

Name: _____

Partners: _____

Metamorphic Environments and Rocks

Lab Objective: Similar to previous labs, this lab is about learning the necessary skills for identifying metamorphic rocks. The second part of the lab is to help you think about how these rocks relate to different tectonics settings at the time of their formation. The third part looks at identifying deformation features in the landscape.

Metamorphic Rocks

Metamorphic rocks are rocks that have undergone a change from their original form due to changes in temperature, pressure or chemical alteration. The classification of metamorphic rocks is based on the minerals that are present and the temperature and pressure at which these minerals form. Determination of this information is not easily accomplished in this lab. Therefore, a simplified system is used based on texture and composition. However, understanding what the different settings of formation for these metamorphic rocks are critical to the lab.

Factors Controlling Metamorphism

Texture and mineral content of metamorphic rock depend on: parent rock *composition*; *temperature* and *pressure* during metamorphism; effects of *tectonic forces*; effects of *fluids*, such as water; and *time*.

- During metamorphism, usually no new elements (other than hydrogen and oxygen from water) are added to rocks during metamorphism. The resulting metamorphic rock will have very similar elemental composition to that of the parent rock.
- Heat for metamorphism comes primarily from outward flow from Earth's deep interior. All minerals are stable over a finite temperature range, so if the range is exceeded, new mineral structures result. If temperature gets high enough, then melting will occur, resulting in an igneous rock (and not a metamorphic rock).
- Confining pressure is pressure applied in all directions. Pressure is generally proportional to depth of burial within the Earth. Metamorphic pressure typically increases 1 kilobar per 3.3 km of burial within the crust. High-pressure minerals have a more compact structure and a higher density.
- Tectonic forces often lead to forces that are not equal in all directions (*differential stress*). *Compressive stress* causes flattening perpendicular to stress (Fig. 1b). *Shearing* causes flattening by sliding parallel to stress (Fig. 1c). Planar rock texture of aligned minerals produced by differential stress is known as *foliation*. Foliation increases with pressure and time.
- Hot water (as vapor) is the most important fluid. Rising temperature causes water to be released from unstable minerals. Hot water is very reactive and acts as a rapid transport agent for mobile ions.
- Metamorphism, particularly from high pressures, may take millions of years. Longer times allow newly stable minerals to grow large and increase foliation.

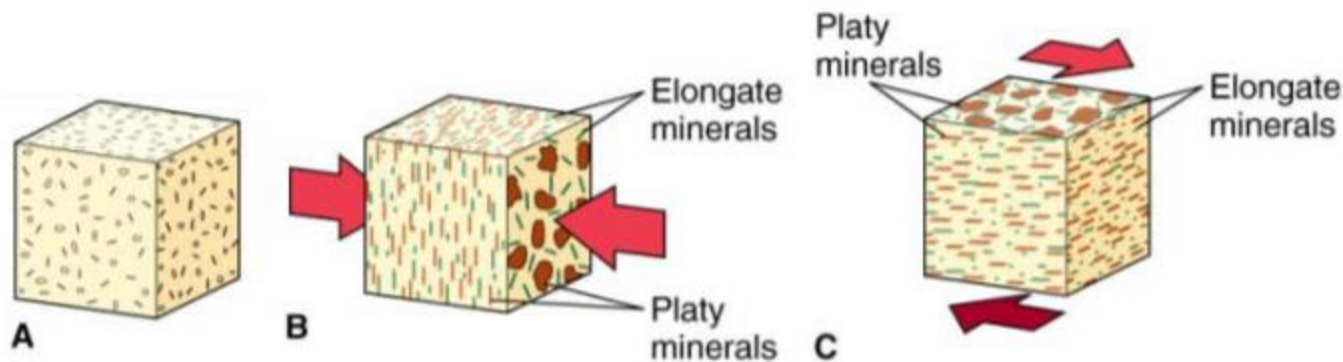


Figure 1. The effect of tectonic forces on a rock with originally random grain orientation (from McGraw-Hill). A) Rock prior to metamorphism. B) Development of a foliation during compression (typical in convergent settings). C) Development of a foliation during shearing (typical in transform settings).

