



ECIV 3302 Engineering Geology

Chapter 6 SEDIMENTARY ROCKS

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The materials are mostly adapted from the presentation of Stan & Cindy Hatfield

What is a Sedimentary Rock?

- Sedimentary rocks are products of mechanical and chemical weathering.
- Generally formed by the deposition, burial, compaction, and cementation of sediments.
- 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

What is a Sedimentary Rock?

- Sedimentary rocks are important for economic considerations because they may contain
 - Coal
 - Petroleum and natural gas
 - Sources of iron, aluminum, and manganese

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
 - Occurs within the upper few kilometers of Earth's crust

Turning Sediment into Rock

■ Diagenesis

- Includes:
 - **Recrystallization** – development of more stable minerals from less stable ones
 - **Lithification** – sediments are transformed into solid rock by
 - ✓ Compaction and cementation
 - ✓ Natural cements include calcite, silica, and iron oxide

Types of Sedimentary Rocks

- Sediment originates from mechanical and/or chemical weathering
- Rock types are based on the source of the material
 - **Detrital (Clastic) rocks:** transported sediment as solid particles, made of broken pieces)
 - **Chemical (& biochemical) rocks:** sediment that was once in solution and precipitates.
 - **Biochemical (Organic) rocks**

Types of Sedimentary Rocks

- a. **Clastic** (also called **Detrital**): made of broken pieces of other rocks



Types of Sedimentary Rocks

- b. **Chemical:** minerals dissolved in lakes, seas or underground water



Mineral crystals are made as the shallow water that has flooded the bottom of Death Valley evaporates.
Click on image for full size (**66K JPG**)

Courtesy of Martin Miller, University of Oregon

Types of Sedimentary Rocks

c. **Biochemical (Organic)**: remains of plants and animals are deposited in thick layers

■ *Examples*

- Fossil rich limestone is made from the shells of ocean animals; used to make chalk



Detrital Sedimentary Rocks

- The chief constituents of detrital rocks include:
 - Clay minerals
 - Quartz
 - Feldspars
 - Micas
- Particle size is used to distinguish among the various rock types

