University of Anbar

College of Science

Department of Applied Geology

Tectonics

Title of the lecture

Transform plate boundaries and special locations in the plates

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Transform plate boundaries

We saw **earlier** that the spreading axis of the mid oceanic ridge consists of short segments linked by fracture zones. The geometric relationship of fracture zones to ridge segments, and evidence indicating that fracture zones are made up broken-up crust, that led geoscientists to conclude that the fracture zones were faults. They then incorrectly assumed that sliding on faults in fracture zones broke an originally continuous ridge into the segments and displaced the segments sideways Fig. 1(a). This interpretation implies that one segment moves with respect to its neighbor, as shown by the arrows in Fig 1(b). A Canadian Tuzo Wilson realized the above interpretation could not be correct.

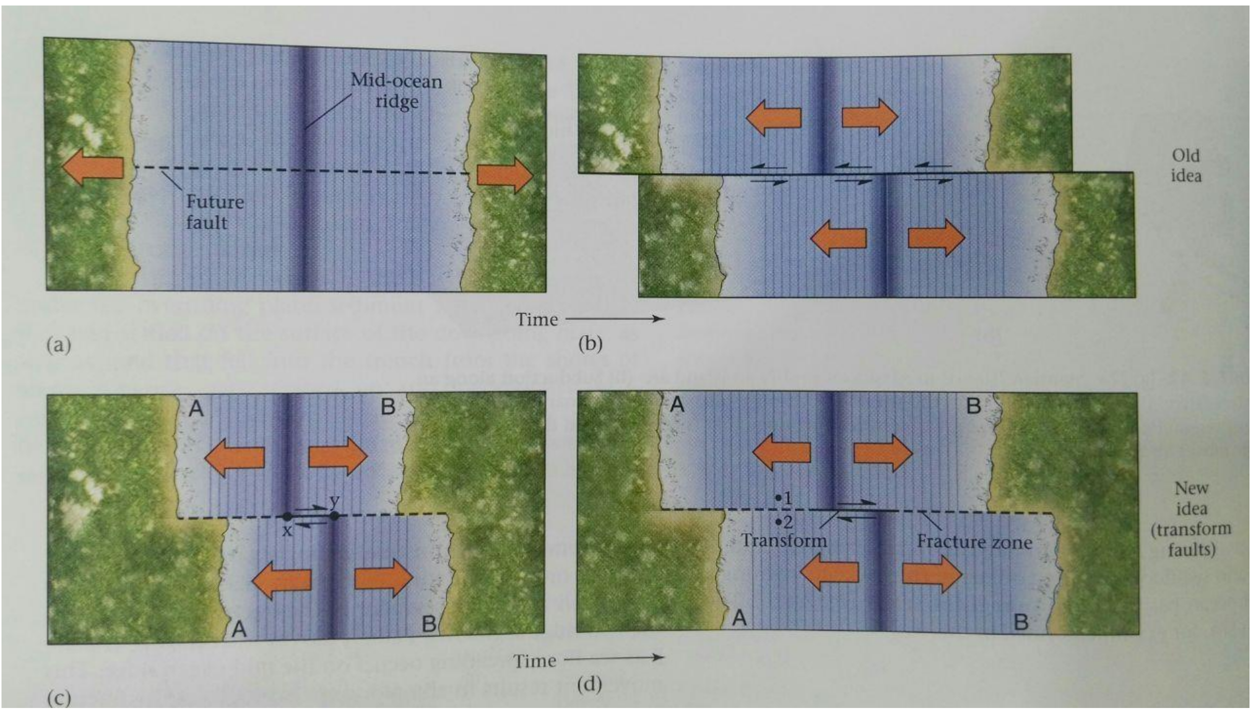

Fig. 1. (a) Incorrect interpretation of an oceanic fracture zone, the fault forms and cut across an originally continuous ridge. (b) After slip of the fault, indicated by the arrows, the ridge consists of two segments. (c) In Wilson´s correct interpretation, the ridge initiates at the same time as the transform, and thus was never continuous. (d) Even though the ocean grows, the transform can stay the sane length.

