Rocks II

by Dr. W.

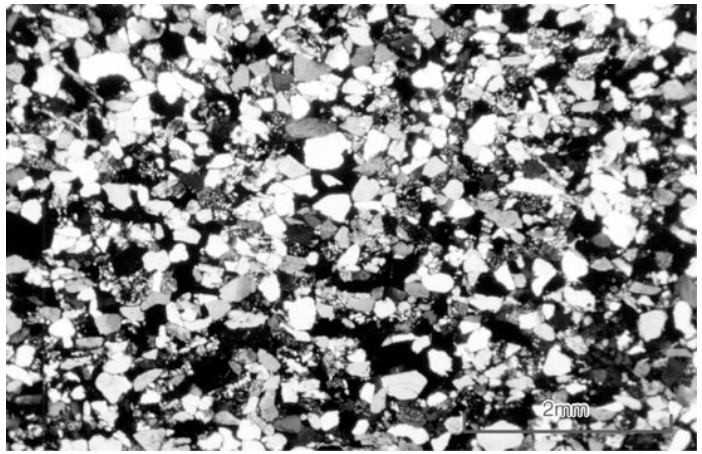
Sedimentary Rocks

- *Detrital* or *clastic* rocks—rocks made up of smaller fragments
- *Chemical* rocks—rocks made up of chemical precipitates from a solution
  - *Evaporites*—rocks that form when a water solution evaporates
  - *Bioclastics*—rocks that form from the skeletons of once-living organisms

Detrital Rocks

- Classified by size of the grains that make them up
  - *Shale* = particles less than 1/256 mm
  - *Siltstone* = 1/16 - 1/256 mm
  - *Sandstone* = 1/16 - 2 mm
  - *Conglomerate* (rounded pebbles) or *breccia* (angular pebbles) = over 2 mm
- Sediments form into rock (*consolidation*) by *compaction* (pressure) and often by *cementation* (precipitation of a mineral that "glues" the grains together)
  - If all grains are the same size, the rock is said to be *sorted*; if there's a wide size range of grains, the rock is *unsorted*.

This is an example of a well-sorted sandstone, as seen in thin section



Sedimentary rocks are usually *bedded*—laid down in layers (like these in the Grand Canyon). Rocks may be described as *thickly bedded* or *thinly bedded*.

Sedimentary rocks are usually laid down by water, but not always—these *aeolian sandstones*, in southern Nevada, were laid down as windblown sand dunes.

Windblown silt may form thick layers, usually poorly consolidated, known as *loess*. Wide areas of eastern Arkansas are covered with loess beneath the soil. The thickest deposits in the world are in eastern China, where this picture was taken.

Chemical sedimentary rocks

- Classified by chemical composition
  - $CaCO_3$ gives *limestone*
  - SiO_2 gives *chert* or *flint*
  - NaCl gives *rock salt* (*halite*)
  - $CaSO_4$ gives *gypsum*
  - Once-living plant matter gives *lignite* (softest coal) or *bituminous coal* (less soft coal)

Metamorphic Rocks

- *Foliated rocks* have been compressed primarily in one direction, causing a banded appearance, with the bands at right angles to the direction of compaction
  - This may look like the layering of sedimentary rocks, but it isn't!
- *Nonfoliated rocks* have been compressed from all directions, and don't have a banded appearance.

Contexts of Metamorphism

- Metamorphic agents
  - Heat
  - Pressure
    - This may be *confining pressure* (from all directions)
    - . . . or *differential stress* (along one axis).
  - Hydrothermal fluids
    - Extremely hot water rich in dissolved minerals

Contexts of Metamorphism

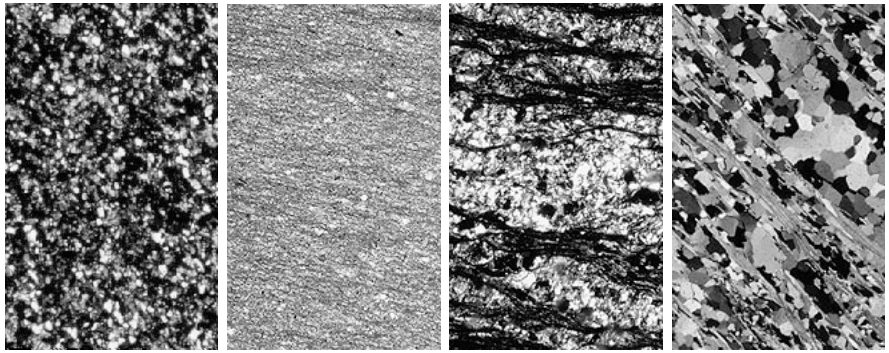
- *Contact metamorphism* results from heat from magma intrusion
  - If rock is metamorphosed not only by heat but by chemical exchange with magma, this is called *metasomatism*.
    - Example: the rock *skarn* is metasomatic
    - In contrast, *hornfels* is like skarn but is not metasomatic.
- *Regional metamorphism* results from heat and directed pressure associated with mountain-building