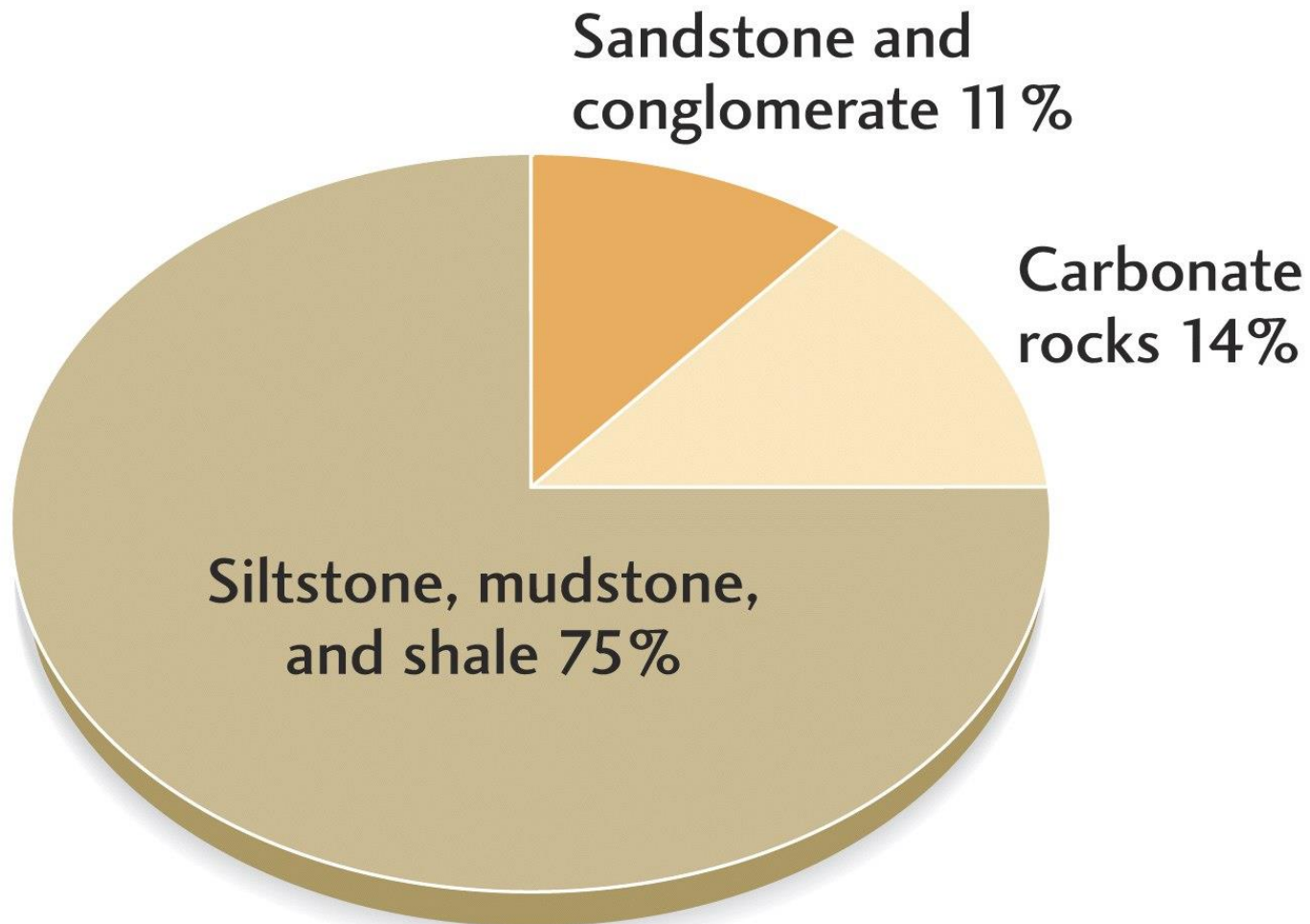
Detrital Sedimentary Rocks

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



Detrital Sedimentary Rocks



Detrital Sedimentary Rocks

■ Common **detrital** sedimentary rocks:

1. **Shale**

- Mud-sized particles in thin layers that are commonly referred to as **laminae**
- Most common sedimentary rock

2. **Sandstone**

- Composed of sand-sized particles (well sorted to poorly sorted)
- Forms in a variety of environments
- Quartz is the predominant mineral

Detrital Sedimentary Rocks



(c) Shale



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Shale with plant remains

Detrital Sedimentary Rocks

- ✚ Alternating sequences of **shale** and **sandstone** exposed in the Grand Canyon. **Shale** cannot support steep cliffs or form erosion



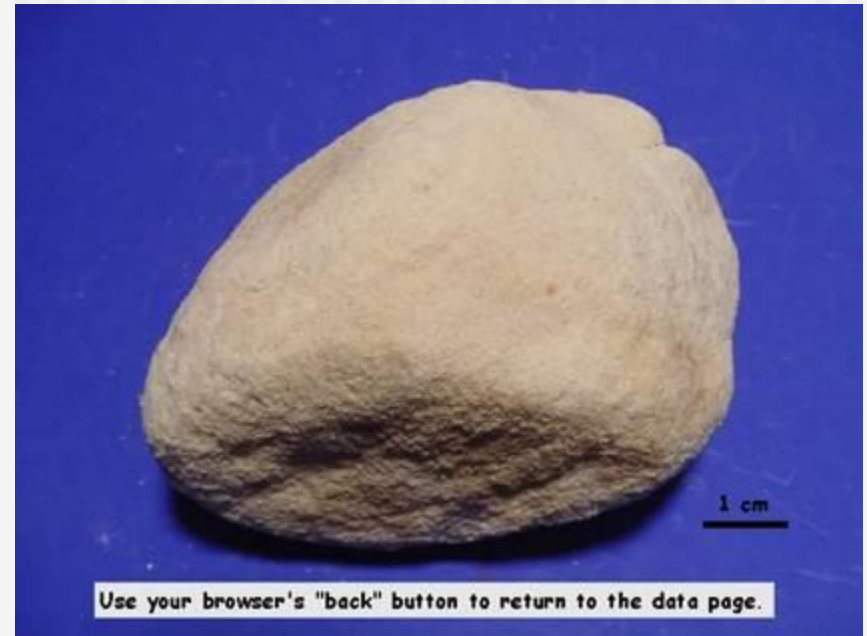
Detrital Sedimentary Rocks

Sandstone

Arkose (with feldspar)



