Earthquakes & Volcanoes

S. Marshak / Feb. 2024

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Our Dynamic Planet . . .
Earthquakes and Volcanoes

TOPIC 1 — Where do earthquakes occur? Clues from plate tectonics.

TOPIC 2 — The nature of faulting; Measurement of earthquakes

TOPIC 3 — Earthquake destruction, and earthquake mitigation

TOPIC 4 — Causes and classification of volcanoes

TOPIC 5 — Volcanic destruction, and eruption forecasting

TOPIC 6 — Tsunamis

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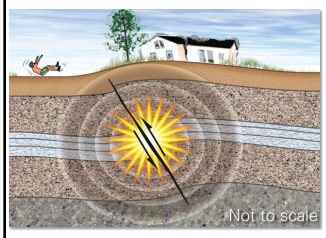

Earthquake:

- An event during which rock suddenly ruptures to form a fracture on which slip happens, or an event during which a preexisting fracture suddenly slips.
- The event releases energy which travels through the Earth in the form of vibrations (**seismic waves**).
- The term also refers to the episode of **ground shaking** that happens when the vibrations displace the surface of the Earth.

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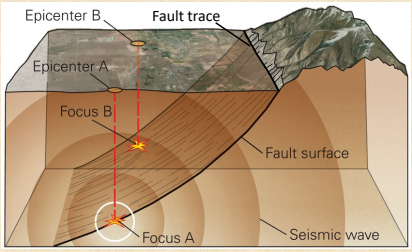
Two key terms used when discussing earthquakes:

- **Focus**: The location underground where slip begins on a fault.
- **Epicenter**: The point on the Earth's surface directly above the focus.

Note . . .

- A **cross-section** (vertical slice) through the Earth can show the focus.
- A **map** of earthquake distribution shows epicenters.



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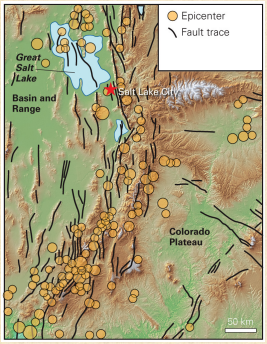

For example . . .

This map of Utah shows epicenters (yellow dots) and fault traces (black lines).

A **fault trace** is the line of intersection between a fault plane and the ground surface.

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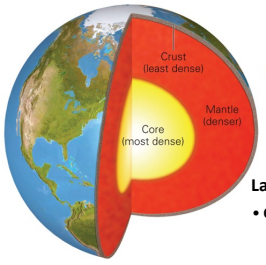

To understand where earthquakes occur, we first need to understand the overall structure and behavior of the Earth.

Layers of the Earth (as defined by composition)

- **Crust** —
  Oceanic: Dense ***basalt*** (4 – 5 miles thick)
  Continental: Less dense ***granite*** (20 - 40 miles thick)
- **Mantle**: Very dense ***peridotite*** (1800 miles thick)
- **Core**: Extremely dense ***iron alloy*** (1500 miles thick)

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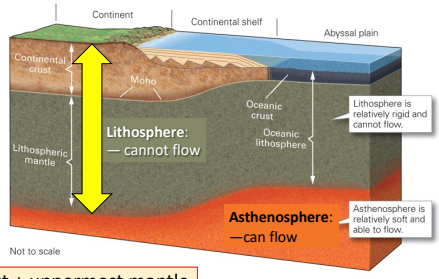
Layering of the outer Earth (as defined by rigidity)



Lithosphere = crust + uppermost mantle

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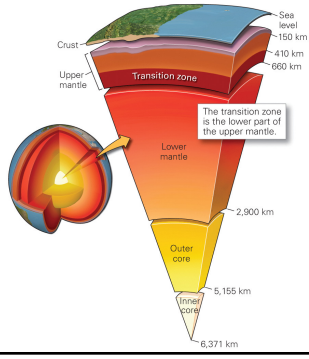
Modern studies indicate indicate that the major layers can be subdivided.



