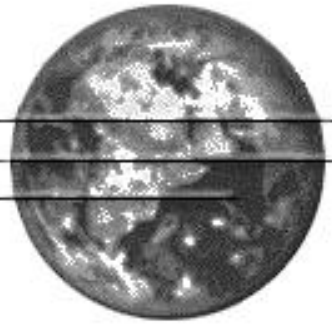
Geoscience 101

The Solid Earth



Lecture 6

October 18, 20, 23
October 19, 24

METAMORPHIC ROCKS

CHAPTER 8

This is only an outline of the lecture. You will need to go to class to fill in the outline, although much of the relevant information is also in the text.

METAMORPHIC ROCKS

Reading: Ch 8, Read 169-179 (table 8.1)

METAMORPHIC ROCKS AND THE ROCK CYCLE

Metamorphic rocks are rocks whose original texture, mineralogy, and chemical composition have been changed by temperature, pressure and interaction with fluids, within the Earth.

These changes occur without melting the rock.

Metamorphism involves recrystallization: change in sizes of crystals, and reactions of minerals with each other to form different minerals.

Any rock can be changed into a metamorphic rock by these processes.

In the Earth, temperature and pressure generally increase with depth.

Sedimentary rocks form in the upper part of the crust. Metamorphism is generally limited to the lower crust.

CONDITIONS CAUSING METAMORPHISM

TEMPERATURE

Increasing temperature has several effects on rocks:

1) crystals tend to grow larger by joining together.

2) hydrous minerals tend to lose water, and in the process are transformed to different minerals: clay ---> biotite ---> hornblende, for example

3) reactions may occur between minerals.

METAMORPHIC GRADE

Metamorphic grade describes the temperature at which a rock formed:

low grade means low temperature, high grade means high temperature.

CONFINING PRESSURE

Increasing confining pressure has different, and sometimes opposite, effects:

1) water in the crust may be forced into minerals, resulting in reactions opposite to the above: hornblende ---> biotite, for example.

2) other reactions between minerals may occur, such as the breakdown of Na-plagioclase to Jadeite + Quartz.

DIRECTED PRESSURE

Directed pressure is different in different directions.

In and around subduction zones, strong pressures in one direction may cause minerals to respond by recrystallizing in a new orientation with their long axis perpendicular to the maximum pressure. -->||

The crystals are growing in the direction where there is less pressure, and shrinking where the pressure is greatest.

This recrystallization creates foliation --a texture in the rock similar to the grain in wood.

FLUIDS

1) Fluids transfer heat upward from deeper levels in the crust, or away from magma.

2) Fluids may bring different elements into the rock, or dissolve out some of the original elements.

   In this way, fluids change the chemical composition and the minerals in the rock.

KINDS OF METAMORPHISM

CONTACT METAMORPHISM

Contact metamorphism involves the effect of heat and sometimes fluids.

It is caused by intrusion of magma into the shallow crust, particularly into sedimentary rock.

There may also be chemical reactions with fluids from the intruding magma (see p. 182).

Contact metamorphism can also be found in the soil or rock underlying a lava flow.

BURIAL METAMORPHISM

Burial metamorphism involves the gradual effects of increasing temperature and pressure that occur as sedimentary rock is buried deeper and deeper in the crust.

Eventually, it changes to metamorphic rock, yet may retain its sedimentary appearance.

The minerals will react with each other without destroying the original layering.

The rock looks like a very hard sedimentary rock, but will have some different minerals, such as mica instead of clay.

REGIONAL METAMORPHISM

This is the most interesting type of metamorphism, because it can tell us what happens deep in the Earth in subduction zones.

Changes are caused by increased temperature, confining and directed pressure, and fluids.

Regionally metamorphosed rocks are foliated.

That is, they have a directional texture caused by directed pressure.

The depths and temperatures they have been subjected to cover the full range of possiblities, from very deep (high pressure) and relatively cool on a subducting plate, to hot and low pressure near volcanoes.

METAMORPHIC TEXTURES

FOLIATED ROCKS

These rocks commonly form in and around subduction zones, deep in the crust. They are Not often exposed at the surface in western Oregon.

SLATE is low grade metamorphosed shale or mudstone. The original clays have metamorphosed to microscopic mica crystals. The texture results from growth of these micas perpendicular to the directed pressure. --> |

PHYLLITE is slightly higher grade, and is shiny because the micas have grown larger.

SCHIST has mica crystals that are big enough to see. It is a pretty rock because it sparkles. Higher grade schist may have other minerals such as garnets, staurolite, or varieties of amphibole. Schist usually has a sedimentary precursor.

GNEISS is high grade. The minerals have separated into layers by shape and composition, with the light colored, equant minerals (quartz and felspar) alternating with bands of dark platy or elongated minerals (amphibole or biotite). Gneiss may form from either sedimentary or igneous parents.

NON-FOLIATED ROCKS

HORNFELS forms in contact metamorphism. If the original rock was shale, mica or amphibole may grow, but will be randomly oriented. Fluids may cause other mineralogical changes. (There is some on Mary's Peak--hard to find).

QUARTZITES are metamorphosed quartz-rich sandstones. They are hard, compact, and very durable. Separate sand grains can no longer be distinguished.

MARBLE is metamorphosed limestone. The clay mud that is present in most limestone has been separated into dark streaks in the marble. (Sand in the original may form bands of quartzite.) The microscopic calcite crystals in the limestone have grown to distinguishable crystals (if you look closely). (Kidder Hall south entrance, inside).

ARGILLITE is metamorphosed mudstone (shale or siltstone) that is not foliated, either because there is no directed pressure, or because there was so much silt (little quartz grains) in the rock that foliation didn't develop.

METAMOPHOSED MAFIC ROCKS

GREENSTONE results when the basalt on the seafloor is metamorphosed by hot fluids circulating near mid-ocean ridge volcanic activity. It is a low grade rock. It contains chlorite mica.

GREENSCHIST is a term that usually refers to regionally metamorphosed rock of basalt parentage. It has a schistose appearance created by chlorite mica and a green amphibole called actinolite. It is a medium grade rock.
(It can be found in the Klamath Mountains of southwestern Oregon and northwestern California.)

BLUESCHIST is ocean crustal rock that has been buried very deeply on a subducting plate, but remained at low temperature. It is a very dense, blue-grey rock. It's color is provided by a blue amphibole called glaucophane.
(Jetty and seastacks at Bandon, Oregon)

AMPHIBOLITE results when basalt is metamorphosed at high temperature. It contains hornblende and plagioclase. It usually doesn't appear foliated.
(Klamath Mountains)

SERPENTINITE is metamorphosed peridotite (ultramafic rock). It contains serpentine, a sheet silicate. (Siskiyous --along the Illinois River near Selma)