Chapter 13 Unsafe Ground: Landslides and Other Mass Movements

What is the controlling force for mass wasting?

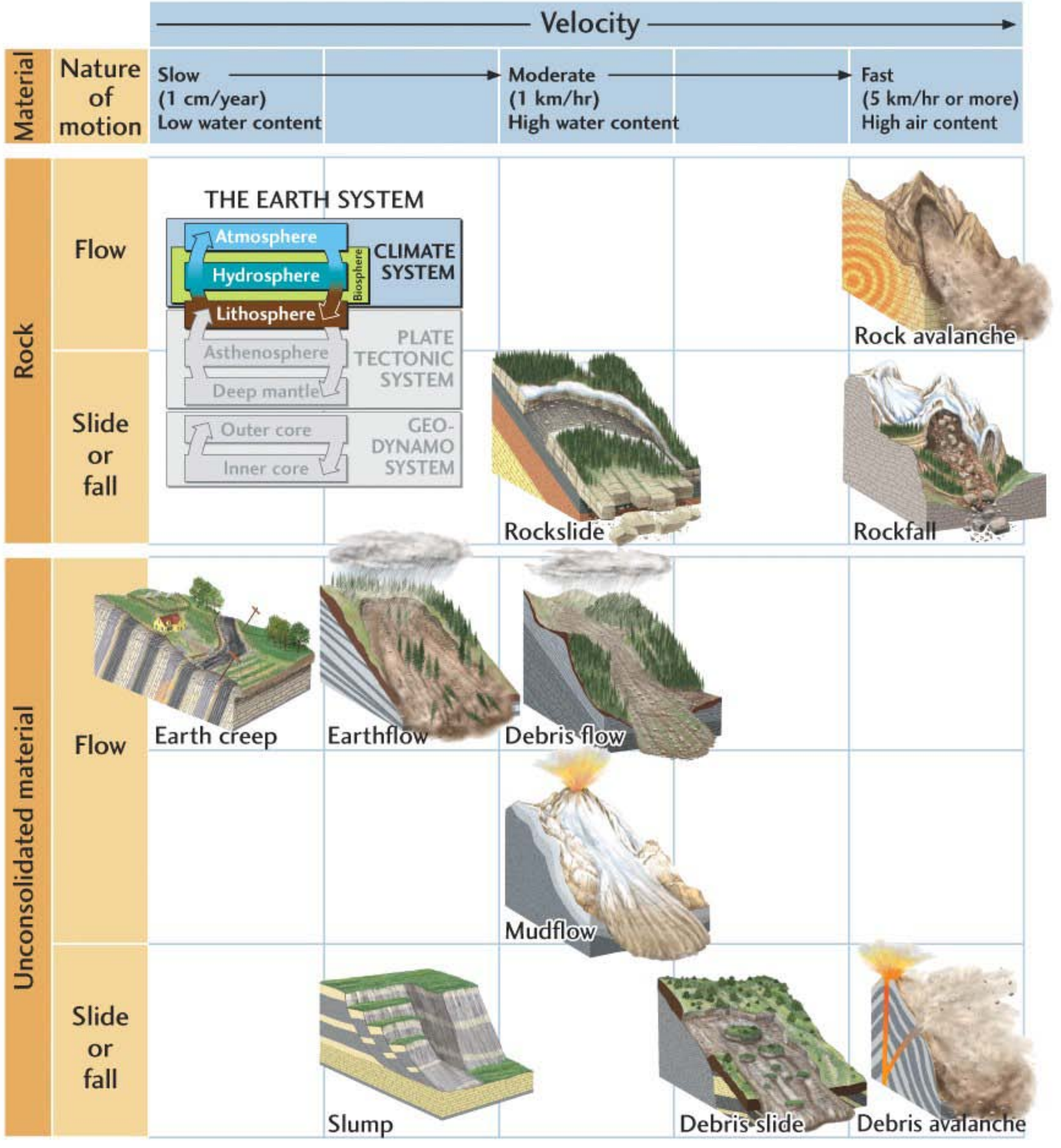
What factors influence mass wasting?

Classification of Mass Wasting

Mass wasting events are classified by:

- Nature of material (consolidated or unconsolidated)
- Speed (few cm/yr to km/hour).
- Nature of movement (as one unit or as a fluid)

MASS MOVEMENTS ARE CLASSIFIED ACCORDING TO THE DOMINANT MATERIAL, WATER OR AIR CONTENT, AND VELOCITY OF THE MOVEMENT



Mass Wasting classification

Rock Fall

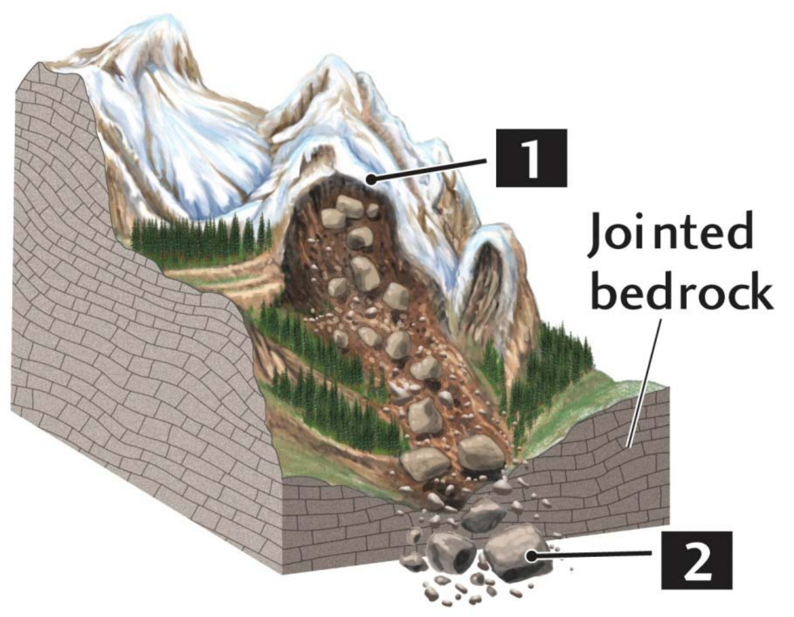
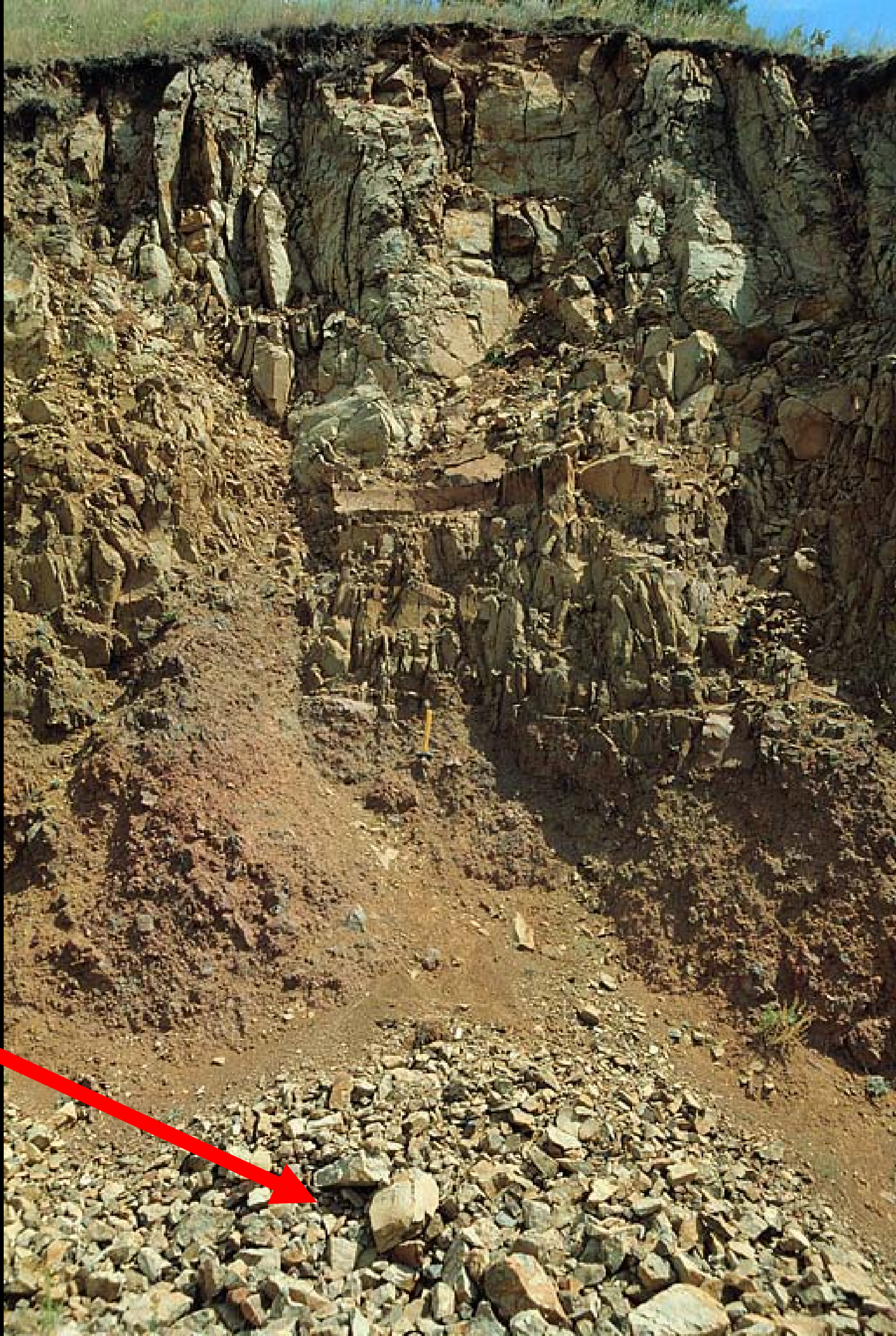
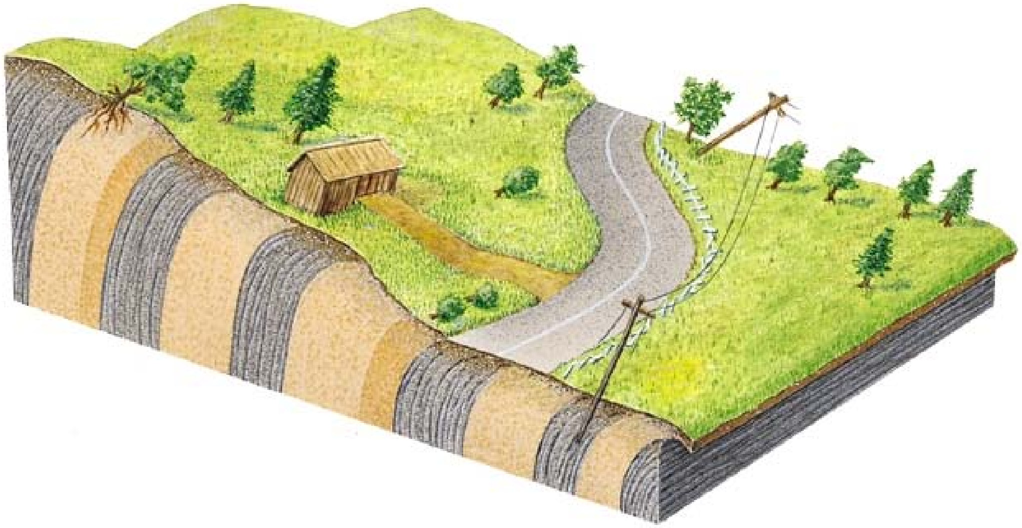


Fig 12.7

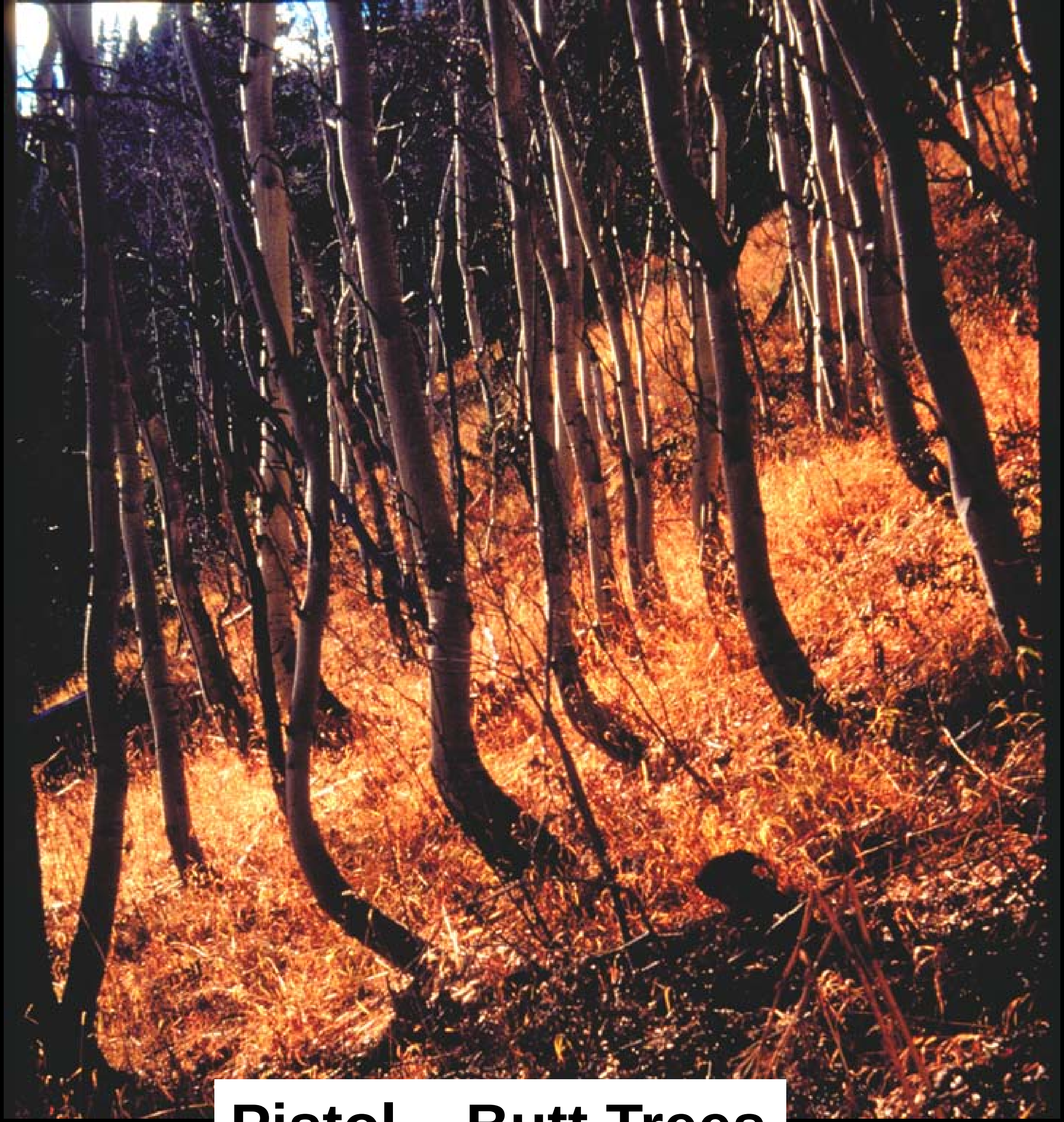
Talus





Soil Creep

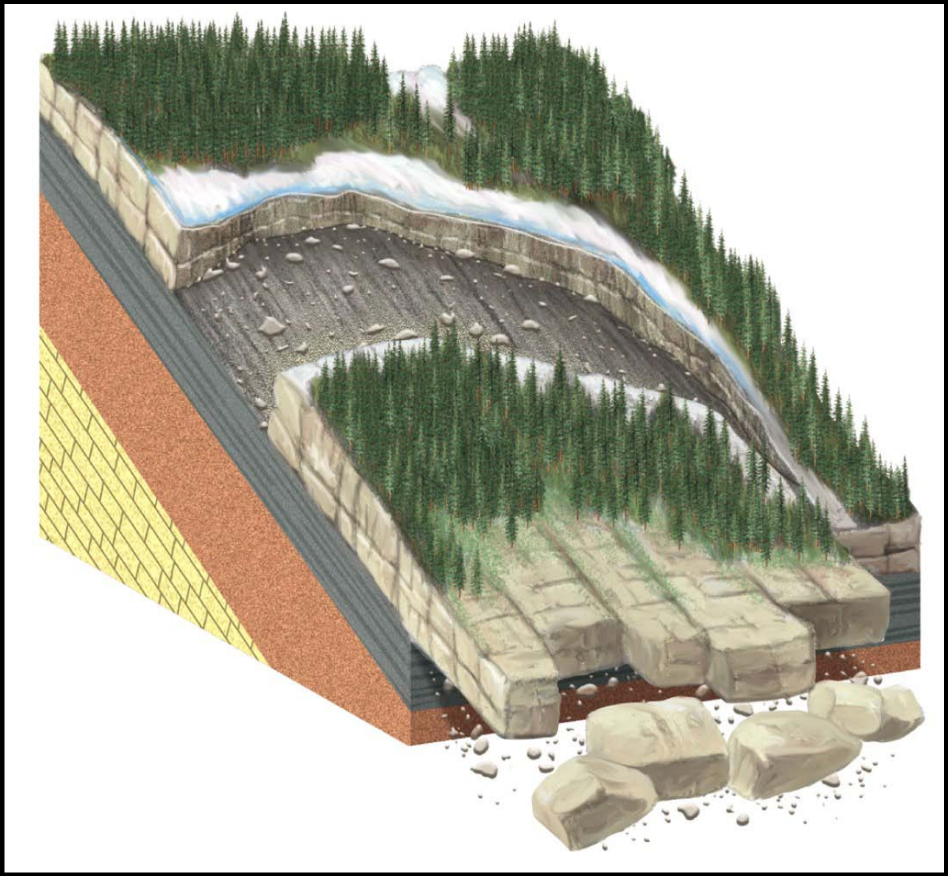
Fig 12.10



Pistol – Butt Trees

Classification

Slide - Single mass of rock or sediment is released and moves rapidly along a plane of weakness.



Rock Slide

Gros Ventre, Wyoming

(1925)

("Grow-Vaunt")