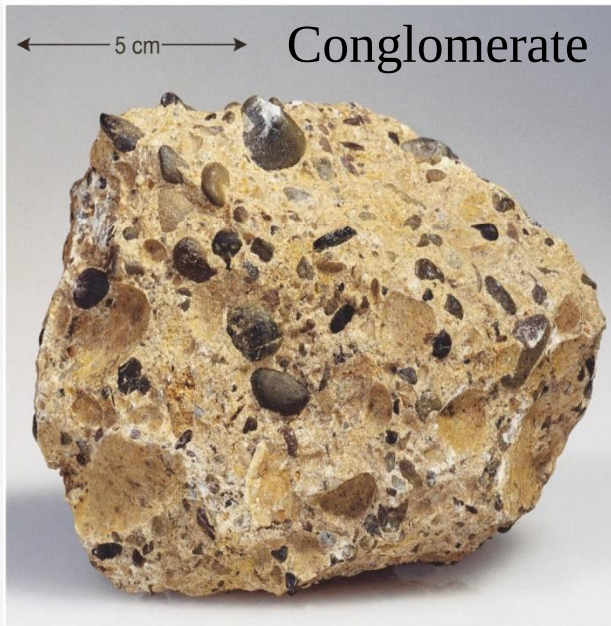
Quartz Sandstone



Detrital Sedimentary Rocks

3. Conglomerate and breccia

- Both are composed of particles greater than 2mm in diameter
- Conglomerate consists largely of rounded gravels
- Breccia is composed mainly of large angular particles



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Chemical Sedimentary Rocks

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

Chemical Sedimentary Rocks

■ Common **chemical** sedimentary rocks

1. **Limestone**

- Most abundant chemical 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 Rocks

Limestones Chalk

Fossiliferous



Coquina



Chemical Sedimentary Rocks

Limestones
(inorganic)
Travertine

Stalactites hanging
(tight) to the ceiling of a
cave



Chemical Sedimentary Rocks

Limestones
Oolitic
(inorganic)



Chemical Sedimentary Rocks

■ Common **chemical** sedimentary rocks

2. **Dolostone**

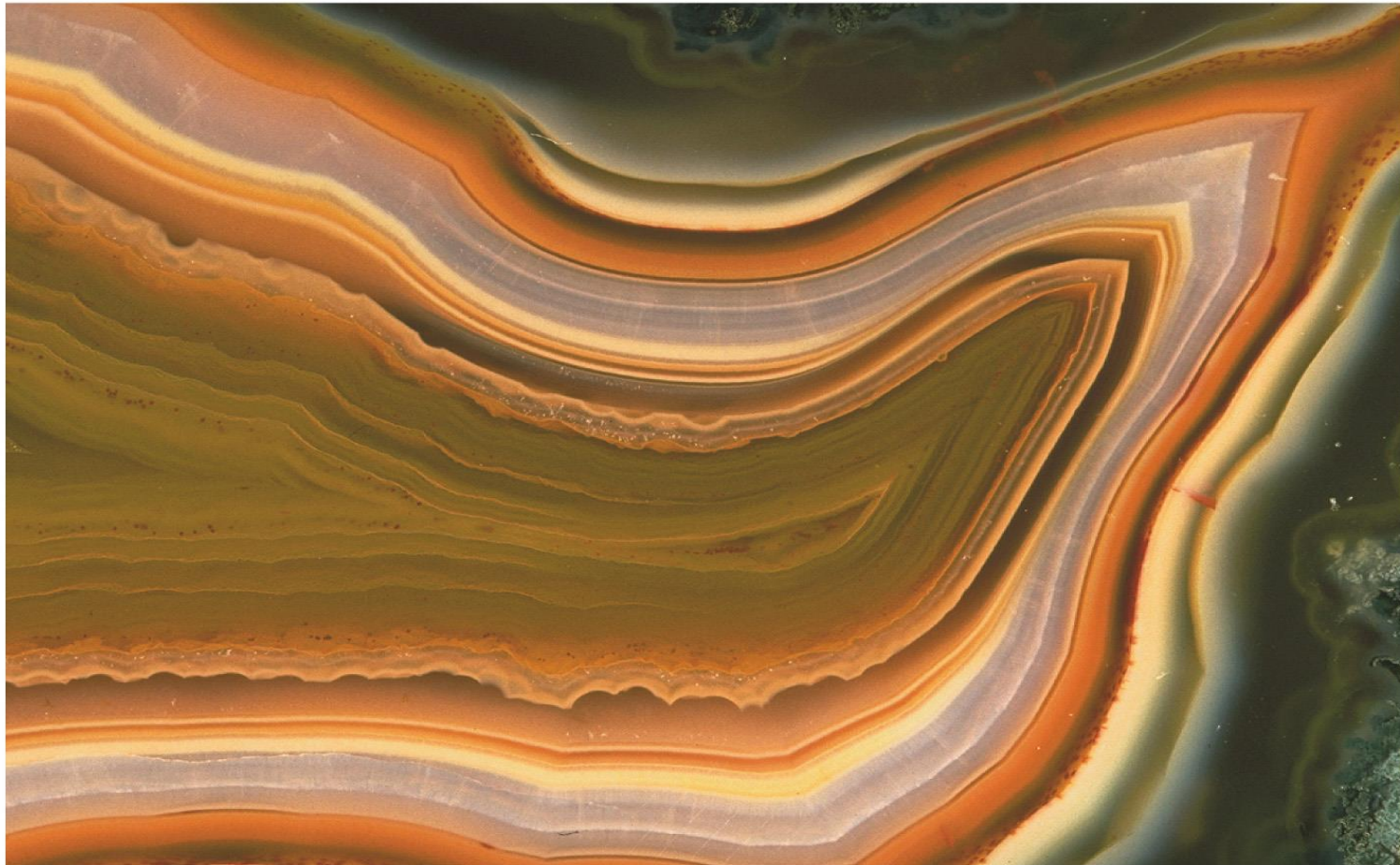
- Typically formed secondarily from limestone

