Introduction to Geology

GEO-101

Sedimentary Rocks

The University of Alabama
College of Arts and Sciences
Geological Sciences

What is a sedimentary rock?

- **Sedimentary rocks are products of mechanical and chemical weathering**
- **They account for about 5% (by volume) of Earth's outer 10 miles**
- **Contain evidence of past environments**
  - **Provide information about sediment transport**
  - **Often contain fossils**

Question

- **70% of rocks exposures are of sedimentary rock**
- **By looking at the layers, we can interpret our geologic past**

What is a sedimentary rock?

- **Sedimentary rocks are important for economic considerations because they may contain**
  - **Coal**
    - **Originated in ancient tropical swamps**
  - **Petroleum and natural gas**
    - **Originated as foraminifera in the ancient oceans**
    - **Oil and gas is stored in the pore spaces**
  - **Sources of iron, aluminum, and manganese**
  - **What else??**

Turning sediment into rock

- **Many changes occur to sediment after it is deposited**
- **Diagenesis = chemical, physical, and biological changes that take place after sediments are deposited**
  - **Burial promotes diagenesis**
  - **Occurs in upper few kilometers of crust at <150-200ºC**

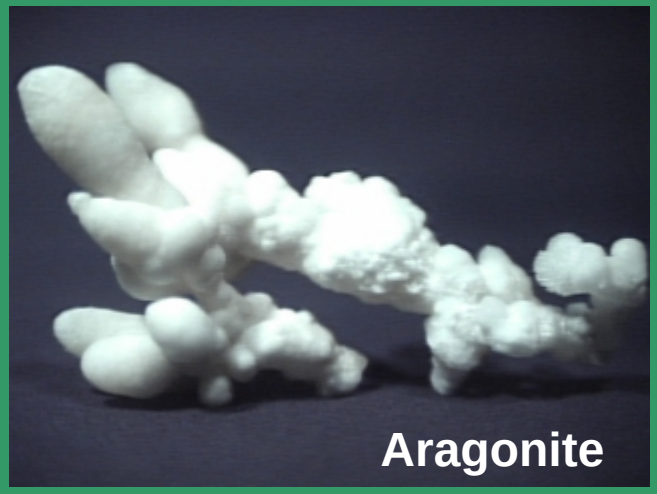
Turning sediment into rock

- **Diagenesis**
  - **Includes**
    - **Recrystallization – development of more stable minerals from less stable ones**
      - **Aragonite (a form of calcium carbonate secreted by marine animals to form shells) recrystalizes to form the more stable mineral calcite as burial takes place**
      - **The end result is limestone**

http://www.palaeos.com

Mollusk – aragonite shell

http://mineral.galleries.com/



Aragonite

Calcite

Turning sediment into rock

- **Diagenesis**
  - **Includes**
    - **Lithification – sediments are transformed into solid rock by**
      - **Compaction: the most common diagenetic change**
      - **The weight of the overlying material compresses the sediment – pore space is reduced**
      - **Burial of a clay may result in a 40% reduction in volume**
      - **Sands do not compact as much**
      - **The squeezing out of pore water may promote other processes????**

Turning sediment into rock

From: http://www.brookes.ac.uk/geology

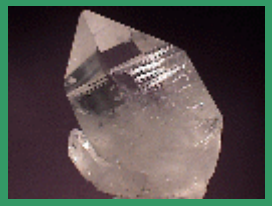
- **Diagenesis**
  - **Includes**
    - **Lithification – sediments are transformed into solid rock by**
      - **Cementation: the most important process for turning sediments to rock**
      - **Cement is carried by fluids circulating in the pore spaces**
      - **In time the cement precipitates onto the sediment grains and eventually fills the pore spaces and joins the particles**
      - **Natural cements include calcite (reacts with HCl), silica (the hardest), and iron oxide (reddish color)**

2 Questions

Types of sedimentary rocks

- **Sediment originates from mechanical and/or chemical weathering**
- **Rock types are based on the source of the material**
  - **Detrital sedimentary rocks – transported sediment as solid particles**
  - **Chemical sedimentary rocks – sediment that was once in solution**

Detrital sedimentary rocks



http://mineral.galleries.com

- **The chief constituents of detrital rocks include**
  - **Clay minerals: the most abundant product of chemical weathering of silicate minerals – e.g. feldspars**
  - **Quartz: very durable and resistant**
  - **Feldspars**
  - **Micas**
- **Chemical weathering will rapidly destroy feldspars and micas, so if they are present in a rock it indicates they might not have traveled far from their source**
- **Particle size is one parameter used to distinguish among the various rock types**

TABLE 7.1 Particle Size Classification for Detrital Rocks

Size Range (millimeters)	Particle Name	Common Sediment Name	Detrital Rock
>256	Boulder		
64–256	Cobble	Gravel	Conglomerate
4–64	Pebble		or breccia
2–4	Granule		
1/16–2	Sand	Sand	Sandstone
1/256–1/16	Silt	Mud	Shale, mudstone,
<1/256	Clay		or siltstone

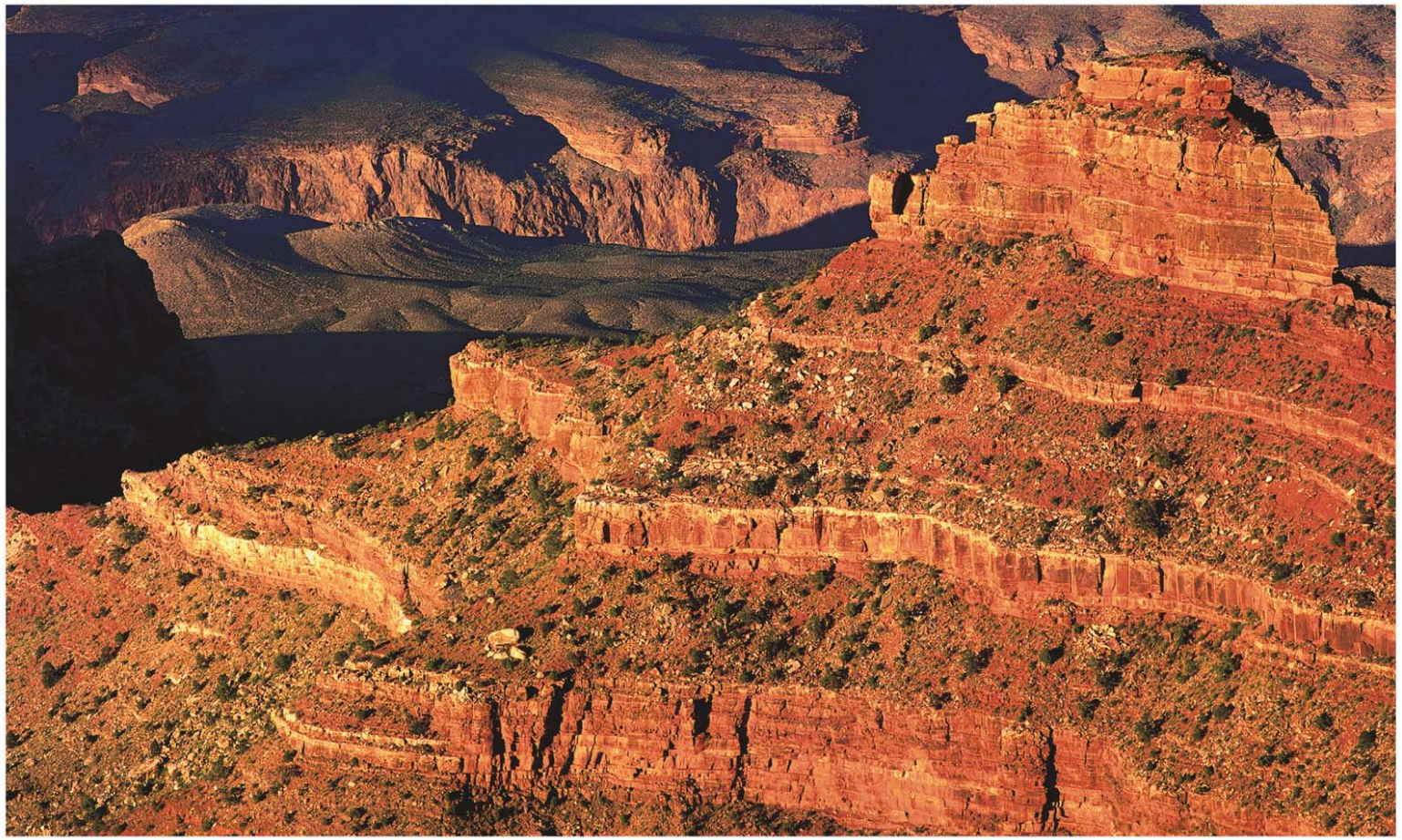
- **Particle size tell us a lot about the energy of the depositional environment**

