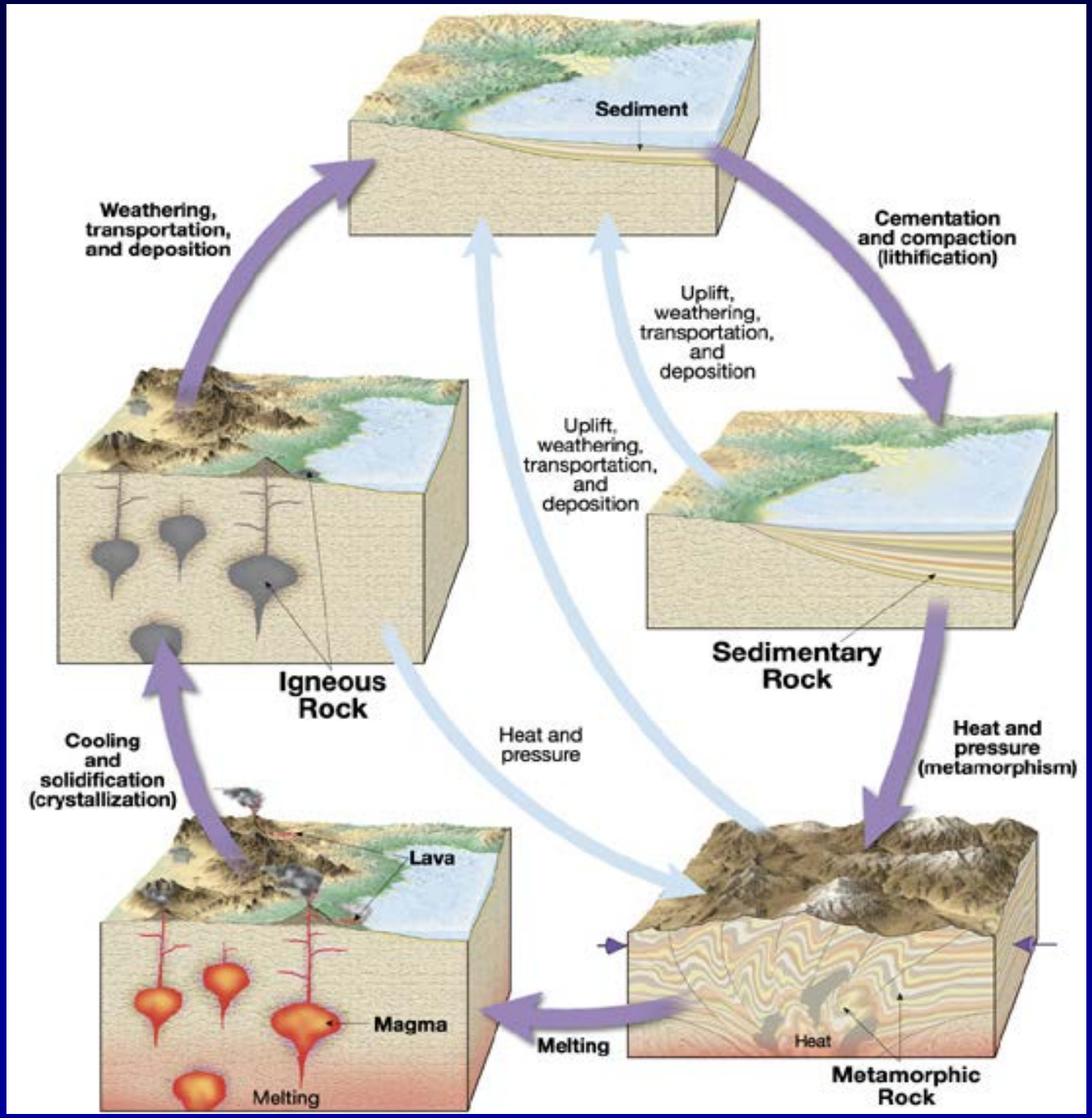
Photo by P. Weis, U.S. Geological Survey


Sediment
Weathering, transportation, and deposition
Cementation and compaction (lithification)
Uplift, weathering, transportation, and deposition
Uplift, weathering, transportation, and deposition
Igneous Rock
Sedimentary Rock
Cooling and solidification (crystallization)
Heat and pressure
Heat and pressure (metamorphism)
Lava
Magma
Melting
Melting
Heat
Metamorphic Rock

Sedimentary Rocks

Adapted from Brunkel (2012)

What is a sedimentary rock?

- Product of mechanical and chemical weathering and erosion
- 5% (by volume) of Earth's outer 10 miles

From Rocks to Soils

Fresh Rocks (I)

Weak Rocks - Stiff Soils (II-V)

Soils (VI)

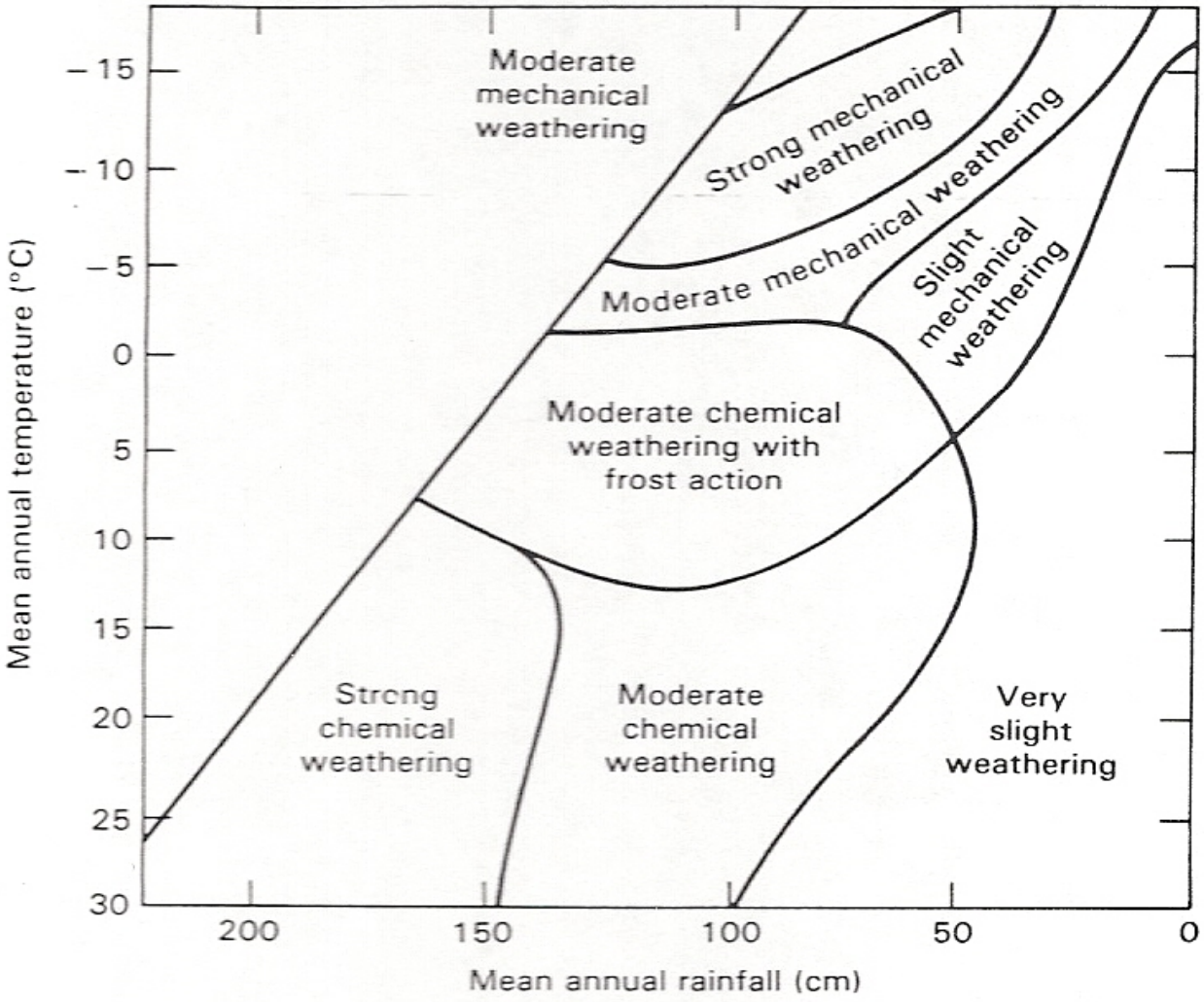


Figure 9-1 Climatic influences on types of weathering processes. (From Peltier, 1950; reproduced by permission from the *Annals of the Association of American Geographers*, 40:219, Fig. 3.)

Erosion – Point A to Point B

- Gravity
  - Sometimes stuff rolls downhill
- Water
  - Obvs the largest mover of sediments
- Wind
  - Moves a lot of small stuff – fine sand, silt
- Ice
  - Moves a lot of stuff, all sizes, in one big push

Erosion

- Where does the sediment stop?
- What happens to it when it stops?

Sediments

Sediments form by:

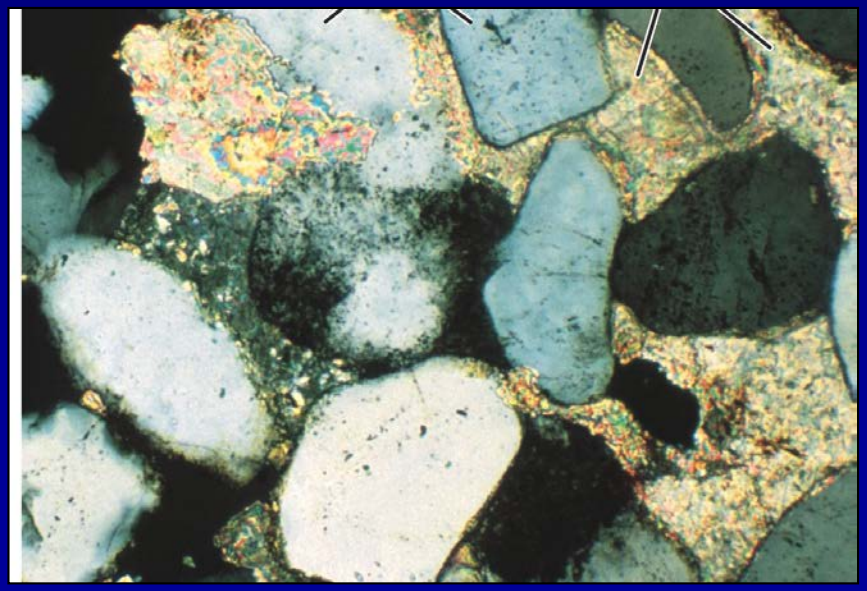
- Weathering of rocks (mainly continental rocks)
- The remains of small skeleton building organisms
- Inorganic crystals that precipitate from solution

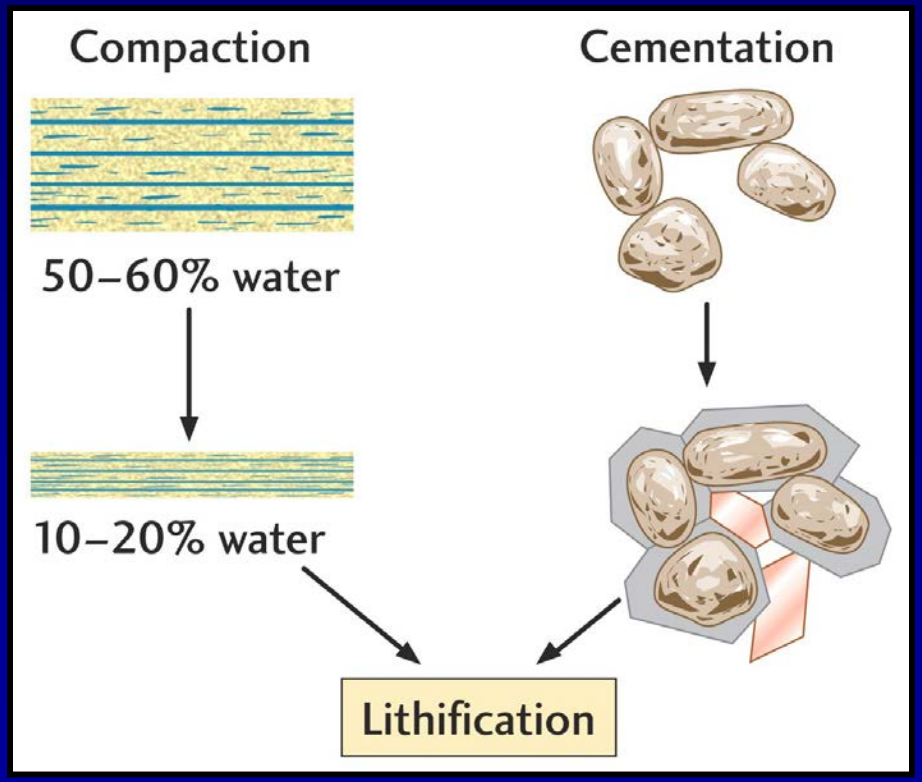
Sediments

- Sediments are small pieces rocks (or minerals) from other rocks
- Sediments are transported and deposited by erosional processes
- Sediments go through the process of lithification to become sedimentary rocks