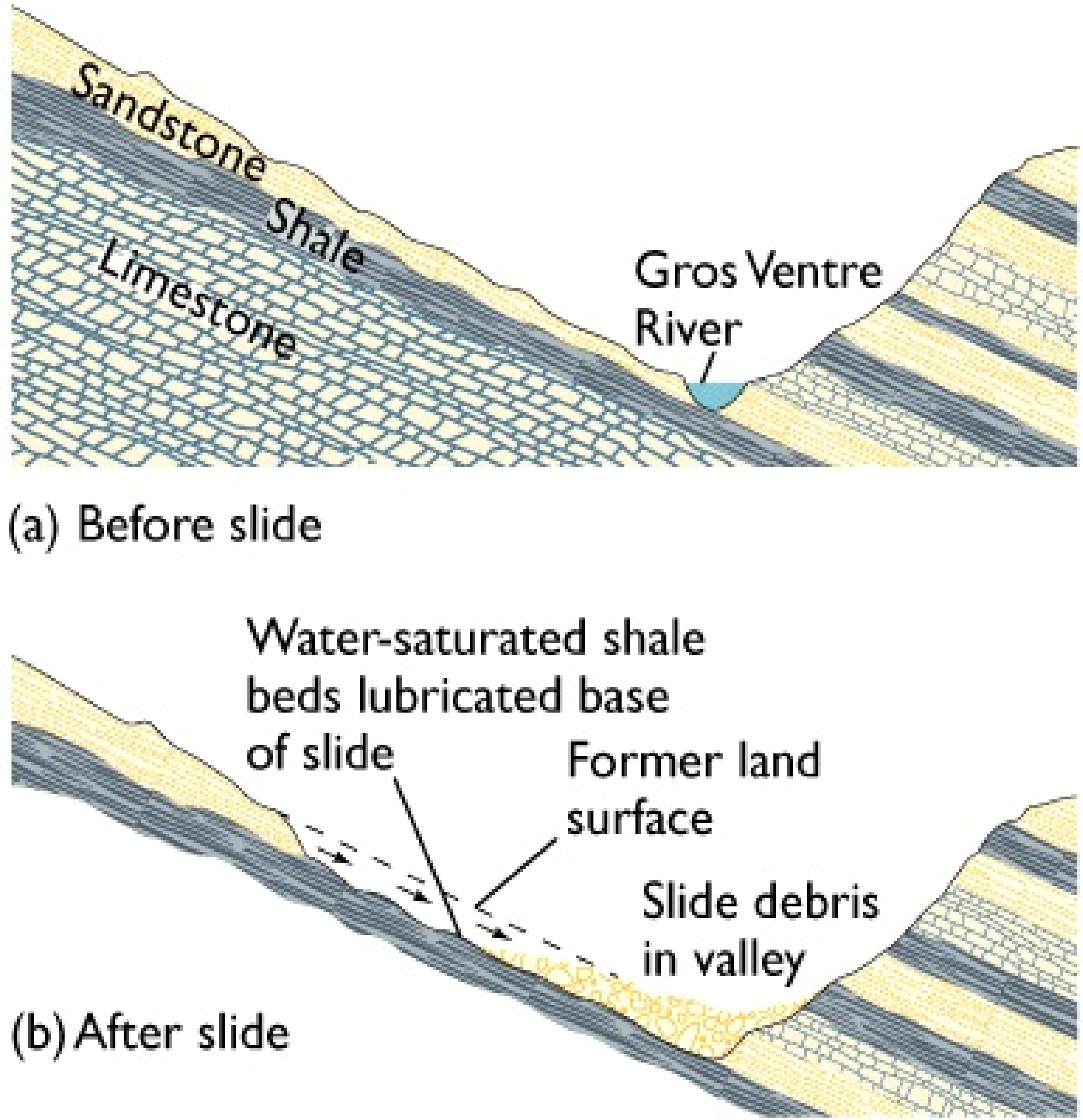
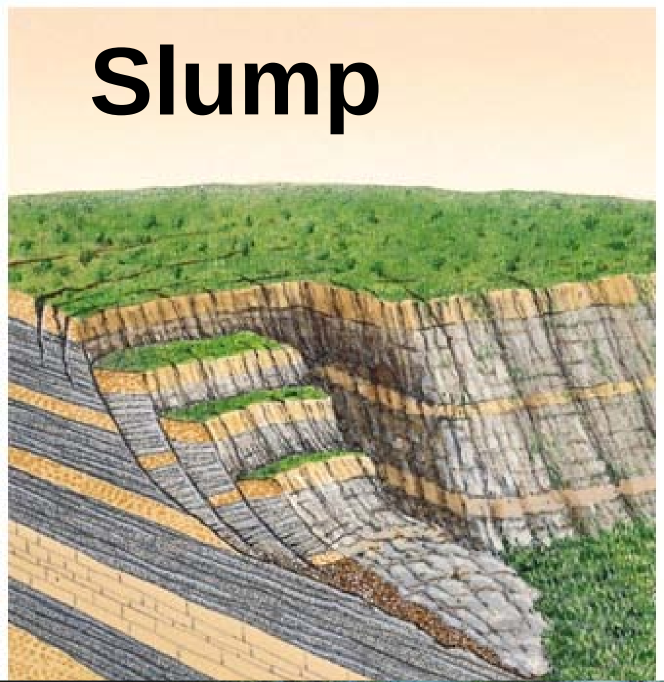
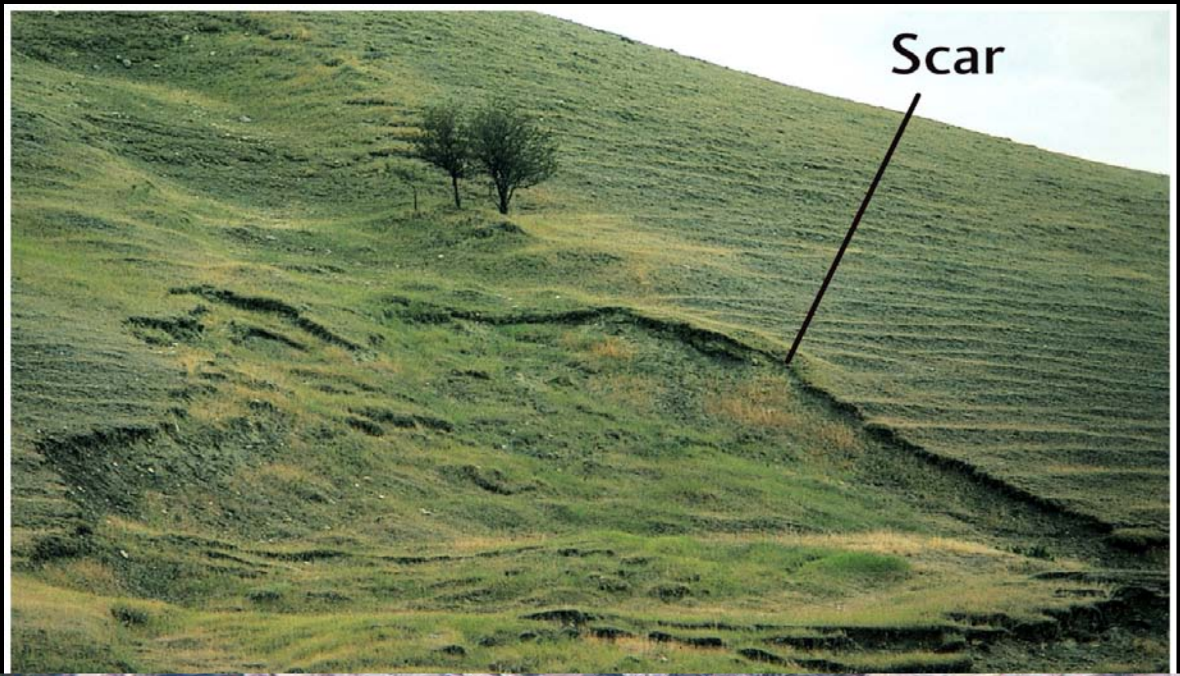


Fig 12.16

What type of mass wasting?





Slump near Naches, Washington
S. Kuehn

What should you look for as indicators of potential problems?

- evidence of prior mass wasting

  hummocky topography, irregular surface, scars on mountain side, accumulation of rock and unconsolidated material at base of slope
- open cracks on the surface
- look for planes of weakness (beds parallel valley wall)
- unnatural steep slopes

- Structural damage – Settling and cracking of building foundations
- Toppling, bowed, or pistol-butt trees
- Gullying and surface erosion
- Springs -- Mid-slope ground-water seepage from the bluff face;

Triggers

1. Heavy rain –

- undercutting slopes by running water
- increased weigh of wet soil
- increased fluid pressure reduces frictional resistance

2. Earthquakes

- ground shaking can trigger landslides

Triggers

3. Volcanoes

- ground shaking can trigger landslides

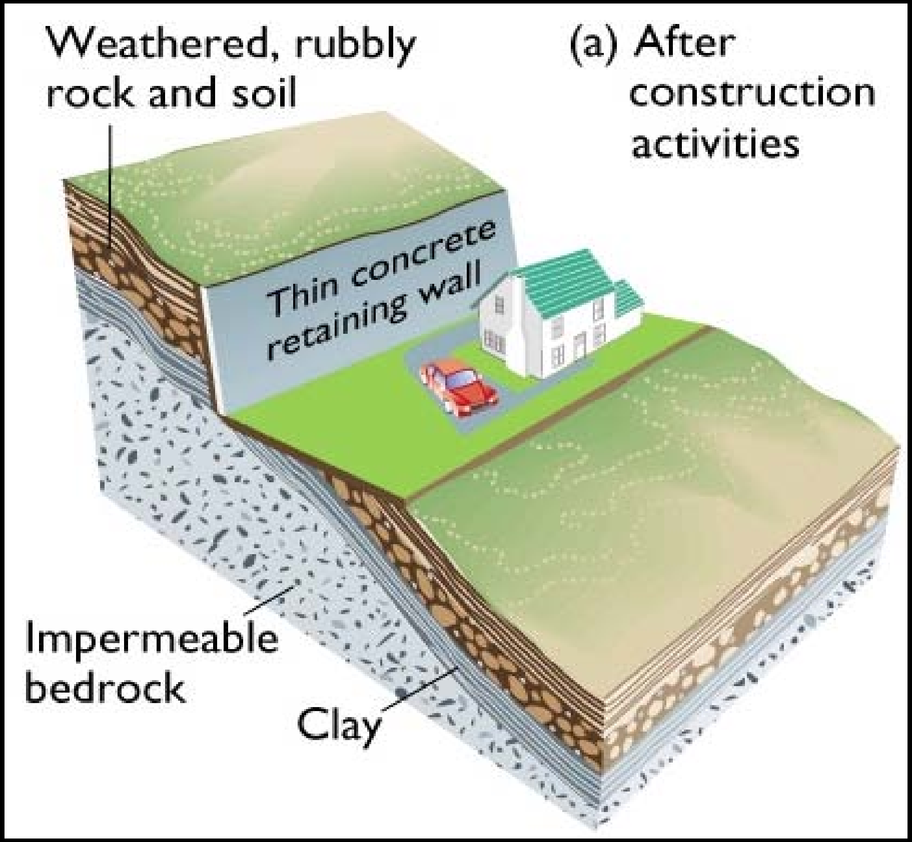
Triggers

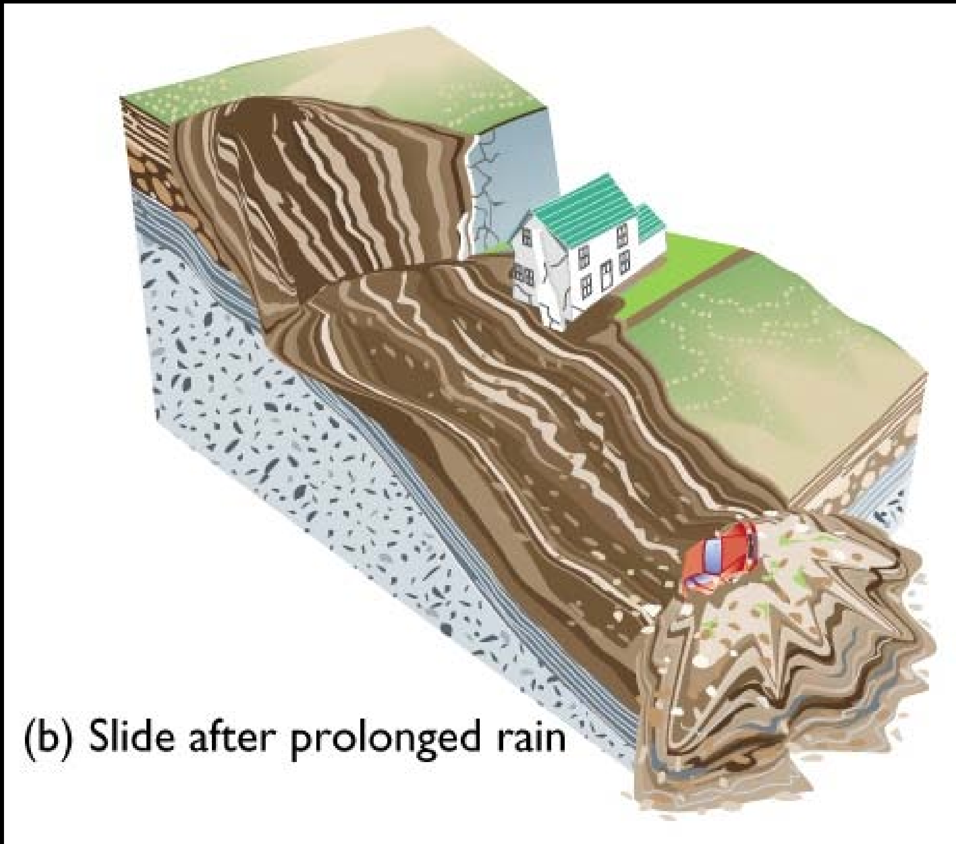
4. Human activity

Impact of Human Activities

- Added mass of building on slopes
- Removal of vegetation
- Increasing angle of slopes
- Addition/removal of water

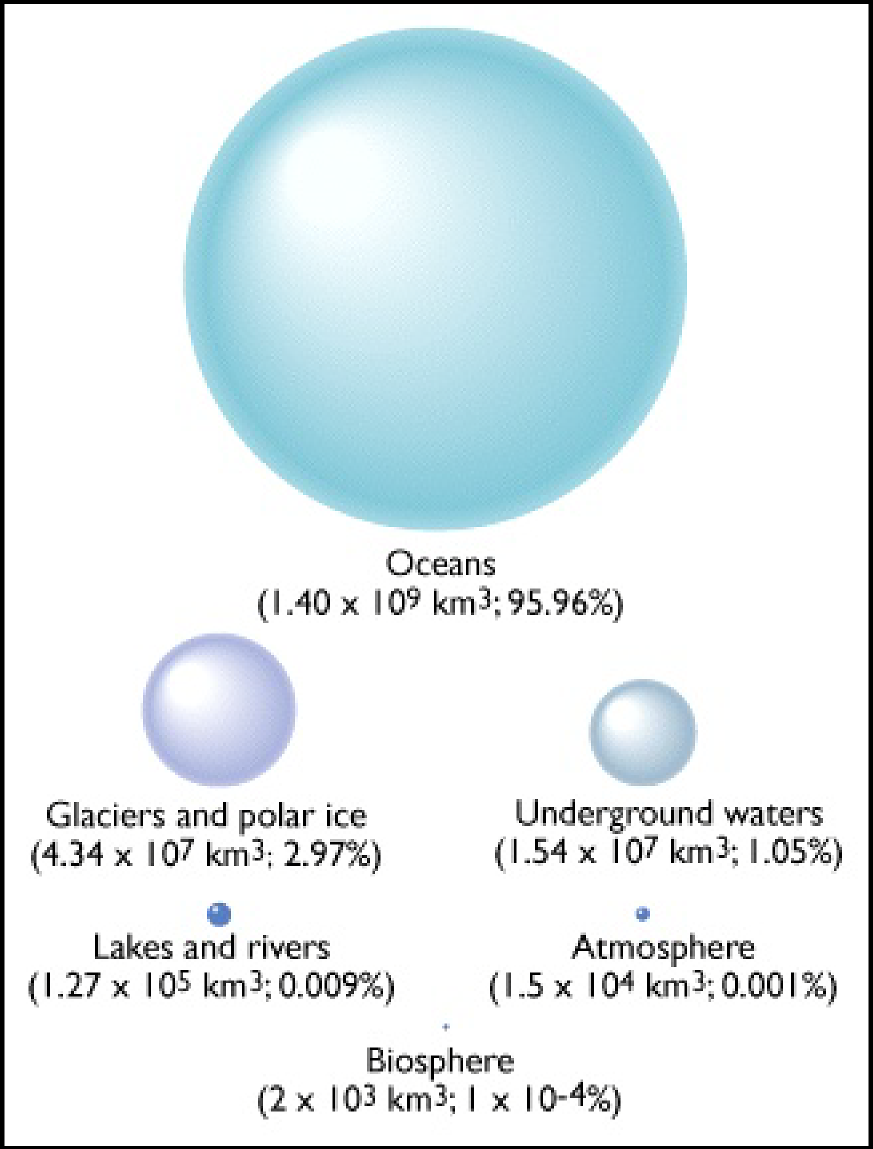
Triggers


Weathered, rubbly rock and soil
(a) After construction activities
Thin concrete retaining wall
Impermeable bedrock
Clay


(b) Slide after prolonged rain

Chapter 14 Running Water: The Geology of Streams and Floods

Water reservoirs



Stream Channel Patterns

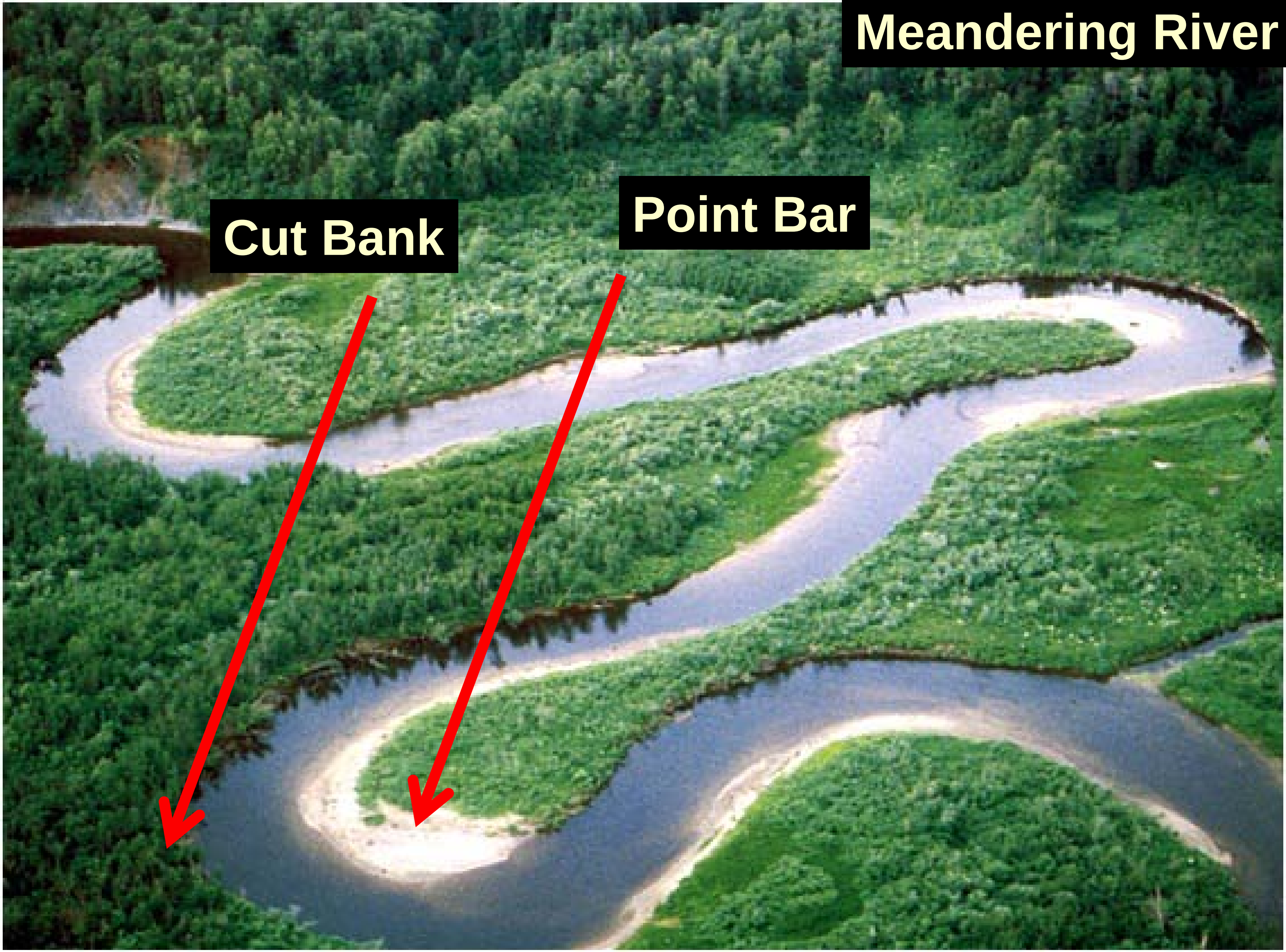
- Straight
- Braided
- Meandering

Braided River: High-sediment load, high velocity

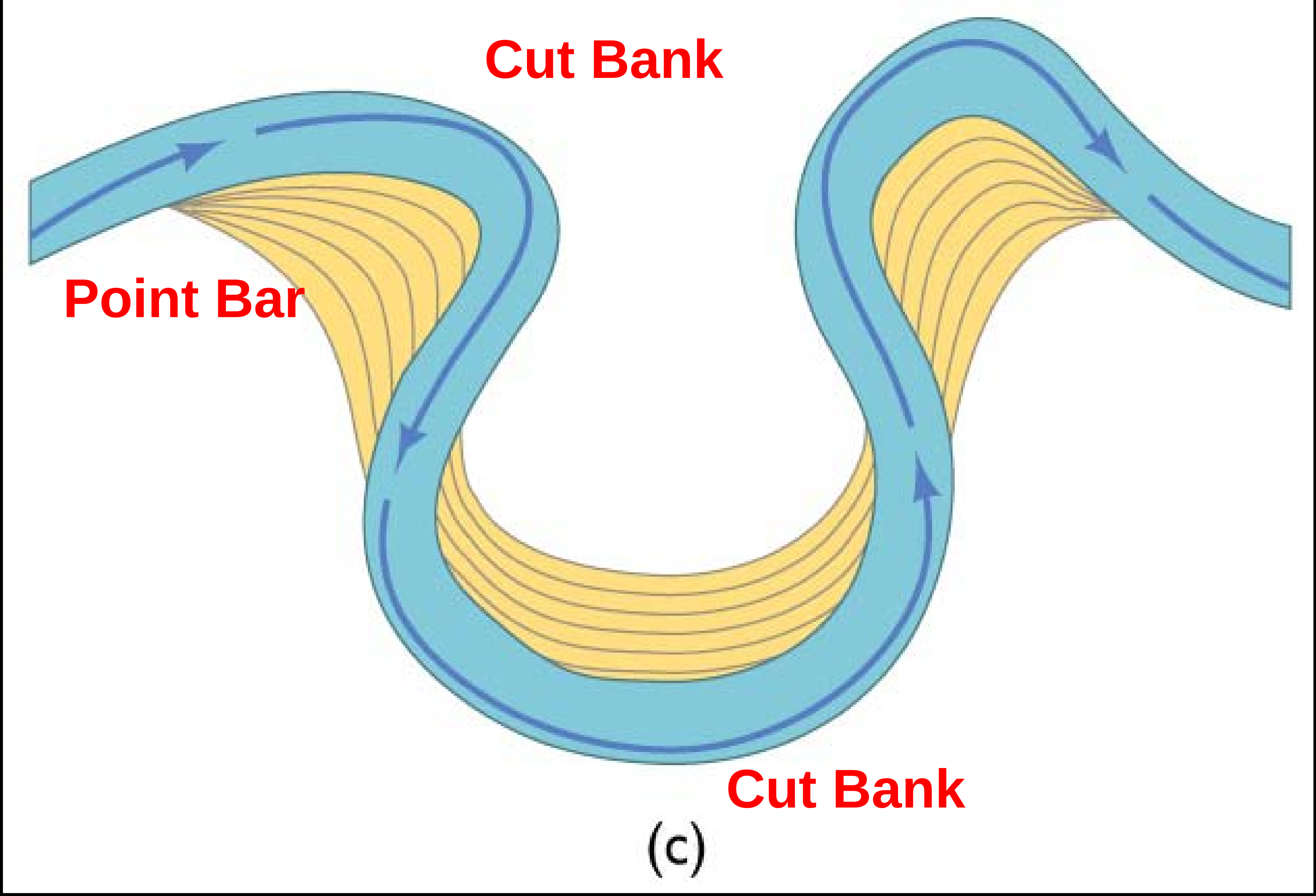
Meandering Channel

- Meander – to wander
- One main (trunk) channel that winds back and forth across the floodplain.
- Forms on low slopes through easily eroded bedrock.