Detrital sedimentary rocks

- **Common detrital sedimentary rocks**
  - **Shale**
    - **Silt- and clay-sized (microscopic) particles in thin layers that are commonly referred to as lamina**
    - **Simple tests for silt??**
    - **Most common sedimentary rock**
    - **Forms in non-turbulent settings – flood plains, lagoons.**

Detrital sedimentary rocks

- **Common detrital sedimentary rocks**
  - **Shale**
    - **Black shale – organic rich**
    - **Must have formed in swamp like environment**
    - **A swamp is an oxygen poor environment where organic material does not readily oxidize and decay**
    - **Exhibits an ability to split into layers – *fissility***
    - **Often quite weak as lack of pore space slows cementation**
    - **Relative impermeability makes this an important cap rock**



- **Shale is easily eroded – makes up the slopes in this photograph**
- **When mixed with limestone, shale can be used to make portland cement**
- **Also often used for pottery, brick, tile, and china**

1 Question

Detrital sedimentary rocks

- **Common detrital sedimentary rocks**
  - **Sandstone**
    - **Composed of sand-sized particles (1/16 - 2 mm)**
    - **Forms in a variety of environments**
    - **Quartz is the predominant mineral**

TABLE 7.1 Particle Size Classification for Detrital Rocks

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>256	Boulder	Gravel	Conglomerate or breccia
64–256	Cobble		
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2–4	Granule		
1/16–2	Sand	Sand	Sandstone
1/256–1/16	Silt	Mud	Shale, mudstone, or siltstone
<1/256	Clay		

- **Sorting – the degree of similarity is particle size in a sedimentary rock**
- **If all the grains are about the same size it is *well sorted***
- **If all grain size varies widely it is *poorly sorted***

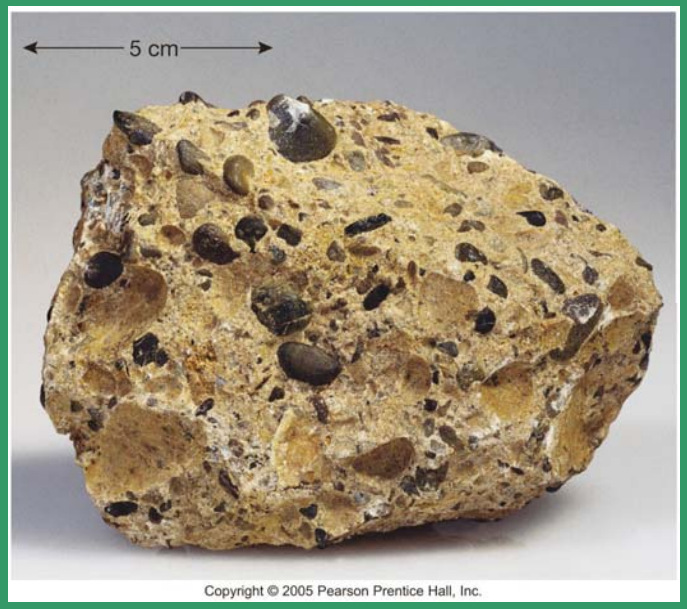
A quartz sandstone

- If a sandstone is rich in feldpar is it called a arkose – it probably came from a granitic source

- If a sandstone also has rock fragments it is called a greywacke – turbidity currents
- The shape of the grains can tell us how far they were transported
- Matrix

Detrital sedimentary rocks

- **Conglomerate and breccia**
  - **Both are composed of particles greater than 2mm in diameter – large enough to be recognized as distinctive rock types**
  - **Very valuable for determining the source of the rock**
  - **Conglomerate consists largely of rounded gravels**
  - **Mountain rivers, rapidly eroding coasts, glacial and landslide deposits**
  - **Breccia is composed mainly of large angular particles – not transported as far**



3 Questions

Chemical sedimentary rocks

- **Consist of precipitated material that was once in solution**
  - **Salt**
  - **Calcite**
- **Precipitation of material occurs by**
  - **Inorganic processes**
  - **Organic processes (biochemical origin)**

http://www.palaeos.com

Chemical sedimentary rocks

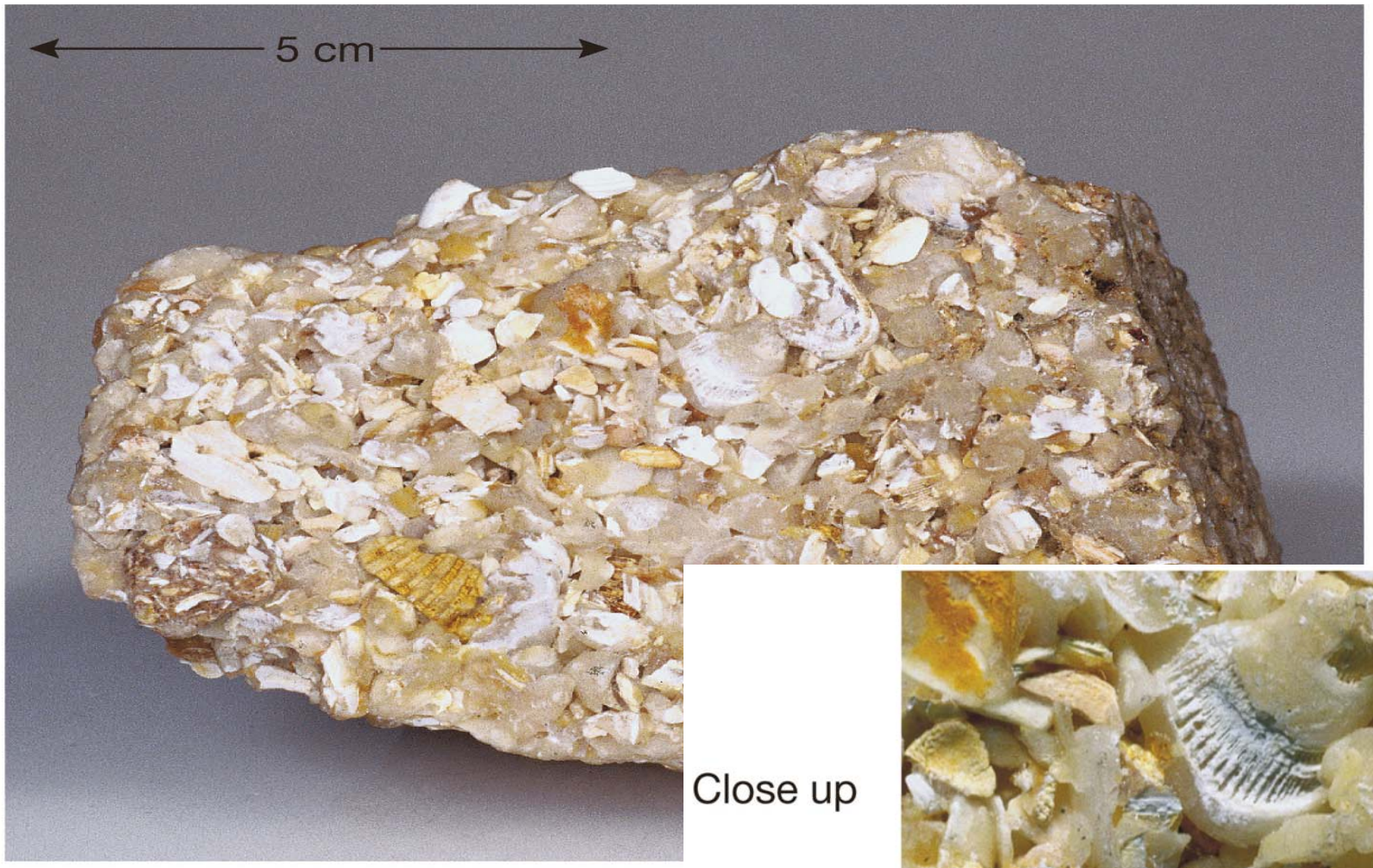
- **Common chemical sedimentary rocks**
  - **Limestone**
    - **Most abundant chemical rock**
    - **Composed chiefly of calcite**
    - **Marine biochemical limestones form as coral reefs, coquina (broken shells), and chalk (microscopic organisms)**

