

Metamorphic Rocks

For this lab, you will be making observations and interpretations about metamorphic rocks. I recommend that you print the data table provided and fill it in as you analyze each sample. Then, use your table to answer the questions at the end of the lab. Also answer these questions on our online class site so that you can get credit for the laboratory exercise.

Metamorphism

Metamorphic rocks form when pre-existing rocks are subjected to temperatures and/or pressures that are different from the environment in which they form. For example metamorphism can be caused by burial of rock, folding and thrusting of rock over other rock, heat from a pluton, or pressure from subduction. During metamorphism, rocks may undergo mineralogical and textural changes. During metamorphism, the rock does not melt. Instead it is a solid state recrystallization.

Metamorphic Grade

Metamorphic grade is the intensity of metamorphism to which the rock was subjected. In other words, it is a description of how much heat and pressure a rock has experienced in order to be changed to its current metamorphic state. Metamorphic grade is described as being low grade, medium grade, or high grade. During low-grade metamorphism, rock is exposed to relatively low temperatures and pressures (300-400°C; less than 3-4 kilobars). During medium-grade metamorphism, rock is exposed to intermediate temperatures and pressures (400-600°C; 4-12 kilobars). During high-grade metamorphism, rock is exposed to high temperatures and pressures (600-800°C; 12-15 kilobars). It is by studying the mineralogy and textures of metamorphic rocks that we are able to determine the degree or grade of metamorphism.

Mineralogical Changes

Each mineral is stable within a specific range of temperatures and pressures. When not at these temperatures or pressures, minerals can become unstable and react with each other to form new minerals. Therefore, we can analyze the suite of minerals in the rock and figure out what temperatures and pressures would be possible for each of those minerals to be present in the rock, thus determining the metamorphic grade.

Textural Changes

Textural refers to the size, shape, and orientation of grains in a rock. During metamorphism, heat and pressure can change the textures of rocks. Consider the sizes of minerals. Minerals may recrystallize to form larger crystals of the same minerals. For example, the calcite in fossiliferous limestone will recrystallize into large, interlocking crystals of calcite, forming marble, while the fossils, shells, and mud in the matrix are destroyed. Therefore, a rock with larger crystals of calcite would be formed.

Some textural changes from metamorphism are a result of pressure being stronger in one direction than another, resulting in deformation, or change in shape. During deformation, it is common for platy minerals (like micas) to align perpendicular to the direction of compression, creating what is called foliation. Foliation is a texture that results from the parallelism of platy and flattened minerals in a metamorphic rock. Foliated rocks often have flat surfaces, especially

in the minerals are too small to be visible. If foliation is present, you know you are dealing with low to medium metamorphism, where pressure was influential. Mica minerals do not withstand high temperatures. At high temperatures, micas will react with minerals around them to form feldspars and other minerals. If a metamorphic rock has bands of dark and light layers, it is considered compositionally layered, and is a sign of high grade metamorphism. If a metamorphic rock does not have layering or foliation, and instead has random, intergrown crystals, it is referred to as nonfoliated. This is usually a sign that pressure was not involved in the metamorphism.

Protolith

The protolith (proto=early, lith=rock), is the type of rock it used to be before the heat and pressure were added, transforming the rock into the metamorphic rock it is now. This is also often referred to as the parent rock. Since metamorphism can happen to any rock, even a metamorphic rock can be a protolith for another metamorphic rock. However, for the purposes of this class, we will go back all the way until the protolith was either a sedimentary or igneous rock. For example, when shale (a fissile, sedimentary mudstone) is metamorphosed, it first becomes slate, but upon application of more heat and pressure, the slate will change to phyllite, then schist, and finally gneiss. Therefore, the protolith for slate, phyllite, schist, and gneiss is shale. Gneiss actually has two protoliths, as seen in figure 1 below. This figure also shows the protoliths and other characteristics of common metamorphic rocks, which you will use to analyze metamorphic rocks.

Figure 1. Common Metamorphic Rocks

Texture	Major Minerals/Material	Additional Observations	Protolith	Rock Name
Foliated	Micas – muscovite, biotite, etc.	Dull appearance, similar to that of a chalkboard	Shale	Slate
Foliated	Micas – muscovite, biotite, etc.	Has a sheen to it; sometimes has wavy, wrinkled surfaces	Shale	Phyllite
Foliated	Micas – muscovite, biotite, etc.	Often glittery appearance	Shale	Schist
Layered	Feldspars, quartz, hornblende	Minerals are separated into light and dark layers	Shale or granite	Gneiss
Nonfoliated	Calcite	Fizzes in acid	Limestone	Marble
Nonfoliated	Quartz	Sometimes has a sugary texture; sometimes shows conchoidal fracture	Sandstone	Quartzite
Nonfoliated	Plant material (no minerals)	Black, low density, semi-metallic luster	Bituminous coal	Anthracite
Nonfoliated	Graphite	Writes on paper	Bituminous coal	Graphite
Nonfoliated	Serpentine	Waxy appearance, slippery feel	Basalt	Serpentinite

Figure 2. Data table for observations of metamorphic rocks.

