Deformation of Rocks: Big Ideas

- Earth scientists use the structure, sequence, and properties of rocks, to reconstruct events in Earth's history
- Understanding geologic processes active in the modern world is crucial to interpreting Earth's past
- Over Earth's vast history, both gradual and catastrophic processes have produced enormous changes
  - Super-continents formed and broke apart
  - mountains formed and eroded away

Deformation of Rocks

- Folds and faults are geologic structures caused by deformation.
- Structural geology is the study of the deformation of rocks and its effects.

Fig. 7.1

Orientation of Deformed Rocks

We need some way to describe the distribution of geologic structures. So we use the terms strike and dip.

Strike: compass direction of a rock layer as it intersects with a horizontal surface.

Dip: acute angle between the rock layer and the horizontal surface, measured perpendicular to strike.

Strike and Dip on a Rooftop

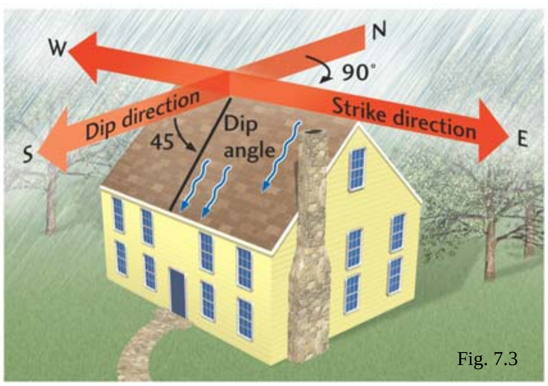


Fig. 7.3

Strike and Dip in a Rock Structure

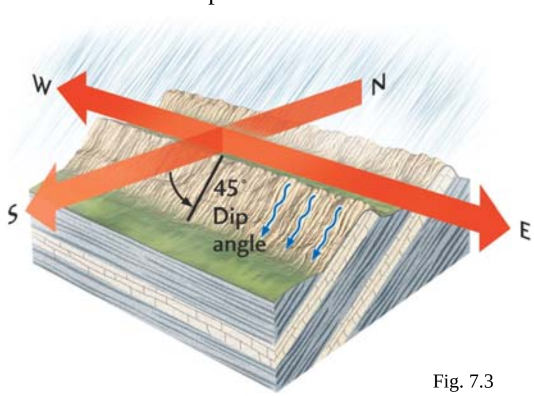


Fig. 7.3

Strike and Dip in a Rock Structure

Fig. 7.2

Stress:
force per unit area

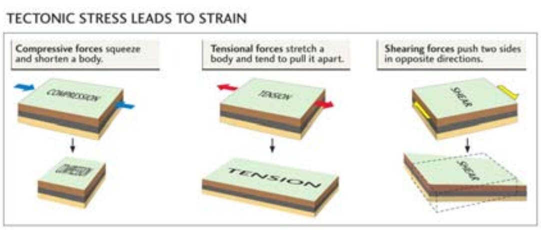


Fig. 7.7

Strength

- **ability of an object to resist deformation**
- **compressive or tensile**

Fig. 7.5

Strain

Any change in original shape or size of an object in response to stress acting on the object

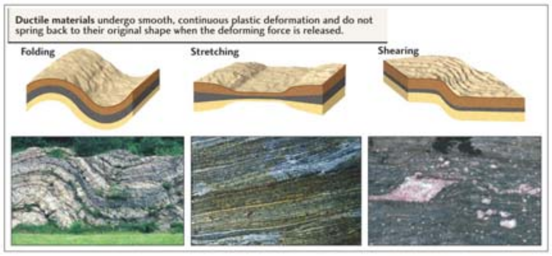
Fig. 7.1

Elastic Deformation

***Temporary* change in shape or size that is recovered when the deforming force is removed**

Ductile (Plastic) Deformation

- **Permanent change in shape or size that is not recovered when the stress is removed**
- **Occurs by the slippage of atoms or small groups of atoms past each other in the deforming material**



Brittle Deformation (Rupture)

- **Loss of cohesion of a body under the influence of deforming stress**
- **Usually occurs along sub-planar surfaces that separate zones of coherent material**

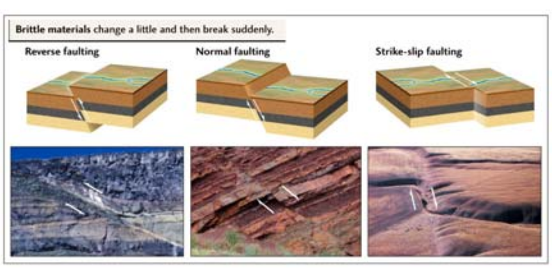


Fig. 7.6

Factors that Affect Deformation

- temperature
- pressure
- strain rate
- rock type

The variation of these factors determines whether a rock will fault or fold.

