

## Rocks

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## Rocks

- Three types of rocks:
  - Igneous - formed from molten rock (i.e., magma or lava)
  - Sedimentary - formed from the debris of other rocks
  - Metamorphic - rocks that have been subjected to great stresses and have changed their texture or chemical state from their original form

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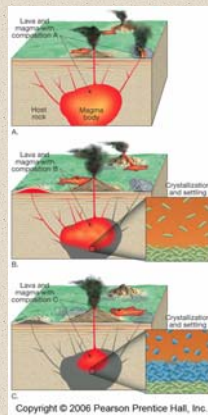
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## Igneous Rock Formation

- Magma (molten rock) originates deep within the interior of the Earth
- Rises to surface because it is less dense than surrounding rock
- As the magma rises, it cools and begins to crystallize
- Similar to water freezing into ice



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### Igneous Textures

- The rate at which the magma (or lava) cools determines the texture, or crystal sizes, of the igneous rock
- The texture also yields clues to the type of geologic setting in which the igneous rocks formed

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### Igneous Textures

- Aphanitic
  - Fine-grained
  - Grains (crystals) usually too small to be seen with naked eye
  - Indicative of a fast cooling history



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### Igneous Textures

- Phaneritic
  - Coarse-grained
  - Grains (crystals) can be seen with naked eye
  - Indicative of slow cooling history



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## Igneous Textures

- Porphyritic
  - Fine and Coarse-grained
  - Rock composed of both large and small crystals
  - Indicative of both slow and fast cooling history



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## Igneous Textures

- Glass
  - No identifiable crystals
  - Indicative of instantaneous cooling
  - Example: Obsidian



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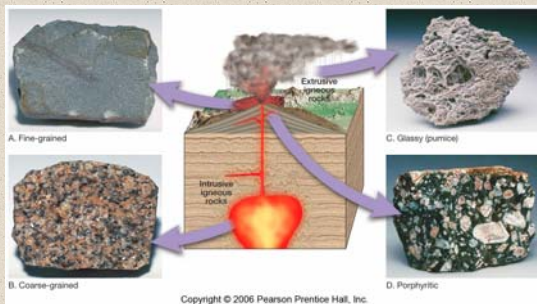
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## Textures of Igneous Rocks



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### Composition of Igneous Rocks

- All igneous rocks contain silica ranging in content from ~45% to ~80%
- Based on this fact, igneous rocks are classified according to the amount of silica they contain

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### Composition of Igneous Rocks

- Felsic
  - Contain high amounts of silica
  - Contain abundant quartz and feldspar
  - Also contain sodium and potassium
  - Usually light in color
  - Relatively low densities
  - Examples:
    - Granite - Intrusive
    - Rhyolite - Extrusive

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### Composition of Igneous Rocks

- Mafic
  - Contain low amounts of silica
  - Contain abundant iron and magnesium
  - Low amounts of sodium and potassium
  - Usually dark in color
  - Relatively high densities
  - Examples:
    - Gabbro - Intrusive
    - Basalt - Extrusive

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## Composition of Igneous Rocks

- Intermediate
  - Contain moderate amounts of silica
  - Contain high amounts of plagioclase feldspar
  - Moderate amounts of sodium and calcium
  - Various colors (depending on silica content)
  - Moderate densities
  - Examples:
    - Diorite - Intrusive
    - Andesite - Extrusive

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## Composition of Igneous Rocks

- Ultramafic
  - Contain very low amounts of silica
  - Large amounts of iron and magnesium
  - Dark color
  - Very high density
  - Example:
    - Peridotite

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## Classes of Igneous Rocks

Chemical Composition	Granitic (Felsic)	Andesitic (Intermediate)	Basaltic (Mafic)	Ultramafic	
Dominant Minerals	Quartz Potassium feldspar Sodium-rich plagioclase feldspar	Amphibole Sodium- and calcium-rich plagioclase feldspar	Pyroxene Calcium-rich plagioclase feldspar	Olivine Pyroxene	
TEXTURE	Coarse-grained (phanitic)	Granite	Diorite	Gabbro	Peridotite
	Fine-grained (aphanitic)	Rhyolite	Andesite	Basalt	
	Porphyritic	"Porphyritic" precedes any of the above names whenever there are appreciable phenocrysts			Uncommon
	Glassy	Obsidian (compact glass) Pumice (frothy glass)			
Rock Color (based on % of dark minerals)	0% to 25%	25% to 45%	45% to 85%	85% to 100%	

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## Sedimentary Rocks

- Two types of sedimentary rocks
  - Detrital - formed from the debris of other rocks
  - Chemical - formed through chemical processes

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## Sedimentary Rocks

- Processes involved in the formation of sedimentary rocks
  - Weathering - The breaking down of rocks to form sediment
  - Erosion - The transport of sediment (rock debris) via wind, rivers, animals, etc.
  - Deposition - The settling of rock debris in some depositional basin (low-lying area where sediment transportation ceases; lake, ocean, swamp, etc.)