Sample #	Texture	Major Minerals/Material	Additional Observations	Protolith	Rock Name
1					
2					
3					
4					
5					
6					
7					
8					
9					

Observe each of the images of samples of metamorphic rocks in Figure 3. Record your observations for appropriate textures and composition in the data table provided in Figure 2 (Hint: use information from Figure 1 to help you with ideas). Compare your data to the information in Figure 1 to help you classify each of the metamorphic rocks in this lab.

Figure 4. Samples of Metamorphic Rocks (for scale, assume that each sample is actual size).

Sample #1 Full View



Sample #1 Close Up



Sample #2 Full View (as well as a wavy, wrinkled surface.)



Sample #2 Close Up (Notice that this has a sheen to it)



Sample #3 Full View (If you were to pick it up, you would notice that this has very low density.)



Sample #3 Close Up



Sample #4 Full View



Sample #4 Close Up (Notice: fizzes in HCl.)



Sample #5 Full View



Sample #5 Close Up



Sample #6 Full View



Sample #6 Close Up



Sample #7 Full View



Sample #7 Close Up



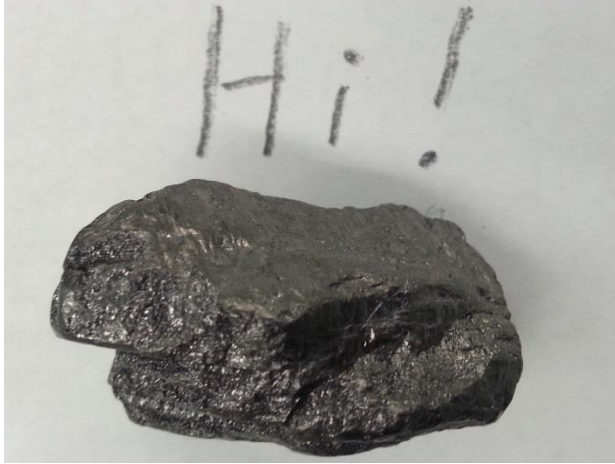
Sample #8 Full View



Sample #8 Close Up (This has a slippery feel to it.)



Sample #9 Full View (Notice: this sample writes on paper.)



Sample #9 Close Up



Sample #10 Full View



Sample #10 Close Up



Answer the questions below. Use your completed data table (Figure 2) to answer these questions. You could skip these, and use your completed data table to answer the same questions online.

1. Sample #1: What is the texture of this rock?
 - A. Foliated
 - B. Layered
 - C. Nonfoliated
2. Sample #1: What major mineral(s)/material makes up this rock?
 - A. Micas (muscovite, biotite, etc.)
 - B. Feldspar, quartz, and hornblende
 - C. Calcite
 - D. Quartz
 - E. Plant material (no minerals)
 - F. Graphite
 - G. Serpentine

3. Sample #1: Which of the following is and additional observation that best describe this rock?
- A. Dull appearance, similar to that of a chalkboard
 - B. Has a sheen to it; has wavy, wrinkled surfaces
 - C. Glittery appearance
 - D. Minerals are separated into light and dark layers
 - E. Fizzes in acid
 - F. Has conchoidal fracture
 - G. Black, low density, semi-metallic luster
 - H. Writes on paper
 - I. Waxy appearance, slippery feel.
4. Sample #1: What is the protolith for this rock?
- A. Shale
 - B. Shale or granite
 - C. Limestone
 - D. Sandstone
 - E. Bituminous Coal
 - F. Basalt
5. Sample #1: What is the name of this rock?
- A. Slate
 - B. Phyllite
 - C. Schist
 - D. Gneiss
 - E. Marble
 - F. Quartzite
 - G. Anthracite
 - H. Graphite
 - I. Serpentine
6. Sample #2: What is the texture of this rock?
- A. Foliated
 - B. Layered
 - C. Nonfoliated
7. Sample #2: What major mineral(s)/material makes up this rock?
- A. Micas (muscovite, biotite, etc.)
 - B. Feldspar, quartz, and hornblende
 - C. Calcite
 - D. Quartz
 - E. Plant material (no minerals)
 - F. Graphite
 - G. Serpentine
8. Sample #2: Which of the following is and additional observation that best describe this rock?