Joints

Cracks in rocks along which there has been no appreciable displacement.

Fig. 7.13

Faults

Fractures in rocks created by earthquakes.

- **Dip-slip faults**
  - **normal**
  - **reverse**
- **Strike-slip faults**
- **Oblique-slip faults**

Dip-slip Faults: Motion of the fault blocks is parallel to the dip direction.

Fig. 7.1

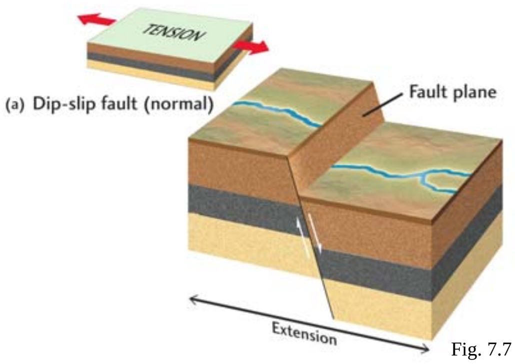
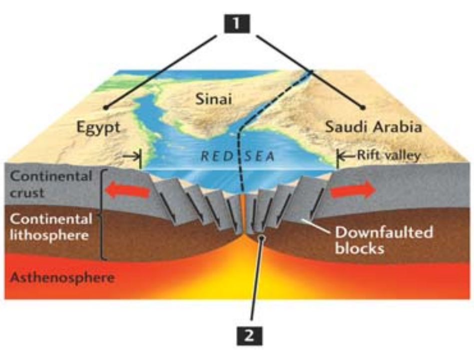


Fig. 7.7

Rift Valley



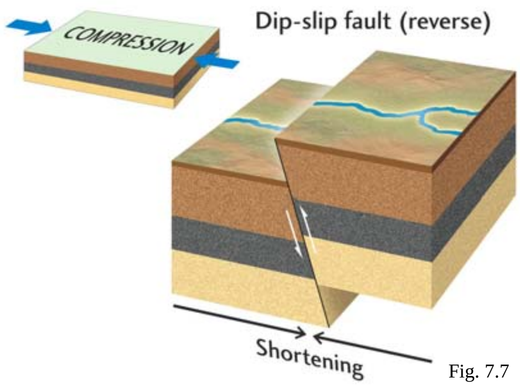
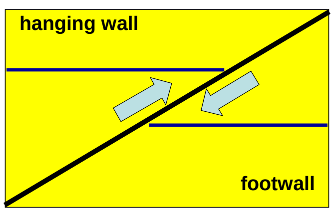


Fig. 7.7

Thrust Fault

Thrust faults are low-angle reverse faults.



cross section

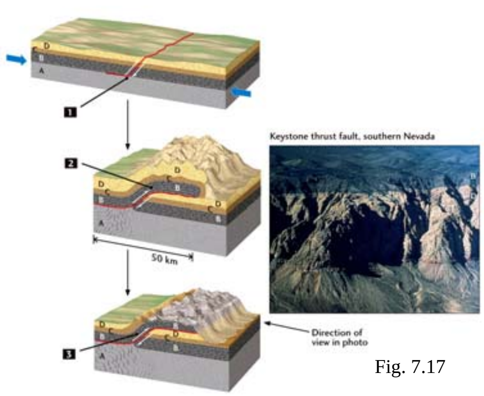


Fig. 7.17

Strike-slip Faults: Motion of the fault blocks is parallel to the strike direction