3. **Chert**

- Composed of microcrystalline quartz
- Varieties include **flint** and **jasper** (banded form is called **agate**)

Chemical Sedimentary Rocks

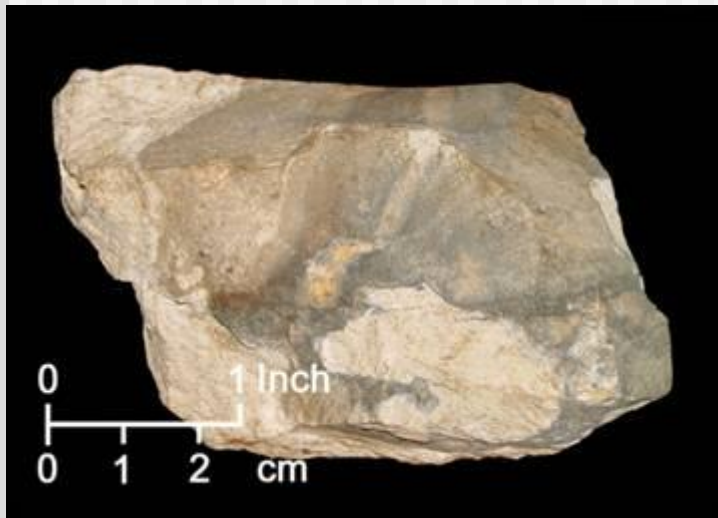
Agate



A.

Chemical Sedimentary Rocks

Quartz (SiO_2)
"flint", "chert"



Chemical Sedimentary Rocks

■ Common **chemical** sedimentary rocks

4. **Evaporites**

- Evaporation triggers deposition of chemical precipitates
- Examples include **rock salt** and **rock gypsum**