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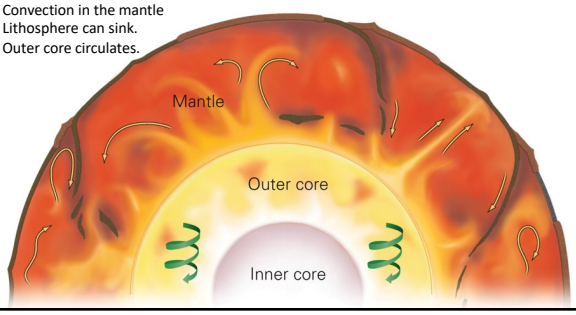
Modern dynamic image of the Earth's interior —

- Convection in the mantle
- Lithosphere can sink.
- Outer core circulates.



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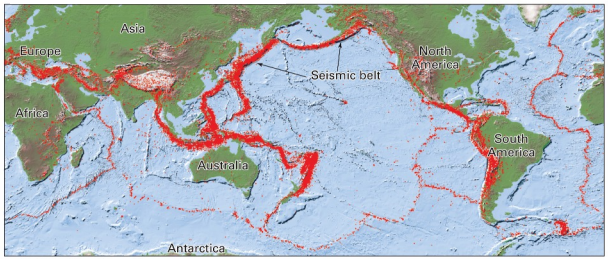
The distribution of earthquakes defines the locations of plate boundaries.



Plates move relative to one another. As this happens, they shear against each other at plate boundaries. This generates earthquakes. (Plate interiors are ~ stable.)

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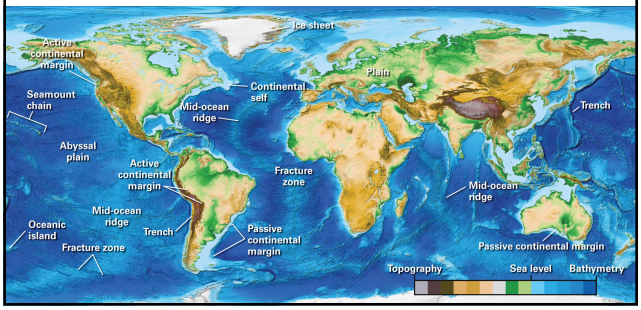
The location of plate boundaries also controls the distribution of topographic and bathymetric features, such as mid-ocean ridges, trenches, and fracture zones.



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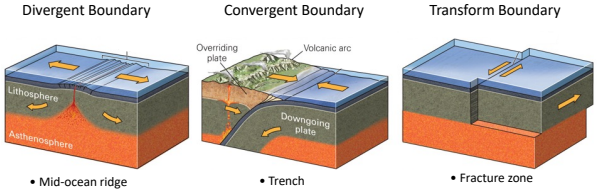
There are three types of plate boundaries.



- Mid-ocean ridge
- Sea-floor spreading

- Trench
- Subduction

- Fracture zone
- Strike-slip fault

NOTE: There are major **faults** (fractures on which slip occurs) at each plate boundary.

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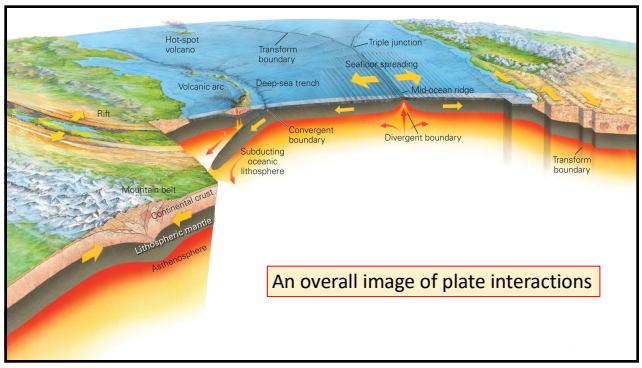

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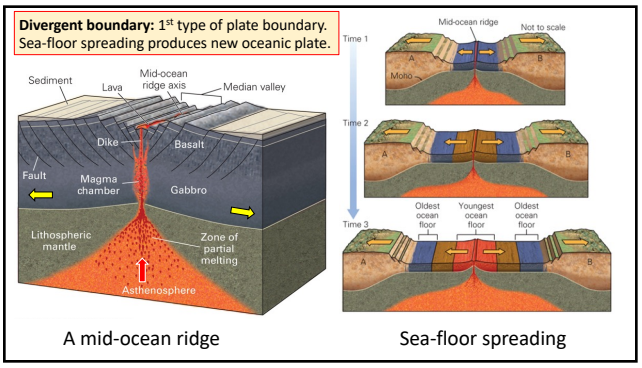

