How Did These Ocean Features and Continental Margins Form?

The terrain below contains various features on the seafloor, as well as parts of three continents. Some general observations of each feature provide clues about what that feature is. You will use this information to interpret how each feature formed, what the area was like in the past, and how it will look in the future.

Goals of This Exercise:

- Observe the terrain and make observations about the shape, size, and character of each feature.
- Use the general descriptions to determine which features are present in different parts of the terrain.
- Interpret how each feature formed and use this information to infer the present-day plate tectonics of the area.
- Use all the information to reconstruct what the area probably looked like 20 million years ago and what it will look like 20 million years into the future.

1. This figure shows a region approximately 1,000 kilometers (600 miles) wide. The seafloor is shaded according to depth, with lighter blue colors indicating shallower areas. Numbers indicate the isotopic ages of volcanic rocks in millions of years before present (labeled *Ma*). The view is toward the north.

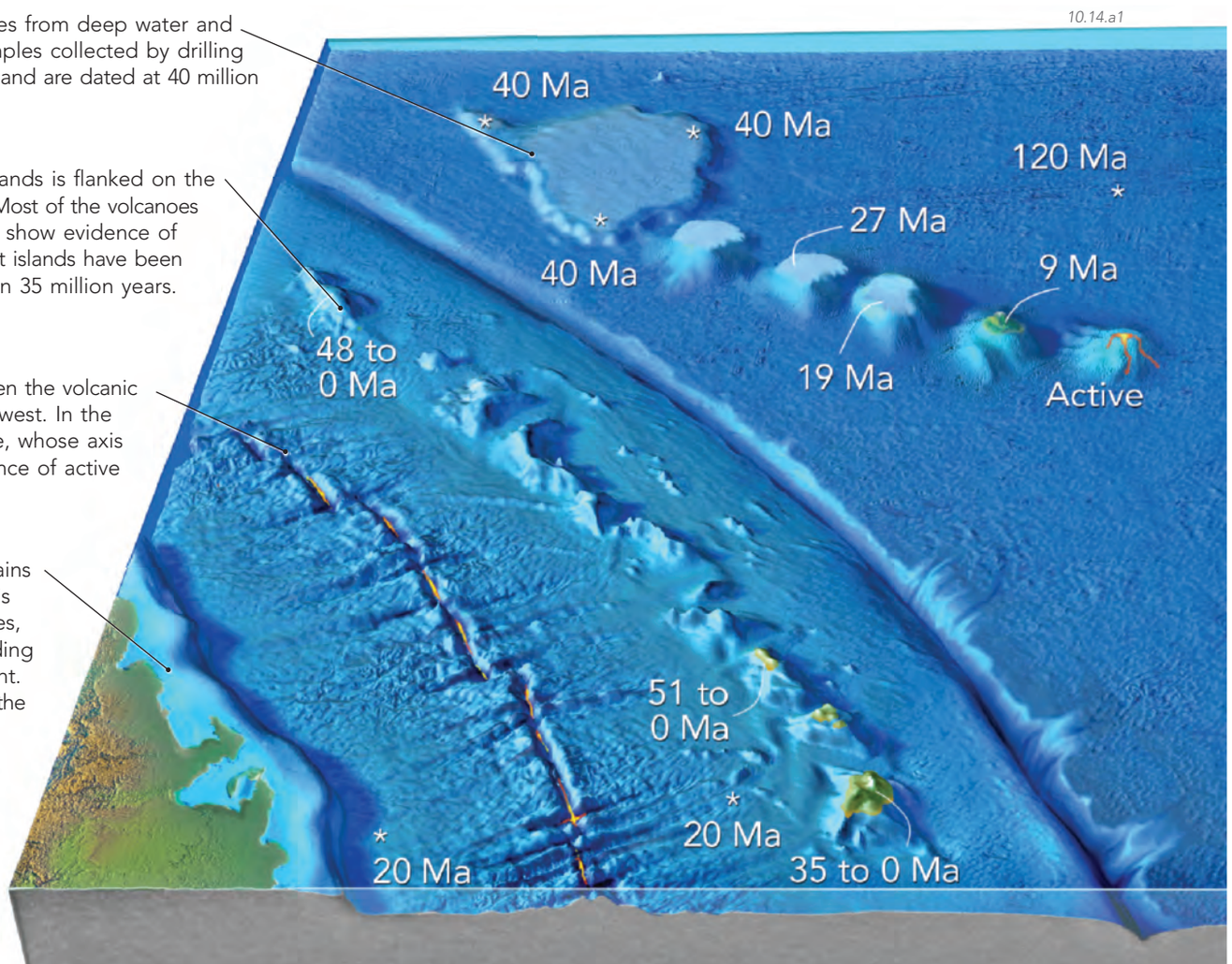
2. A broad oceanic plateau rises from deep water and locally forms small islands. Samples collected by drilling and dredging are mostly basalt and are dated at 40 million years.

