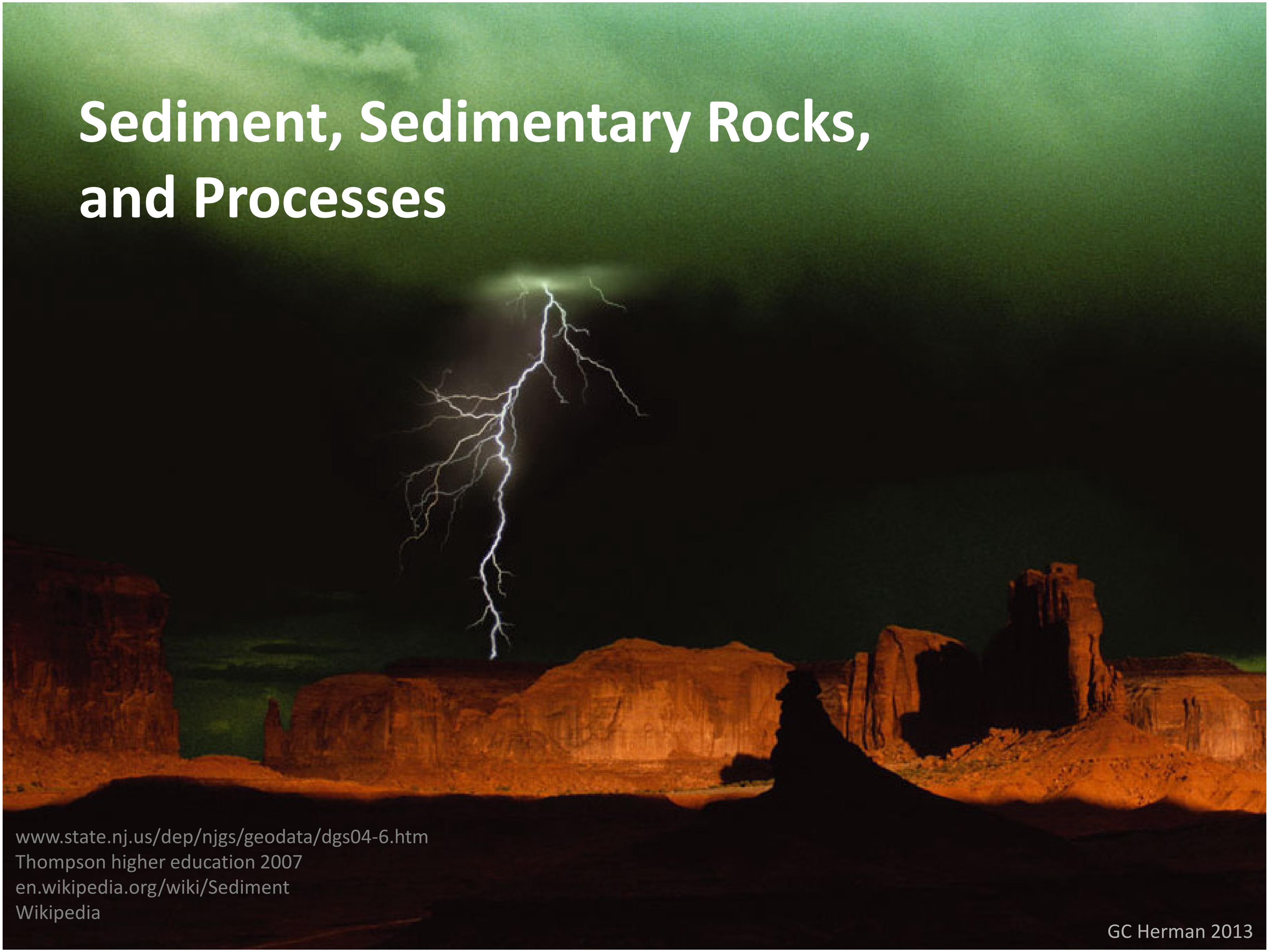
Sediment, Sedimentary Rocks, and Processes



www.state.nj.us/dep/njgs/geodata/dgs04-6.htm
Thompson higher education 2007
en.wikipedia.org/wiki/Sediment
Wikipedia

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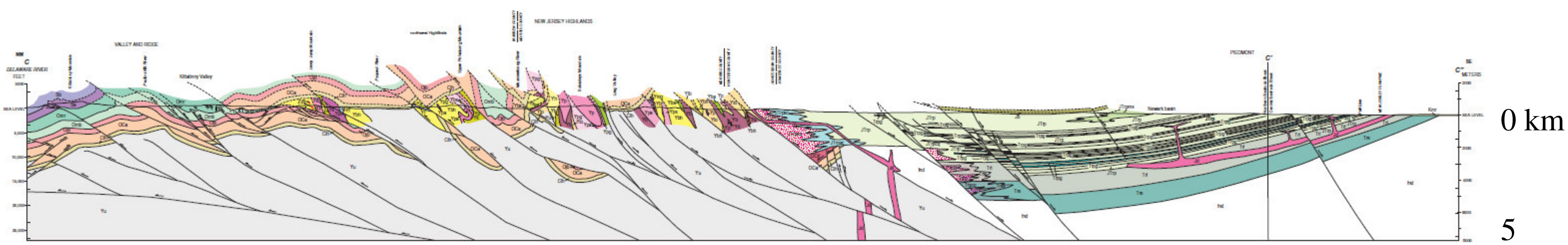
Sediment, Sedimentary Rocks, and Processes

- Sediment sources, transport, and deposition
- Lithification: Converting sediment into sedimentary rock
- Types of sedimentary rocks
- Sedimentary facies
- Sediment and sedimentary rocks resources

Sediment and Sedimentary Rocks

• The Earth’s crust is mostly composed of *crystalline* rocks, a term reserved for *igneous and metamorphic* rocks.



Drake, A. A., Jr., Volkert, R. A., Monteverde, D. H., Herman, G. C., Houghton, H. F., Parker, R. A., and Dalton, R. F., 1996, Bedrock geological map of northern New Jersey: U.S. Geological Survey Miscellaneous Investigation Series Map I-2540-A, scale 1:100,000, 2 sheets.

Profile interpretation across northern New Jersey

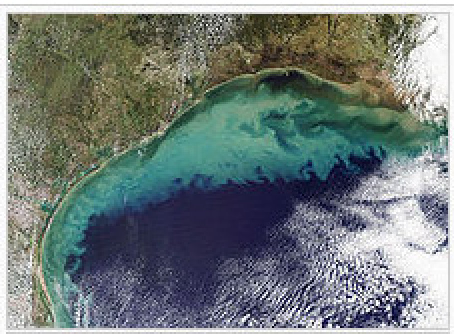
• Sediment and sedimentary rocks only comprise an estimated 5% of the crust by volume, but are the most commonly encountered at the surface.

Sediment comes from pre-existing rocks and includes:

1. All solid particles derived by weathering,

2. Minerals that are formed from solutions such as sea water that contain chemical elements, and

3. Minerals extracted from water by organisms to build their shells.



Sediment in the Gulf of Mexico

Ancient channel deposit in the Stellarton Formation (Pennsylvanian), Coalburn Pit, near Thorburn, Nova Scotia.

Glacial sediments from Montana

Holocene eolianite and a carbonate beach on Long Island, Bahamas.

