Sediment and Sedimentary Rocks

Chapter 14

Relationship to Earth's Systems

- *Atmosphere*
  - Most sediments produced by weathering in air
  - Sand and dust transported by wind
- *Hydrosphere*
  - Water is a primary agent in sediment production, transportation, deposition, cementation, and formation of sedimentary rocks
- *Biosphere*
  - Biological activity key to formation of sedimentary rocks
  - Petroleum and coal resources have biological origin

Sedimentary Rocks

- Produced from *weathering products* of pre-existing rocks or accumulated *biological matter*
  - *Detrital or Clastic* rocks produced from rock fragments
  - *Chemical* rocks produced by precipitation of dissolved ions in water
  - *Organic* rocks produced by accumulation of biological debris, such as in swamps

- Sedimentary rock types and *sedimentary structures* within the rocks give clues to *past environments*

- *Fossils* in sedimentary rocks give clues to the history of life

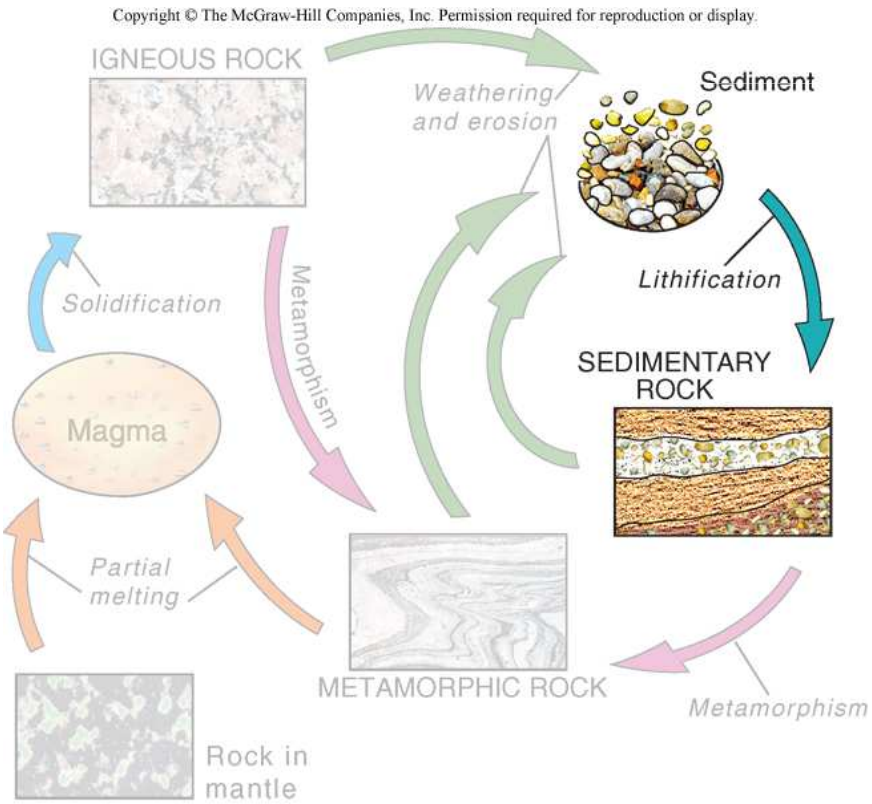
- Important *resources* (coal, oil) are found in sedimentary rocks

Sediment

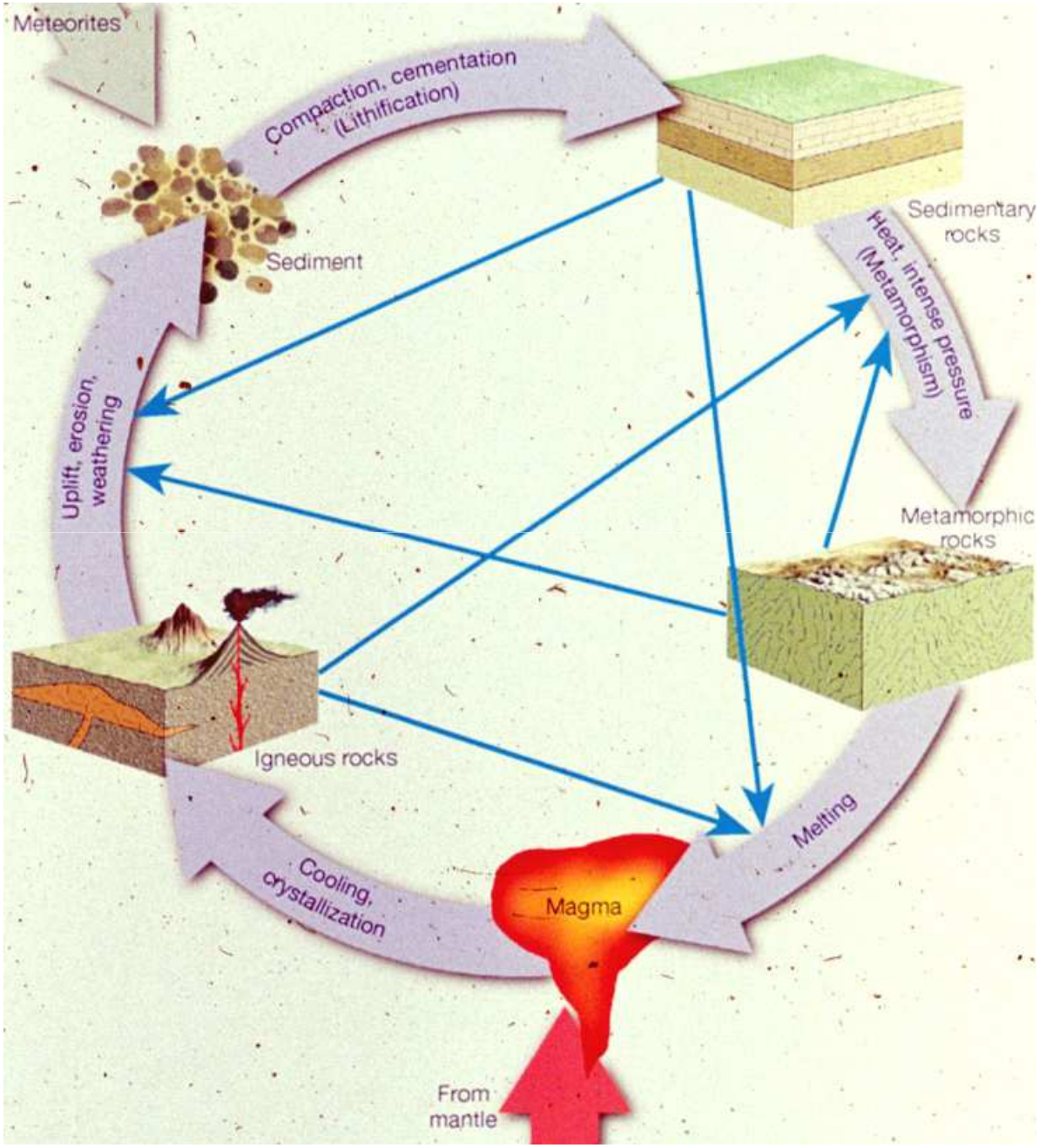
- *Sediment* - loose, solid particles originating from:
  - Weathering and erosion of pre-existing rocks
  - Chemical precipitation from solution

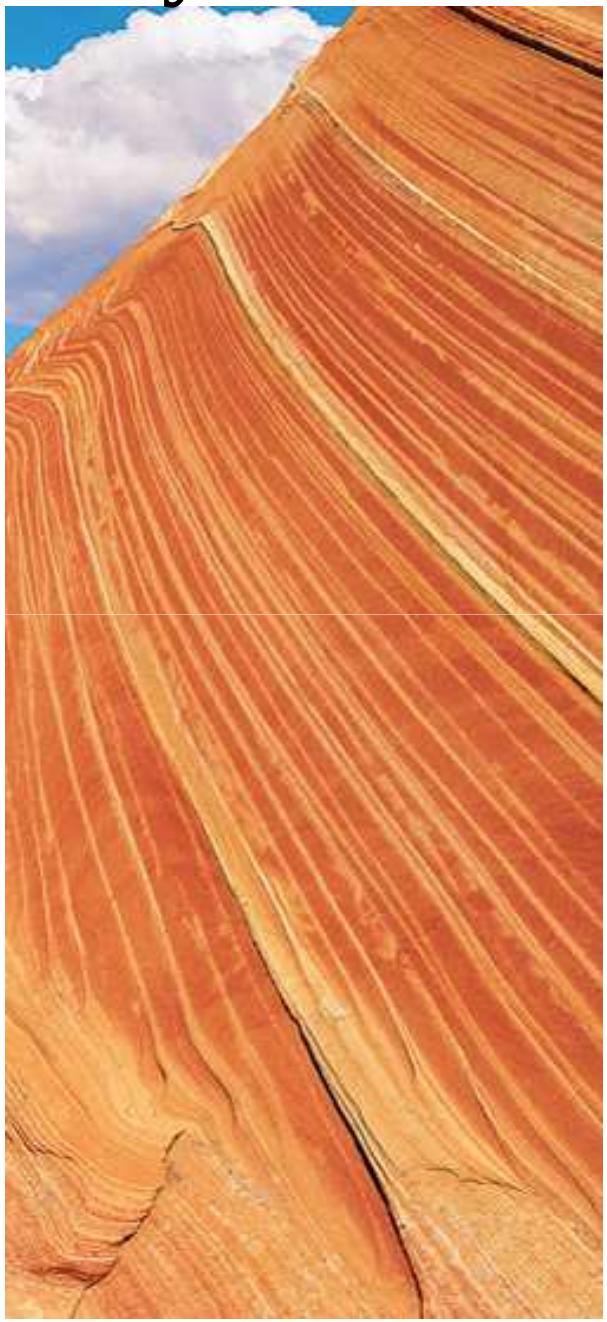
- Classified by *particle size*
  - Boulder - >256 mm
  - Cobble - 64 to 256 mm
  - Pebble - 2 to 64 mm
  - Sand - 1/16 to 2 mm
  - Silt - 1/256 to 1/16 mm
  - Clay - <1/256 mm

