

Investigating a Learning Progression for Reasoning Practices of Geocognition Using GeoMapApp-Based Assessment

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Supplementary Material

[1] Question for spatial reasoning at convergent boundary

Figure 1 describes the landforms and configuration of sea floor around Korea and Japan. There are distance scale and elevation/depth scale on the left side of the figure. Figure 2 depicts cross-sectional profile along the yellow line of Figure 1. Comparing both figures together and considering the configuration along the yellow line, choose a sentence from the four options which is the most similar to your thought.

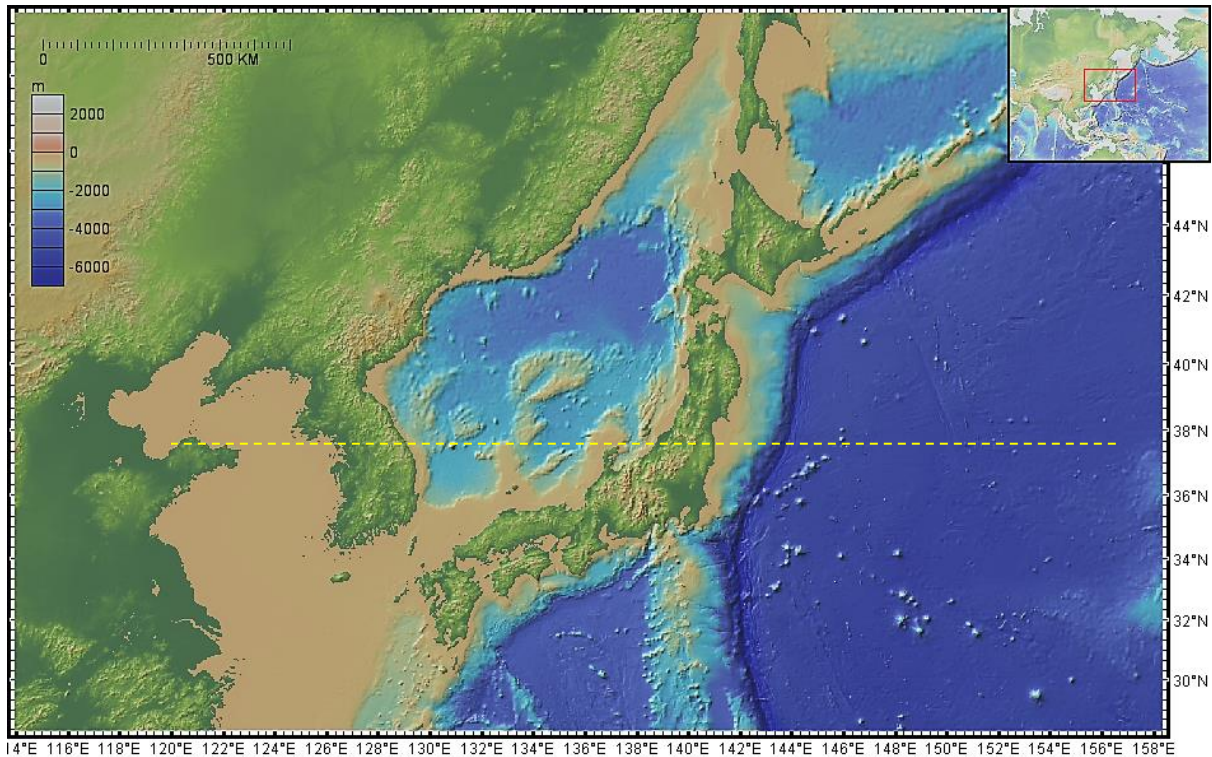


Figure 1 (captured from GeoMapApp, www.geomapapp.org)

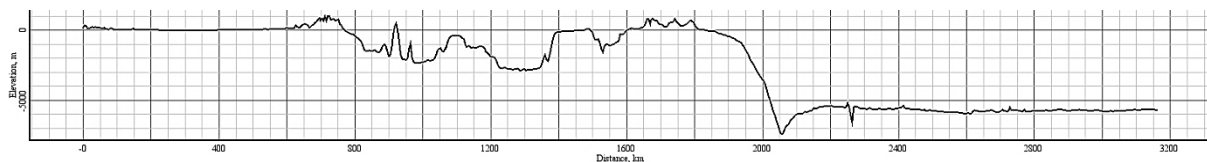


Figure 2 (captured from GeoMapApp, www.geomapapp.org)

- A. The sea floor in the East Sea is more uneven than in the Yellow Sea or the northern Pacific Ocean.
- B. The areas of 128°E-129°E and 139°E-140°E are ridges and the area of 143°E-144°E is an oceanic trench.
- C. The boundary between the Eurasian continental plate and the Pacific oceanic plate may be the area of 140°E-145°E based on the elevation difference of landforms around there.
- D. The edge of the Pacific oceanic plate around 140°E-145°E obliquely sinks down into Japan.

[2] Question for spatial reasoning at divergent boundary

Figure 3 depicts the relief of sea floor in the Atlantic Ocean between South America and Africa. There are distance scale and elevation/depth scale on the left side of the figure. Figure 4 is cross-sectional profile along the white line of Figure 3. Comparing both figures together and considering the configuration along the white line, choose a sentence from the four options which is the most similar to your thought.