A.

- El Capitan, TX
- Permian (248-290 Ma)
- Question

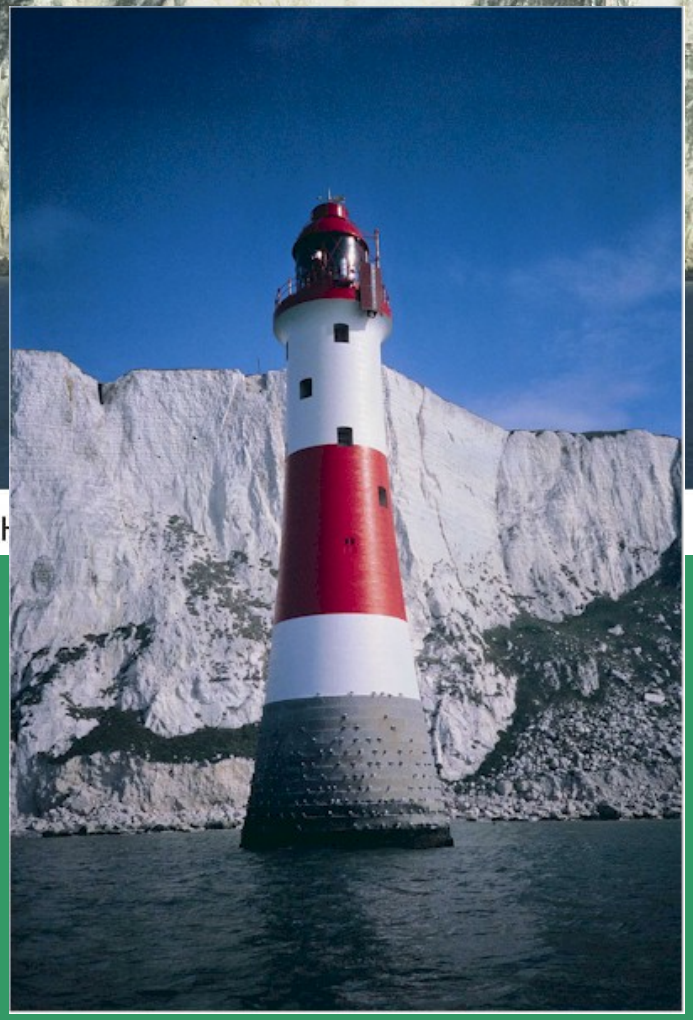
B.

Coquina



Close up

Fossiliferous limestone

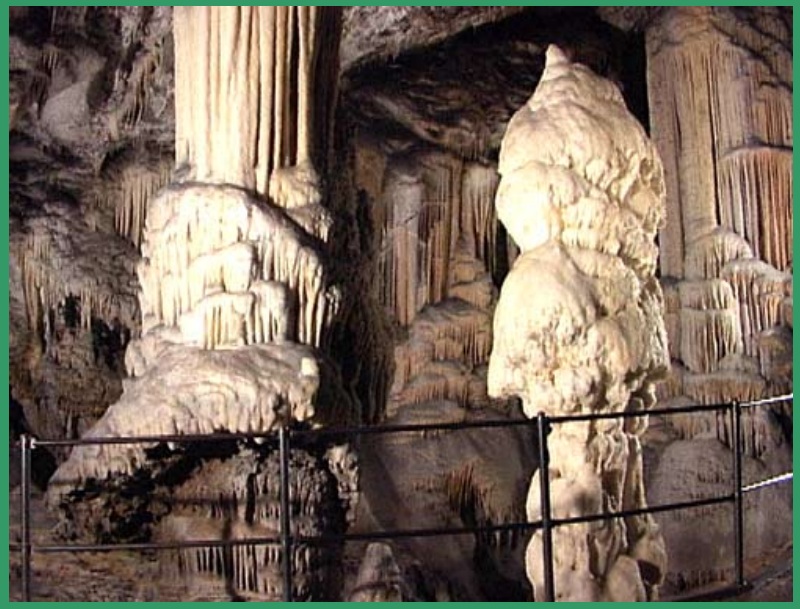


Chalk

- **Soft porous rock made up almost entirely of the hard parts of microscopic organisms – formed in vast shallow seas**

Chemical sedimentary rocks

- **Common chemical sedimentary rocks**
  - **Limestone**
    - **Inorganic limestones include travertine and oolitic limestone**
    - **Travertine can be found in caves and hot springs**




ÇEVRE VE DOĞAL VARLIĞIN KORUNMASI İÇİN
TRAVERTENLERE GİRİLMESİ YASAKTIR
ENTERING THE TRAVERTİNES İS NOT CERTAINLY ALLOWED
TO PROTECT THIS AMAZING NATURAL BEAUTY AS IT USED TO BE.
IL EST INTERDIT CERTAINMENT D' ENTRER DANS LES
TERRASSES DE CALCIUM TOUR PROTEGER CETTE
MERVEILLE NATURELLE.