Gravel



From Sediment to Sedimentary Rock



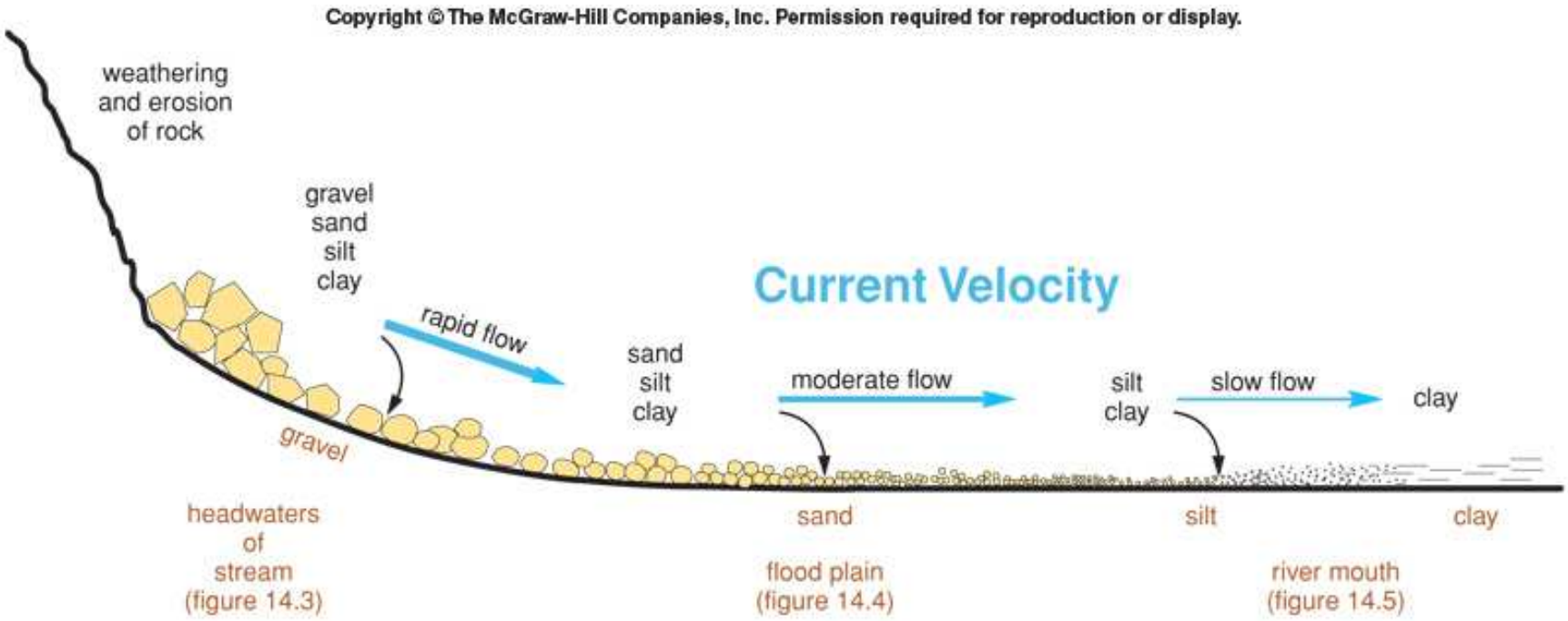


From Sediment to Sedimentary Rock

- *Transportation*
- *Deposition*
- *Preservation*
- *Lithification*

From Sediment to Sedimentary Rock

- *Transportation*
  - Movement of sediment away from its source, typically by water, wind, or ice
  - *Rounding* of particles occurs due to abrasion during transport
  - *Sorting* occurs as sediment is separated according to grain size by transport agents, especially running water
  - Sediment size decreases with increased transport distance



David McGeary

Boulders have been rounded as wave action rolled them against each other

© Parvinder Sethi

Coarse gravel is deposited first along a river's course as the river sorts out the various sediment sizes.

From Sediment to Sedimentary Rock

- *Deposition*
  - Settling and coming to rest of transported material
  - *Environment of deposition* is the location in which deposition occurs
    - Deep sea floor
    - Beach
    - Desert dunes
    - River channel
    - Lake bottom

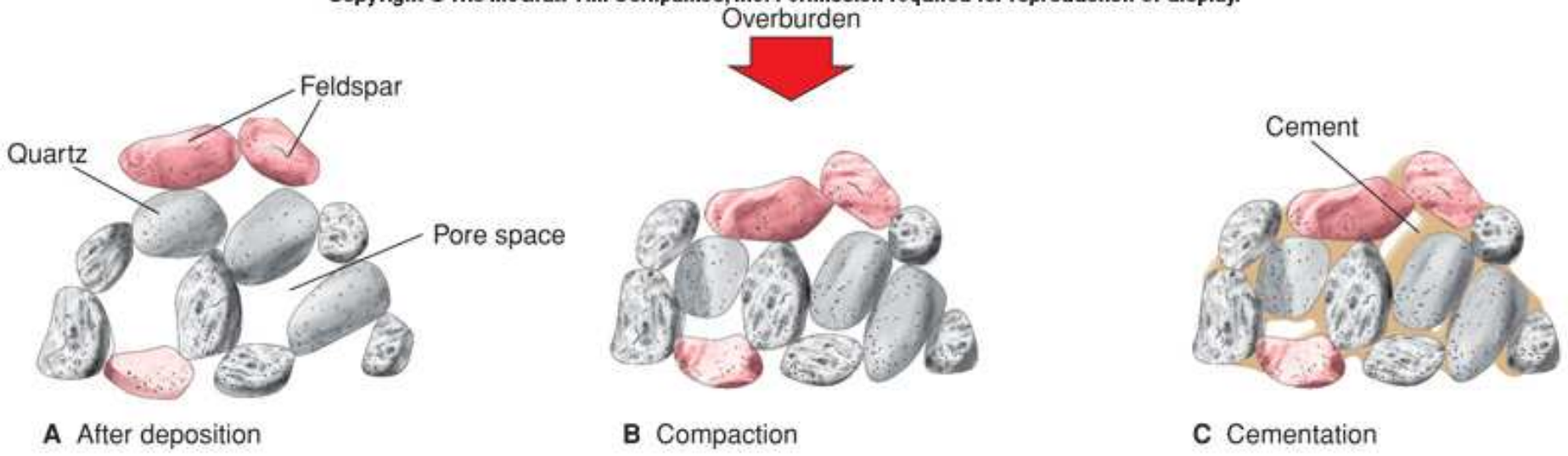
Deposition of sand occurs as a river loses energy

C. W. Montgomery

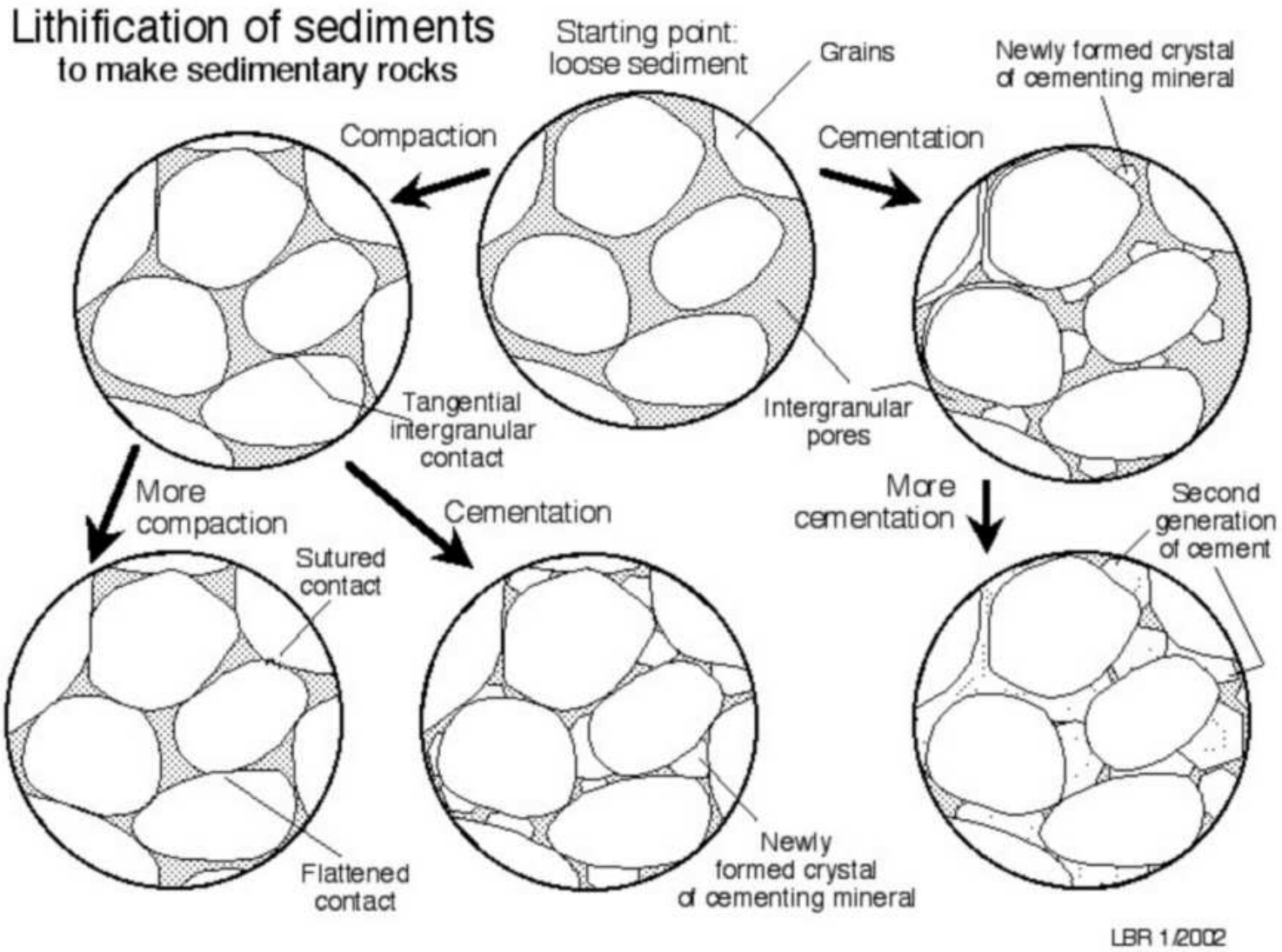
River carrying silt and clay. This fine sediment may come to rest where it enters a lake or the sea

