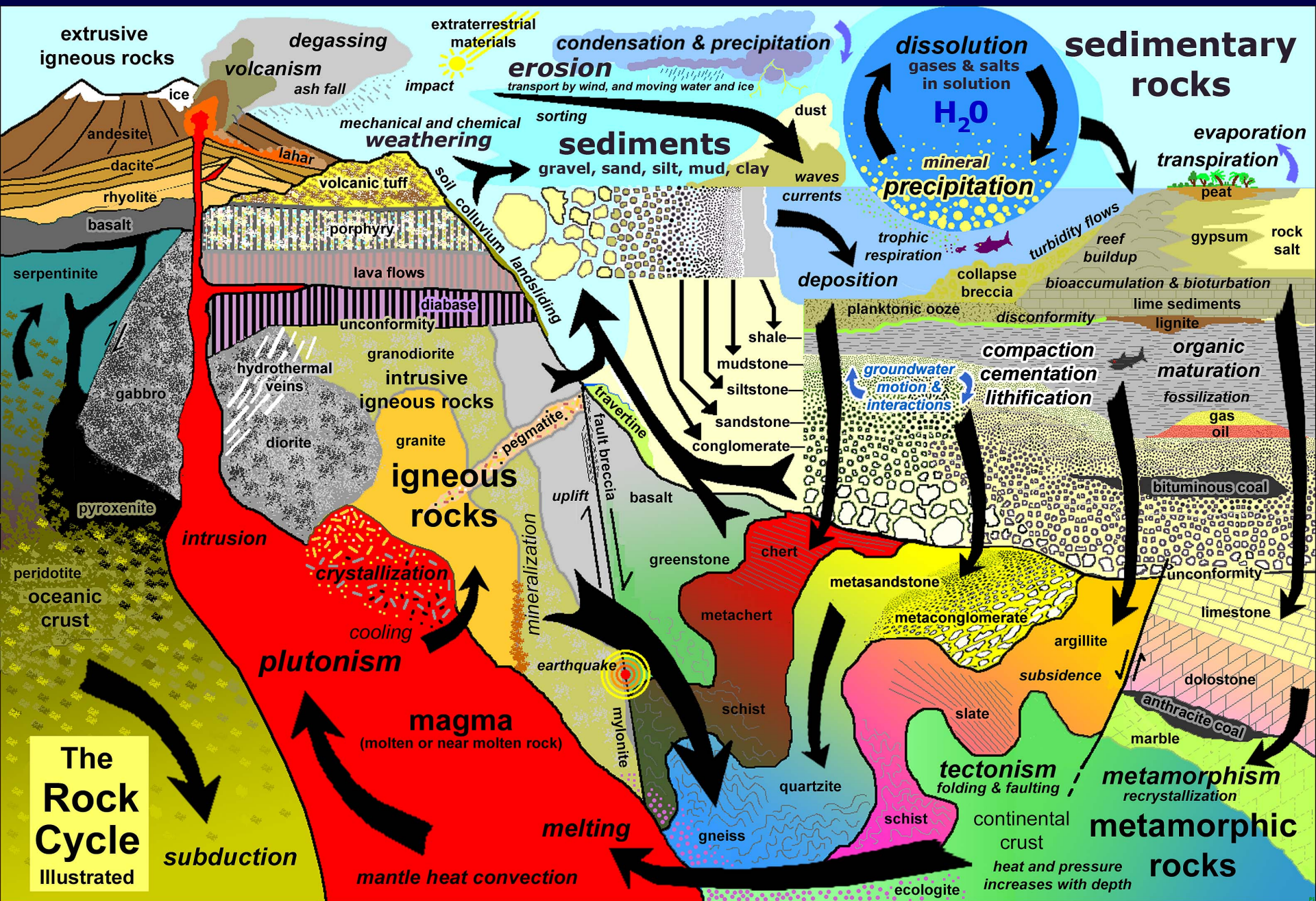




Sedimentary Rocks

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)

Weathering



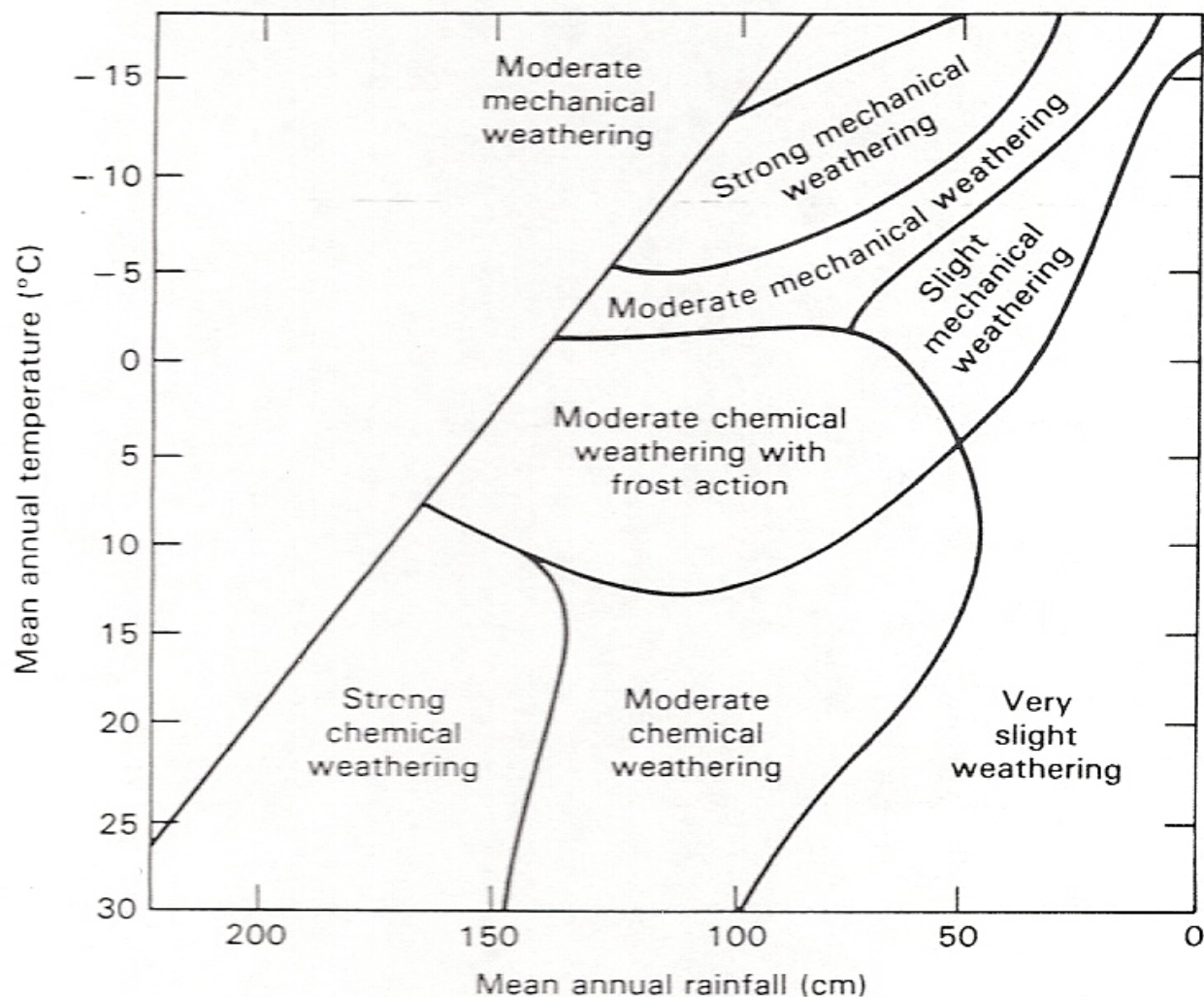


Figure 9-1 Climatic influences on types of weathering processes. (From Peltier, 1950; reproduced by permission from the *Annals of the Association of American Geographers*, 40:219, Fig. 3.)

