University of Anbar

College of Science

Department of Applied Geology

Tectonics

Title of the lecture

Divergent plate boundary and sea-floor spreading

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Divergent plate boundary and sea-floor spreading

At divergent boundaries, or spreading boundaries, two oceanic plate move apart by the process of sea-floor spreading. Where the plates move apart new oceanic lithosphere forms along the divergent boundary Fig.1. this process takes place at the submarine mountain ranges such as the Mid-Atlantic Ridge which rise two km above the adjacent abyssal plains of the ocean. Thus, geologist commonly call a divergent boundary a mid-oceanic ridge or simply ridge.

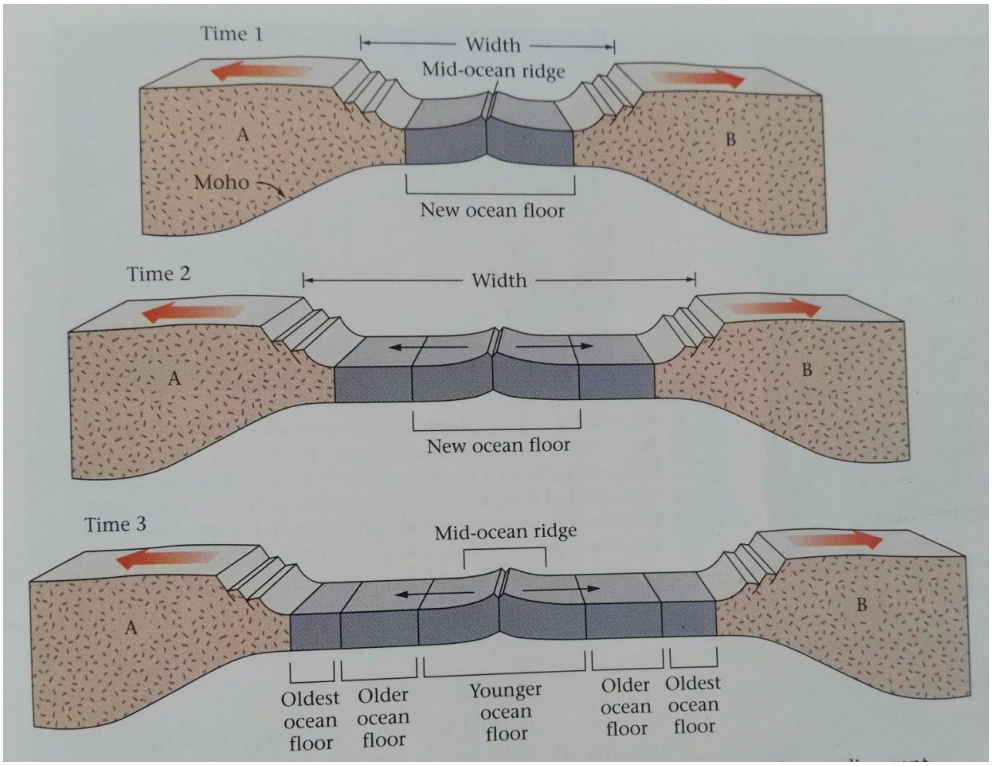

Fig. 1. The successive stages in sea-floor spreading along a divergent boundary; only the crust is shown. The top figure represents an early stage of the process, after the mid-oceanic ridge formed but before the ocean grew very wide., as seen in the next two figures, the ocean gets wider abs continent A drifts away from continent B. Note that the youngest oceanic crust lies closest to the ridge.

The formation new sea floor takes place only across a narrow band, less than a few kilometers wide, along the axis of the ridge. Roughly, the ridges are symmetrical, one side looks like a mirror image of the other. Along its length, the ridge consists of short segments (tens to hundreds of km long). The segments are linked to each other by a narrow bands of break-up crust, which lie at almost 90° to the ridge axis Fig. 2.

