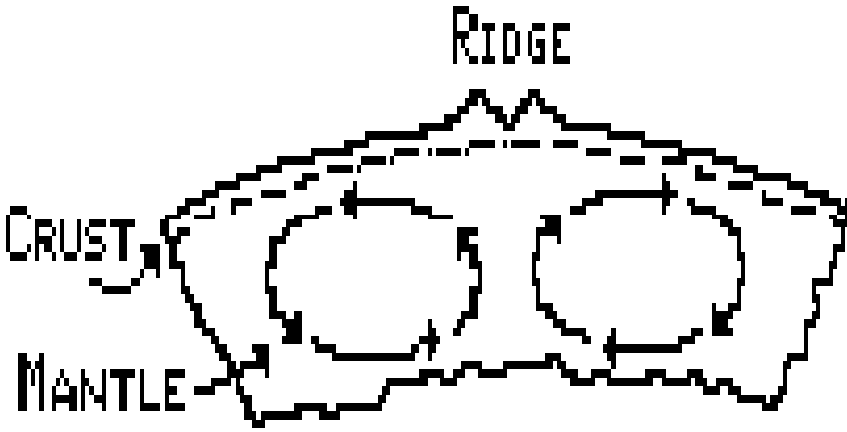
0 1 2 3 4

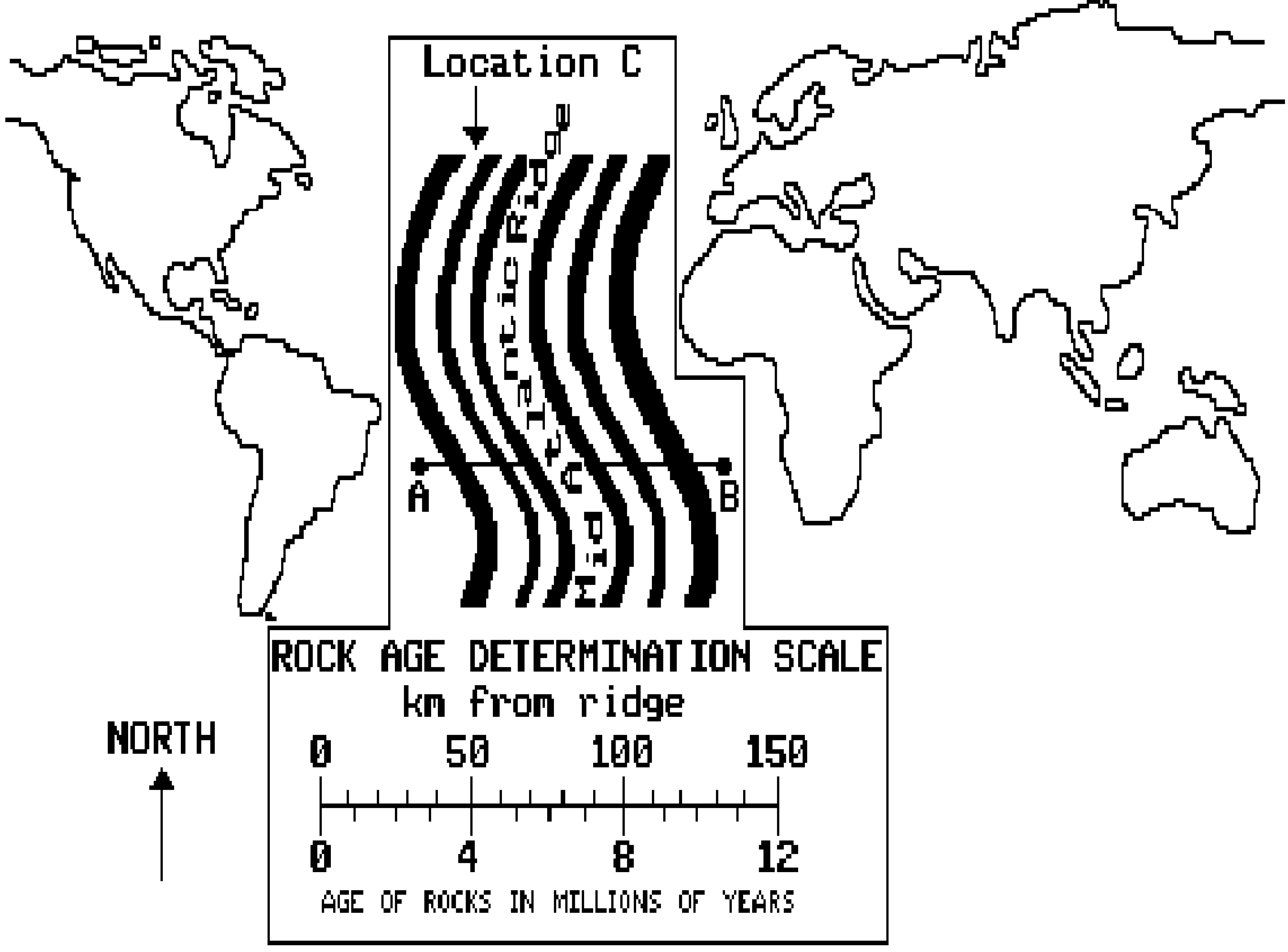
AGE (millions of years)

