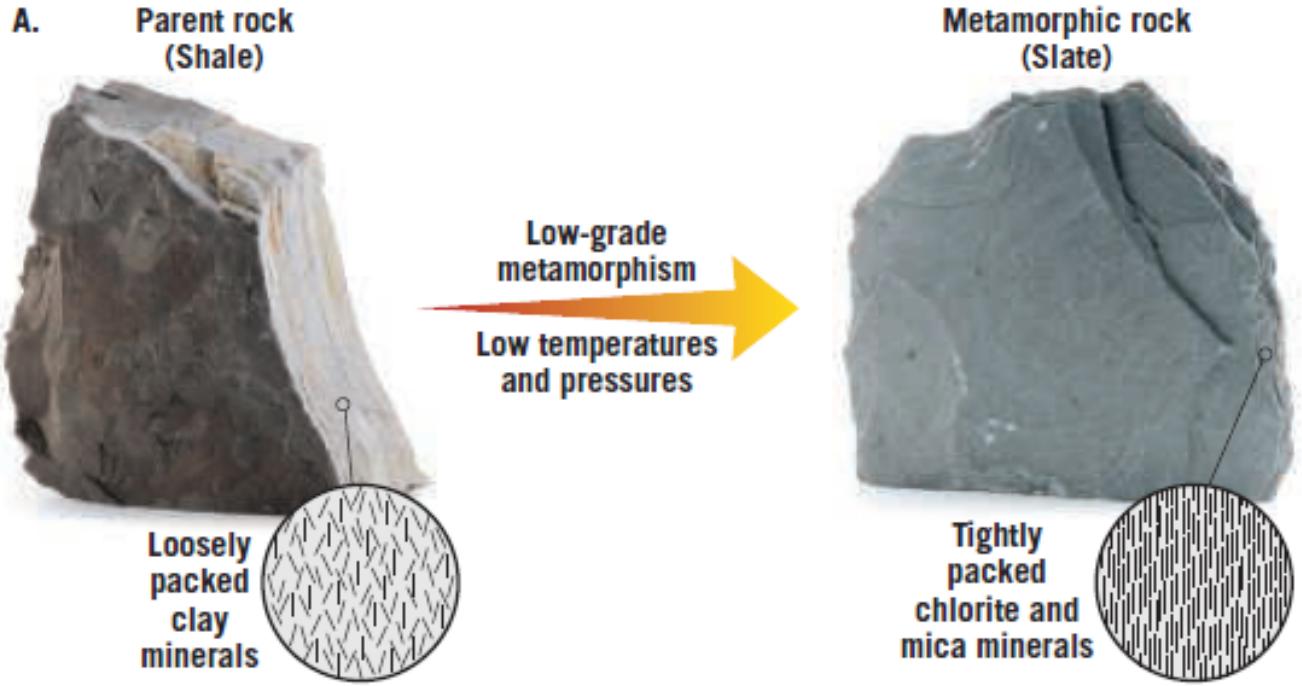
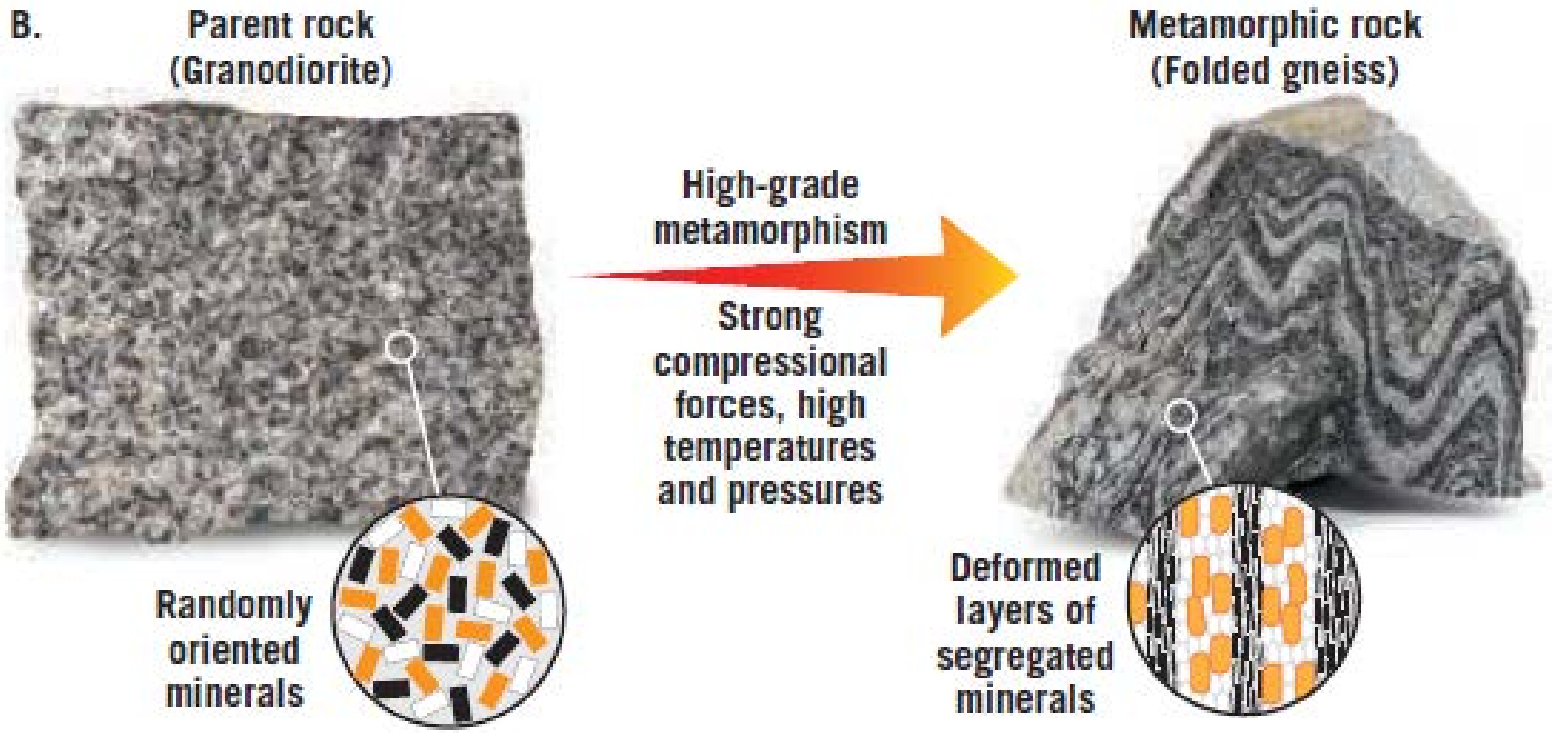
Metamorphic rocks