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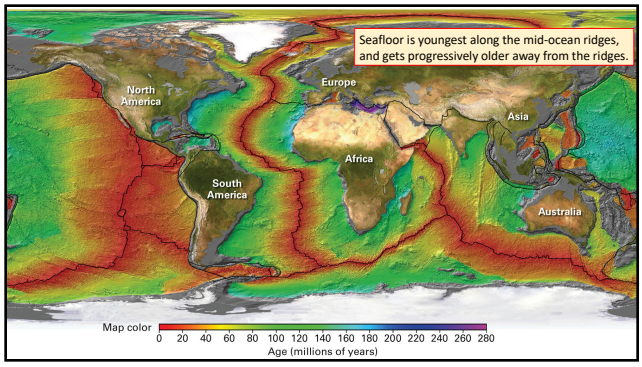

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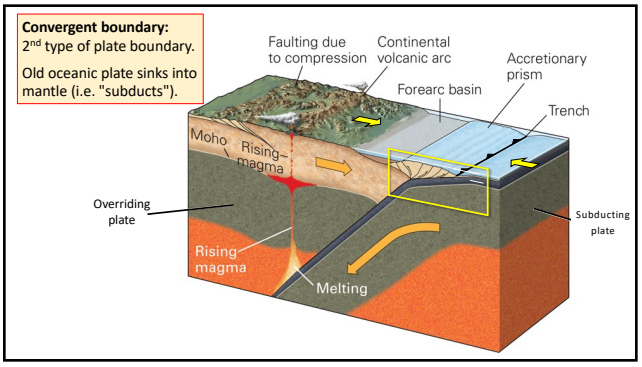

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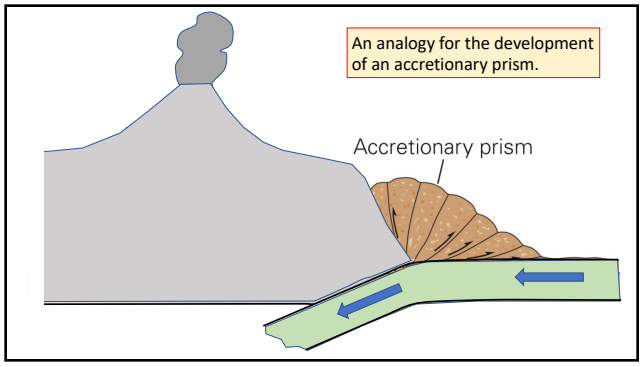

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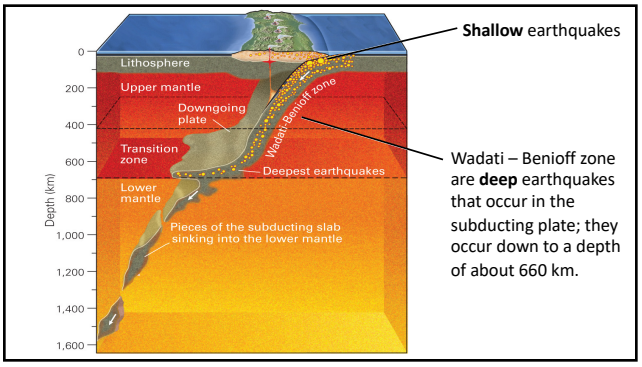

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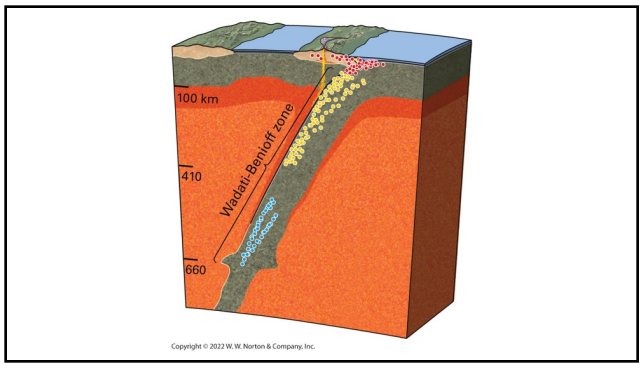