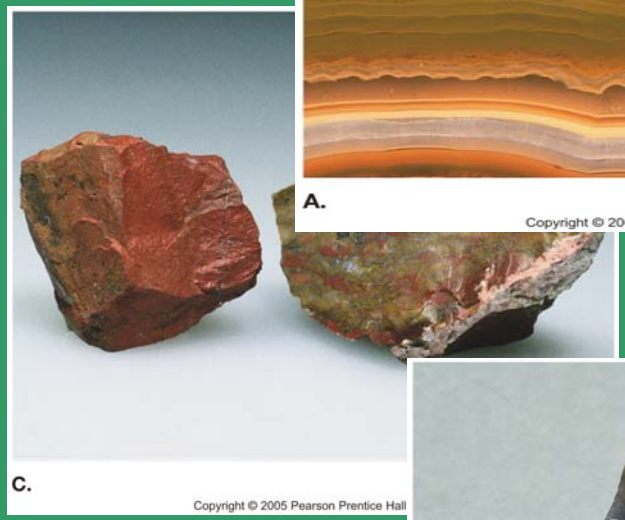
Oolitic limestone

- **Forms in warm climates**
- **Spheres grow as they are rocked back and forth**
- **Water must be supersaturated in calcium carbonate**

Chemical sedimentary rocks

- Common chemical sedimentary rocks
  - Chert
    - Microcrystalline quartz (silica)
    - Silica comes from radiolaria and diatoms
    - Includes flint and jasper (banded form is called agate)
    - May have precipitated from seawater or originated as a biochemical sediment
    - Commonly used for spears and arrowheads

Agate



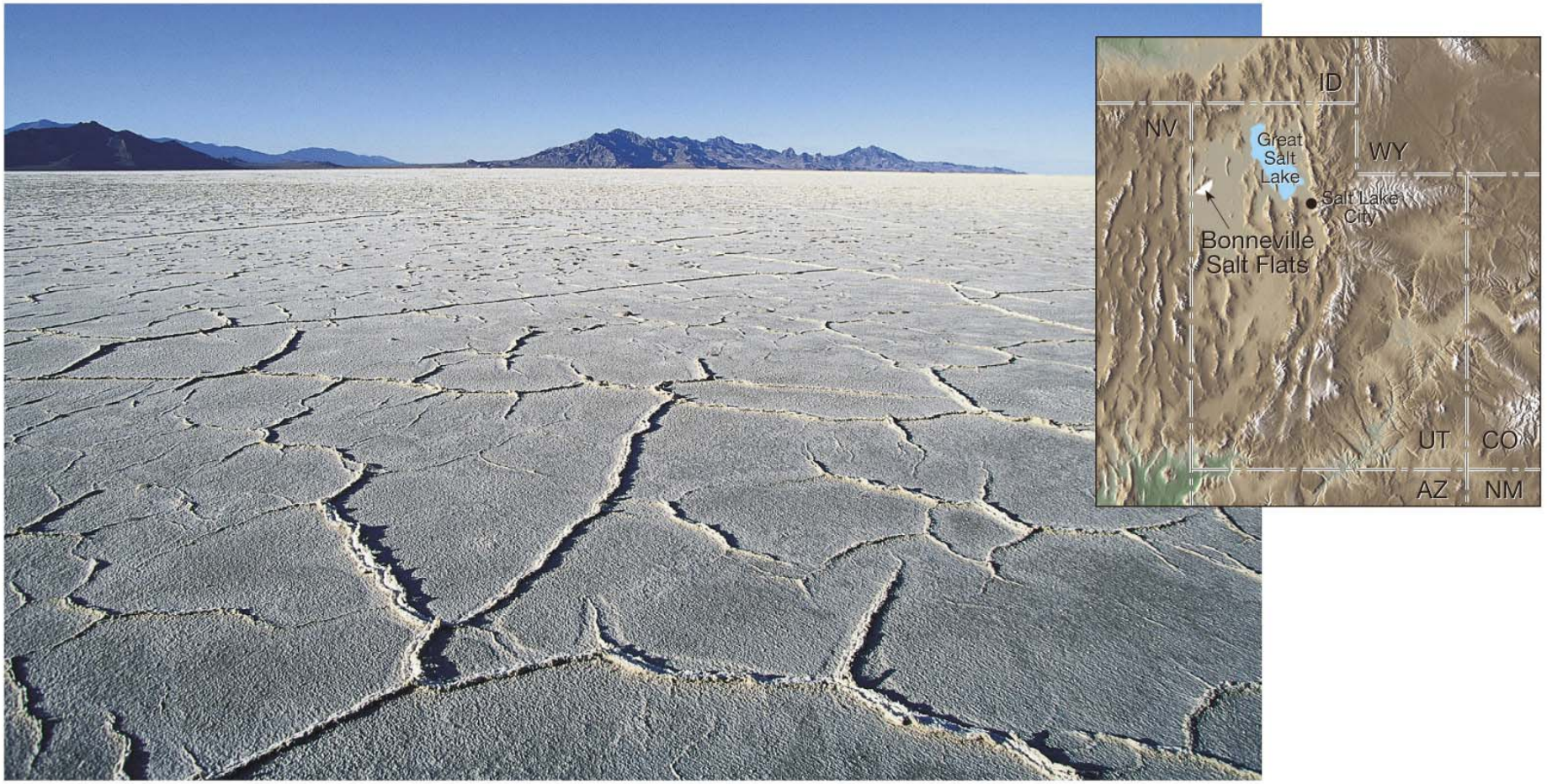
Jade

Flint

1 Question

Chemical sedimentary rocks

- **Common chemical sedimentary rocks**
  - **Evaporites**
    - **Evaporation triggers deposition of chemical precipitates**
    - **Examples include halite and gypsum**



- **Deposited when water containing salt evaporates**
- **Salt is very soluble – precipitates out when ~90% of the water has evaporated**
- **Gypsum is less soluble – precipitates out when ~75% of the water has evaporated**