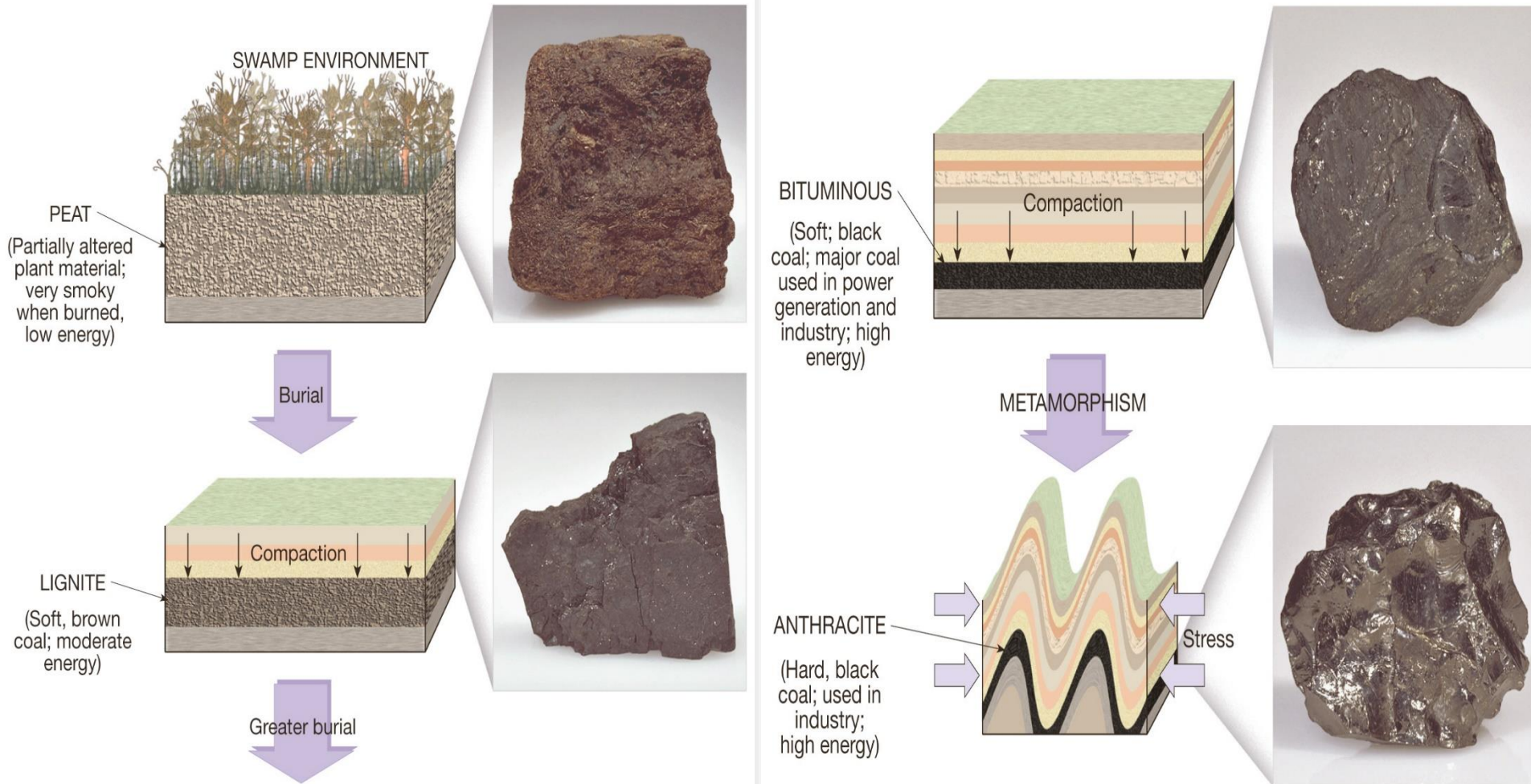
Organic Sedimentary Rocks

■ Common **organic** sedimentary rocks

- **Coal**

- Different from other rocks because it is composed of organic material
- Stages in coal formation (in order)
 - ✓ Plant material
 - ✓ **Peat**
 - ✓ **Lignite**
 - ✓ **Bituminous**

Organic Sedimentary Rocks



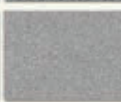
Classification of sedimentary rocks

- Sedimentary rocks are classified according to the *type of material*
- Two major groups:
 - Detrital
 - Chemical

Classification of sedimentary rocks

- Two **major textures** are used in the classification of sedimentary rocks:
 - **Clastic**
 - Discrete fragments and particles
 - All detrital rocks have a clastic texture
 - **Non-clastic**
 - Pattern of interlocking crystals
 - May resemble an igneous rock

Identification of sedimentary rocks

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	Sandstone
		(If abundant feldspar is present the rock is called Arkose)	
Fine (1/16 to 1/256 mm)		Mud	Siltstone
Very fine (less than 1/256 mm)		Mud	Shale or Mudstone

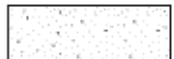
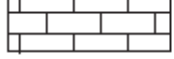
Chemical and Organic Sedimentary Rocks			
Composition	Texture	Rock Name	
Calcite, CaCO ₃	Nonclastic: Fine to coarse crystalline	Crystalline Limestone	
		Travertine	
	Clastic: Visible shells and shell fragments loosely cemented	Coquina	Biochemical Limestone
	Clastic: Various size shells and shell fragments 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 •2H ₂ O	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	

FIGURE 6.16 Identification of sedimentary rocks. Sedimentary rocks are divided into three groups—detrital, chemical, and organic. The main criterion for naming detrital sedimentary rocks is particle size, whereas the primary basis for distinguishing among chemical sedimentary rocks is their mineral composition.