3. A curved belt of volcanic islands is flanked on the east by a deep oceanic trench. Most of the volcanoes are composed of andesite and show evidence of recent explosive eruptions. Most islands have been volcanically active for more than 35 million years.

4. There is a narrow sea between the volcanic islands and a continent to the west. In the center of the sea is a low ridge, whose axis contains a rift valley and evidence of active submarine eruptions of basalt.

5. The western continent contains a narrow shelf offshore. There is no evidence of recent volcanoes, earthquakes, or mountain building along this edge of the continent. The oldest oceanic crust next to the continent is 20 million years old.

6. A linear chain of islands and seamounts extends from the oceanic plateau toward the southeast. The islands and seamounts are shaped like volcanoes and are composed of volcanic rocks, mostly basalt. The ages of the volcanic rocks decrease to the southeast. The shield volcano at the southeast end of the chain is still active.



Procedures

Use your observations of this region to complete the following steps, entering your answers in the appropriate places on the worksheet.

1. Observe the terrain and determine which types of features are shown (e.g., mid-ocean ridge, continent, etc.).
2. Based on the descriptions, describe how each feature probably formed.
3. Interpret whether adjacent features are related to one another using their relative positions and ages.
4. Identify the main geologic features on the cross section along A–A′.
5. In the appropriate place on the worksheet, draw a cross section along the front of the terrain. Show your interpretations of the plate geometries and different types and thicknesses of crust.
6. Describe what the area might have looked like 20 million years ago based on the ages and relative motions of the plates. Draw a very simplified map of your interpretation on the worksheet.
7. Predict what the area will look like 20 million years into the future. Draw a simplified map of your interpretation on the worksheet.

