EESC 4701: Igneous and Metamorphic Petrology

METAMORPHIC ROCKS

LAB 8 HANDOUT

Sources: Caltech, Cornell, UCSC, TAMIU

Introduction

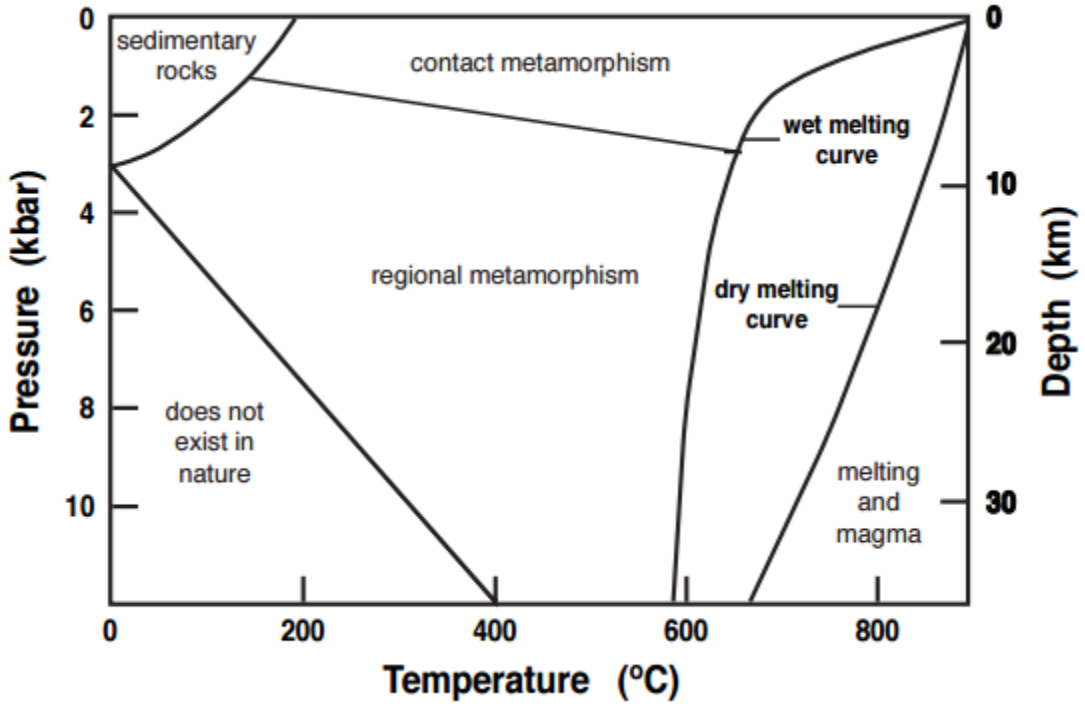
Metamorphism is the process by which physical and chemical changes in a rock are brought about by changes in geologic pressures and temperatures, often in combination with chemically active fluids. Many of the minerals in metamorphic, or changed, rocks are the same silicates, carbonates, etc. which are also common in igneous and sedimentary rocks. However, there are other minerals found mainly, or exclusively, in metamorphic rocks. Often these characteristic metamorphic minerals make up only a relatively minor component of a typical metamorphic rock. Most common metamorphic rocks are primarily composed of minerals such as quartz, feldspars, micas, amphiboles and sometimes augite.

Metamorphic rocks are formed when pre-existing rocks are changed by a combination of chemically active fluids and high geologic temperatures and pressure which are different from the temperatures and pressures at the surface of the earth. Metamorphism of preexisting rocks is a combination of: **a) Cataclasis** - mechanical shearing and granulation of the original grains and **b) recrystallization** - the process whereby minerals are transformed into new minerals which are often different in composition from the original minerals, or simply larger crystals of the original minerals.

Types of metamorphism

Contact metamorphism occurs in rocks adjacent to the magmatic intrusions, predominantly due to the high temperatures there.

Regional metamorphism is the result of large segments of the earth's crust being deformed during periods of major mountain building. In some cases, this deformation occurs over areas hundreds of miles wide and thousands of miles in length. Rocks in these deformation belts are subjected to stretching and squeezing stresses that cause drastic physical changes (cataclasis) in the rock. Rock masses buried to such great depth deform or "flow" as a plastic rather than a brittle solid. Because of this, many rocks formed under these conditions have a texture that is characterized by the parallel arrangement of platy minerals such as the micas.