In Wilson´s interpretation, the fracture zone formed at the same time as the ridge axis itself, and thus the ridge consisted of separate segments to start with. These segments were linked (not offset) by fracture zones. Fig 1 (c) shows the arrows to indicate the direction that ocean crust was moving relative to the ridge axis, as a result of sea-floor spreading. The movement direction on the fracture zone must be opposite to the movement direction of incorrect interpretation. In Wilson model, slip occur only along the segment of the fracture zone between the two ridge segments. Plate A moves with respect to plate B as sea-floor spreading occurs on the mid-oceanic ridge. This movement result in slip along the segment of the fracture zone between points X and Y. But to the west of the point X, the fracture zone continues merely as a boundary between two different parts of plate A. The portion of plate A at point 1, just to the north of the boundary Fig I (d), must be younger than the portion at point 2 just to the south, because point 1 lies closer to the ridge axis; bit since point 1 and 2 move at the same speed, this segment of the fracture zone does not slip.

Wilson introduced the term transform fault for the actively slipping segment of a fracture zone between two ridge segments, and he point out that transform faults made a third type of plate boundary. Geologists now also call then transform boundary or transforms. At a transform boundary, one plate slides sideways past another, but no new plate forms and no old plate is consumed. Transform boundaries are defined by a vertical fault on which slip parallels the earth´s surface.

Most transforms are fairly short, and serve only to link segments of mid-oceanic ridge Fig. 2.

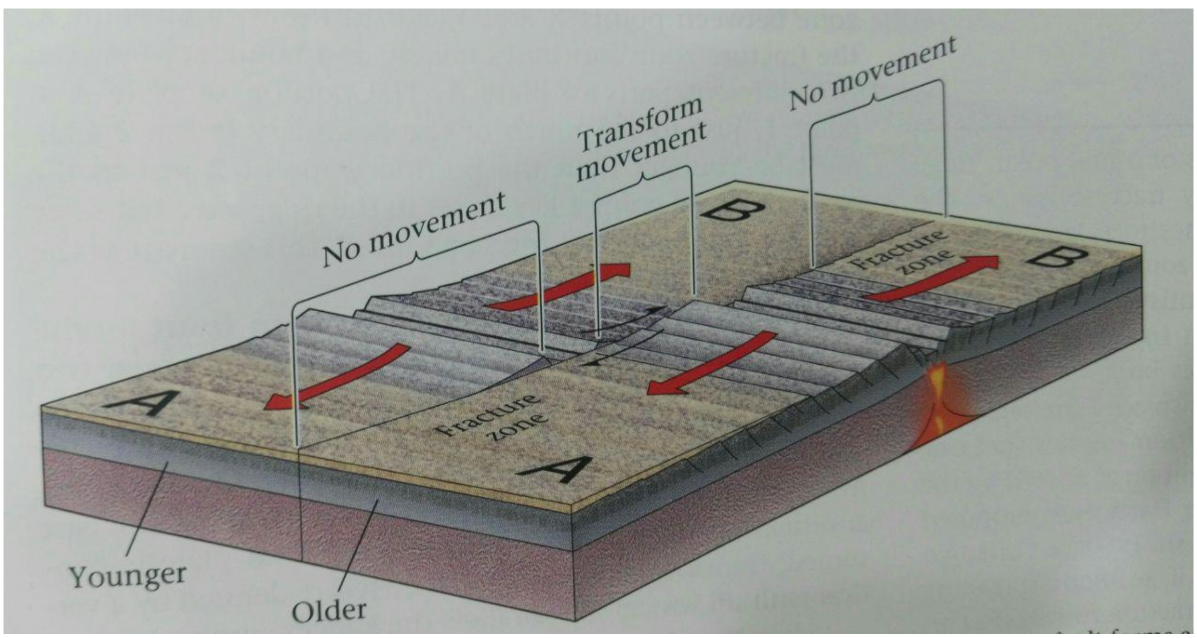

Fig. 2. The fracture zone beyond the ends of the transform does not slip, and thus is not plate boundary

Not all t5ransforms link ridge segments. Some, such as the Alpine Fault of New Zealand, link trenches, while others link a trench to a ridge segment. Not all transform faults occur in oceanic lithosphere; few cut across continental lithosphere. The San Andreas Fault defines part of the plate boundary between the North American plate and the Pacific plate Fig. 3. On average, the Pacific Plate moves about 6 cm north, relative to North America.