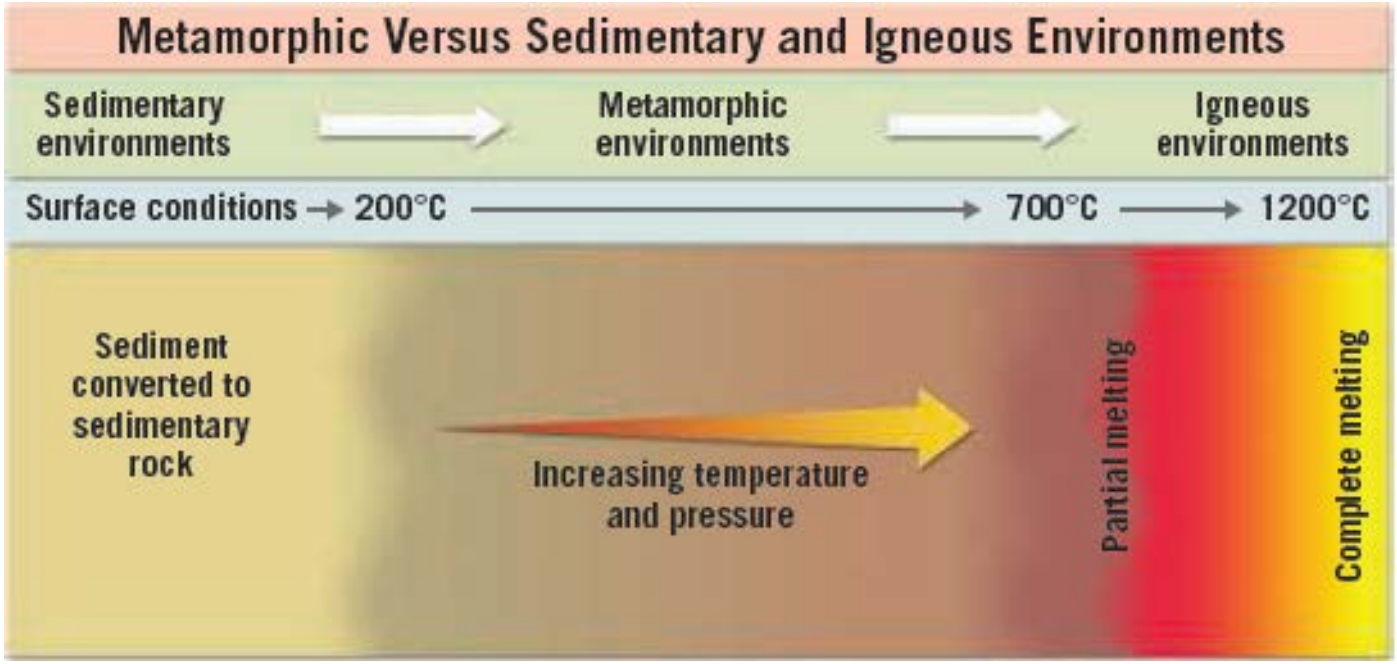
Velledits Felicitász



Low-grade metamorphism illustrated by the transformation of the common sedimentary rock shale to the more compact metamorphic rock slate.



