University of Anbar

College of Science

Department of Applied Geology

Tectonics

Title of the lecture

Convergent plate boundaries and subduction

Ass. Prof. Dr. Abdulkhaleq A. Alhadithi

2020

Convergent plate boundaries and subduction

At convergent plate boundaries, or convergent margins, two plates, at least one of which is oceanic, move toward each other. One ocean plate bends and begins to sink down into the asthenosphere beneath the other plate. Geologists refer to the sinking process as subduction, so convergent boundaries are also known as subduction zones. Convergent boundary consumes old ocean lithosphere, and delineates by deep oceanic trench, therefore sometimes called trenches.

The amount of oceanic plate consumption worldwide, averaged over time, equals the amount of sea-floor spreading worldwide, so the surface area of the earth remains constant.

Subduction occurs for a simple reason: oceanic lithosphere, once it has aged at least 10 million years, is denser than asthenosphere (because lithosphere cools and contracts as it ages), and thus can sink through the asthenosphere. When it lies flat on the surface of the asthenosphere, oceanic lithosphere cannot sink because the resistance of the asthenosphere to flow is too great; however, once the end of the convergent plate is pushed into the mantle Fig. 1. Because the asthenosphere resists flow, oceanic lithosphere can sink only very slowly, at a rate of less than 10-15 cm per year.

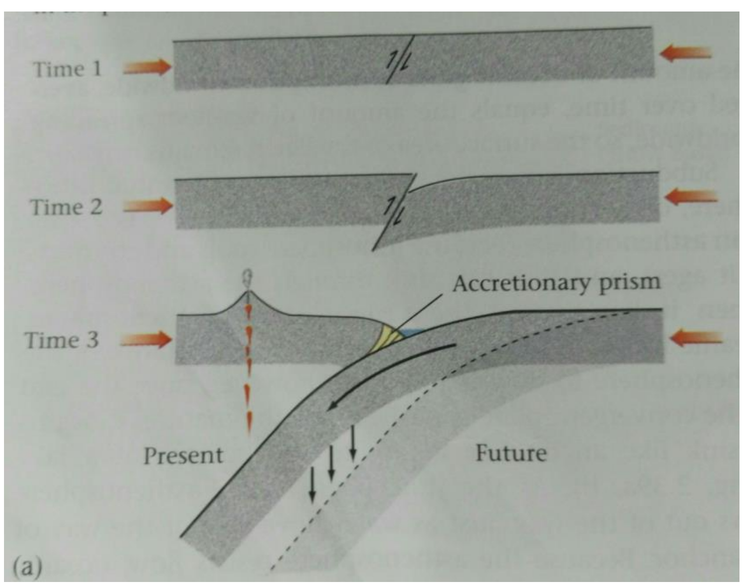

Fig. 1. The concept of subduction. A plate bends, and one-piece pushes over the another

The downgoing plate, the plate that has been subducted, must be composed of oceanic lithosphere. The overriding plate, which does not sink, can consist of either oceanic or continental lithosphere. Continental lithosphere cannot be subducted because it is too buoyant. If continental crust moves into a convergent margin, subduction stops. Most oceanic lithosphere eventually sink, all ocean floor in the planet is less than about 200 million years old, but because continental lithosphere cannot subduct, some continental crust has persisted at the surface of the earth for over 3.8 billion years.

Earthquakes and the fate of subducted plates

At convergent plate boundaries, the downgoing plate grinds along the base of the overriding plate, a process that generates large earthquakes. Theses earthquakes fairly close to the earth´s surface. Earthquakes also happen in downgoing plate at greater depth, deep below the overriding plate. Geologists have detected earthquakes within downgoing plates at depth of 670 km; the belt of earthquakes in a downgoing plates the Wadati-Benioff Zone Fig. 2.