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:

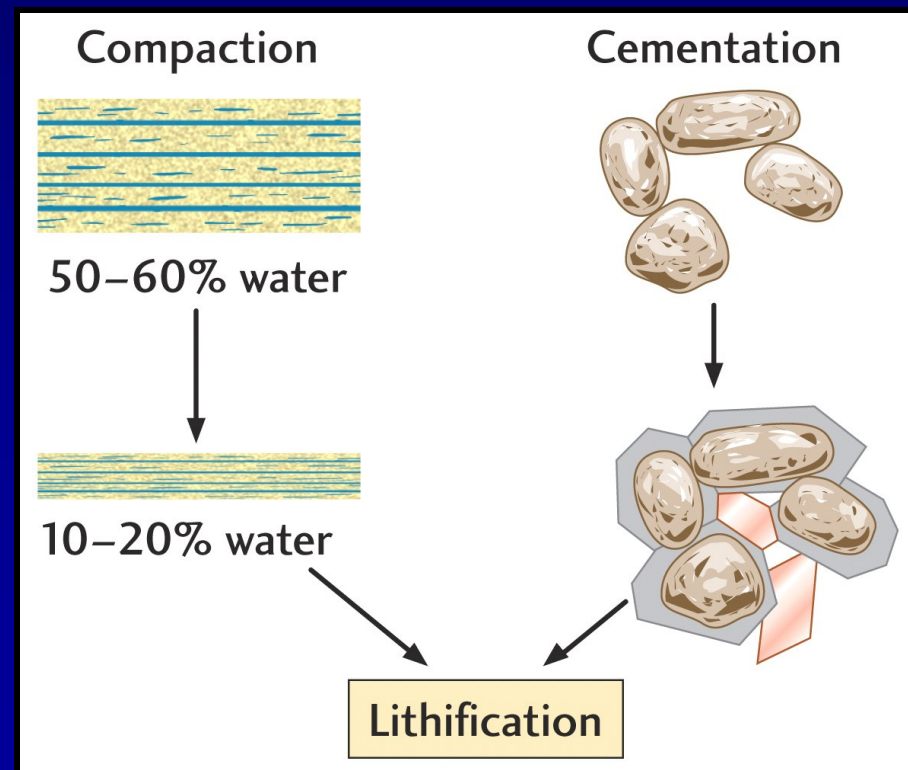
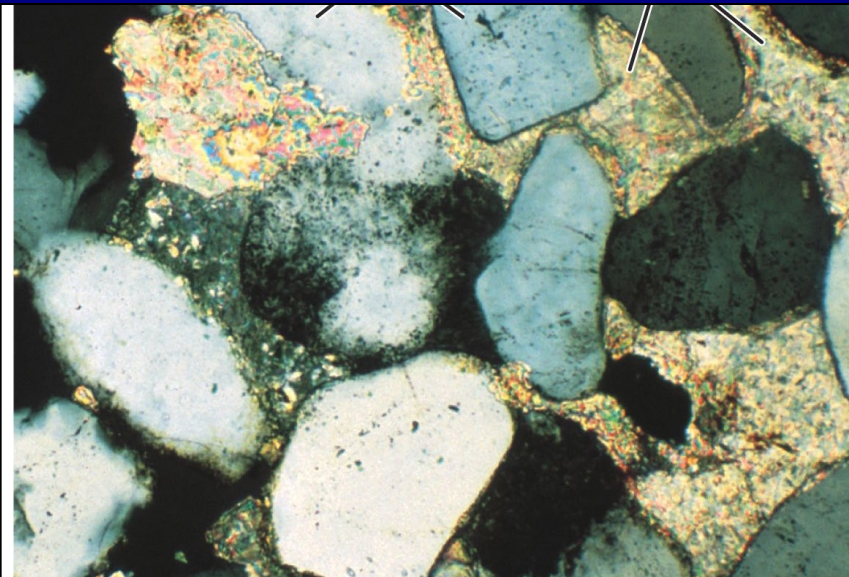
- Weathering of rocks (mainly continental rocks)
- The remains of small skeleton building organisms
- Inorganic crystals that precipitate from solution

Sediments

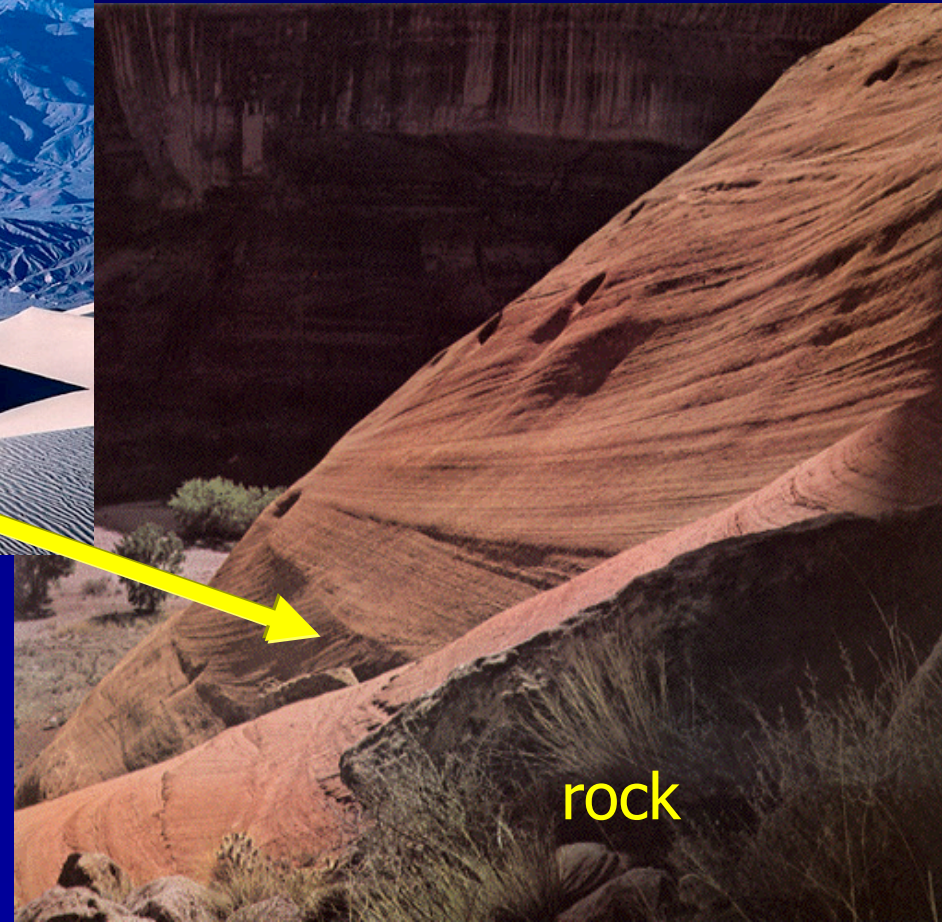
- Sediments are small pieces rocks (or minerals) from other rocks
- Sediments are transported and deposited by erosional processes
- Sediments go through the process of **lithification** to become sedimentary rocks

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**

CLASSIFICATION OF SEDIMENTARY ROCKS

Rocks are formed at or near the surface of the earth. Most sediments are deposited in beds or layers by water or wind as weathering (erosion). Sedimentary rocks can be classified on the basis of origin as clastic, chemical precipitates, or organic.

Clastic rocks are composed of rock fragments or mineral grains broken from any type of pre-existing rock. Precipitated rocks may result from chemical precipitation from fresh or salt water. Organic sediments may form from either plant or animal particles. There is a large variety of

sedimentary rocks but approximately 98% of all sedimentary rocks are composed of various types of shales, sandstones, and limestones. Shale is the main weathering product of the feldspar and is the most abundant of the minerals.

CLASTIC		CHEMICAL		ORGANIC
Conglomerate - Composed of rounded rock fragments of 2mm, pebbles and up and have a sandy matrix.	Conglomerate	Limestone - A fine to coarse-grained bedded rock consisting essentially of the mineral calcite (calcium carbonate).	Limestone	Bituminous Coal - Black with a dull luster, sometimes referred to as soft coal and accounting for about 90% of all coal mined. Contains approximately 50% fixed carbon.
Sandstone - Sandstones may be subdivided according to composition and texture. Particle size range 1/6 to 2mm. Quartz grains are the dominant mineral.	Sandstone	Dolomite - A fine to coarse-grained bedded rock consisting essentially of the mineral dolomite (calcium, magnesium carbonate).	Dolomite	Lignite Coal - Usually brownish in color with a relative low content of fixed carbon, compacted from beds of peat and other organic debris.
Siltstone - In general this group is composed of the same minerals as the sandstone; sizes range from 1/256 to 1/16mm.	Siltstone	Travertine - A general term for massive, non-crystalline calcite as found in caves, usually opaque and often colored.	Travertine	Asphaltum - A completely organic deposit of solid hydrocarbons.
Shale - Clay size particles, less than 1/256 mm, characterize the clays. Bedding planes are usually apparent.	Shale	Calcareous Tufa - A light, porous limestone formed in springs as deposits on water plants, twigs or debris.	Calcareous Tufa	Fossil Limestone - A fine to coarse-grained bedded rock consisting essentially of calcium carbonate often with identifiable fossil shells.
Ferruginous Sandstone - the cementing material of the sandstone particles will often impart a reddish color to the rock. Iron oxides may be red or yellow.	Ferruginous Sandstone	Rock Gypsum - Fine-grained or coarsely crystalline, consisting of the mineral gypsum, a residue from saturated sea waters.	Rock Gypsum	Coquina - A highly porous and loosely cemented formation of shells and fragments mainly calcium carbonate.
Breccia - The fragments which are re-cemented are sharp and angular. They may have many different origins.	Breccia	Rock Salt - Transparent to white or gray crystalline rock composed essentially of the mineral halite (sodium chloride).	Rock Salt	Chalk - A limestone deposit, calcium carbonate, made up primarily of tiny protozoan shells.
Arkose - Particles are similar in size to sandstone or somewhat larger and are composed of over 20% feldspar.	Arkose	Chert - A fine-grained compact rock composed mainly of chalcedony.	Chert	Oil Shale - This shale may contain a higher percentage of calcium compounds than silica shales and has entrapped plant and animal remains related to petroleum.