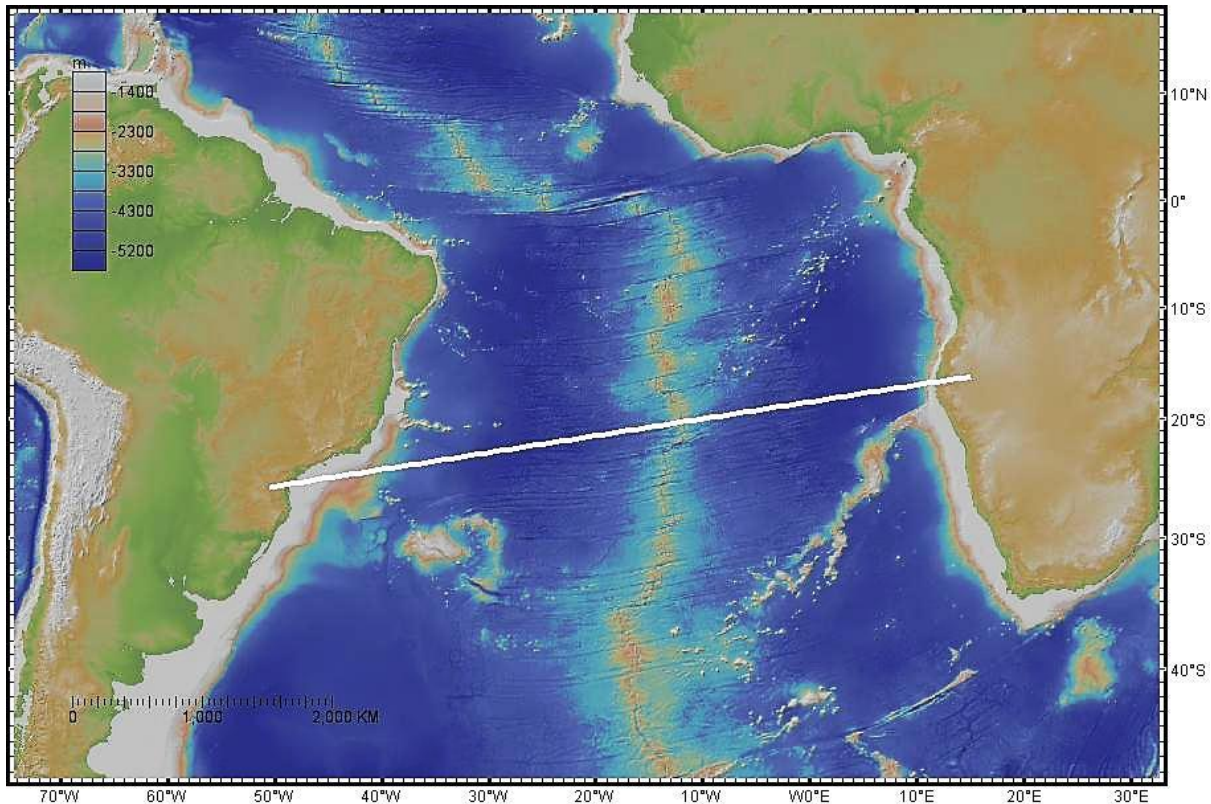


Figure 3 (captured from GeoMapApp, www.geomapapp.org)

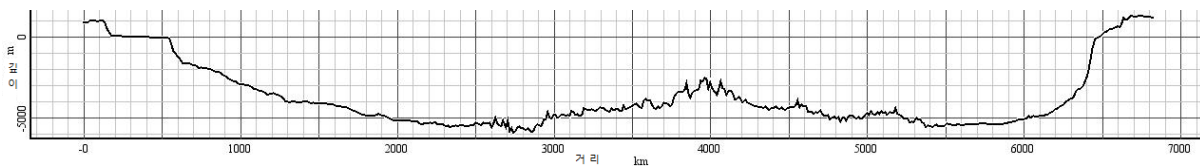


Figure 4 (captured from GeoMapApp, www.geomapapp.org)

- A. Sea floor in the Atlantic Ocean is generally even and the central part of it is a little lifted up.
- B. The area of 12°W-13°W is ocean ridge, and that of 5°E is abyssal plain.
- C. The area of 12°W-13°W is the boundary between the South American plate and the African plate, for the relief of sea floor is symmetrical around there.
- D. The edge of the South American plate was lifted up near 12°W-13°W.

[3] Question for temporal reasoning at convergent boundary

Figure 5 depicts the distribution of bed rock (basalt) age at the Pacific Ocean. There are distance scale and colored age scale on the left side of Figure 5. “mY” stands for a million year.

Considering bed rock age distribution along the white line, choose a sentence from the four options which is the most similar to your thought.

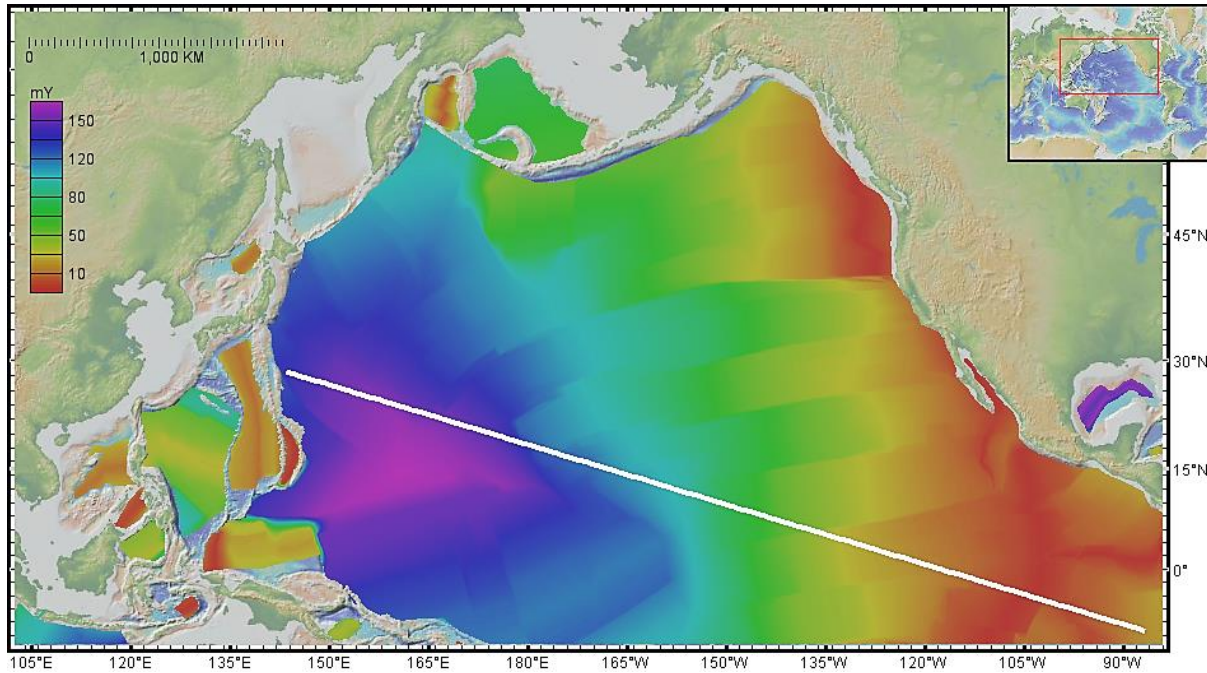


Figure 5 (captured from GeoMapApp, www.geomapapp.org)

- A. Rocks in purple area are older than others, and the age of rocks is getting younger as it goes to rightward from purple to red.
- B. Rocks in purple area were formed at the age of dinosaurs, and rocks in red area were formed before the Stone Age.
- C. Rocks in purple area were formed at the east Pacific Ocean 150 mY ago, and rocks in red area were also formed at the east Pacific Ocean 10 mY ago.
- D. When oceanic crust moved to left, young rocks in red area also moved to left and grew older.