From Sediment to Sedimentary Rock

- *Preservation*
  - Sediment must be preserved, as by burial with additional sediments, in order to become a sedimentary rock
- *Lithification*
  - General term for processes converting loose sediment into sedimentary rock
  - Combination of *compaction* and *cementation*

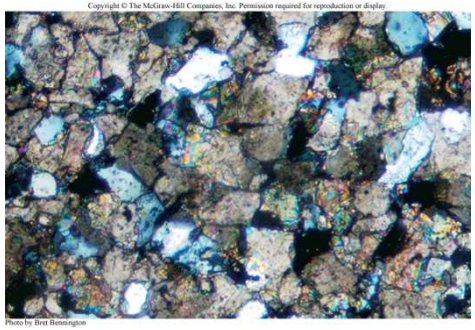


The process of lithification: taking loose sediment and turning it into rock

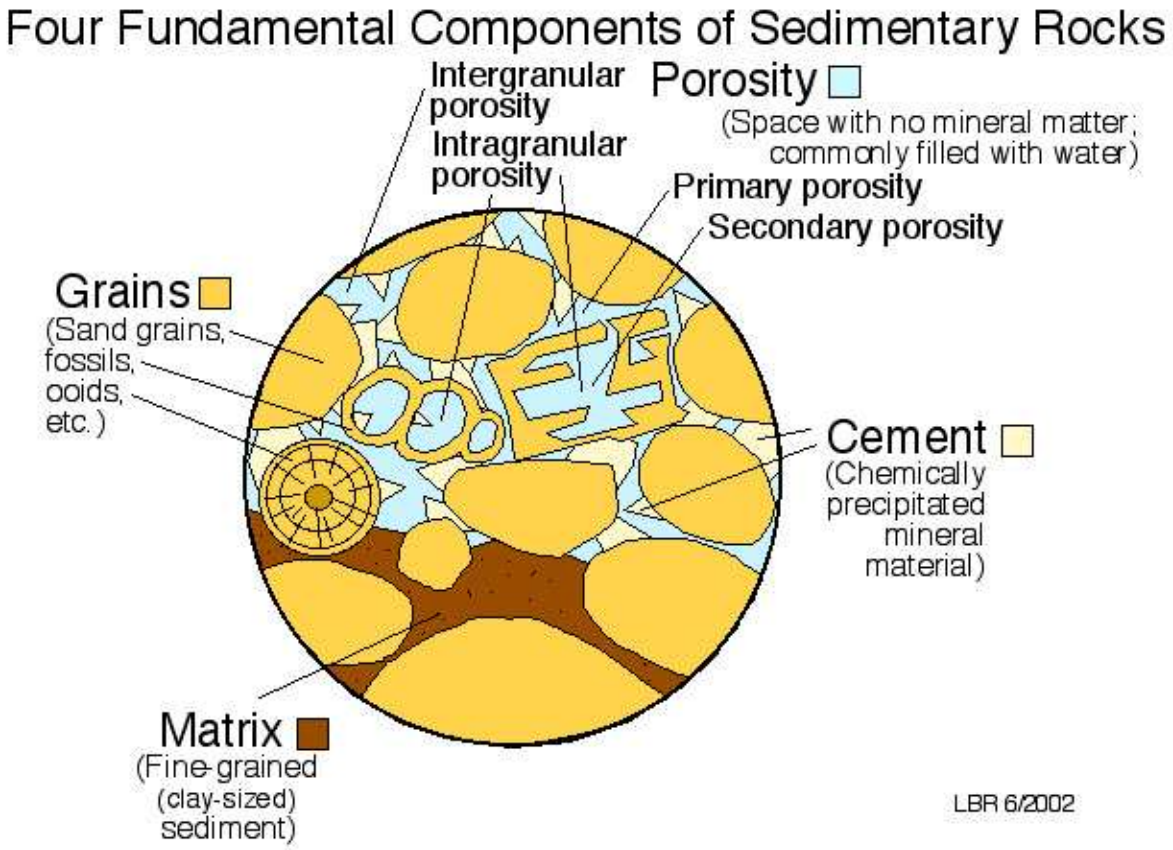


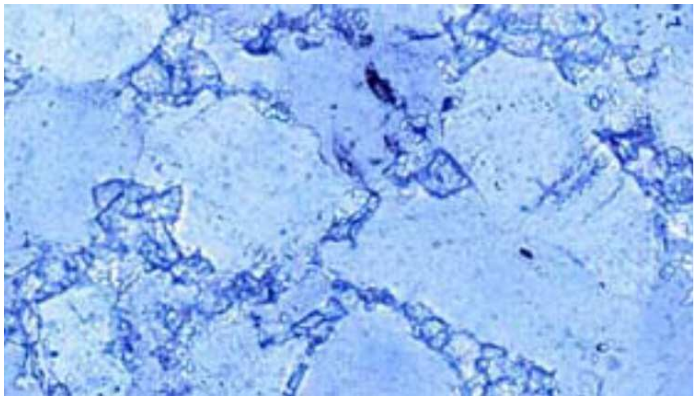
Types of Sedimentary Rocks

- *Detrital or clastic sedimentary rocks*
  - Most common sedimentary rock type
  - Form from cemented sediment grains that come from pre-existing rocks
- *Chemical sedimentary rocks*
  - Have crystalline textures
  - Form by precipitation of minerals from solution
- *Organic sedimentary rocks*
  - Accumulate from remains of organisms

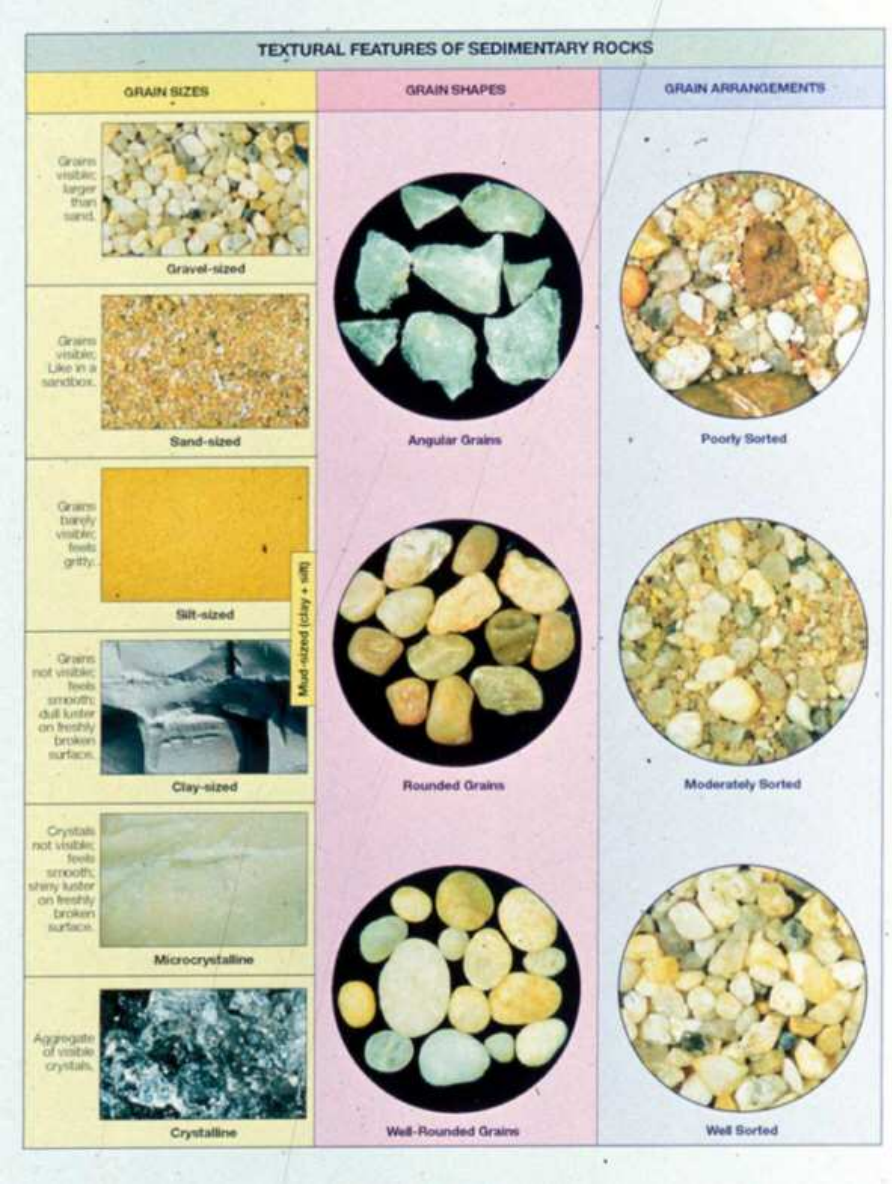


The fundamental components of a sedimentary rock: porosity, grain size, and cement





Characteristics of sediment and what controls how we classify sedimentary rocks



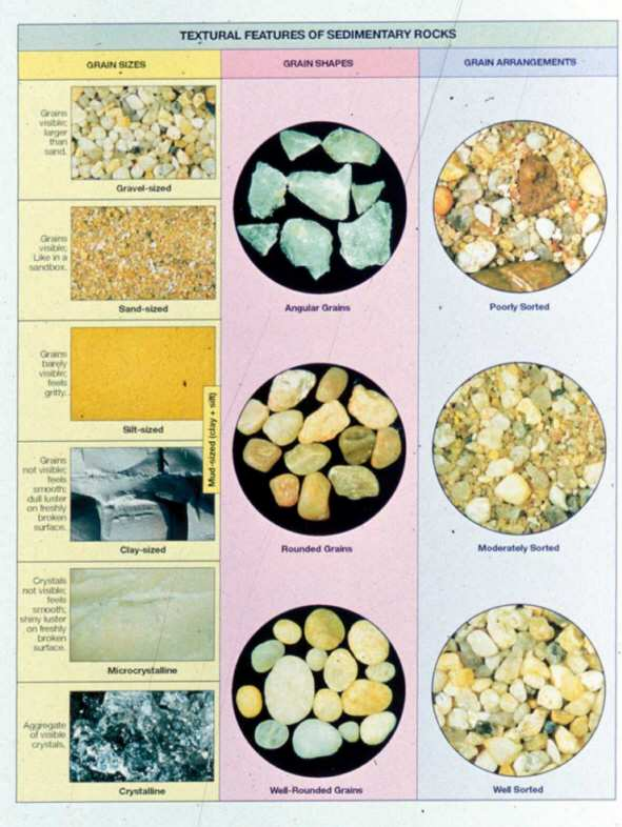
Size, sorting and composition of grains

Detrital/Clastic Sedimentary Rocks

- **Coarse grained**
- **Moderate**
- **Fine grained**

Clastic Sedimentary Rocks

- *Breccia and Conglomerate*
  - *Coarse-grained clastic* sedimentary rocks
  - Sedimentary breccia composed of coarse, ***angular*** *rock fragments* cemented together
  - Conglomerate composed of ***rounded*** *gravel* cemented together