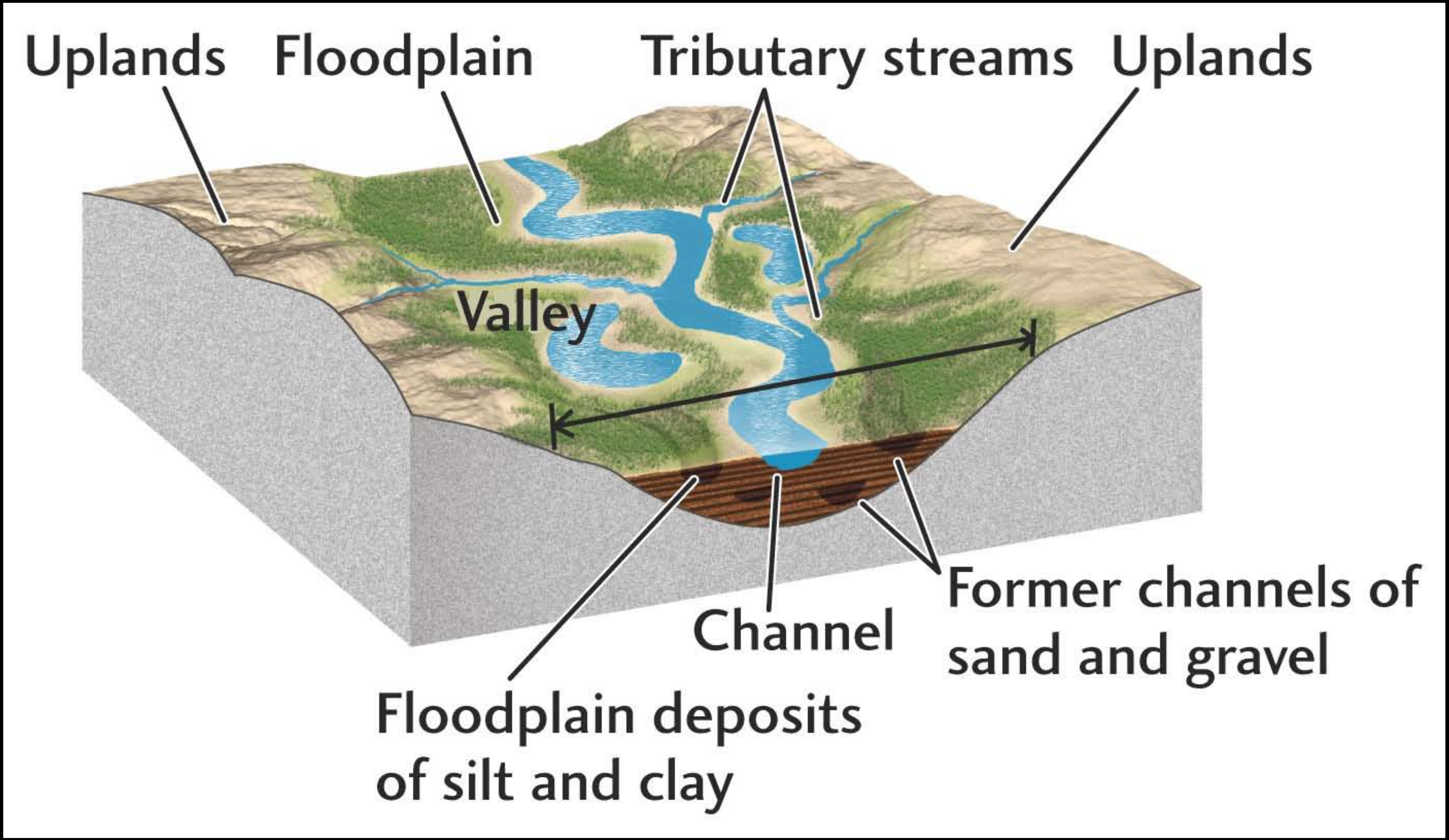
Meandering River



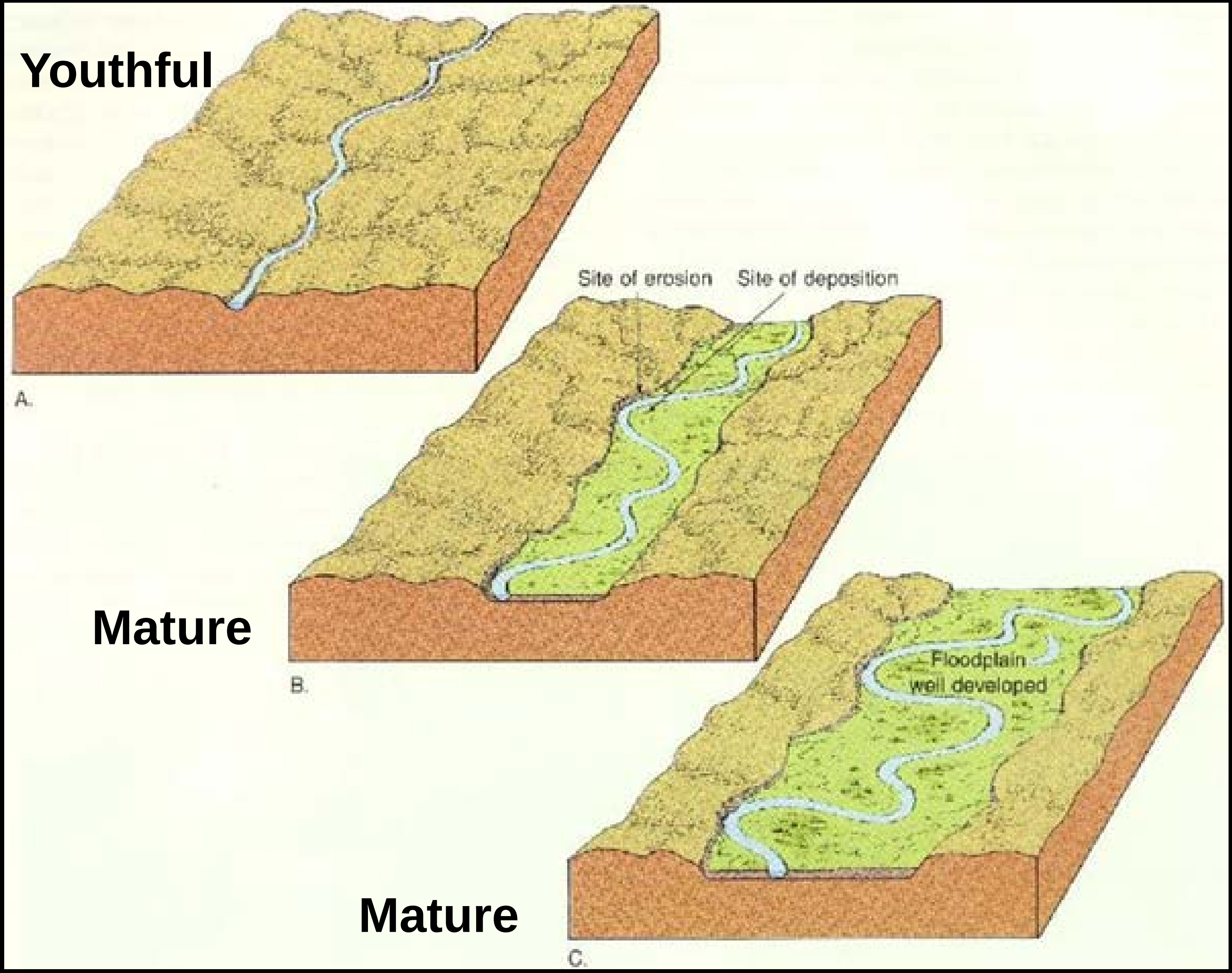
Meandering Stream (cont.)



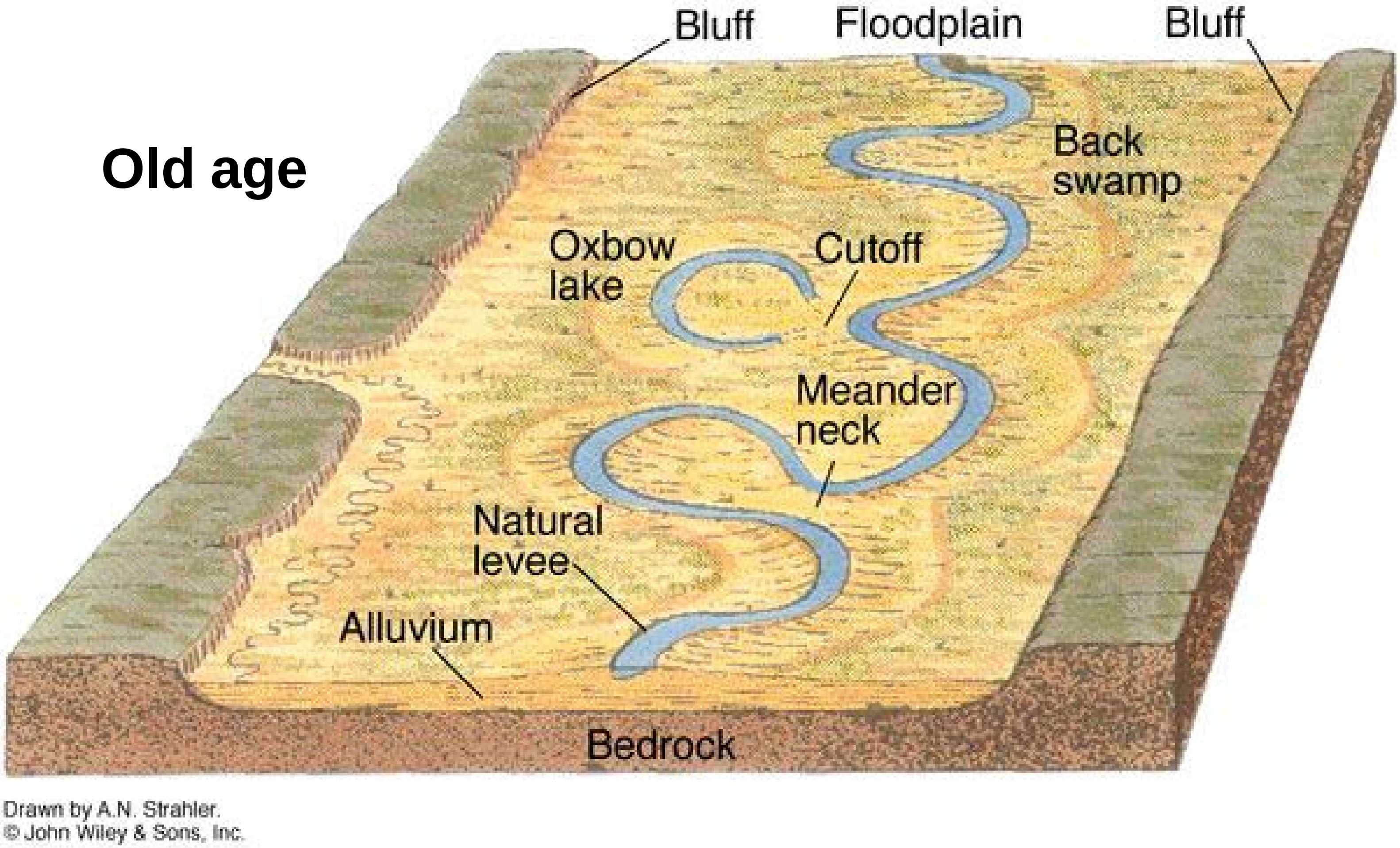
Morphology of a river system



Life stages of a river



Old age


Bluff
Floodplain
Bluff
Back
swamp
Oxbow
lake
Cutoff
Meander
neck
Natural
levee
Alluvium
Bedrock
Drawn by A.N. Strahler.
© John Wiley & Sons, Inc.

What is the life stage of this river?

Drainage Patterns

Drainage controlled by underlying structures.

Dendritic = Flat Lying Layers

Trellis = Folded Rock Layers

Rectangular = Joints or Faults

Radial = High Mtn. Peak (Volcanoes)