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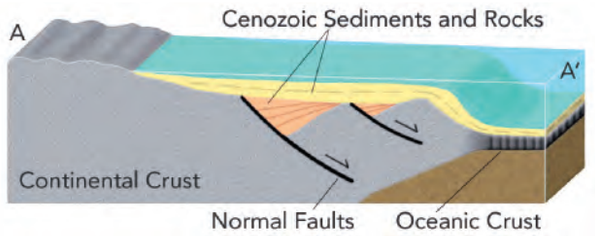
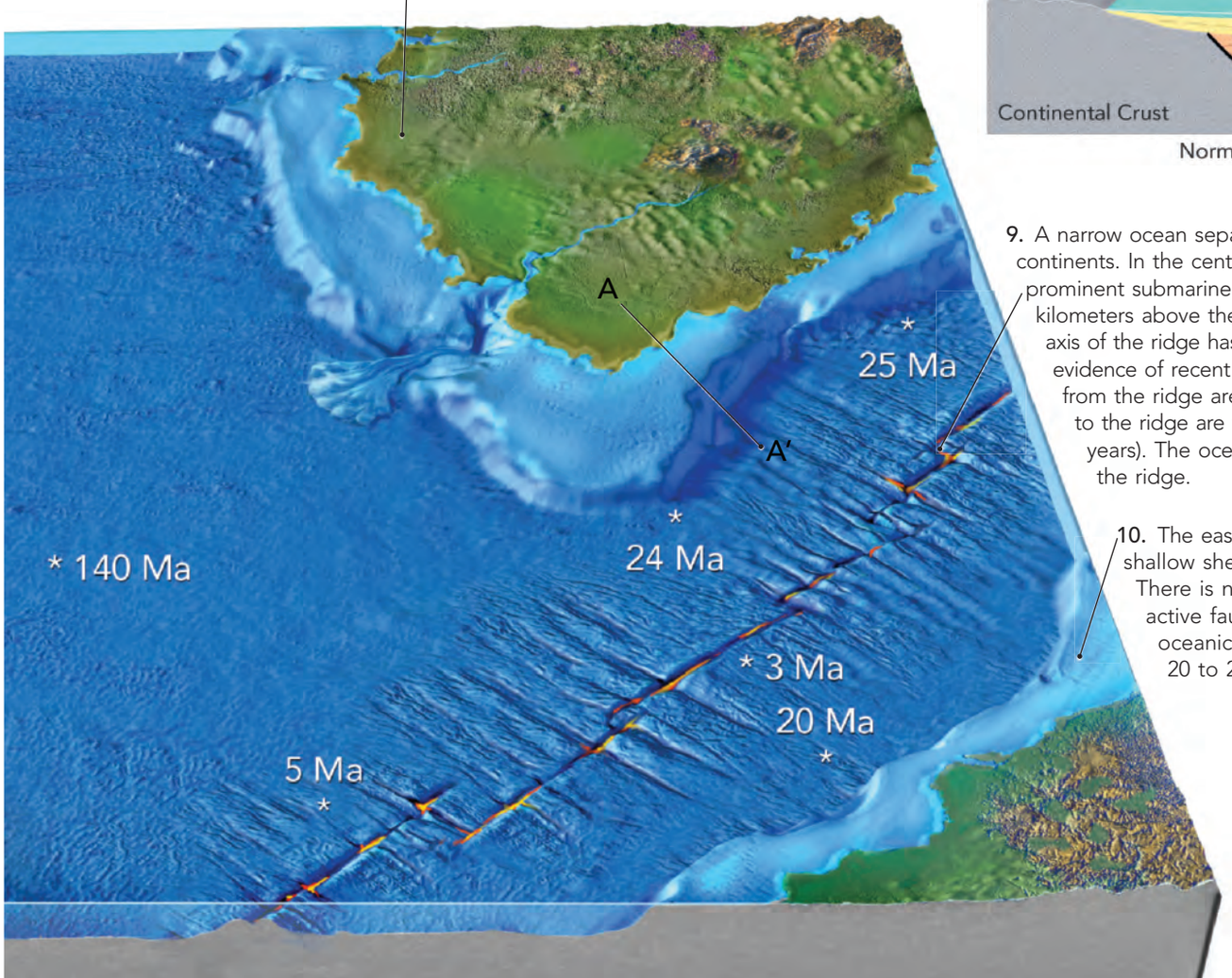
7. The shelf surrounding the central continent is broad and shallow, extending several hundred kilometers out from the shoreline. The edge of the shelf shows no evidence of earthquakes or active faulting. Several large canyons are cut into the shelf and lead down to large piles of sediment on the abyssal plain. The continent has fairly subdued topography.

8. To explore for oil, the shelf of the central continent has been investigated using seismic surveys. A geologic cross section summarizing these results is presented below for the line A–A′ (shown on the map). All sedimentary layers are Cenozoic (younger than 65 million years).

10.14.a2





9. A narrow ocean separates the central and eastern continents. In the center of the ocean there is a prominent submarine ridge that rises several kilometers above the surrounding seafloor. The axis of the ridge has a well-defined rift and shows evidence of recent volcanism. Samples dredged from the ridge are basalt. Most samples close to the ridge are very young (less than 5 million years). The oceanic crust is older farther from the ridge.

10. The eastern continent is flanked by a shallow shelf covered with sediments. There is no evidence for earthquakes, active faulting, or volcanism. The oldest oceanic crust next to the continent is 20 to 25 million years old.

Name _____ Chapter 10 Investigation Worksheet

To complete this worksheet, see the instructions in the textbook (Chapter 10 Investigation).

Table 1. Identification of Features on the Ocean Floor

Different oceanic features are numbered (1 through 10) adjacent to the figure below. Write the name for each feature using the choices listed below. Note that the numbered spaces below do NOT correspond to the numbered descriptions in the textbook.