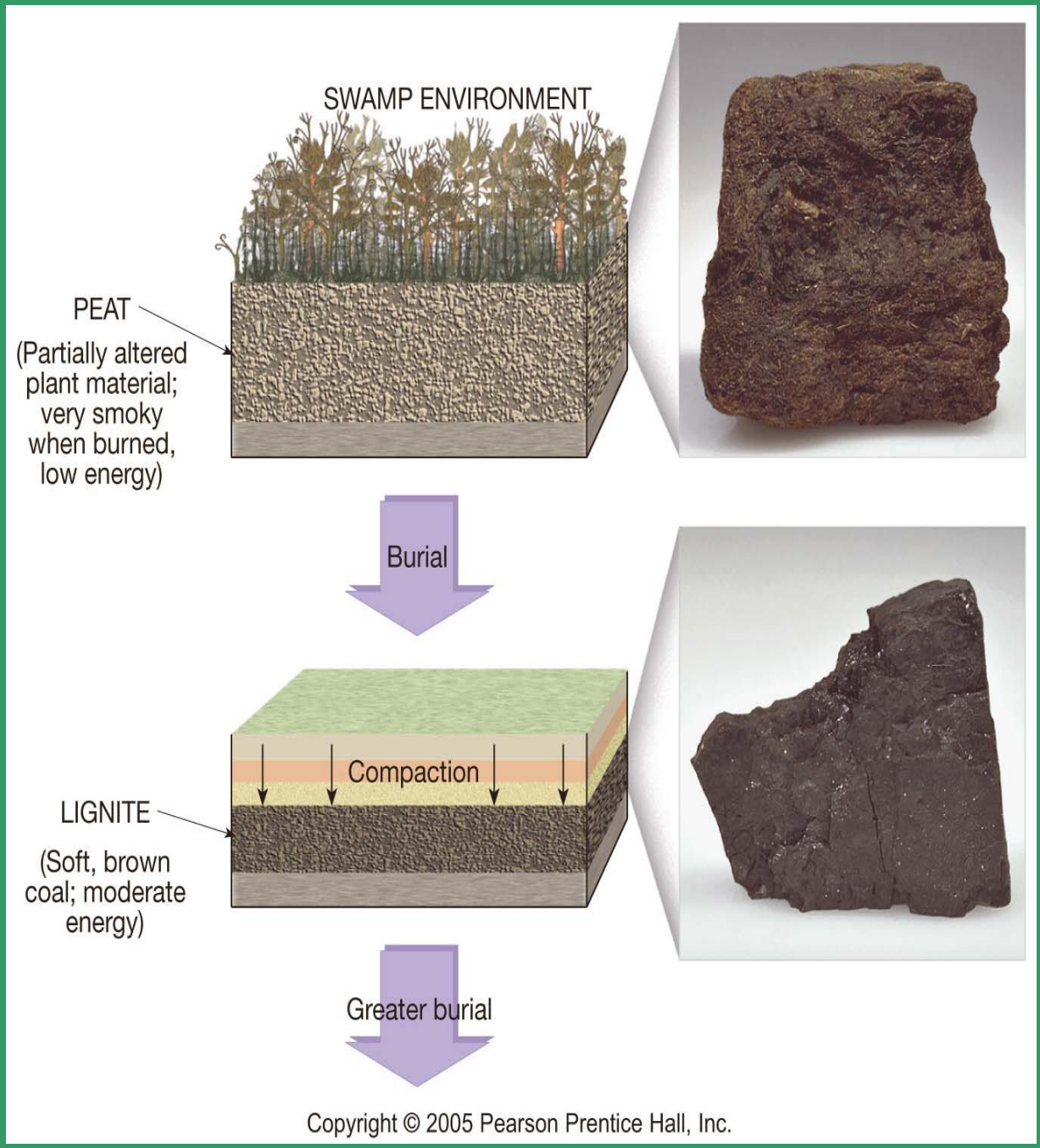
- **Two methods of producing salt**

From:http://www.science-education.org/images/salt_truck.gif

Chemical sedimentary rocks

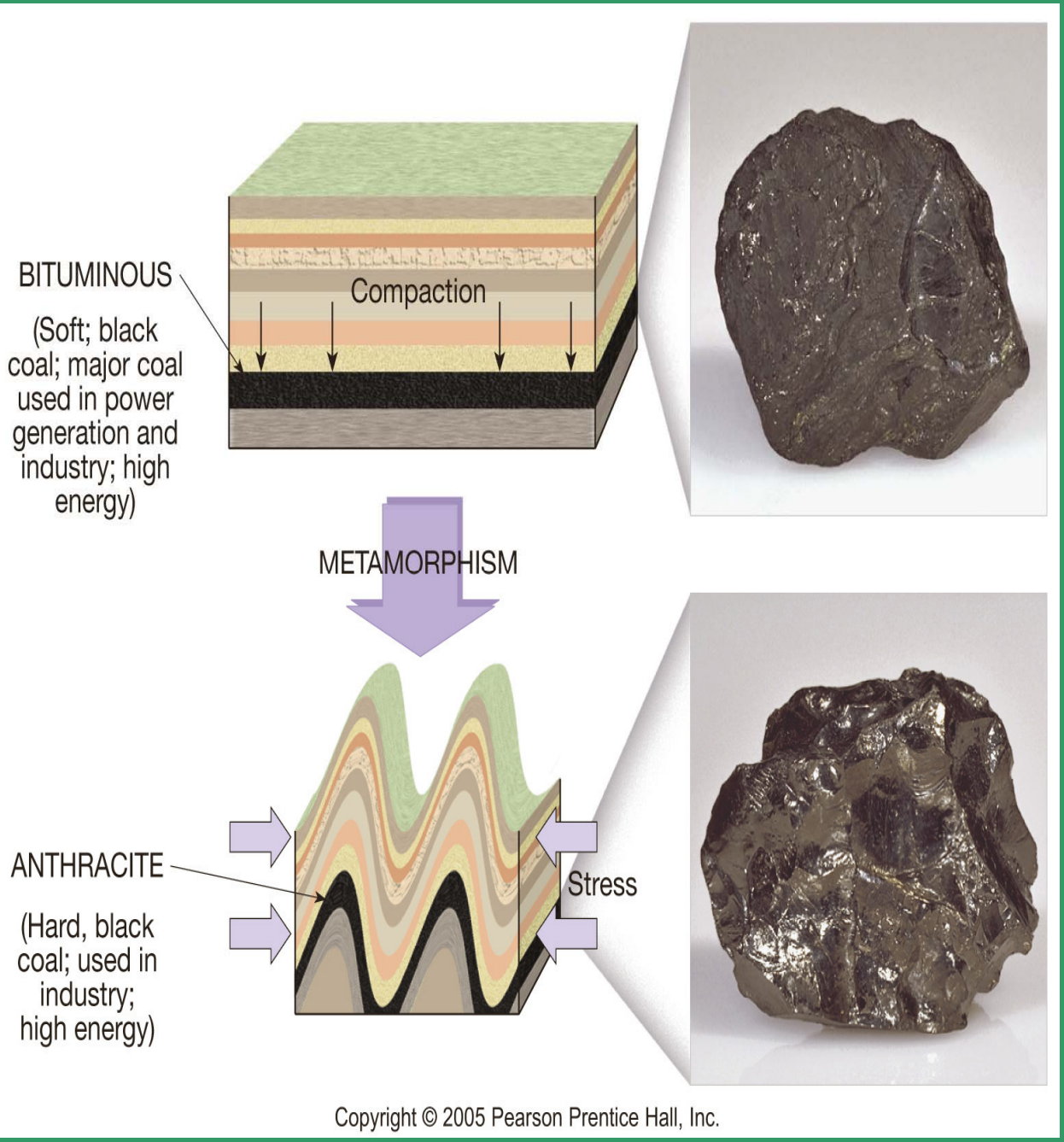
- **Common chemical sedimentary rocks**
  - **Coal**
    - **Different from other rocks because it is composed of organic material**
    - **If you look at coal under a magnifying glass you will see plant matter still identifiable**
    - **Remember that a rock is an aggregate of minerals – is coal a rock?**

Plant material in a swamp will only partially decompose – oxygen poor environment



Stages of coal formation

- Deeper burial = higher temperatures
- Chemical reactions yield water, gases
- Carbon % increases, increasing fuel ranking



Stages of coal formation

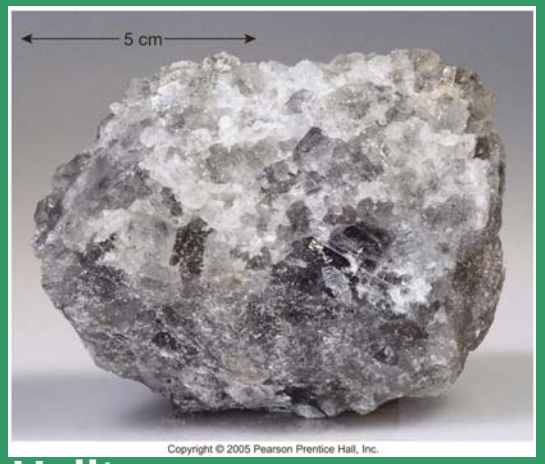
- Final thickness ~10% of peat layer
- Under extreme heat and pressure coal becomes anthracite, a clean burning but fairly uncommon fuel

Classification of sedimentary rocks

- Sedimentary rocks are classified according to the type of material
- Two major groups
  - Detrital
  - Chemical
- Can also be classified as:
- Clastic
  - Discrete fragments and particles
  - All detrital rocks have a clastic texture
- Nonclastic
  - Pattern of intergrown crystals
  - May resemble an igneous rock