[4] Question for temporal reasoning at divergent boundary

Figure 6 depicts the distribution of bed rock (basalt) age at the Atlantic Ocean. There are distance scale and colored age scale on the left side of the figure. “mY” stands for a million year. In Figure 7, cross-sectional profile of bed rock age along the white line of Figure 6 is plotted on a graph. Comparing both figures together and considering bed rock age distribution along the white line, choose a sentence from the five options which is the most similar to your thought.

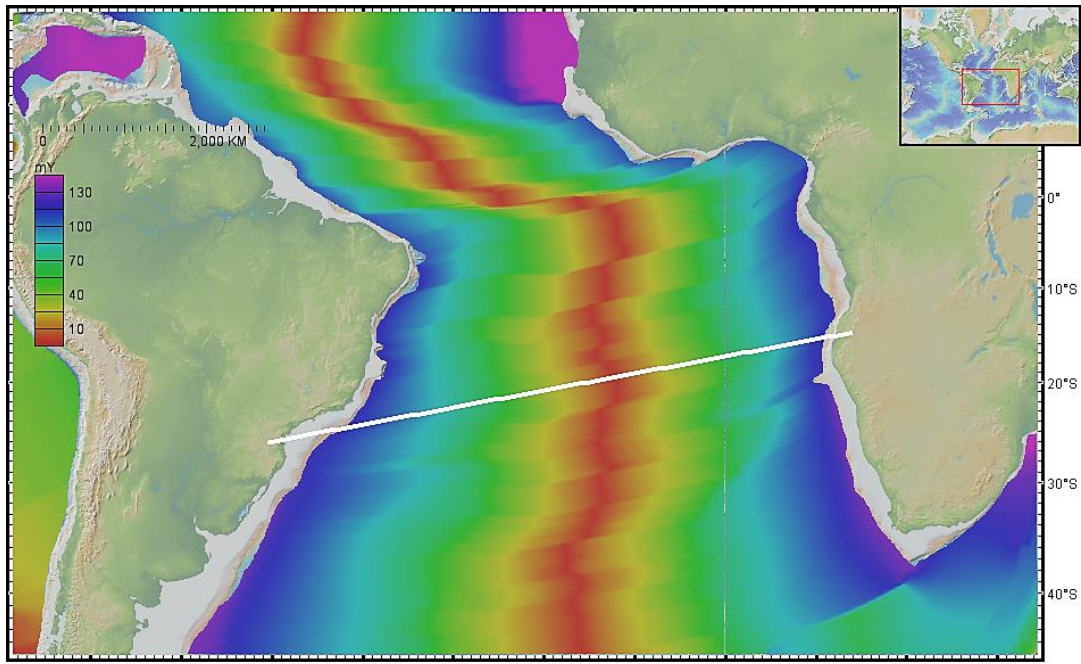


Figure 6 (captured from GeoMapApp, www.geomapapp.org)

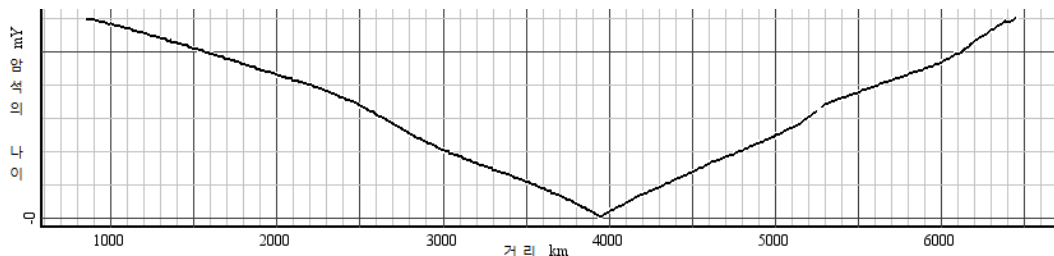


Figure 7 (each grid of Y-axis stands for 20 mY, captured from GeoMapApp, www.geomapapp.org)

- A. The farther from the red area of 13°W towards both left and right, the older rocks are.
- B. Rocks in red area were formed at the center of the Atlantic Ocean about 10 mY ago, and rocks in blue area were also formed at the center of the ocean about 120 mY ago.
- C. When oceanic crusts at the central part of the Atlantic Ocean moved away from each other, young rocks in there also moved away bilaterally and grew older.
- D. When two continental plates moved away from each other, rocks at the area of 13°W moved away bilaterally at the speed of about 20-30 km per mY.