Dendritic drainage

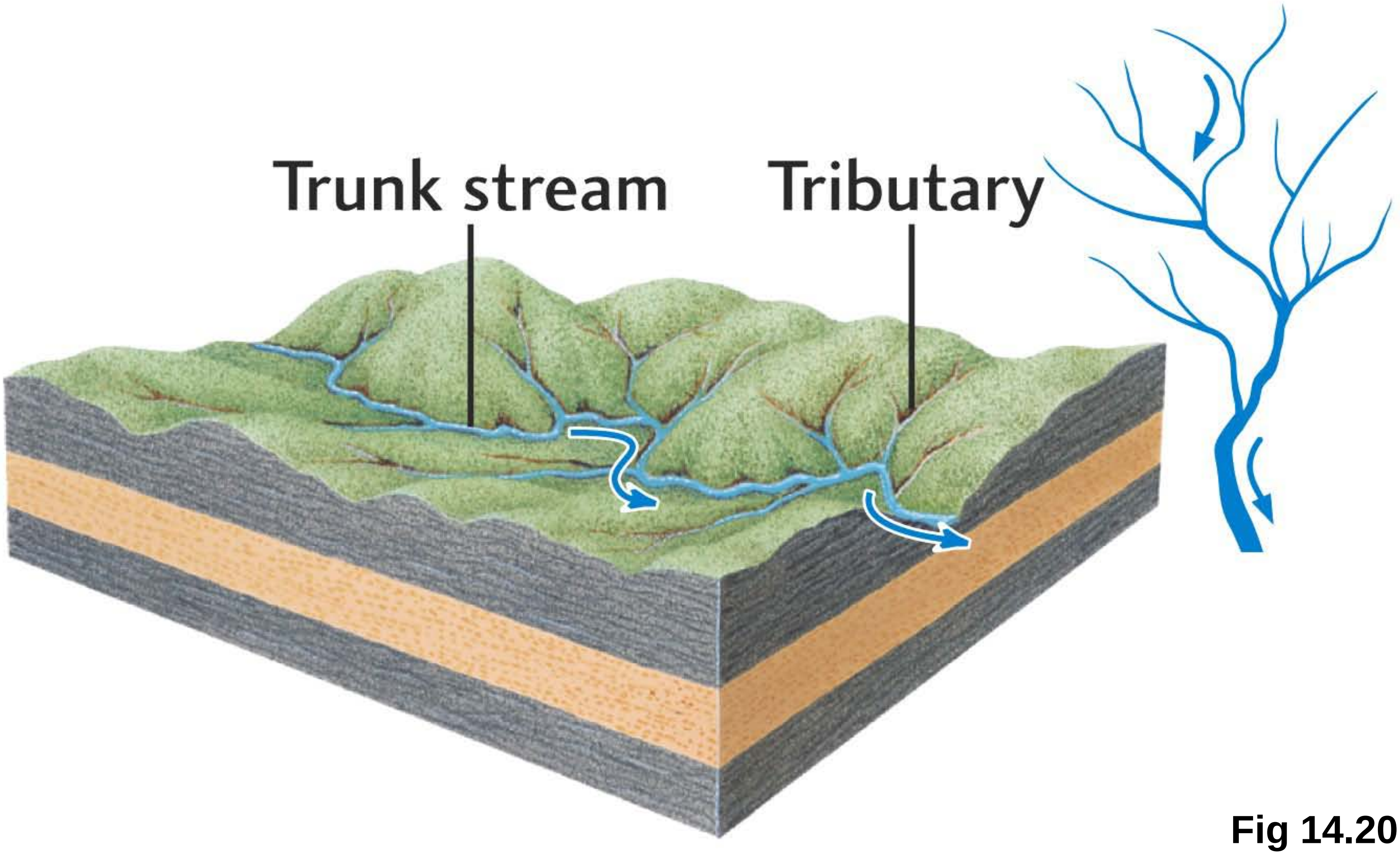


Fig 14.20

Rectangular drainage

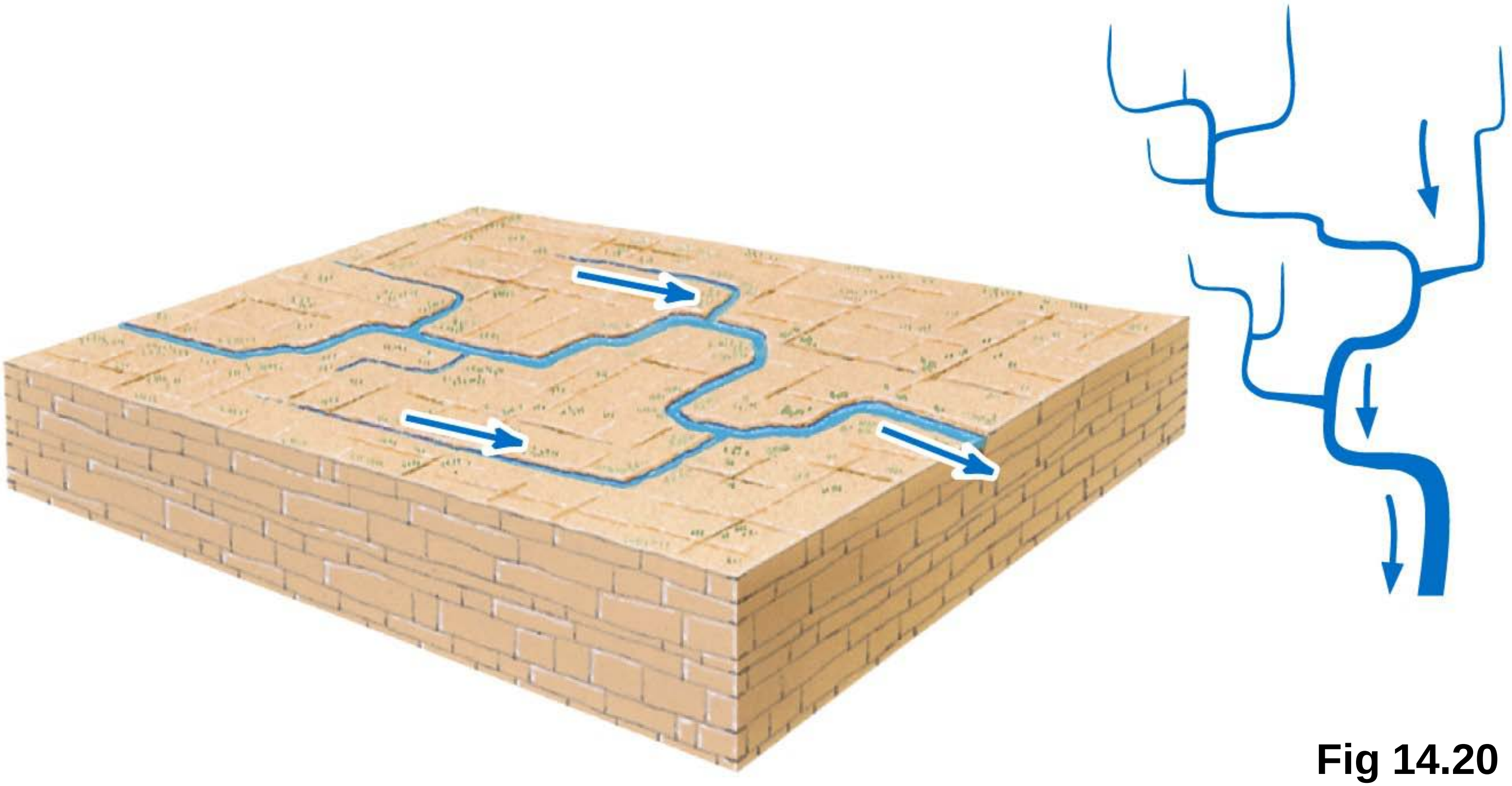


Fig 14.20

Note rectangular change in river path

Trellis drainage

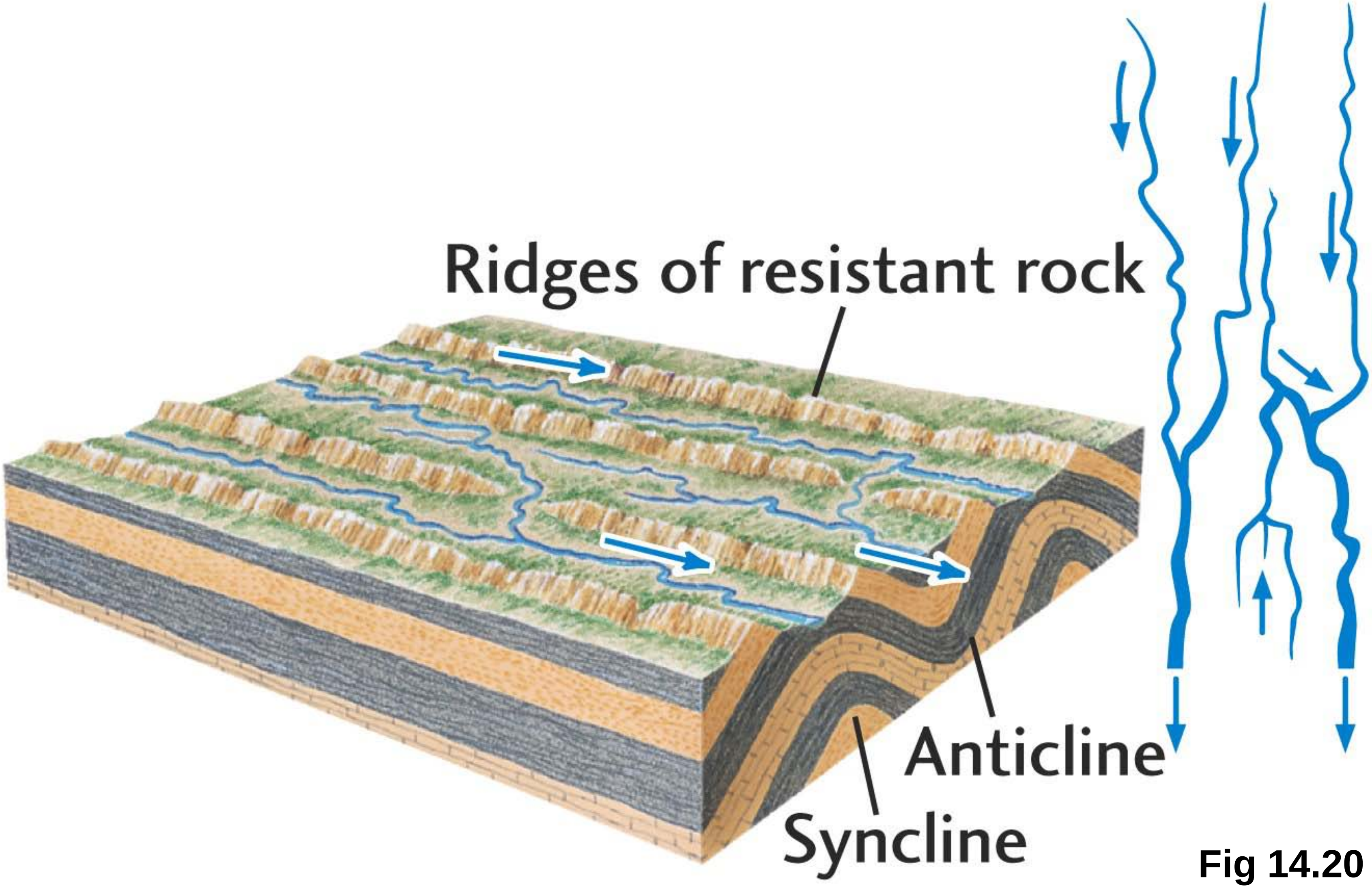


Fig 14.20

Trellis drainage

Radial drainage

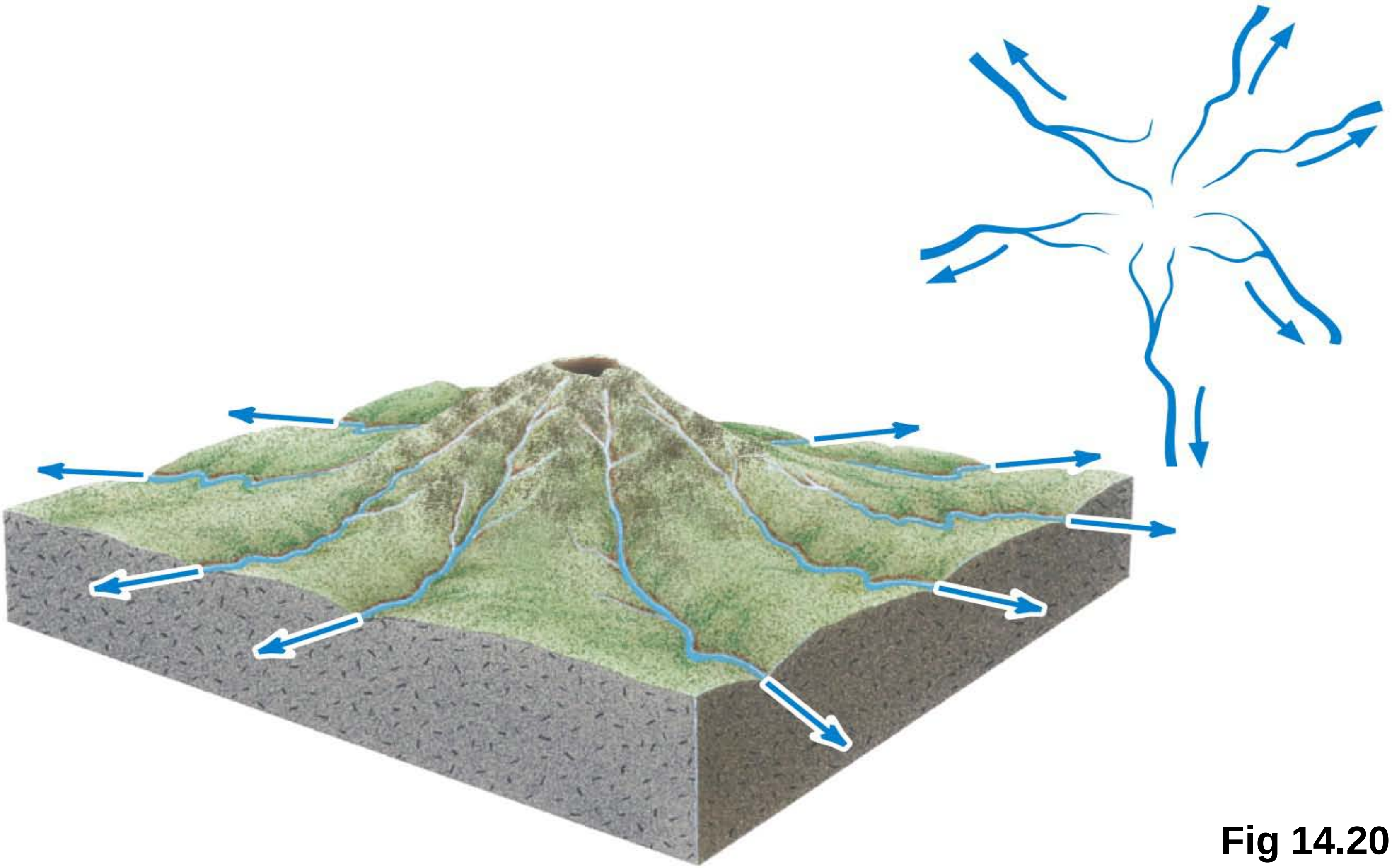
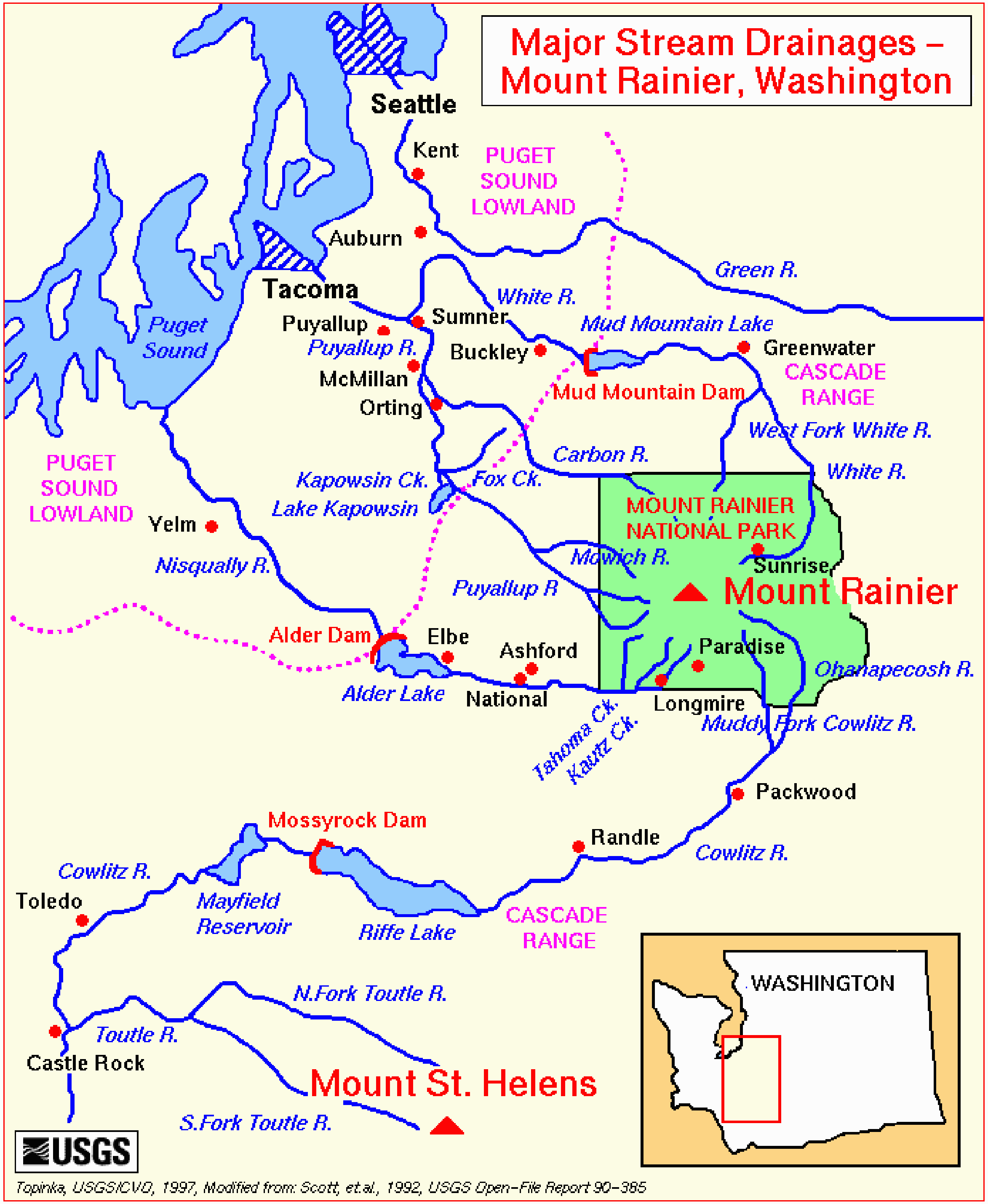
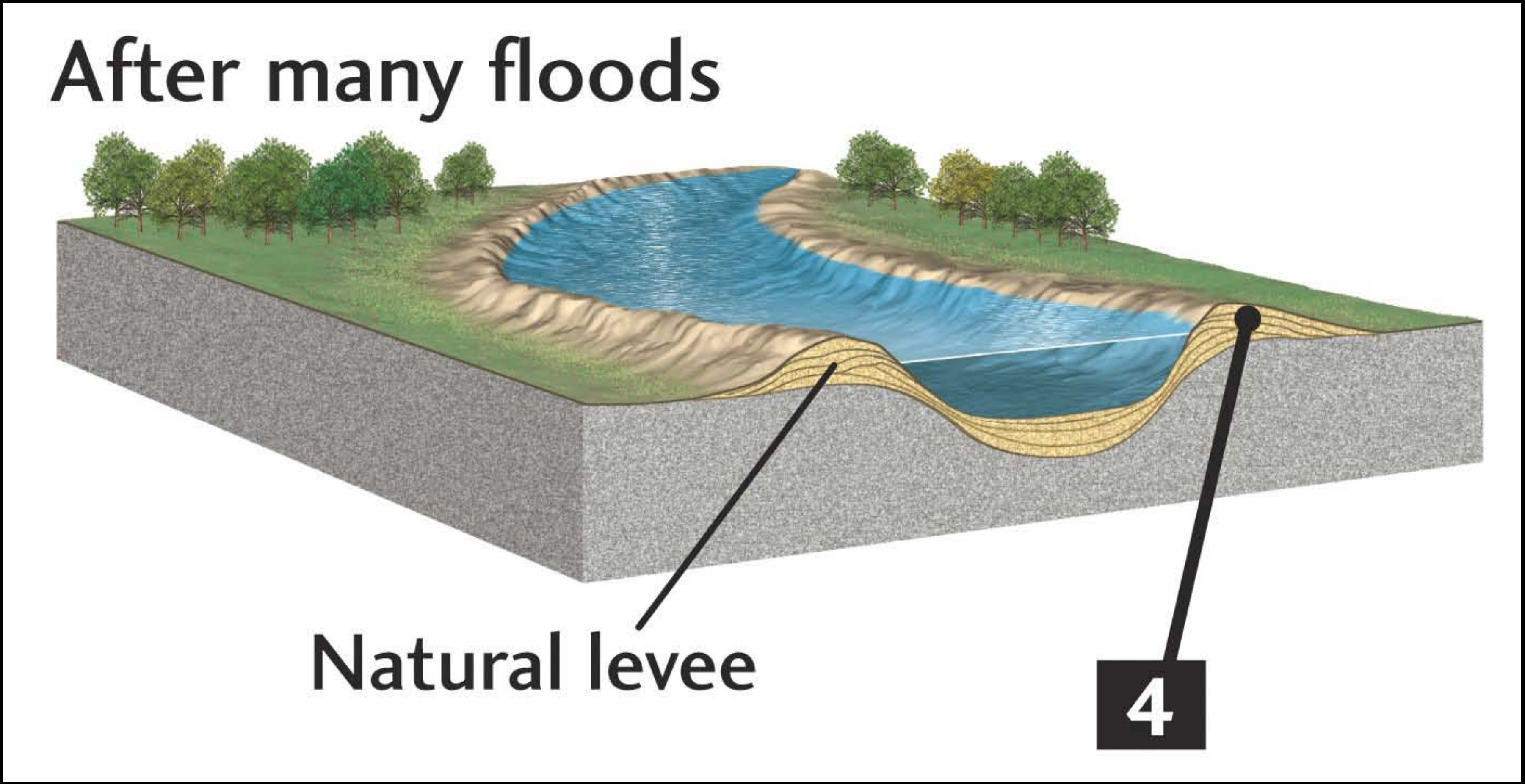


Fig 14.20

Radial drainage



Other Features of Streams



Other Features of Streams

Terraces – Mark previous level of floodplain. Formed by renewed down cutting to lower base level.

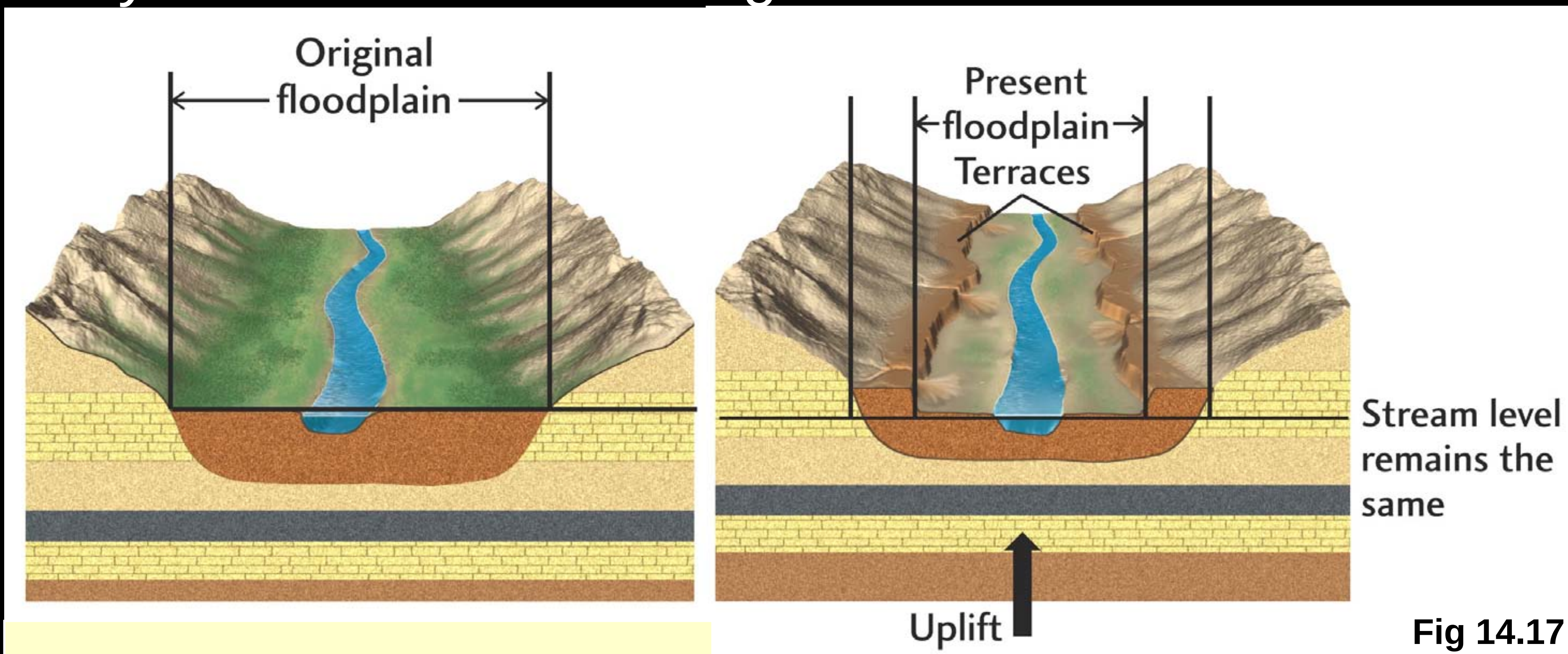
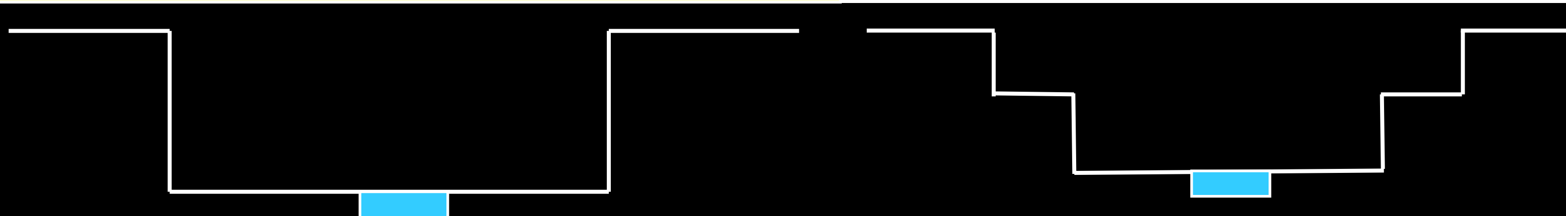


Fig 14.17



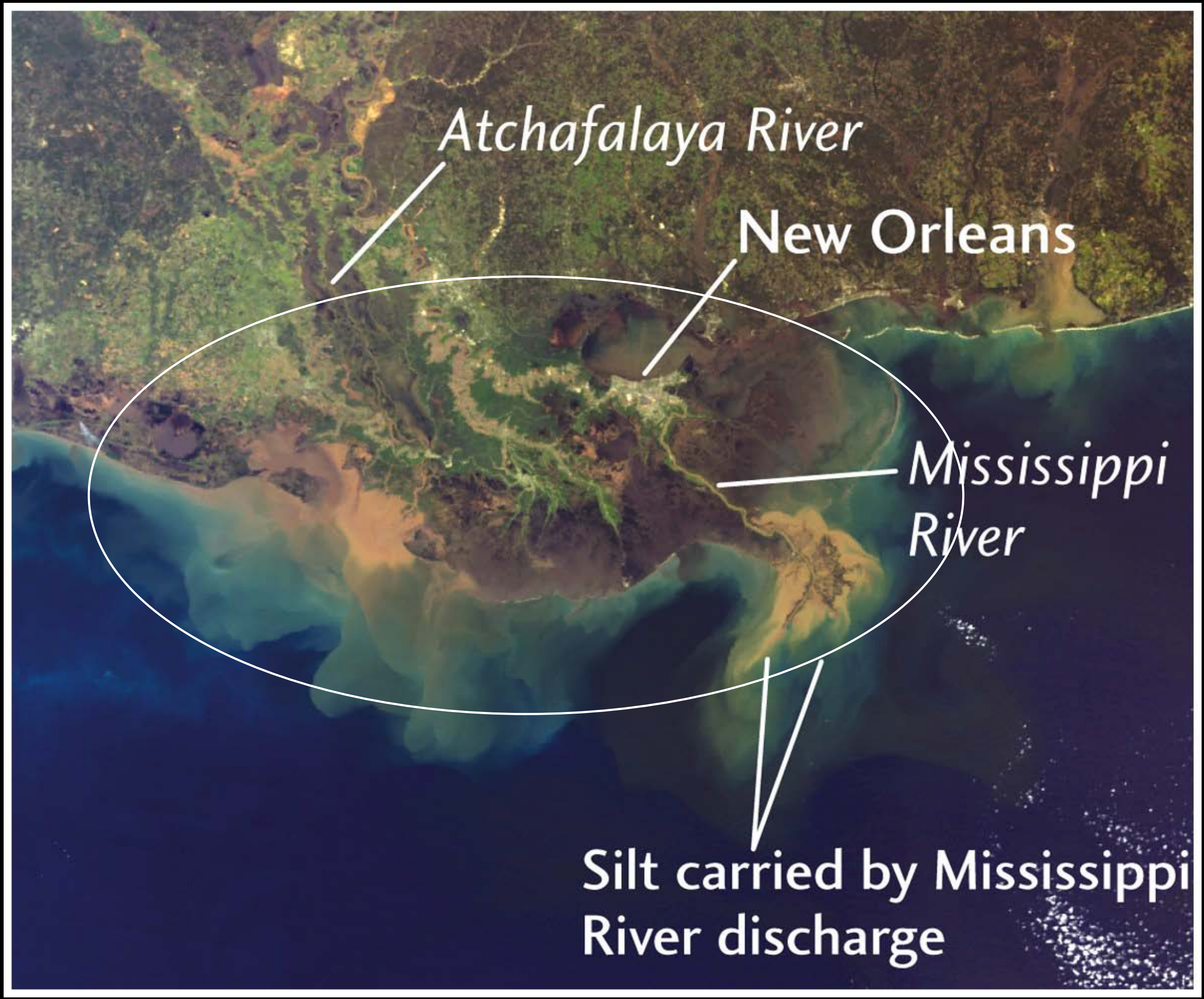
Profile View

River terraces

Fig. 14-18 Geology 2nd edition - Chernicoff

Alluvial Fan

Delta


Atchafalaya River
New Orleans
Mississippi River
Silt carried by Mississippi River discharge