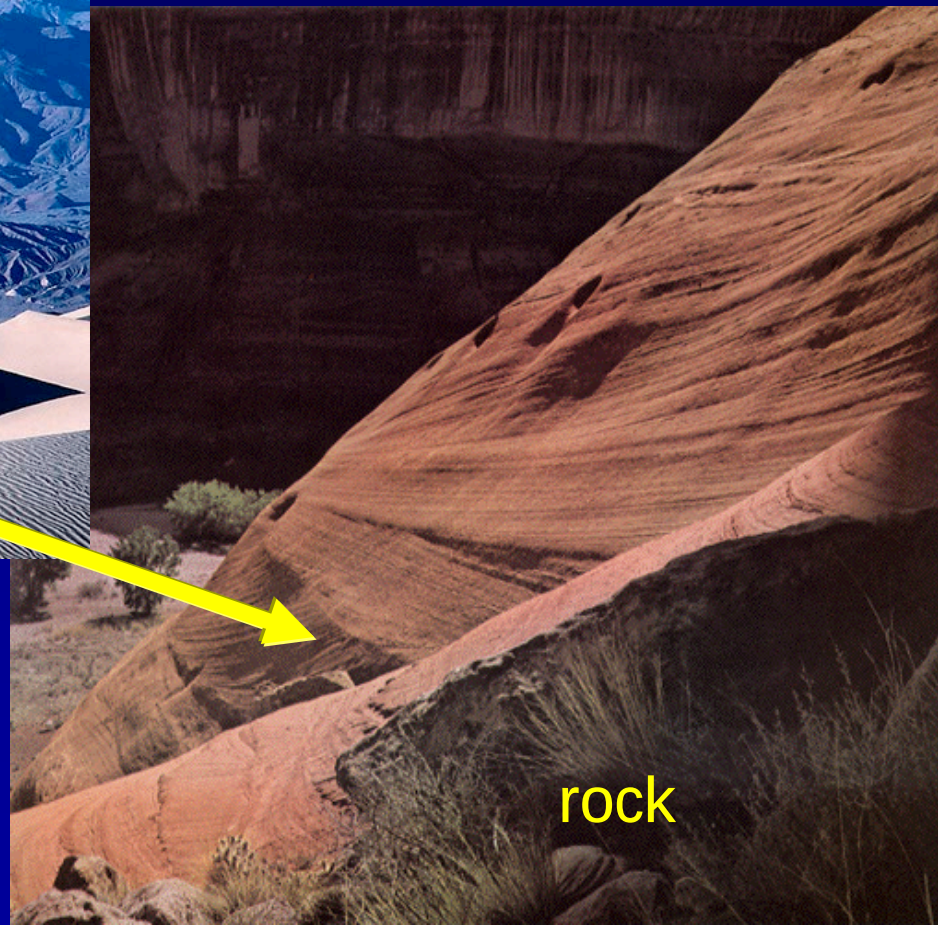
Lithification

- the process of turning sediments into rocks
- Compaction and Cementation
- The Matrix





Turning sediment into rock



Sedimentary rocks

- Provide evidence of past environments
  - i.e, Limestone reefs indicate past tropical climate, dune sandstones indicate past arid climate and show wind direction.
  - Often contain fossils

Sedimentary rocks

- Sedimentary rocks economically important
  - Coal
  - Petroleum and natural gas
  - Sources of iron, aluminum, and manganese

2 Types of sedimentary rocks

- **Detrital (Clastic) sedimentary rocks** – formed from sediment that was transported as *solid particles (clasts)* of quartz, clay, feldspar, mica.

2 Types of sedimentary rocks

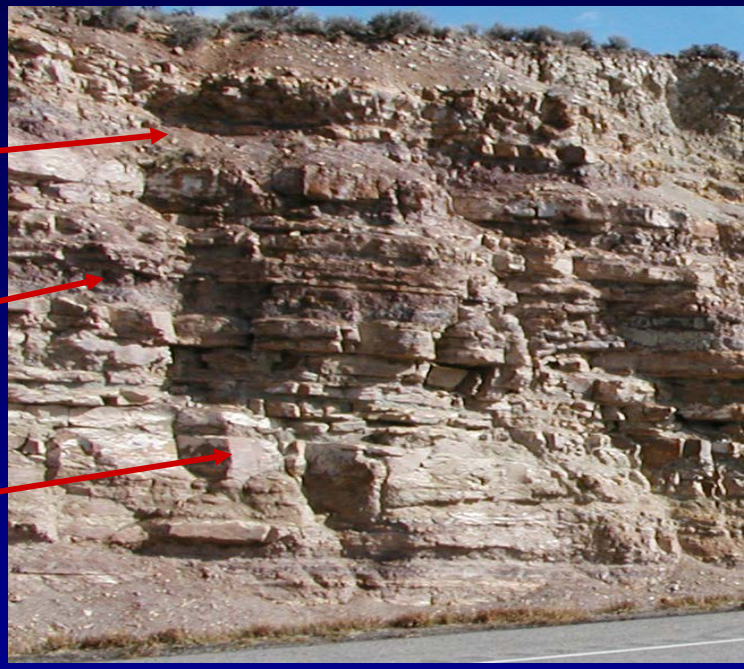
- **Chemical sedimentary rocks** – formed from sediment that was *precipitated* from solution through metabolism by organisms or by inorganic precipitation.

Clastic sedimentary rock names

- Named according to **particle size**.

Fine to Coarse:

- **Shale** – clay size
- **Siltstone** – silt size
- **Sandstone** – sand size
- **Conglomerate** (rounded) and **Breccia** (angular) – pebble to boulder size

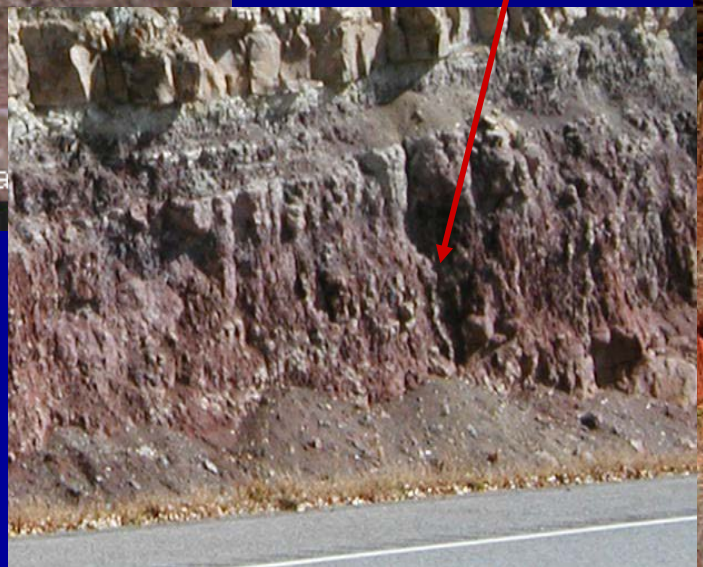


increasing grain size

increasing transport energy

- **Shale**
  - Most common sedimentary rock (50%)
  - Clay-sized particles, some silt.
  - Deposited in low-energy environment, settling out from suspension.
  - Often compacted to thin layering = laminae
  - Black shale is organic rich. Source of hydrocarbons.
  - Very weak in outcrop (recessive)

- **Siltstone**
  - Composed of silt-sized particles
  - Deposited in low to moderate energy environment.
  - Moderate resistance in outcrop (forms “badlands”)



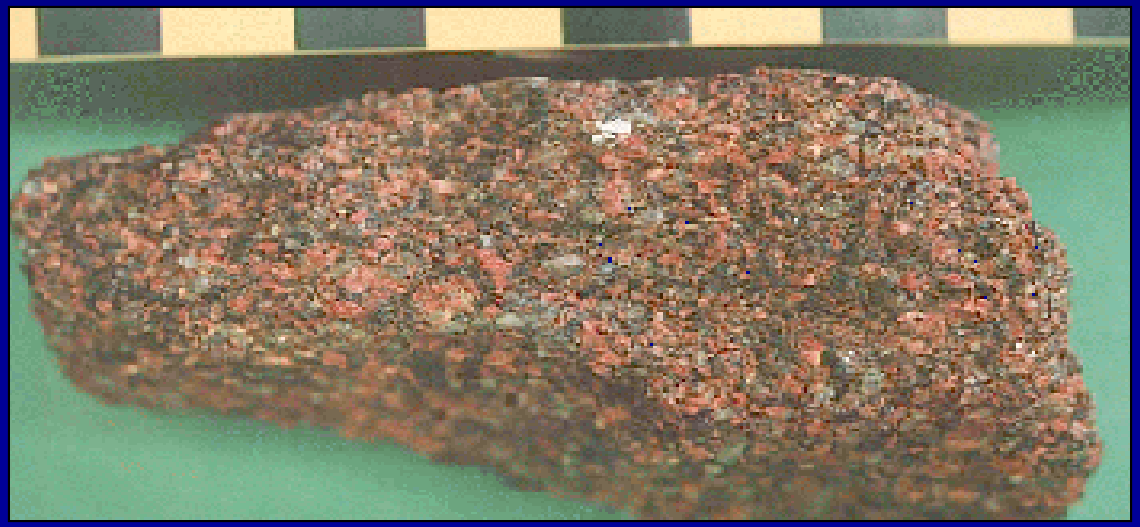
- **Siltstone**
  - **Sedimentary structures like mud cracks tell you about depositional environment of siltstone**

Silt in modern lake bed

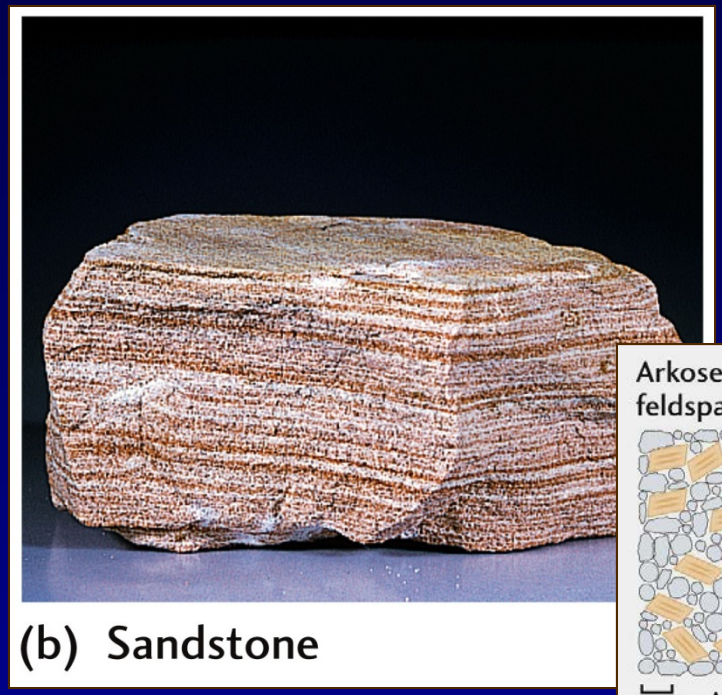
600 my old Precambrian silt*stone* in outcrop

- **Sandstone**
  - **Sorting of grains – tells you about transport medium**
  - **Shape of grains – tells you about distance of transport**
  - **rounded = more transport and abrasion**

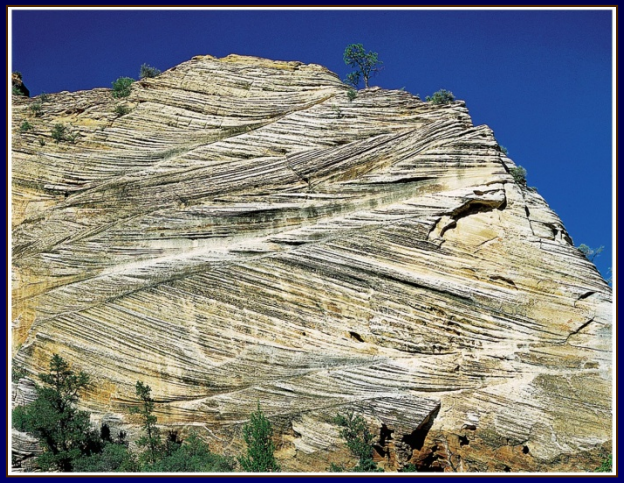
- **Sandstone**
  - **Composition** of the grains - tells you about distance of transport and the source terrain that they were eroded from.
    - Chemically **unstable minerals** like feldspars, mica, and ferromagnesian silicates **indicate short transport** distance from igneous source terrains
    - **Arkose**: sandstone with quartz, K-feldspar, muscovite indicates short transport from granite source terrain.