[5] Question for retrospective reasoning at convergent boundary

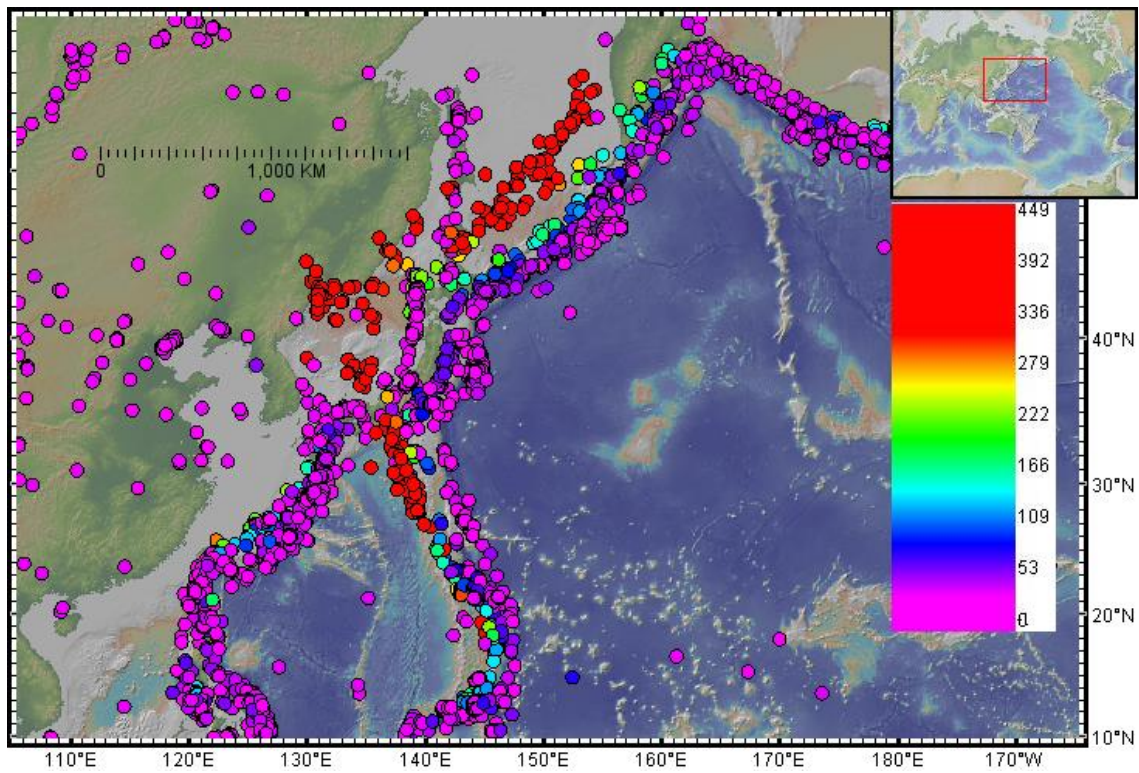


Figure 8 (captured from GeoMapApp, www.geomapapp.org)

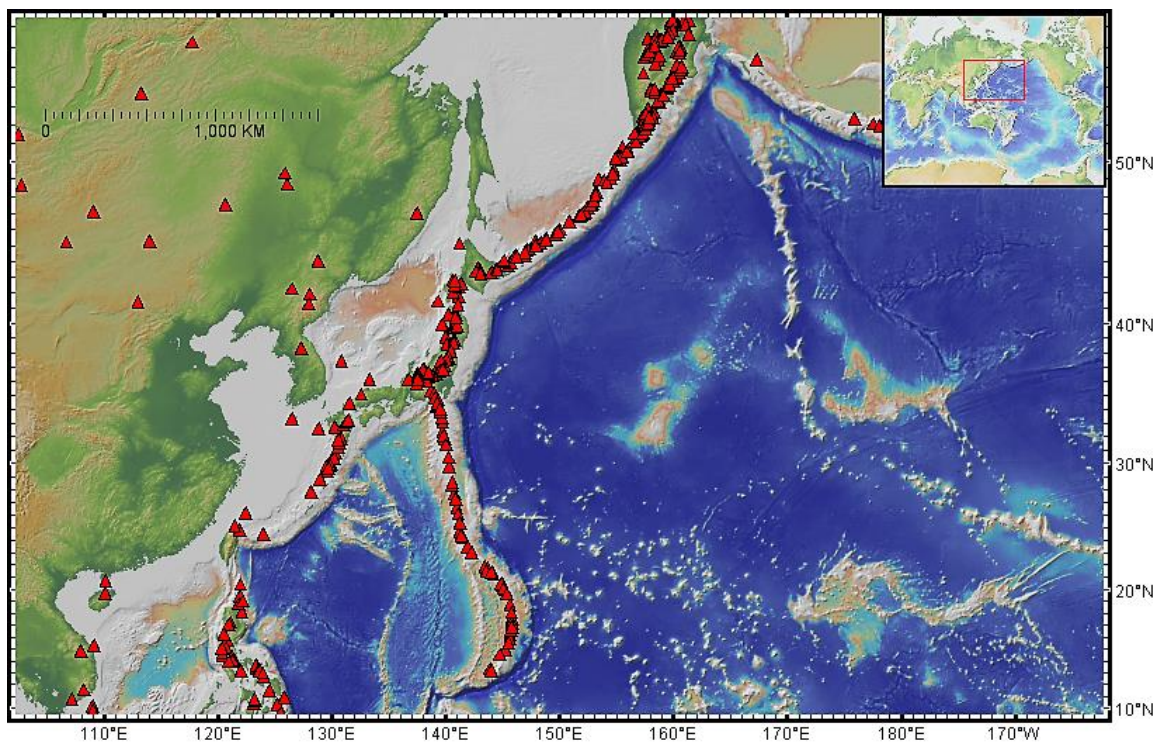


Figure 9 (captured from GeoMapApp, www.geomapapp.org)

Figure 8 depicts the locations of earthquakes (magnitude 5.0 and greater) which broke out in recent 40 years. Different colors of each circle stand for focal depths of earthquakes aligned with the color scale on the right side of the figure. Figure 9 depicts the locations of volcanoes at the same area, the north eastern Asia. Comparing both figures together, choose a sentence from the four options which is the most similar to your thought.

- A. Focal depths of earthquakes increase from the Pacific Ocean towards the Asian continent, and volcanoes erupted where the focal depth of earthquake was deeper than 100 km.
- B. The locations of earthquakes and those of volcanoes are similar so that this area corresponds to a plate boundary.
- C. Since an oceanic plate moving toward and converging with a continental plate goes down under the continental plate, focal depths of earthquakes increase towards the continent and volcanoes erupt along the subduction zone.
- D. If you presume that an oceanic plate dives under a continental plate obliquely, then it can be told that focal depths of earthquakes increase towards the continent and volcanoes erupt at a deep point of inclined oceanic plate.

[6] Question for retrospective reasoning at transform fault and divergent boundary

Figure 10 is a magnified sea floor at one part of mid-ocean ridge in the Atlantic Ocean. Considering the configuration of sea floor relief around the ridge, choose a sentence from the four options which is the most similar to your thought.