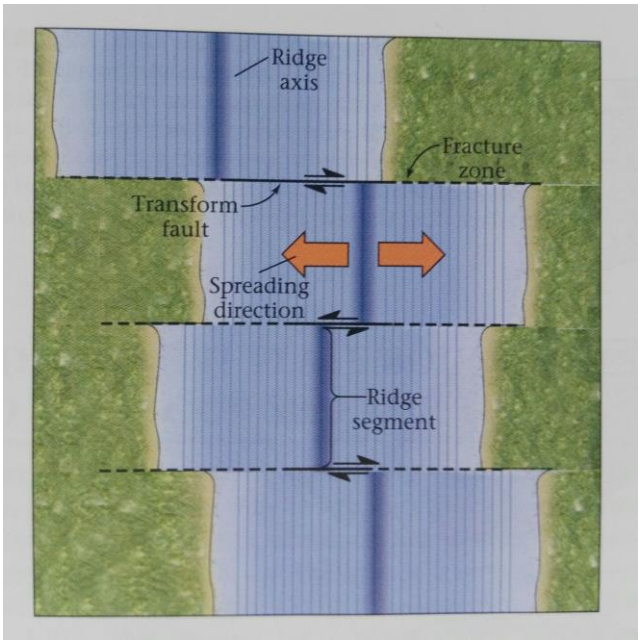

Fig. 2. A map sketch of a mid-oceanic ridge. Transform faults, on which there sliding, are shown by solid lines. Fracture zones, on which there is no sliding, are shown by broken lines.

The formation of oceanic crust at a mid-oceanic ridge

As sea-floor spreading takes place, hot asthenosphere (the soft flowable part of the mantle) rises beneath the ridge Fig. 3.

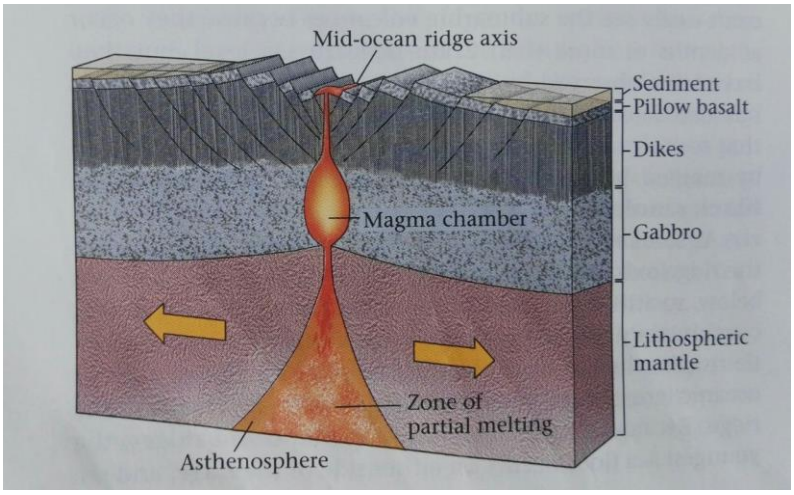

Fig 3. How new lithosphere forms at a mid-oceanic ridge.

As this asthenosphere rises, it begins to melt, producing molten rock, or magma. Molten rock underground is magma, while molten rock on earth´s surface is lava. Magma has a lower density than solid rock, so it behaves buoyantly and rises. It eventually fills the space, or magma chamber, in the crust below the ridge axis. Some of the magma solidified along the side of the chamber, to make the coarse-grained, mafic igneous rock called gabbro. Some of the magma rises still higher to fill vertical cracks, where it solidifies and form wall-like sheets, or dikes, of basalt.

Finally, some magma rises all the way to the surface of the sea floor at the ridge axis and spills out of small submarine volcanoes. The resulting lava cools to form a layer of basalt blobs, called pillow basalt, on the sea floor. We cannot easily see the submarine volcanoes because the occur at depths of more than 2 km beneath sea level. There is chimneys spewing hot, mineralized water that rose through cracks in the sea floor, after being heated by magma below the surface. These chimneys are called black smoker Fig. 4.