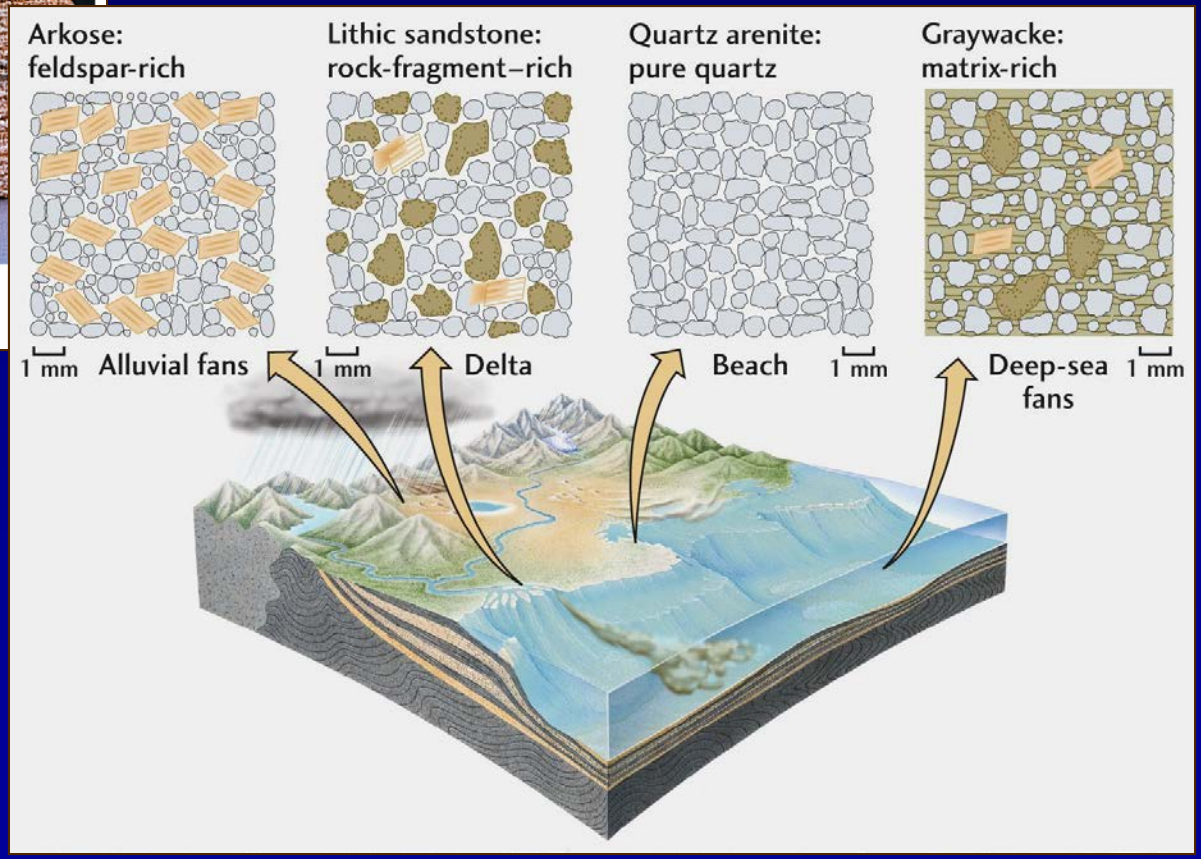


Sandstones



(b) Sandstone





- **Sandstone**
  - **Sedimentary structures like cross bedding and ripple marks tell you about depositional environment of sandstone**

Sand in modern beach trench

Cross bedding

500 my old Cambrian sand*stone* in outcrop

- **Sandstone**
  - **Sedimentary structures like cross bedding and ripple marks tell you about depositional environment**

Sand on modern beach

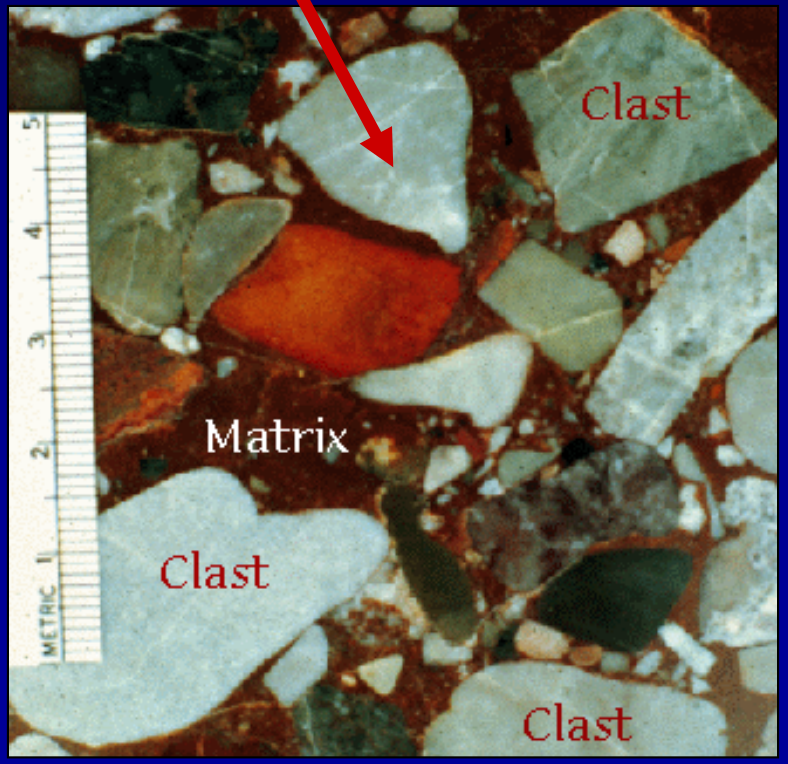
500 my old sand*stone* in outcrop

Ripple marks

Clastic sedimentary rock names

Conglomerate and Breccia

- **Pebble to boulder size requires very HIGH energy**
- **Conglomerate consists largely of rounded gravels**
- **Breccia is composed mainly of large angular particles**



Conglomerate

Close up

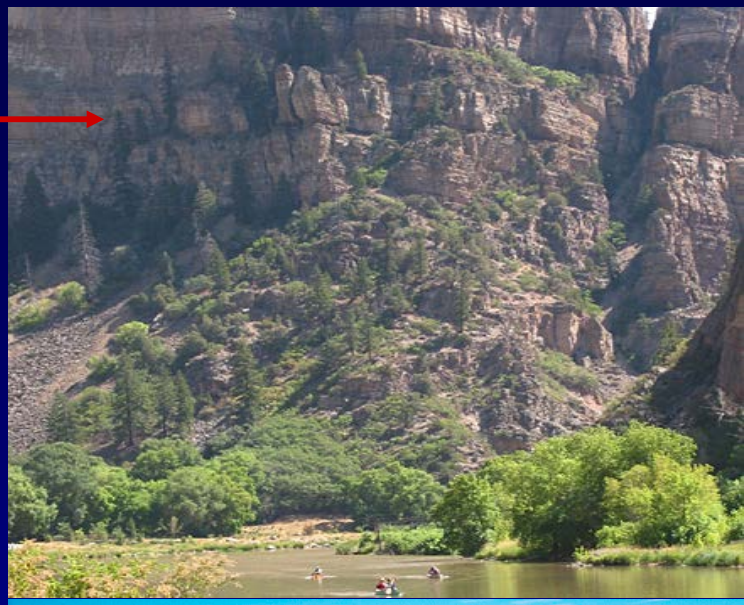
Breccia

Chemical sedimentary rocks

- Consist of precipitated material that was once in solution
- Precipitation of material occurs in two ways
  - Inorganic processes
  - Organic processes (biochemical origin)

Chemical sedimentary rock names

- Limestone
- Dolostone
- Chert
- Evaporites
- Coal



Chemical sedimentary rock names

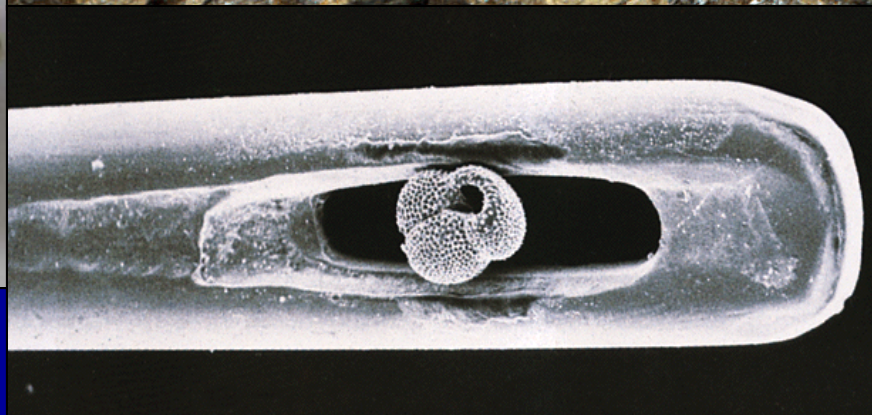
- **Limestone**
  - **Most abundant chemical sed. rock**
  - **Composed chiefly of the mineral calcite**
  - **Marine biochemical limestones form as coral reefs, coquina (broken shells), and chalk (microscopic organisms)**
  - **Inorganic limestones include travertine and oolitic limestone**

Chemical sedimentary rock names

- **Limestone**
  - Biochemical limestones: **coral reefs**

Chemical sedimentary rock names

- Limestone
  - Biochemical limestones: **coquina** (broken shells), and **chalk** (microscopic organisms)

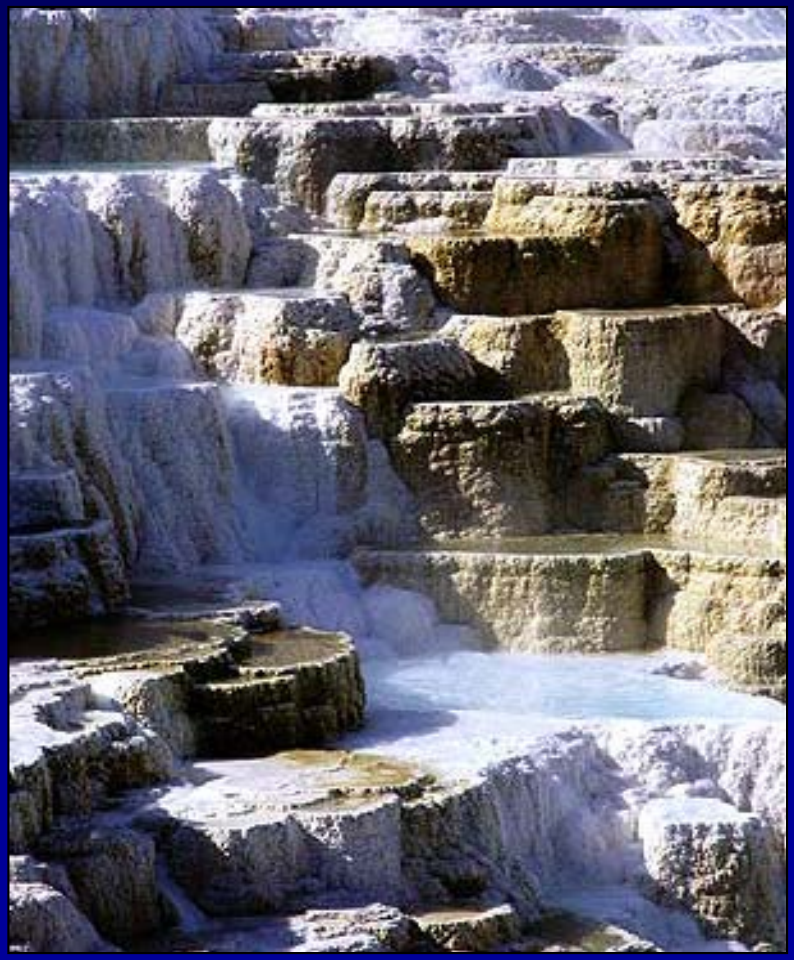


Chemical sedimentary rock names

- **Dolostone**
  - **Alteration of limestone from infiltrating magnesium-rich waters. $CaCO_3$ changes to $Ca,MgCO_3$.**
  - **Importance is that it is harder and doesn't dissolve as readily as limestone.**

inorganic limestone

– **travertine** – **inorganic** limestone formed by precipitation of calcium carbonate from solution in caves & thermal springs



minerals in solution from groundwater

$CaCO_3$ in mineral springs.

