

# Physical Geology Lab -- Metamorphic Rocks, Rock Review, and Introduction to Geologic Maps

## Part 1: Examination and naming of metamorphic rocks. (45-60 minutes)

**Objectives:** To examine the variety of commonly occurring metamorphic rocks, to learn to recognize foliation, to use grain size and foliation to name metamorphic rocks, and to learn the approximate temperature of formation of each foliated rock type.

Before proceeding, please read the names and description of the metamorphic rocks on Page 3.

Metamorphic rocks are recognized by their *texture* **OR** their *mineralogy*. Because they form under very high pressures, metamorphic rocks have no open pore spaces; their mineral grains have grown tightly against each other making the rocks very hard, dense and tough.

**Foliation** is the main texture that distinguishes most metamorphic rocks. This “layering” or banding can range from paper-thin to very coarse. Foliated metamorphic rocks are named according to the grain size and appearance of the foliation. (See identification table below.)

Foliation occurs for two reasons:

1. At lower metamorphic temperatures (250-500°C) the elongated minerals (like hornblende) or platy minerals (like micas) grow with a strongly parallel orientation (oriented perpendicular to the direction of maximum applied pressure).
2. At higher temperatures (500-700°C) the different types of minerals separate into distinct thick layers recognized as light and dark “mineral segregation banding.”

Note: Many metamorphic rocks form around 500°C, so many samples have both parallel grains and some discontinuous mineral banding.

Common metamorphic minerals with flat, platy grain shapes include: muscovite (white); biotite (brown-black); chlorite (green), and serpentine (bright green).

The most common elongated mineral is hornblende (jet-black member of the amphibole family); epidote (pistachio-green), and kyanite (sky-blue) can also be found.

Mixed with the elongated or platy minerals may be a variety of other mineral types: quartz (light gray to white), feldspars (white to cream), garnet (red, round crystals).

Note: Plutonic igneous rocks may also have the appearance of foliation due to minerals being smeared out during the last stages of magma movement—geologists often call these rocks “foliated,” but realize they are not metamorphic.

**Non-foliated** metamorphic rocks also occur, usually because none of the minerals present form platy or elongated crystals, but form blocky-shaped grains instead. These rocks generally contain only one major mineral, and are named according to that mineral. (See chart below.)

Note: There are intermediate degrees of foliation. The weakly or poorly foliated types are generally grouped with the non-foliated types for identification/naming.

Date \_\_\_\_\_ Lab Section \_\_\_\_\_ Name \_\_\_\_\_

**Assignment for metamorphic rocks:** Examine a variety of metamorphic rock samples in the “box of rocks” and throughout the lab and identify/name them using the charts below. Fill in the table below for at least 7 samples and turn it in. You will see that there are very few samples which are difficult to name. Practice enough so you are confident about naming metamorphic rocks on the Lab Practical Midterm Exam next week.

| Foliated or not? | If foliated, grain size; mineral segregation banding? | If not foliated, name of main mineral | Metamorphic Rock Name |
|------------------|---|---------------------------------------|-----------------------|
|                  |   |                                       |                       |
|                  |   |                                       |                       |
|                  |   |                                       |                       |
|                  |   |                                       |                       |
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|                  |   |                                       |                       |
|                  |   |                                       |                       |

# Charts of Names for Metamorphic Rocks

**Names of foliated metamorphic rocks**, their textures and visual characteristics, approximate maximum temperature of recrystallization include the following (which grade into each other):

|                 |  |           |
|-----------------|--|-----------|
| <u>slate</u>    | ultra-fine-grained, splits perfectly along planes of foliation | 250-350°C |
| <u>phyllite</u> | fine-grained (like silk threads), surface shines like silk     | 350-400°C |
| <u>schist</u>   | coarse-grained, foliation may be irregular, disrupted          | 400-550°C |
| <u>gneiss</u>   | coarse-grained, distinct to perfectly formed mineral banding   | 550-650°C |

Note: Once a foliated rock is named, any recognizable minerals may be added in front of the rock name, such as "biotite-garnet schist" or "quartz-muscovite phyllite." (Not necessary for this class.)