0 50 100 150

DISTANCE (km)



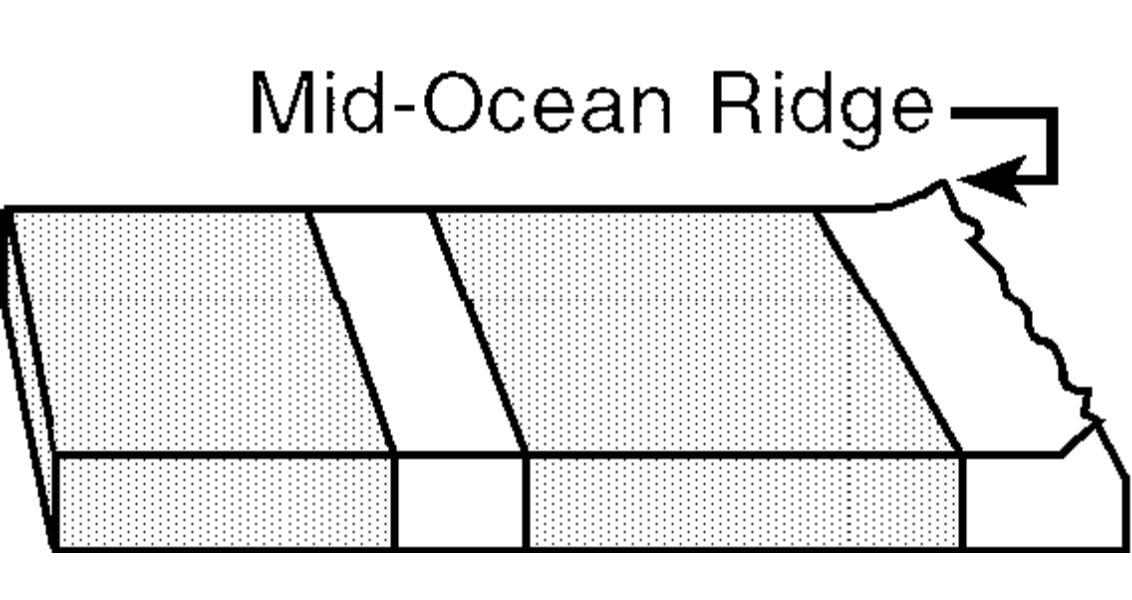

RIDGE
CRUST
MANTLE



Polarity (INDICATED FOR ONLY A PORTION OF THE ATLANTIC OCEAN BASIN)

Normal– THE MAGNETIC MINERALS IN THESE ROCKS INDICATE MAGNETIC NORTH AS IT IS TODAY.

Reverse– THE MAGNETIC MINERALS IN THESE ROCKS INDICATE MAGNETIC NORTH WHERE MAGNETIC SOUTH IS TODAY.


Mid-Ocean Ridge