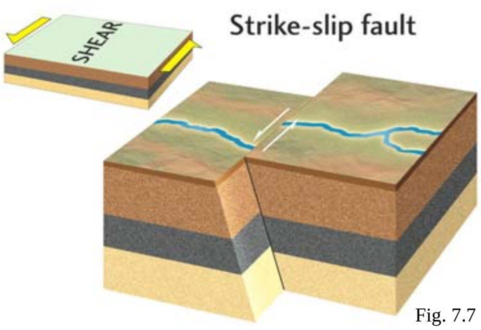
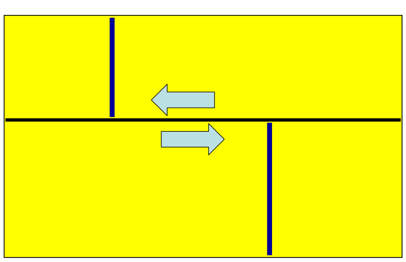


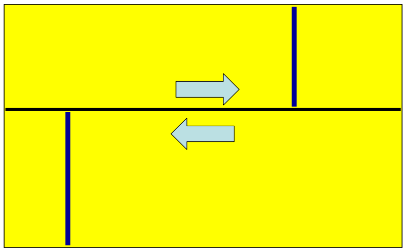
Fig. 7.7

Left-lateral Strike Slip Fault



aerial (map) view

Right-lateral Strike Slip Fault



aerial (map) view

San Andreas Fault

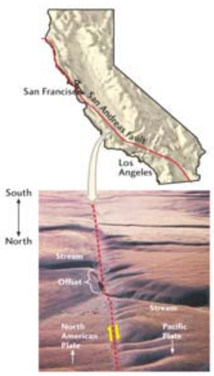


Fig. 7.6

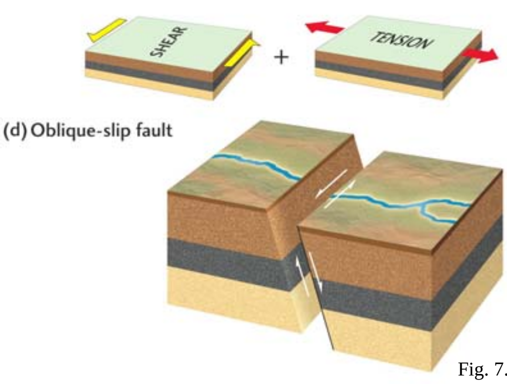


Fig. 7.7

Folding of Rocks

- Produced by horizontal or vertical forces
- Scale can be from cm to 100's of km

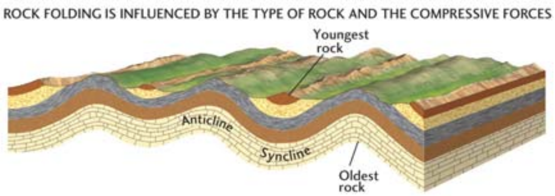
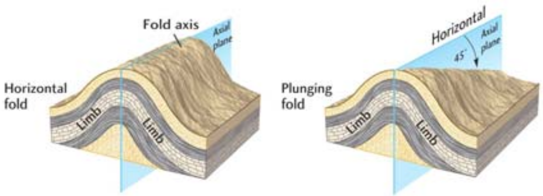


Fig. 7.10

Fold Terminology

axial plane: the plane of mirror symmetry dividing the fold into two limbs

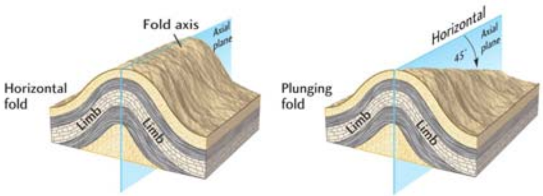
axis: the line formed by the intersection of the axial plane and a bedding plane



Fold Terminology

horizontal fold: fold where the axis is horizontal

plunging fold: fold where the axis is not horizontal



More Fold Terminology

syncline: a sequence of folded rocks with the youngest rocks on the inside of the fold

anticline: a sequence of folded rocks with the oldest rocks on the inside of the fold