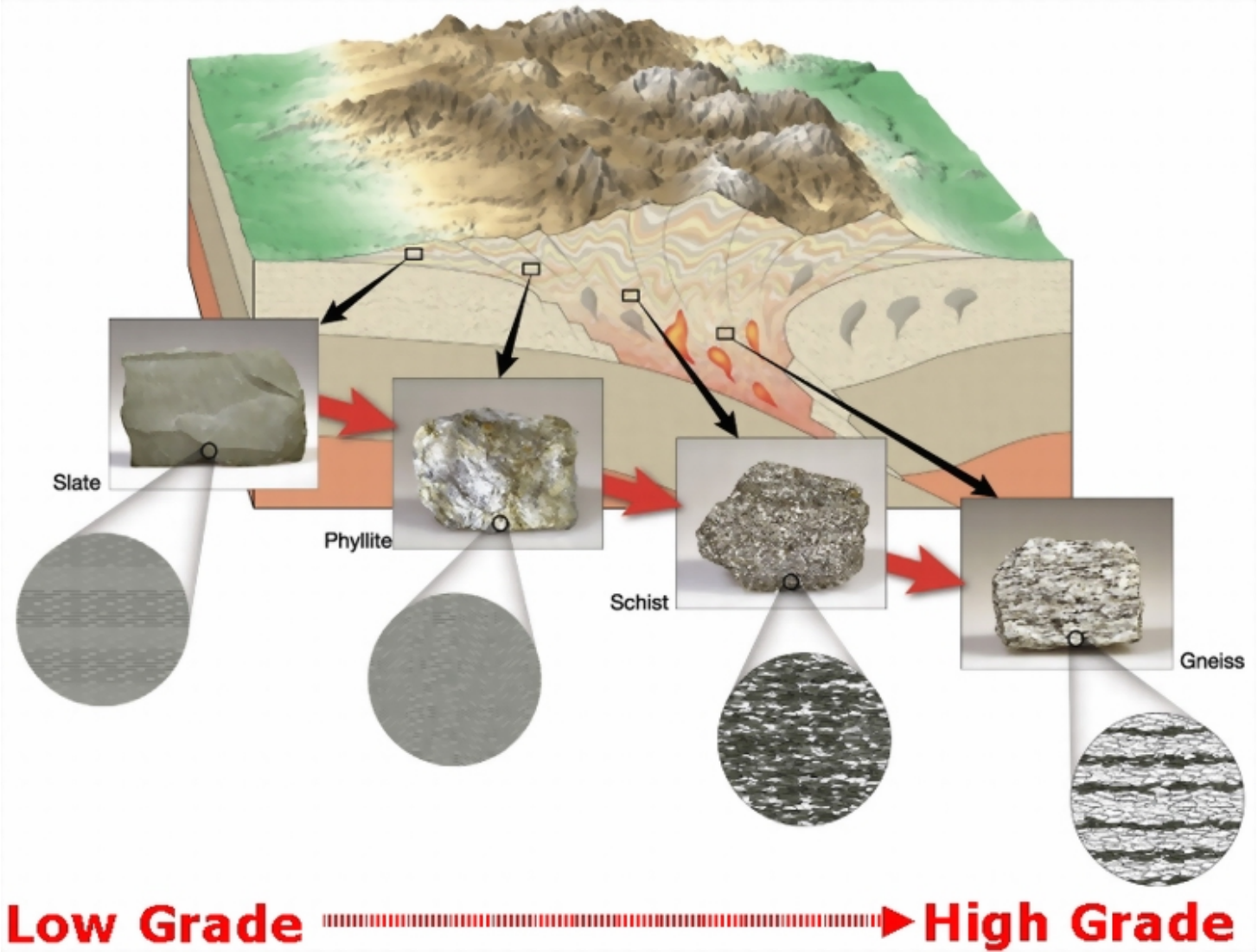
High-grade metamorphic environments obliterate
the existing texture and often change the mineralogy of the parent rock.
High-grade metamorphism occurs at



- Metamorphism occurs over a range of
- temperatures that lie between those experienced in
- sedimentary environments and temperatures that
- approach those at which rocks melt. Pressure, which
- includes confining pressure and differential stress,
- also plays a major role in metamorphism.