Cobbles on a beach

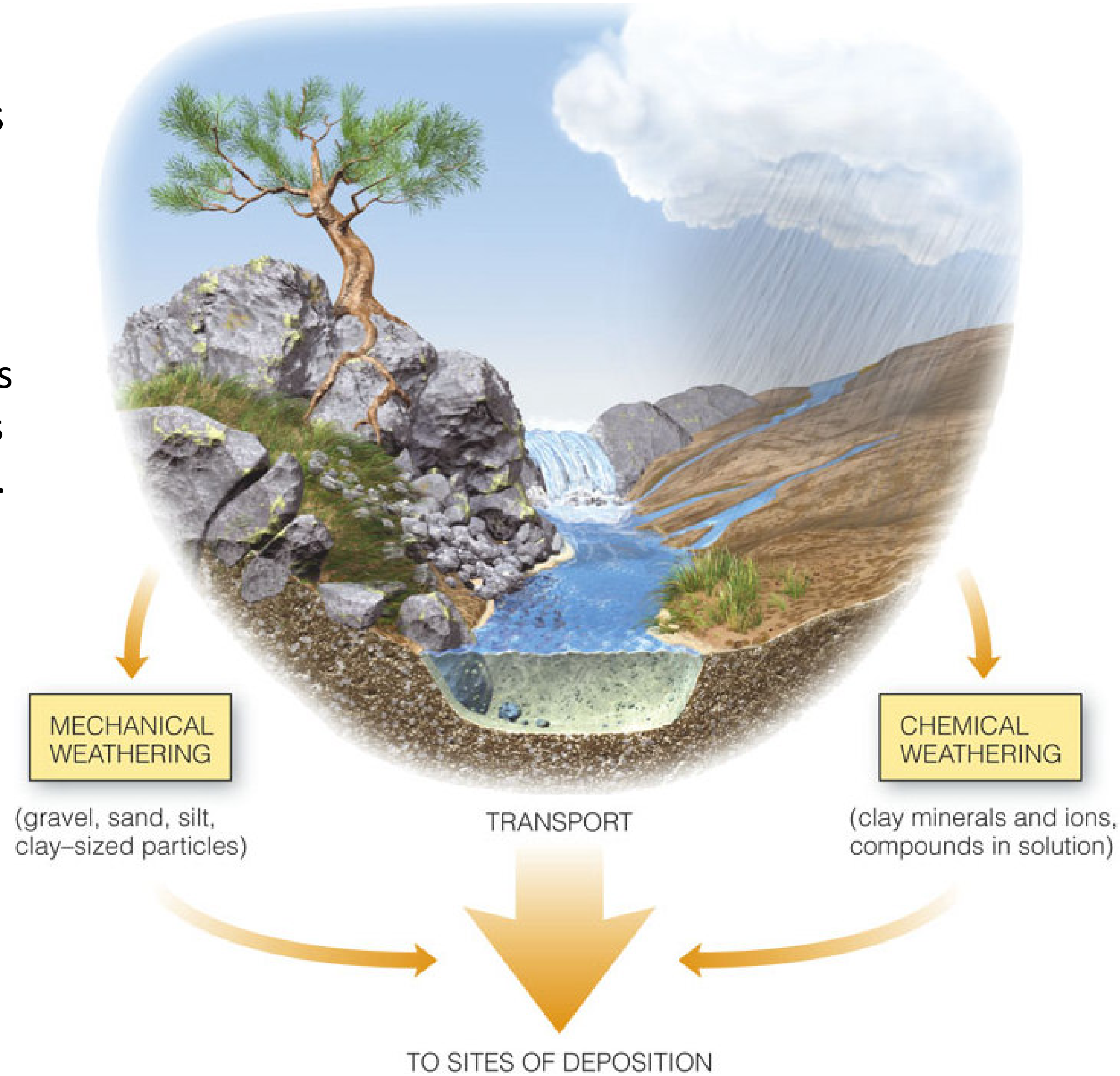
River Rhône flowing into Lake Geneva

Sediment

- The two primary types of sediment are ***detrital*** and ***chemical***.

- *Detrital sediment* consists of solid particles, products of mechanical weathering.

- *Chemical sediment* consists of minerals precipitated from solution by inorganic processes and by the activities of biological organisms.



Sediment Particle Sizes

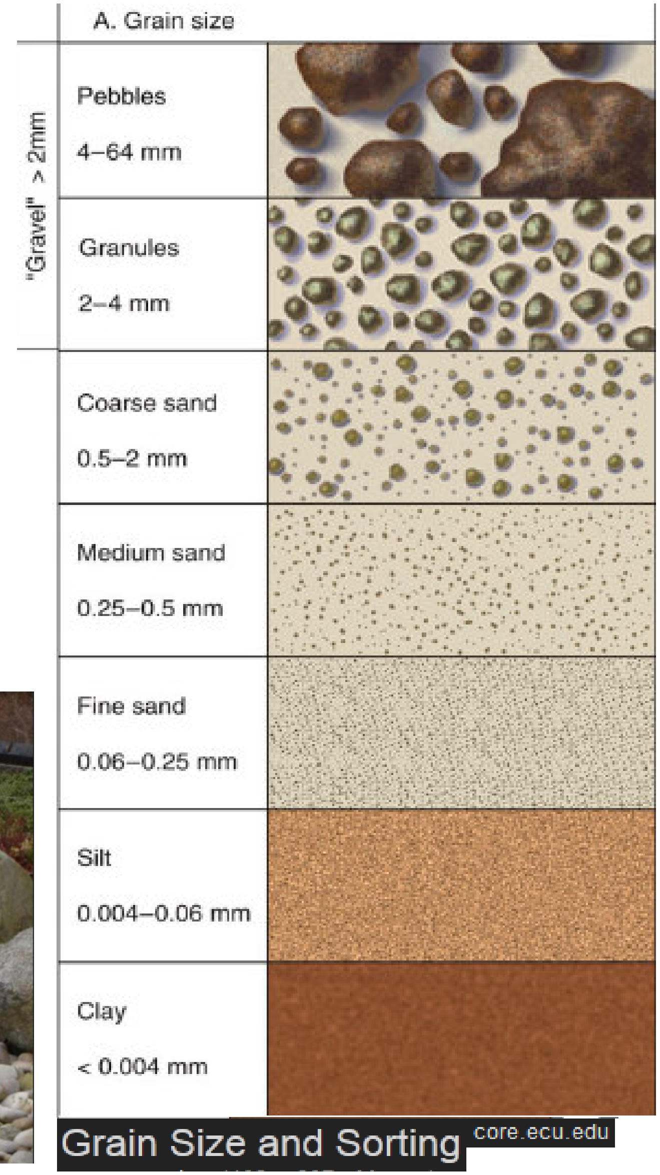
Sedimentary particles are classified according to grain (particle) sizes, in decreasing diameter:

1. Gravel, includes boulders (> 256 mm or ~10 in.), cobbles (64-256 mm or ~2.5 –10 in.), and pebbles

2. Sand

3. Silt, and

4. Clay (or mud).



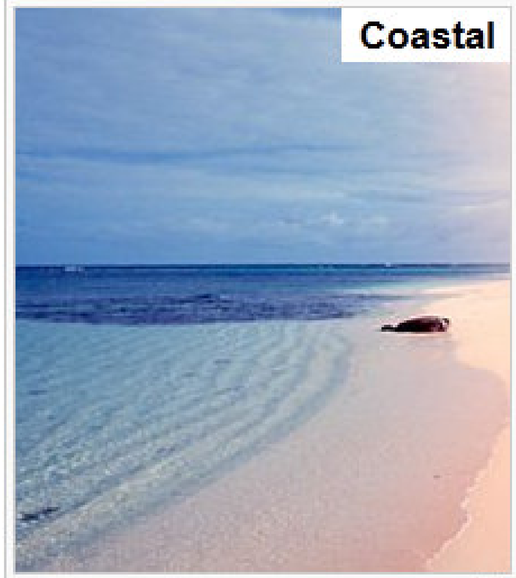
Sediment Transport

- Sediment is transported by running water, wind, glaciers, and sea currents

Sand blowing off a crest in the Kelso Dunes of the Mojave Desert, California.