FIGURE 6.16 Identification of sedimentary rocks. Sedimentary rocks are divided into three groups—detrital, chemical, and organic. The main criterion for naming detrital sedimentary rocks is particle size, whereas the primary basis for distinguishing among chemical sedimentary rocks is their mineral composition.

Identification of sedimentary rocks

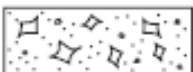
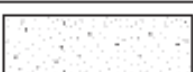
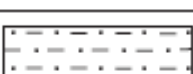
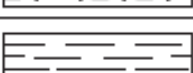
Scheme for Sedimentary Rock Identification

INORGANIC LAND-DERIVED SEDIMENTARY ROCKS					
TEXTURE	GRAIN SIZE	COMPOSITION	COMMENTS	ROCK NAME	MAP SYMBOL
Clastic (fragmental)	Pebbles, cobbles, and/or boulders embedded in sand, silt, and/or clay	Mostly quartz, feldspar, and clay minerals; may contain fragments of other rocks and minerals	Rounded fragments	Conglomerate	
			Angular fragments	Breccia	
	Sand (0.2 to 0.006 cm)		Fine to coarse	Sandstone	
	Silt (0.006 to 0.0004 cm)		Very fine grain	Siltstone	
	Clay (less than 0.0004 cm)		Compact; may split easily	Shale	
CHEMICALLY AND/OR ORGANICALLY FORMED SEDIMENTARY ROCKS					
TEXTURE	GRAIN SIZE	COMPOSITION	COMMENTS	ROCK NAME	MAP SYMBOL
Crystalline	Varied	Halite	Crystals from chemical precipitates and evaporites	Rock Salt	
	Varied	Gypsum		Rock Gypsum	
	Varied	Dolomite		Dolostone	
Bioclastic	Microscopic to coarse	Calcite	Cemented shell fragments or precipitates of biologic origin	Limestone	
	Varied	Carbon	From plant remains	Coal	

Types of Sedimentary Rock

1. Clastic

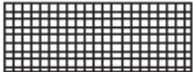
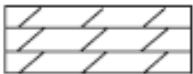
- Formed from the deposition, burial, compaction, and cementation of sediments (fragments of other rock)

TEXTURE	GRAIN SIZE	COMPOSITION	COMMENTS	ROCK NAME	MAP SYMBOL
Clastic (fragmental)	Pebbles, cobbles, and/or boulders embedded in sand, silt, and/or clay	Mostly quartz, feldspar, and clay minerals; may contain fragments of other rocks and minerals	Rounded fragments	Conglomerate	
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	Clay (less than 0.0004 cm)		Compact; may split easily	Shale	

Types of Sedimentary Rock

2. Chemical (Crystalline)

- **Precipitates:** minerals fall out of solution when the water chemistry changes
- **Evaporates:** minerals left behind when water evaporates

TEXTURE	GRAIN SIZE	COMPOSITION	COMMENTS	ROCK NAME	MAP SYMBOL
Crystalline	Varied	Halite	Crystals from chemical precipitates and evaporites	Rock Salt	
	Varied	Gypsum		Rock Gypsum	
	Varied	Dolomite		Dolostone	

Sedimentary Environments

- A geographic setting where sediment is accumulating
- Determines the nature of the sediments that accumulate (grain size, grain shape, etc.)

Sedimentary Environments

■ Types of sedimentary environments:

1. **Continental**

- Dominated by stream erosion and deposition
- Glacial
- Wind (eolian)

2. **Marine**

- Shallow (to about 200 meters)
- Deep (seaward of continental shelves)