Chemical sedimentary rock names

- **Chert**
  - Chemical sedimentary rock made up of microscopic quartz
  - Varieties include flint (black), jasper (red), agate (banded)
  - Important tool material for neolithic cultures.

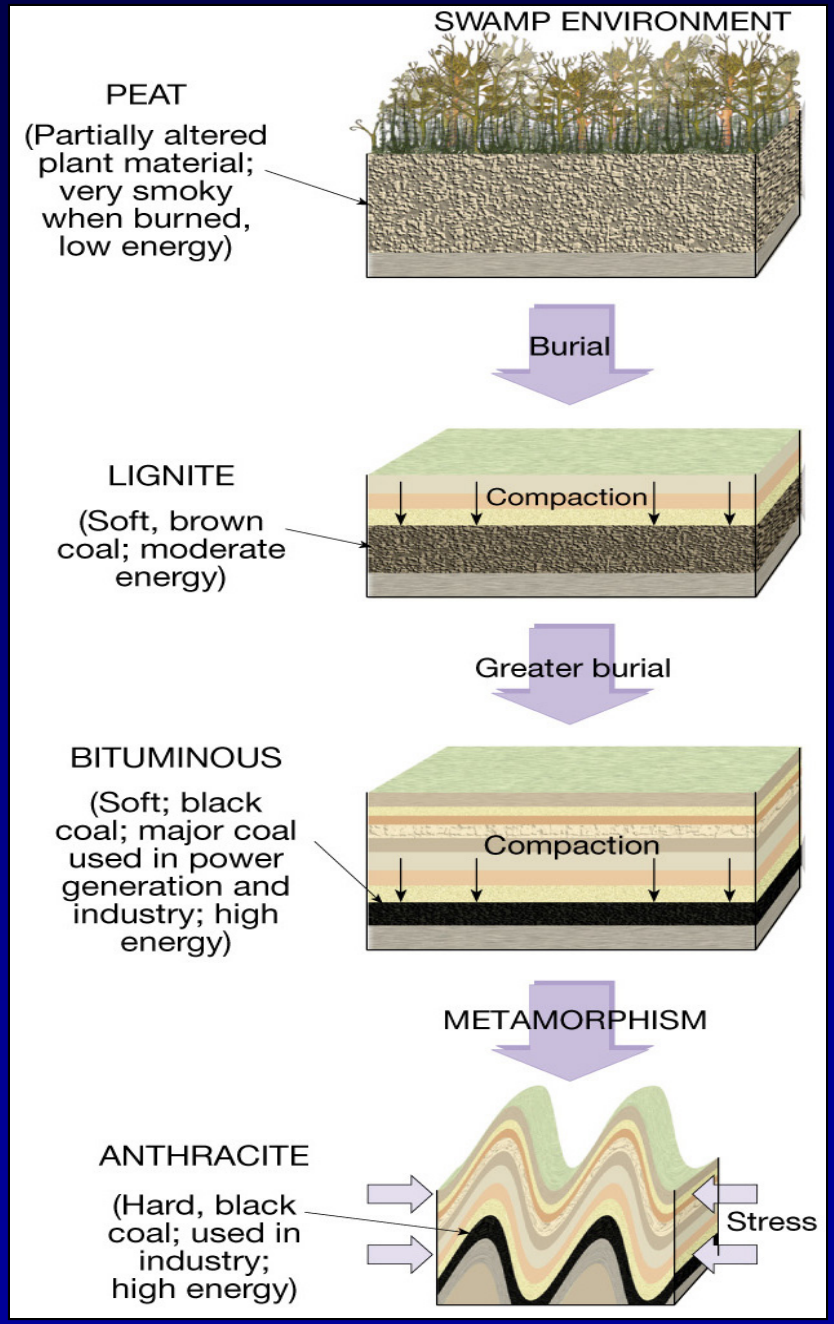
Chemical sedimentary rock names

- **Evaporites**
  - Evaporation leads to supersaturation and precipitation
  - Definite order as a lake dries up: Gypsum* first, Halite (rock salt) second, sylvite (salt substitute (KCl) last

Chemical sedimentary rock names

- **Coal**
  - Made up of organic molecules - hydrocarbons. Different from organic limestone which is 100% calcite, an inorganic mineral.
  - Coal Stages:
    1. Plant material
    2. **Peat**
    3. **Lignite**
    4. **Bituminous**

Increasing Heat & metamorphism



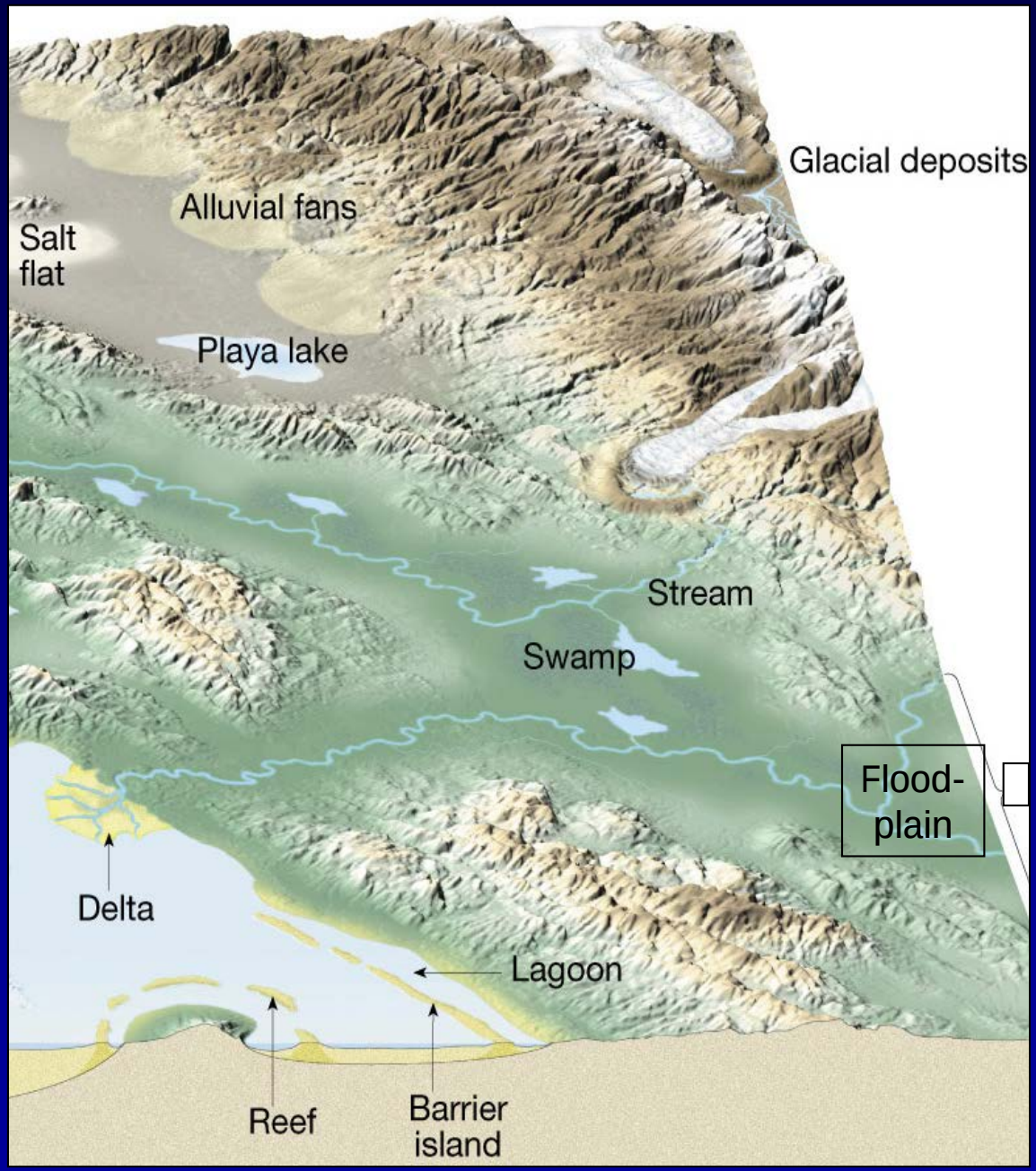
Sedimentary environments

- The geographic setting where sediment accumulates. Determines the nature of the sediments – grain size, sorting or chemical composition.
- Types of sedimentary environments
  - Continental
  - Transitional (shoreline)
  - Marine

Continental depositional environments

Dominated by:

-Erosion
-Stream deposition
-Glacial deposition
-Wind deposition (eolian)