Chapter 16 A Hidden Reserve: Groundwater

Water table – boundary between unsaturated and saturated zone

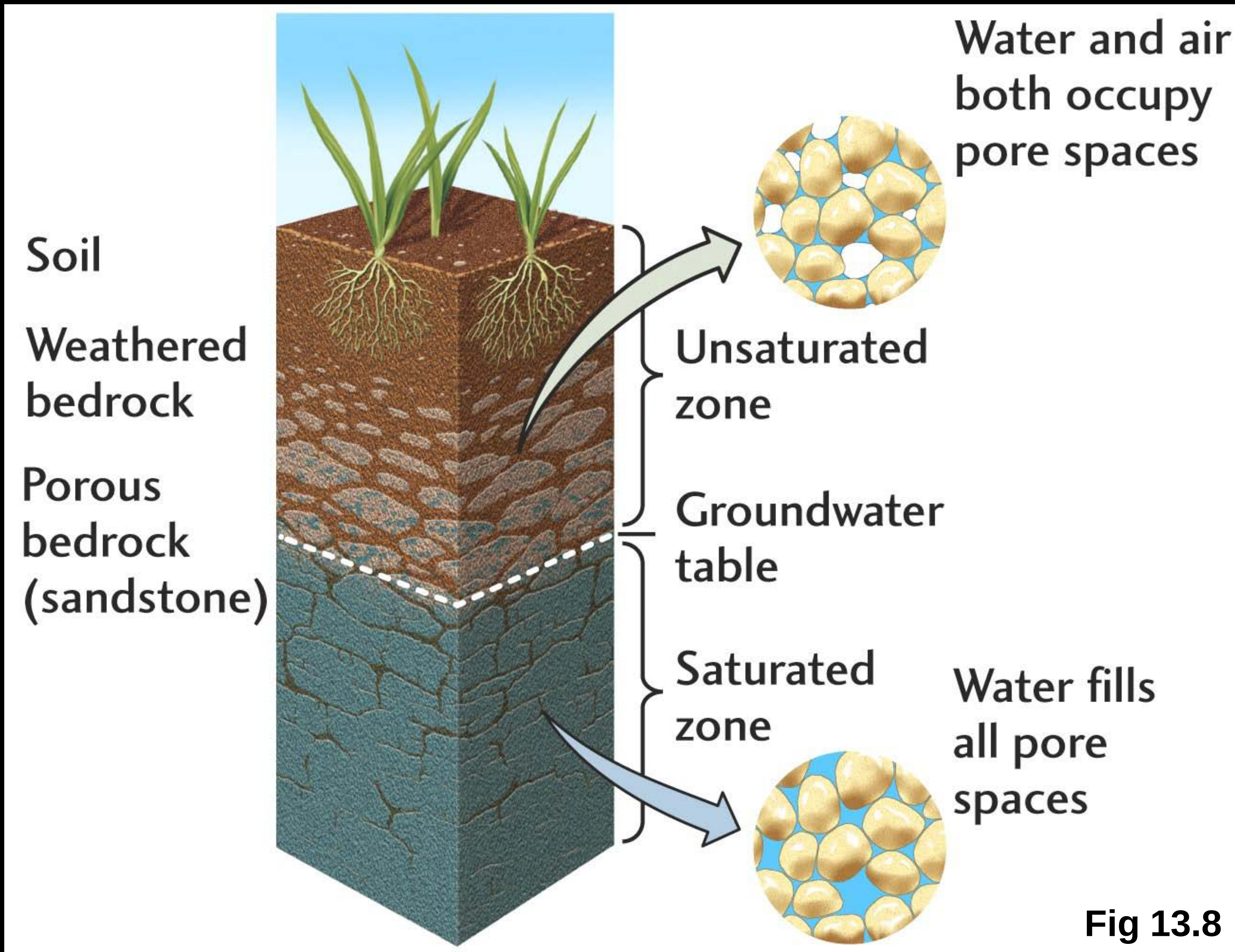
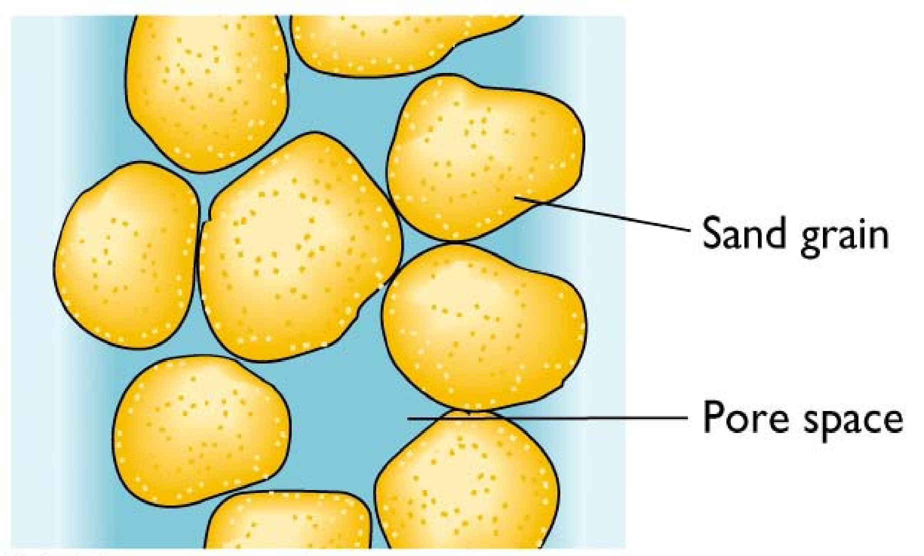


Fig 13.8

How does it get there?

Porosity – Total volume of pore (void) space in sediment or rock. May be fractures within rock or spaces between grains.



(a) Porous sandstone

How does it get there?

Permeability – The ability of water to flow through spaces in rock or sediment. (Spaces must be connected!)

(e) Unfractured shale

(f) Fractured shale

Groundwater Storage

Aquifer – material (sediment and rock) that store and transmit groundwater in sufficient quantities.

High porosity and high permeability.

Rock types?

unconsolidated	*consolidated*
gravel, sand	sandstone, conglomerate

Groundwater Storage

Aquicludes (also called Aquitards or Confining Beds) – Beds/Rocks through which water cannot move, or moves very slowly.

Low Permeability (Porosity varies).

Rock Types?

unconsolidated	*consolidated*
mud, clay	mudstone, shale, slate

The two types of aquifers are:

Unconfined aquifer - open to the surface (unsaturated zone and saturated zone) with a water table

Confined aquifer is sandwiched between two aquicludes and is not open to the surface at that location

Any rock type can be considered an aquifer if it is fractured and the fractures are interconnected!

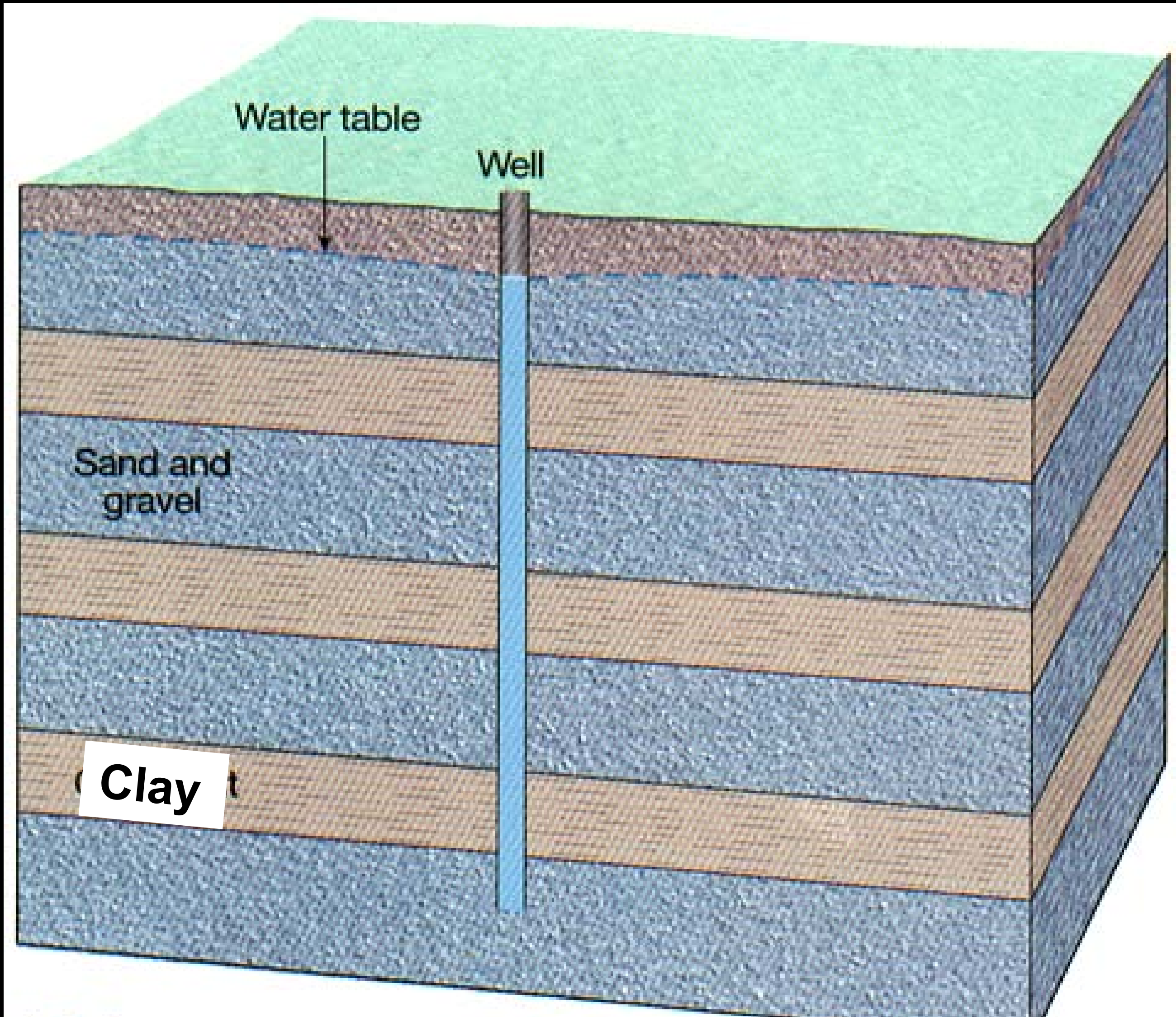
Groundwater storage

Unconfined aquifer

Confined aquifer

Aquiclude

Aquifer



A. Before extensive pumping of well

Groundwater storage

Artesian Well

Confined Aquifer

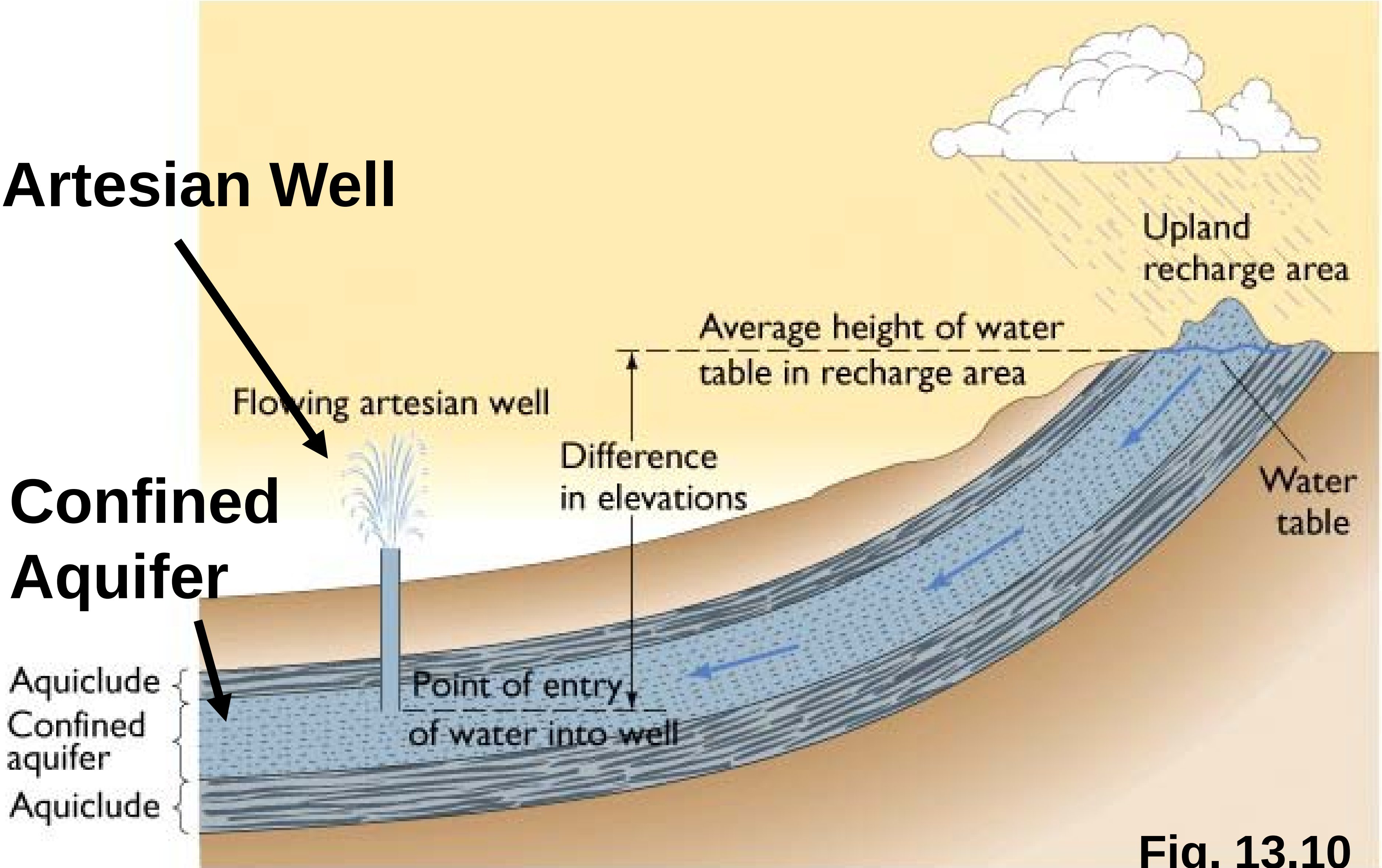
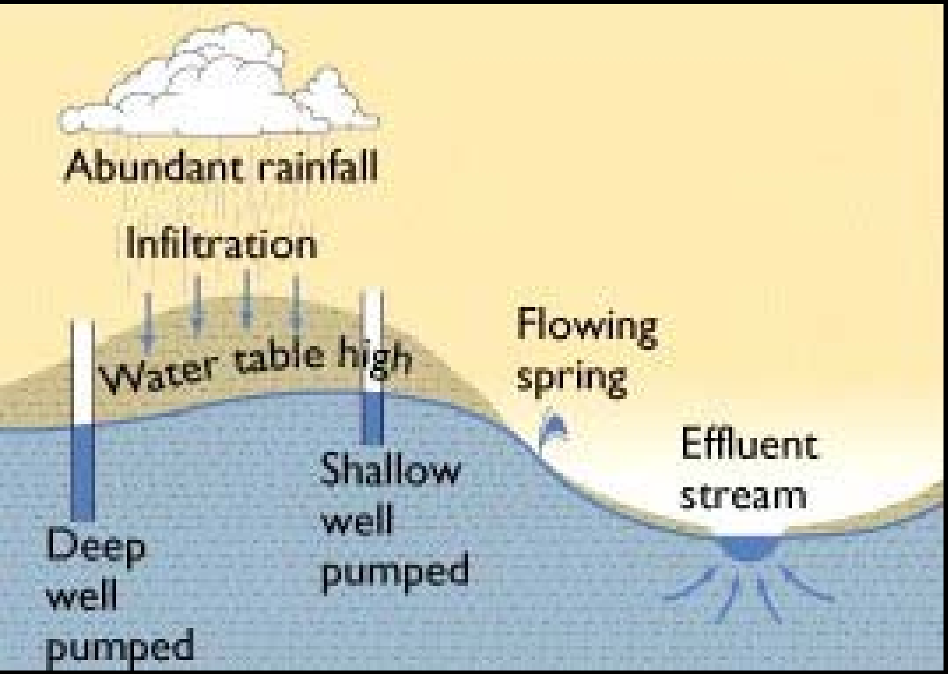
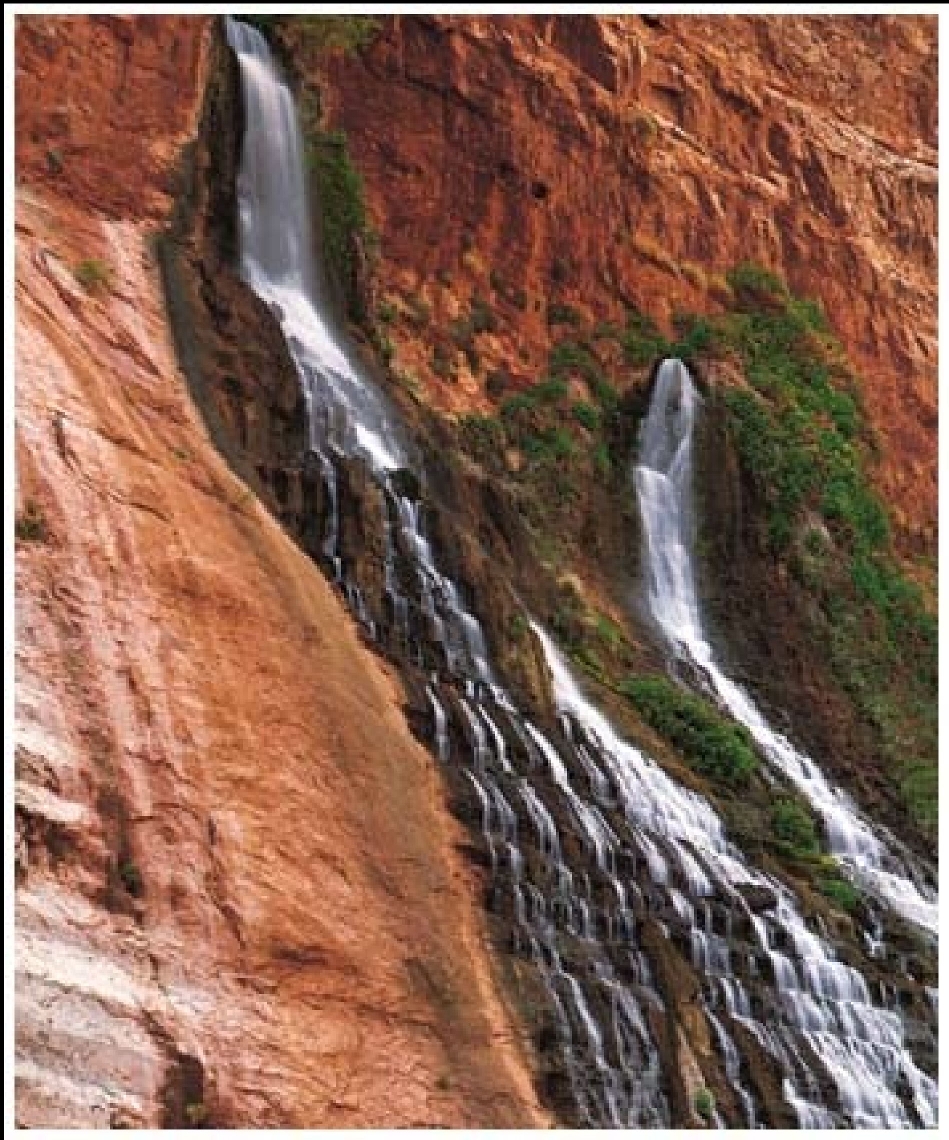


Fig. 13.10

Springs: Where the surface intersects the water table





Geysers: Intermittent hot fountains/columns of water

Managing Groundwater

Groundwater Withdraw is greater than Groundwater Recharge

- Cone of Depression

  Excessive pumping draws down the water table into a cone-shaped depression around a pumping well.

Think of a ice cream shake or malt as an analogy.

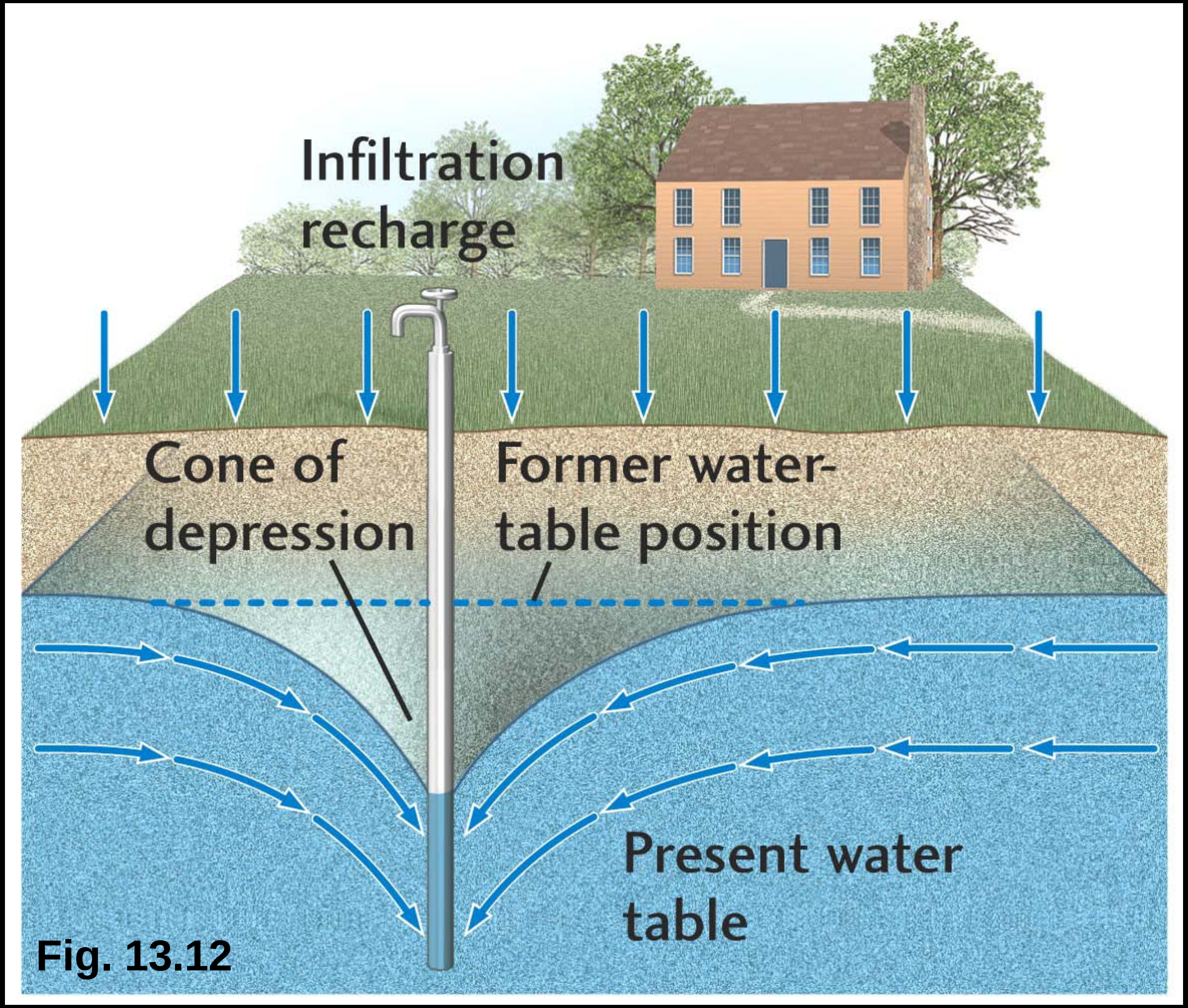
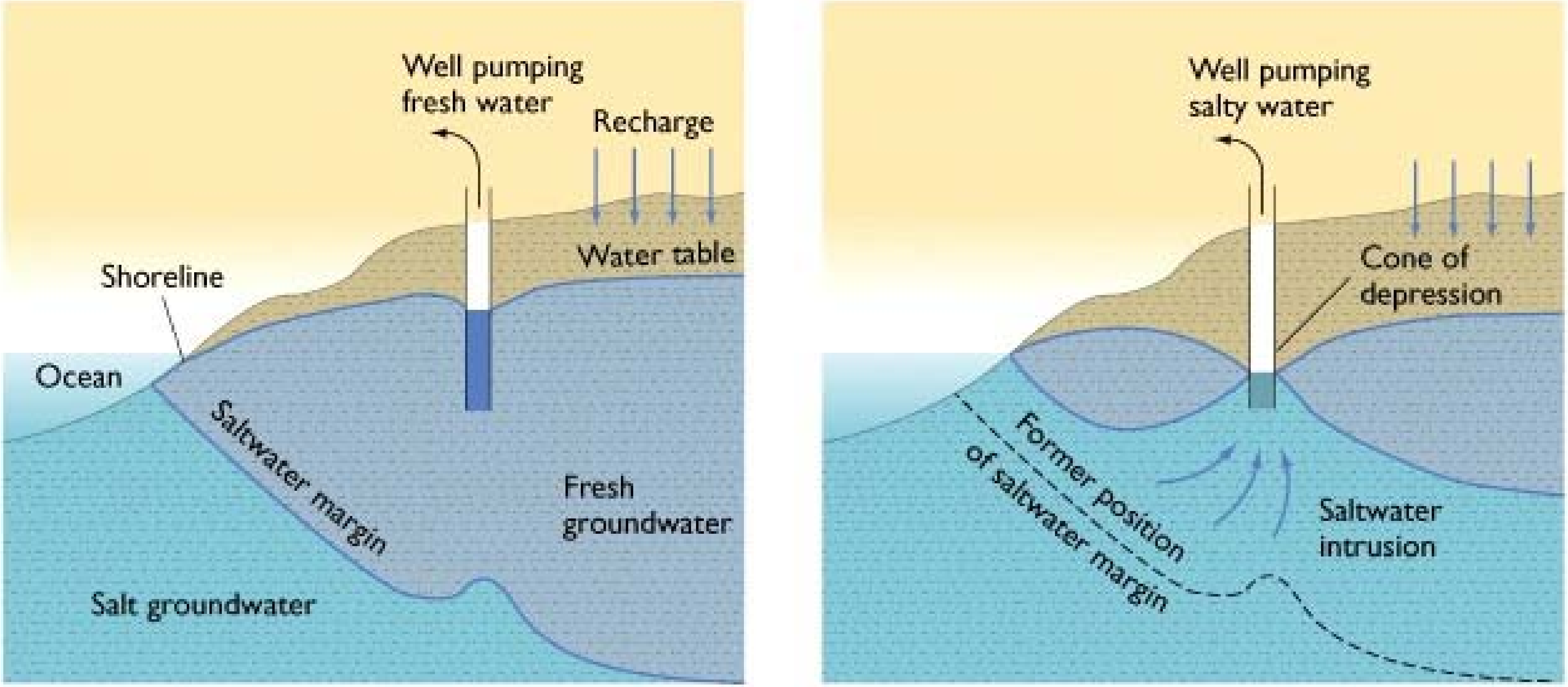