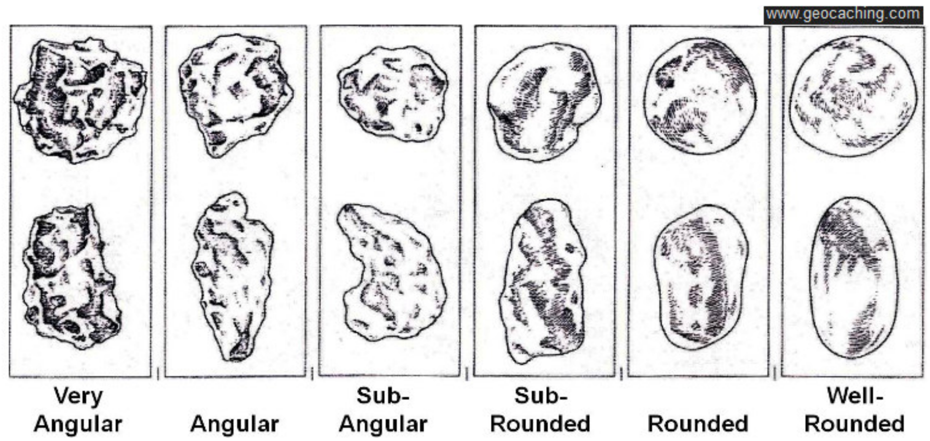
Toklat River, East Fork, Polychrome overlook, Denali National Park, Alaska. This river, like other braided streams, rapidly changes the positions of its channels through processes of erosion, sediment transport, and deposition.

A glacier joining the Gorner Glacier, Zermatt, Switzerland. These glaciers transport sediment and leave behind lateral moraines.



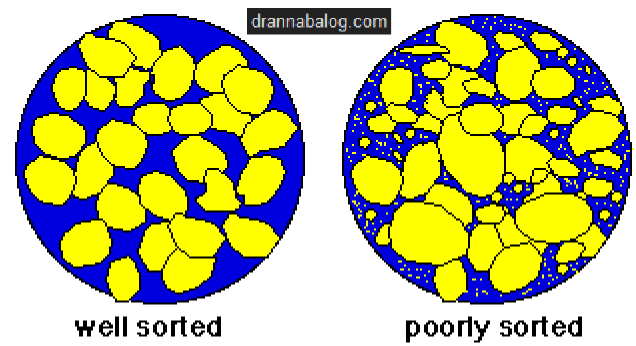
Sand ripples, Laysan Beach, Hawaii. Coastal **sediment transport** results in these evenly spaced ripples along the shore. Monk seal for scale.

Sediment Rounding and Sorting



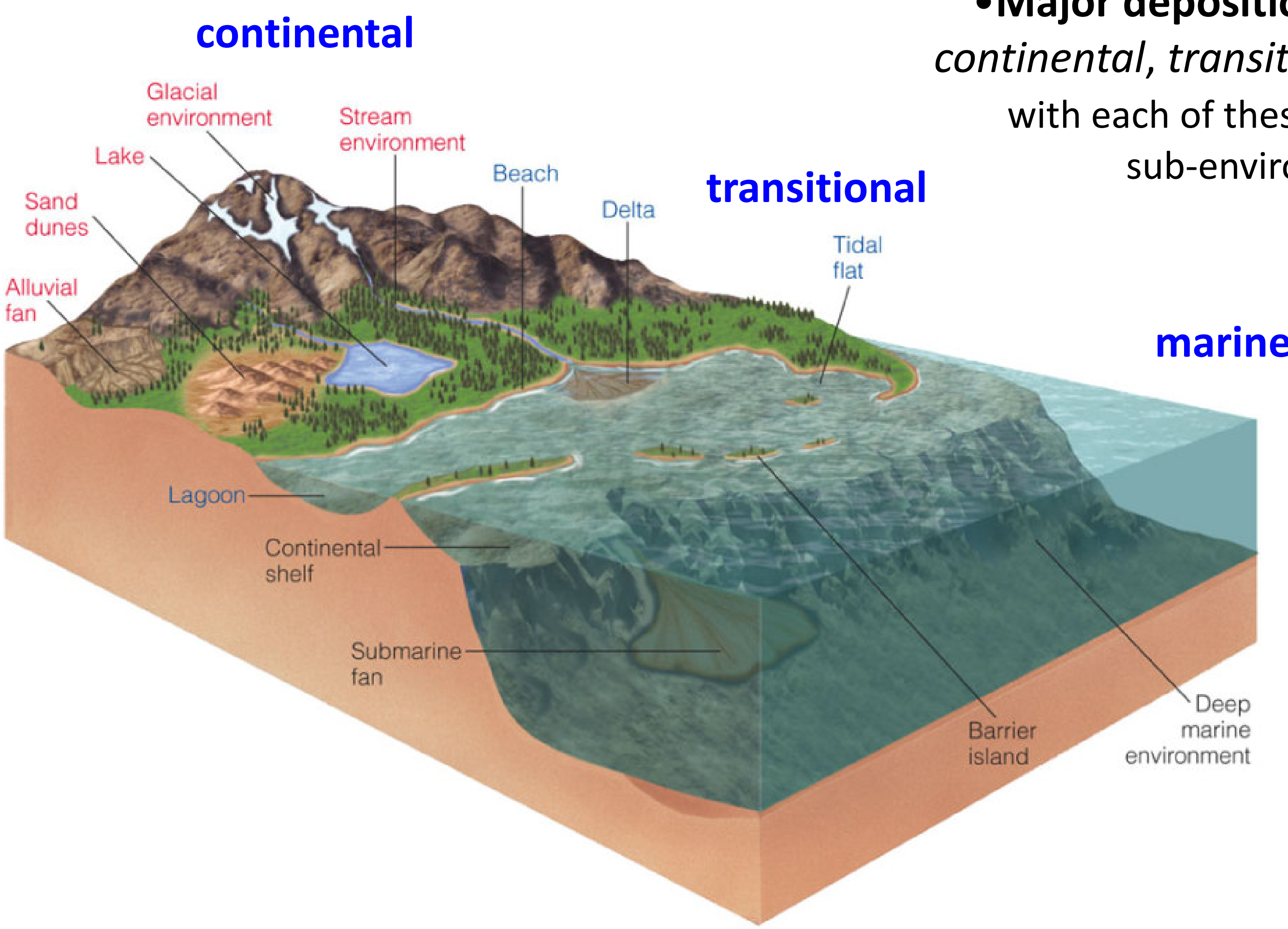
- Transportation of sediment results in ***rounding*** and ***sorting***.

- The amount of *rounding* and *sorting* depends on:



1. The particle size distribution (sorting)
2. Distance of transportation (rounding), and
3. Depositional processes.

Depositional Environments are areas of sediment deposition that can be defined by their physical characteristics (topography, climate, wave and current strength, salinity, etc.).



- **Major depositional settings** are *continental*, *transitional*, and *marine*, with each of these having specific sub-environments.

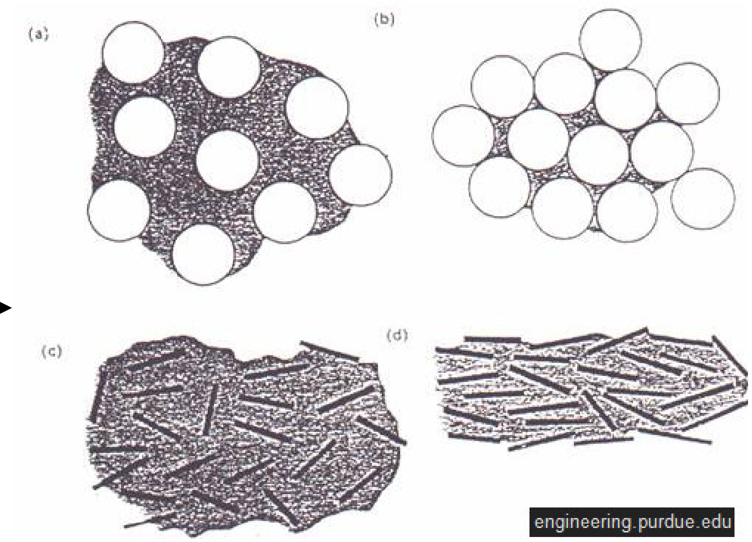
- They are interpreted based on the sedimentary structures, textures and fossils in sedimentary rocks, and by comparison of these properties with present-day depositional environments.