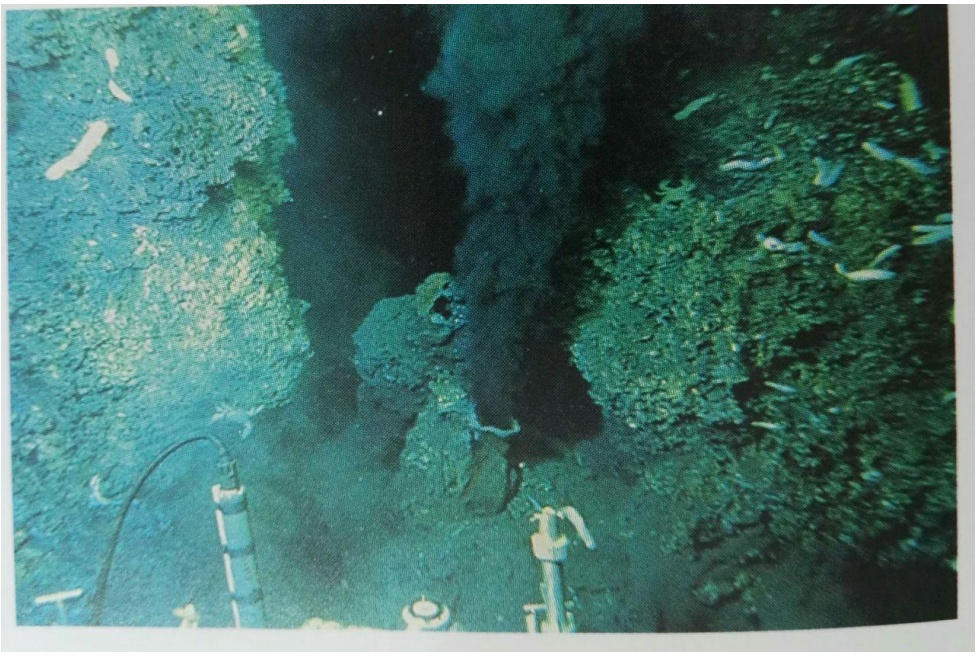

Fig. 4. Black smoker along mid-oceanic ridge. The cloud of smoke actually consists of tiny mineral grains

Magma from the mantle rises to the earth´s surface at the ridge, solidifies to form oceanic crust, and then move laterally away from the ridge. Because all sea floor forms at mid-oceanic

ridges, the youngest sea floor occurs on either side of the ridge, and sea floor becomes progressively older away from the ridge. In the Atlantic Ocean, the oldest sea floor lies adjacent to the passive continental margins on other side of the ocean Fig. 5.