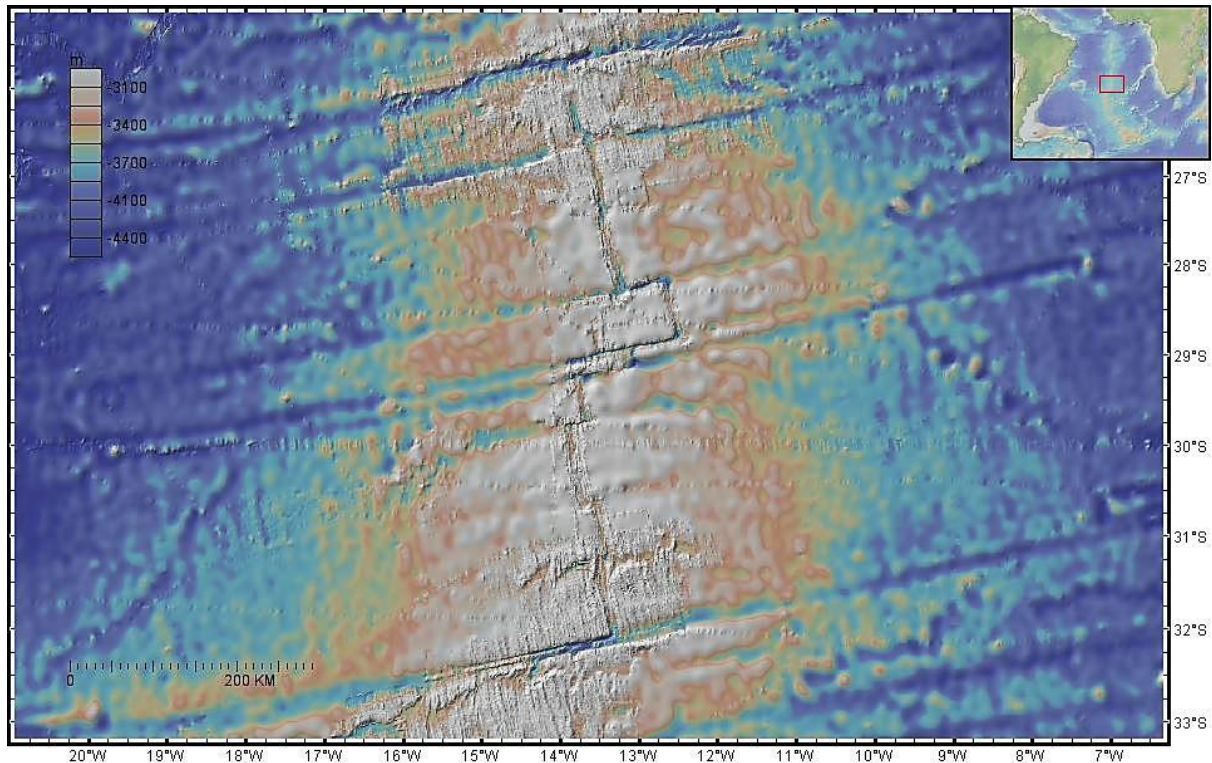


Figure 10 (captured from GeoMapApp, www.geomapapp.org)

- A. Vertical gaps in white area correspond to rift valleys, and each rift valley is not aligned with one line.
- B. This area corresponds to a divergent boundary of two oceanic plates because sea floor relief is symmetrical to the axis of mid-ocean ridge.
- C. Since the speed of oceanic plates' moving away at a divergent boundary is not constant, the axes of mid-ocean ridge are out of alignment.
- D. If you presume that two oceanic plates move away from each other with the axes of ridge out of alignment, then fracture zones where two plates move in the opposite direction can occur between two neighboring axes of ridge.

[7] Question for system thinking at convergent boundary

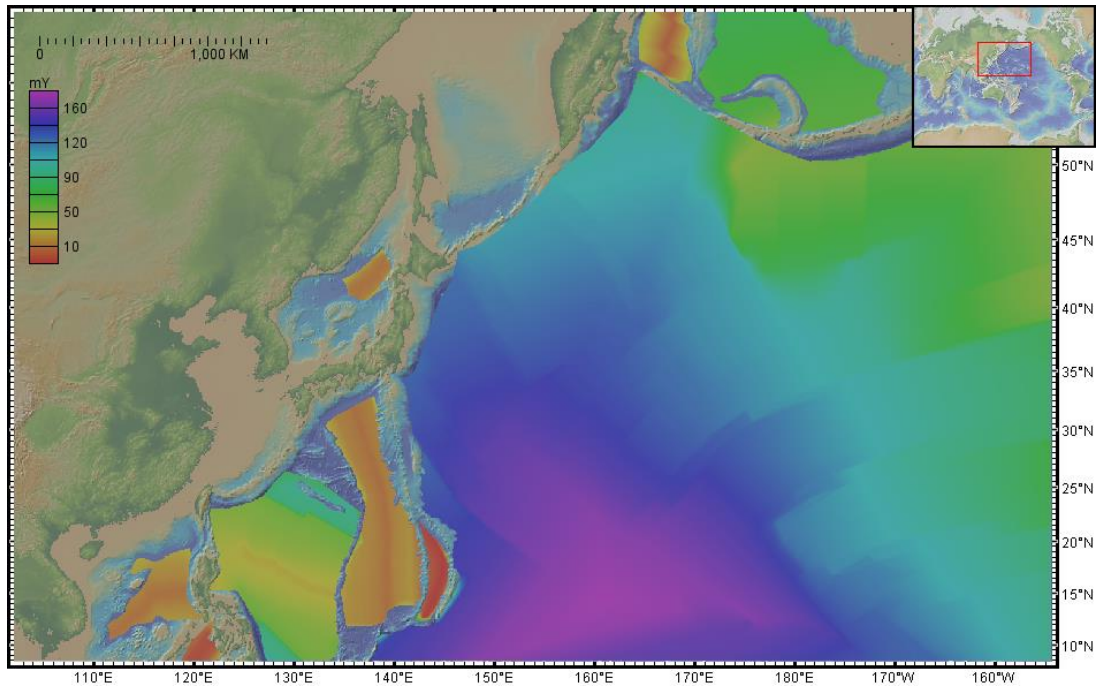


Figure 11 (captured from GeoMapApp, www.geomapapp.org)