Sediment Lithification into Sedimentary Rocks

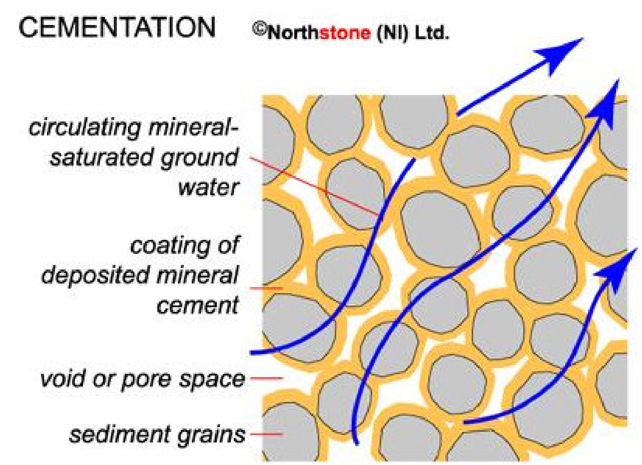
•***Lithification*** *of sediment into sedimentary rock occurs by* ***compaction*** *and* ***cementation****.*

Compaction reduces the volume of pore space

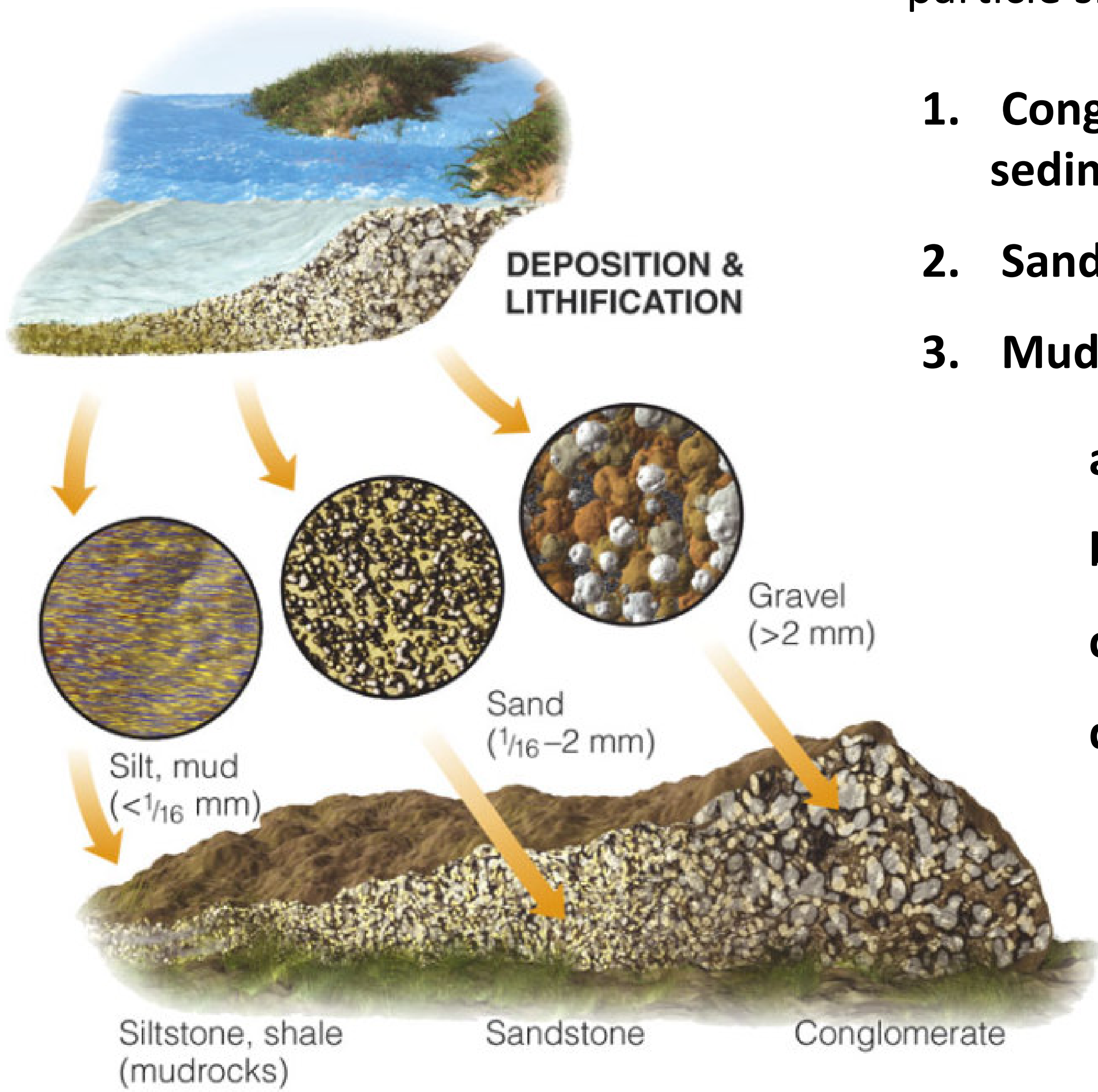
Mud can be compacted by as much as 40%



•**Common cements** are *calcium carbonate* and *silica*, with *iron oxide* and *iron hydroxide* being important in some rocks.



Detritai Sedimentary Rocks are classified on the basis of particle size and include:



1. **Conglomerate and sedimentary breccia,**
2. **Sandstone, and**
3. **Mudrock** which includes:
    a. **Siltstone,**
    b. **Claystone,**
    c. **Mudstone**, and
    d. **Shale.**

Conglomerate and Sedimentary Breccia

- contain coarse-grained rock particles

The gravel in conglomerate is rounded, whereas the gravel in breccia is angular rubble.

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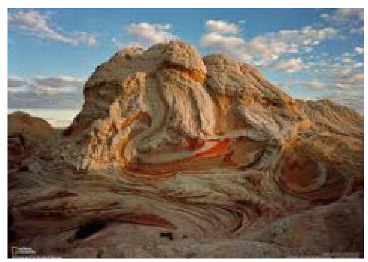
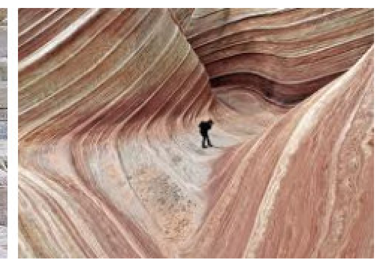
Sandstone is composed of sand-sized (medium) rock particles

- The main constituent is ordinarily quartz sand
- The most common type is quartz sandstone even though feldspar and ferromagnesian silicates, are more abundant rock types.
- This is because feldspars have good cleavage, which promotes chemical weathering





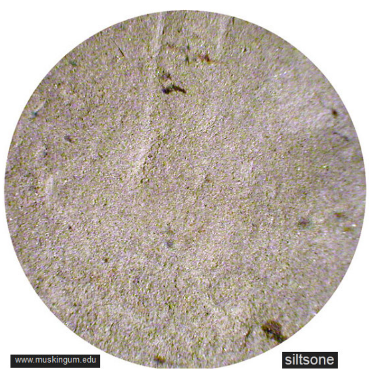


- Forms in several depositional environments including streams channels, deltas, beaches, sand dunes, and the continental shelf.

Mudrock is composed of mud-sized (fine) rock particles

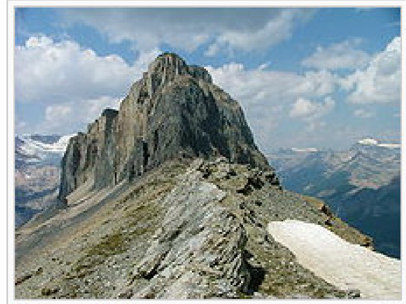
- *40% of all sedimentary rocks are mudrocks, making them more abundant than conglomerate and sandstone*
- Transported by strong and weak currents but deposited in weak currents where they are kept suspended by minor water turbulence.
- Deposited in low energy environments like lagoons, quiet offshore waters like lakes, and on river floodplains.