- A. Dull appearance, similar to that of a chalkboard
- B. Has a sheen to it; has wavy, wrinkled surfaces
- C. Glittery appearance
- D. Minerals are separated into light and dark layers
- E. Fizzes in acid
- F. Has conchoidal fracture
- G. Black, low density, semi-metallic luster
- H. Writes on paper
- I. Waxy appearance, slippery feel.

9. Sample #2: What is the protolith for this rock?

- A. Shale
- B. Shale or granite
- C. Limestone
- D. Sandstone
- E. Bituminous Coal
- F. Basalt

10. Sample #2: What is the name of this rock?

- A. Slate
- B. Phyllite
- C. Schist
- D. Gneiss
- E. Marble
- F. Quartzite
- G. Anthracite
- H. Graphite
- I. Serpentine

11. Sample #3: What is the texture of this rock?

- A. Foliated
- B. Layered
- C. Nonfoliated

12. Sample #3: What major mineral(s)/material makes up this rock?

- A. Micas (muscovite, biotite, etc.)
- B. Feldspar, quartz, and hornblende
- C. Calcite
- D. Quartz
- E. Plant material (no minerals)
- F. Graphite
- G. Serpentine

13. Sample #3: Which of the following is an additional observation that best describes this rock?

- A. Dull appearance, similar to that of a chalkboard
- B. Has a sheen to it; has wavy, wrinkled surfaces

- C. Glittery appearance
- D. Minerals are separated into light and dark layers
- E. Fizzes in acid
- F. Has conchoidal fracture
- G. Black, low density, semi-metallic luster
- H. Writes on paper
- I. Waxy appearance, slippery feel.

14. Sample #3: What is the protolith for this rock?

- A. Shale
- B. Shale or granite
- C. Limestone
- D. Sandstone
- E. Bituminous Coal
- F. Basalt

15. Sample #3: What is the name of this rock?

- A. Slate
- B. Phyllite
- C. Schist
- D. Gneiss
- E. Marble
- F. Quartzite
- G. Anthracite
- H. Graphite
- I. Serpentine

16. Sample #4: What is the texture of this rock?

- A. Foliated
- B. Layered
- C. Nonfoliated

17. Sample #4: What major mineral(s)/material makes up this rock?

- A. Micas (muscovite, biotite, etc.)
- B. Feldspar, quartz, and hornblende
- C. Calcite
- D. Quartz
- E. Plant material (no minerals)
- F. Graphite
- G. Serpentine

18. Sample #4: Which of the following is an additional observation that best describes this rock?

- A. Dull appearance, similar to that of a chalkboard
- B. Has a sheen to it; has wavy, wrinkled surfaces
- C. Glittery appearance
- D. Minerals are separated into light and dark layers

- E. Fizzes in acid
- F. Has conchoidal fracture
- G. Black, low density, semi-metallic luster
- H. Writes on paper
- I. Waxy appearance, slippery feel.

19. Sample #4: What is the protolith for this rock?

- A. Shale
- B. Shale or granite
- C. Limestone
- D. Sandstone
- E. Bituminous Coal
- F. Basalt

20. Sample #4: What is the name of this rock?

- A. Slate
- B. Phyllite
- C. Schist
- D. Gneiss
- E. Marble
- F. Quartzite
- G. Anthracite
- H. Graphite
- I. Serpentine

21. Sample #5: What is the texture of this rock?

- A. Foliated
- B. Layered
- C. Nonfoliated

22. Sample #5: What major mineral(s)/material makes up this rock?

- A. Micas (muscovite, biotite, etc.)
- B. Feldspar, quartz, and hornblende
- C. Calcite
- D. Quartz
- E. Plant material (no minerals)
- F. Graphite
- G. Serpentine

23. Sample #5: Which of the following is an additional observation that best describes this rock?

- A. Dull appearance, similar to that of a chalkboard
- B. Has a sheen to it; has wavy, wrinkled surfaces
- C. Glittery appearance
- D. Minerals are separated into light and dark layers
- E. Fizzes in acid
- F. Has conchoidal fracture

- G. Black, low density, semi-metallic luster
- H. Writes on paper
- I. Waxy appearance, slippery feel.