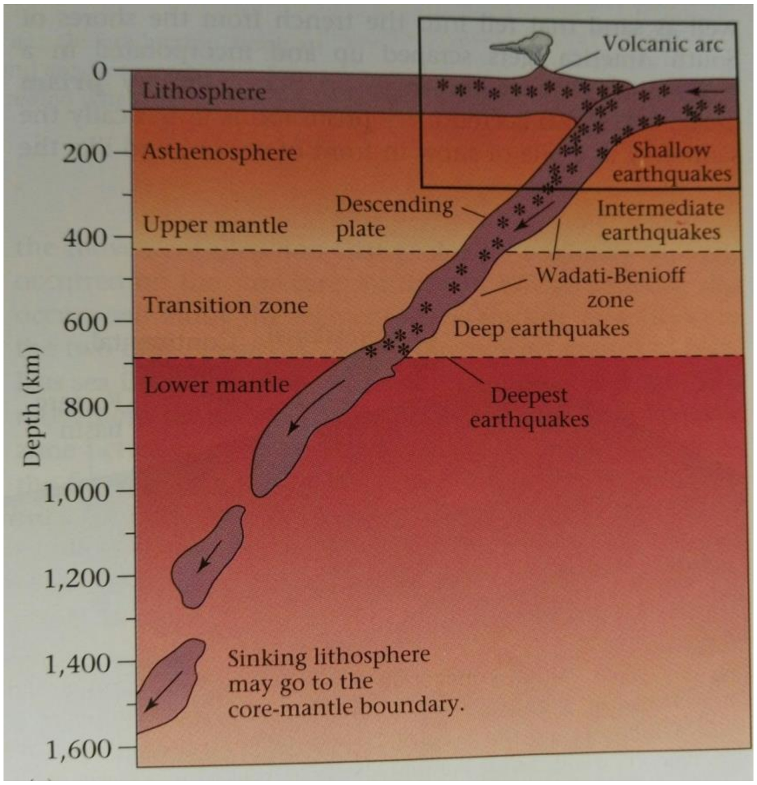

Fig. 2. The Wadati-Benioff Zone is a bad of earthquakes that occur in subducted oceanic lithosphere. The discovery of these earthquakes led to the proposal of subduction.

What causes earthquakes in this zone, they may be result from the breaking of rock during movement on faults within the plate, or they may be due to the sudden collapse of mineral crystals in response to great pressures. At depths greater than 670 km, conditions leading to earthquakes evidently do not occur. The downgoing plates do continue to sink below a depth of 670 km without earthquakes. Studies suggest that the lower mantle may be graveyard for old subducted plates. The plates sink and pile up just above the core-mantle boundary. Most these old plates slowly absorb heat from their surrounding until they become warm and soft enough to start flowing along with rest of the mantle Fig. 3.

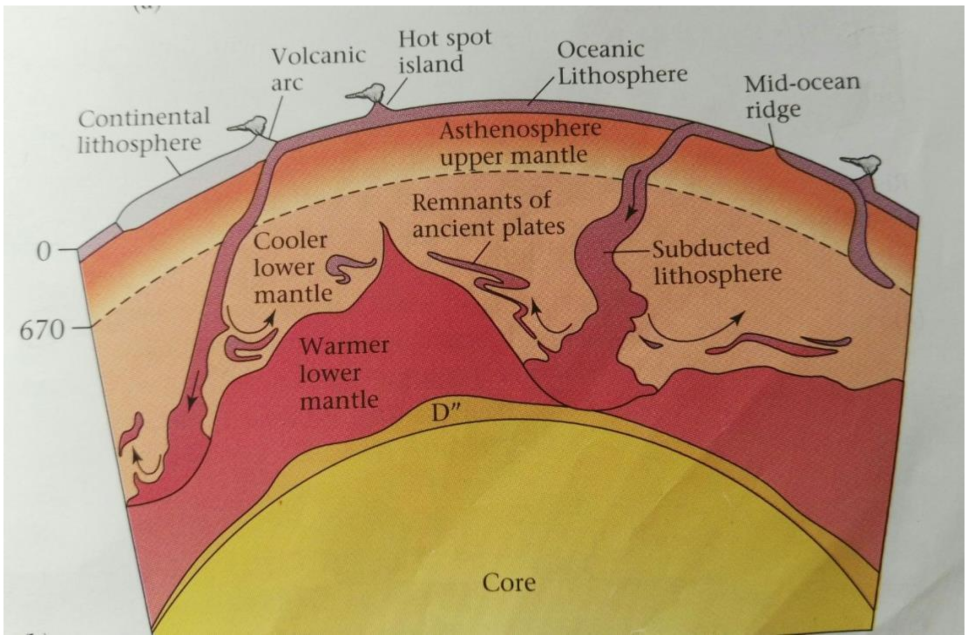

Fig. 3. A model illustrating the ultimate fate of subducted lithosphere.

Geological features of a convergint boundary

let's look at an example, the boundary between the west coast of the South America plate and theeastern edge of the Nazca plate (a portion of the Pacific Ocean floor). A deep oceanic trench, the Peru-Chile trench delineates this boundary. In the Peru-Chile trench, as the downgoing plate slides under the overriding plate, the sediment (clay and plankton) that had settled on the surface of the downgoing plate, as well as sand that fell into the trench from the shores of Soyth America, gets scraped up and incorporated in a wedge-shaped mass known as an accretionary prism Fig. 4.