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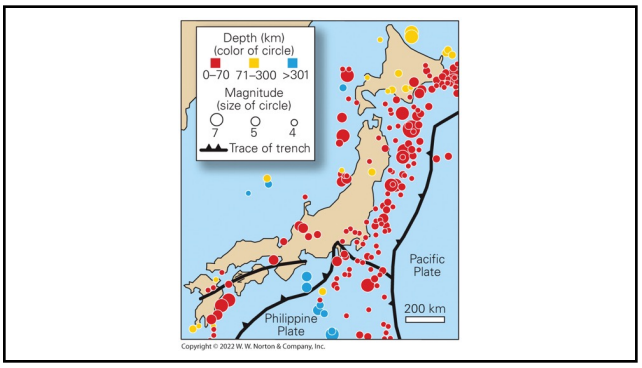

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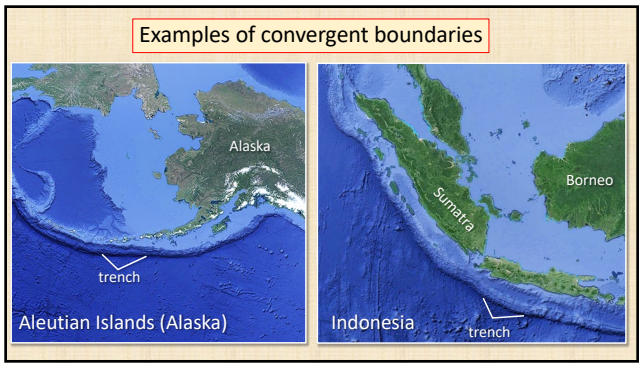

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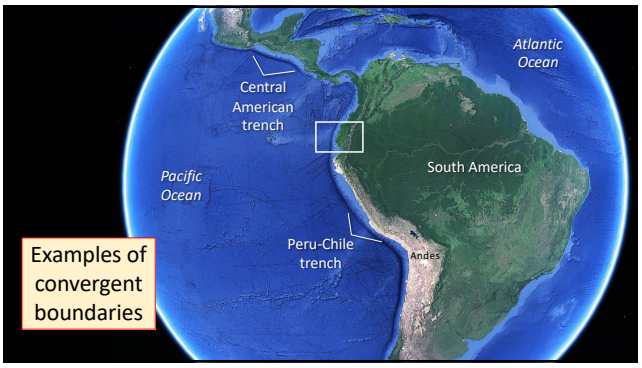

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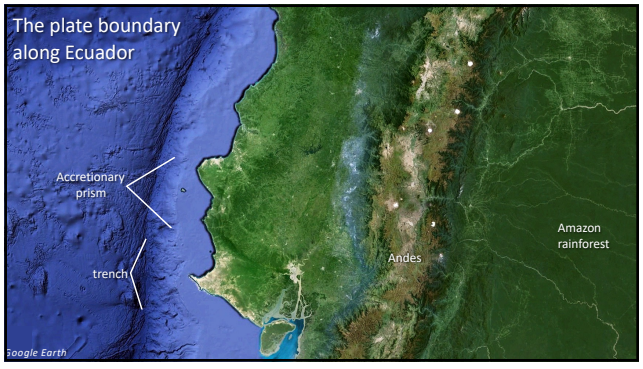

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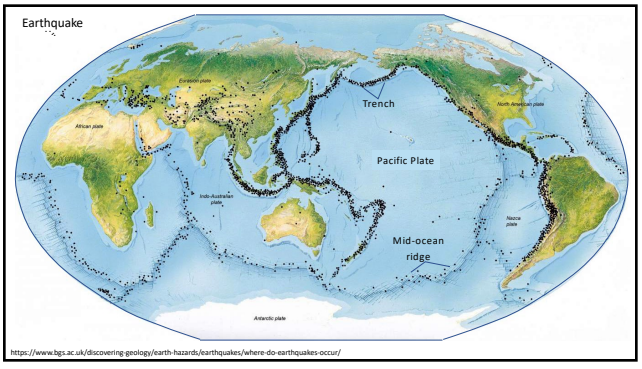

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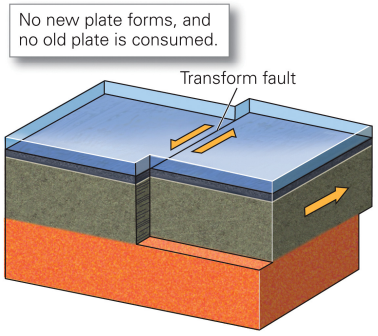
Transform boundary:
the 3rd type of plate boundary.