**Names of non-foliated metamorphic rocks** are assigned according to their dominant mineral. Grain size may be fine to coarse, generally increasing with temperature of metamorphism.

There are only two common types of these "monomineralic" rocks:

quartzite composed nearly 100% of the mineral quartz, sometimes with traces of hematite giving them a reddish color. Very tough rock. Fine-grained to medium grain size. Parent (per-metamorphic) rock is nearly always a clean beach sand(stone) or a dune sand(stone). Remember: quartz has a hardness of 7 and no cleavage.

marble nearly 100% of the grains are calcite, typically white to slightly gray. The rock can be fine-grained to very coarse-grained. Parent rock is always a clean, pure limestone. Remember: calcite H=3, and has good cleavage.

## Special types and special names of metamorphic rocks:

amphibolite banded hornblende (jet-black amphibole) and plagioclase (white feldspar) gneiss; medium to high temperature; metamorphosed basalt, usually sea-floor basalt. An important, common rock type in old and young collision/subduction zones.

serpentinite usually variable, irregular green colored mineral serpentine with small grains of magnetite (black); may be well or poorly foliated; often soft, crumbly rock. Common in exposed, eroded, subduction zones. Usually is a metamorphosed basalt or upper mantle rock (ultramafic) to which a lot of water has been added.

granulite very large grain size (up to 1 meter!); poor foliation; often has large garnet crystals; with coarse plagioclase, hornblende and/or augite (dark-green pyroxene); very high temperature (800°C) product of basalt metamorphism in lower crust or upper mantle. Most garnet used for sandpaper is mined from a granulite mass at Gore Mountain in the Adirondack Mountains of New York.

## Contact metamorphism may produce these rock types:

hornfels black to dark green, very fine-grained, extremely tough. Difficult to identify in the lab because it looks a lot like very fine-grained basalt.

skarn limestone infused with iron-rich fluids; calcite may be major or minor mineral; dark colored; often has abundant garnets; sometimes mined for certain ore minerals such as scheelite (CaWO<sub>4</sub>).

tactite same as skarn, but fluids did not contain much iron, so light colored, often with white garnets.

Note: Contact metamorphism occurs as magma (or its hot, watery fluids) comes into contact with surrounding country rock. Width of a contact metamorphic zone may vary from 1 mm to more than 1 km.

**Part 2: Rock Review (45 minutes)**

Lab Section \_\_\_\_\_ Name \_\_\_\_\_

This is preparation for the Lab Midterm Exam next week. (Lab Midterm counts 20% of the overall lab grade.) Be sure to review the handouts for the three rock types.

**Assignment:** Quickly answer the questions on these 2 pages and hand them in.

**A. Igneous Rocks**

Igneous rocks are named according to their texture and composition. Composition is indicated by several methods: overall color (dark, intermediate, light); detailed mineralogy; or chemical analysis. Composition indicates the general nature of the rock that originally melted to form a magma. Textures include coarse-grained, fine-grained, and several types resulting from quiet or explosive volcanism. Grain size correlates with place/rate of magma/lava cooling.

1. Fill in this table with the appropriate igneous rock names, and use your table to identify at least 4 igneous rocks found in the lab room.

|        | C     | O | L            | O | R    |
|--------|-------|---|--------------|---|------|
|        | Light |   | Intermediate |   | Dark |
| Coarse |       |   |              |   |      |
| Fine   |       |   |              |   |      |

2. Have another student check the names of the samples you identified and indicate here how many you named \_\_\_\_\_, and how many you got right: \_\_\_\_\_.

Name of student who did the checking (required) \_\_\_\_\_

Do you agree with the student who checked your work:?

3. Intermediate magmas are commonly created at subduction zones. Describe and name the slow-cooled rock produced from such a magma (texture, color, probable minerals).

**B. Sedimentary Rocks**

Sedimentary rocks are usually dominated by one of 3 kinds of material: **clastic, chemical, organic**.