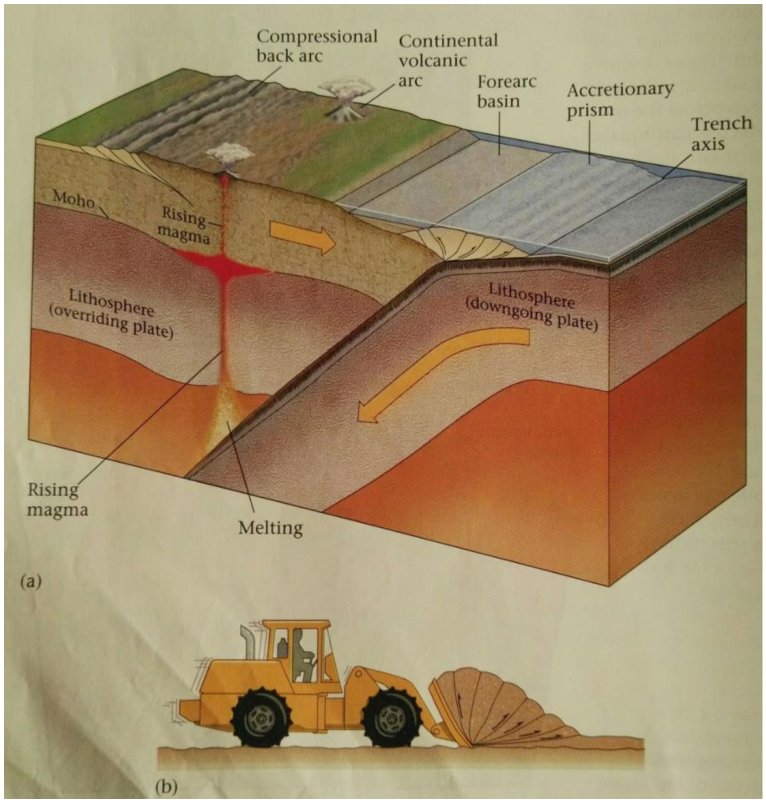

Fig. 4. (a) This model shows the geometry of subduction along an active continental margin. Numerous faults form in the accretionary prism. (b) A bulldozer pushing snow or soil is similar to the development of an accretionary prism.

A chain of volcanoes known as a volcanic arc develops behind the accretionary prism. The magma that feeds these volcanoes forms at or just above the surface of the downgoing plate when the plate reaches a depth of about 150 km below the earth's surface. If the volcanic arc forms where an oceanic plate subducts beneath continental lithosphere, the resulting chain of volcanoes grows on the continent and forms a continental volcanic arc Fig. 4; for example Andes. If the volcanic arc forms where one oceanic plate subducts beneath another oceanic plate, the resulting volcanoes form a chain of island known as a volcanic island arc Fig 5 (a); for example Aleutian Island.

The region on the opposite side of the volcanic arc from the trench is called the back-arc region. In some cases, squashing and compression occur in back-arc regions, casing a mountain range to form. Elsewhere, extension and sea-floor spreading occur in the back-arc, creating a small ocean basin called a marginal sea Fig. 5(b). The Japan Sea, for example, formed in this way.

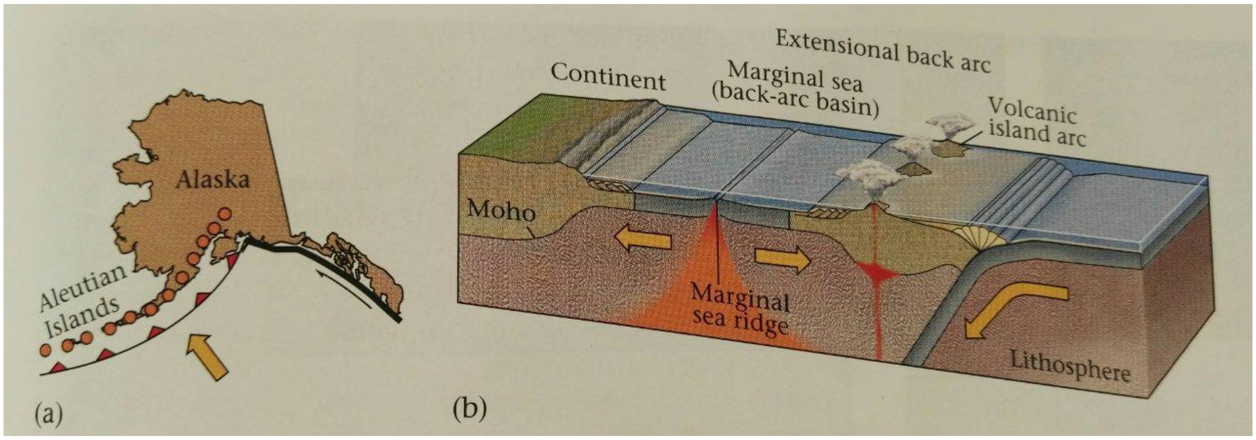

Fig. 5. (a) The Aleutian Islands in Alaska example of island arc. (b) subduction along an island arc.

The reference

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