Breccia

David McGeary

Conglomerate

David McGeary

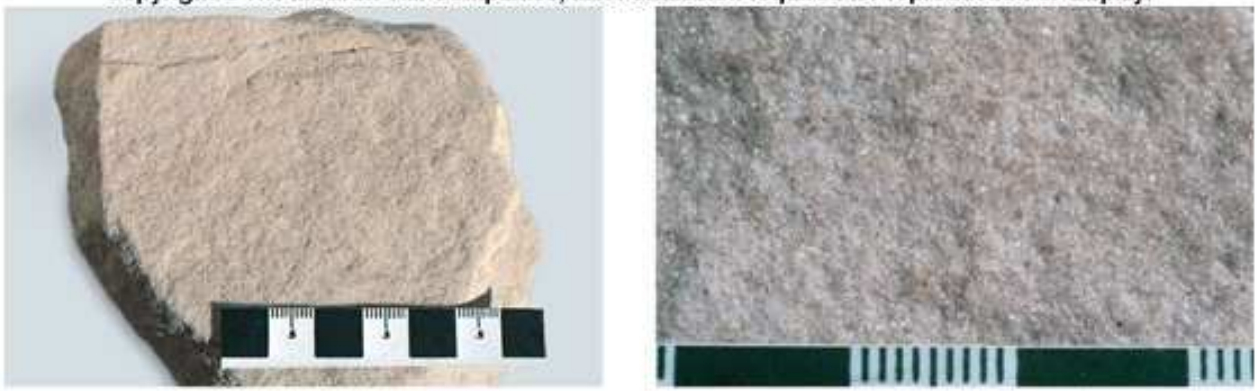
Clastic Sedimentary Rocks

- *Sandstone*
  - *Medium-grained clastic* sedimentary rock
  - Types determined by composition
    - *Quartz sandstone* - >90% quartz grains
    - *Arkose* - mostly feldspar and quartz grains
    - *Graywacke* - sand grains surrounded by dark, fine-grained matrix, often clay-rich

Quartz Sandstone

Arkose

Graywacke



A

B

C

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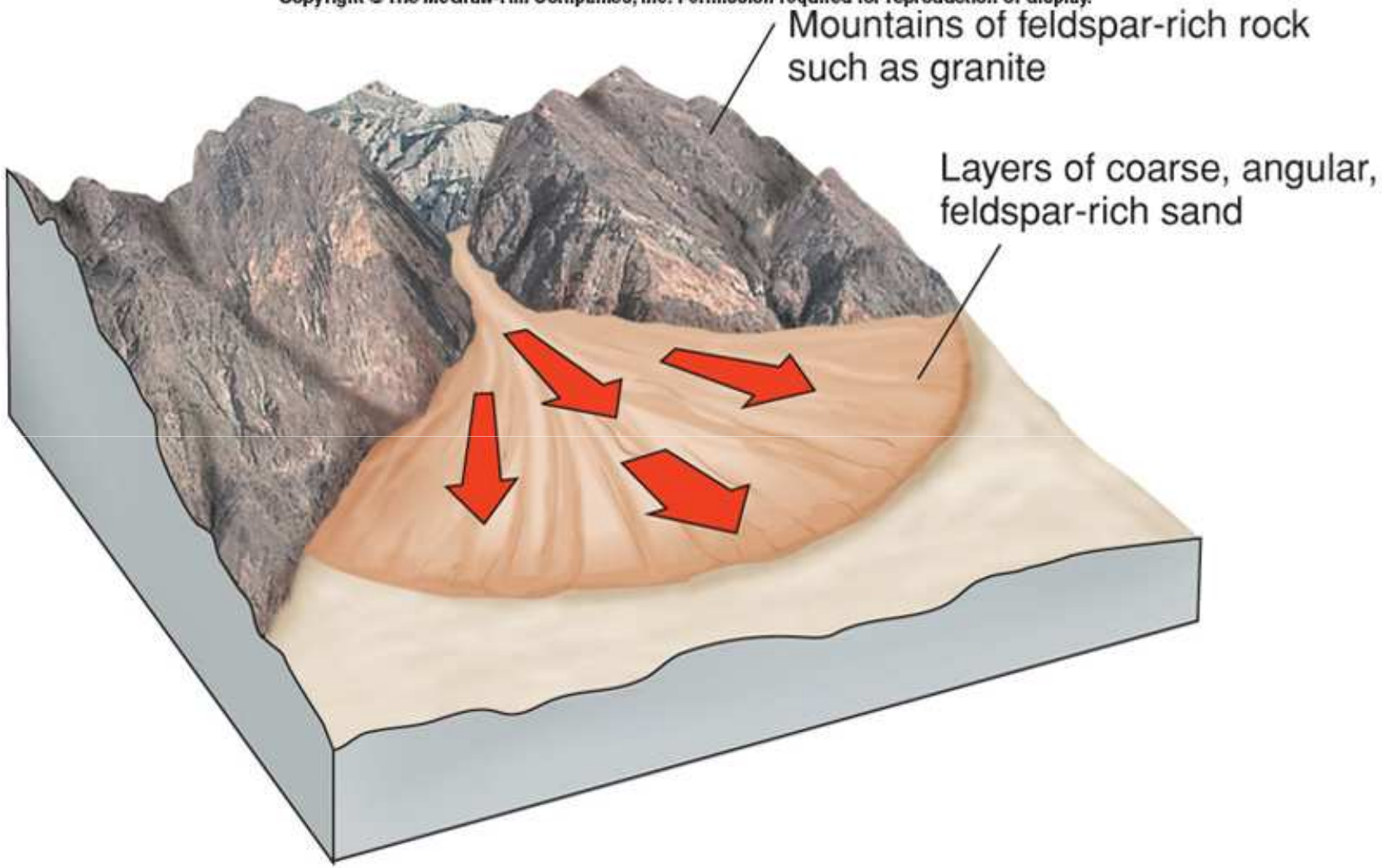
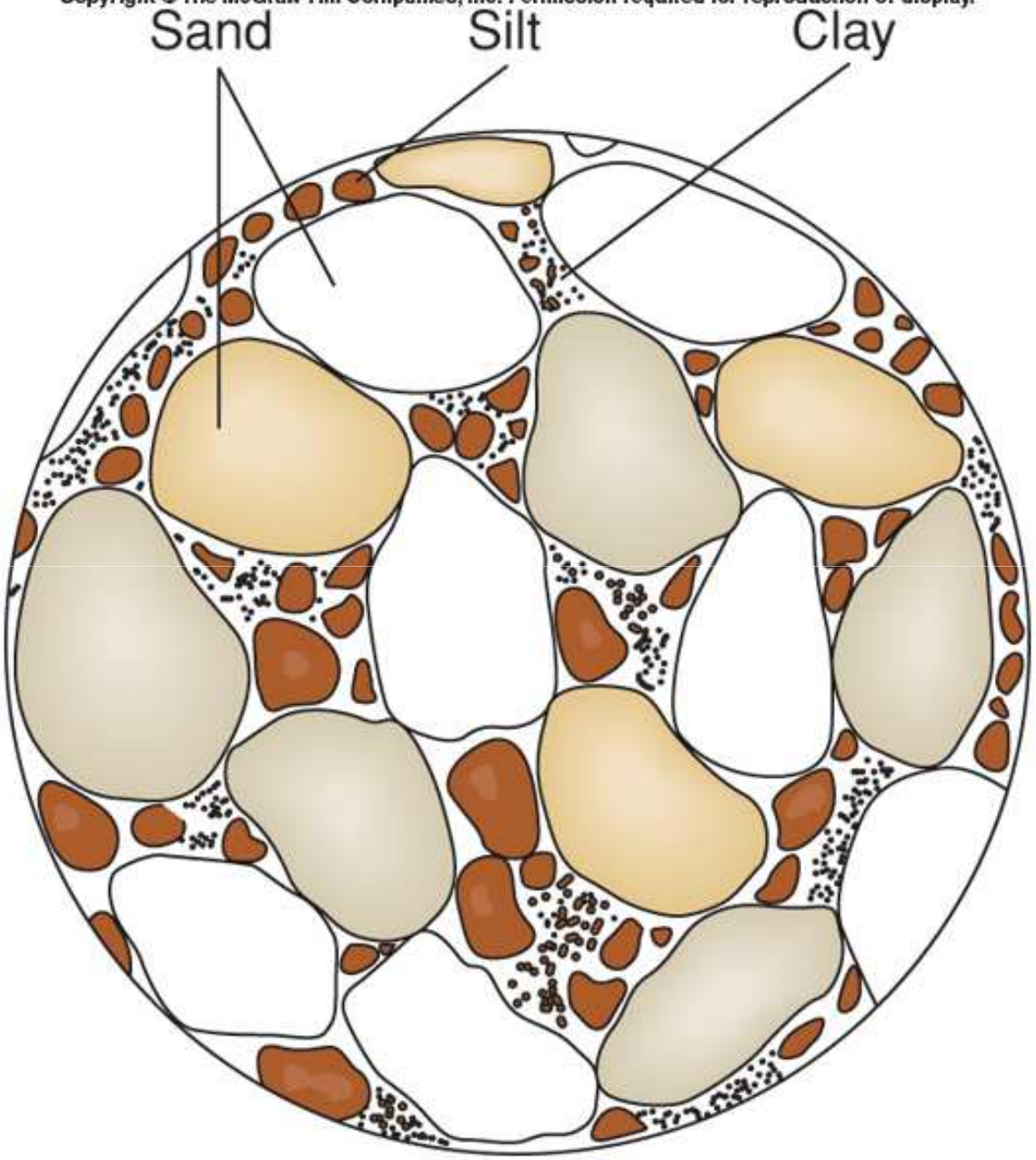