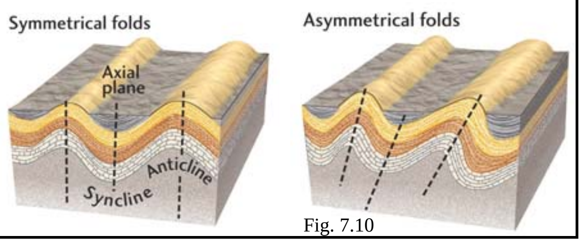


Fig. 7.10

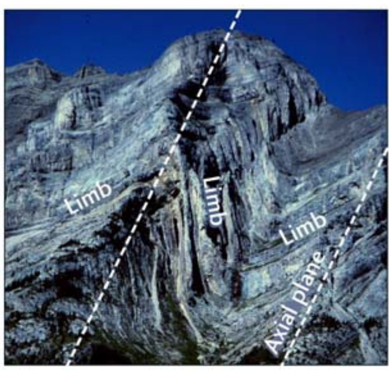


Fig. 7.10

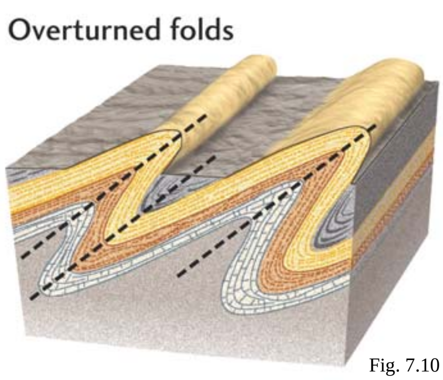


Fig. 7.10

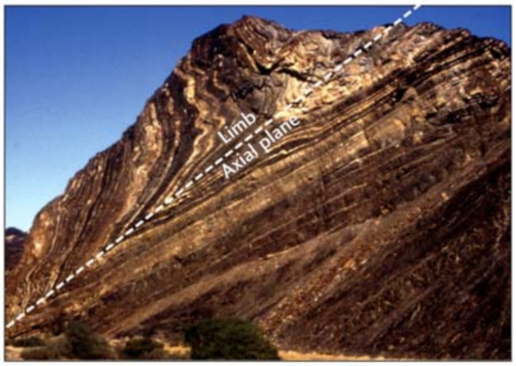


Fig. 7.10

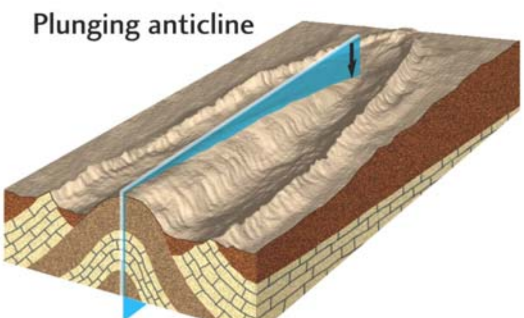


Fig. 7.11

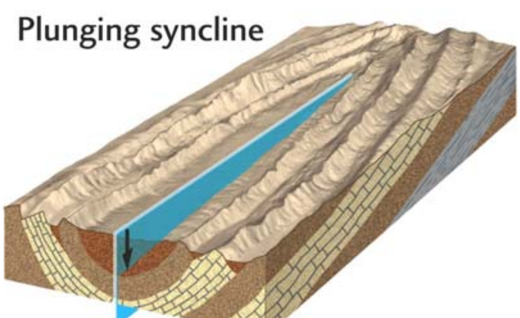
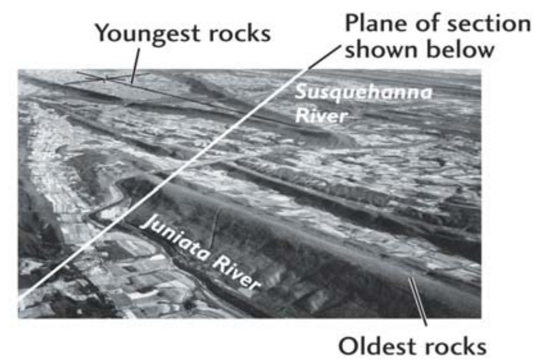


Fig. 7.11



And More Fold Terminology

dome: a sequence of folded rocks in which all the beds dip away from a central point

basin: a sequence of folded rocks in which all the beds dip towards a central point