One plate slides sideways past another, on a strike-slip fault.



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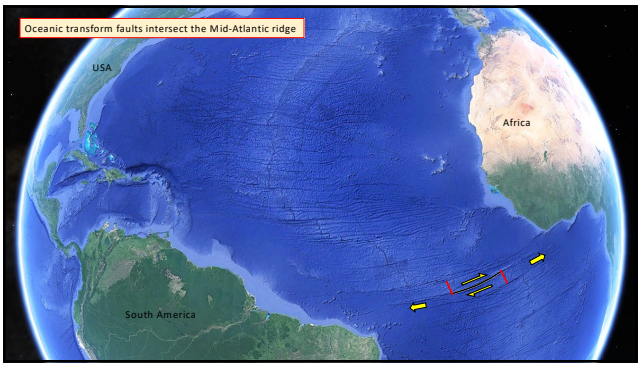

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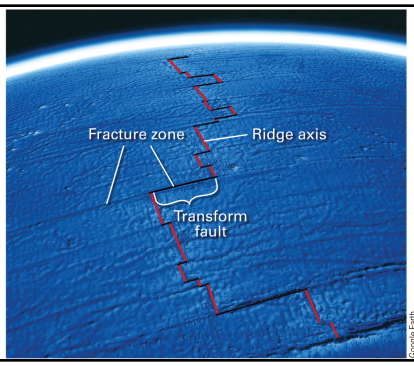

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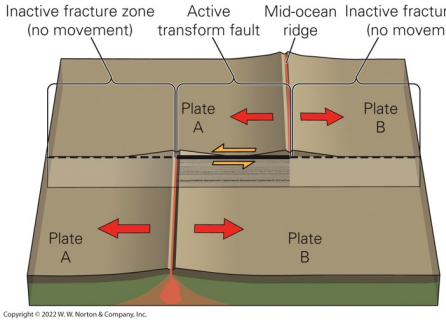

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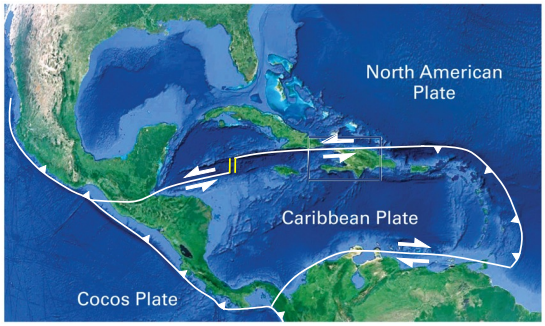

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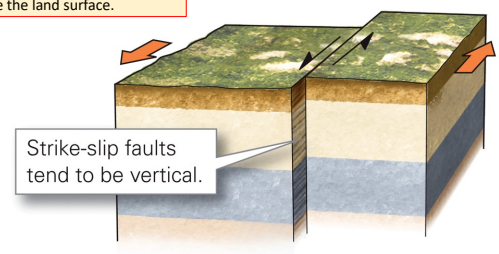
Transform faults can also cut across land. They displace the land surface.



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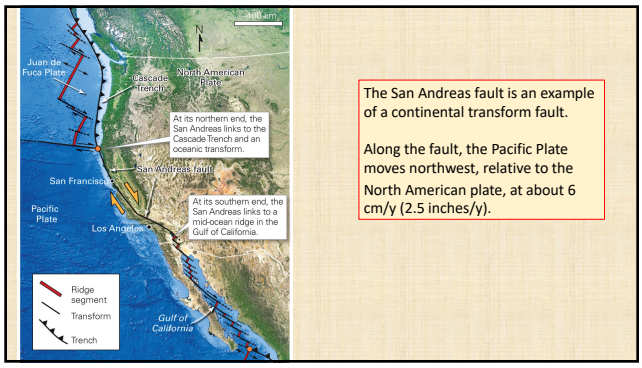