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

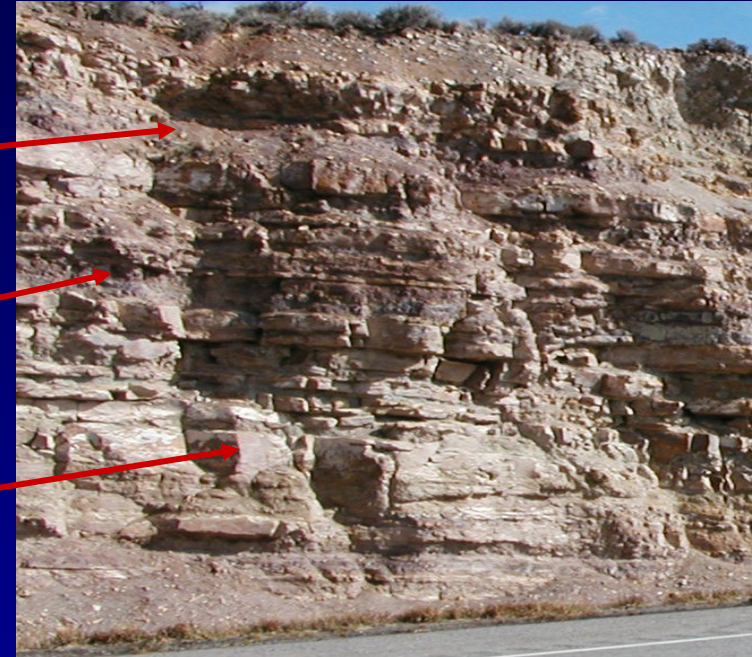


Clastic sedimentary rock names

- Named according to **particle size**.

Fine to Coarse:

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



increasing grain size – pebble to boulder 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”)



■ Sandstone

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

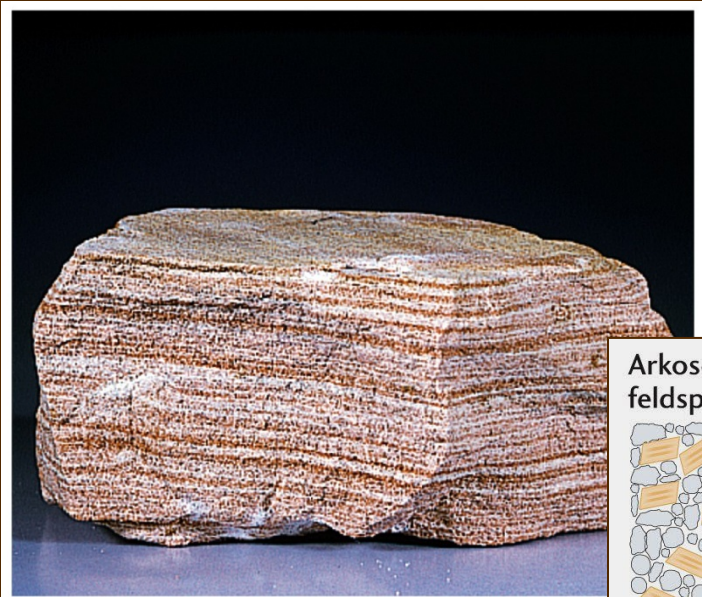


■ Sandstone

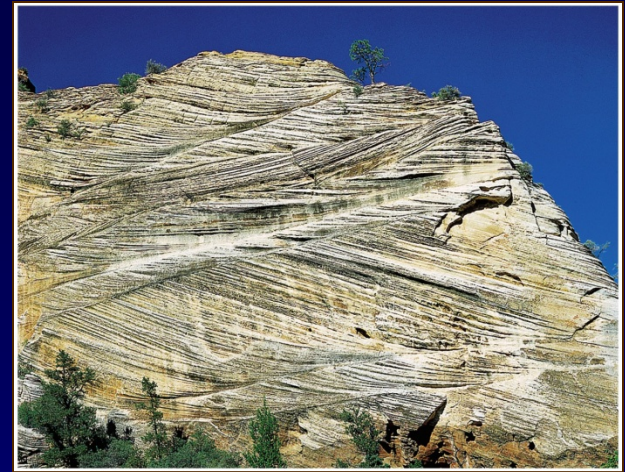
- **Composition** of the grains - tells you about distance of transport and the source terrain that they were eroded from.
 - Chemically **unstable minerals** like feldspars, mica, and ferromagnesian silicates **indicate short transport** distance from igneous source terrains
 - **Arkose**: sandstone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