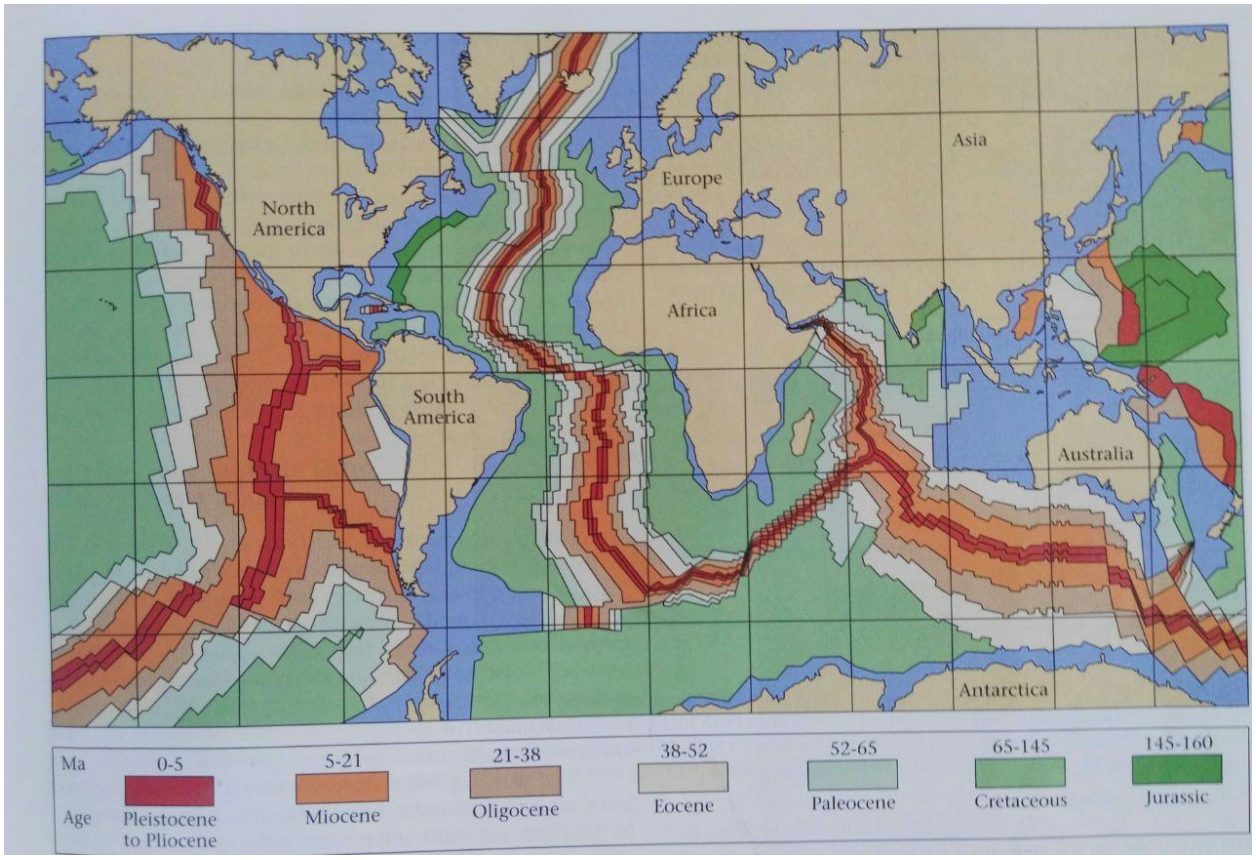

Fig. 5. This map of the world shows the age of the sea floor. Note how the sea floor grows older with increasing distance from the ridge axis. (Ma = million years ago.)

The tension (stretching force) applied to newly formed solid crust as spreading takes place breaks this new crust, resulting in the formation of faults. Slip of the faults causes divergent-boundary earthquakes and creates numerous cliffs that parallel the ridge axis.

The formation of the mantle part of the lithosphere at a mid-oceanic ridge

The mantle part of the lithosphere consists of the cooler uppermost area of the mantle, in which temperatures are less than about 1280°C. At the ridge axis, such temperatures occur almost at the base of the crust, because of the presence of rising hot asthenosphere and hot magma, so the lithospheric mantle beneath the ridge axis effectively does not exist. But as the newly formed oceanic crust moves away from the ridge axis, the uppermost mantle beneath it gradually cools. As soon as mantle cools below 1280°C, it becomes part of the lithosphere. Thus, as oceanic lithosphere moves away from the ridge axis, it grows progressively thicker Fig. 6.

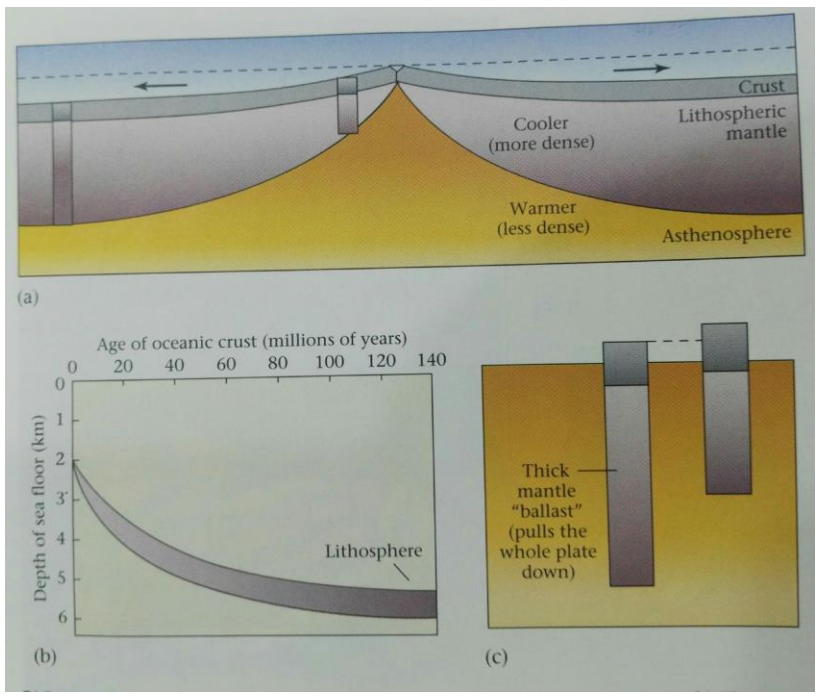

Fig. 6. (a) as sea floor ages, the dense lithospheric mantle thickens. (b) the thickness of the lithosphere and the depth of the sea floor both increase as a plate moves away from the ridge and grows older. (c) like the ballast of a ship, thicker lithosphere sinks deeper into the mantle. This is why old ocean floor is deeper than young ocean floor.

The reference

Stephen, M., (2004) Essentials of geology, first edition, printed in United State of America, P 536.