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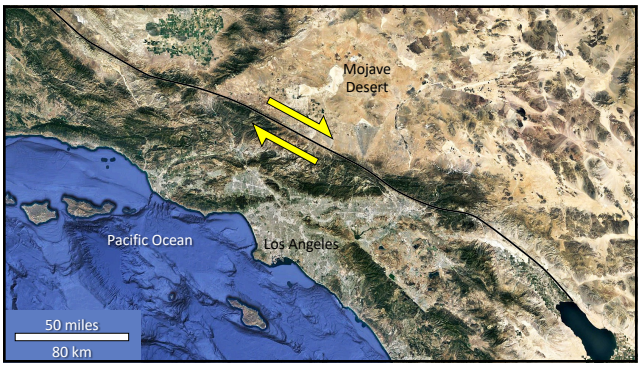

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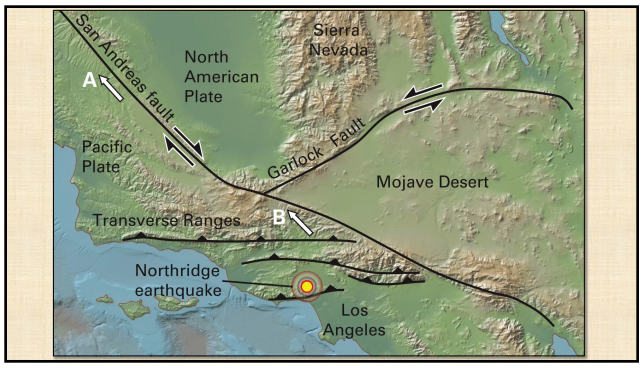

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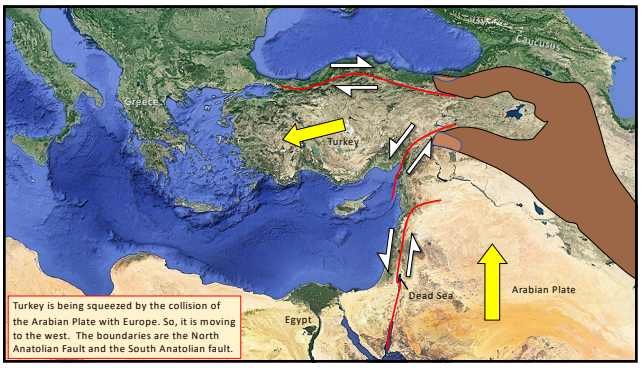

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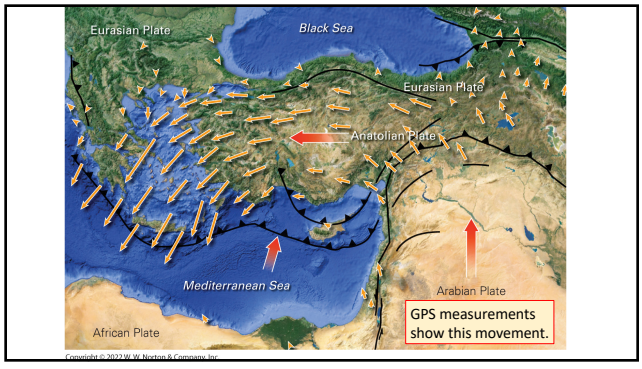

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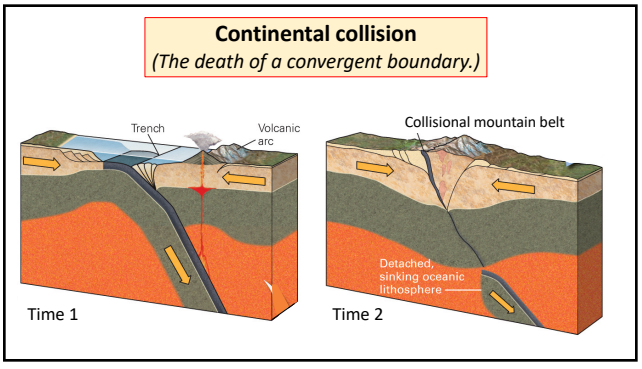