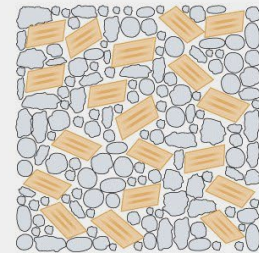
Sandstones



(b) Sandstone



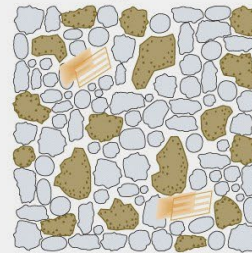
Arkose:
feldspar-rich



1 mm

Alluvial fans

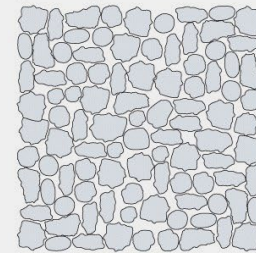
Lithic sandstone:
rock-fragment-rich



1 mm

Delta

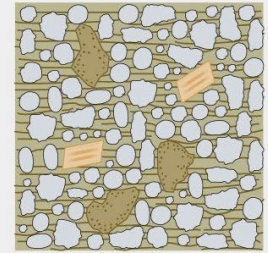
Quartz arenite:
pure quartz



1 mm

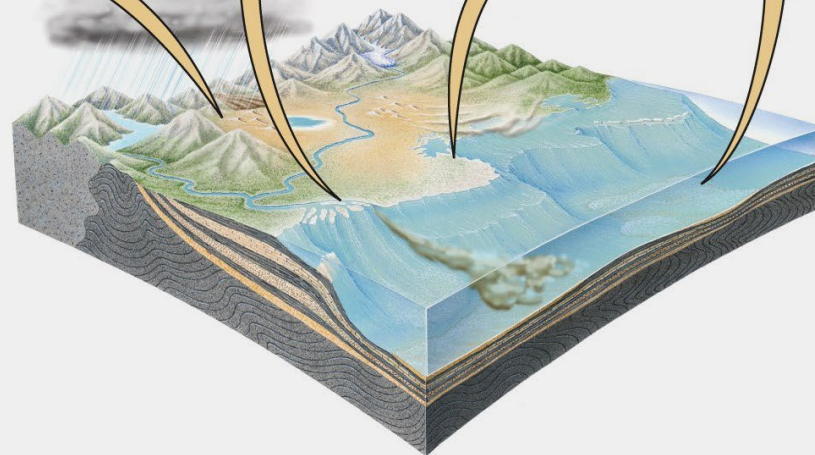
Beach

Graywacke:
matrix-rich



1 mm

Deep-sea
fans



■ Sandstone

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

Cross bedding



Sand in modern beach trench



500 my old Cambrian sandstone in outcrop

■ Sandstone

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



Sand on modern beach



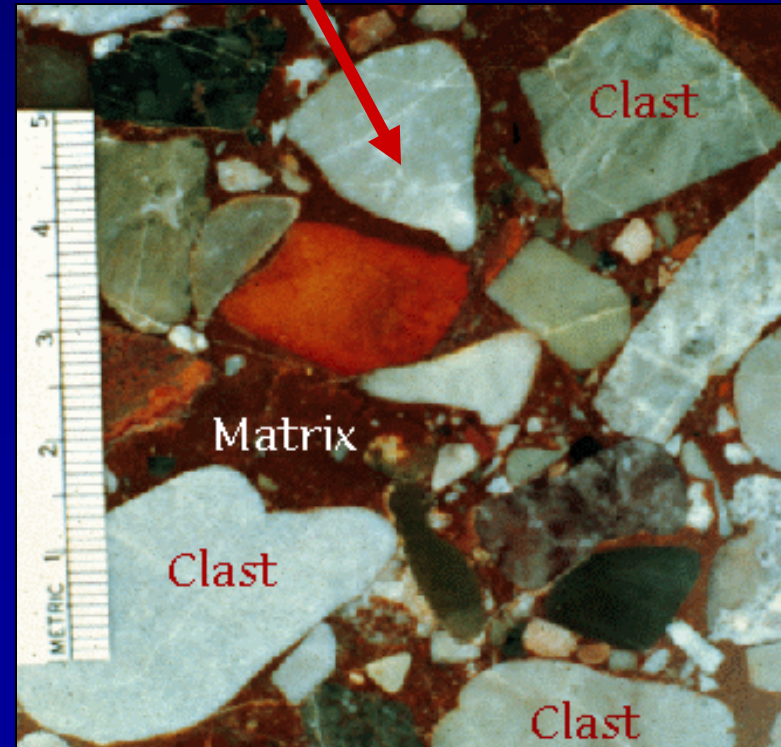
500 my old sandstone in outcrop

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



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



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**

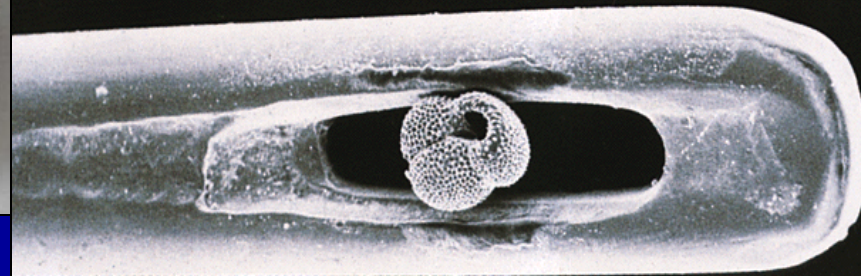
- Biochemical limestones: **coral reefs**



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



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



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Chemical sedimentary rock names

■ Coal

– Made up of organic molecules - hydrocarbons.

Different from organic limestone which is 100% calcite, an inorganic mineral.

– Coal Stages:

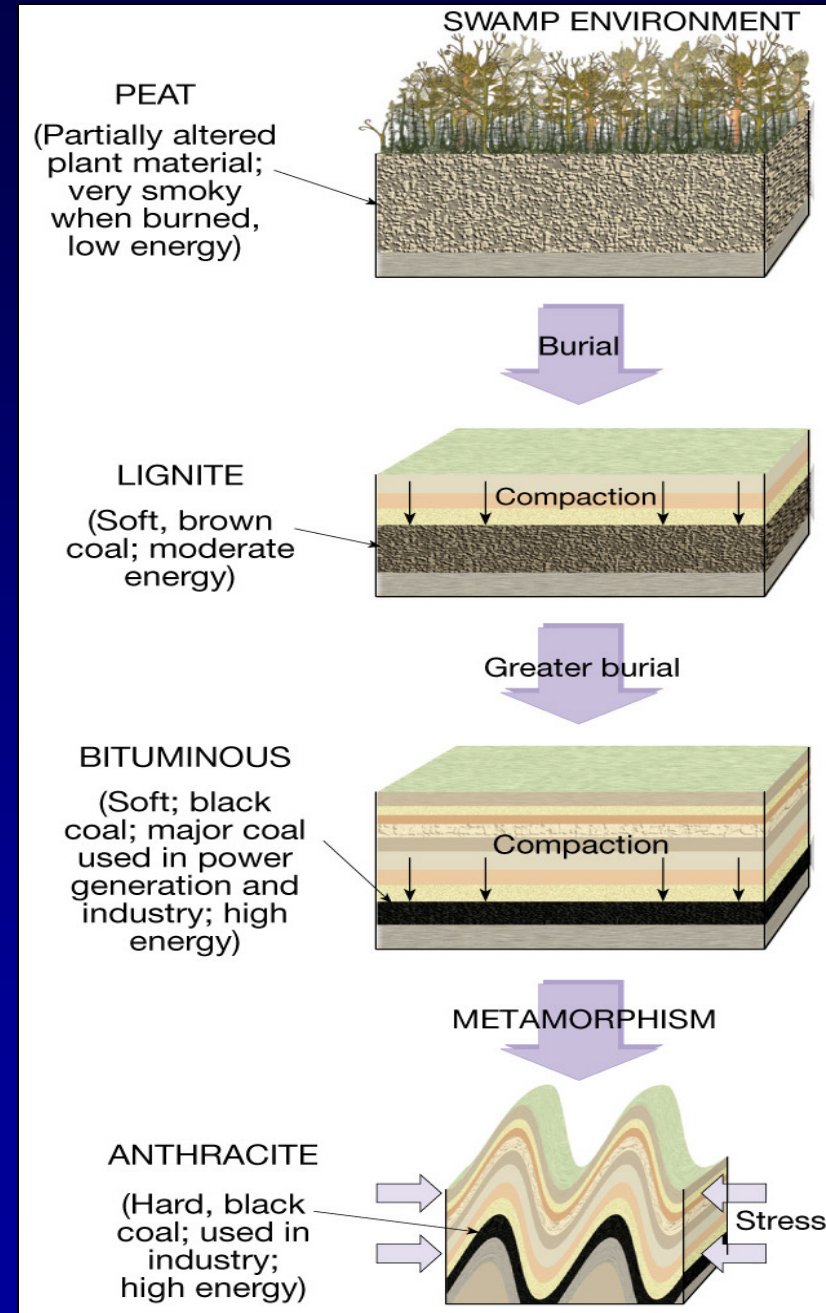
1. Plant material

2. **Peat**

3. **Lignite**

4. **Bituminous**

**Increasing
Heat &
metamorphism**



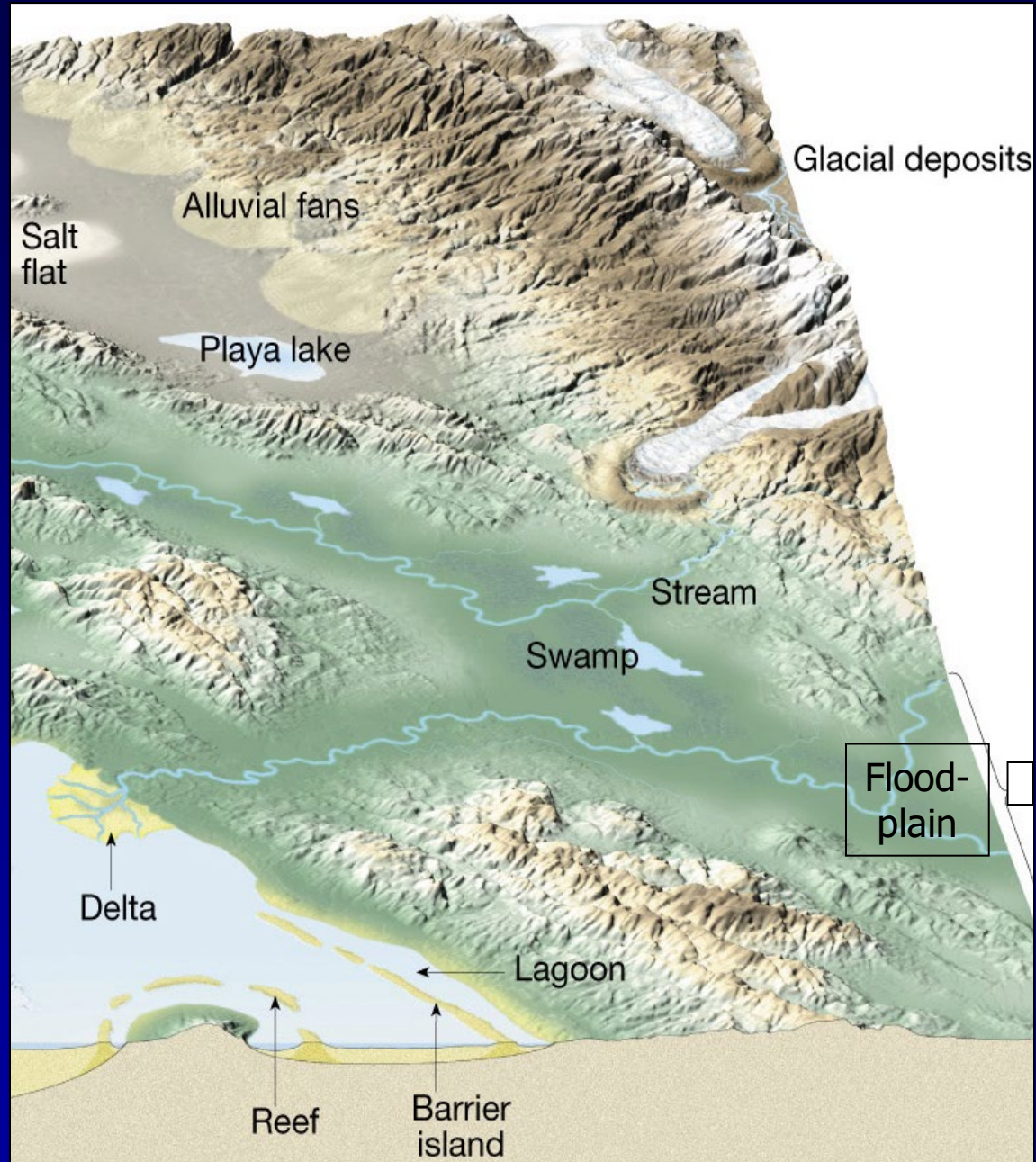
Sedimentary environments

- 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

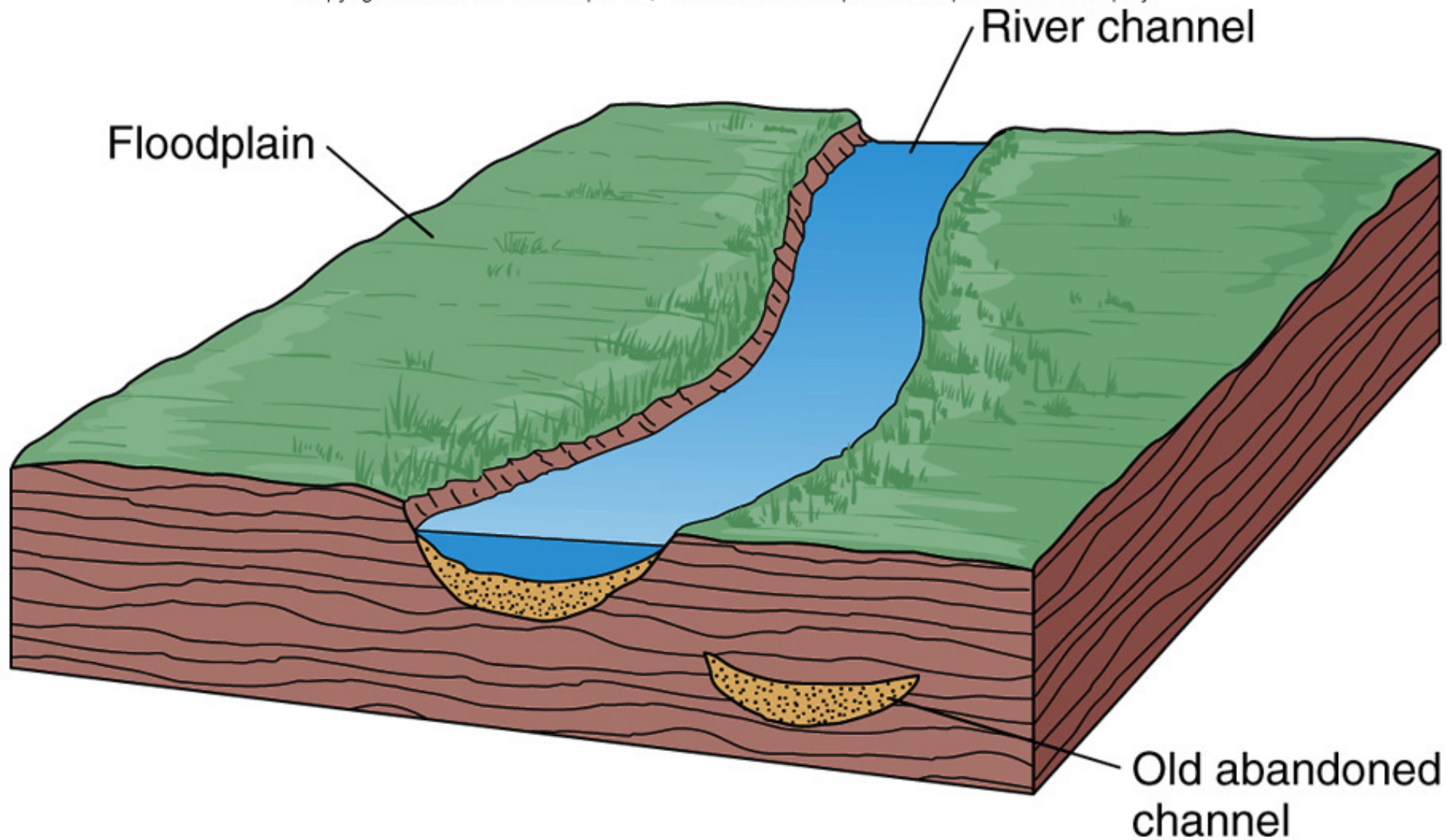
Continental environments of deposition

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



River

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River sedimentation

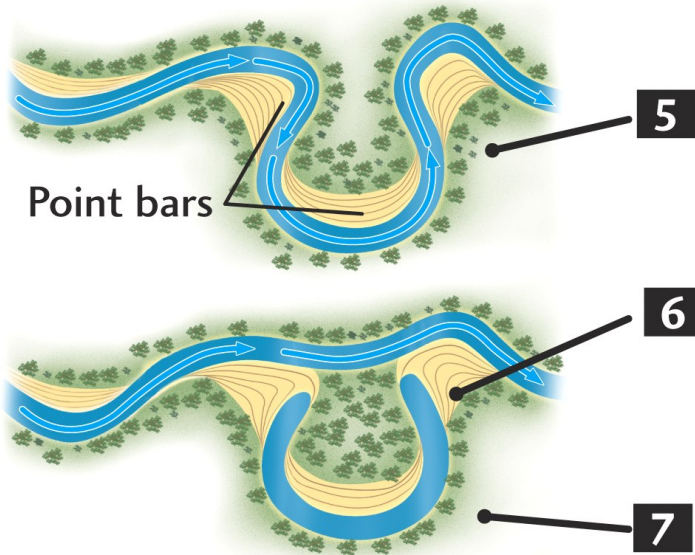


Channel in-filling



Meandering Rivers

LOW-SEDIMENT LOAD, LOW VELOCITY



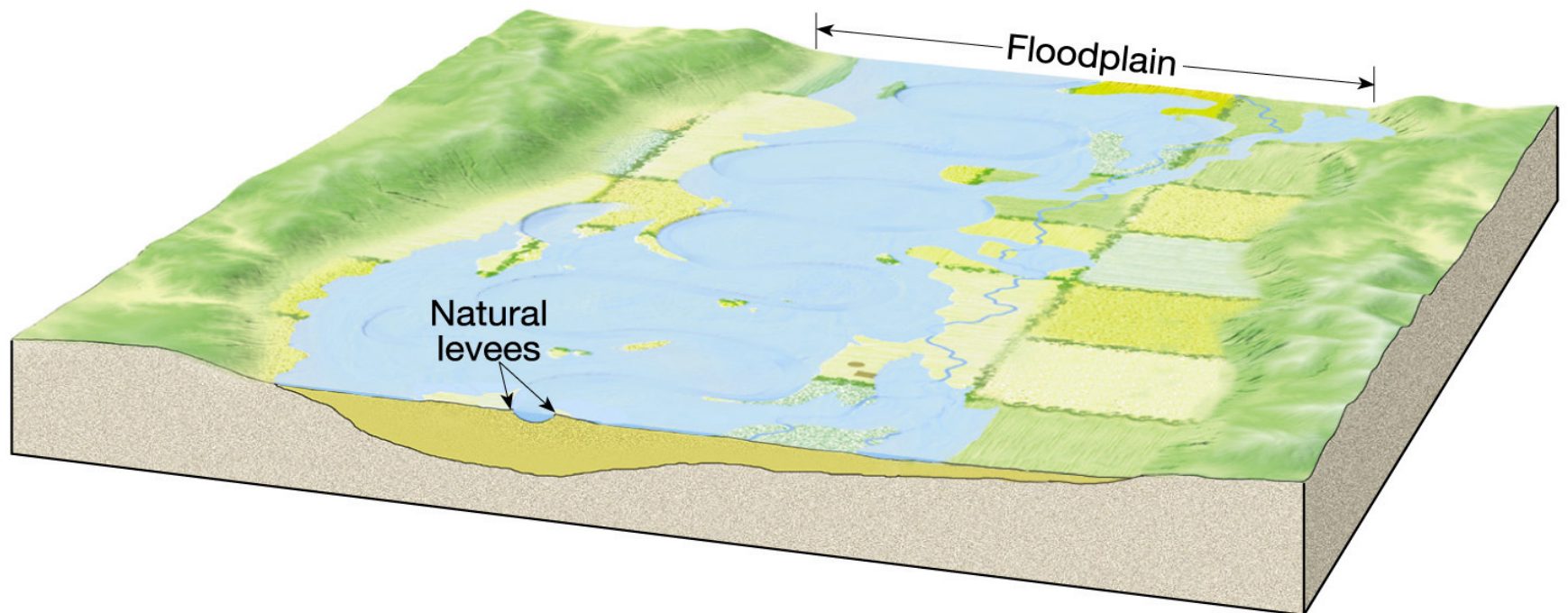
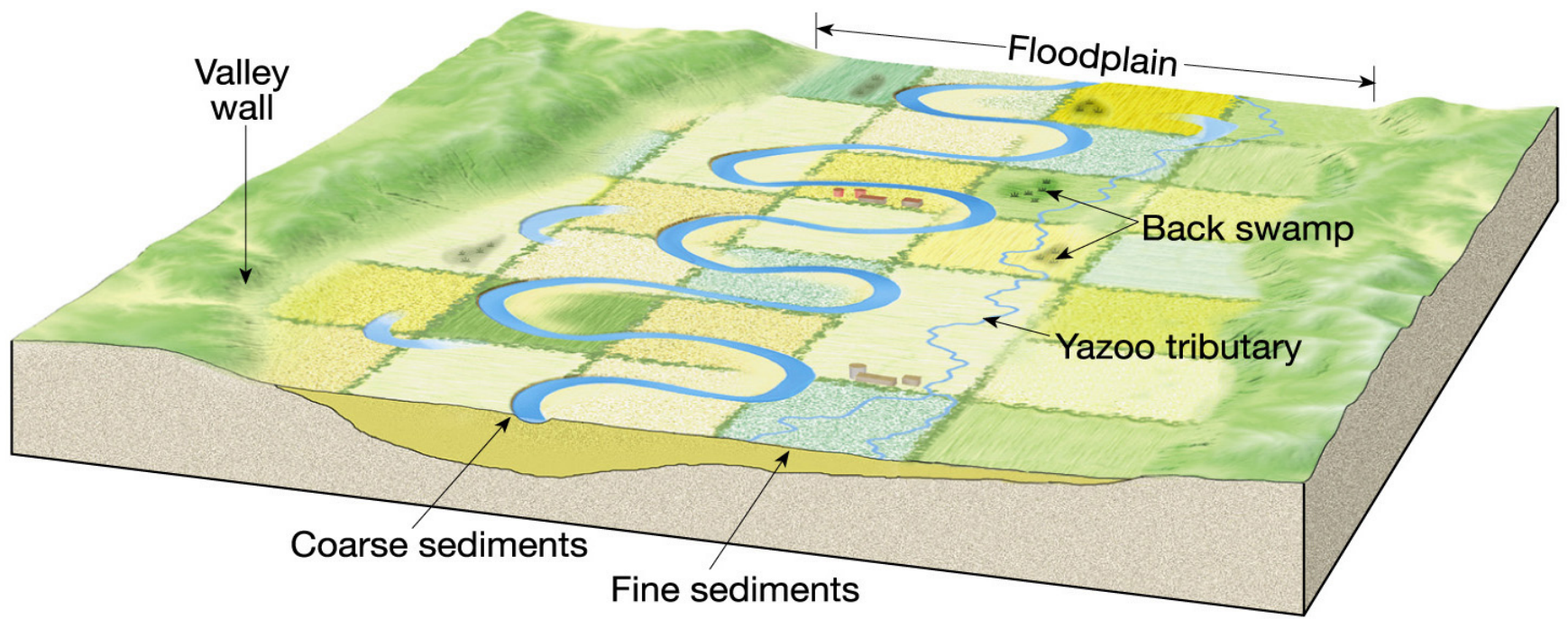
LOW-SEDIMENT LOAD, LOW VELOCITY