Coquina

Sandstone



Halite

Detrital Sedimentary Rocks

Clastic Texture Particle Size		Sediment Name	Rock Name
Coarse (over 2 mm)		Gravel (Rounded particles)	Conglomerate
		Gravel (Angular particles)	Breccia
Medium (1/16 to 2 mm)		Sand (If abundant feldspar is present the rock is called Arkose)	Sandstone
Fine (1/16 to 1/256 mm)		Mud	Siltstone
Very fine (less than 1/256 mm)		Mud	Shale

Chemical Sedimentary Rocks

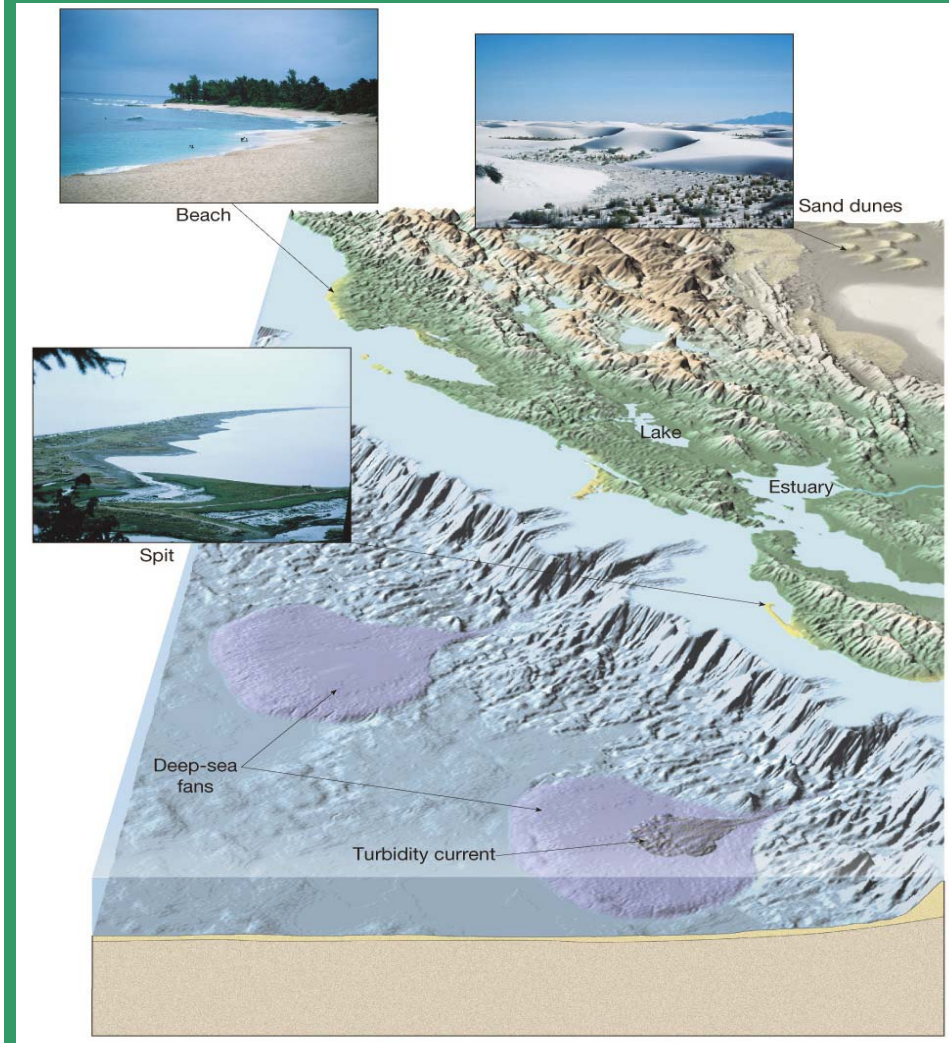
Composition	Texture	Rock Name	
Calcite, $CaCO_3$	Nonclastic: Fine to coarse crystalline	Crystalline Limestone	
		Travertine	
	Clastic: Visible shells and shell fragments loosely cemented	Coquina	Biochemical Limestone
	Clastic: Various size shells and shell fragments cemented with calcite cement	Fossiliferous Limestone	
	Clastic: Microscopic shells and clay	Chalk	
Quartz, SiO_2	Nonclastic: Very fine crystalline	Chert (light colored) Flint (dark colored)	
Gypsum $CaSO_4 \cdot 2H_2O$	Nonclastic: Fine to coarse crystalline	Rock Gypsum	
Halite, NaCl	Nonclastic: Fine to coarse crystalline	Rock Salt	
Altered plant fragments	Nonclastic: Fine-grained organic matter	Bituminous Coal	

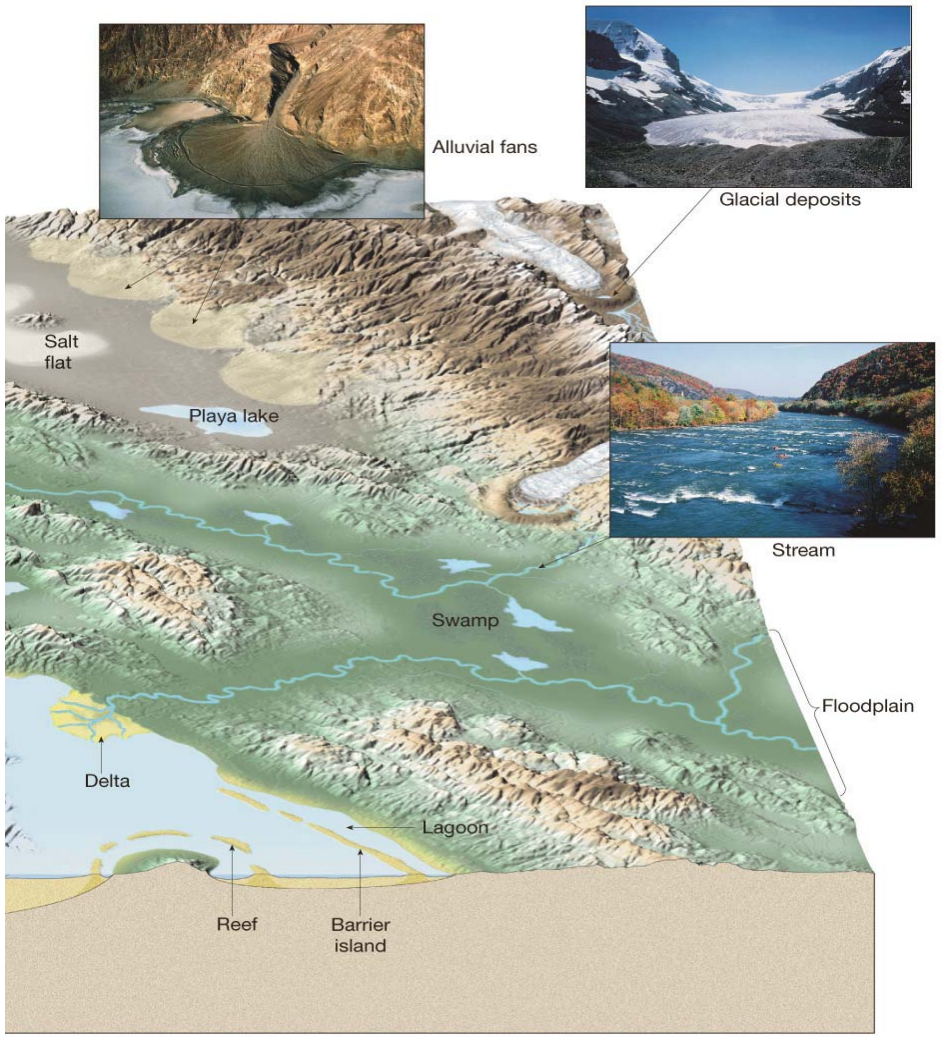
1 Question

Describe this photo…..