Siltstone, Claystone, Mudstone, and **Shale** varieties



Claystone in Slovakia

Siltstone at UAT, Estonia



Burgess Shale

Slate Roof

Black Shale with pyrite

Marcellus Shale, New York

Mudstone and Shale

Mudstone in Montana

Shale from Tennessee shows *fissility* by breaking along closely spaced planes

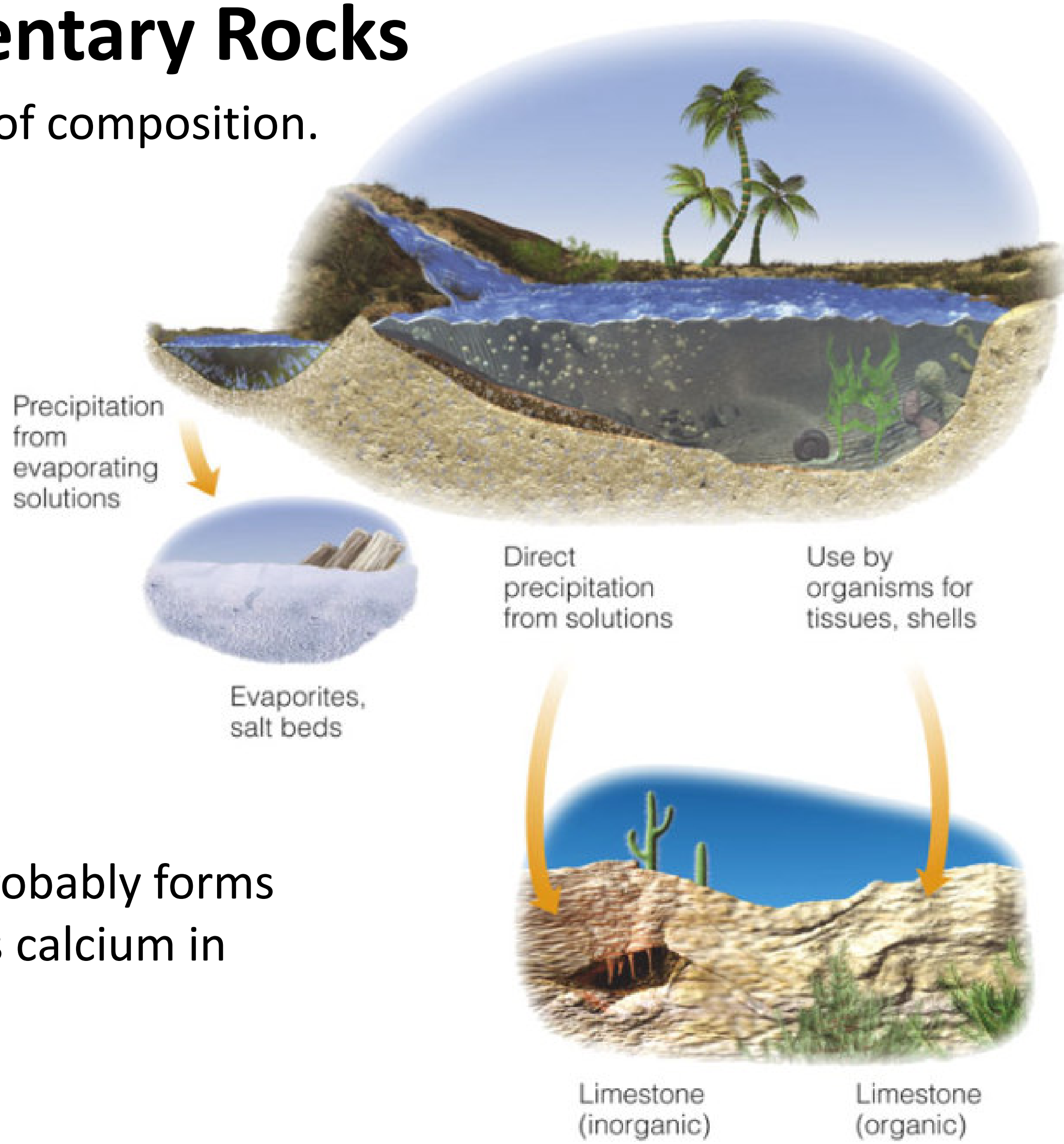
Fossils in Mudrocks

Chemical Sedimentary Rocks

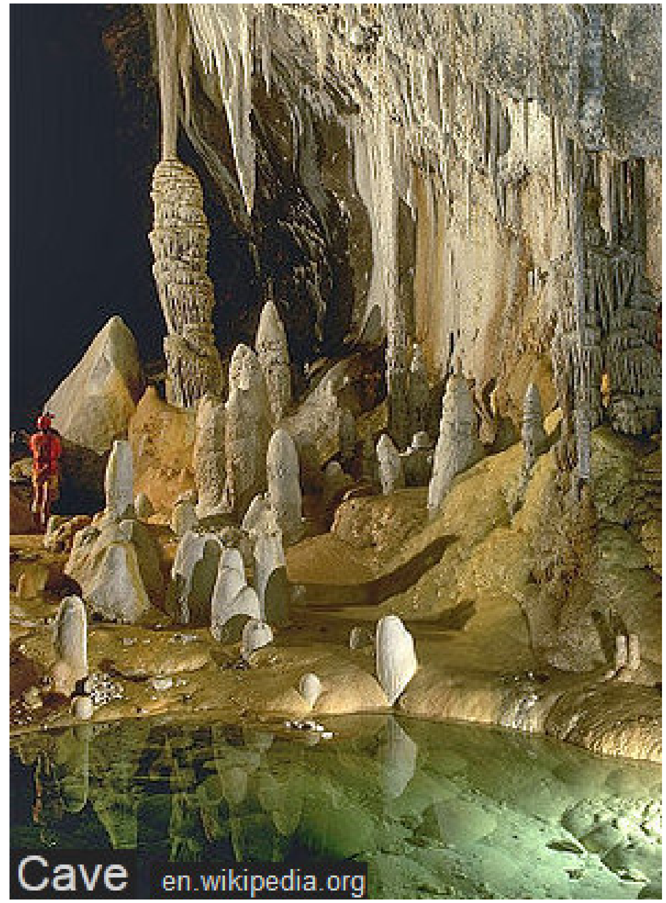
are classified on the basis of composition.

•**Carbonate rocks** consist primarily of minerals containing the carbonate ion, such as **limestone** ($CaCo_3$) and **dolostone** [$CaMg(CO_3)_2$]

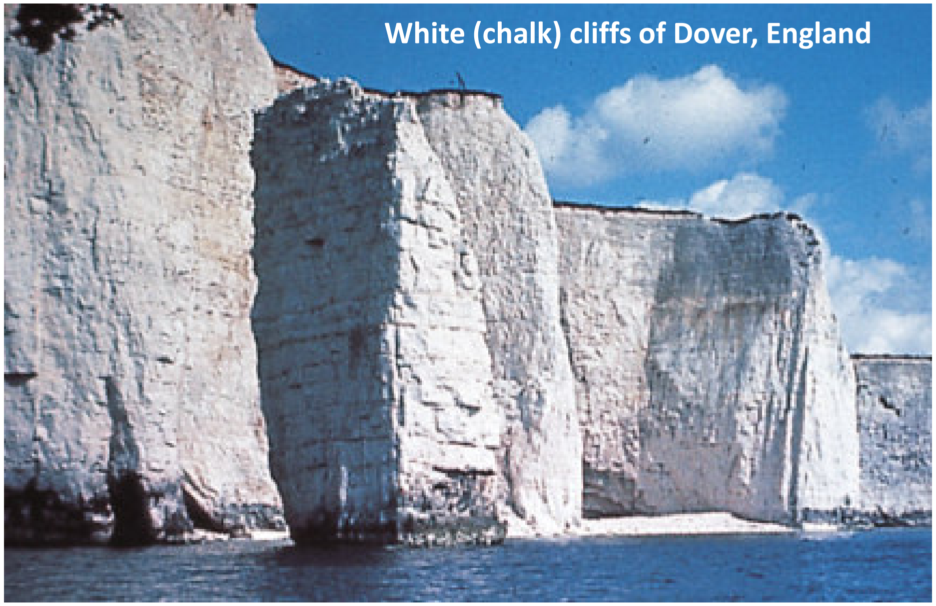
•Dolostone or *Dolomite* probably forms when magnesium replaces calcium in limestone.