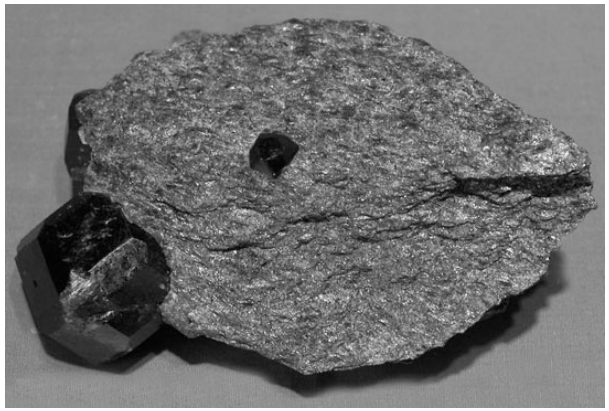
Foliated Rocks

- As pressure increases, mineral crystals slowly dissolve and tend to reprecipitate out in layers perpendictular to compression
  - Shale (or sometimes basalt) becomes *slate*
  - Slate becomes *phyllite*
  - Phyllite becomes *schist*
  - Schist, granite, diorite, etc. become *gneiss*

Granite-derived gneiss outcrop showing foliation (light bands are quartz and feldspar, dark bands are biotite mica and hornblende)

Shale (on the left) may transform to the weakly foliated slate, then to phyllite, finally to schist. . .



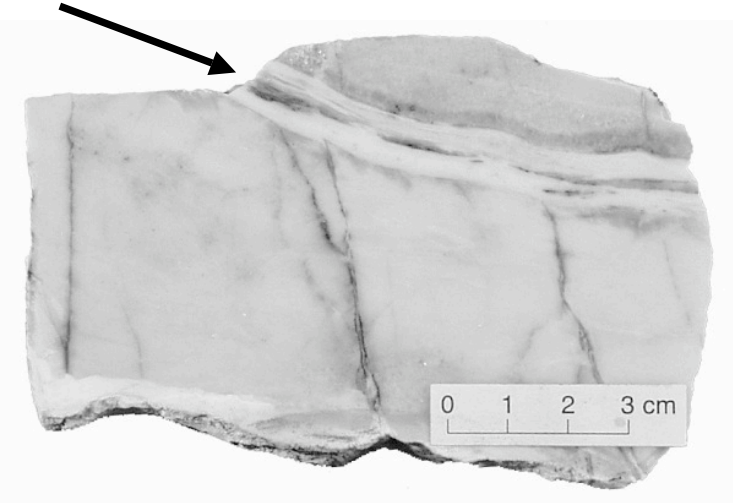


Schist often develops large crystals of mica (giving it a bit of a sheen), and some schists develop large crystals of garnet.

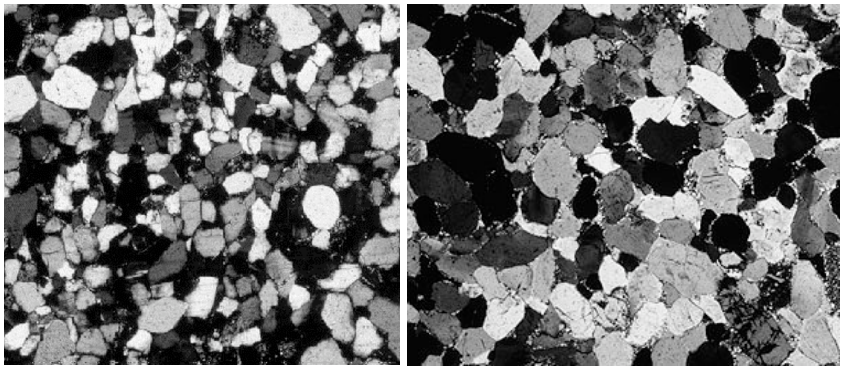
Nonfoliated Metamorphic Rocks

- Pressure comes from all directions at once
- Grains may partially dissolve and reprecipitate as they are compressed against each other
  - Limestone becomes *marble*
  - Sandstone becomes *quartzite*
  - Bituminous coal becomes *anthracite* (hard coal)
  - Silica shales become *novaculite* (Arkansas whetstone)

Sample of marble: no foliation, but where the marble cracked, hydrothermal fluids metamorphosed it further



Compare sandstone (left) and quartzite (right): quartzite grains intrelock with each other. . .