Clastic Sedimentary Rocks

- *Shale*
  - Fine-grained clastic sedimentary rock
  - Splits into thin layers (*fissile*)
  - Silt- and clay-sized grains
  - Sediment deposited in lake bottoms, river deltas, floodplains, and on deep ocean floor

- *Siltstone*
  - Lacks fissility
- *Claystone*
  - Predominantly clay-sized grains; non-fissile
- *Mudstone*
  - Silt- and clay-sized grains; massive/blocky

A

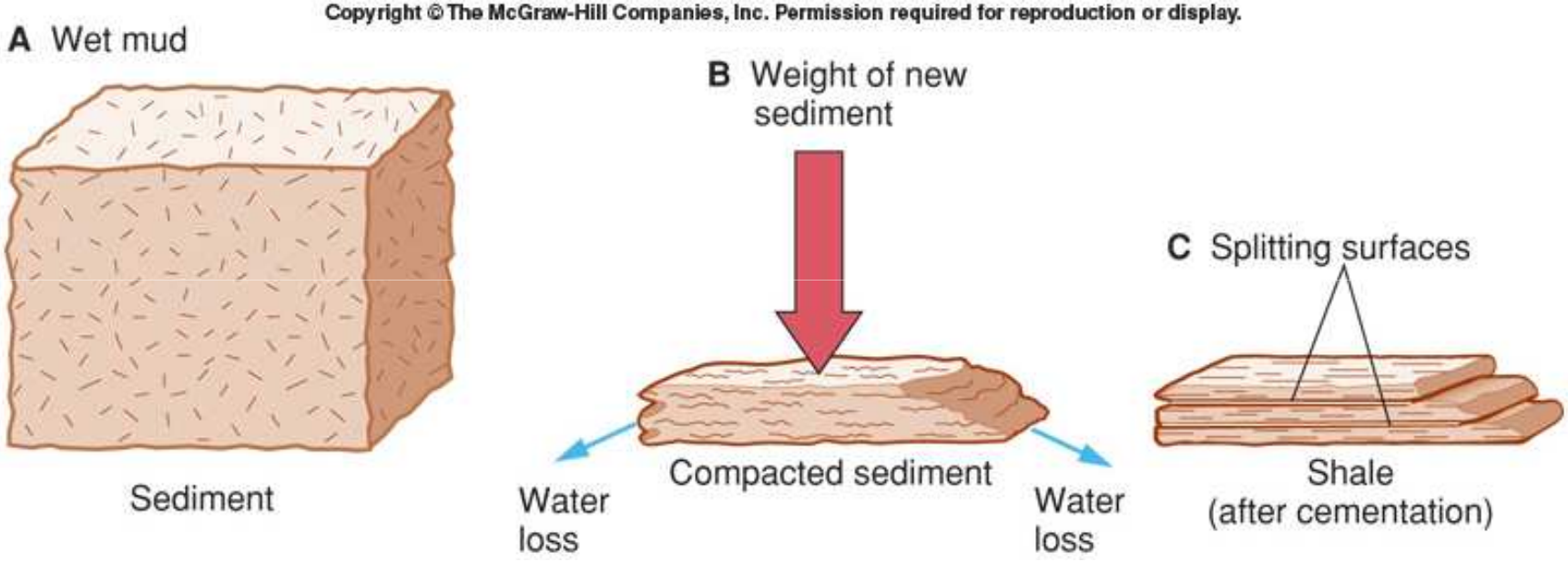
B

(A) © John Buitenkant/Photo Researchers Inc. (B) David McGeary

Outcrop of shale :

Very fine-grained
Very thin layers (laminations)
Tendency to break in small flat pieces

Formation of Shale

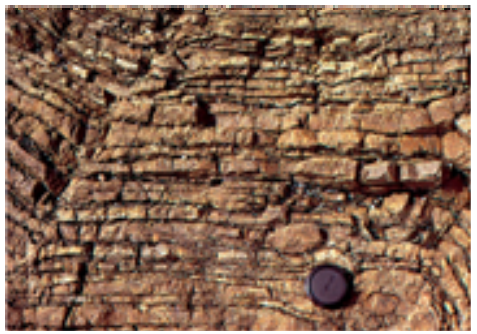


Chemical Sedimentary Rocks

- *Carbonates*
  - Contain CO_3 as part of their chemical composition
  - *Limestone* is composed mainly of *calcite*
    - Most are ***biochemical/biogenic***, but can be ***inorganic***
    - Often contain easily recognizable fossils
    - Chemical alteration of limestone in Mg-rich water solutions can produce *dolomite*

Photo by David McGeary

- *Chert (inorganic/biochemical)*
  - Hard, compact, fine-grained, formed almost entirely of silica
  - Can occur as layers or as lumpy nodules within other sedimentary rocks, especially limestones



- *Evaporites (inorganic)*
  - Form from evaporating saline waters (lake, ocean)
  - Common examples are rock gypsum, rock salt

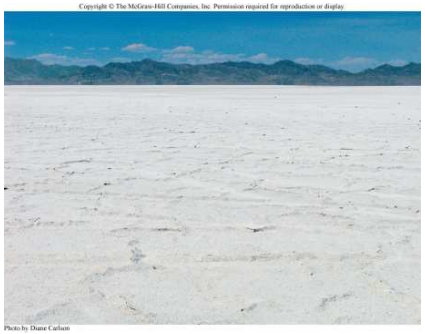
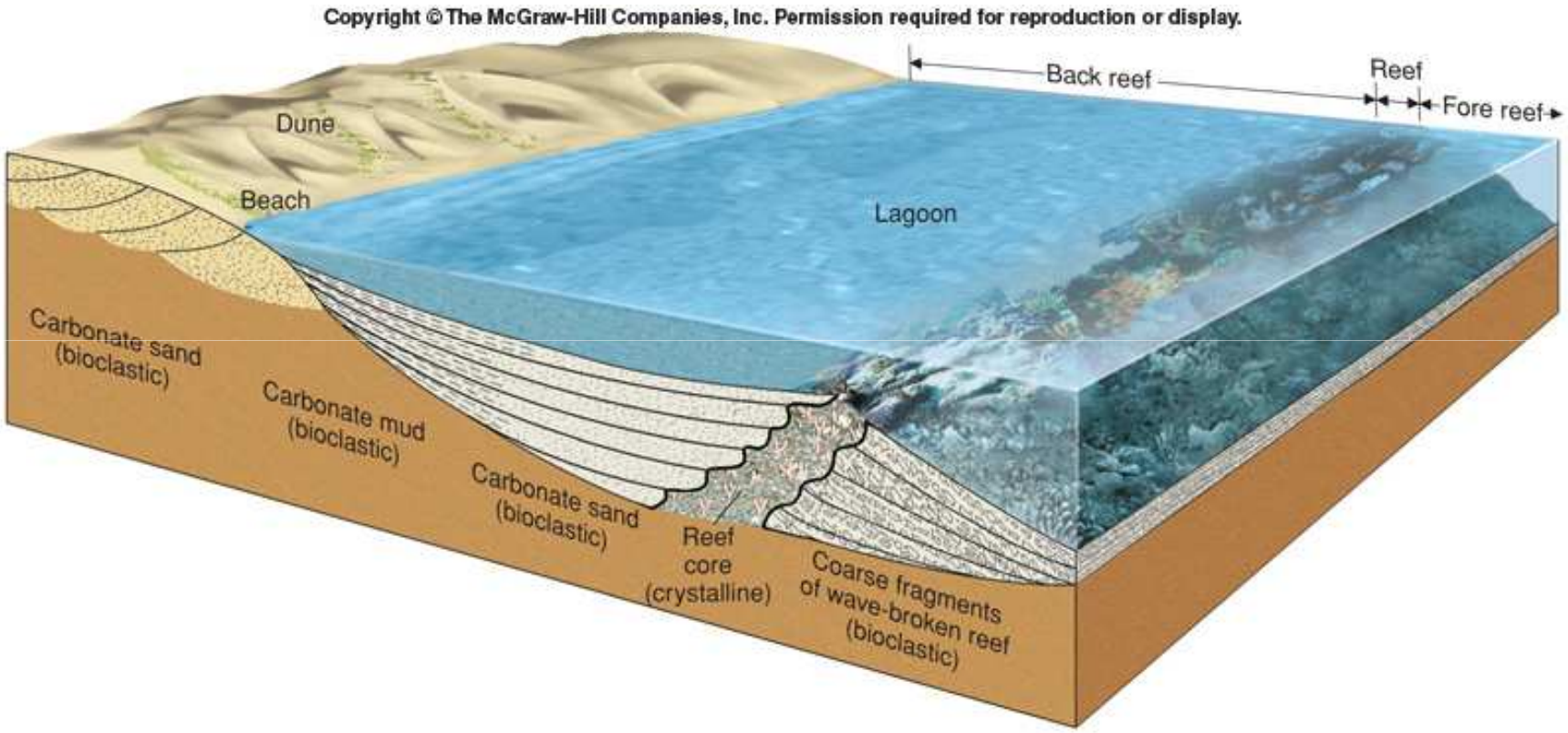


Photo by Diane Carlson

Biogenic Sedimentary Rocks

Biogenic Carbonates



Biogenic Carbonates

David McGeary

Biogenic Carbonates

David McGeary

Biogenic Carbonates

David McGeary

Chalk is a fine-grained variety of biogenic limestone formed of the remains of microscopic marine organisms that live on the sea surface.