Foliated metamorphic rocks

Grades of metamorphism

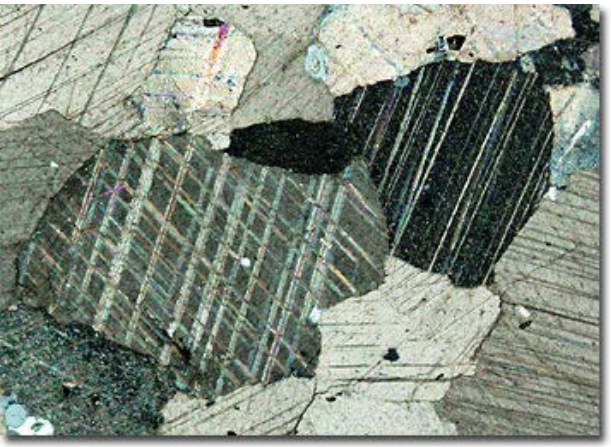


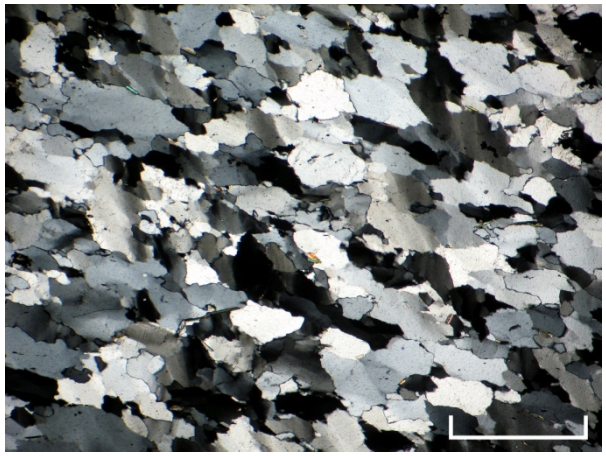
Non-foliated metamorphic rocks

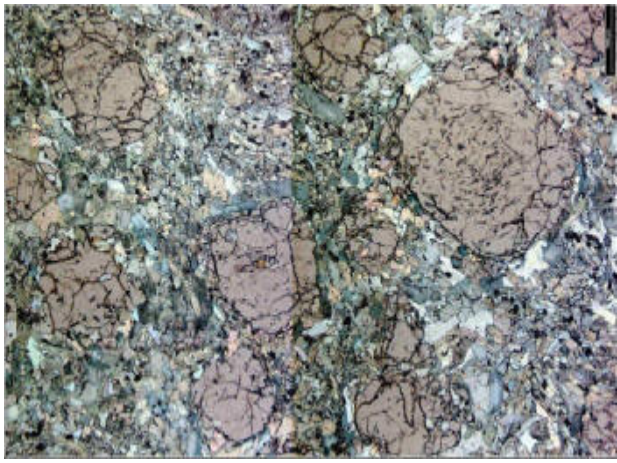












Marble

Quartzite

Eclogite

Some concepts

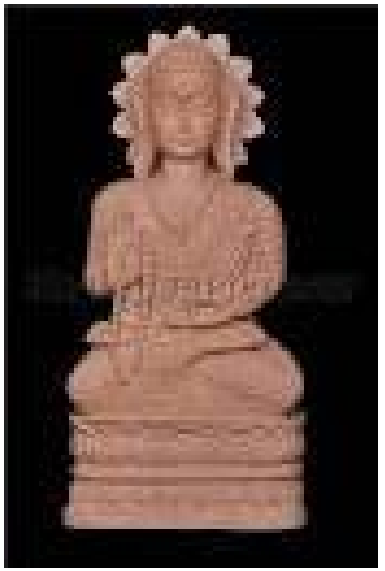
- - **sediment:**
- The unconsolidated grains of minerals, organic matter or preexisting rocks, that can be transported by water, ice or wind, and deposited. The processes by which sediment were formed and is transported occur at or near the surface of the Earth. Formation of sedimentary rocks starts with accumulation of grains and is finished with lithification of the grains.
- - **sedimentology**:
- The study of sedimentary rocks and the process by which they were formed.
- - **sedimentary rocks**:
- One of the three main classes of rocks (igneous, metamorphic and sedimentary). Sedimentary rocks are formed at the Earth's surface through deposition of sediments derived from weathered rocks, biogenic activity or precipitation from solution.
- **A, Clastic sedimentary rocks** such as conglomerates, sandstones, siltstones and shales form as older rocks weathered and eroded, and their particles accumulate and lithify, or harden, as they are compacted and cemented.
- **B, Biogenic sedimentary rocks** form as a result of activity by organisms, including coral reefs that become limestone.
- **C, Precipitates**, such as the evaporite minerals halite (salt) and gypsum can form vast thicknesses of rock as seawater evaporates.

Sediment → Diagenesis → Sedimentary rock









Matrix:

a, carbonate mud

b, sparit

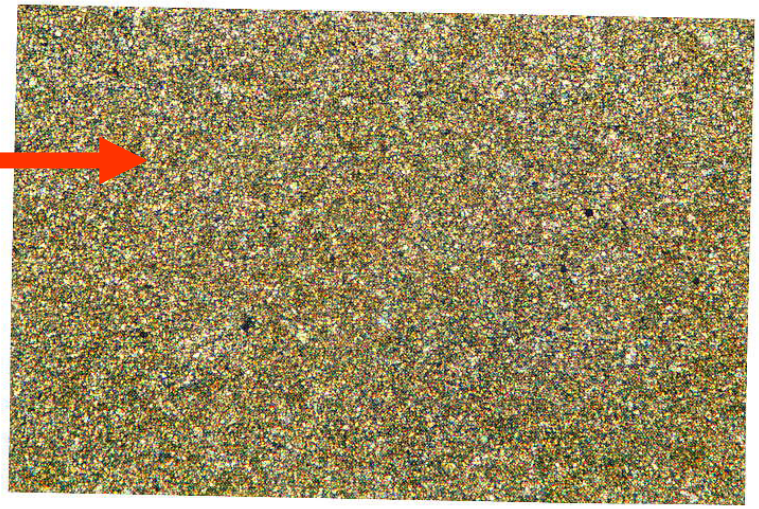


Fig. 5.28 Examples of breakdown of various skeletal components by mechanical abrasion. Echinoderms, coccoliths and many bryozoans are particularly fragile. (**a**) Echinoid; (**b**) ostracod; (**c**) brachiopod; (**d**) calcareous red algae; (**e**) bryozoan; (**f**) bivalve. Not to scale (modified from Bromley 1980)