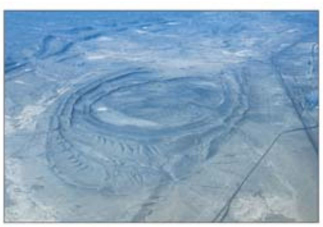


Fig. 7.12

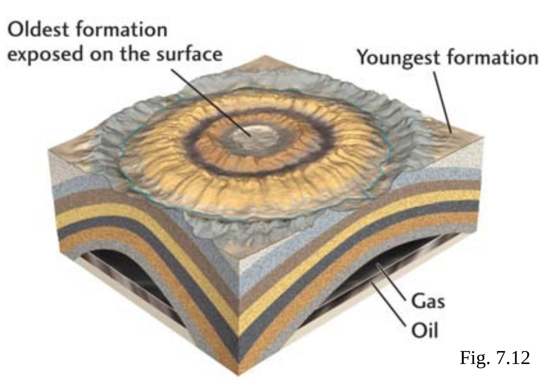


Fig. 7.12

Mountain Belts

- narrow zones of folded, compressed rocks with associated magmatism
- formed at convergent plate boundaries
- two major active belts: Cordilleran (Rockies-Andes) and Alps-Himalaya
- older examples include Appalachians and Urals

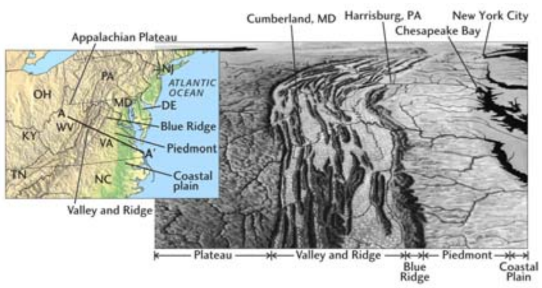


Fig. 10.4

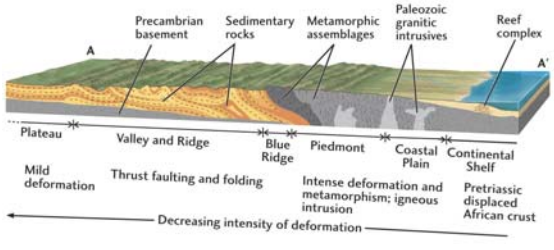


Fig. 10.4

North American Cordillera

Complex geologic history from multiple episodes of deformation and magmatism over the past 500 million years.

Tectonic Provinces of the West

Fig. 10.5

Tectonic History of San Andres Fault

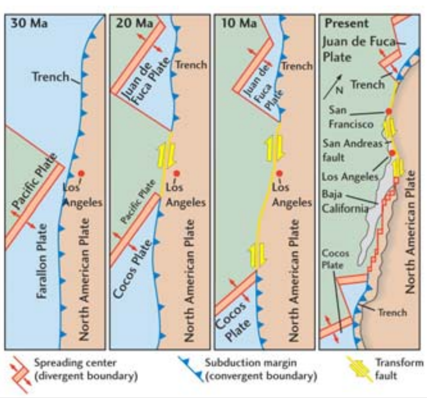


Fig. 10.6

Major Uplift Along Normal Faults

Fig. 10.7

Tectonic Ages

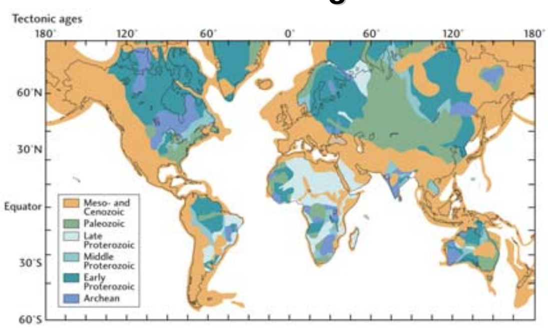


Fig. 10.8b

How Continents Grow

- **Magmatic differentiation**: magma transferred to continents at subduction zones
- **Continental accretion**: buoyant fragments of continents attached to continents as the result of plate motions