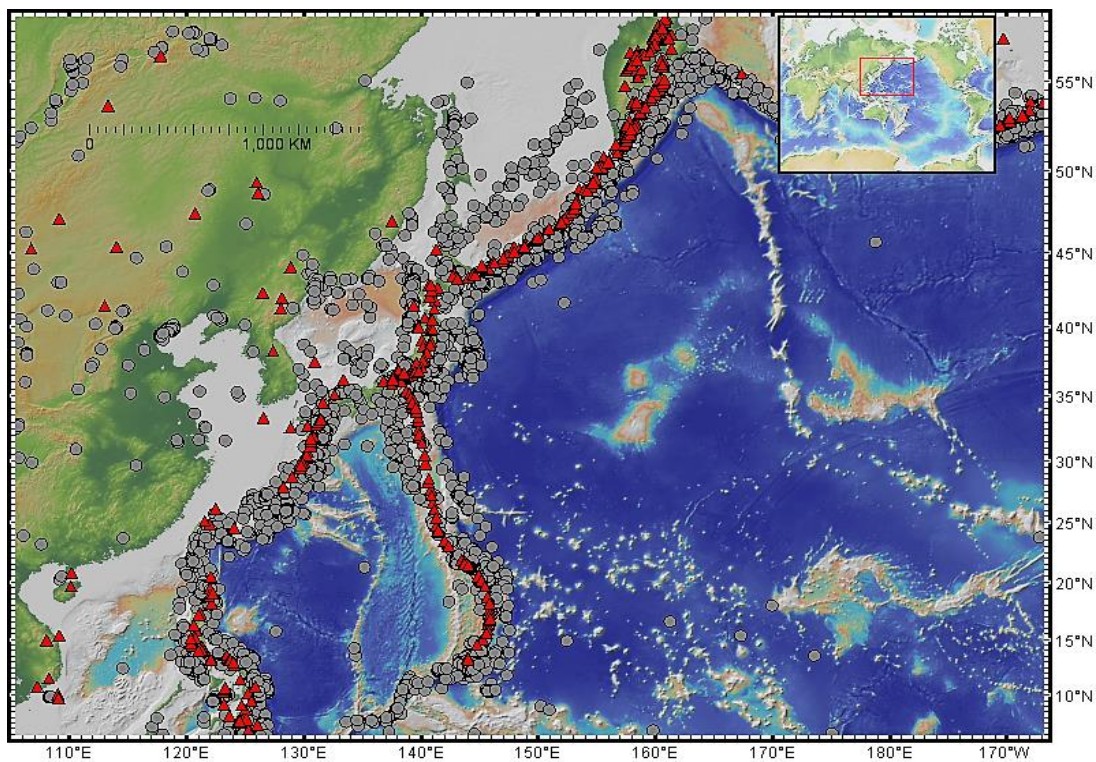


Figure 12 (captured from GeoMapApp, www.geomapapp.org)

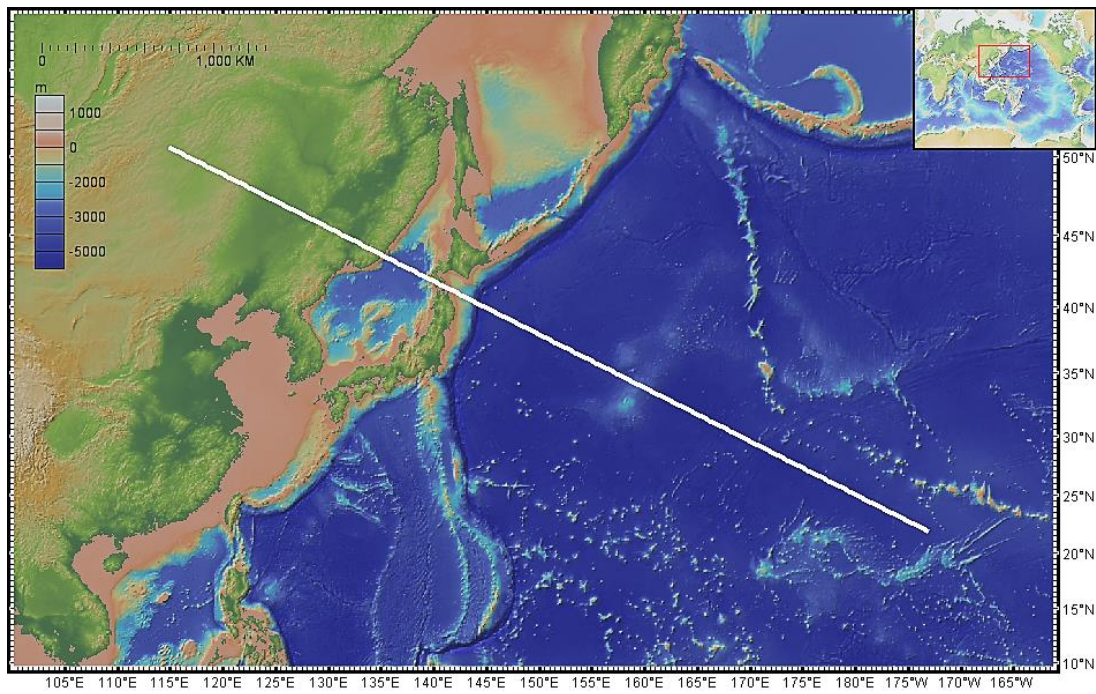


Figure 13 (captured from GeoMapApp, www.geomapapp.org)

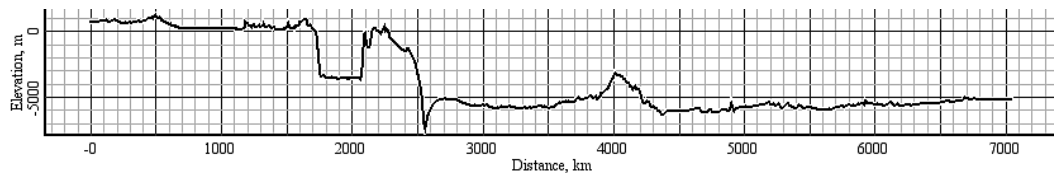
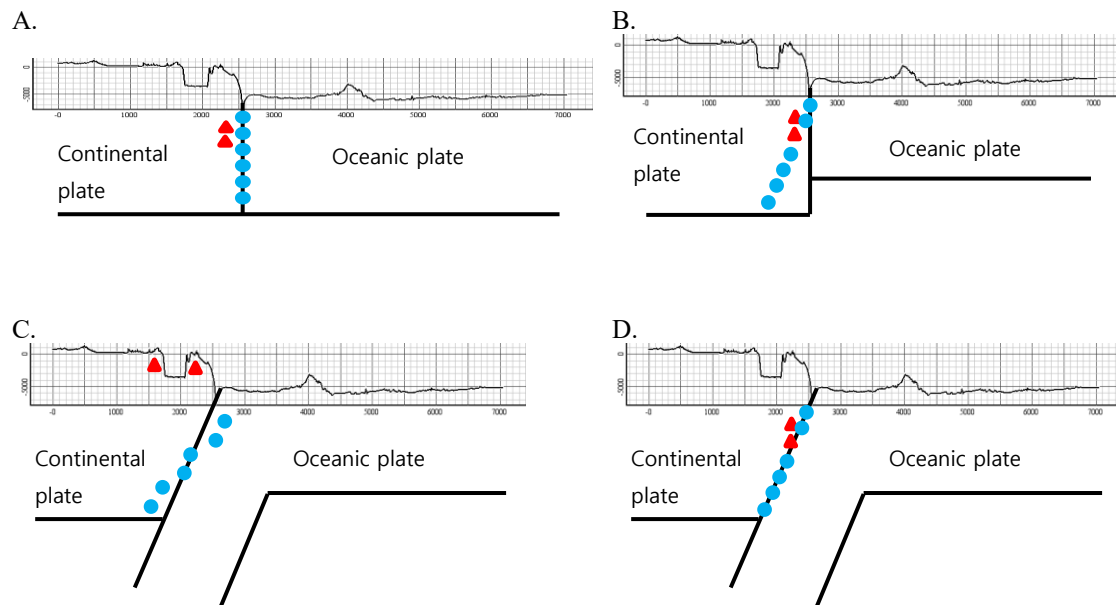