Diagenezis

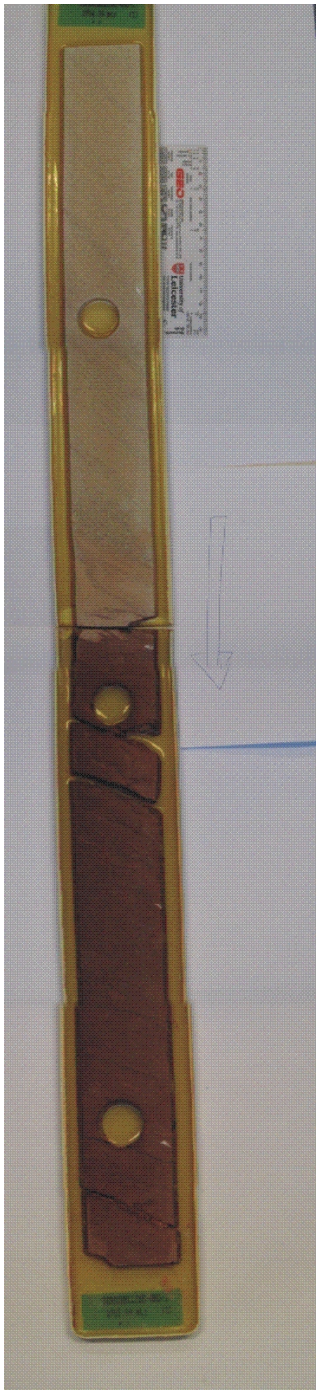




Calcareous mud

Micrit

- **- <u>Sedimentary facies</u>:**
- 1) sedimentary environment
- 2) such properties of a rock, which mirror the formation conditions, circumstances and environment. Such properties are: color, the mineral composition of the rock, fabric and structure, fossil content etc. One sediment/sedimentary rock is different from the adjacent sediment/sedimentary rock because it was deposited in a different depositional environment. The characteristics of the rock unit come from the depositional environment and from the original composition. Sedimentary facies reflect depositional environment in which they were formed.



- **-Diagenesis:**
- The physical, chemical or biological **alteration of sediment**s into sedimentary rock at low temperatures and pressures.
- After deposition, sediments are compacted as they are buried beneath successive layers of sediment and different solutions circulate in the sediments. From this solution different minerals can precipitate, which cement the grains of sediment.
- Grains of sediment, rock fragments and fossils can be replaced by other minerals during diagenesis. Porosity mainly decreases during diagenesis, except in rare cases such as dissolution of minerals and dolomitization.