Inorganic Carbonate

A

B

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Aerial photo of underwater dunes of **“Ooids”** chemically precipitated from sea water on the shallow Bahamas Banks. An **Oolitic limestone** formed by the cementation of Ooids (small spheres)

Evaporites (Inorganic)

Rock salt

Organics in Sedimentary Rocks

- *Coal*
  - Sedimentary rock forming from compaction of partially decayed plant material
- *Oil and natural gas*
  - Originate from organic matter in sediment
  - Subsurface “cooking” can change organic solids to oil and natural gas
  - Can accumulate in porous overlying rocks

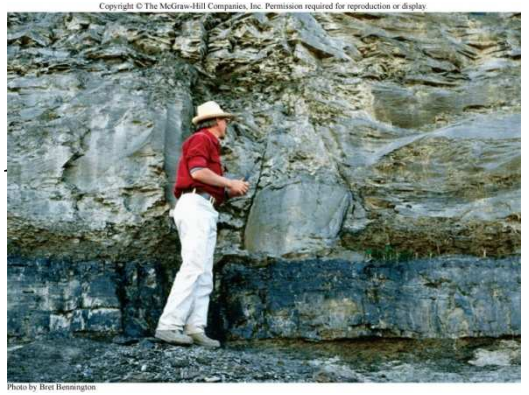
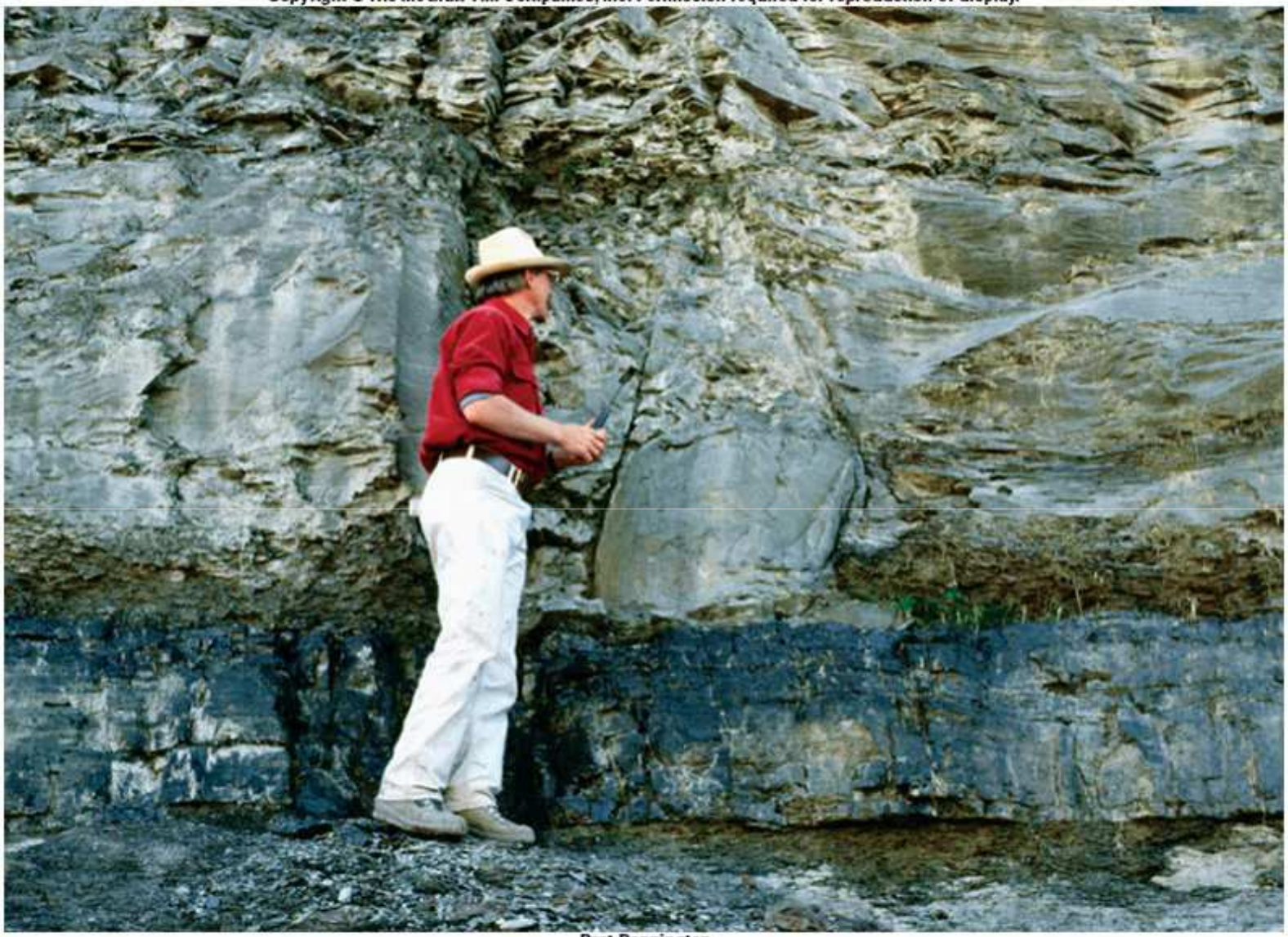


Photo by Bret Bennington



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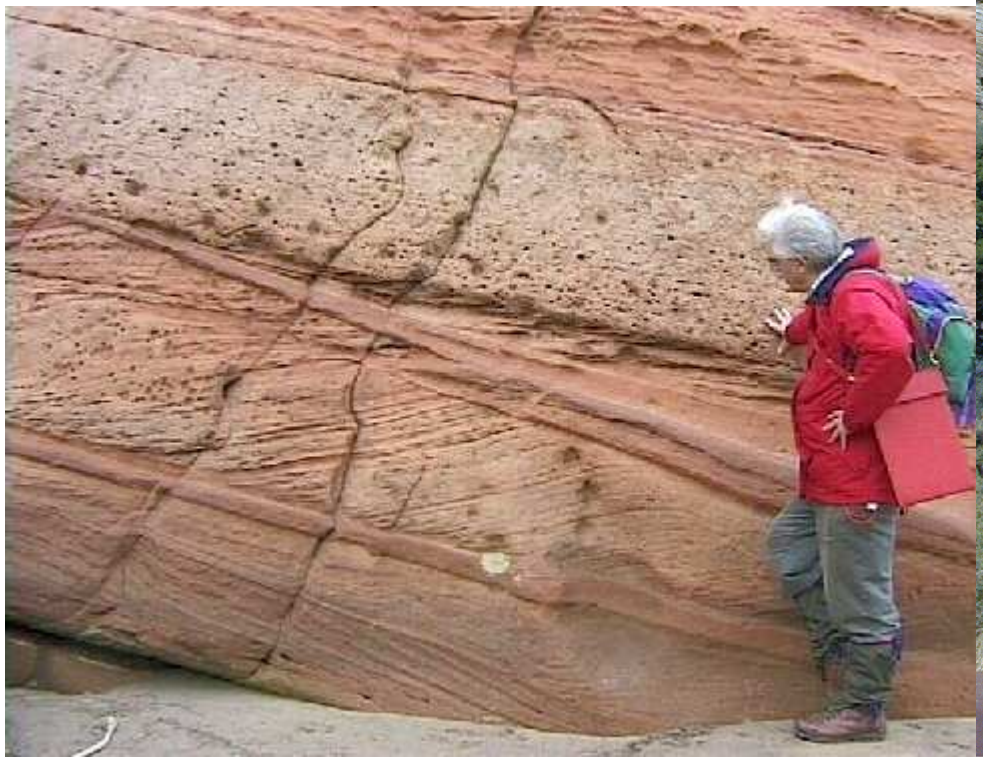
Coal Bed in Black Warrior coal basin, Alabama. Note the fossil tree stump preserved in place at the top of the coal.

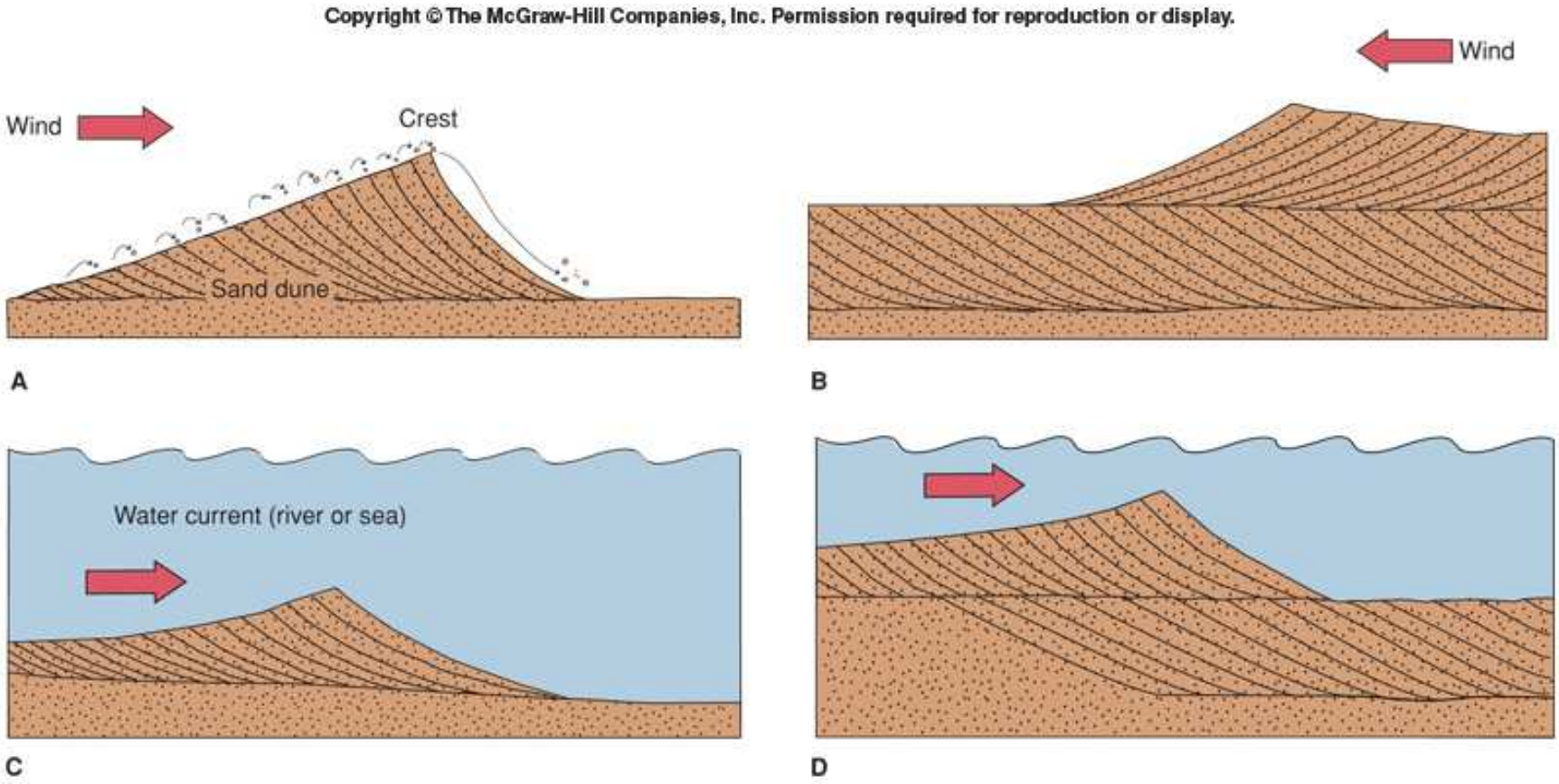
Sedimentary Structures

- *Sedimentary structures*
  - Features within sedimentary rocks produced during or just after sediment deposition
  - Provide clues to how and where deposition of sediments occurred
- *Bedding*
  - Series of visible layers within a rock
  - Most common sedimentary structure
- *Cross-bedding*
  - Series of thin, inclined layers within a horizontal bed of rock
  - Common in sandstones
  - Indicative of deposition in ripples, dunes, deltas