Fig. 13.12

When a well pumps water out of an unconfined aquifer faster than recharge can replenish it, the water level in the aquifer is lowered in a cone-shaped area around the well, called a **cone of depression**

Saltwater Intrusion



(a) Before extensive pumping

(b) After extensive pumping by many wells

Managing Groundwater

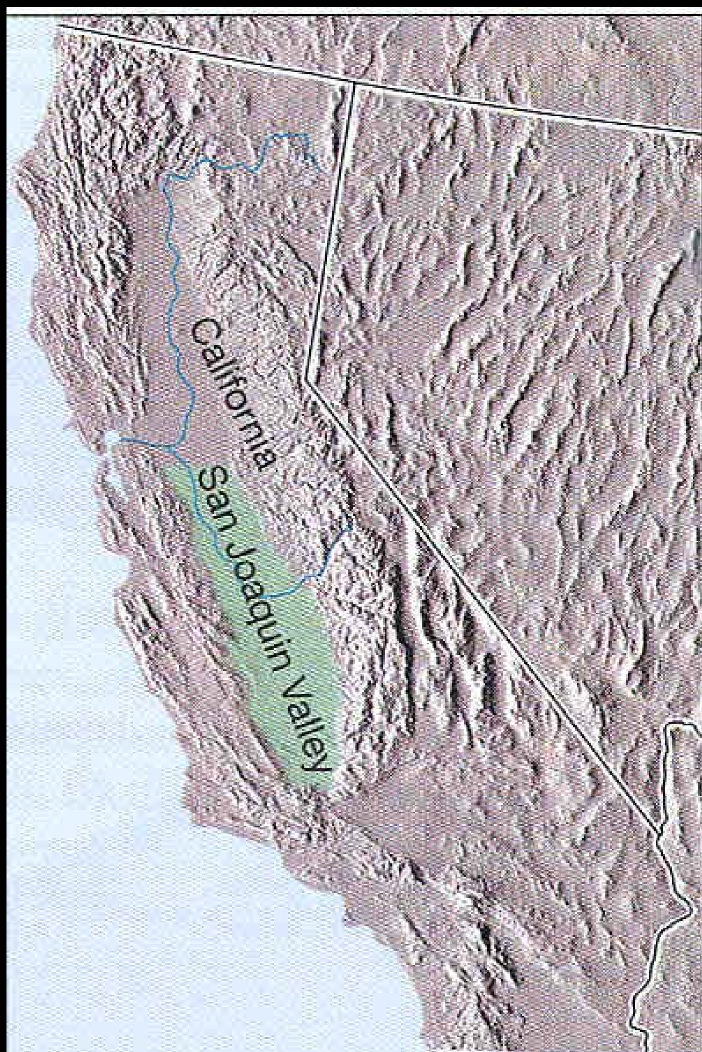
Groundwater Withdraw is greater than Groundwater Recharge

- Subsidence

  When water is removed from pore spaces/cracks in sediment/rocks, the weight of overlying materials causes compaction, and sinking of land surface.

Subsidence

Subsidence (from pumping out water faster than replenishing)



Erosion by Groundwater

Dissolution

- Chemical weathering process by which slightly acidic water dissolves rock.
- Most commonly limestone
- Water picks up CO_2 from the atmosphere and from the soil and becomes slightly acidic (carbonic acid).
- Acid is strongest at the level of the water table.
- Dissolves along fractures, enlarging them into a network of caves and other features called Karst.

Karst topography

Limestone is subjected to chemical weathering

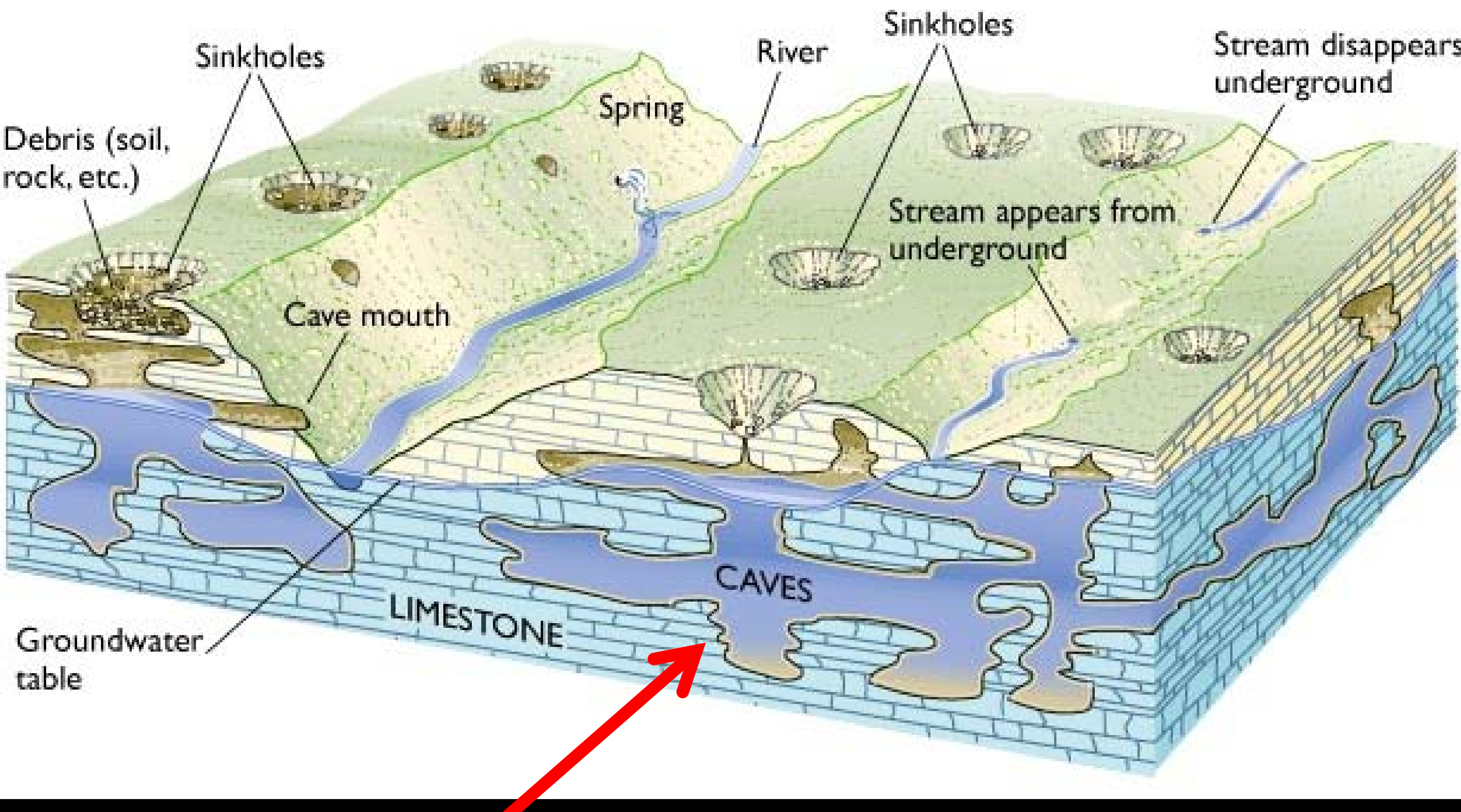


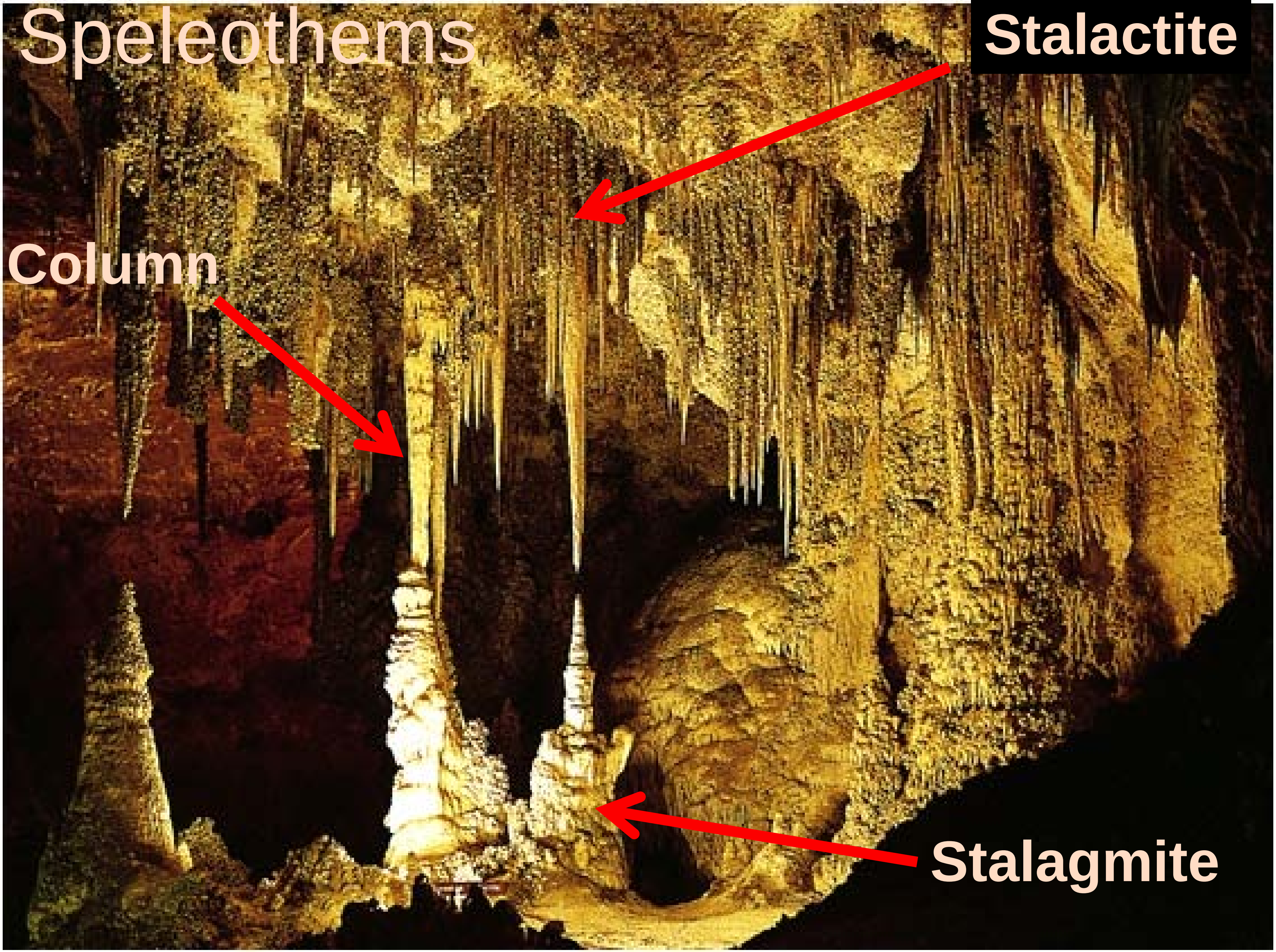
Fig 13.19

Cave Formation

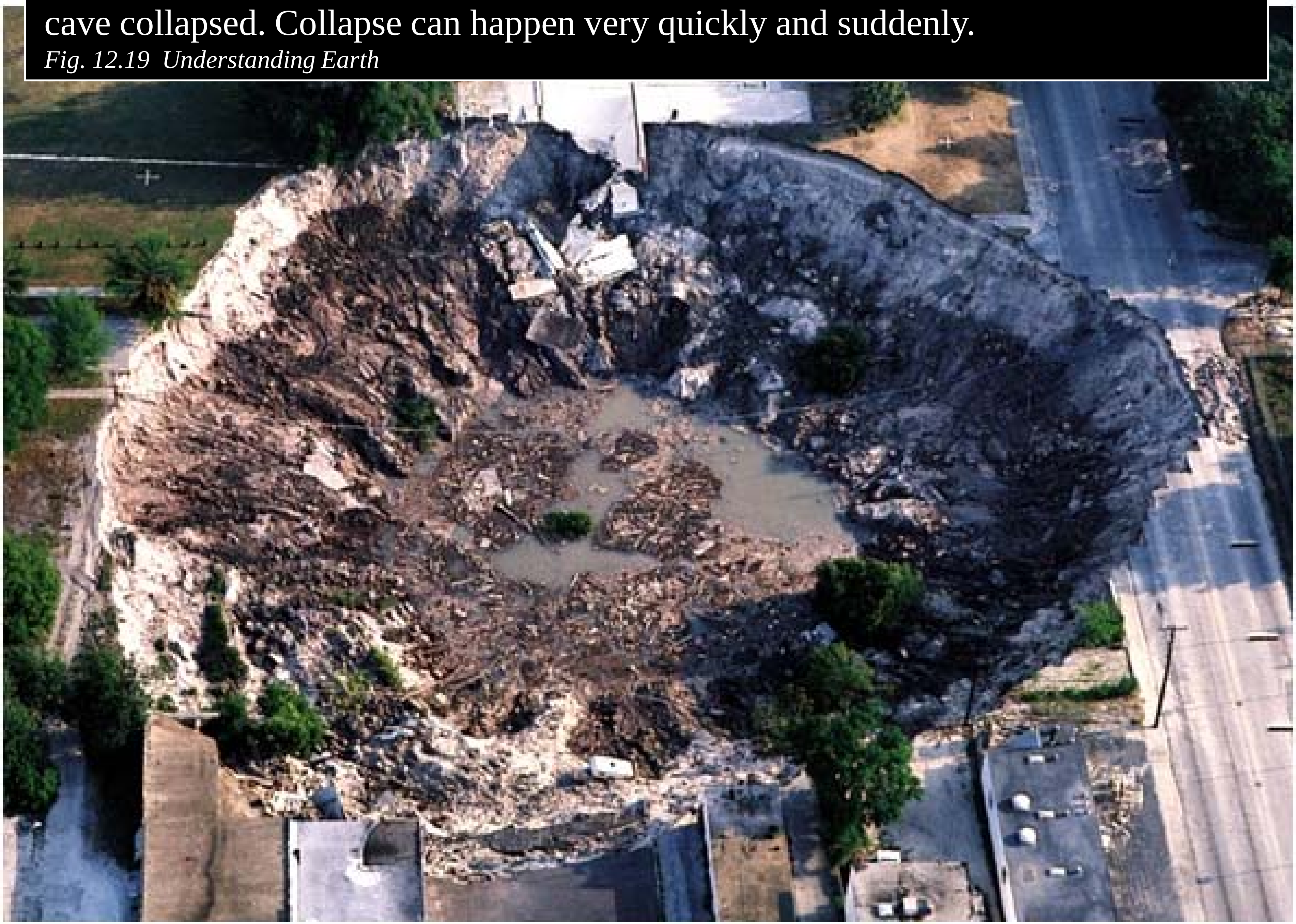
Cave Formation

1. Dissolution occurs near the water table, enlarging previous fractures.
2. Water table drops - leaves a cavity full of air
3. Water infiltrates from above and minerals precipitate as water enters void space.
4. Minerals (Calcite) precipitate as formations known as speleothems.

Website for virtual cave: http://www.goodearthgraphics.com/virtcave.html


Speleothems
Stalactite
Column
Stalagmite

Sinkhole in Winter Park, Florida This sinkhole was created when the roof of a cave collapsed. Collapse can happen very quickly and suddenly.
Fig. 12.19 Understanding Earth

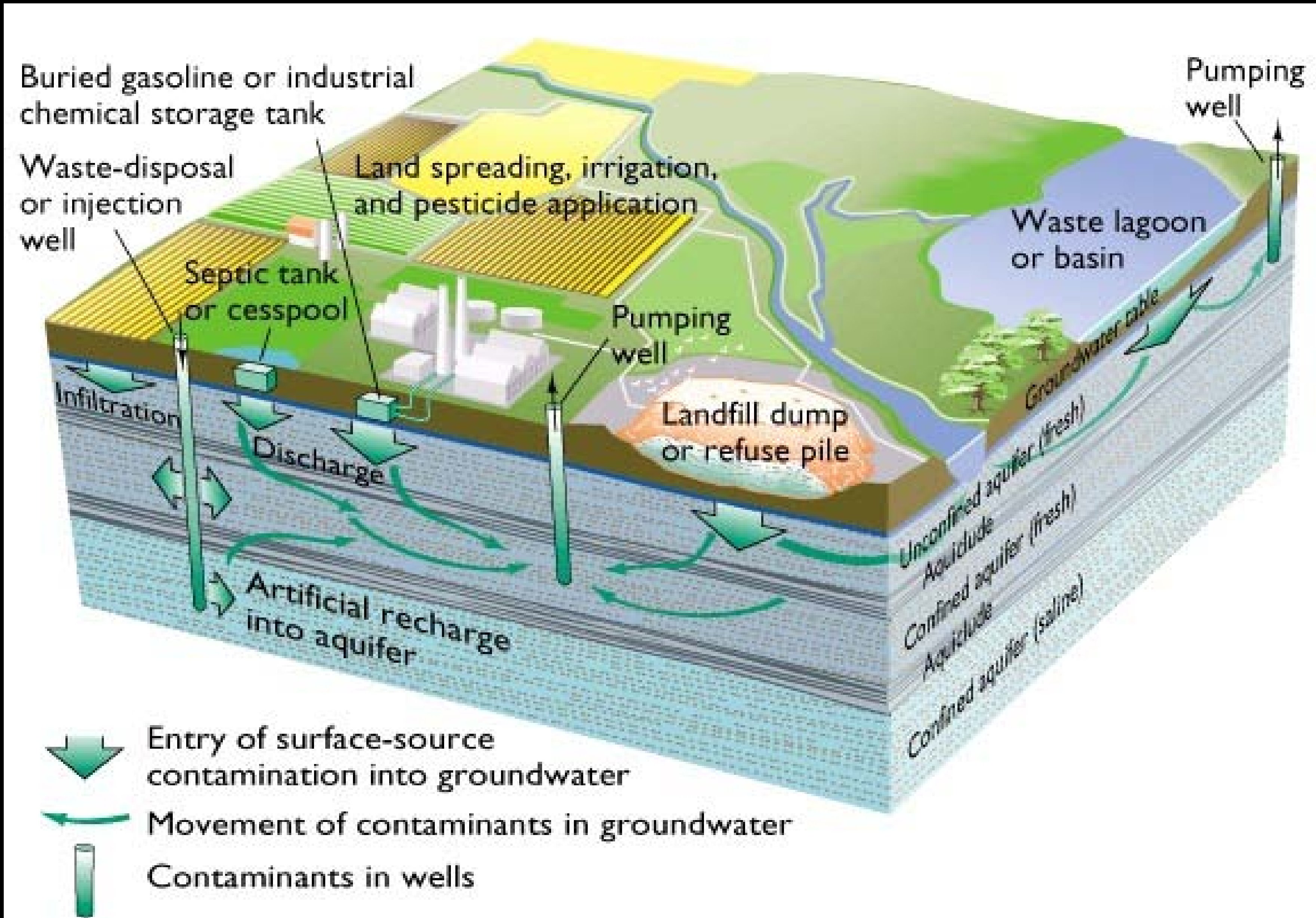


Contamination of our Water Supply

Groundwater Pollutants

- Sewage
- Leaking gasoline tanks
- Pesticide / Herbicides / Fertilizer
- Feed lots
- Cleaning solvents
- Radioactive waste

Contamination of Water Supply



Groundwater review

What are some materials that form aquifers?