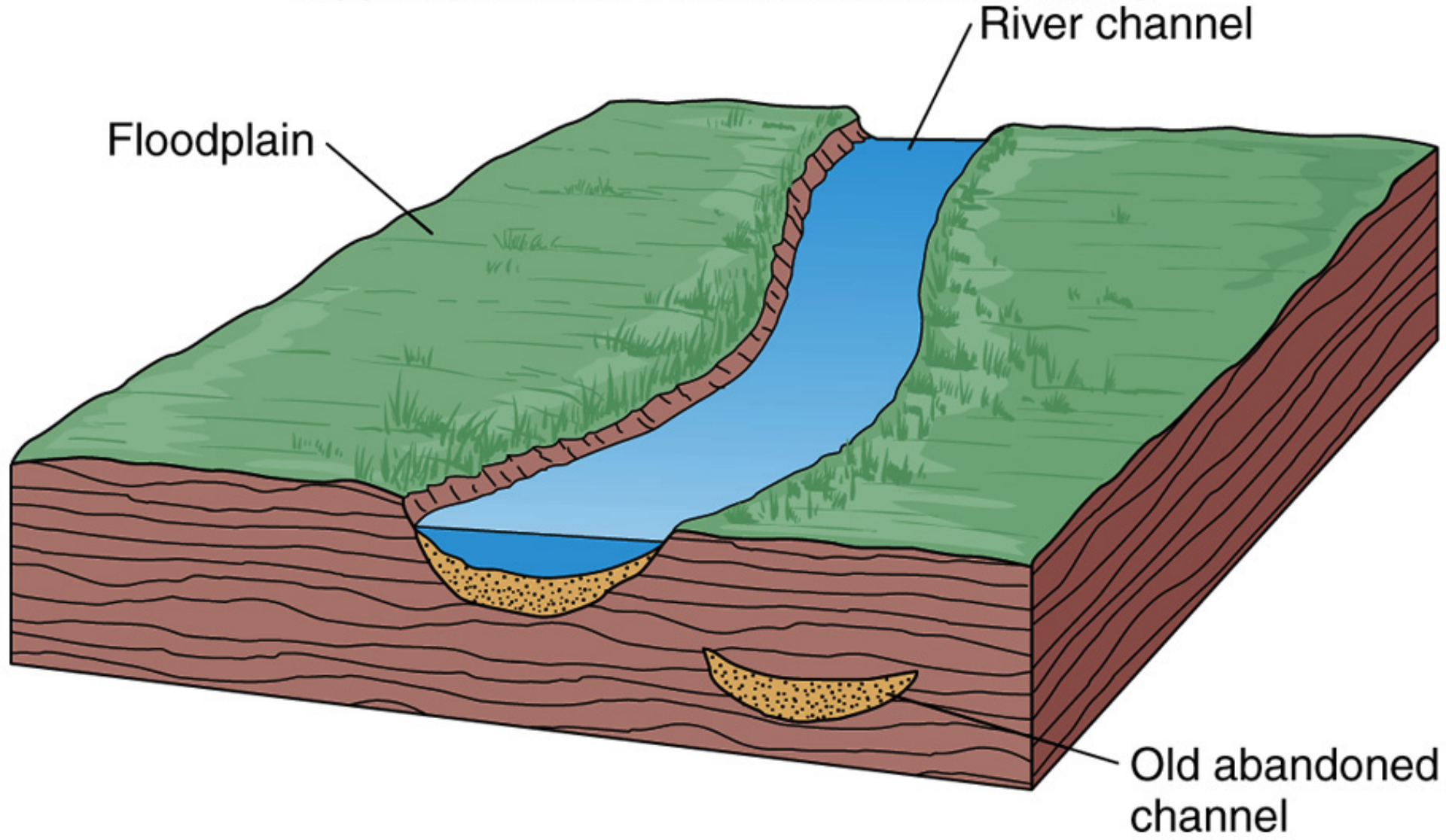


Sedimentary Environments

Continental environments of deposition

- Lakes (lacustrine)
- Alluvial systems
- Deserts/dunes
- Glacial outwash

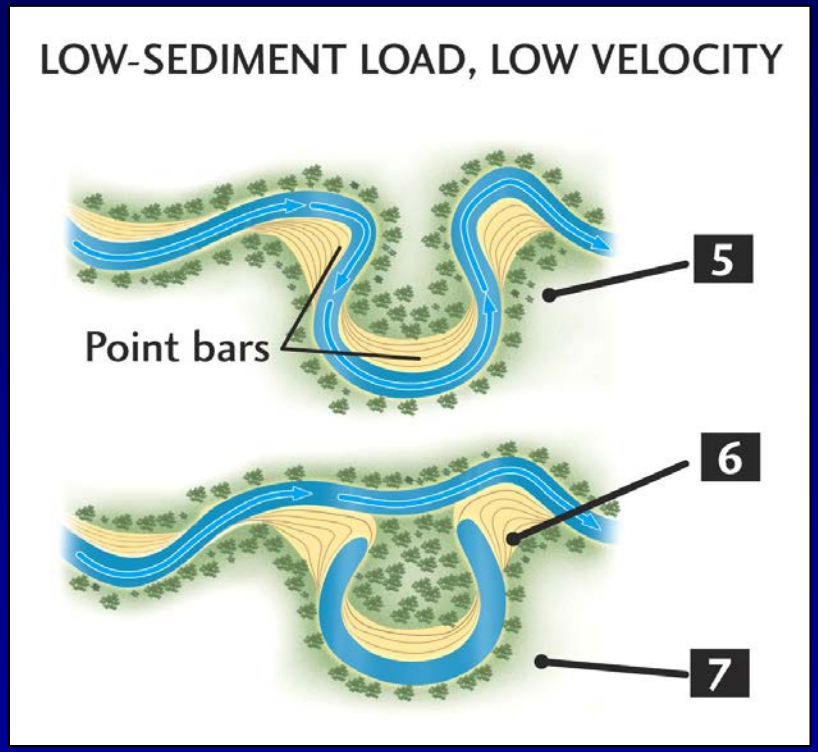
River

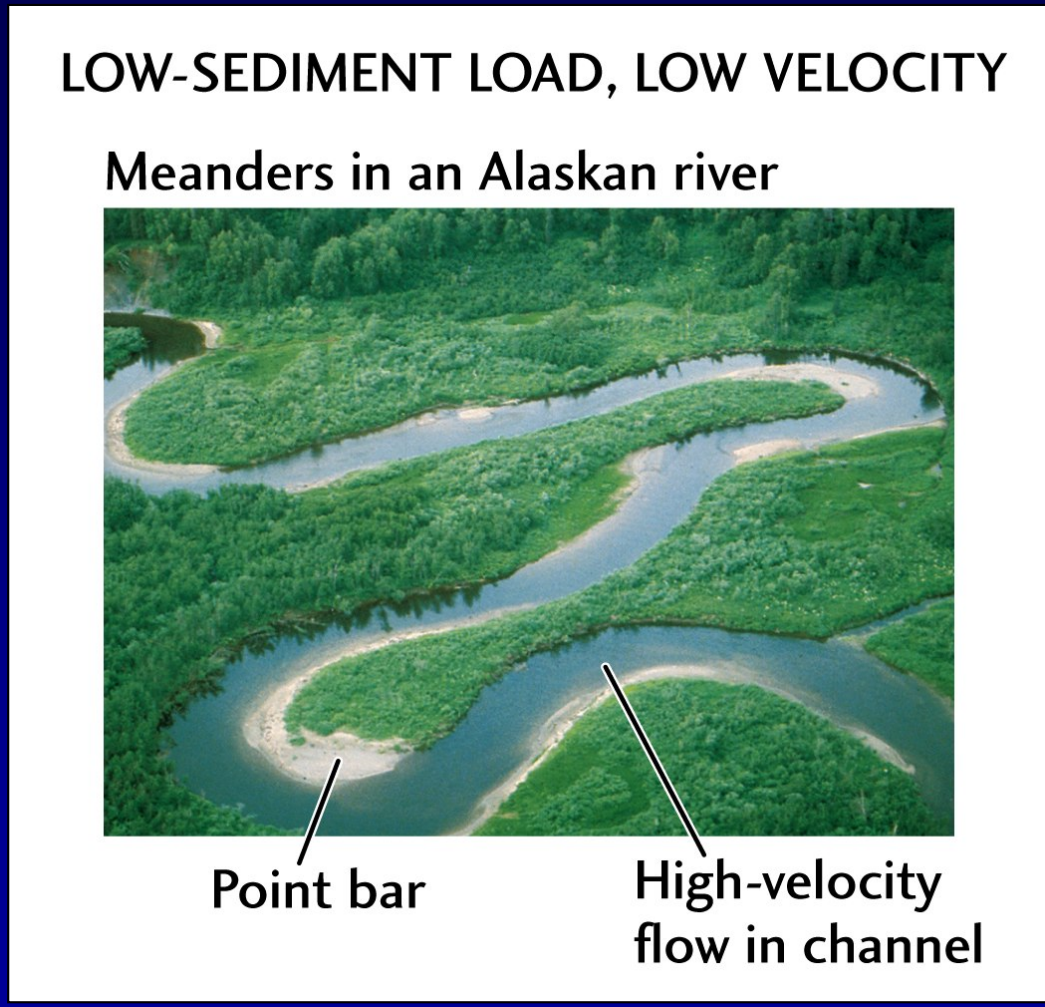


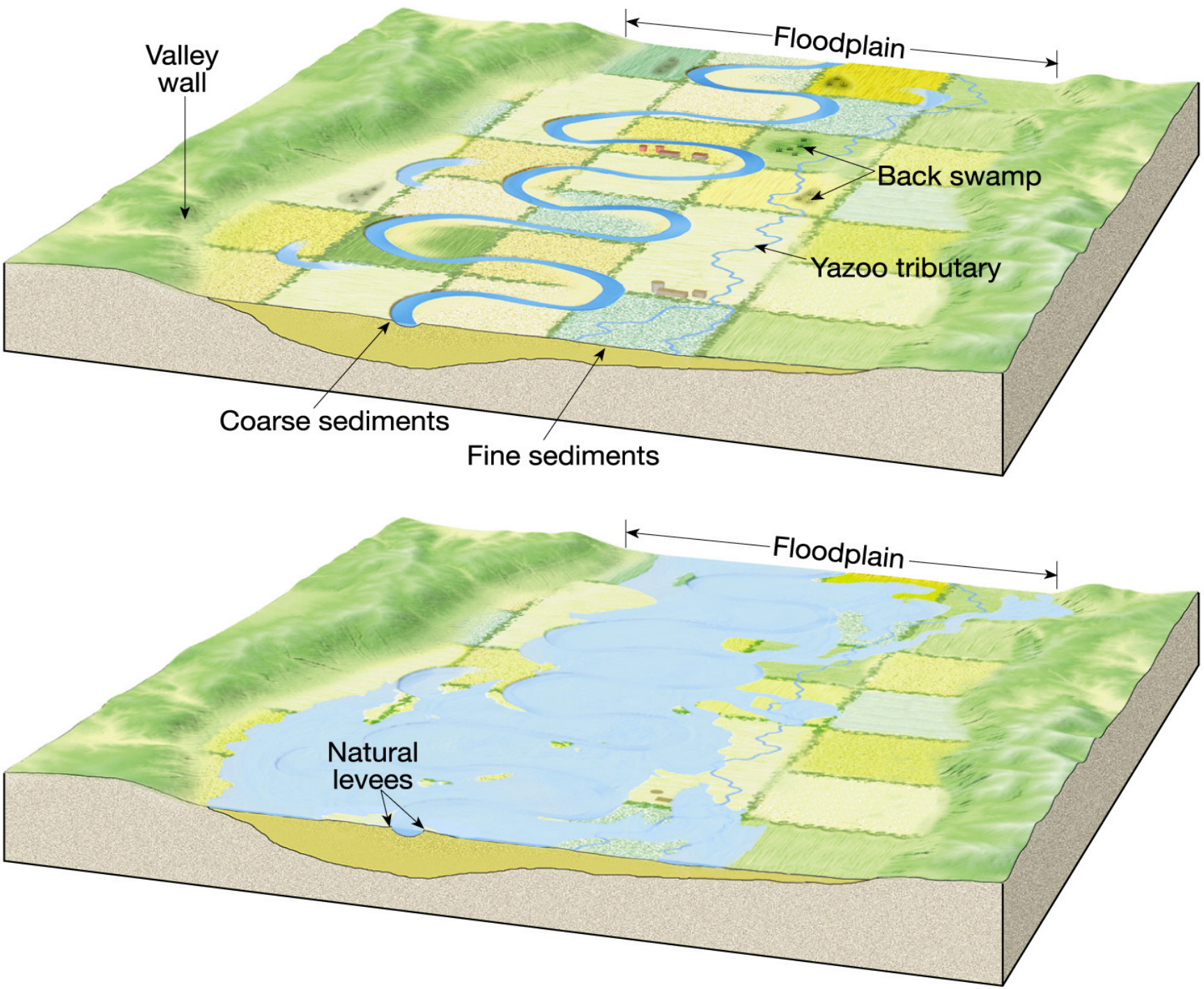
River sedimentation

Channel in-filling

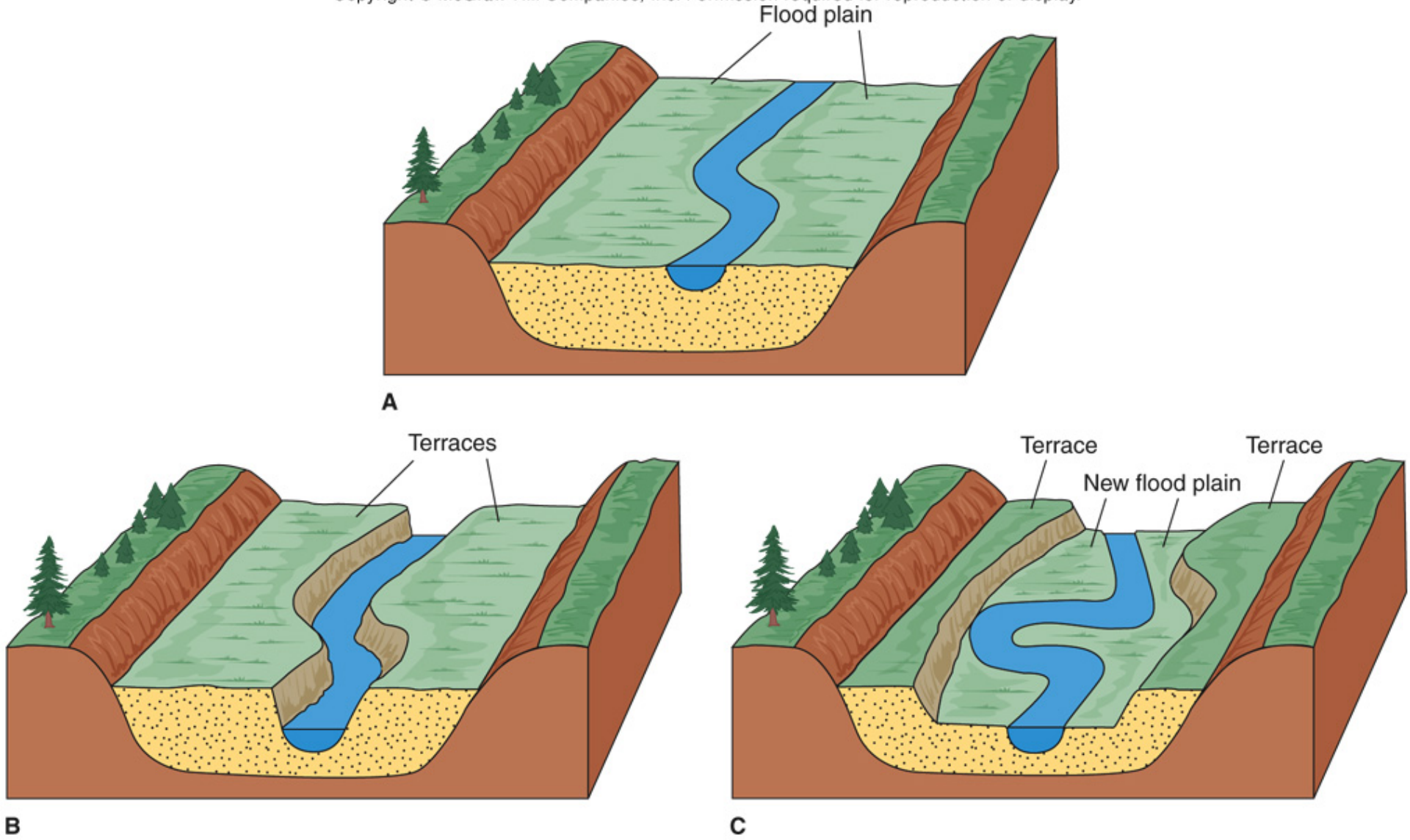
Meandering Rivers






Floodplain
Valley wall
Back swamp
Yazoo tributary
Coarse sediments
Fine sediments
Floodplain
Natural levees

Formation of terraces



River terraces

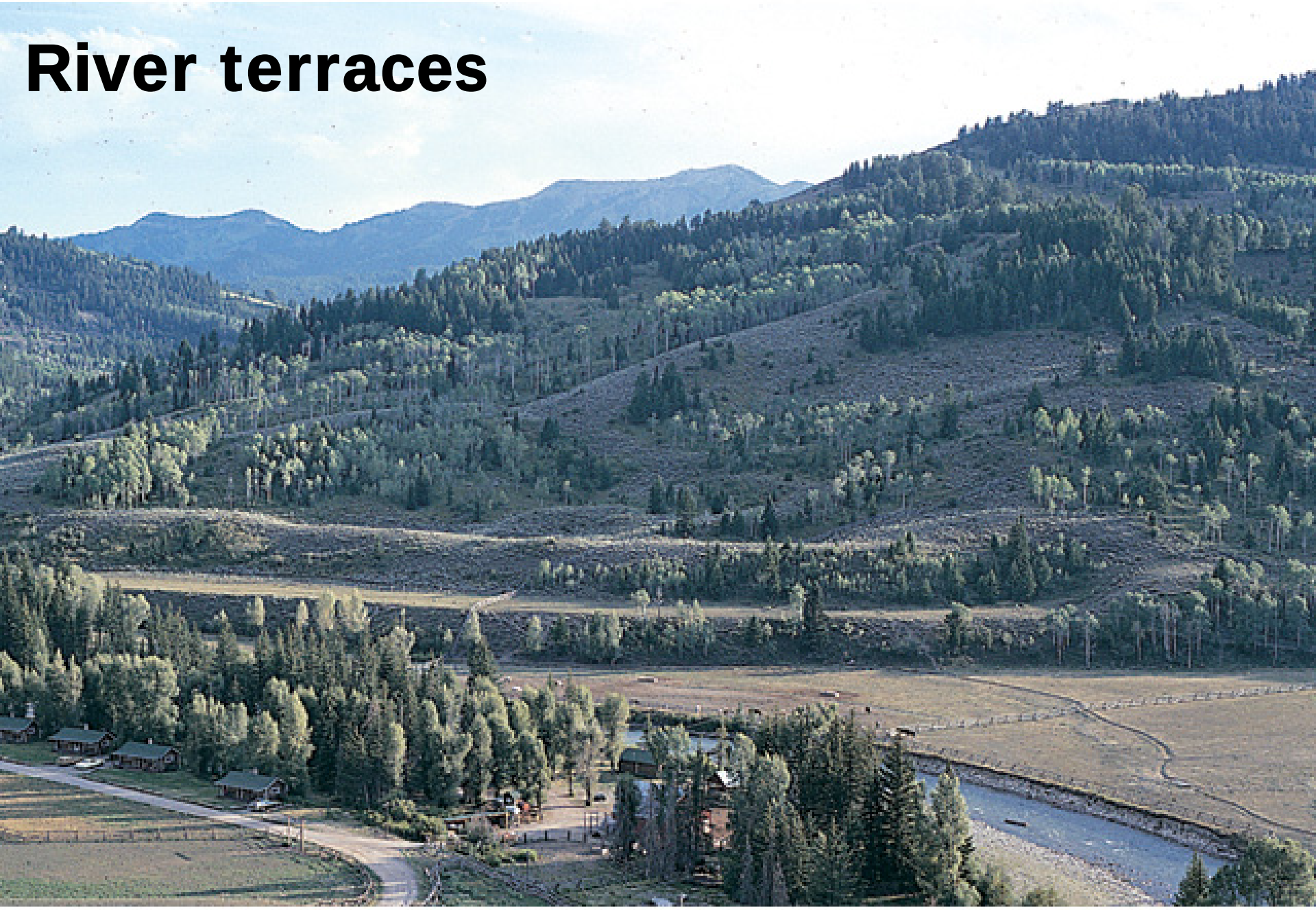


Photo by Diane Carlson

Channel Types

- **Braided streams** – Occur where sediment load exceeds competence or capacity
  - -where steep sediment-laden tributaries enter main streams
  - -places with rapid gradient decrease, such as where mtn. stream enters plain
  - -in front of glaciers