Igneous Rocks -- Economics

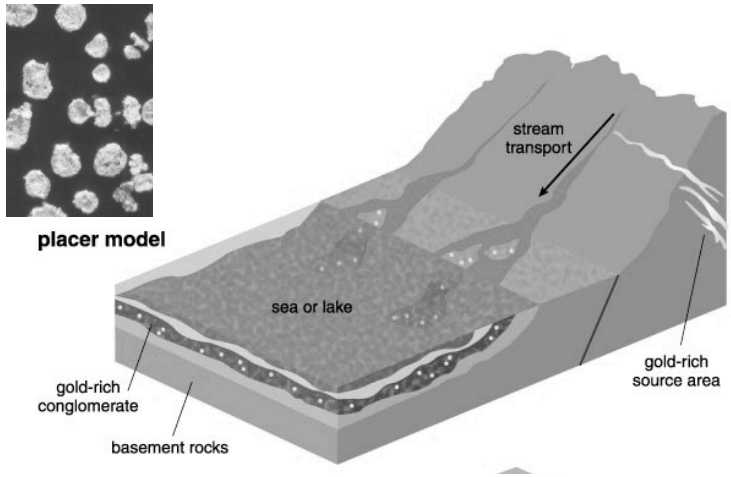
- Granite and similar intrusive rocks quarried for building stone, ornament, etc.
- Basalt quarried for road-building material
- Diamonds form in certain very deep volcanoes known as *kimberlite pipes*
- Because different minerals form at different times in intrusives, within an intrusive rock body you'll find zones that are rich in different minerals. . .
  - Chromite (iron-chromium oxide)
  - Nickel-copper ores
  - Platinum Group Metals (PGMs)

Left: Chromite specimen. Right: Platinum ores being mined from intrusive igneous rock at Impala Mine, Bushveld, South Africa (from PTM)

Sedimentary Rocks -- Economics

- Building and construction materials
- Evaporites (rock salt, gypsum, borax)
- Bituminous coal (duuh)
- "Fossil placers"
  - Placer: sedimentary deposit in which grains of a mineral are concentrated
  - Ancient conglomerates or other sedimentary deposits are sometimes rich in gold grains
  - Diamonds are also sometimes mined from such deposits

Small, rounded gold nuggets from the Witwatersrand Basin of South Africa. Larger diagram shows how placer forms



Chemical conditions in certain sandstones may cause minerals to precipitate out—such as uranium ore in the western United States. . .

Metamorphic Rocks -- Economics

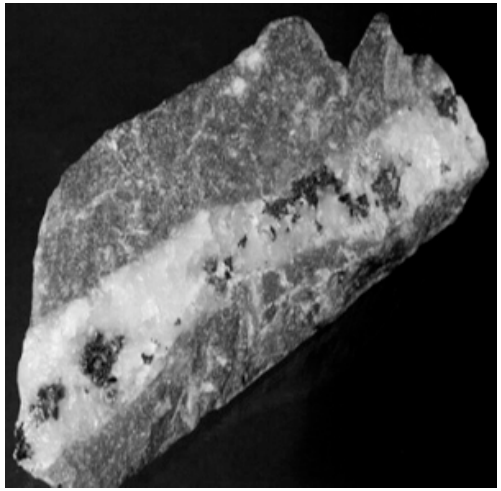
- Building and construction materials (e.g. slate, marble, novaculite)
- Certain important minerals form in various metamorphic rocks, notably garnet; sometimes beryl (emerald), corundum (ruby, sapphire, corundum for abrasives) and ores of tungsten, copper, etc.
- Hydrothermal solutions may produce ores as either *vein deposits* (if they flow through cracks) or *disseminated deposits* (if they percolate through a rock mass)

A large garnet in schist from Connecticut. . .

The Bingham Canyon copper mine in Utah is a disseminated hydrothermal deposit. The pit is 2.5 miles across and 0.5 miles deep—the largest man-made excavation on Earth.

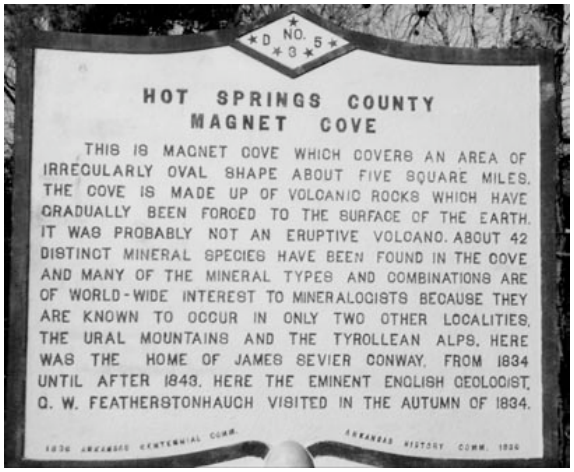
The Comstock Lode in western Nevada was a vein-type hydrothermal deposit—it was discovered in 1859 and exhausted in thirty years. . .

. . . but the metal-rich veins of quartz would have looked like this sample from Ontario—note the gold flecks!



And to bring it home—the zinc mines at Rush, Arkansas (now closed) are in vein-type deposits in limestone. . .

. . . while the ores and minerals around Magnet Cove result from *contact metamorphism*.



Weathering (chemical changes at the surface of the Earth caused by air and water) isn't technically metamorphism, but it has created important products. . .

In tropical climates with heavy rainfall, weathering removes most of the soluble minerals, leaving behind a soil called *laterite*. . .

Laterite that happens to be aluminum-rich is known as *bauxite*—the main ore of aluminum.

Other ores result from weathering, which can cause valuable elements to become concentrated—such as this sample of *hornsilver* from Nevada.