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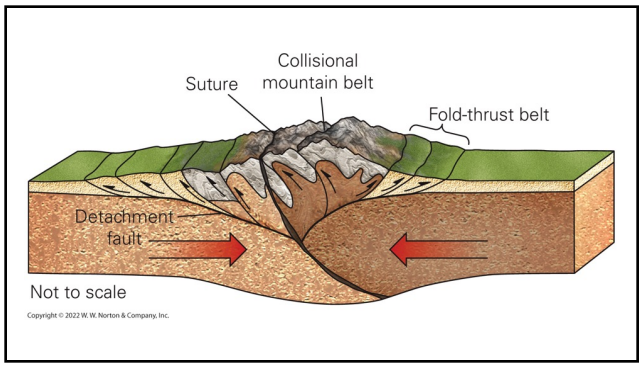

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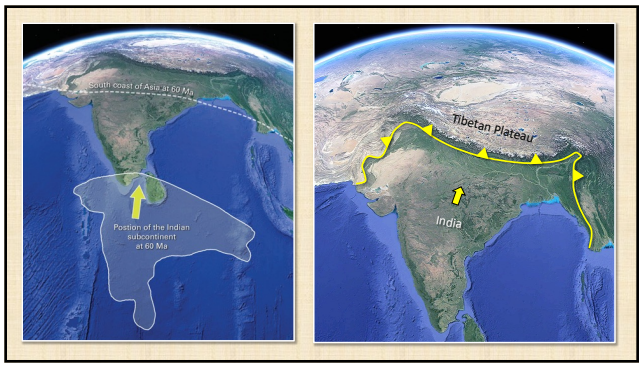

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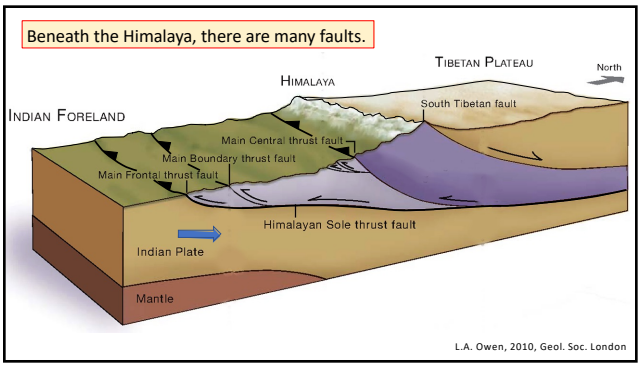

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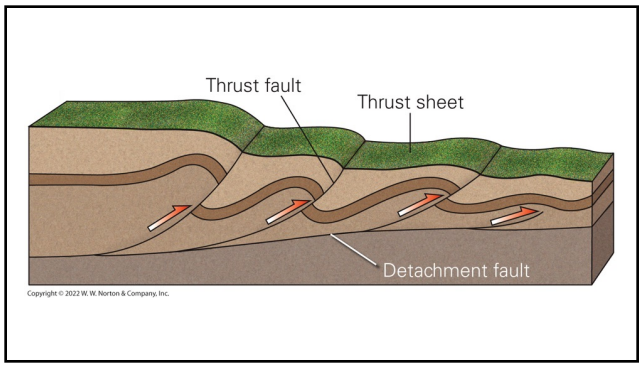

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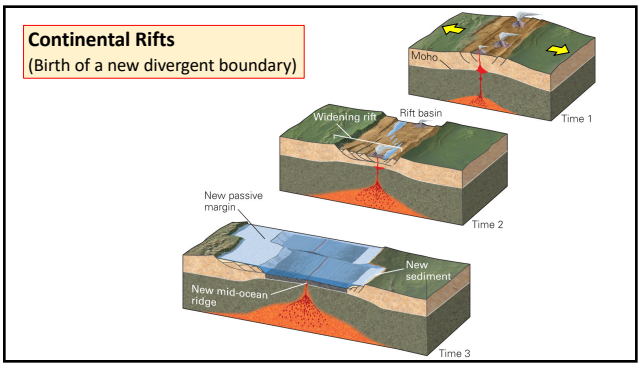