Sedimentary Structures: Cross-bedding



Cross-bedding



The development of cross-beds in wind blown sand (A and B); and water deposited sand (C and D)

Sedimentary Structures

- *Ripple marks*
  - Small ridges formed on surface of sediment layer by moving wind or water
- *Graded bedding*
  - Progressive change in grain size from bottom to top of a bed
- *Mud cracks*
  - Polygonal cracks formed in drying mud
- *Fossils*
  - Traces of plants or animals preserved in rock
  - Hard parts (shells, bones) more easily preserved as fossils

Sedimentary Structures – ripple marks

Sedimentary Structures – graded beds

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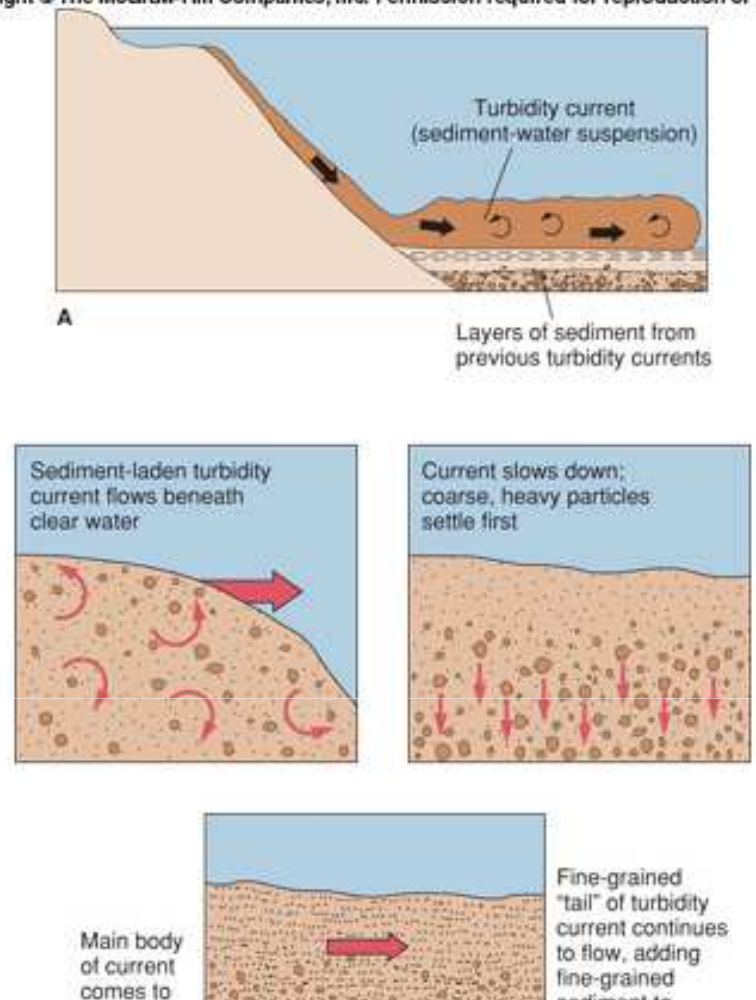
Graded beds



Sedimentary Structures – mud cracks

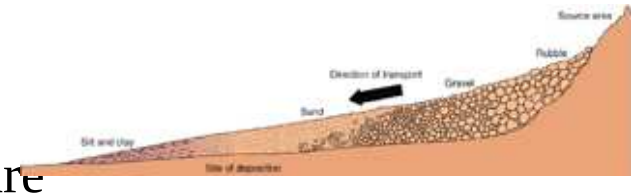
Mud cracks preserved in Shale

Mud cracks in recently dried mud

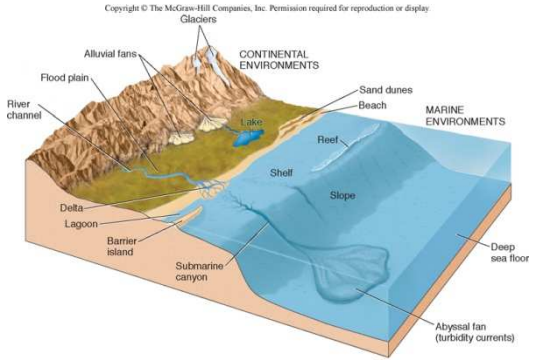
Sedimentary Rock Interpretation

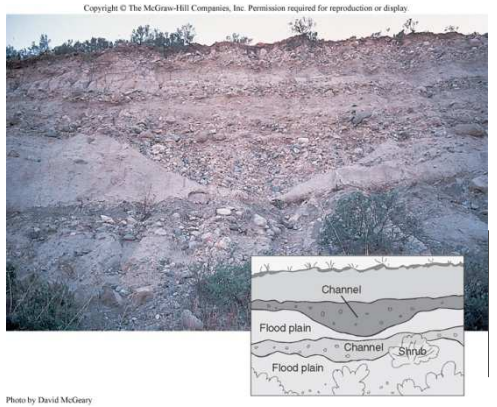
- Sedimentary rocks give important clues to the *geologic history* of an area

- *Source area*
  - Sediment composition, shape, size and sorting are indicators of source rock type and relative location



- *Depositional environment*
  - Location where sediment came to rest
  - Sediment characteristics and sedimentary structures (including fossils) are indicators
  - Examples: river channels and floodplains, lakes, deltas, beaches, dunes, shallow marine, reefs





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Some of the fossils have their original shell material, other fossils are preserved as impressions

A

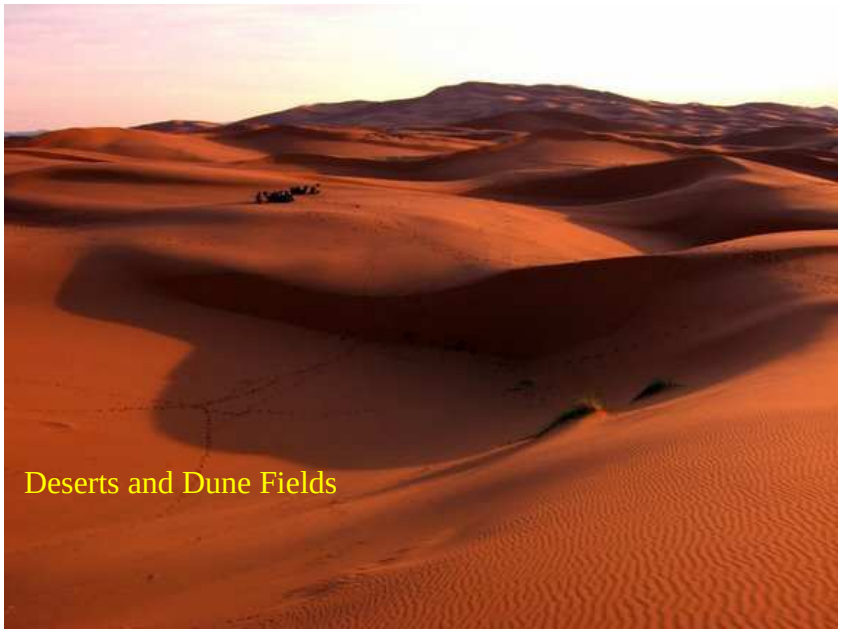
Fossil fish in a rock from western Wyoming