A simple way of thinking about regional and contact metamorphism in P-T space

Metamorphic grade

The grade of metamorphism refers to the intensity of the changes that have produced the metamorphic rock. A low grade metamorphic rock often resembles the original rock from which it was formed. In high grade metamorphic rocks the original character is sometimes totally obscured.

Identification of Metamorphic Rocks

Metamorphic rocks are identified on the basis of their mineral composition and their texture.

Mineral Composition: All the constituent minerals and their relative percentage of a metamorphic rock should be noted. Some of these minerals are included in the name of a metamorphic rock.

Texture: Metamorphic textures consist of two main types, foliated and non-foliated. Foliated metamorphic rocks exhibit any of several possible types of planar features which are the result of the mineral constituents within the rock being oriented in a parallel or subparallel arrangement. Non-foliated metamorphic rocks have no preferred orientation of their mineral grains.

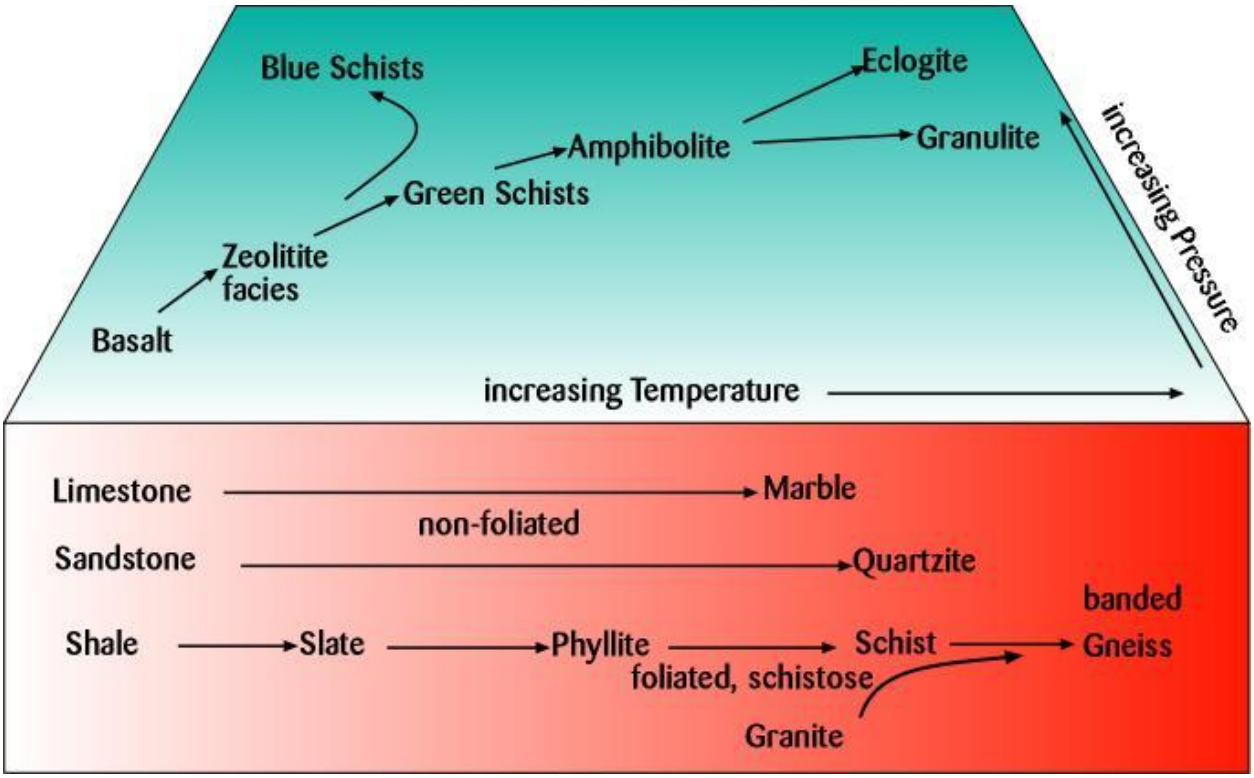
A. **Non-foliated metamorphic rocks**: Non-foliated rocks can be microcrystalline or granular, containing megascopic grains. Rocks with this texture commonly contain equi-dimensional grains of a single mineral such as quartz, calcite, or dolomite (although

some non-foliated metamorphic rocks are made up of several minerals). *Marble* and *quartzite* are examples of non-foliated metamorphic rocks.