Meanders in an Alaskan river



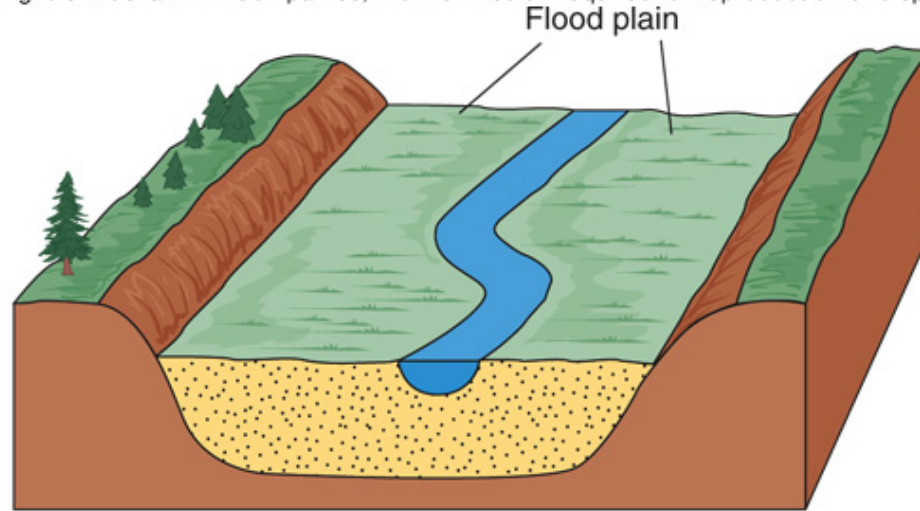
Point bar

High-velocity
flow in channel

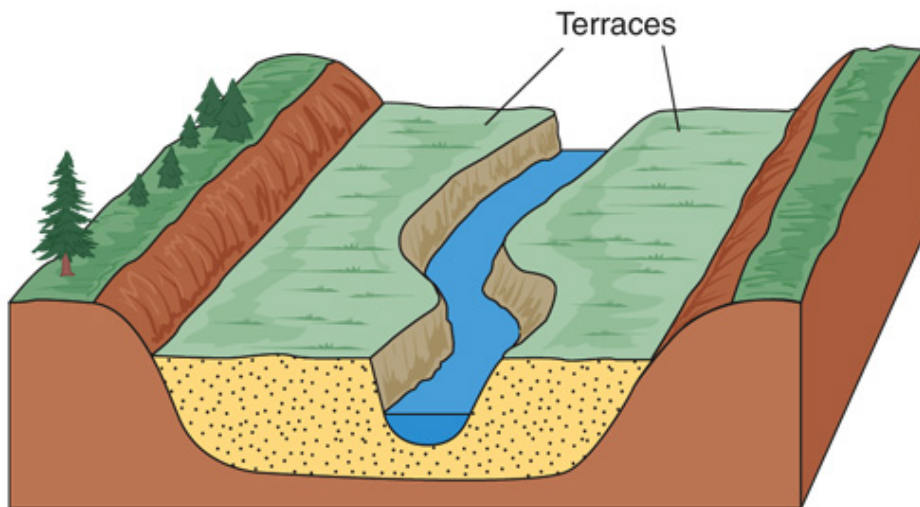


Formation of terraces

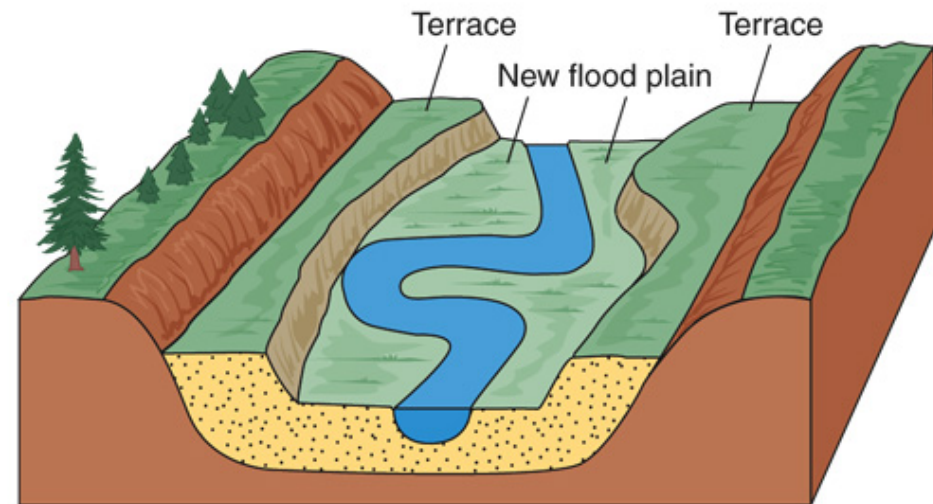
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A



B



C

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.