What are some materials that form aquitards?

What is an unconfined aquifer?

What is a confined aquifer?

What creates a spring?

What rock type are dissolution caves formed in?

Consider the following questions:

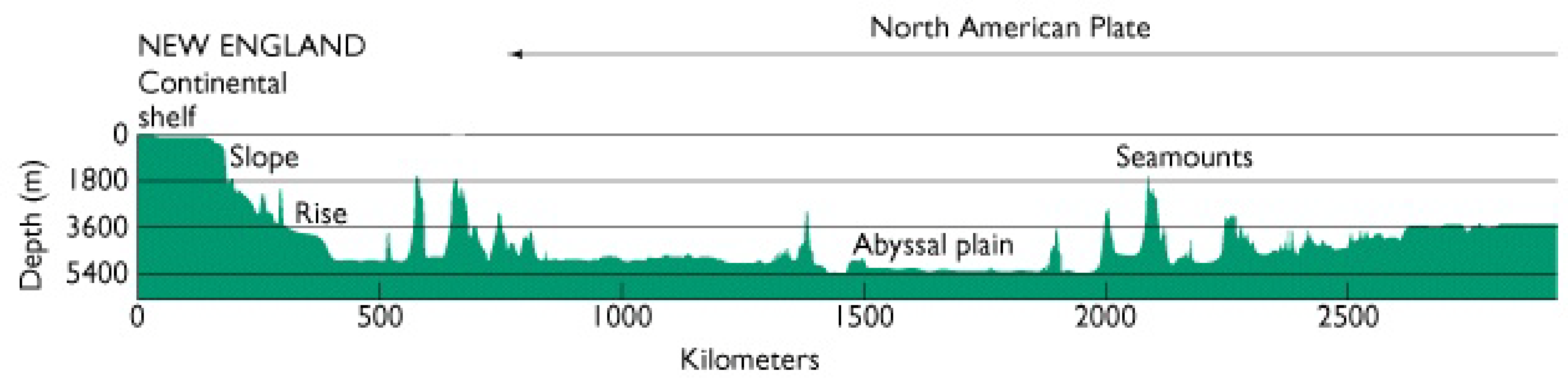
You bought a piece of land in the country to build your house; you need both a water well and a septic system. Where are you going to put them?
Where would you go for information to insure that you have a safe water supply?

You just bought a house in the country, the water tastes a little strange. What are you going to do?

Chapter 15 Restless Realm: Oceans and Coasts

Major Physiographic Features in the Atlantic Ocean

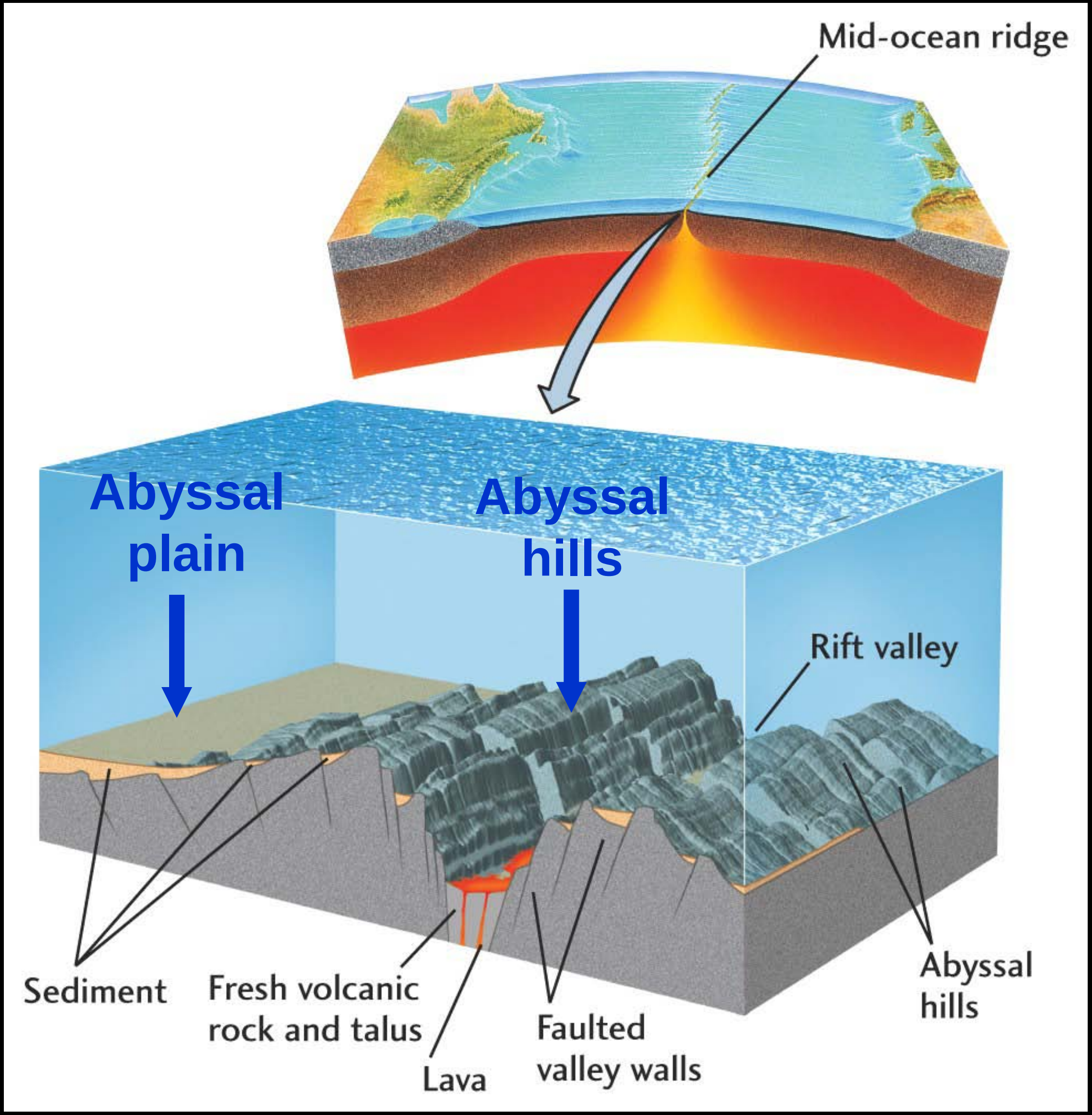
- continental margin
  - continental shelf
  - continental slope
  - continental rise
- abyssal plain
- seamounts and guyots
- amid-ocean ridge
  - abyssal hills
  - central rift valley



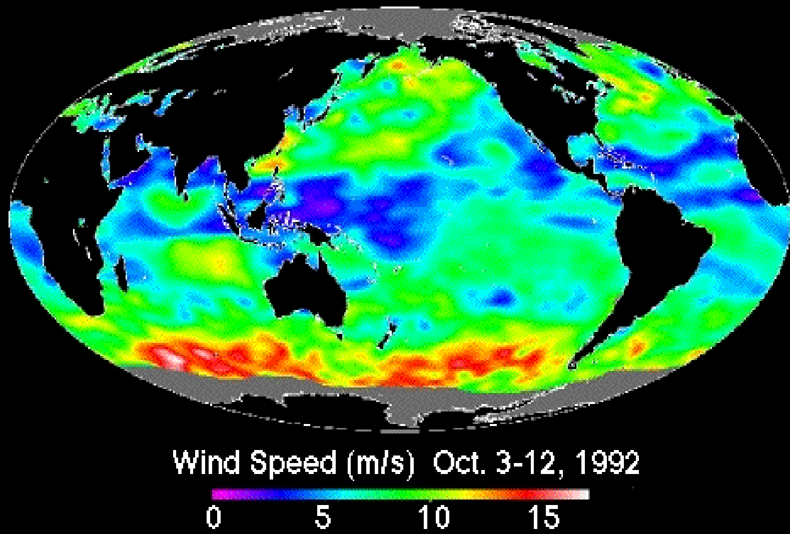
Abyssal Hills

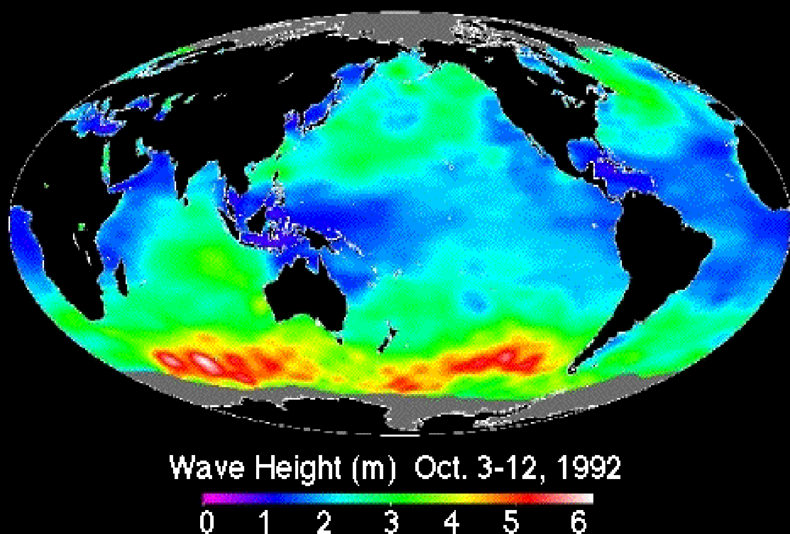
Linear ridges of basalt covered with a thin veneer of deep-sea sediment on the flanks the Mid-ocean ridge.

- **2-km** high submarine mountain belt



Waves are due to wind





Map of satellite data showing the geographic correlation between surface wind speeds and significant oceanic wave height in the first half of October, 1992. The highest winds and waves are found predominantly in the circum-Antarctic region at this time, the southern hemisphere spring. This is a result of both wind speed and fetch.

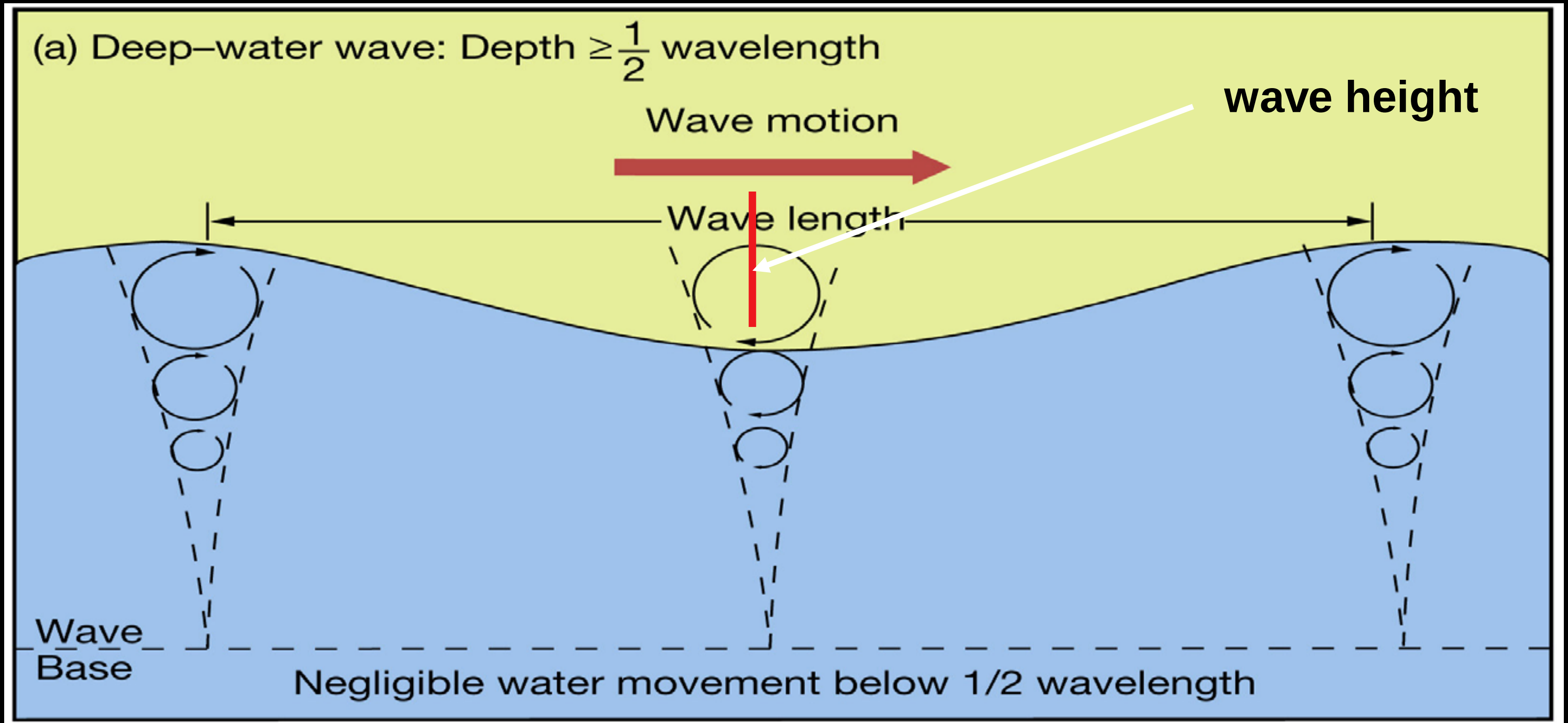
Higher waves can be caused by:

1) Higher wind speed
2) Increased storm duration (time)
3) Longer *fetch* (distance over which wind blows)

Wave characteristics

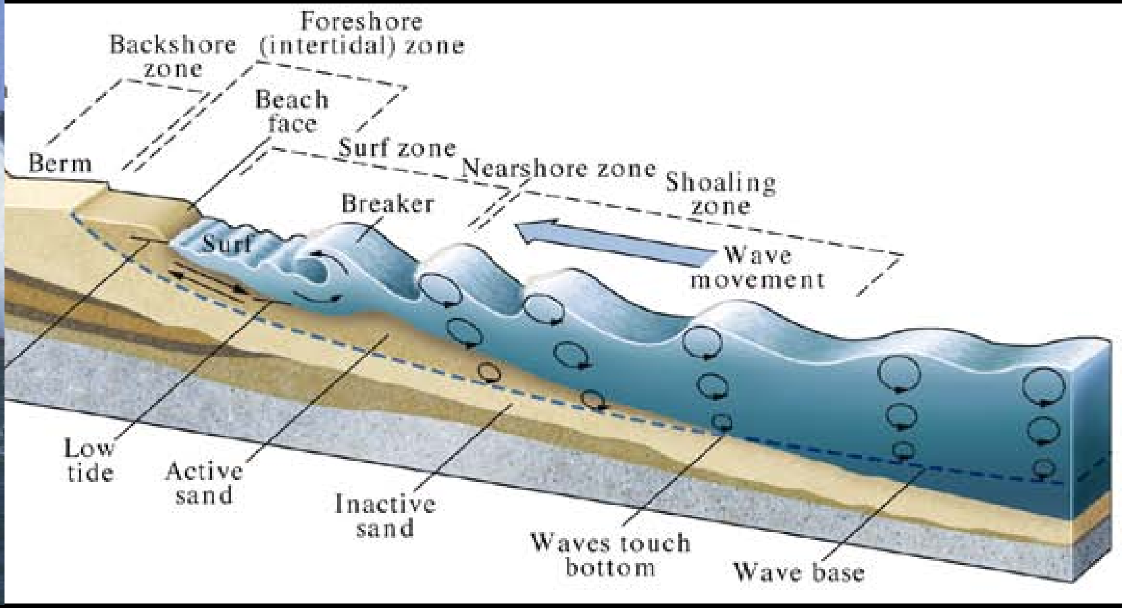
- Wave length – distance between crests
- Wave height – vertical distance between crest and trough
- Period – time between successive waves to pass

Wave base is 1/2 wave length – there is negligible water movement due to waves below this depth

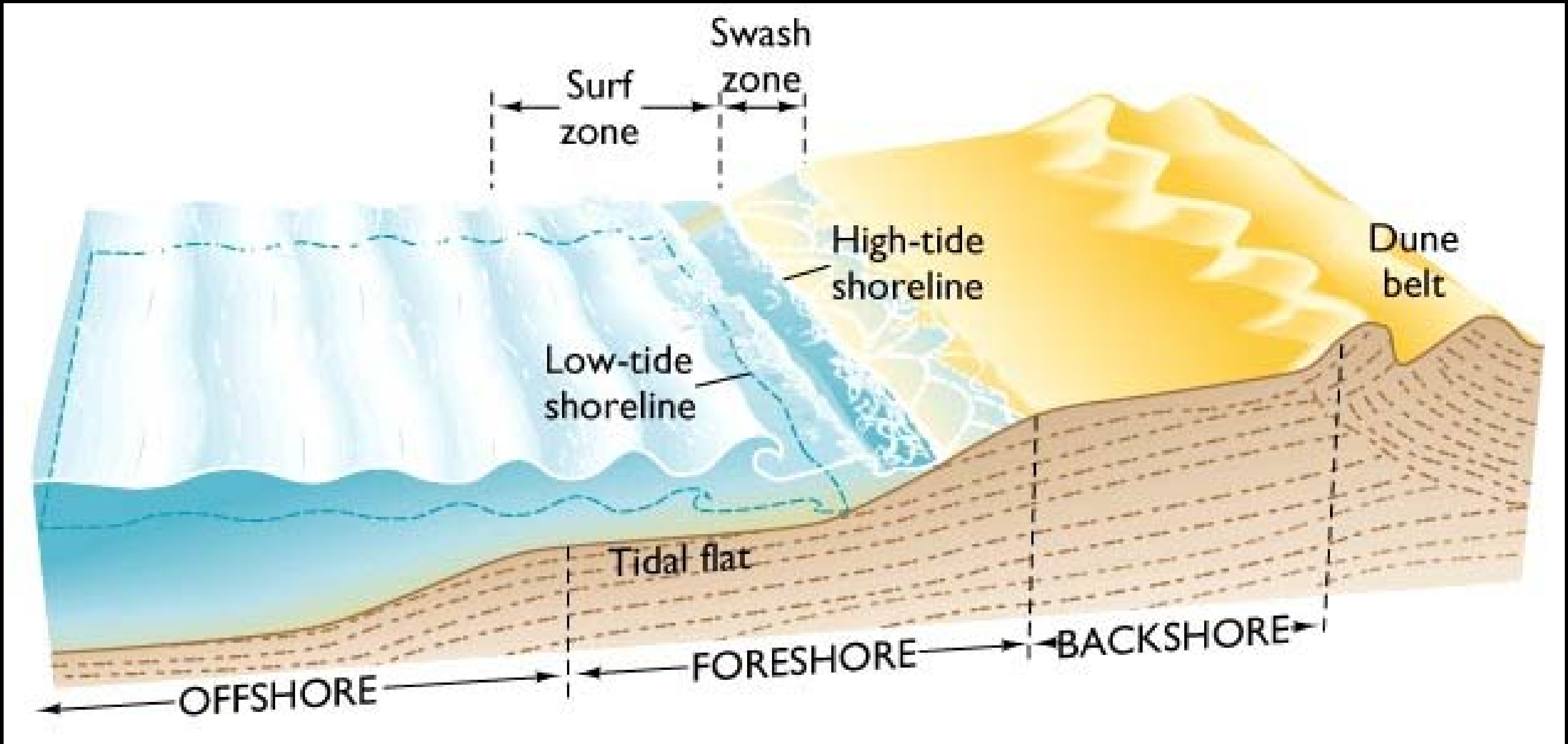


How do breakers form?

- As the swell approaches the shore where the bottom shallows to less than ½ the wavelength, the wave touch bottom causing it to slow
  - the wave period remains the same so the wavelength decreases and the waves height increase (making the wave steeper).
- As bottom shallows further the water can no longer support itself and the waves breaks and crashes in the surf zone



Major Parts of a Beach



Surf zone – offshore belt along which breaking waves collapse as they approach the shore

Swash zone - zone where water run up on the beach from a wave

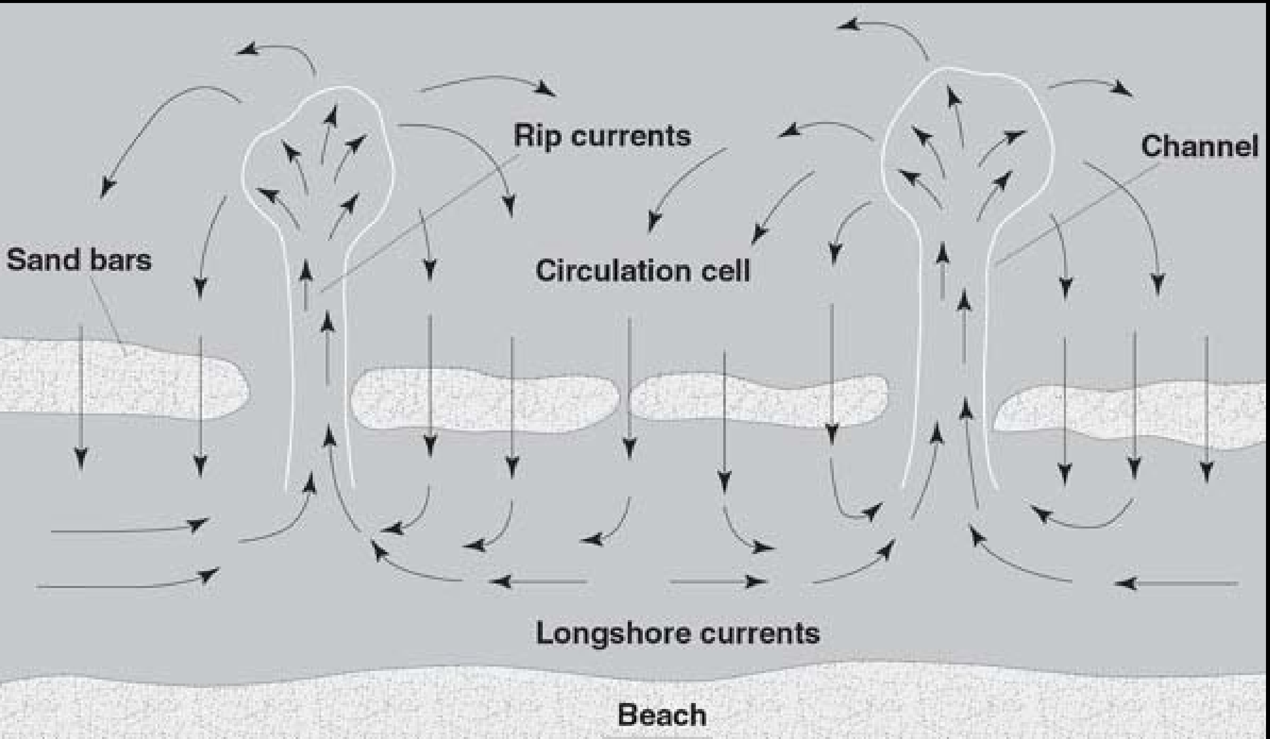
Tidal flats – the area that lie above low tide but are flooded at high tide

Formation of rip currents

-- rapid current draining beach area through shallow nearshore bars

-- fast and dangerous (most beach rescues)

What do you do if caught in a rip current?