Possible choices include: Abyssal plain, back-arc basin, fracture zone, linear island chain, island arc, mid-ocean ridge, oceanic plateau, oceanic trench, continental shelf, and submarine canyon and fan. Each choice is only used one time.

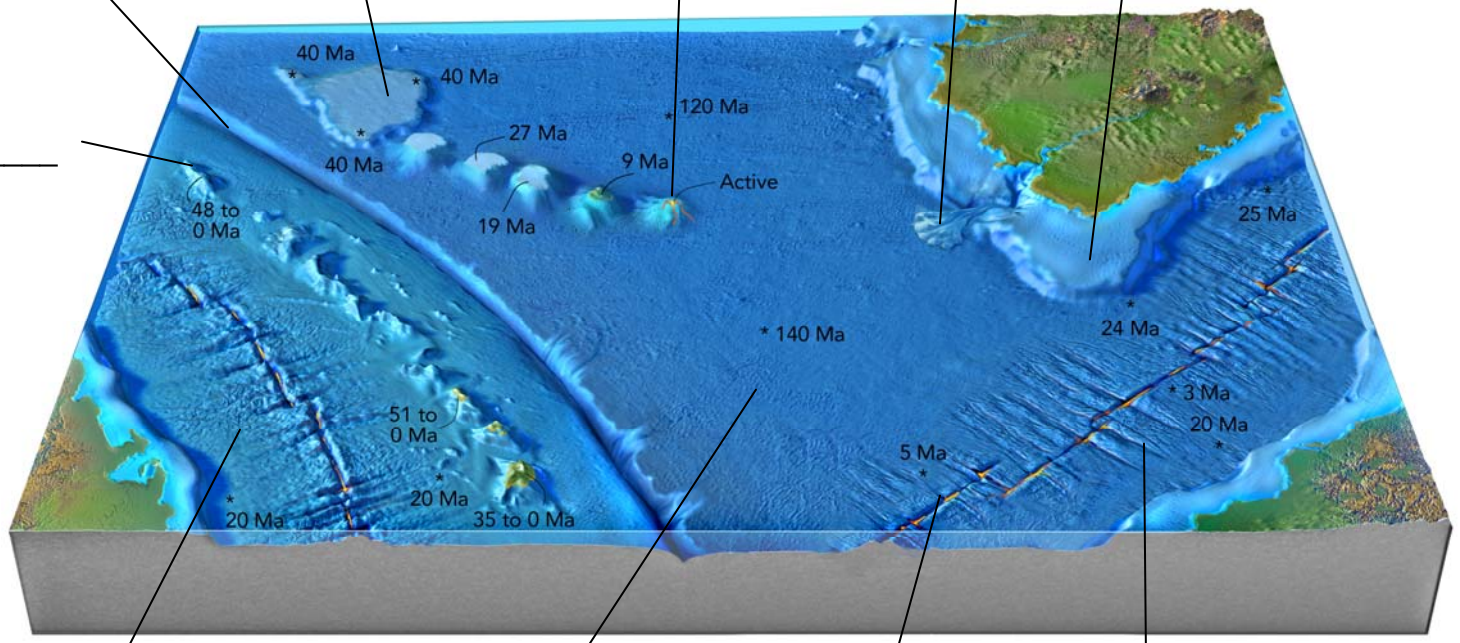
Feature 3: _____

Feature 5: _____

Feature 1: _____

Feature 4: _____

Feature 6: _____



Feature 2: _____

Feature 7 (refers to narrow sea between continent and islands): _____

Feature 8: _____

Feature 9: _____

Feature 10: _____

Table 2. Interpretation of the Formation and Relationship of Features

For each of the numbered features on the previous figure, write the name of the feature in the table below and provide a brief interpretation of how the feature formed.