Sedimentary Environments

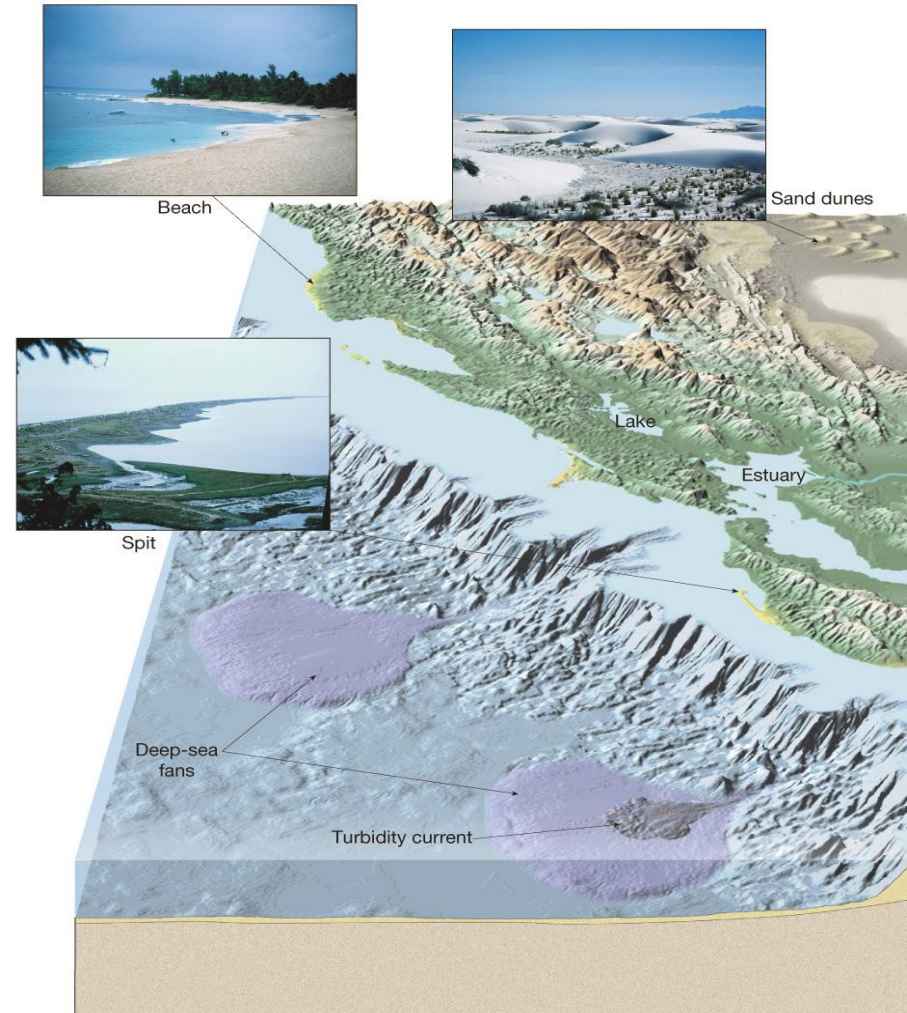
3. Transitional (shoreline)

- Tidal flats
- Lagoons
- Deltas

Sedimentary Environments



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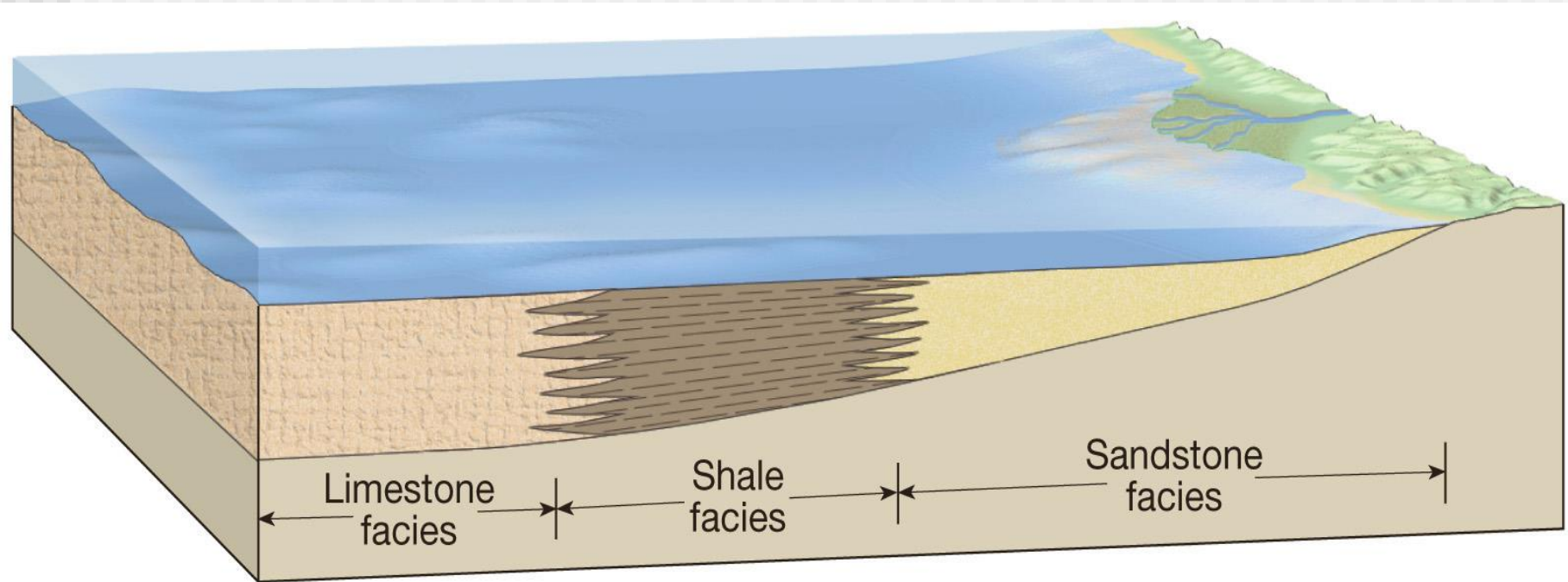