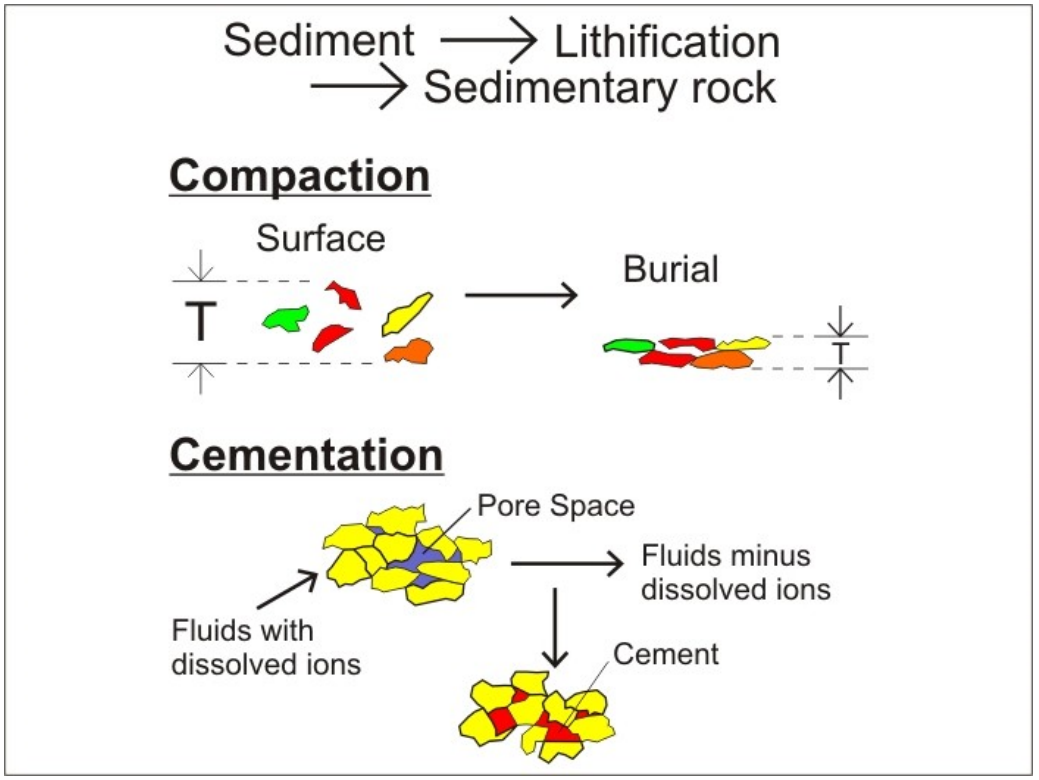
Sediment



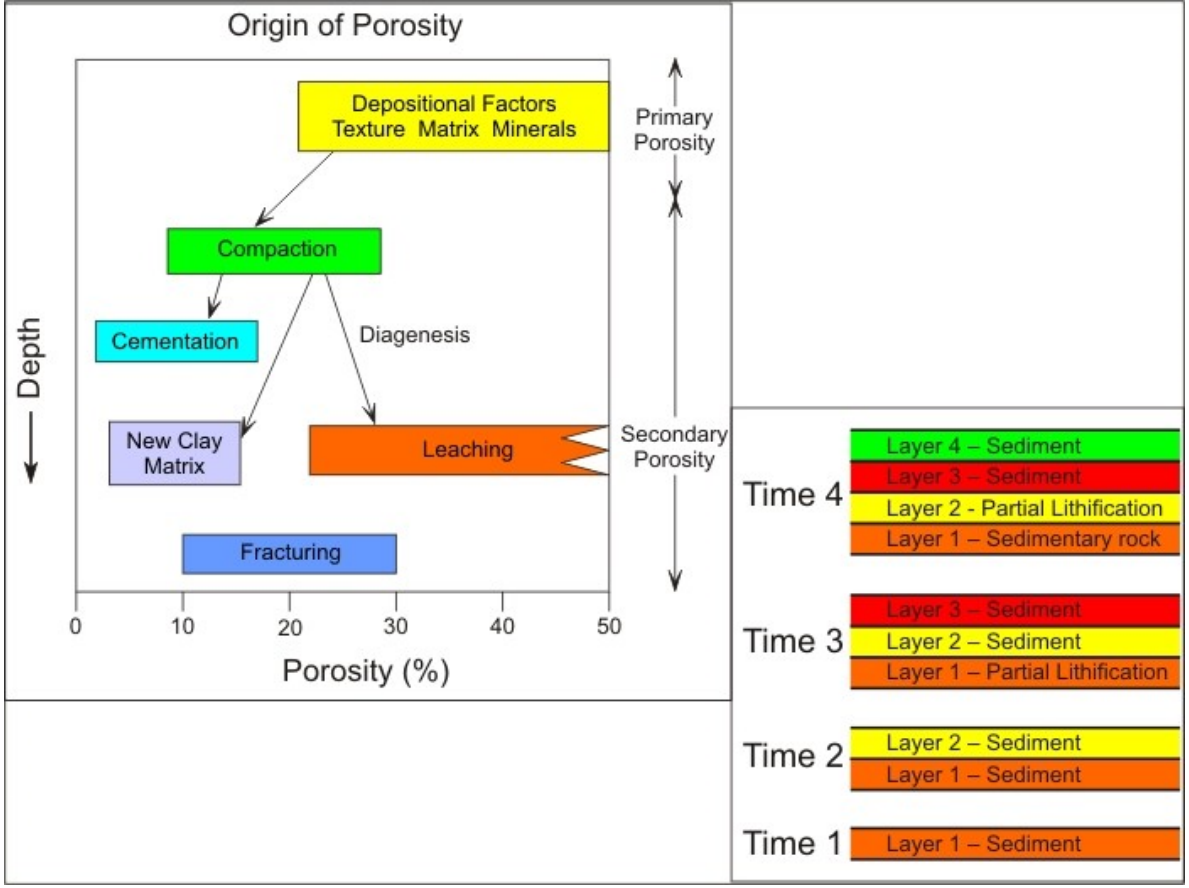
Sedimentary rock



Effect of Diagenetic Processes of Porosity and Permeability



- When sediments are buried, they become altered by the combined affects of physical **compaction** and **chemical reactions** under increased heat and pressure. Sometimes the reactions occur between solid grains and sometimes the reactions occur between grains and subsurface fluids.
- **Initial compaction** upon very early burial **reduces the thickness** of a deposit from T to t. But, not all of the pore spaces are eliminated. There is still pore space available for fluids to move through the sediment in the subsurface. These fluids contain dissolved ions that can precipitate in the pore spaces to form cement. Both of these processes lithify sediments.



- Plot on the left shows the several stages that a rock goes through as it is buried. The vertical axis is depth. The original porosity and permeability of sediment are those at the ground surface. With early burial, the sediment will **compact**, so that **the porosity decreases** substantially. With further burial, processes of **chemical diagenesis** replace physical compaction. **Mineral cements are precipitated** in the pore spaces, further **reducing the porosity.** However, some fluids can actually work in reverse by **dissolving certain chemically unstable mineral grains**. This process is called "**leaching**," and it actually forms secondary porosity. With further burial, the rock becomes brittle under the heavy weight of overlying rock, at which point it may fracture to produce fracture porosity. Slide on the right shows the steps of burial during 4 time intervals. Between Time 1 and Time 4, Layer 1 has become lithified from a sediment to a sedimentary rock.