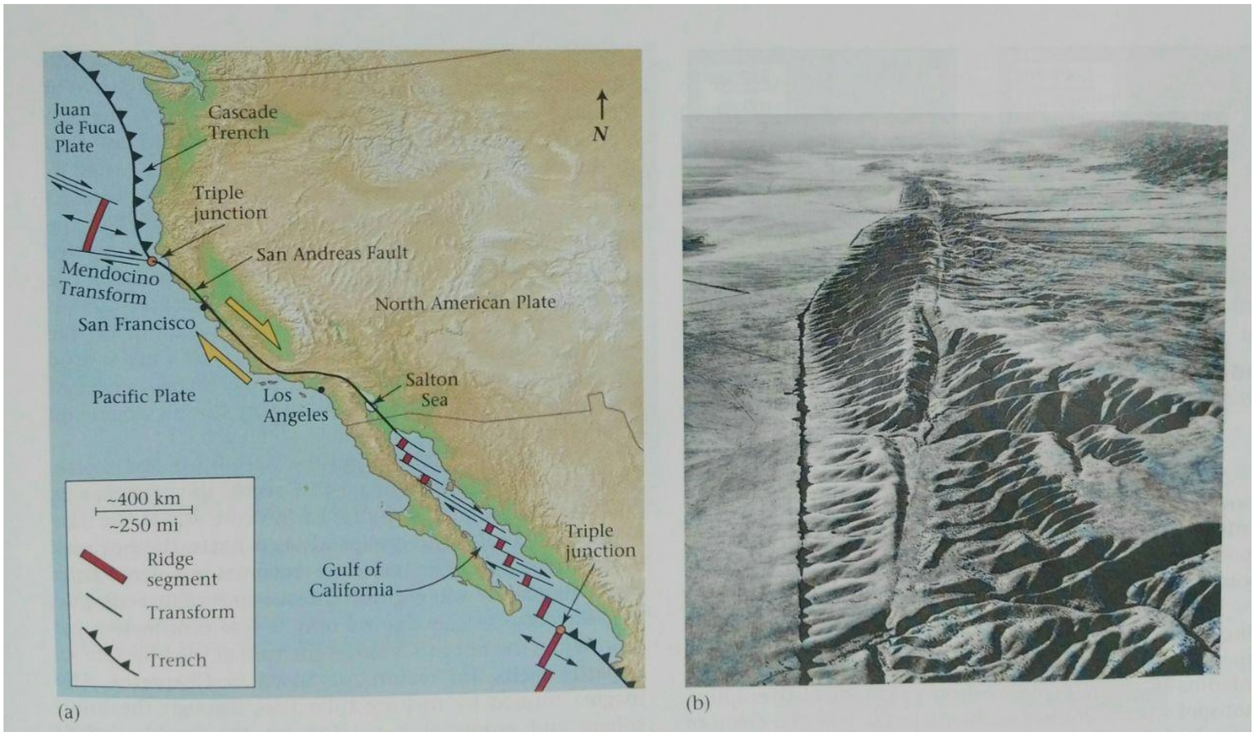

Fig. 3. (a) The San Andreas Fault is a transform plate boundary between the Pacific Plate to the west and the North America Plate to the east. At its southeast end, the San Andreas connects to spreading ridge segments in the Gulf of California. (b) The San Andreas Fault where it cuts across a dry landscape.

Special locations in the plate mosaic

Triple junction

Triple junction is a point where three plate boundaries intersects. We name triple junctions after the types of boundaries that intersect. For example, the triple junction formed where the southeast Indian ocean ridge intersects two arms of mid-Indian ocean ridge (this is the triple junction of the Arica, Antarctica, and Australian plates) is a ridge-ridge-ridge triple junction. The triple junction north of San Francisco is a trench-transform-transform triple junction Fig. 4.