Feature Number	Name of Feature	Interpretation of How Feature Formed (circle the letter for the best answer)
1	(a) back-arc basin (b) fracture zone (c) oceanic trench (d) submarine canyon and fan	(a) Formed by bending down of a slab as it enters a subduction zone. (b) Sediment is transported by turbidity currents from the edge of the continent into deeper water. (c) A broad area of continental crust that has been thinned and overlain by marine sediments. (d) Two oceanic plates diverge, allowing mantle magma to rise and form new oceanic crust. (e) Differences in the age of seafloor cause oceanic crust on one side of this feature to be higher in elevation than oceanic crust on the other side, but the feature is not a plate boundary.
2	(a) fracture zone (b) island arc (c) mid-ocean ridge (d) oceanic trench	(a) A rising plume of mantle melts and causes melting of adjacent lithosphere. (b) Formed where two oceanic plates converge, and melting of the subducted plate results in volcanoes on the overriding plate. (c) A broad area of continental crust that has been thinned and overlain by marine sediments. (d) Cooling of the lithosphere causes subsidence of oceanic crust, which is then covered by deep-water sediments. (e) Two oceanic plates diverge, allowing mantle magma to rise and form new oceanic crust.
3	(a) abyssal plain (b) mid-ocean ridge (c) oceanic plateau (d) continental shelf	(a) Formed where two oceanic plates converge, and melting of the subducted plate results in volcanoes on the overriding plate. (b) A rising plume of mantle melts and causes melting of adjacent lithosphere. (c) Sediment is transported by turbidity currents from the edge of the continent into deeper water. (d) A broad area of continental crust that has been thinned and overlain by marine sediments. (e) Two oceanic plates diverge, allowing mantle magma to rise and form new oceanic crust.
4	(a) fracture zone (b) linear island chain (c) mid-ocean ridge (d) continental shelf	(a) Formed where two oceanic plates converge, and melting of the subducted plate results in volcanoes on the overriding plate. (b) Movement of a plate over a hot spot results in a linear chain of volcanic islands and seamounts. (c) A broad area of continental crust that has been thinned and overlain by marine sediments. (d) Migration of an island arc and trench cause the crust to stretch and rift. (e) Two oceanic plates diverge, allowing mantle magma to rise and form new oceanic crust.

Feature Number	Name of Feature	Interpretation of How Feature Formed (circle the letter for the best answer)
5	(a) mid-ocean ridge (b) oceanic plateau (c) oceanic trench (d) submarine canyon and fan	(a) Formed by bending down of a slab as it enters a subduction zone. (b) Movement of a plate over a hot spot results in a linear chain of volcanic islands and seamounts. (c) Sediment is transported by turbidity currents from the edge of the continent into deeper water. (d) Migration of an island arc and trench cause the crust to stretch and rift.
6	(a) abyssal plain (b) mid-ocean ridge (c) oceanic plateau (d) continental shelf	(a) Formed where two oceanic plates converge, and melting of the subducted plate results in volcanoes on the overriding plate. (b) A rising plume of mantle melts and causes melting of adjacent lithosphere. (c) Movement of a plate over a hot spot results in a linear chain of volcanic islands and seamounts. (d) A broad area of continental crust that has been thinned and overlain by marine sediments.
7	(a) back-arc basin (b) oceanic trench (c) continental shelf (d) submarine canyon and fan	(a) Movement of a plate over a hot spot results in a linear chain of volcanic islands and seamounts. (b) Sediment is transported by turbidity currents from the edge of the continent into deeper water. (c) Migration of an island arc and trench cause the crust to stretch and rift, leading to spreading (d) Differences in the age of seafloor cause oceanic crust on one side of this feature to be higher in elevation than oceanic crust on the other side, but the feature is not a plate boundary.
8	(a) abyssal plain (b) island arc (c) mid-ocean ridge (d) continental shelf	(a) Movement of a plate over a hot spot results in a linear chain of volcanic islands and seamounts. (b) A broad area of continental crust that has been thinned and overlain by marine sediments. (c) Migration of an island arc and trench cause the crust to stretch and rift. (d) Cooling of the lithosphere causes subsidence of oceanic crust, which is then covered by deep-water sediments.
9	(a) back-arc basin (b) mid-ocean ridge (c) oceanic plateau (d) oceanic trench	(a) Formed by bending down of a slab as it enters a subduction zone. (b) Two oceanic plates diverge, allowing mantle magma to rise and form new oceanic crust. (c) Movement of a plate over a hot spot results in a linear chain of volcanic islands and seamounts. (d) A broad area of continental crust that has been thinned and overlain by marine sediments.
10	(a) fracture zone (b) island arc (c) oceanic trench (d) submarine canyon and fan	(a) Formed by bending down of a slab as it enters a subduction zone. (b) Formed where two oceanic plates converge, and melting of the subducted plate results in volcanoes on the overriding plate. (c) Migration of an island arc and trench cause the crust to stretch and rift. (d) Differences in the age of seafloor cause oceanic crust on one side of this feature to be higher in elevation than oceanic crust on the other side, but the feature is not a plate boundary.

