Lab 12: METAMORPHIC MINERALS & ROCKS 100 pts

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 pre-existing 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.

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.

1. ***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.

2. ***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.

3. ***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.

4. ***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.

Use of the Metamorphic Rock Identification Chart

The identification chart on the following page will be used to identify metamorphic rocks in this exercise.

1. For each specimen list the texture of the rock on the *form for metamorphic rock determination.* The texture will be either foliated of non-foliated and should further indicate whether the rock contains microscopic or megascopic grains.

2. Identify all of the constituent minerals in the rock. This should be listed in approximate order of abundance in the appropriate column of your rock identification form. It is normally impossible to identify the minerals present in fine-grained metamorphic rocks; these rocks will simply have to be given the basic name as determined from the metamorphic rock chart.

3. Determine the basic name of the rock. Once the texture and mineral composition of the rock has been determined, turn to the *metamorphic rock determination chart* that follows to determine the *basic* name of the rock. This chart is arranged into columns and rows in which you start on the top row.

- The first decision concerns whether the rock is foliated or not.
- The next decision concerns grain size.
- Depending on your decision, you then continue to isolate a single column containing the possible rock names. By looking at the characteristics of the possible named rocks, you can then determine which rock your unknown might be.

4. Prefix this basic name with the names of the minerals identified in the rock to properly complete the name. It is not necessary to include the mineral name in the non-foliated metamorphic rocks. However, if the rock is foliated and granular with visible grains, then you must always prefix the basic rock name with the minerals identified in the rock *except* for orthoclase, plagioclase and quartz. Examples would be: Hornblende-biotite gneiss, muscovite-garnet-epidote schist, augite granulite, hornblende- epidote-garnet amhibolite, etc. Never name a rock "mica schist;" name it according to the type of mica. For example: Biotite schist, chlorite-epidote-garnet schist, muscovite schist, chlorite schist, etc.

If you experience difficulty in naming your rock by the chart it is possible that you made the wrong decision at one of the steps in your chart. For instance, if you determined that your rock was unfoliated and yet it does not seem to fit any of the names listed, it is possible that you overlooked a slight foliation, so you might want to look down under the poorly foliated rocks. You should be warned that the distinction between strongly and poorly foliated rocks, while generally true for the rocks listed, is not always the case, Some amphibolites or granulites can be quite strongly foliated, and gneisses in some cases exhibit rather poor foliation. Therefore, if you experience difficulty always be sure to check under another of the possible textures since you might be dealing with a rock that is an exception to the general rule. Once you have used the chart a few times and become familiar with the names, you will find that for many metamorphic rocks you can go directly to the basic name of the rock simply by recognizing that rock type.

5. <u>Probable origin.</u> In the final column of your metamorphic rock determination form, you should list the probable original composition of the rock prior to its metamorphism (protolith), or any other information as to what the original rock might have been. High-grade metamorphic rocks typically preserve little indication of their original character, whereas lower-grade metamorphic rocks in many cases do have features indicative of their original character. When this is the case these features, and what they indicate, should be listed in the right-hand column.