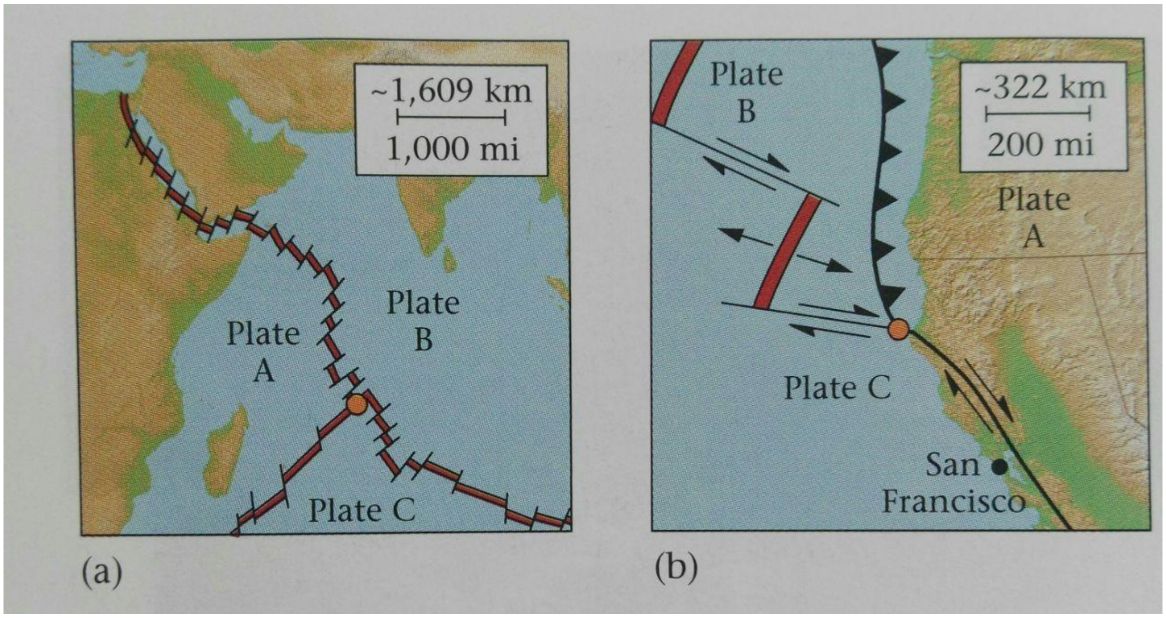

Fig. 4. (a) a ridge-ridge-ridge triple junction (at the dot). (b) a trench-transform-transform triple junction.

Hot spots

There are types of volcanoes, some volcanoes occur in volcanic arc, and other types are small volcanoes that lie along mid-oceanic ridge. both types of volcanoes are plate boundary volcanoes. Not all volcanoes on earth are plate boundary volcanoes. For example, Hawaii, a huge active volcano, lies in the middle of Pacific Ocean, and Yellowstone National Park, site of a recent volcano, lies in the interior of the United States. There are one hundred volcanoes that exist as isolated points and are not related to plate boundaries, these are called hot-spot volcanoes or hot-spot Fig. 5. Most hot spots are located in the interior of plates, away from the boundaries, but few happen to lie on mid-oceanic ridges.

What causes hot-spot volcanoes? Wilson noted that an erupting hot-spot volcano formed an island at the end of the chain of the now-dead volcanic island and seamounts. Volcanoes along convergent plate boundary are all active at about the same time. Wilson also noted that all the hot-spot volcanoes in the Pacific lie at the southeast end of the northwest-southeast-lying chain of dead volcanoes Fig. 6. Wilson suggested that a hot spot volcano develops over a heat source in the mantle that is fixed relative to the moving plate; an active volcano represents the location of the heat source.