Sedimentary rocks

Classification of sedimentary rocks



- Clastic (siliciclastic)
- Chemical-biogenic
- Organic
- (Pyroclastic)





SEDIMENTARY ROCK ANALYSIS AND CLASSIFICATION

STEP 1: What is the rock's composition?		STEP 2: What are the rock's textural and other distinctive properties?			STEP 3: Rock Name(s)	
DETRITAL (CLASTIC)	Mainly rock fragments or mineral grains (quartz, feldspar, clay) weathered from other rocks	Mainly gravel (≥ 2 mm)		Rounded grains	CONGLOMERATE	
				Angular grains	BRECCIA	
		Mainly sand (1/16 – 2 mm)		Mostly quartz grains	QUARTZ SANDSTONE	SANDSTONE
				Mainly feldspar and quartz	ARKOSE	
				Sand is mixed with much silt and/or clay (mud)	GRAYWACKE	
		Mainly Mud (< 1/16 mm)	Mostly silt (1/256 – 1/16 mm)	Breaks into blocks or layers	SILTSTONE	MUDSTONE
			Mostly clay (< 1/256 mm)	Crumbles or breaks into blocks	CLAYSTONE	
				Fissile (splits easily)	SHALE	

Sedimentary rocks



Conglomerate



Sandstone



Claystone

CLASTIC SEDIMENTARY ROCKS