CLASSIFICATION OF METAMORPHIC ROCKS

TEXTURE	GRAIN SIZE	COMPOSITION	COMMENTS	ROCK NAME
Foliated	Fine grained, minerals not visible	Clay minerals, micas	Dense, dark breaks into flat sheets.	**Slate**
		Clay minerals, micas	Satiny luster. Smaller xls than schist.	**Phyllite**
Foliated or Lineated	Medium to coarse grained, minerals visible	Micas (muscovite, biotite, chlorite), talc, garnet, kyanite, staurolite, quartz, mafic minerals.	Large flat shiny xls. Rock name is preceded by diagnostic mineral names, e.g. quartz schist, mica schist, quartz mica schist, kyanite biotite hornblende schist, etc.	**Schist**
Banded		Feldspars, quartz, micas, mafic minerals	Banding due to alternation of light (felsic) and dark (mafic) minerals	**Gneiss**
		Feldspars, quartz, micas, mafic minerals	Gneiss with light-colored, “eye-shaped” xls.	**Augen Gneiss**
Non-foliated (no oriented grains)	Medium to coarse grained, minerals visible	Calcite ($CaCO_3$)	Hardness of 3; fizzes rapidly with dilute HCI Meta. limestone	**Marble**
		Dolomite ($(Ca, Mg)(CO_3)_2$)	Fizzes with dilute HCI only when powdered. Meta. limestone	**Dolomitic Marble**
		Quartz (SiO_2)	Hardness of 7; breaks across grains. Meta. sandstone.	**Quartzite**
		Amphiboles	Interlocked xls, generally black; prismatic with 2 cleavages at 60° / 12O°	**Amphibolite**
		Anything that could be a conglomerate	Breaks across grains as well as around them. Stretched out pebbles.	**Meta-conglomerate**
		Fine calcite matrix with large xls of various minerals (garnet, pyroxene)	Usually results from contact metamorphism with limestone. Often a good metal ore.	**Skarn**
	Fine grained, minerals not visible	Clay minerals, micas	Dense, dark colored. Like slate without cleavage.	**Hornfels**
		Carbonaceous material	Black, shiny, conchoidal fracture	**Anthracite Coal**

In many cases the distinction you have made above holds true. Finer grained rocks and minerals are more typical of lower grade metamorphism and in many cases coarser grained rocks represent a higher grade of metamorphism. However, it is never safe to depend on this generalization since factors other than the simple grade of metamorphism can sometimes affect the grain size of a particular metamorphic rock.

NOTE: The following questions refer to pairs of rock samples, the first being an unmetamorphosed rock (protolith) that you can examine from previous lab materials, the second being its metamorphic counterpart from this lab exercise.

2. Compare the sedimentary rock limestone with the metamorphic rock marble. Marble is known to result from metamorphism of limestone because the gradual change of one to the other can be traced in the field.

a) Test for effervescence with acid. What happens? **(1 pt)**

____

b) Based on your observation of the marble and your answer above, how the metamorphism changed the mineral content of the metamorphic rock?**(3 pts)**

____

____

c) Observe the grain size. Has metamorphism produced a change in the texture or grain size? If so, describe. **(3 pts)**

____

____

3. Compare the sedimentary rock sandstone with the metamorphic rock quartzite. Through tracing gradual changes in the field it has been deduced that quartzite is produced from the metamorphism of quartz sandstone.

a) Test for the hardness of the metamorphic rock, and examine the surface for evidence of mineral cleavages. Has metamorphism changed the mineral composition? If so, describe: **(3 pts)**

____

____

b) Observe the grain size and grain shape with a hand lens or microscope. Has metamorphism altered the rock texture? If so, describe: **(3 pts)**

____

4. In the field, geologists have found gradual transitions from sedimentary shale to metamorphic slate, from slate to phyllite, and from phyllite to schist. Compare the mineralogical and textural changes in these rocks and record them in the table below: **(6 pts)**

	Shale to slate	**Slate to Phyllite**	**Phyllite to schist**
Mineralogical changes			
Textural changes			

5. Now compare the tray of metamorphic rocks in general to sedimentary and igneous rocks. What criteria could you use to recognize whether a rock is metamorphic as opposed to igneous or sedimentary? **(6 pts)**

Lab 12: Metamorphic Rock Determination Worksheet

#	Structure/Texture	Mineral Composition	Probable Origin	Rock name

Lab 12: Metamorphic Rock Determination Worksheet

#	Structure/Texture	Mineral Composition	Probable Origin	Rock name

Lab 12: Metamorphic Rock Determination Worksheet

#	Structure/Texture	Mineral Composition	Probable Origin	Rock name

Lab 12: Metamorphic Mineral ID Worksheet

	Hard-ness	Luster	Color	Streak	Specimen structure or crystal form	Cleavage/fracture	Heft	Misc. Properties	Name
23									
24									
25									
26									
27									
28									
29									
30									
31									
32									