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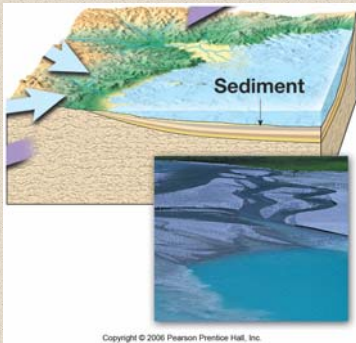
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## Sedimentary Rocks



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## Detrital Sedimentary Rocks

- Classified according to sediment (grain) size
- The size of sediments can vary greatly:
  - Boulders (largest)
  - Cobbles
  - Pebbles
  - Sand
  - Silt
  - Clay (smallest)
- The texture (grain size) of the rock also provides clues into the type of environment in which the rock formed

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## Common Detrital Sedimentary Rocks

- **Conglomerate**
  - Composed of large particles (pebble-size) held within a matrix of finer grained sediments
  - Indicative of a high-energy environment



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## Common Detrital Sedimentary Rocks

- **Sandstone**
  - Composed mostly of sand-sized particles
- Indicative of a moderate-energy environment



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### Common Detrital Sedimentary Rocks

- Shale
  - Composed mostly of silt and clay sized particles
- Indicative of a low-energy environment



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### Common Chemical Sedimentary Rocks

- Limestone
  - Composed of calcium carbonate ( $\text{CaCO}_3$ )
  - $\text{CaCO}_3$  produced by tiny marine organisms for shell development
  - As organism die, shells fall to basin floor, accumulate, and eventually compact to form chemical sedimentary rock (limestone)

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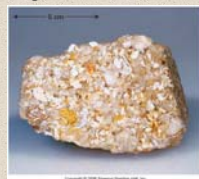
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### Common Chemical Sedimentary Rocks

- Coquina
  - Composed of entirely of shell fragments cemented together
  - Composed of  $\text{CaCO}_3$



- Chalk
  - Composed entirely of the shells of microscopic organisms ( $\text{CaCO}_3$ )

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## Common Chemical Sedimentary Rocks

- Evaporites
  - The process of evaporation causes minerals to precipitate from water
  - These minerals may accumulate on the basin floor
  - Examples
    - Halite
    - Gypsum



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## Common Chemical Sedimentary Rocks

- Coal
  - Composed chiefly of carbon
  - Coal forms in environments high in organic materials (swamps, marshes, etc.)
  - Organic material accumulates in an oxygen-deficient environment (swamp bottom) where decomposition is slow



<http://technology.polyprp.org/webdesign2005/SETES/baulta/coal.jpg>

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## Features of Sedimentary Rocks

- Sedimentary rocks are unique in the sense that they can contain structures not commonly found in igneous or metamorphic rocks
- The structures can be identified and interpreted by geologists to understand what the environment was like when the rock formed
- Sometimes, these interpretations can go back hundreds of millions of years

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## Features of Sedimentary Rocks

- Layers

- Sedimentary rocks are typically laid down in a series of layers or beds
- The changes in rock texture and structures within each layer can indicate a change in the environment at any given location



<http://www.arc.laseries.edu/~borough/RockLayers.jpg>

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## Features of Sedimentary Rocks

- Mudcracks

- Mudcracks form as sediment contracts when water evaporates from its surface
- This cracked appearance can be preserved as a series of mudcracks
- Indicative of an arid environment



<http://www.geology.sdsu.edu/visualgeology/geology101/mudcrak.htm>

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## Features of Sedimentary Rocks

- Ripple Marks

- Ripple marks form as water currents shift sediment into a wave-like pattern
- This pattern can be preserved as the sediment changes into a rock
- Usually indicative of a near-shore environment



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## Features of Sedimentary Rocks