  - **Form longitudinal bars** – deposited in middle rather than at points in river, with bar long axes ~parallel to river banks.

Alluvial Fans

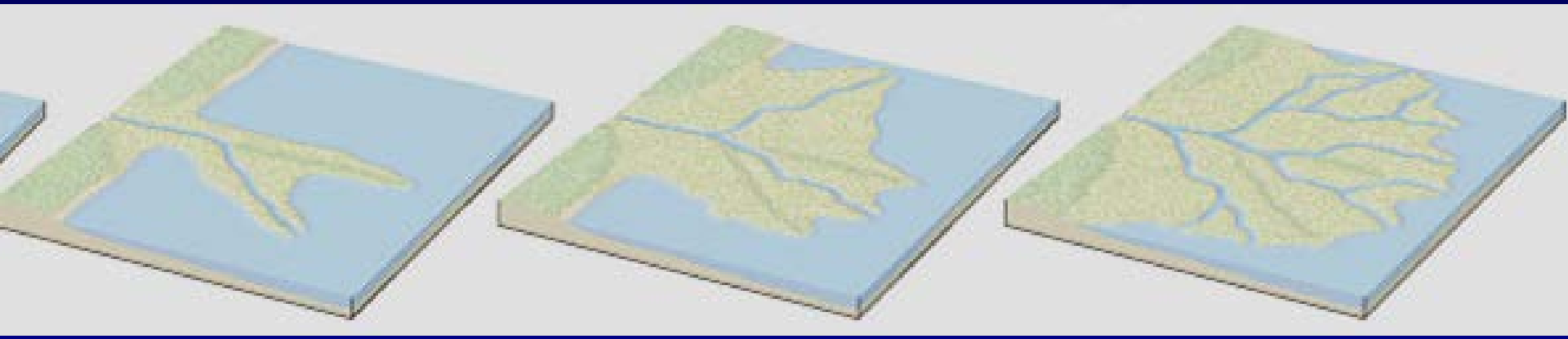
- **Alluvial fans – arcuate "fan-shaped" deposits of coarse material that form where a high-gradient stream enters a low gradient main valley.**
  - **Represents an instantaneous drop in competence and capacity.**

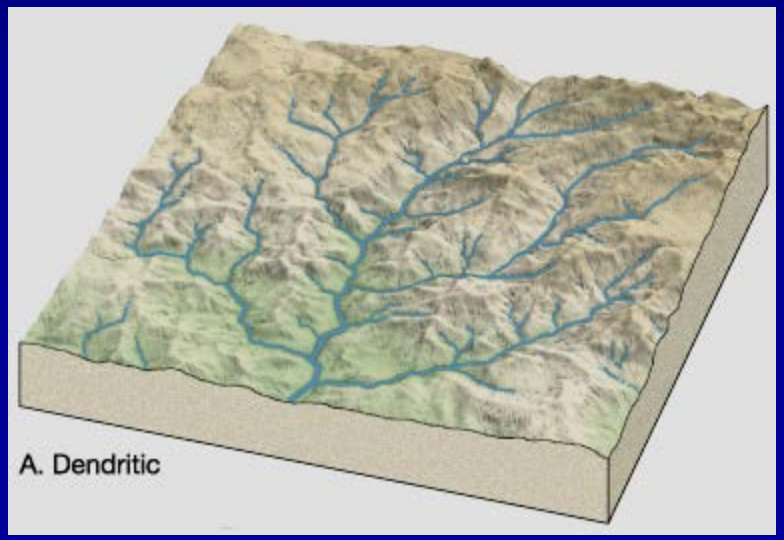
Deltas

- **Deltas – arcuate "delta-shaped" landforms that form where a stream or river enters a standing body of water.**
  - **Represents an instantaneous drop in competence and capacity.**

Delta Components in Map View

- **Disributaries** – **Note that the branching pattern is opposite of most stream channels which branch *upstream***





Marine depositional environments

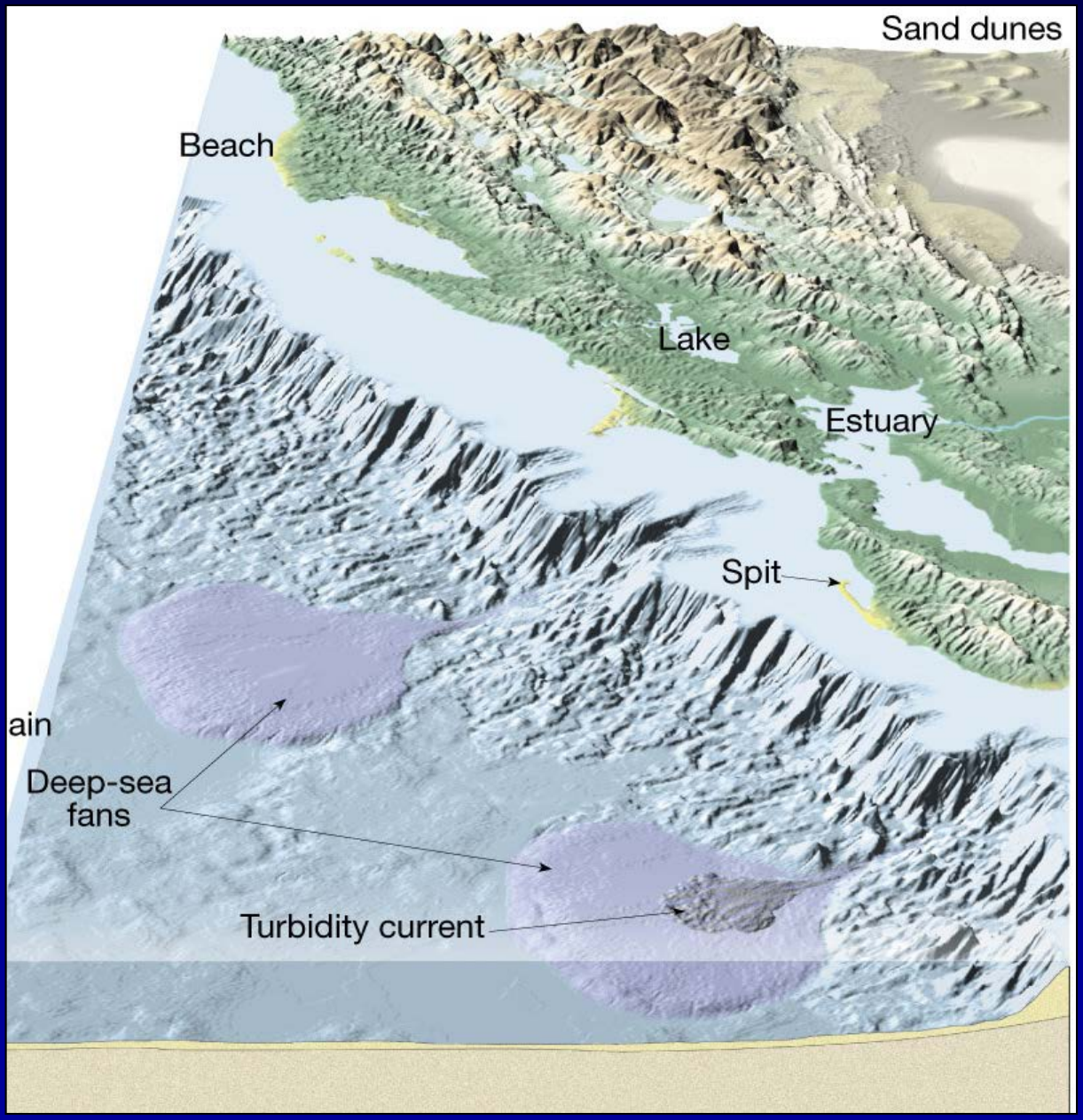
Main Divisions:

-Shallow (<200 m)
coral reefs

sandy near river mouths

-Deep Water
mainly shale

deep water sandstones in deep sea fans



Sedimentary Environments

Marine environments of deposition

- Continental shelf
- Reefs
- Continental rise
- Deep sea

Transitional depositional environments

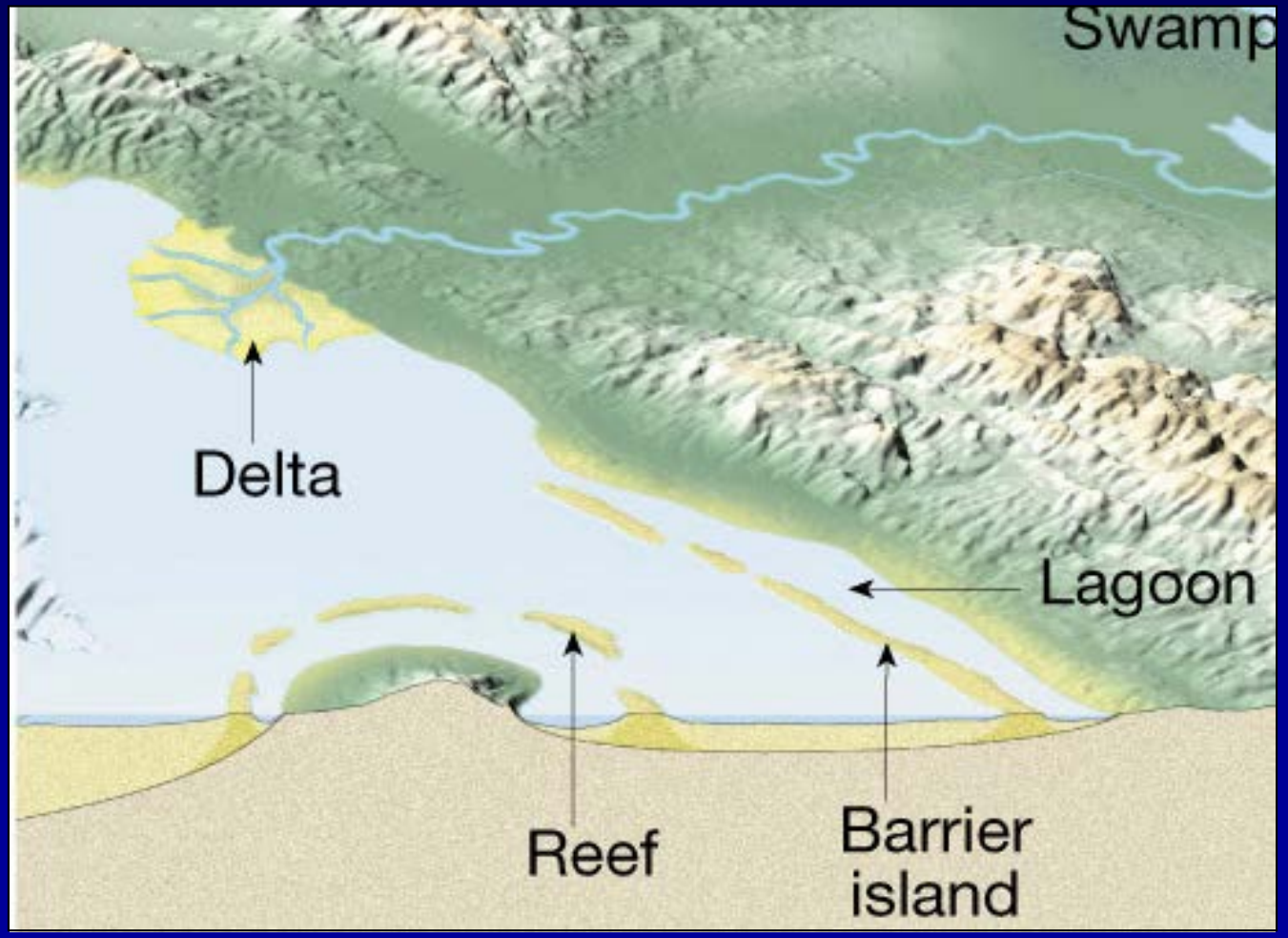
At interface of land and ocean:

-beaches, barrier isl.

-tidal flats

-deltas

-lagoons



Sedimentary structures

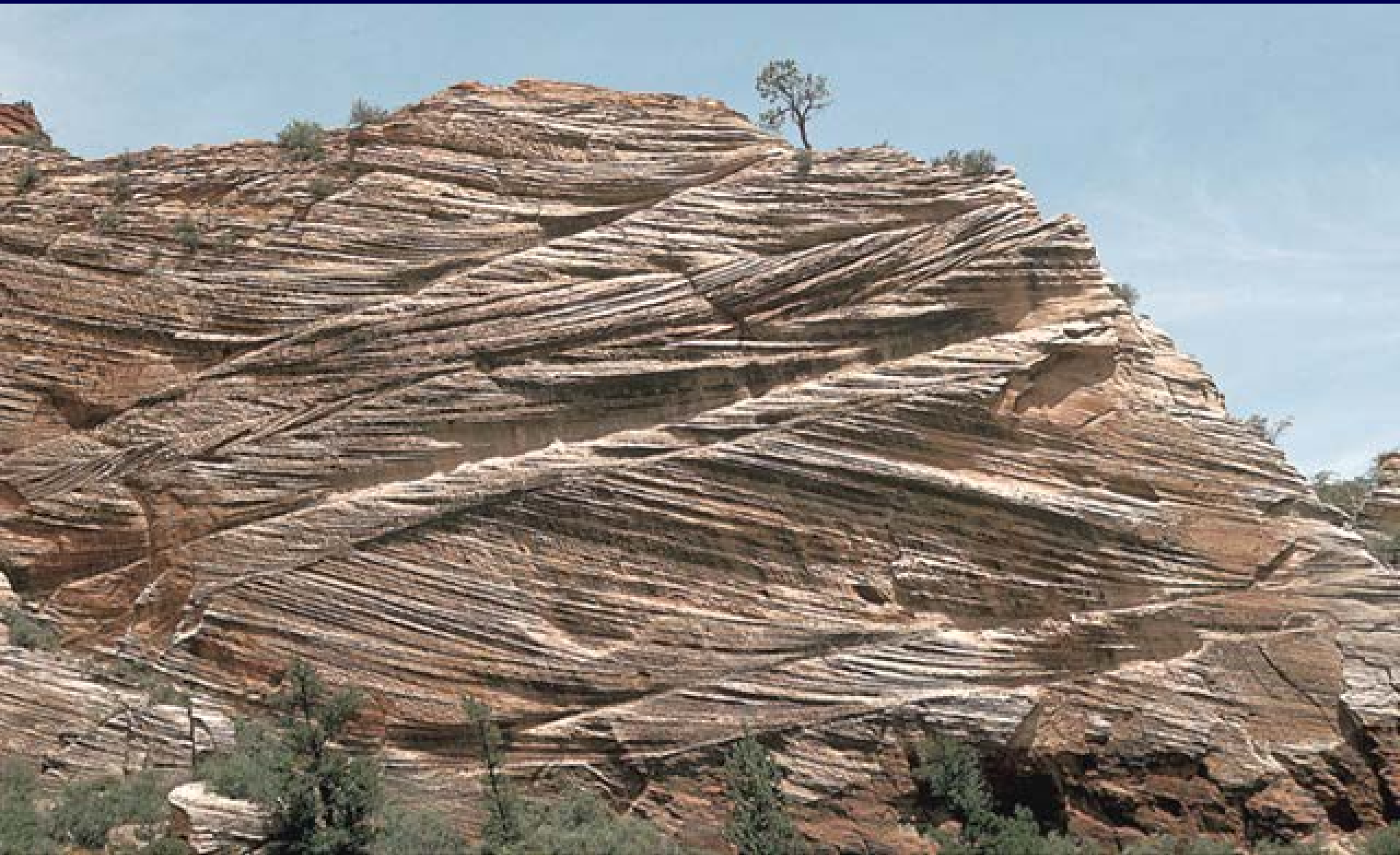
- BEDDING-
  - Bedding plane
- Principle of Original Horizontality

Law of original horizontality

Bedding planes

strata

Cross bedding

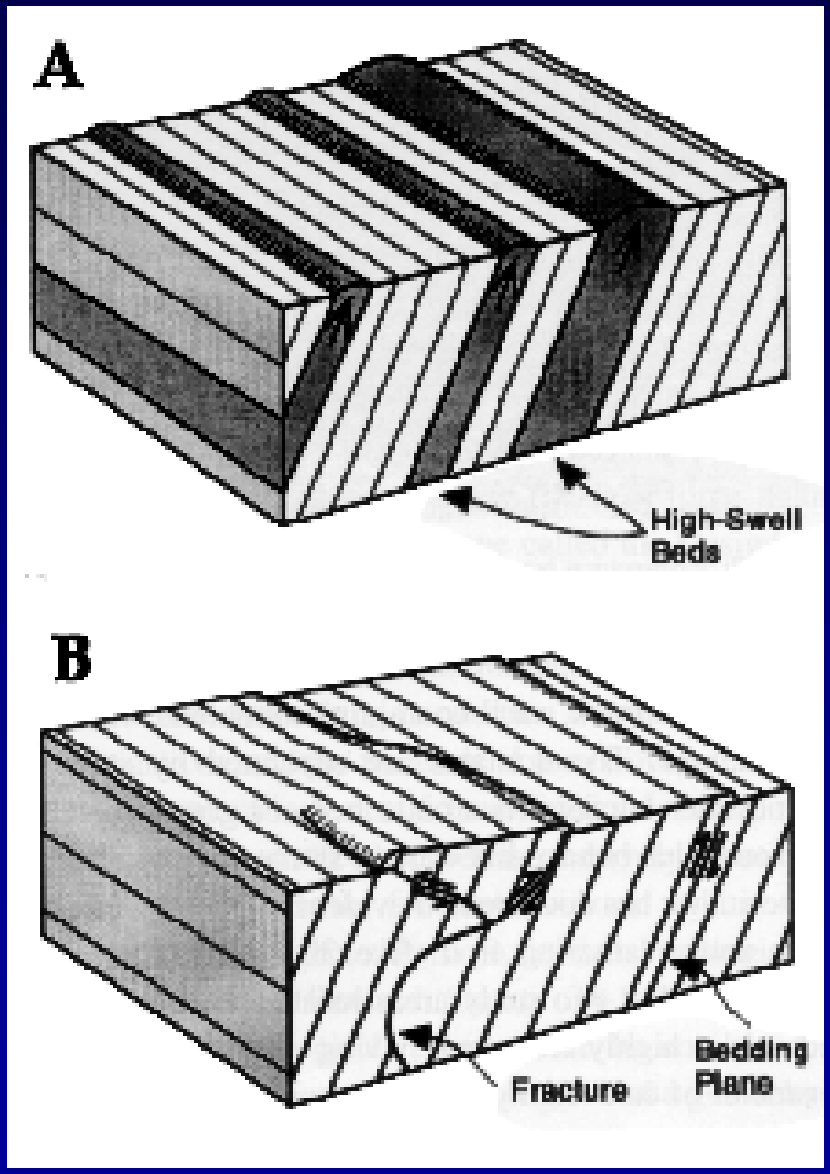


Engineering – Sed Rx

- *Sandstones and conglomerates*
  - Variability
  - Cement
  - Structure
  - Deposit boundaries
  - Permeability
  - Rippability