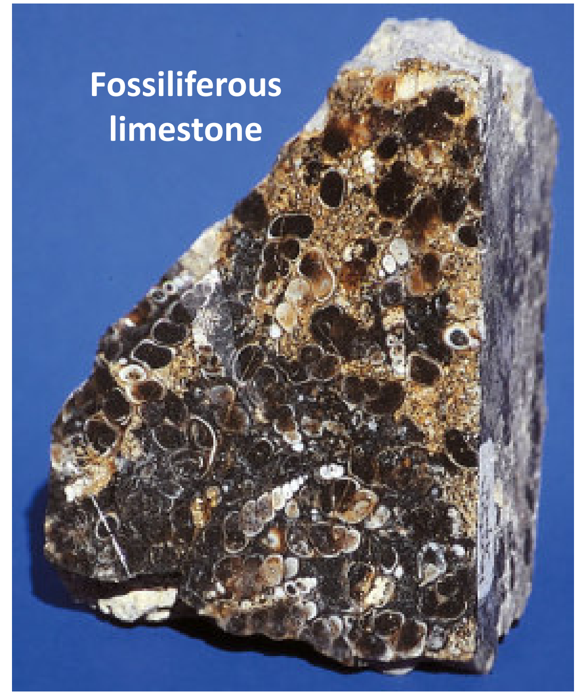


Limestone and Dolostone



Chalk, Coquina, and Ooids





Coquina is limestone composed of broken shells

Limestone with **ooids** (spherical grains of $CaCO_3$

Coral

From Wikipedia, the free encyclopedia

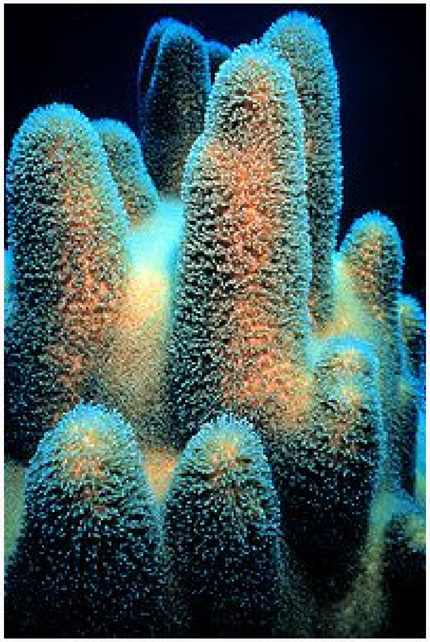
For other uses, see Coral (disambiguation).

Corals are marine invertebrates in class Anthozoa of phylum Cnidaria typically living in compact colonies of many identical individual "polyps". The group includes the important reef builders that inhabit tropical oceans and secrete calcium carbonate to form a hard skeleton.

A coral "head" is a colony of myriad genetically identical polyps. Each polyp is a spineless animal typically only a few millimeters in diameter and a few centimeters in length. A set of tentacles surround a central mouth opening. An exoskeleton is excreted near the base. Over many generations, the colony thus creates a large skeleton that is characteristic of the species. Individual heads grow by asexual reproduction of polyps. Corals also breed sexually by spawning: polyps of the same species release gametes simultaneously over a period of one to several nights around a full moon.

Although some corals can catch small fish and plankton, using stinging cells on their tentacles, like those in sea anemone and jellyfish, most corals obtain the majority of their energy and nutrients from photosynthetic unicellular algae that live within the coral's tissue called zooxanthella (also known as Symbiodinium). Such corals require sunlight and grow in clear, shallow water, typically at depths shallower than 60 metres (200 ft). Corals can be major contributors to the physical structure of the coral reefs that develop in tropical and subtropical waters, such as the enormous Great Barrier Reef off the coast of Queensland, Australia. Other corals do not have associated algae and can live in much deeper water, with the cold-water genus *Lophelia* surviving as deep as 3,000 metres (9,800 ft).[3] Examples live on the Darwin Mounds, north-west of Cape Wrath, Scotland. Corals have also been found off the coast of the U.S. in Washington State and the Aleutian Islands in Alaska.

Coral



Pillar coral, *Dendrogyra cylindricus*

Scientific classification

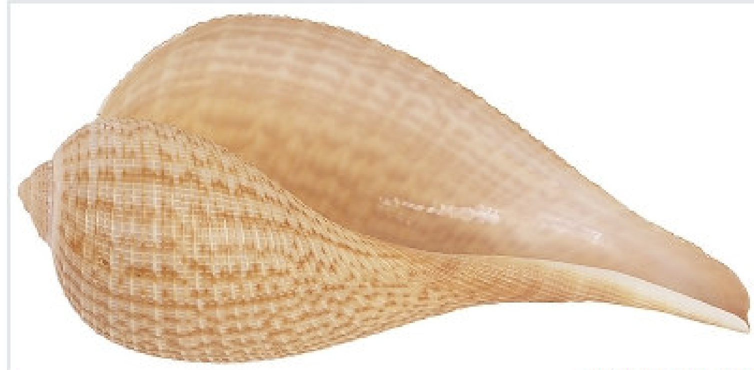
Kingdom:	Animalia
Phylum:	Cnidaria
Class:	Anthozoa Ehrenberg, 1831

http://www.scientificamerican.com/article.cfm?id=how-are-seashells-created

How are seashells created?

Francis Horne, a biologist who studies shell formation at Texas State University, offers this answer.

The exoskeletons of snails and clams, or their shells in common parlance, differ from the endoskeletons of turtles in several ways. Seashells are the exoskeletons of mollusks such as snails, clams, oysters and many others. Such shells have three distinct layers and are composed mostly of calcium carbonate with only a small quantity of protein--no more than 2 percent. These shells, unlike typical animal structures, are not made up of cells. Mantle tissue that is located under and in contact with the shell secretes proteins and mineral extracellularly to form the shell. Think of laying down steel (protein) and pouring concrete (mineral) over it. Thus, seashells grow from the bottom up, or by adding material at the margins. Since their exoskeleton is not shed, molluscan shells must enlarge to accommodate body growth. This pattern of growth results in three distinct shell layers: an outer proteinaceous periosteum (uncalcified), a prismatic layer (calcified) and an inner pearly layer of nacre (calcified).



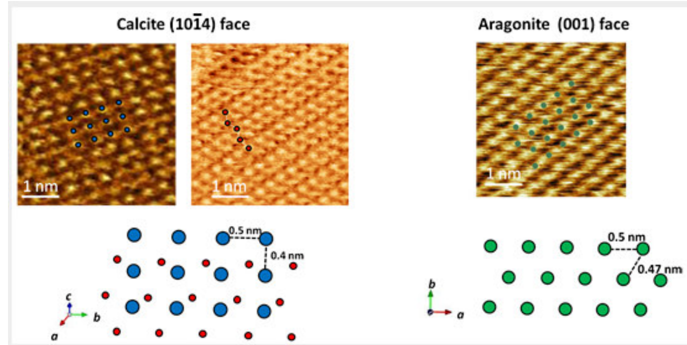
Calcium carbonate make up parts of a whelk shell.

Aragonite

From Wikipedia, the free encyclopedia

Aragonite is a carbonate mineral, one of the two common, naturally occurring, crystal forms of calcium carbonate, $CaCO_3$ (the other form being the mineral calcite). It is formed by biological and physical processes, including precipitation from marine and freshwater environments.

Aragonite's crystal lattice differs from that of calcite, resulting in a different crystal shape, an orthorhombic system with acicular crystals. Repeated twinning results in pseudo-hexagonal forms. Aragonite may be columnar or fibrous, occasionally in branching stalactitic forms called *flos-ferri* ("flowers of iron") from their association with the ores at the Carinthian iron mines.