Sedimentary environments

- **A geographic setting where sediment is accumulating**
  - **Each setting is characterized by a particular combination of geologic processes**
  - **Determines the nature of the sediments that accumulate (grain size, grain shape, etc.)**
  - **By studying present day environments, geologist can more easily interpret the rock record**
  - **The geologic setting may change with time**





Spit

Transitional environment

Beach

Transitional environment

Sand dunes

Continental environment

Alluvial fans

Continental environment

Glacial deposits

Continental and/or transitional environment

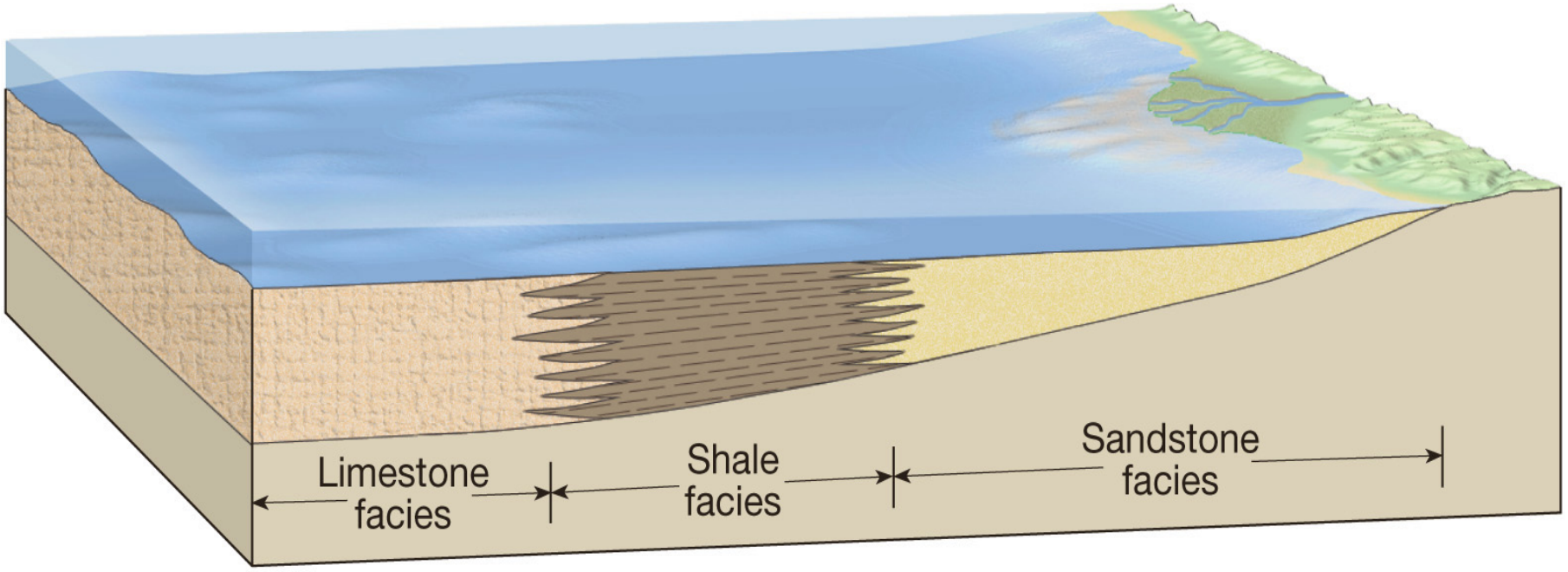
Stream

Continental and/or transitional environment

1 Question

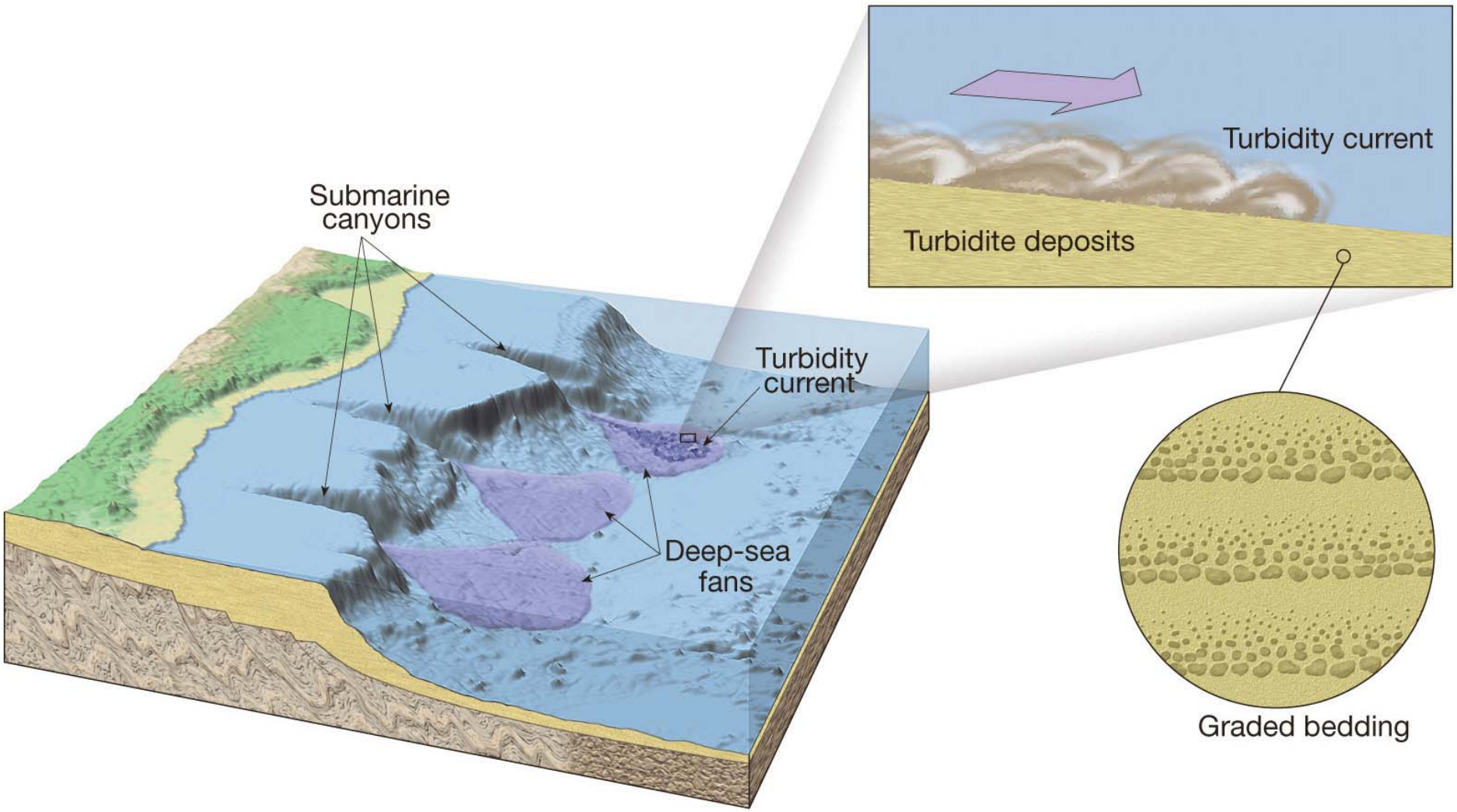
Sedimentary environments

- **Sedimentary facies**
  - **Different sediments often accumulate adjacent to one another at the same time**
  - **Each unit (facies) has distinctive characteristics reflecting the environmental conditions**
  - **Facies merge together**