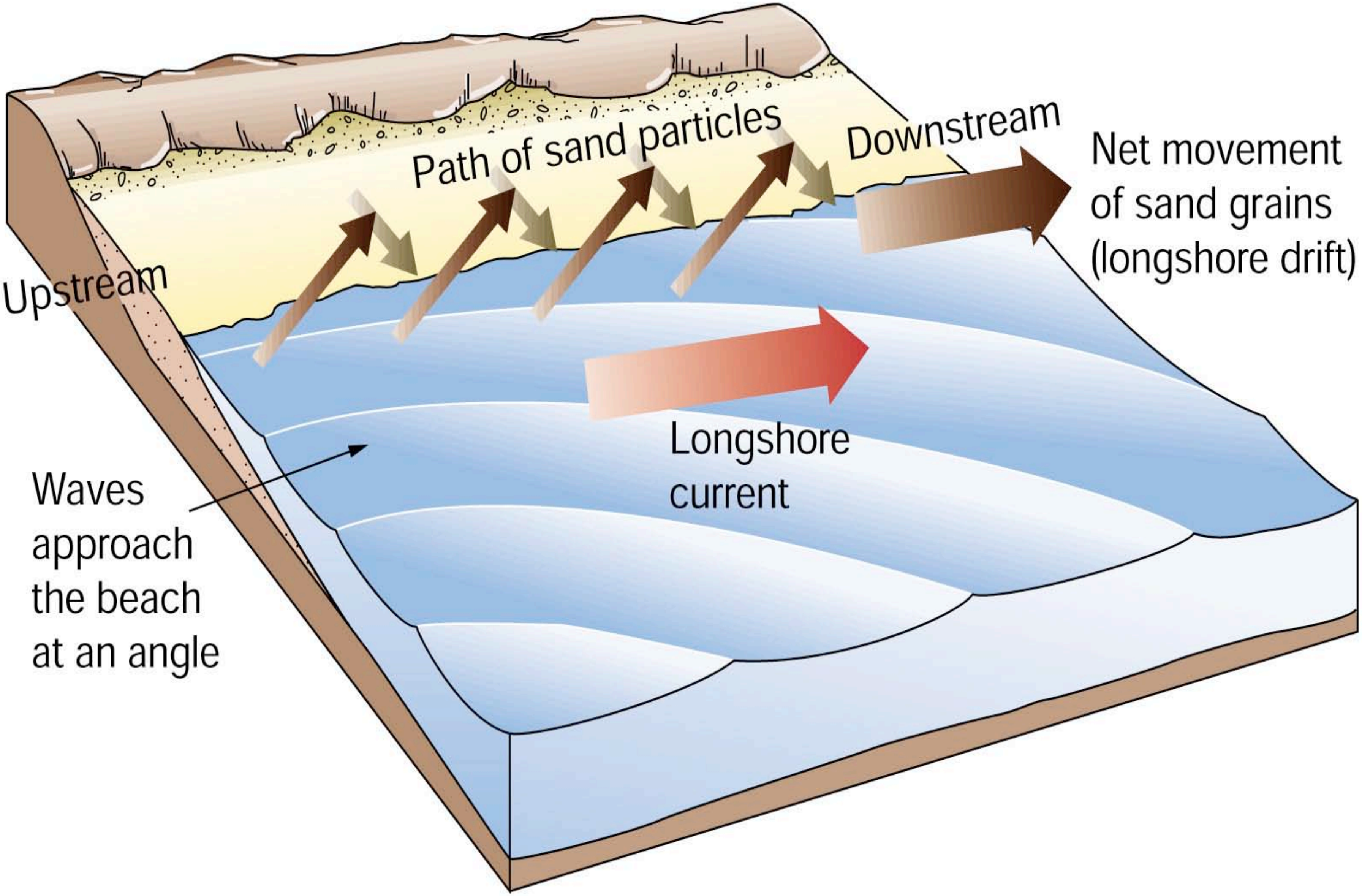


Far from shore the lines of swells are parallel to each other but are usually at some angel to the shoreline.

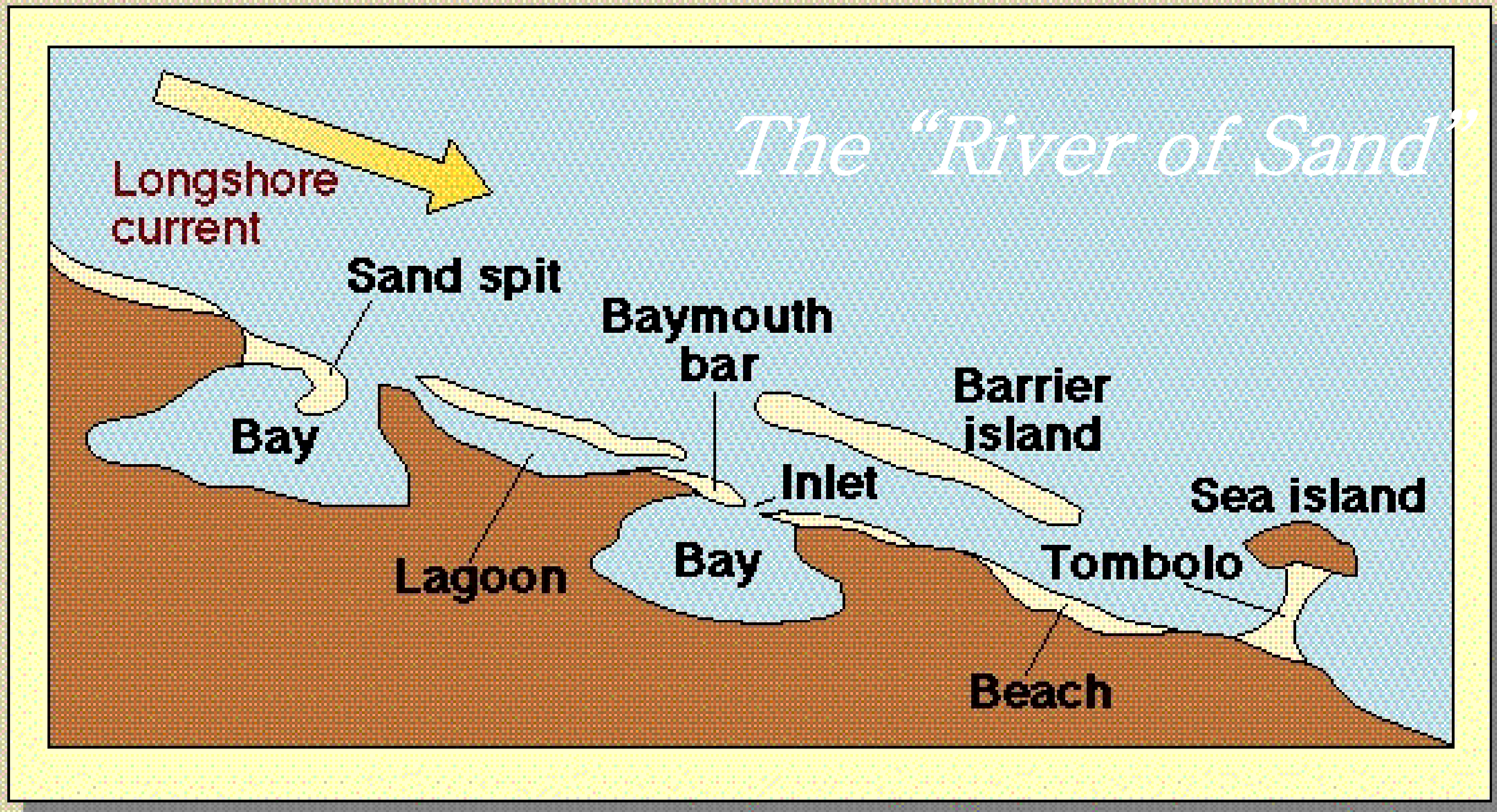
Wave refraction occurs as waves slow down in progressively more shallow water depths allowing the wave fronts to bend and approach the shore nearly parallel.

Fig. Story 17.13

Wave refraction moves sediment along the beach in a zigzag motion known as longshore drift.



Many coastal depositional features are formed by longshore drift.



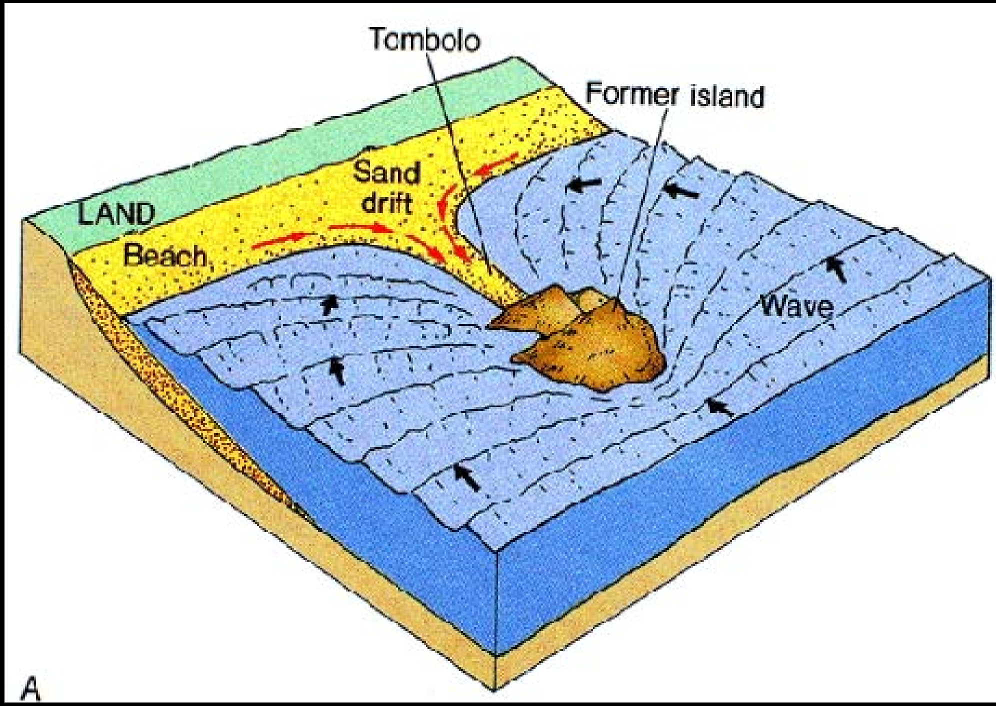
A composite diagram of the large-scale features of depositional coasts. Not all of these features would be found in such close proximity or in this order on a real coast.

Sand Spits

-- common wherever sand
is supplied and a longshore current is present

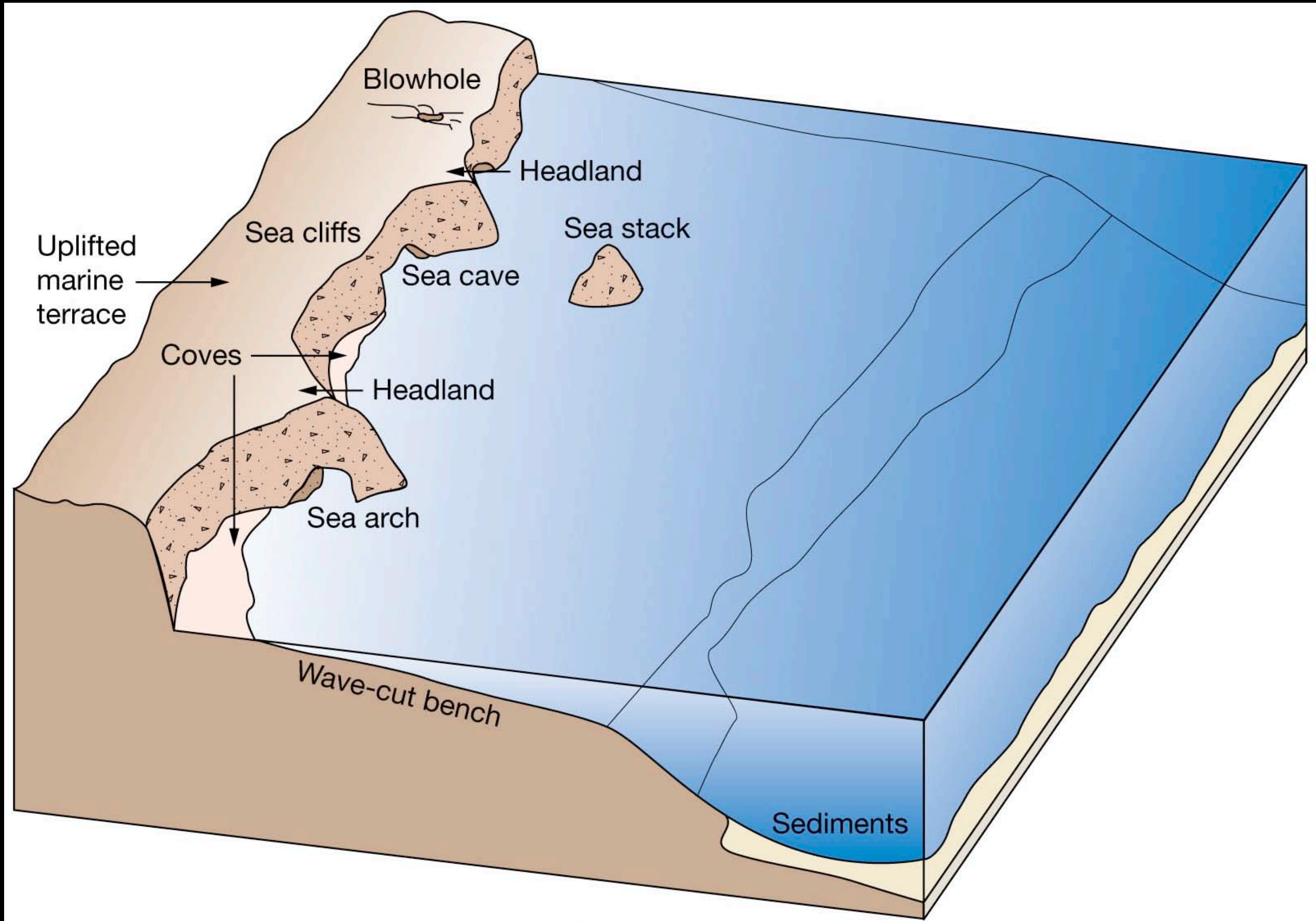
Tombolos

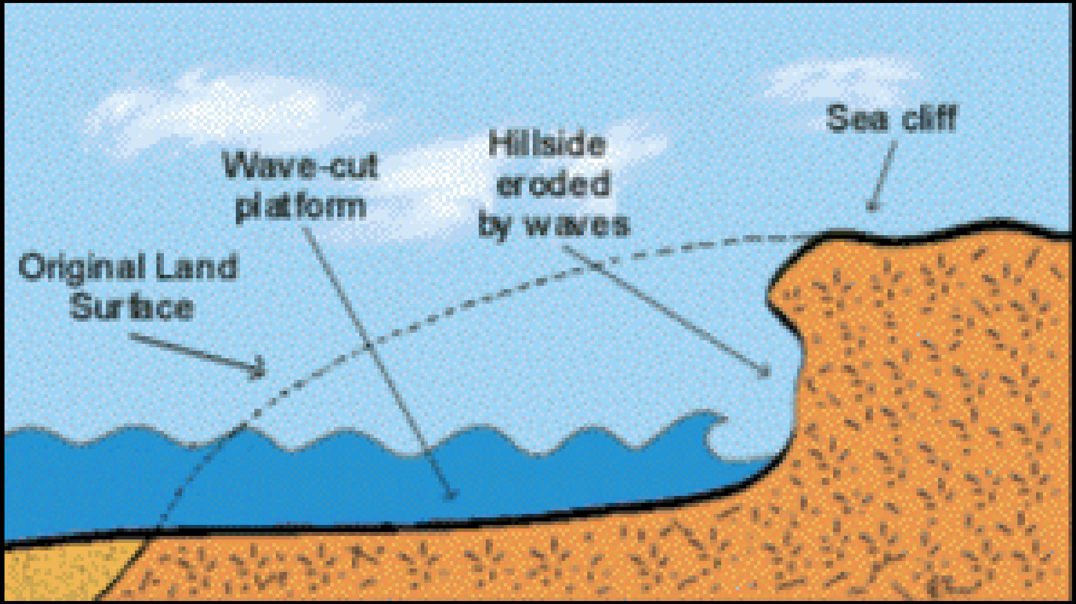
-- island shields beach
   from wave energy
-- leads to sand build
up



Emergent coasts

-- uplifted, tectonically active coasts often rocky
-- rocky headlands alternate with pocket beaches
-- formed by wave erosion





Wave cut platforms

-- abrasion across surf zone erodes bedrock flat – common feature on rocky coasts

Sea stacks and arches - remnants of erosion

Uplifted beach terraces

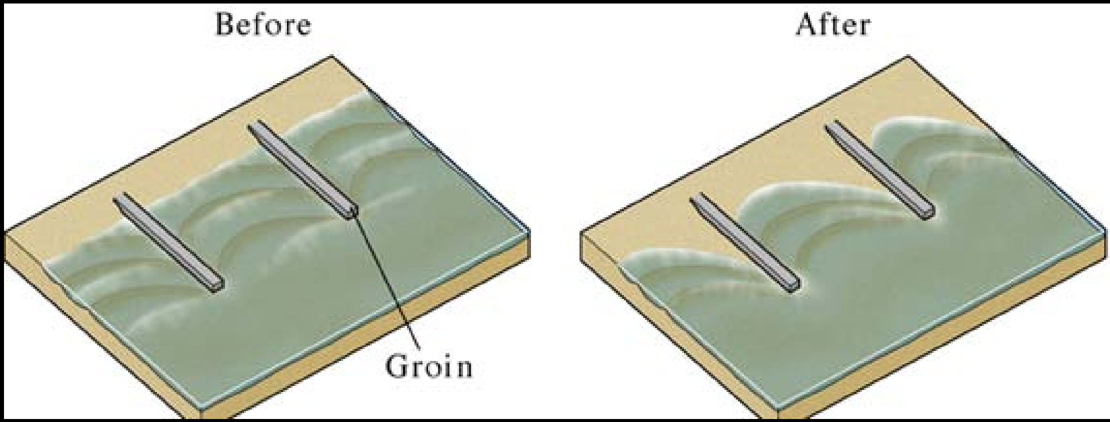
- -- can be either wave cut platforms or beaches or both
- -- common on emergent coasts

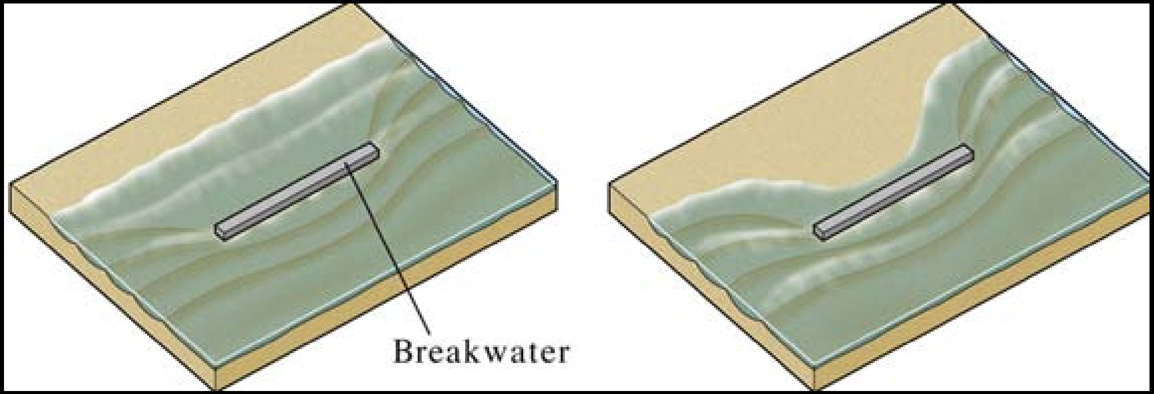
-- EX:, CA, OR, WA, entire west coast of US

Preventing beach erosion

- **Structural** approaches (e.g., groins, breakwater, jetties): typically cause increased erosion down-current of structure
- **Non-structural** approaches (e.g., beach nourishment, land use planning): expensive, but doesn't cause erosion in new areas

Groins - catch part of the "river of sand" from longshore drift





Breakwater - reduces local wave energy so sand is deposited, not carried away

Groins and breakwaters