1. Write the names of the particle sizes in clastic rocks from coarsest to finest:

\_\_\_\_\_

2. Name the sedimentary rock that goes with each particle size in #1, in the same order.

\_\_\_\_\_

3. What are the names of the chemical sedimentary rocks composed primarily of:

Calcite? \_\_\_\_\_ Quartz? \_\_\_\_\_

4. What are the names of the organic sedimentary rocks composed primarily of:

Plant material? \_\_\_\_\_ Shells? \_\_\_\_\_

5. Name and describe with a few complete sentences, in as much detail as you can, the large sample on the instructor's table.

### **C. Metamorphic Rocks**

1. Briefly define metamorphism or explain the process of metamorphism.

2. Foliation is the key texture of metamorphic rocks. Define foliation and explain what it is that creates this texture (Hint: it's related to pressure).

3. Mineral identification is not needed to name the foliated metamorphic rocks. Is color important in naming foliated metamorphic rocks? \_\_\_\_\_ Why or why not?

4. Foliated rock names:                      slate                      phyllite                      schist                      gneiss

Approx. max. temp:

Grain size:

5. A few metamorphic rocks are not foliated. What are the rock names for:

A non-foliated meta-limestone? \_\_\_\_\_

A non-foliated meta-beach sand? \_\_\_\_\_

**Part 3: Geologic Maps (45 minutes)**      Lab Section \_\_\_\_\_ Names \_\_\_\_\_

(Note: Instructors may choose to delay this part of the lab and integrate it with lab for next week.)

Geologic maps are the traditional way that the results of many thousands of man-hours spent systematically studying rocks in the field are communicated. Detailed maps prepared by many scientists are combined to create geologic maps covering larger portions of the crust.

This week you will examine the Snoqualmie Pass 1:100,000 Geologic Quadrangle Map. This map covers many square miles in the central Cascade Mountains of Washington State, east of Seattle. All major rock groups are found in this region where the most recent geologic processes are arc volcanism and glaciation. The complexity is typical of volcanic arcs around the world today, and in the geologic past.

**Assignment:** Work with a partner and examine a copy of this geologic map, its Explanation or Legend on a separate sheet, and the separate sheet of cross-sections. Then answer the following questions. Put both names at the top of this page and turn it in when done.

1. About how wide east-west is the map?      miles \_\_\_\_\_ kilometers \_\_\_\_\_  
About how long north-south is the map?      miles \_\_\_\_\_ kilometers \_\_\_\_\_  
How much area does the map cover?      square miles \_\_\_\_\_ In square km \_\_\_\_\_
  
2. Note that the Geologic Time Periods for the various rock units are given in the legend. What is the range of absolute ages for the rocks on this map? From \_\_\_\_\_ to \_\_\_\_\_.
  
3. Regarding the metamorphic rock units in the map area:
  - a. Name some of the types of metamorphic rocks mentioned in the legend:
  
  - b. Where on the map is one of these located? And give the letter symbol and color used for that rock on the map and legend:
  
4. Find the sheet of cross sections, and locate section C – C'. On the map find the line along which this cross section was constructed. Match the cross section to the line, and find the fault that is farthest east along C – C'.
  - a. What part of the map is this cross section located in?
  
  - b. What is the age and rock type of unit Tm? (east of the fault you found)
  
  - c. Has unit Tm been deformed since it was originally created? \_\_\_\_ What is your Evidence?
  
  - d. How deep below sea level does the cross section extend (include units)?
  
5. The north-central part of this large map area has been eroded deeper than the rest, exposing the Snoqualmie Batholith underneath the volcanic rocks. What types and ages of rocks make up this batholith?
  
6. Note the large irrigation reservoirs in the eastern part of the map. These occupy broad valleys created by glaciers flowing off the mountains about 20,000 years ago. Are there any glaciers left in these mountains today? \_\_\_\_\_ If so, where? If not, why not?
  
7. Rock unit Qlh occurs along the White River near the west edge of the map. The legend says this is a "Lahar". What is a lahar?