Table 3. Interpreted Relationship Between Adjacent Features

Briefly describe a possible relationship between each pair of features identified below.

Related Features	Possible Interpretation of How the Features are Related (circle the letter for the best answer)
Features 1 and 2	(a) Two oceanic plates diverge, forming a rift, and allowing magma to reach the surface. (b) Oceanic crust is subducted and releases water, and magma rises into the overriding plate. (c) A rising mantle plume causes widespread melting when it first encounters the lithosphere, and magmatism continues as the plate moves over the hot spot. (d) Spreading causes two plates to slip past one another on transform faults, and differences in elevation reflect differences in the age of the crust.
Features 3 and 4	(a) Two oceanic plates diverge, forming a rift, and allowing magma to reach the surface. (b) Oceanic crust is subducted and releases water, and magma rises into the overriding plate. (c) A rising mantle plume causes widespread melting when it first encounters the lithosphere, and magmatism continues as the plate moves over the hot spot. (d) Two oceanic plates converge along an irregular boundary, which causes tears and wrinkles in the crust.
Feature 9 and 10	(a) Oceanic crust is subducted and releases water, and magma rises into the overriding plate. (b) Turbidity currents scour deeply into oceanic crust in the middle of the ocean, causing grooves and ridges. (c) Spreading causes two plates to slip past one another on transform faults, and differences in elevation reflect differences in the age of the crust. (d) Two oceanic plates converge along an irregular boundary, which causes tears and wrinkles in the crust.

Table 4: Cross Section Along the Front of the Terrain

On the front of the terrain below, sketch your interpretation of the geometry of plates at depth, such as a subduction zone or mid-ocean ridge. Use figures from the book as a guide for how to draw in the different types and thicknesses of crust and lithosphere.

Table 5. Interpretation of the Landscape in the Past or In the Future

For each question below, circle the appropriate answer about how the area is interpreted to have looked 20 million years ago or will look 20 million years into the future.

Question	Possible Answer
Where was the oceanic plateau relative to the hot spot 20 million years ago?	(a) farther away than today; (b) the same distance as today; (c) half the distance as today; (d) on top of the hot spot
What was the length of the linear chain of islands 20 million years ago?	(a) longer than today; (b) same length as today; (c) half as long as today; (d) it did not yet exist
Which way is the plate on which the oceanic plateau rests moving relative to the hot spot at depth? Assume that on the main figure you are looking north.	(a) west; (b) northwest; (c) north; (d) northeast; (e) east southeast; (f) south; (g) southwest
How wide was the narrow sea between the western continent and adjacent volcanic islands 20 million years ago?	(a) wider than it is today; (b) same width as it is today; (c) a little narrower than it is today; (d) it was much narrower
How wide was the narrow ocean between the central and eastern continents 20 million years ago?	(a) wider than it is today; (b) same width as it is today; (c) a little narrower than it is today; (d) it was much narrower
How wide do you think the narrow ocean between the central and eastern continents will be 20 million years into the future?	(a) nearly twice as wide as it is today; (b) a little wider than today; (c) same width as today; (d) much narrower than today
What do you think might happen to the oceanic plateau 20 million years into the future?	(a) it may become much larger than it is today; (b) it may collide with and become part of the central continent; (c) it may subside and become part of the abyssal plain; (d) it may collide with the trench
Your instructor may have you draw on a separate sheet of paper a simple map of the area 20 million years ago showing the relative positions of the different features. Be sure to draw and label mid-ocean ridges, trenches, and other features.	
Your instructor may have you draw on a separate sheet of paper a simple map of the area 20 million years into the future showing the relative positions of the different features. Be sure to draw and label mid-ocean ridges, trenches, and other features.	