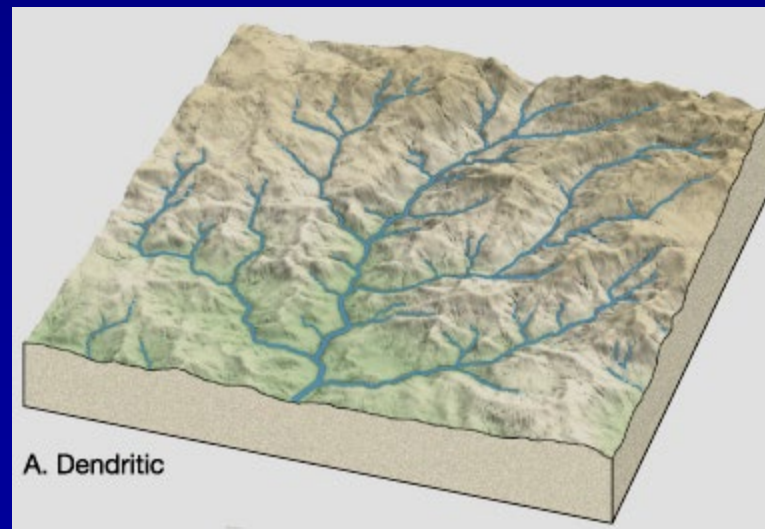
Deltas

- **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

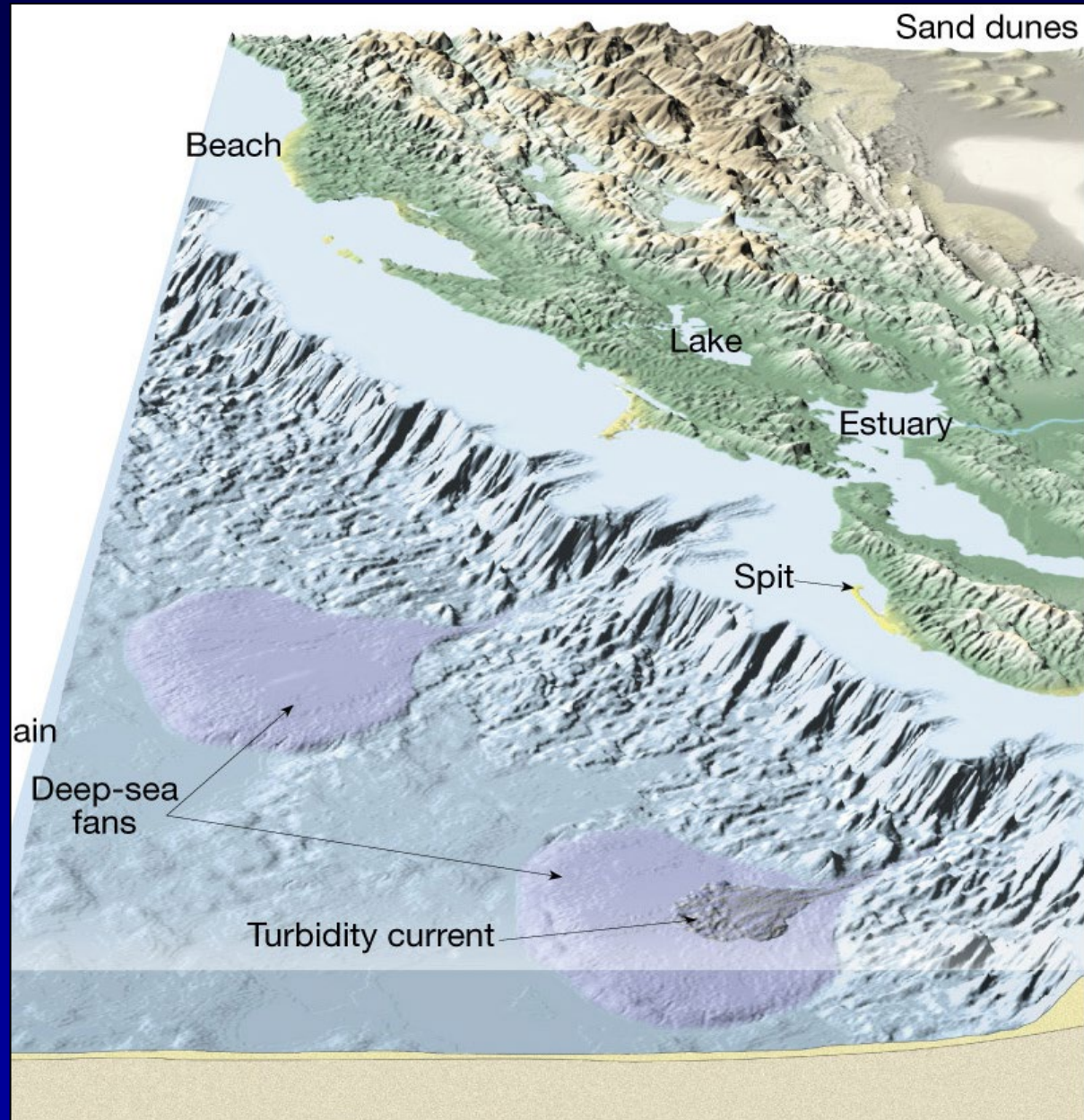
- **Disributaries** – Note that the branching pattern is opposite of most stream channels which branch *upstream*



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



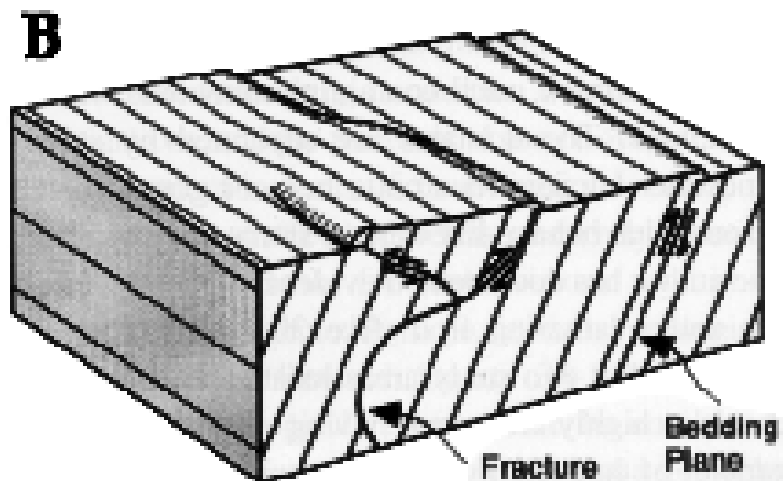
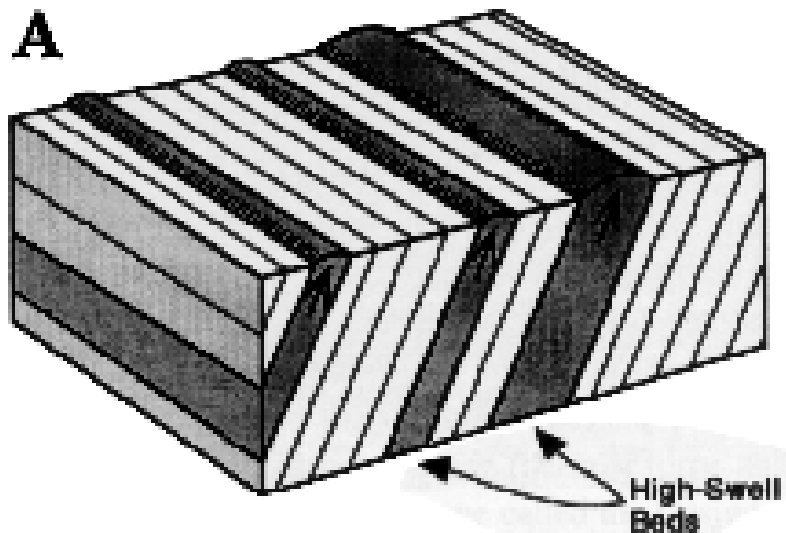
Engineering – Sed Rx