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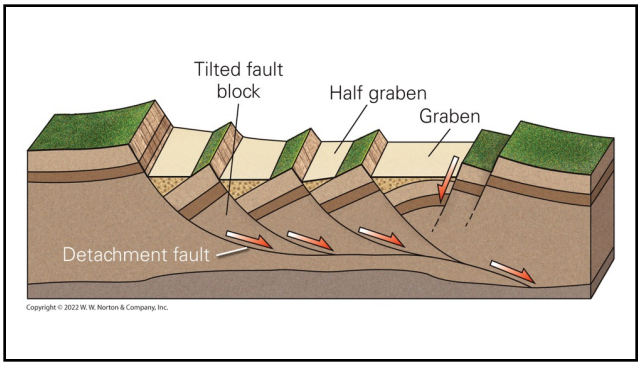

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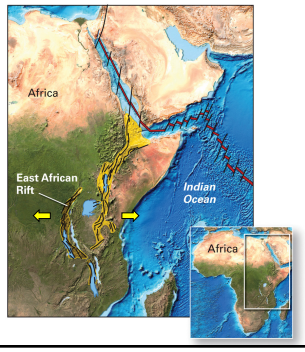
The East African Rift



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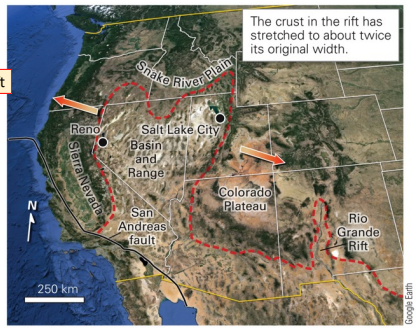
The Basin and Range Rift



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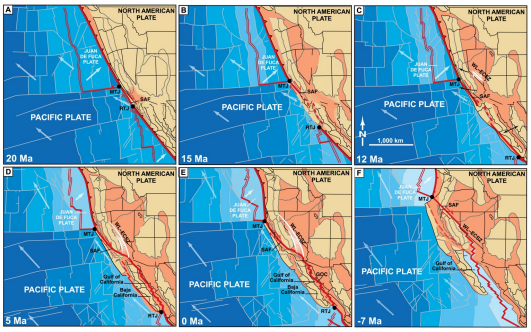

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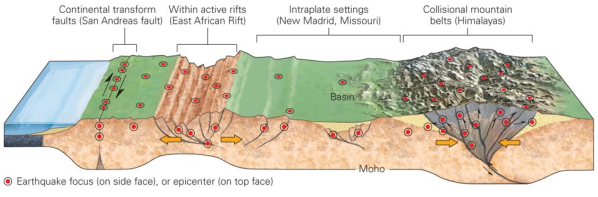
Intraplate earthquakes:
These are generally due to reactivation of old faults.



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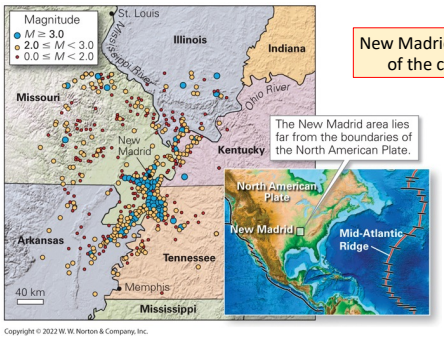
New Madrid seismic zone of the central USA



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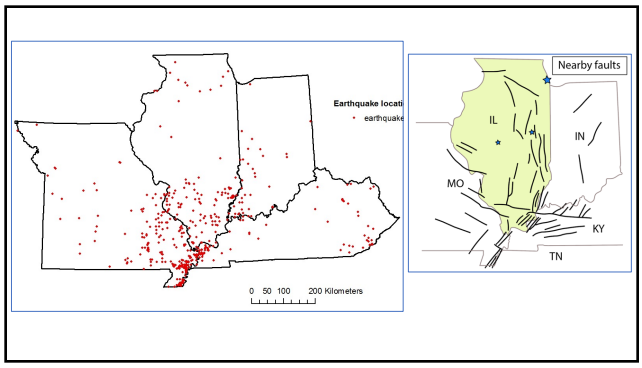

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In sum . . . . .

- About 90% of earthquakes happen along the three types of plate boundaries.
- In addition, earthquakes happen at rifts and in collisional mountain belts.
- A few earthquakes happen along old faults within otherwise fairly stable continents.

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