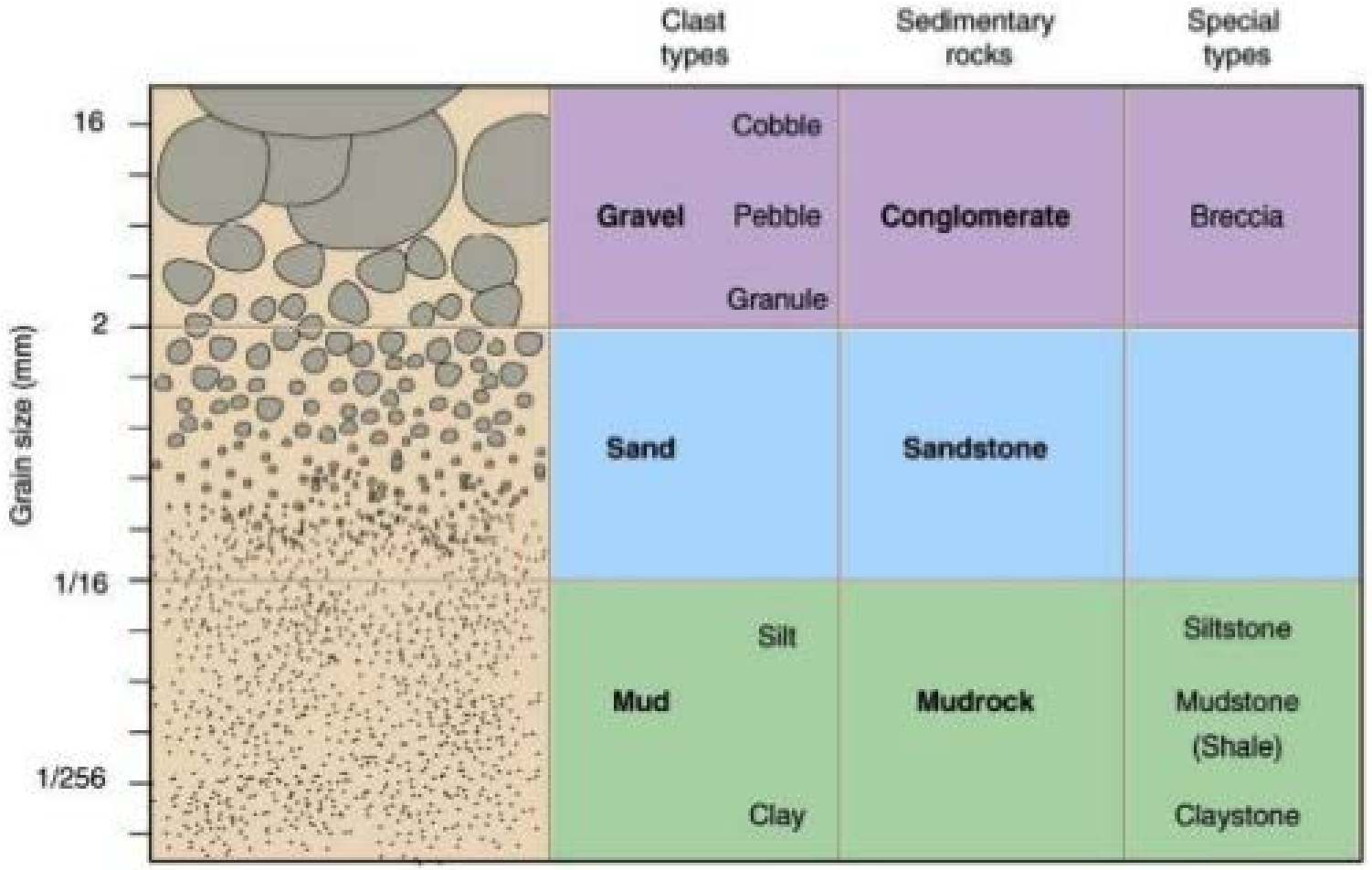




Crystalline limestone Fossiliferous limestone Travertine Dolomite Chert

BIOGENIC-CHEMICAL ROCKS

Siliciclastic Classification



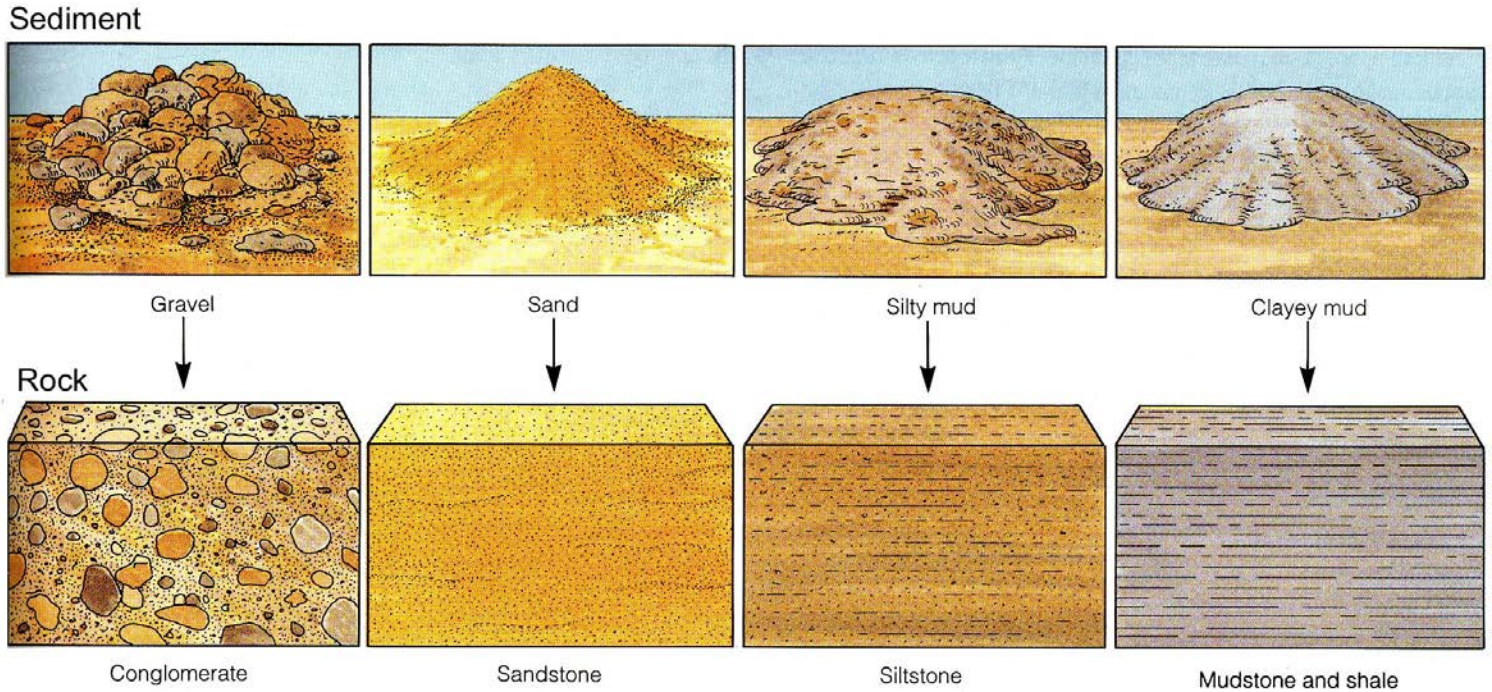
Siliciclastic sedimentary rocks form through the physical accumulation of particles (clasts) and are subdivided on the basis of particle (grain) size.

SEDIMENT COMES IN ALL SIZES

256 mm and up	BOULDERS	GRAVEL
64-256 mm	COBBLES	
2-64 mm	PEBBLES	
0.0625-2 mm	SAND	
0.002-0.0625 mm	SILT	
0.002 mm and smaller	CLAY	

Clastic (siliciclastic) sediments

Name of Particle	Range Limits of Diameter (mm)[a]	Names of Loose Sediment	Name of Consolidated Rock
Boulder	More than 256	Boulder gravel	Boulder conglomerate
Cobble	64 to 256	Cobble gravel	Cobble conglomerate
Pebble	2 to 64	Pebble gravel	Pebble conglomerate
Sand	1/16 to 2	Sand	Sandstone
Silt	1/256 to 1/16	Silt	Siltstone
Clay	Less than 1/256	Clay	Mudstone and shale



Structure of siliciclastic/carbonate rocks