Figure 14 (captured from GeoMapApp, www.geomapapp.org)

Figure 11 depicts the distribution of bed rock (basalt) age in the Pacific Ocean, and Figure 12 depicts the location of earthquakes and volcanoes in the East Asia. Figure 13 describes the landforms and configuration of sea floor in this area. Figure 14 shows a cross-sectional profile along the white line of the Figure 13. Supposed to draw the cross-sectional structure of continental plate and oceanic plate beneath Figure 14 to summarize all information from Figure 11 to Figure 14, which is the most similar to your thought among the four options below? (Blue circles stand for the location of earthquakes, and red triangles correspond to magma forming points in those plates)



[8] Question for system thinking at divergent boundary

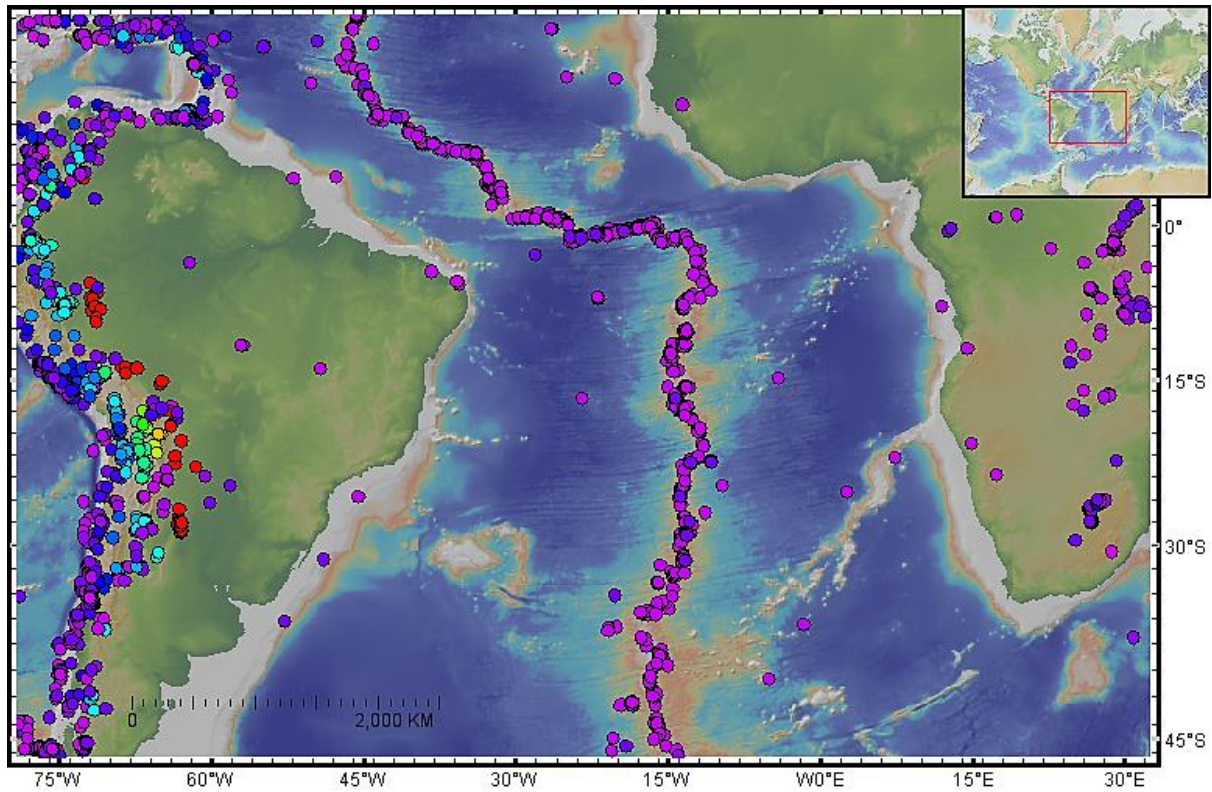


Figure 15 (captured from GeoMapApp, www.geomapapp.org)