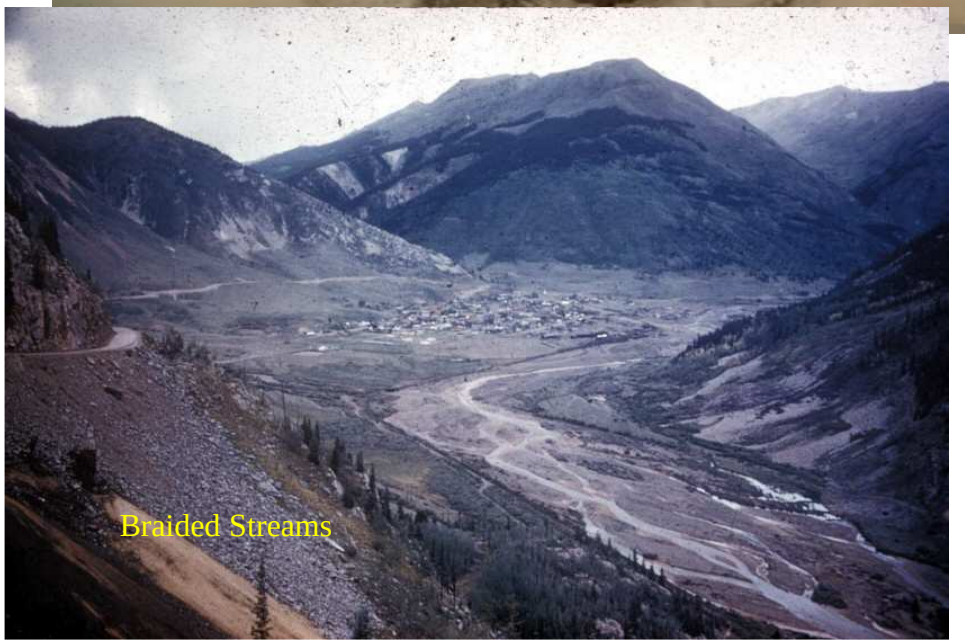
B

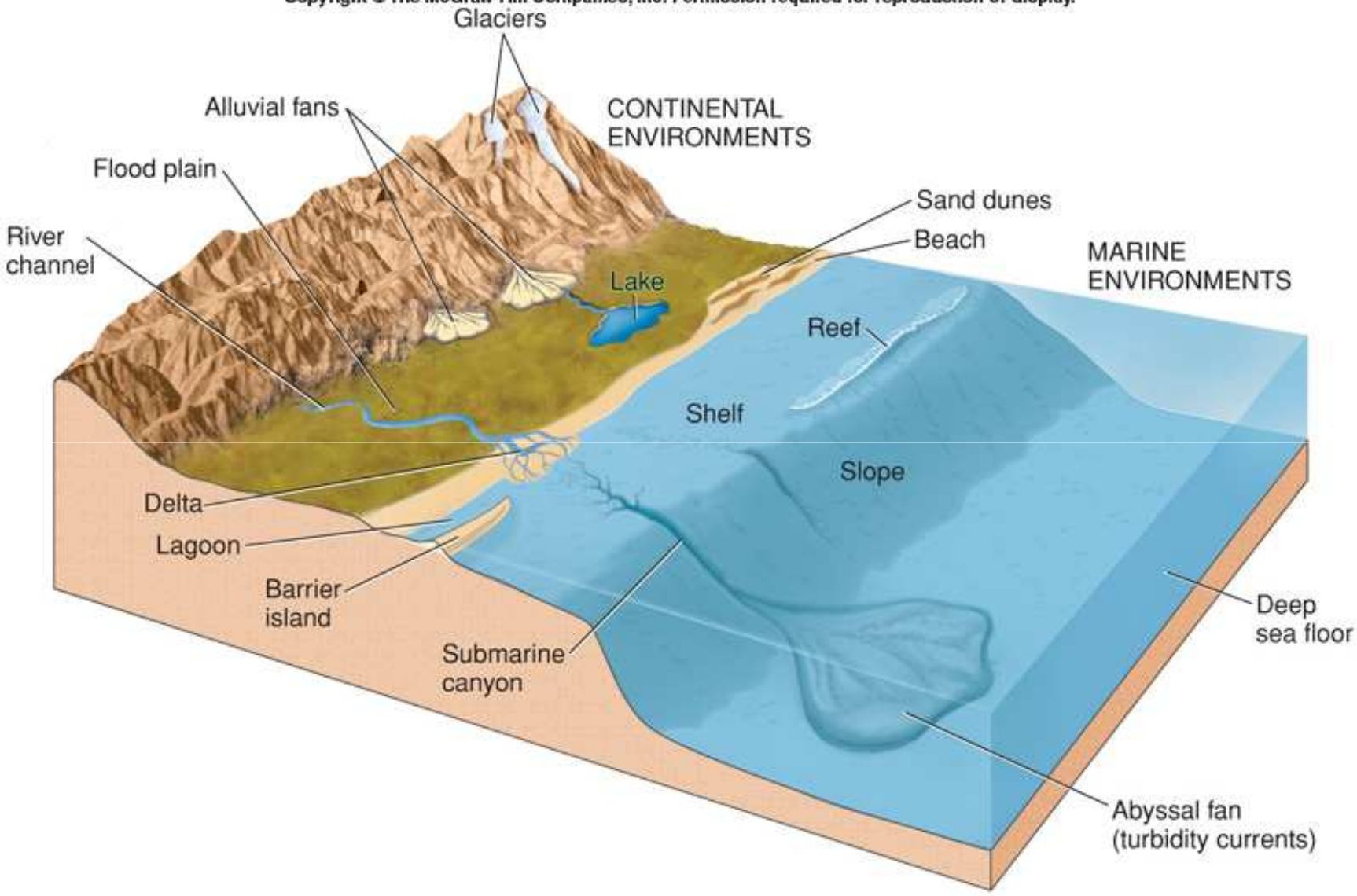
Dinosaur footprint in Shale, Tuba city, Arizona

(A) U.S. Geological Survey (B) David McGeary

Terrestrial Environments



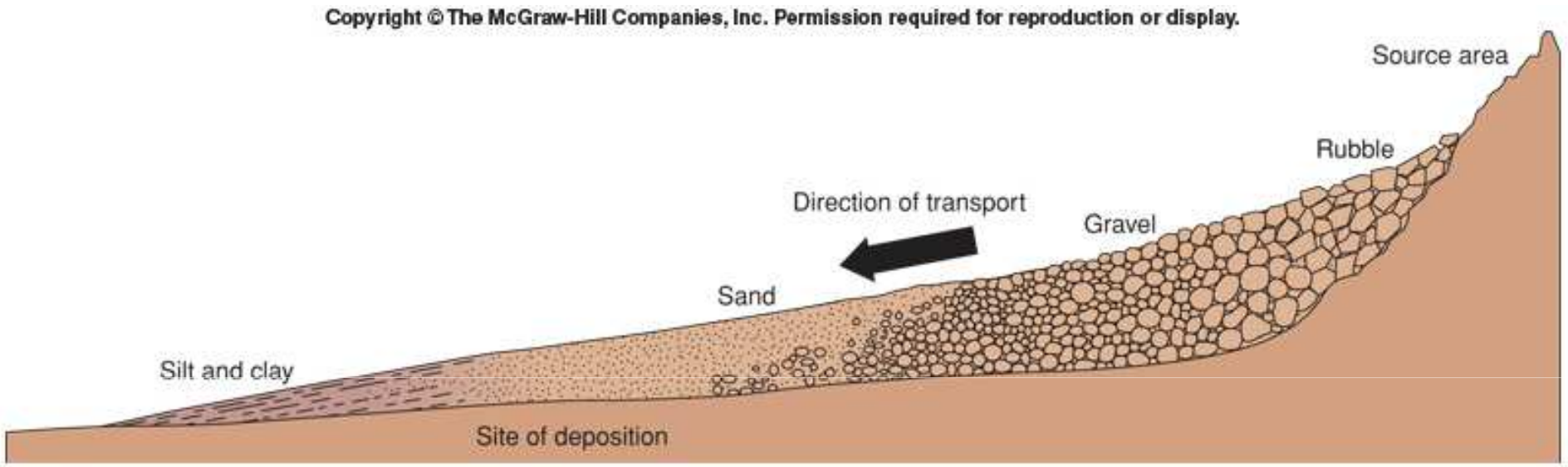




Transitional Environments

Deltas

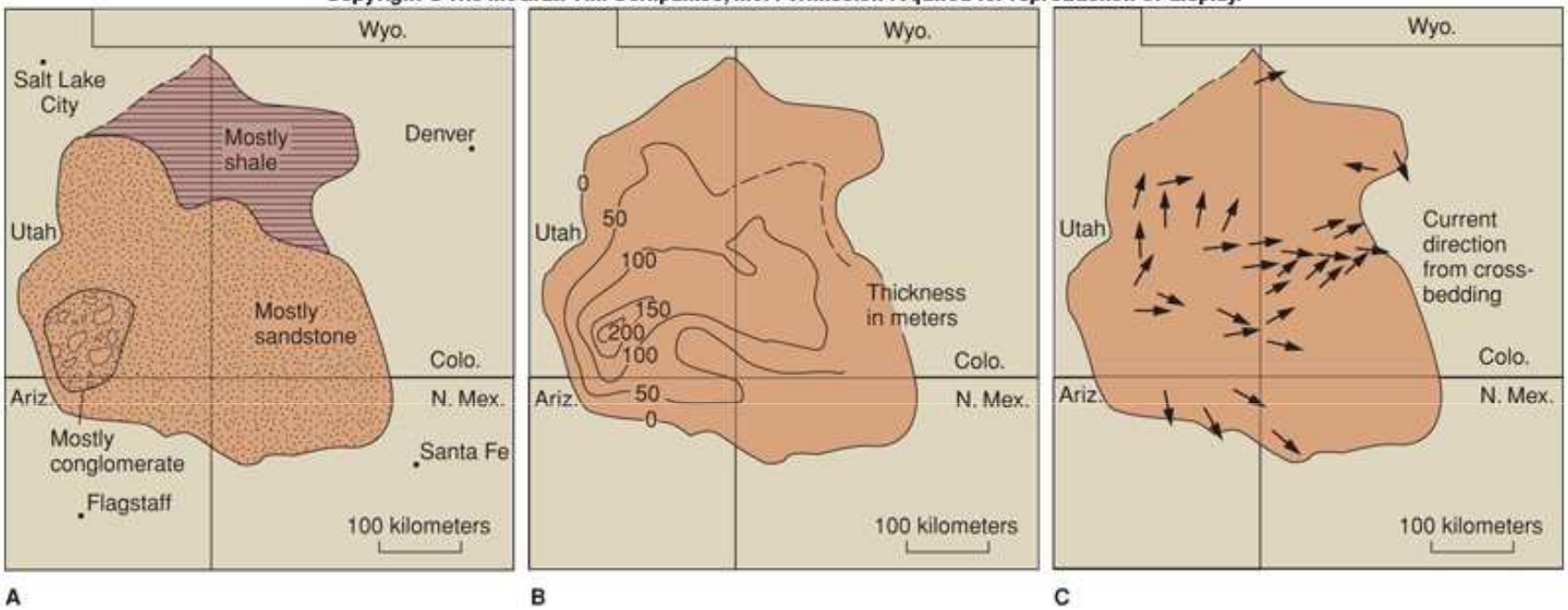
Sediment Transport



Sediment deposit often become thinner away from the source area, and sediment grains become finer and more rounded.

The rocks that form from these sediments would change with distance from the source area: from breccia to conglomerate to sandstone to shale.

The Morrison Formation



Morrison formation famous for it uranium concentration and its dinosaur fossils

(A)The sediment grains become coarser to the southwest
(B) The deposit becomes thicker to the southwest
(C) Cross-bedding shows that the deposits currents came mostly from southwest

End of Chapter 14