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Sedimentary Environments

- Sedimentary facies:
 - Different sediments often accumulate adjacent to one another at the same time
 - Each unit (called a **facies**) possesses a distinctive set of characteristics reflecting the conditions of a particular environment
 - The merging of adjacent facies is a gradual transition

Sedimentary Environments



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Sedimentary Facies

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
 - **Cross-bedding**
 - **Graded beds**
 - **Ripple marks**
 - **Mud cracks**
 - **Fossils**

Characteristics of Sedimentary Rocks

- May stratified because the sediments are laid down in horizontal layers called strata. (one layer is called stratum)
- May also contain fossil i.e: remains, prints or other indications of plants & animals found buried in rocks



Dipping sedimentary layers of rock, Rocky Mountains, Canada.

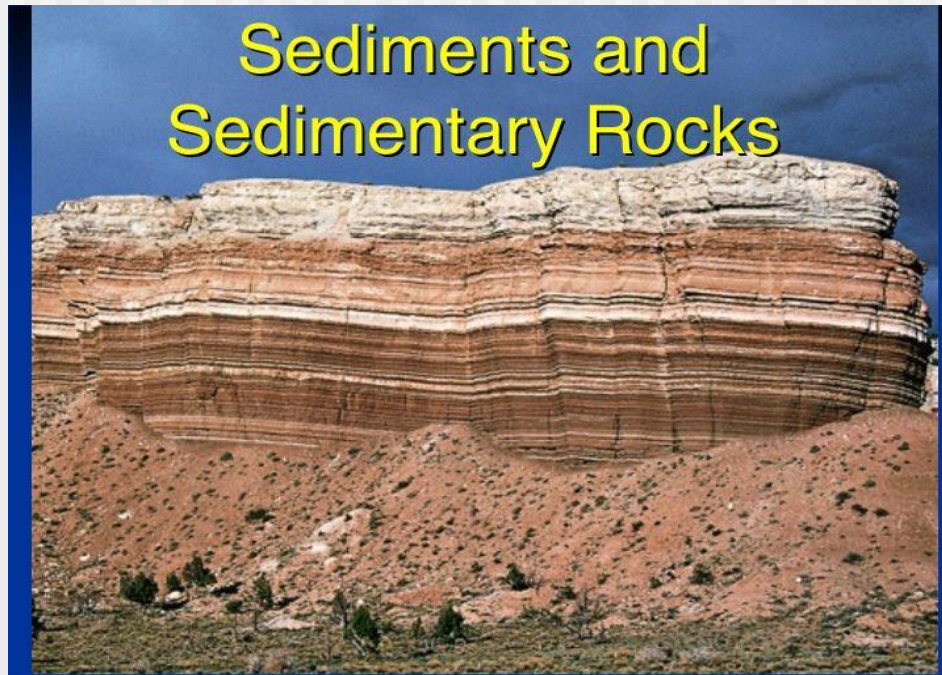
<http://www.geog.ouc.bc.ca/physgeog/contents/10f.html>

Fossils: Evidence of Past Life

- By definition, fossils are the traces or remains of prehistoric life now preserved in rock
- Fossils are generally found in sediment or sedimentary rock (rarely in metamorphic and never in igneous rock)
- Geologically fossils are important for several reasons
 - Aid in interpretation of the geologic past
 - Serve as important time indicators
 - Allow for correlation of rocks from different places

Features of Sedimentary Rocks

1. **Stratification** (bedding) is when layers of sedimentary rocks form stacked on top of each other



Features of Sedimentary Rocks

2. **Ripple Marks** are sand patterns formed by the action of winds, streams, waves, or currents



Features of Sedimentary Rocks

3. **Mud Cracks** develop in clay when it dries out and hardens into rock.