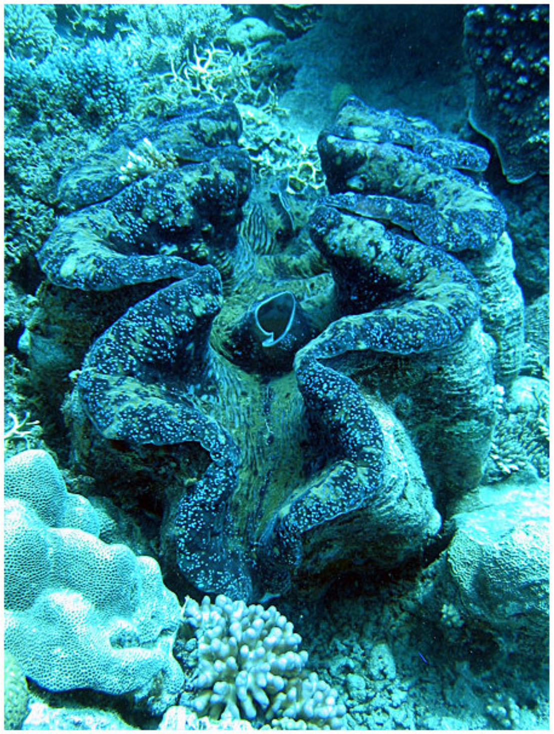


Atomic sequences of a calcite (1014) surface and an aragonite (001) surface along with their model drawings (bottom). Blue indicates the calcium atoms in calcite; red, the oxygen atoms; and green, the calcium atoms in aragonite. Credit: National Institute for Materials Science

http://phys.org/news/2011-09-submerged-atomic-resolution-imaging-calcium.html

Mollusc shell

From Wikipedia, the free encyclopedia



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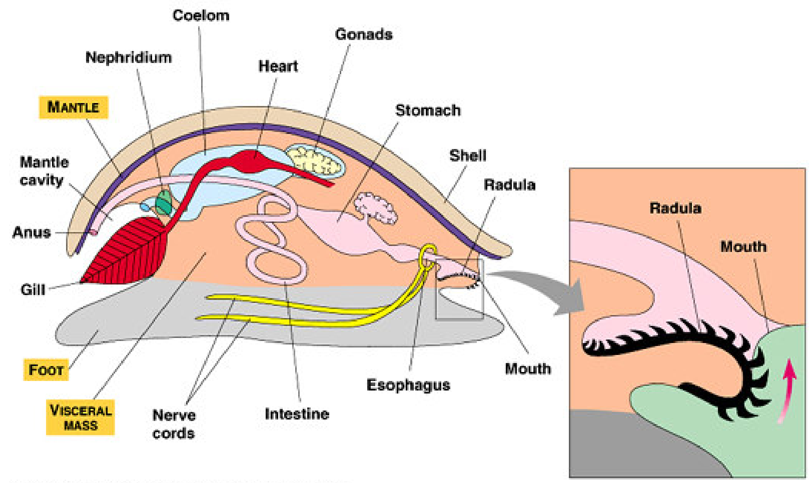
Giant_clam_or_Tridacna_gigas.jpg (450 × 600 pixels, file size: 216 KB, MIME type: image/jpeg)



http://www.bio.miami.edu/dana/160/160S13_15.html

•The mantle edge secretes a shell which has two components.

•Organic constituent made up of polysaccharides and glycoproteins that widely varying framework subtleties

• Shell formation occurs in a closed, sealed environment by a leathery, outer layer of the shell (periostracum) where additional growth occurs, and the inner mantle.

• The periostracum acts as the framework from which outer layers of carbonate can be suspended as ions are pumped into the calcifying epithelium

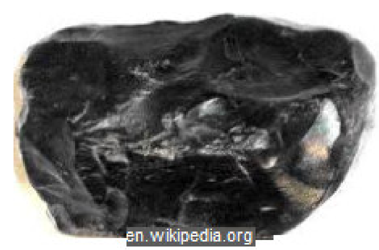
• In shelled molluscs, the mantle is the organ that forms the shell, and adds to the shell to increase its size and strength as the animal grows. Shell material is secreted by the ectodermic (epithelial) cells of the mantle tissue

Chert, flint, jasper, chalcedony, agate

- Are varieties of microcrystalline quartz (SiO_2) that are hard, conchoidally fracture, and contain minor impurities that give them their color.

- Biochemical and/or chemical precipitant from hydrothermal solutions

Jasper

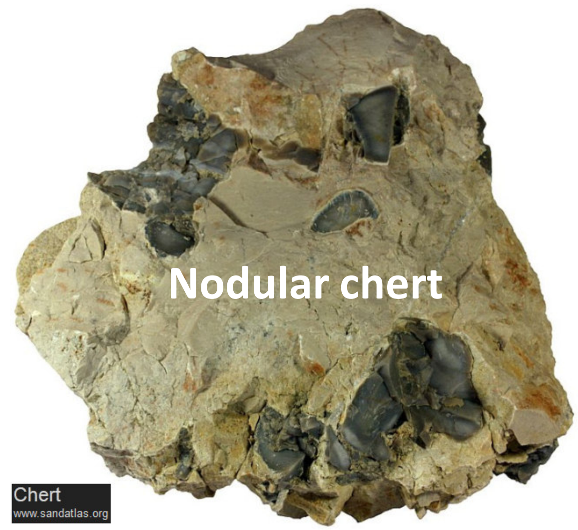


Flint

Chert, flint, jasper, chalcedony, agate

- Found in bedded and nodular forms.

- Forms as either primary or secondary forms, the latter meaning that it was formed after the hosting rock had already formed.



Coal is a biochemical sedimentary rock composed largely of altered land plant remains. Common types are *bituminous* and *anthracite*

Peat

Lignite

Coal

Coal types

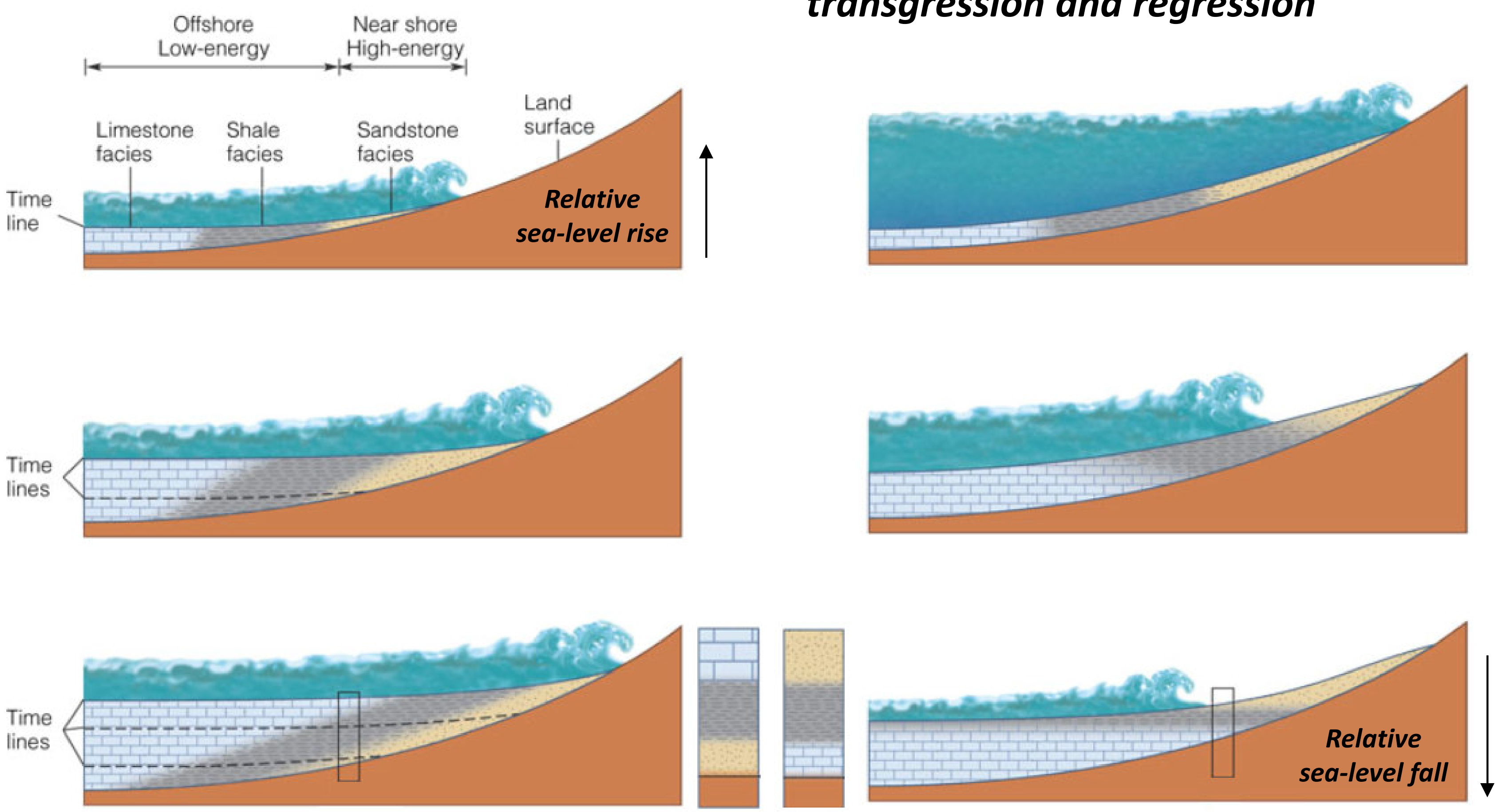
Anthracite ← *Increasing pressure and temperature from burial* Bituminous

Bedded Rock Salt (Halite - NaCl) **and Gypsum** ($CaSO_4 \cdot 2H_2O$)

are *chemical evaporite sediments* formed by precipitation of minerals during the evaporation of water.