Engineering – Sed Rx

- *Shales and Mudstones*
  - Variability- Gas?
  - Compactability
  - Structure
  - Deposit boundaries
  - Permeability
  - Slake
  - Heave



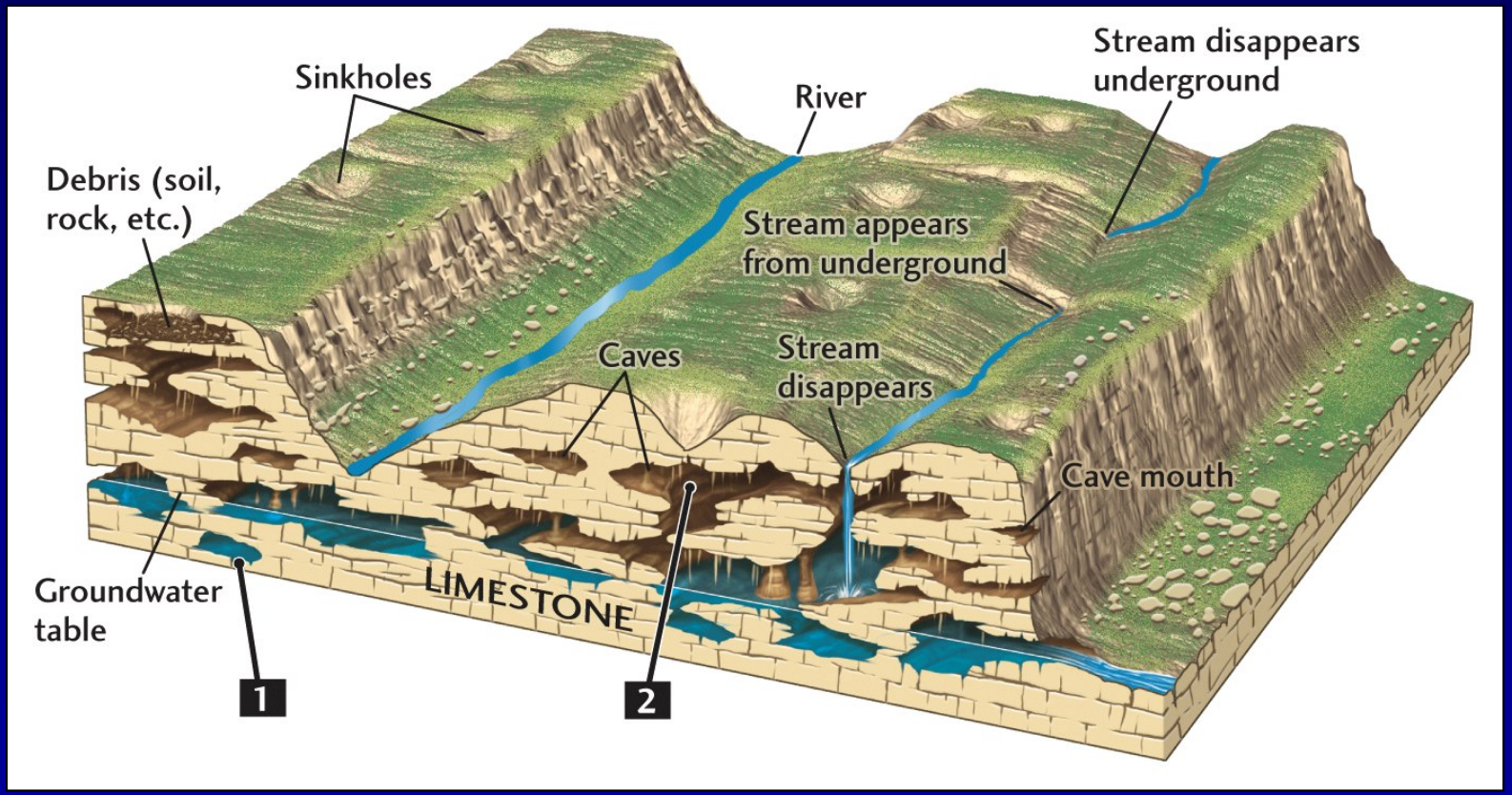
Interbedded nature

Chemical Sed Rx

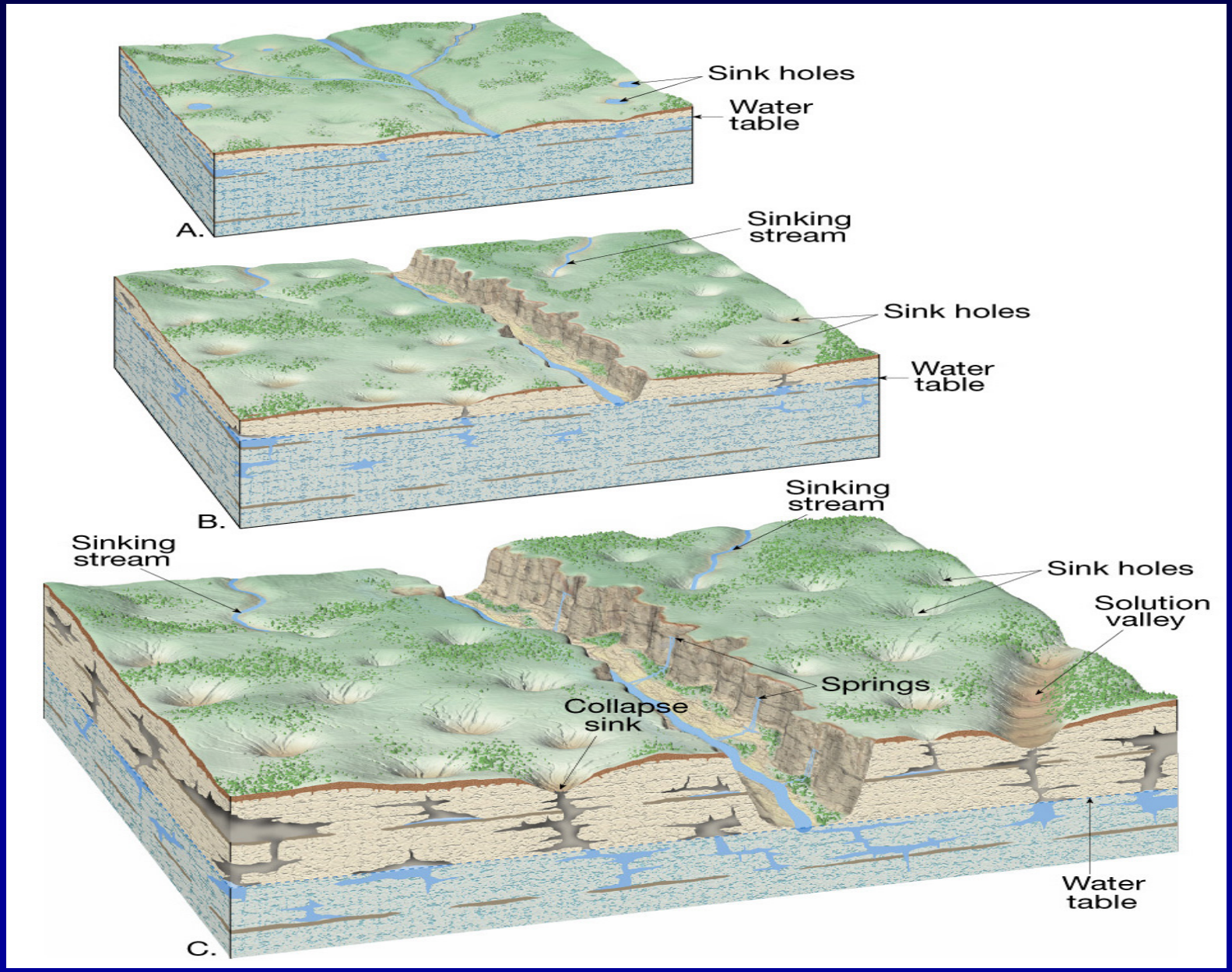
- Surface and underground
- Development of Karst topography
- Evaporites – gypsum/anhydrite and halite

Karst Topography

- **Dissolution of carbonate rocks**

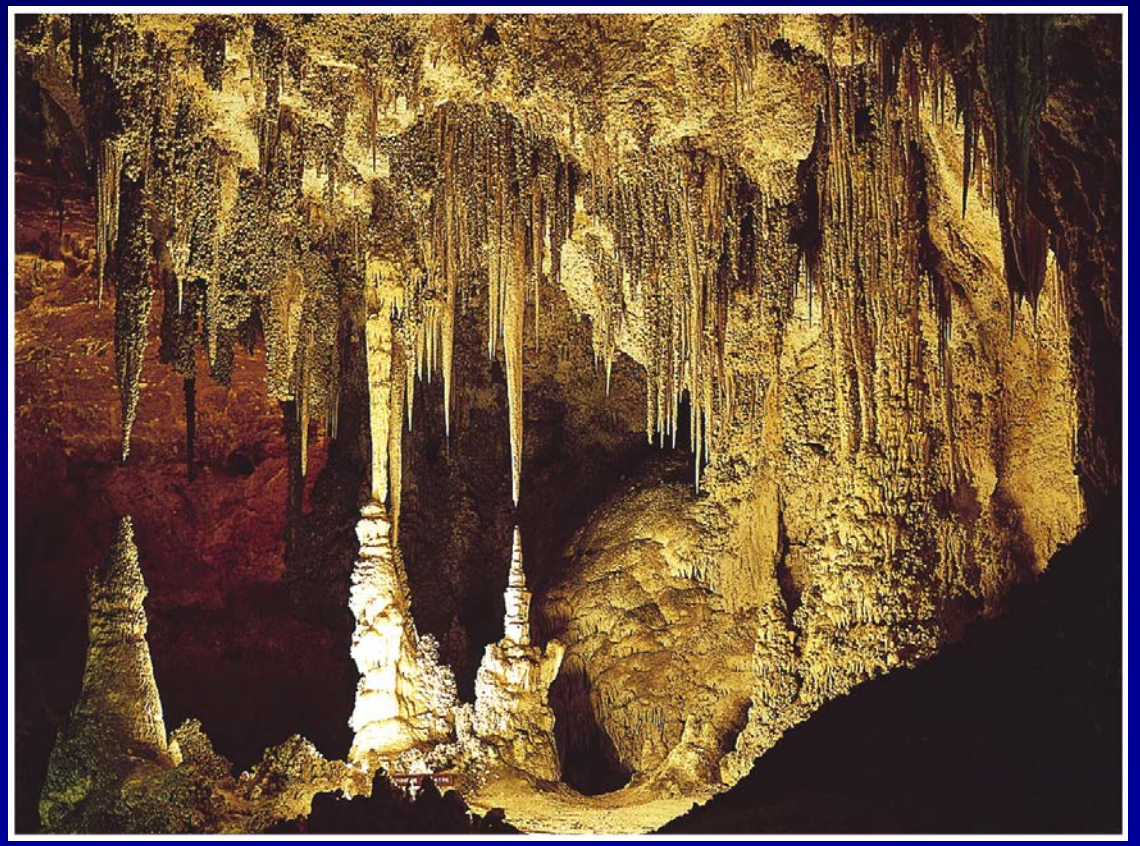


Development of karst topography



Karst Topography

- Limestone caves
- Sinkholes



Development of karst topography

Engineering- Chem Sed Rx.

- Dissolution
- Plastic deformation
- Voids, cavities, caves
- Groundwater
- Variability
- Interbedded