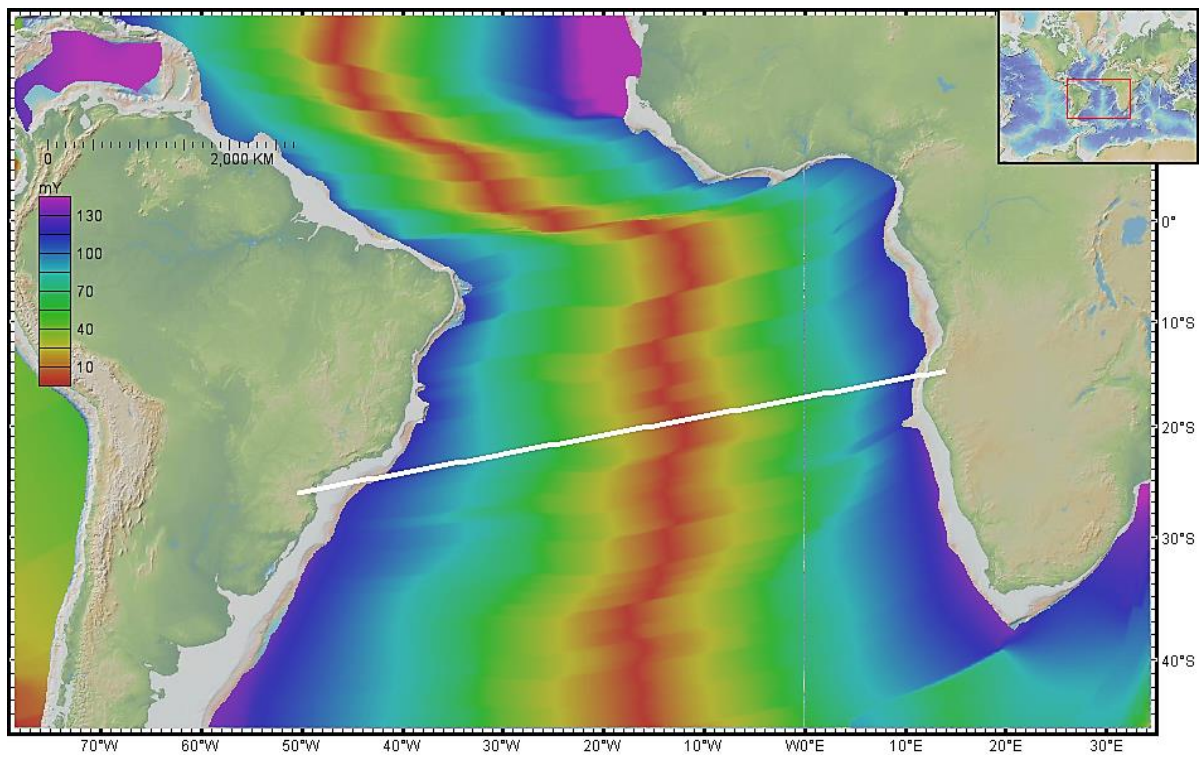


Figure 16 (captured from GeoMapApp, www.geomapapp.org)

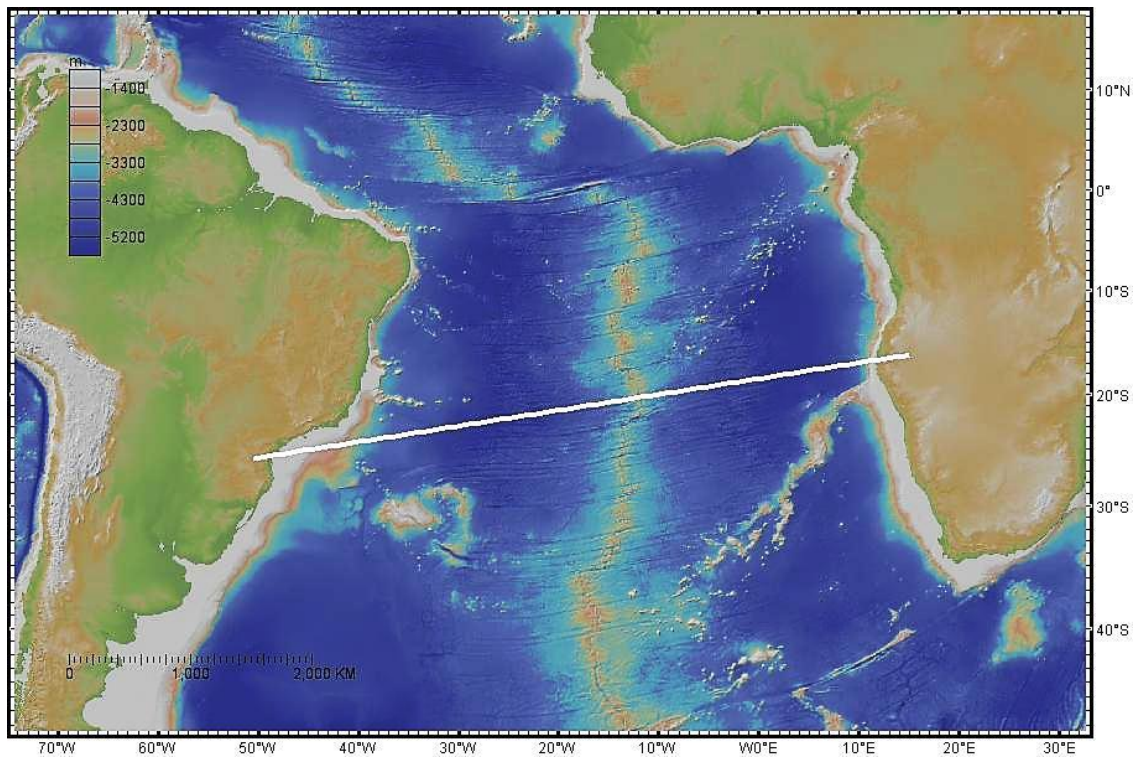


Figure 17 (captured from GeoMapApp, www.geomapapp.org)

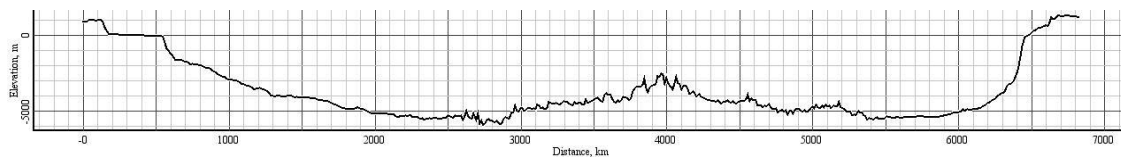
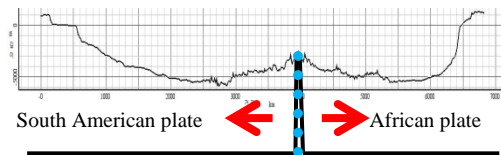


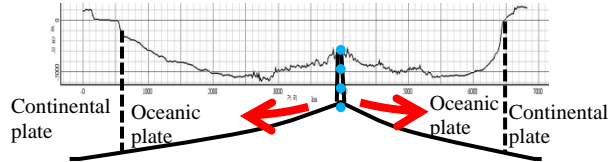
Figure 18 (captured from GeoMapApp, www.geomapapp.org)

Figure 15 depicts the location of earthquakes in the Atlantic Ocean. Figure 16 depicts the distribution of bed rock (basalt) age at the Atlantic Ocean. Figure 17 depicts the relief of sea floor in the Atlantic Ocean between South America and Africa. Figure 18 shows a cross-sectional profile along the white line of the Figure 17. Supposed to draw the cross-sectional structure of continental plate and oceanic plate beneath Figure 18 to summarize all information from Figure 15 to Figure 18, which is the most similar to your thought among the four options below? (Blue circles stand for the location of earthquakes)

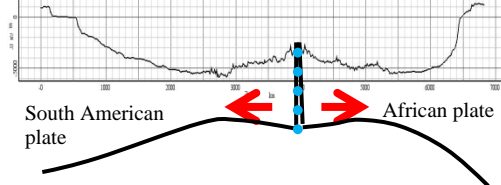
A.



B.



C.



D.