Sedimentary Facies are bodies of sediment or sedimentary rocks that are distinct from adjacent sediment or sedimentary rocks and are deposited in different depositional environments.

Three stages and facies of marine transgression and regression



marine transgression ***marine regression***

Sedimentary Facies

•A **marine transgression** occurs when *sea level rises with respect to the land*, resulting in offshore facies overlying nearshore facies.

•A **marine regression**, occurs when the *land rises relative to sea level*, results in nearshore facies overlying offshore facies.

•Marine transgressions and regression are cause by:

1) uplift or subsidence of the continents,

2) varying rates of sea-floor spreading, and

3) the amount of seawater accumulated in glaciers on land

Mark A. Wilson (Department of Geology, The College of Wooster)

Sedimentary Structures are recognizable features that normally form during or shortly after deposition

•Beds or strata

Bedding planes *separate individual beds*

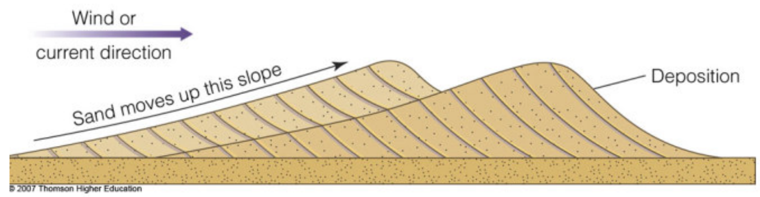
• Graded bedding

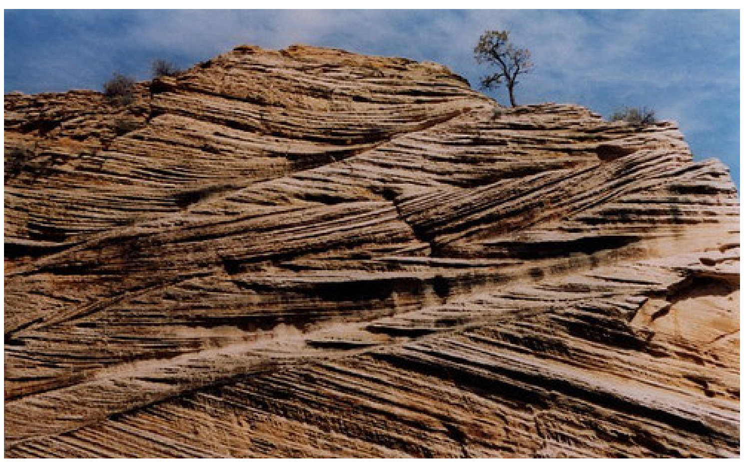
Grain-size decreases upward or downward in a single bed resulting from a decrease or increase of flow velocity of the transporting media

Sedimentary Structures

- **Cross-bedding**

Layers deposited at angles to the depositional surface that are good indicators of paleocurrents





Cross-bedding in the Navajo Sandstone

Sedimentary Structures

•Ripple marks

Alternating ridges and troughs formed by directional wind or water currents

•Mud cracks

Form in clay-rich sediment by desiccation shortly after deposition

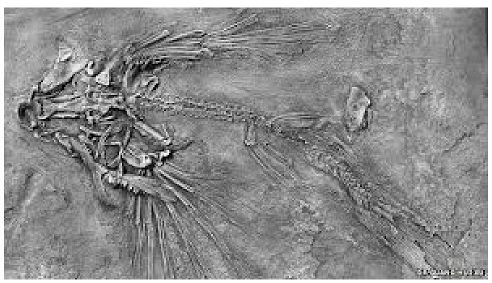
Fossils are the remains or traces of ancient organisms preserved in rocks

- Are usually found only in sediments and sedimentary rocks.

- *They provide the only record of prehistoric life, and are used by geologists to correlate strata, and to interpret depositional environments.*












Sediment and Sedimentary Rocks as Resources

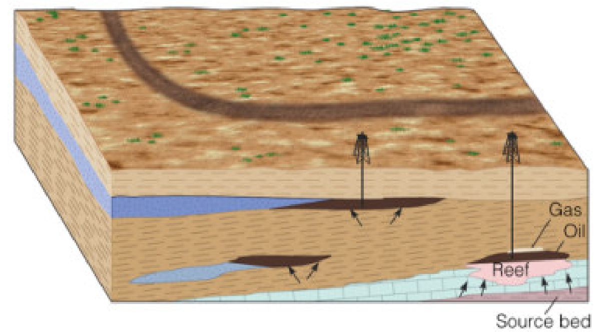
- Many important natural resources are sedimentary rock deposits including *sand, gravel, coal, clay, evaporites* and *banded-iron formations*.

- Most oil and gas reserves are found within sedimentary rocks.

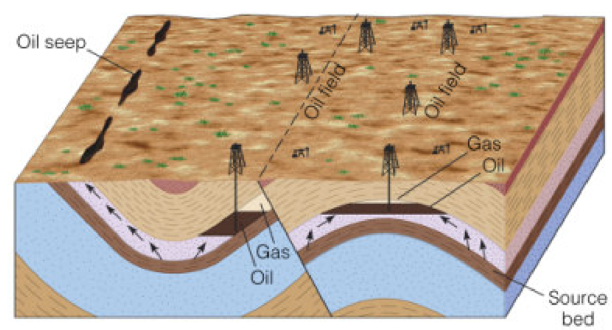
- Oil and gas shale and tar sands are sedimentary deposits also containing increasingly important petroleum and natural gas reserves.

Three kinds of Hydrocarbon traps

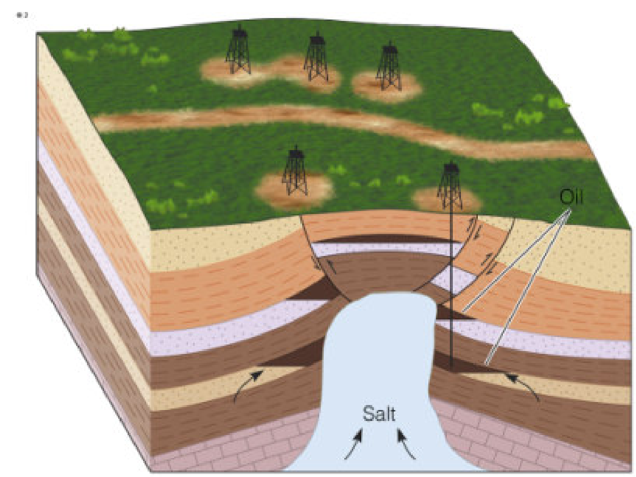
Stratigraphic



Structural from faulting



Structural from salt domes



Sediment and Sedimentary Rocks as Resources

•Banded-iron formations (BIFS) are found on all continents and consist of alternating bands of iron and chert.

•They account for most of the iron ore mined in the world today.

•Their origin is poorly inderstood because they formed about 2 billion years ago when the Earth had little oxygen in the atmophere.

•Consequently, silica and iron were in a reduced form and were much more present in seawater than today,