- Fossils
  - Any type of evidence for ancient life
  - May be found as a body fossil (clam shell, dinosaur bone, fern imprint) or a trace fossil (footprints, gastroliths)
  - Excellent clues for studying ancient environments

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## Fossils



[http://www.geology.sdsu.edu/visualgeology/geology101/fossil\\_1.htm](http://www.geology.sdsu.edu/visualgeology/geology101/fossil_1.htm)

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## Sedimentary Rocks

- Processes involved in the formation of sedimentary rocks
  - **Compaction** - as sediment accumulates on basin floor, the gradually increasing weight of overlying sediment reducing the amount of pore space between grains
  - **Cementation** - liquids can flow through the pore spaces between unconsolidated (loose) sediment. As this occurs, minerals may precipitate from the liquid and "cement" sediments together. Common cements include silica and calcite.

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## Metamorphic Rocks

- Occurs when rocks are subjected to conditions unlike those when the rock first formed
- Causes a change in the texture and/or composition of the original rock

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## Agents of Metamorphism

- Heat
  - Very important because heat drives chemical reactions that result in recrystallization
  - Increased heat can be caused by
    - The intrusion of a magma
    - The subduction of rocks to greater depths
- Pressure
  - Increased pressure caused by
    - Subduction of rock to greater depths
    - Episodes of mountain building
- Chemically Active Fluids

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## Types of Metamorphism

- Contact
  - Native rock comes into contact with magma
  - Heat is the primary metamorphic agent
- Regional
  - Associated with large-scale mountain building
  - Heat and pressure are primary metamorphic agents
- Dynamic
  - Heat and pressure generated along faults

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### Textures of Metamorphic Rocks

- Degree of metamorphism is reflected in the rock's texture and composition
- Low-grade metamorphism causes rocks to become more dense
- High grade metamorphism can cause recrystallization which tends to produce larger crystals

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### Textures of Metamorphic Rocks

- Foliated
  - Rocks exhibit a layered or banded appearance
  - Caused by the realignment of minerals oriented to a preferred direction (perpendicular to the direction of applied stress)
- Non-foliated
  - Rocks do not exhibit a layered or banded appearance
  - Appear massive

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### Common Foliated Metamorphic Rocks

- Slate
  - Composed primarily of tiny mica flakes
  - Exhibits very noticeable cleavage (i.e., splits easily into sheets)
  - Often confused with shale
  - Low-grade metamorphism
- Schist
  - Platy rocks that can be split into thin flakes
  - Commonly has visible sheets of mica
  - Moderate-high grade metamorphism

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## Common Foliated Metamorphic Rocks

- Gneiss
  - Exhibit banding; distinct segregation of light and dark-colored minerals
  - Less platy with a lack of noticeable mica sheets
  - High-grade metamorphism




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## Common Non-Foliated Metamorphic Rocks

- Quartzite
  - Formed from sandstone
  - Quartz grains fuse together under high-grade metamorphic conditions
  - Very hard
- Marble
  - Formed from limestone
  - Composed of large interlocking calcite crystals
  - Impurities (trace elements) may alter the color

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## Classes of Metamorphic Rocks

Rock Name	Texture	Grain Size	Comments	Parent Rock
Slate	Foliated	Very fine	Excellent rock cleavage, smooth dull surfaces	Shale, mudstone, or siltstone
Phyllite		Fine	Breaks along wavy surfaces, glossy sheen	Slate
Schist		Medium to Coarse	Micas dominate, scaly foliation	Phyllite
Gneiss		Medium to Coarse	Compositional banding due to segregation of minerals	Schist, granite, or volcanic rocks
Marble	Non-foliated	Medium to coarse	Interlocking calcite or dolomite grains	Limestone, dolostone
Quartzite		Medium to coarse	Fused quartz grains, massive, very hard	Quartz sandstone
Anthracite		Fine	Shiny black organic rock that may exhibit conchoidal fracture	Bituminous coal

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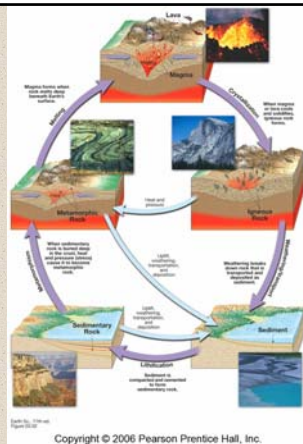
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# The Rock Cycle



<http://www.lchs.org/hoyhurst/ips/rockcycle.htm>

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