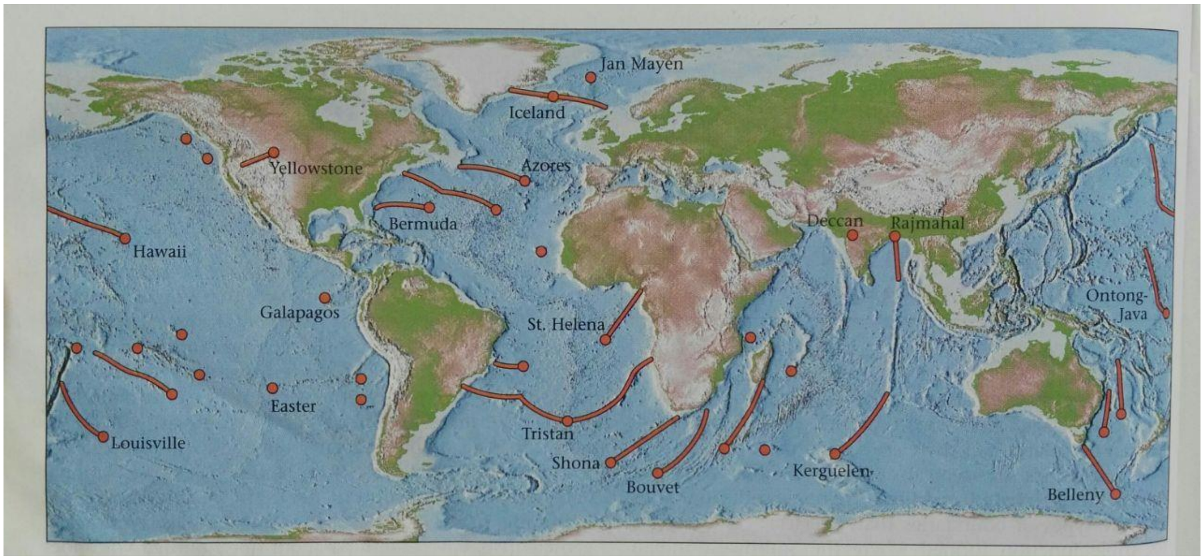

Fig. 5. The dots represent the locations of hot-spot volcanoes. The tails represent the tracks along the hot-spot.

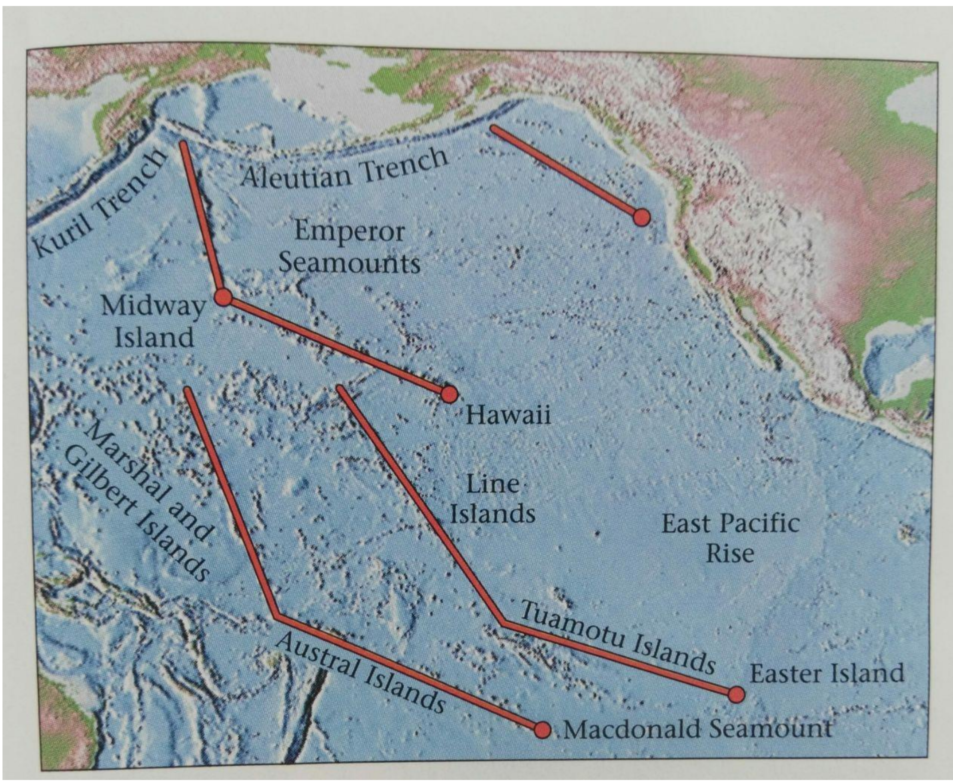

Fig. 6 hot-spot tracks in the Pacific Ocean. The small dotes represent islands or seamounts. The straight lines indicate the geometry of the tracks. Note that the chains have a 40° bend in them, resulting from a change in the direction of motion of the Pacific plate about 40 million years ago.