Sedimentary structures

- **Provide information useful in the interpretation of Earth history**
- **Types of sedimentary structures**
  - **Strata, or beds (most characteristic of sedimentary rocks)**
  - **Bedding planes that separate strata**



Bedding planes can be created by changes in grain size, pauses in deposition

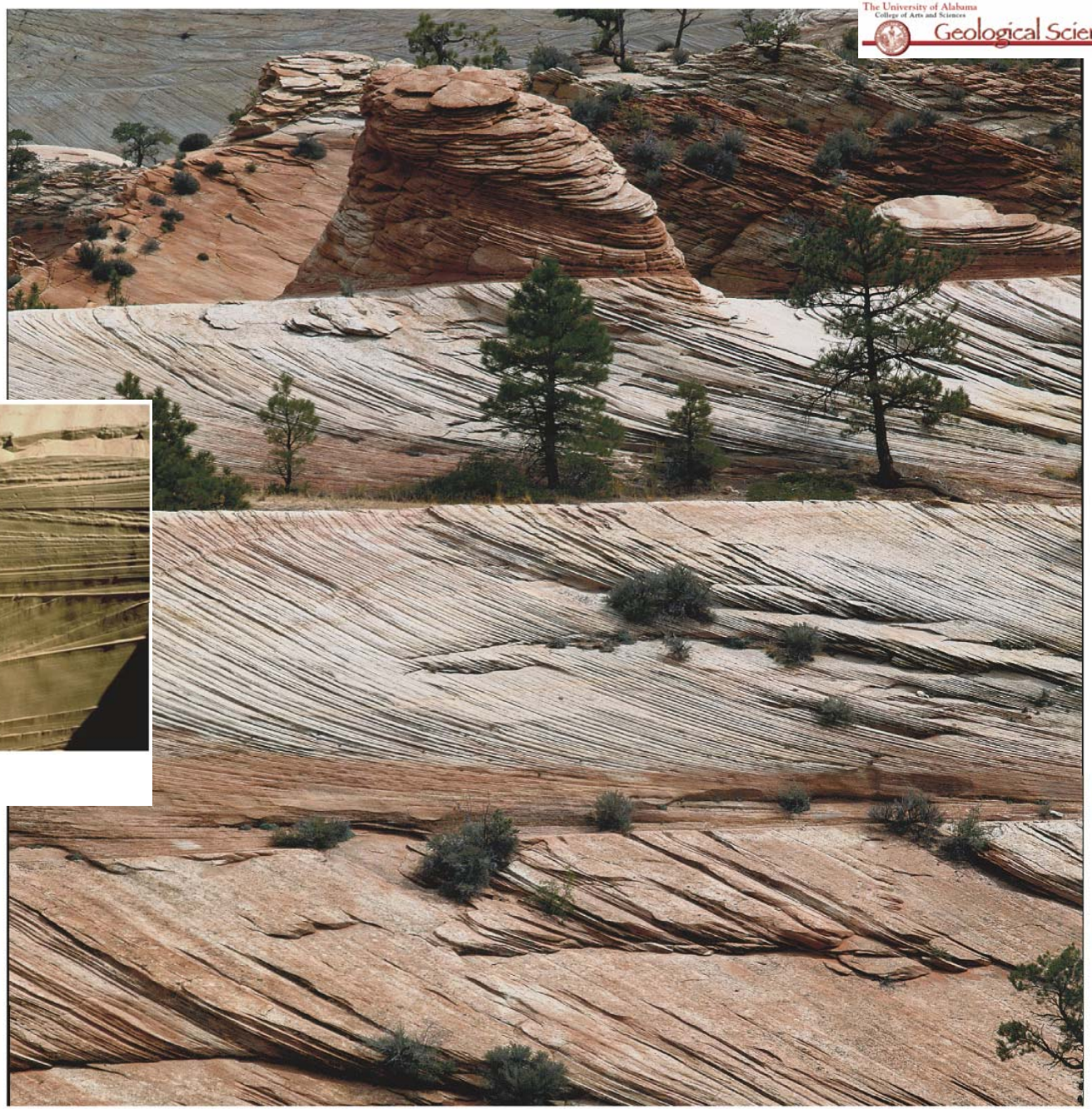
Sedimentary structures

- **Types of sedimentary structures**
  - **Cross-bedding**

Sand dunes

A.

A.

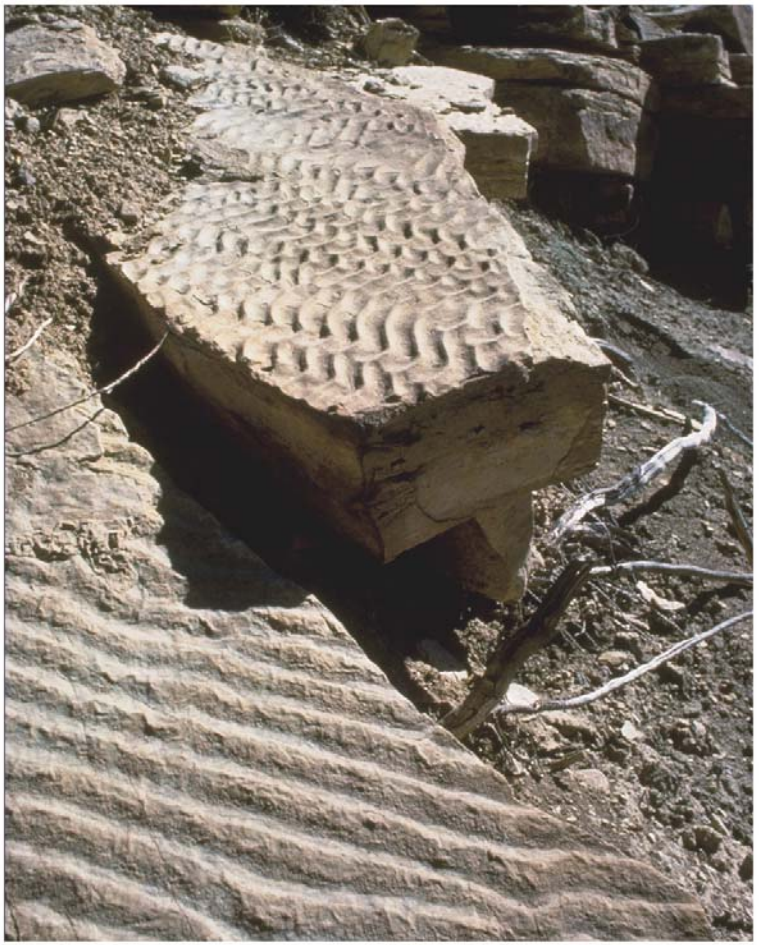


B.

Sedimentary structures

- **Types of sedimentary structures**
  - **Ripple marks – symmetric and asymmetric**

B.



A.

Sedimentary structures

- **Types of sedimentary structures**
  - **Mud cracks – indicative of a tidal flat, shallow lake, or desert basin environment**

Sedimentary structures

- **Types of sedimentary structures**
  - **Fossils**

A.

Trilobite – 590-248 Ma

B.

Tyrannosaurus – 248-65 Ma