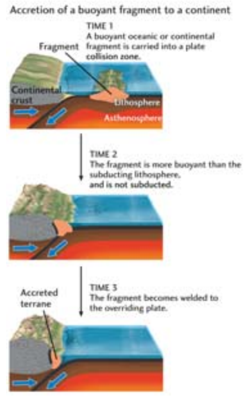


Fig. 10.12a

How Continents Grow:
Accretion of Fragments

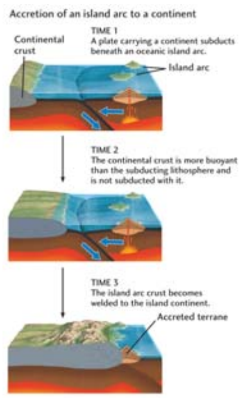


Fig. 10.12b

How Continents Grow:
Accretion of Island Arcs

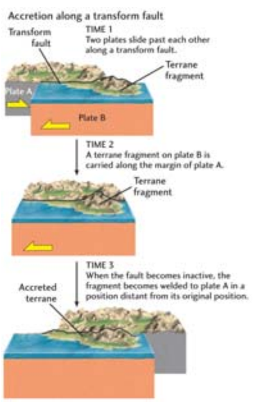


Fig. 10.12c

How Continents Grow:
Accretion Along Transform Fault

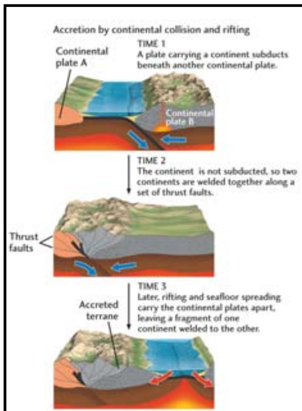


Fig. 10.12d

How Continents Grow:
Accretion by Continental Collision/Rifting

Fig. 10.11

"Suspect Terranes" of Western North America

Multiple accretions of older island arcs, oceanic plateaus, oceanic crust, and marine sedimentary rocks.

Orogeny

- mountain building
- particularly by folding and thrusting of rock layers
- often accompanied by magmatic activity

The Himalayan Orogeny: The Indian Plate subducts under the Eurasian Plate.

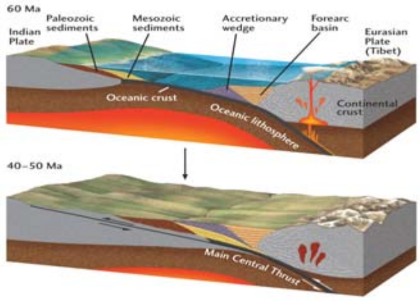


Fig. 10.15

The Himalayan Orogeny: India subcontinent collides with Tibet and breaks along the Main Central Thrust fault.

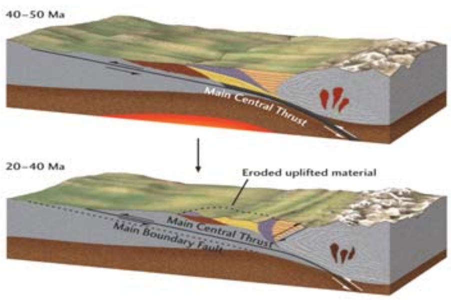


Fig. 10.15

The Himalayan Orogeny:
A second thrust fault forms, lifting the first fault.

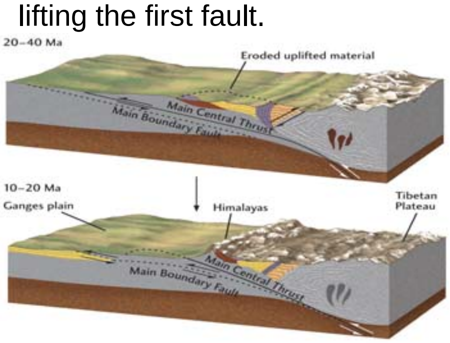


Fig. 10.15

Tectonic Features: Collision of India and Eurasia

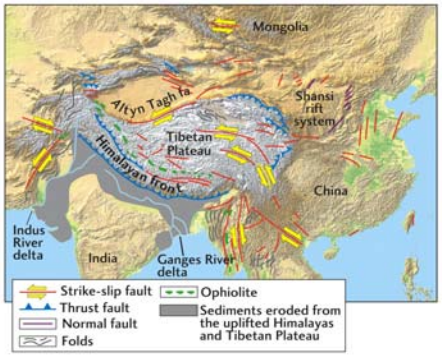


Fig. 10.16

The Wilson Cycle

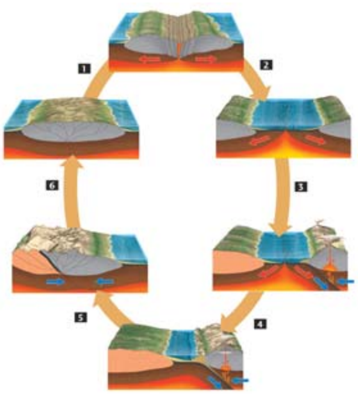


Fig. 10.18