- *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

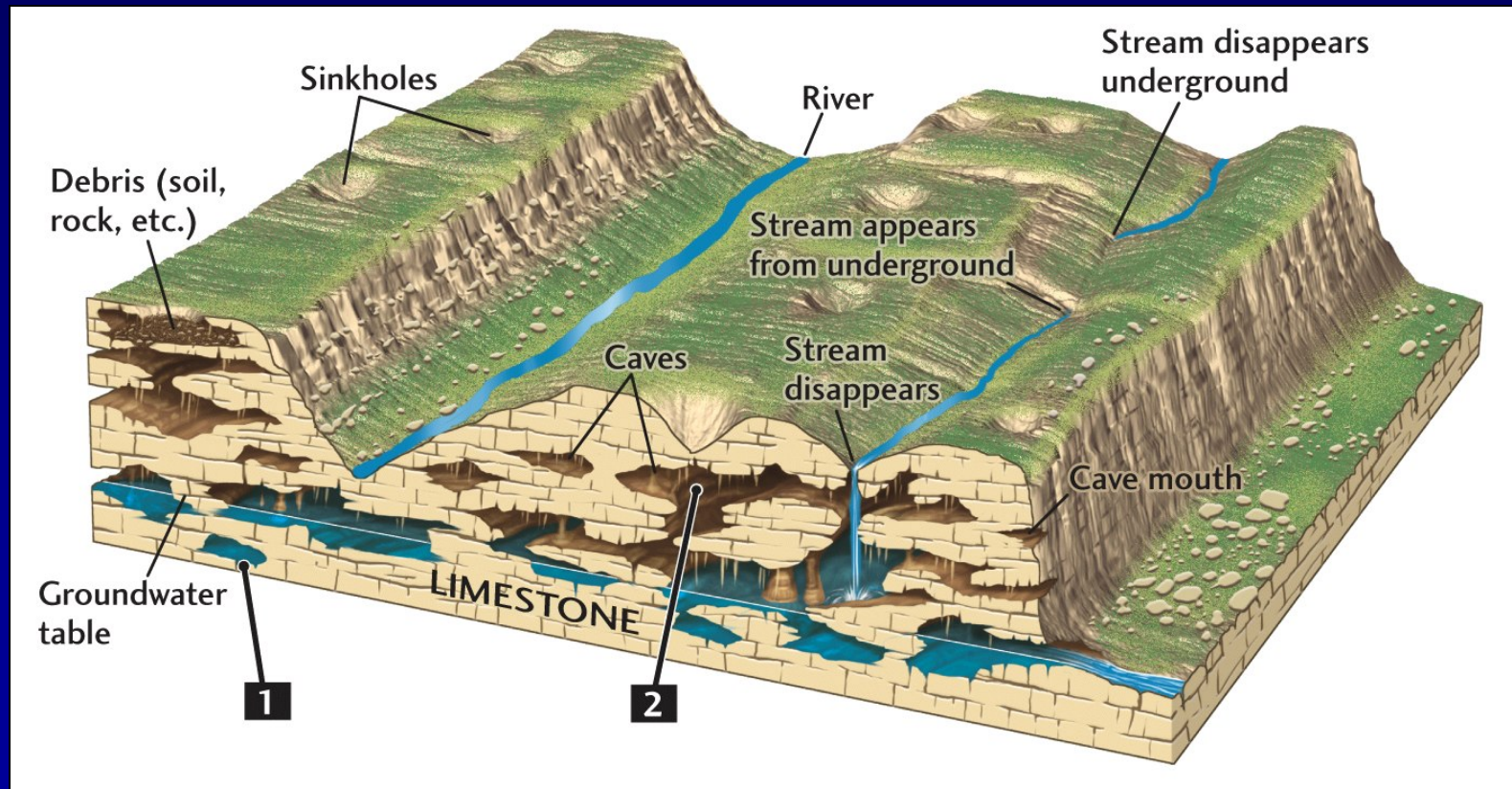


Chemical Sed Rx

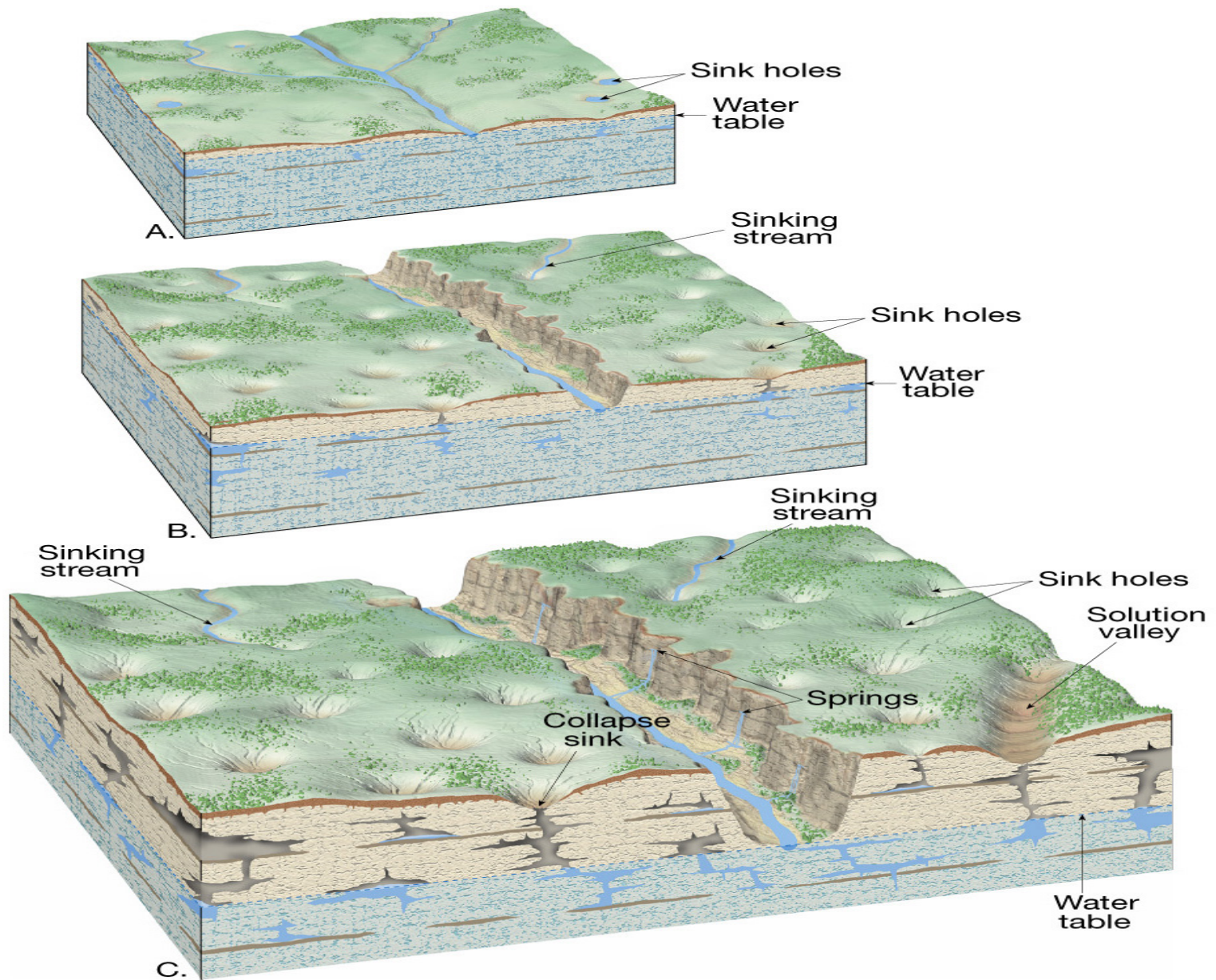
- Surface and underground
- Development of Karst topography
- Evaporites – gypsum/anhydrite and halite

Karst Topography

- Dissolution of carbonate rocks

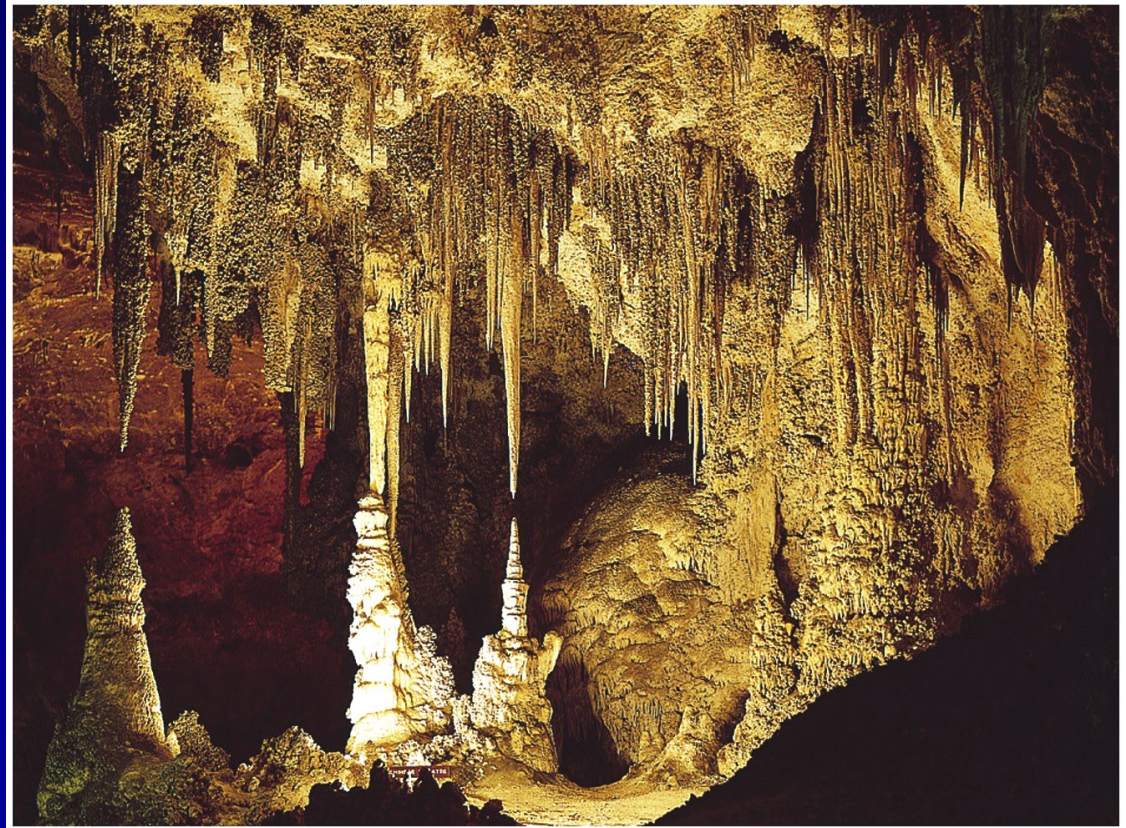


Development of karst topography



Karst Topography

- Limestone caves
- Sinkholes



Development of karst topography



Engineering- Chem Sed Rx.

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