B. **Foliated metamorphic rocks**: Most of the metamorphic rocks you will see in the lab or on field trips exhibit one of several types of planar features called "foliation." These planar features are the result of the parallelism of the mineral constituents and may be any of four possible types.
    a. ***Rock cleavage*** - Rock cleavage is the tendency of some fine-grained metamorphic rocks to split along one particular direction (similar to fissility, the tendency of some fine-grained sedimentary rocks to split along their bedding planes). Rocks in which recrystallization has not proceeded sufficiently to produce visible mineral grains exhibit a foliation of this type. *Slate* and *phyllite* are two examples of rocks exhibiting rock cleavage (in slate, this is termed **slaty cleavage**).
    b. ***Schistose rocks*** - Schistosity is a foliated texture produced by parallel or subparallel alignment of platy minerals such as chlorite or micas. Quartz, hornblende and feldspar may also be present in the rock. Generally the minerals in schistose rocks are rather small in size although distinctly visible. *Schist* is an example of a rock exhibiting schistosity.
    c. ***Gneissic rocks*** - These rocks have a coarsely foliated texture in which minerals of different composition occur in alternating layers. A gneissic rock often consists of alternating layers or bands of light colored quartz-and feldspar-rich layers alternating with darker ferromagnesian mineral layers. *Gneiss* is a common example of this type of rock.
    d. ***Lineation*** - Lineation is a foliation produced by elongate minerals such as actinolite, hornblende or tremolite arranged subparallel to each other, producing a single direction, or lineation, of mineral grains in the rock. Lineation is usually observed in rocks exhibiting other types of foliation as well.

C. **Miscellaneous**
    a. ***Porphyroblastic texture*** - Certain metamorphic mineral species such as garnet and staurolite tend to recrystallize to form large, individual crystals, while other species such as mica and biotite tend to form masses composed of small interlocked grains. If two species with differing behaviors recrystallize in the same location, the resulting metamorphic rock will typically contain large crystals of one species embedded in a matrix of small crystals of the other. For example, large garnets are often found embedded in a mass of fine-grained muscovite or biotite. Metamorphic rocks possessing this type of texture are termed **porphyroblasts**.

Simple view on the origin of metamorphic rocks



Common metamorphic minerals

See: http://minerva.union.edu/hollochk/c_petrology/met_minerals.htm

(For more detailed information, refer to your earlier handout with optical proprieties of minerals)

Identification table for common metamorphic rocks in hand sample

	TEXTURE	PARTICLE SIZE	COMPOSITION	COMMENTS	ROCK NAME
Foliated	Foliated	Fine grained, minerals not visible	Minerals with basal cleavage: commonly mica, graphite, etc.	Dense; thin pieces will pass the "tink" test	**Slate**
			Minerals with basal cleavage: commonly mica, graphite, etc.	Satiny luster; very shiny and reflective in sunlight	**Phyllite**
	Foliated or Lineated	Medium to coarse grained; grain size generally increases with metamorphic grade, and water is lost	Muscovite, biotite, chlorite, talc, garnet, kyanite, staurolite, feldspar, quartz, tourmaline, and many others	Name is preceded by diagnostic minerals: such as quartz schist, mica schist, quartz mica schist, kyanite biotite hornblende schist, etc.	**Schist**
	Color Banded		Feldspar, quartz, mica, ferromagnesian minerals	Color banding due to alternation of light (felsic) and dark (mafic) minerals	**Gneiss**
	Mixed metamorphic and igneous rock		Feldspar, quartz, mica, ferromagnesian minerals	Alternating layers of felsic igneous rock and mafic gneiss; the last metamorphic grade prior to complete melting	**Migmatite**
Non-foliated	Non-oriented grains	Medium to coarse grained, minerals visible	Calcite ($CaCO_3$)	Hardness of 3; fizzes with dilute HCl	**Marble**
			Dolomite ($(Ca,Mg)(CO_3)_2$)	Fizzes with dilute HCl only when powdered	**Dolomitic Marble**
			Quartz (SiO_2)	H = 7; breaks through grains (as opposed to sandstone that breaks around grains)	**Quartzite**
			Amphibole; commonly hornblende	Generally black; prismatic crystals with 2 directions of cleavage at 60° / 12O°	**Amphibolite**
			Anything that could be a conglomerate	Breaks through clasts as well as around them; clasts may be flattened or stretched	**Meta-conglomerate**
		Fine grained, minerals not visible	Clay minerals, mica	Dense, dark colored	**Hornfels**
			Carbonaceous material	Black, shiny, conchoidal fracture	**Anthracite Coal**