The chain of seamounts and in active volcanic islands linked to the hot-spot volcano represent locations on the plate that were once over the source but have since moved off. The heat source came to be associated with a **mantle plume**, a column of very hot rock rising up through the mantle from the are near the core-mantle boundary Fig. 7.

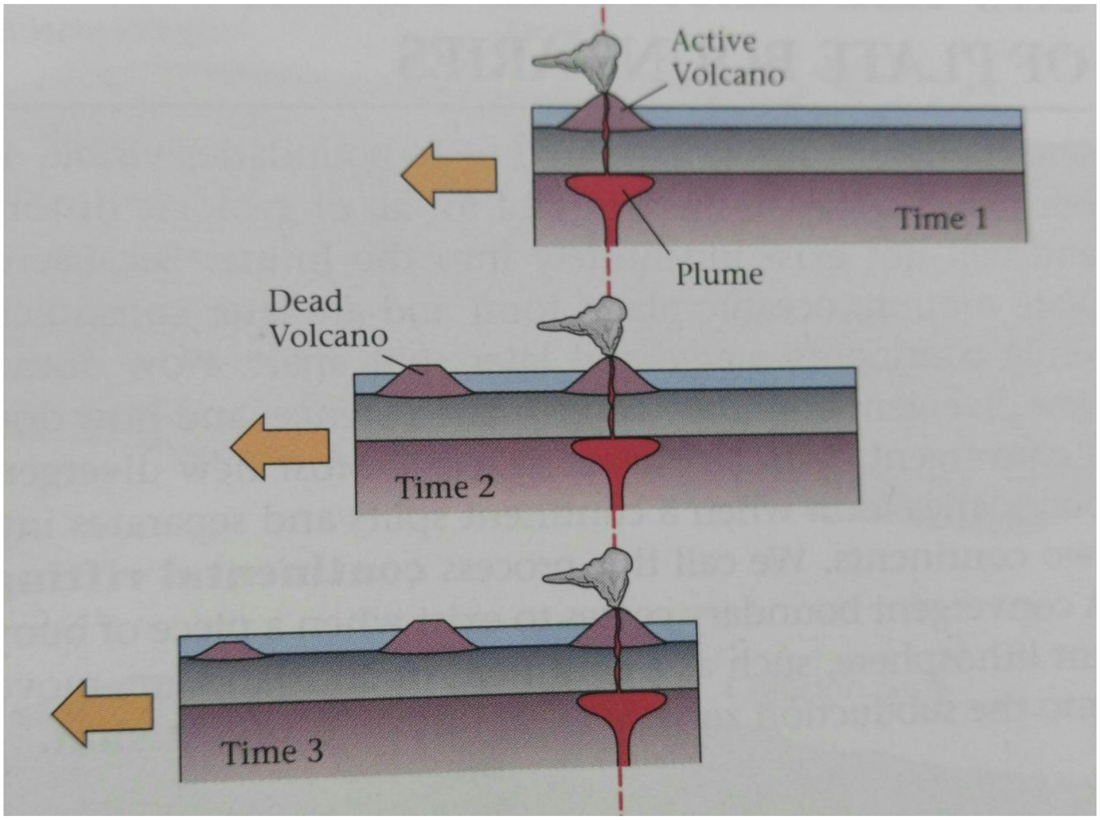

Fig. 7. A mantle plume causes a hot spot to form at the base of a plate, leading to the growth of a volcano on the surface of the plate. As the plate moves, the volcano carried off the hot spot; it then dies, and a new volcano forms above the hot spot. As the process continues, a chain of extinct volcanoes develops, with the oldest one farther from the hot spot. The extinct volcanoes gradually sink below sea level and become seamounts. Only the volcano above the hot-spot erupts.

The reference

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