Types of Metamorphism

Contact metamorphism

High temperature is the dominant factor causing contact metamorphism. There is no directed pressure, so this type of metamorphism produces *non-foliated* rocks. It occurs adjacent to magma bodies that intrude the cooler country rock. Contact metamorphism occurs in narrow zones (~1-100m wide) that are known as *contact aureoles*. Rocks may be fine- (e.g., hornfels) or coarse-grained (e.g., marble, quartzite).

Regional metamorphism

High directed pressure and temperature are the dominant causes for regional metamorphism, and results in rocks with *foliated* textures. Regional metamorphism is prevalent in intensely deformed mountain ranges, and may occur over wide temperature range. Increasing pressure and temperature will produce increasing *metamorphic grade* rocks. Prograde metamorphism of shale produces: slate→phyllite→schist→gneiss.

Texture

Texture is divided into two groups. Foliated textures show a distinct planar character. This means that the minerals in the rock are all aligned with each other. This planar character can be flat like a piece of slate or folded. Non-foliated textures have minerals that are not aligned. Essentially, the minerals are randomly oriented.

Foliated

Foliated textures show four types of foliation; foliated rocks are named based on the type of foliation. Slaty cleavage is composed of platy minerals that are too small to see. Typically, these rocks split along parallel, planar surfaces. Phyllitic foliation is composed of platy minerals that are slightly larger than those found in slaty cleavage, but generally are still too small to see with the unaided eye. The larger size gives the foliation a slightly shiny appearance. Schistose foliation (or schistosity) is composed of larger minerals, which are visible to the unaided

eye. Platy minerals tend to dominate. Gneissic banding is the easiest of the foliations to recognize. It is composed of alternating bands of dark and light minerals. If certain minerals are dominant in schists or gneisses, those minerals will be included in the name of the rock.

Non-foliated

Non-foliated textures are identified by their lack of planar character. Further identification and naming of non-foliated rocks is dependent on the composition of the minerals or components in the rock. Anthracite coal is similar to bituminous coal. Both are black in color and composed of carbon, however, anthracite coal is generally shiny in appearance and breaks with a conchoidal fracture (broken glass also shows this type of fracture). Metaconglomerate is composed of pebbles and gravel that have been flattened due to directed pressure. Quartzite is composed of quartz sand grains. Marble is composed of calcite and will readily react to a small drop of HCl.

Metamorphic Rock Identification Chart					
Texture	Foliation	Composition	Type	Parent Rock	Rock Name
Foliated	Slaty	Mica	Regional	Mudstone (e.g., shale)	Slate
	Phyllitic	Quartz, mica, chlorite	Regional	Mudstone (e.g., shale)	Phyllite
	Schistose	Mica, quartz	Regional	Slate	Schist
	Schistose	Amphibole, plagioclase	Regional	Basalt or Gabbro	Amphibolite
	Gneissic banding	Feldspar, mica, quartz	Regional	Schist	Gneiss
Non-foliated	N/A	Carbon	Contact or Regional	Bituminous coal	Anthracite coal
	N/A	Quartz, rock fragments	Contact or Regional	Conglomerate	Metaconglomerate
	N/A	Calcite	Contact or Regional	Limestone	Marble
	N/A	Quartz	Contact or Regional	Sandstone	Quartzite

Part One: Using your rock kit, the information above, your lecture notes, and the flowchart, identify the following rocks.

Sample Number	Rock Name	Texture (Foliated or Non-Foliated)	Type of Foliation if foliated* <<N/A if not foliated>>	Mineral Composition	Parent Rock	Type of Metamorphism
37						
38						
39						

Sample Number	Rock Name	Texture (Foliated or Non-Foliated)	Type of Foliation if foliated* <<N/A if not foliated>>	Mineral Composition	Parent Rock	Type of Metamorphism
40						
41						
42				*note reacts to acid		
44						
45						
46						
47						

*Types of foliation:

- | | |
|-------------------|---------------------|
| 1. Slaty cleavage | 2. Phyllitic |
| 3. Schistosity | 4. Gneissic banding |

Metamorphic Rock Identification Flow Chart