24. Sample #5: What is the protolith for this rock?

- A. Shale
- B. Shale or granite
- C. Limestone
- D. Sandstone
- E. Bituminous Coal
- F. Basalt

25. Sample #5: What is the name of this rock?

- A. Slate
- B. Phyllite
- C. Schist
- D. Gneiss
- E. Marble
- F. Quartzite
- G. Anthracite
- H. Graphite
- I. Serpentine

26. Sample #6: What is the texture of this rock?

- A. Foliated
- B. Layered
- C. Nonfoliated

27. Sample #6: What major mineral(s)/material makes up this rock?

- A. Micas (muscovite, biotite, etc.)
- B. Feldspar, quartz, and hornblende
- C. Calcite
- D. Quartz
- E. Plant material (no minerals)
- F. Graphite
- G. Serpentine

28. Sample #6: Which of the following is an additional observation that best describes this rock?

- A. Dull appearance, similar to that of a chalkboard
- B. Has a sheen to it; has wavy, wrinkled surfaces
- C. Glittery appearance
- D. Minerals are separated into light and dark layers
- E. Fizzes in acid
- F. Has conchoidal fracture
- G. Black, low density, semi-metallic luster
- H. Writes on paper

I. Waxy appearance, slippery feel.

29. Sample #6: What is the protolith for this rock?

- A. Shale
- B. Shale or granite
- C. Limestone
- D. Sandstone
- E. Bituminous Coal
- F. Basalt

30. Sample #6: What is the name of this rock?

- A. Slate
- B. Phyllite
- C. Schist
- D. Gneiss
- E. Marble
- F. Quartzite
- G. Anthracite
- H. Graphite
- I. Serpentine

31. Sample #7: What is the texture of this rock?

- A. Foliated
- B. Layered
- C. Nonfoliated

32. Sample #7: What major mineral(s)/material makes up this rock?

- A. Micas (muscovite, biotite, etc.)
- B. Feldspar, quartz, and hornblende
- C. Calcite
- D. Quartz
- E. Plant material (no minerals)
- F. Graphite
- G. Serpentine

33. Sample #7: Which of the following is and additional observation that best describe this rock?

- A. Dull appearance, similar to that of a chalkboard
- B. Has a sheen to it; has wavy, wrinkled surfaces
- C. Glittery appearance
- D. Minerals are separated into light and dark layers
- E. Fizzes in acid
- F. Has conchoidal fracture
- G. Black, low density, semi-metallic luster
- H. Writes on paper
- I. Waxy appearance, slippery feel.

34. Sample #7: What is the protolith for this rock?
- A. Shale
 - B. Shale or granite
 - C. Limestone
 - D. Sandstone
 - E. Bituminous Coal
 - F. Basalt
35. Sample #7: What is the name of this rock?
- A. Slate
 - B. Phyllite
 - C. Schist
 - D. Gneiss
 - E. Marble
 - F. Quartzite
 - G. Anthracite
 - H. Graphite
 - I. Serpentine
36. Sample #8: What is the texture of this rock?
- A. Foliated
 - B. Layered
 - C. Nonfoliated
37. Sample #8: What major mineral(s)/material makes up this rock?
- A. Micas (muscovite, biotite, etc.)
 - B. Feldspar, quartz, and hornblende
 - C. Calcite
 - D. Quartz
 - E. Plant material (no minerals)
 - F. Graphite
 - G. Serpentine
38. Sample #8: Which of the following is an additional observation that best describes this rock?
- A. Dull appearance, similar to that of a chalkboard
 - B. Has a sheen to it; has wavy, wrinkled surfaces
 - C. Glittery appearance
 - D. Minerals are separated into light and dark layers
 - E. Fizzes in acid
 - F. Has conchoidal fracture
 - G. Black, low density, semi-metallic luster
 - H. Writes on paper
 - I. Waxy appearance, slippery feel.
39. Sample #8: What is the protolith for this rock?
- A. Shale

- B. Shale or granite
- C. Limestone
- D. Sandstone
- E. Bituminous Coal
- F. Basalt

40. Sample #8: What is the name of this rock?

- A. Slate
- B. Phyllite
- C. Schist
- D. Gneiss
- E. Marble
- F. Quartzite
- G. Anthracite
- H. Graphite
- I. Serpentine

41. Sample #9: What is the texture of this rock?

- A. Foliated
- B. Layered
- C. Nonfoliated

42. Sample #9: What major mineral(s)/material makes up this rock?

- A. Micas (muscovite, biotite, etc.)
- B. Feldspar, quartz, and hornblende
- C. Calcite
- D. Quartz
- E. Plant material (no minerals)
- F. Graphite
- G. Serpentine

43. Sample #9: Which of the following is an additional observation that best describes this rock?

- A. Dull appearance, similar to that of a chalkboard
- B. Has a sheen to it; has wavy, wrinkled surfaces
- C. Glittery appearance
- D. Minerals are separated into light and dark layers
- E. Fizzes in acid
- F. Has conchoidal fracture
- G. Black, low density, semi-metallic luster
- H. Writes on paper
- I. Waxy appearance, slippery feel.

44. Sample #9: What is the protolith for this rock?

- A. Shale
- B. Shale or granite
- C. Limestone

- D. Sandstone
- E. Bituminous Coal
- F. Basalt

45. Sample #9: What is the name of this rock?

- A. Slate
- B. Phyllite
- C. Schist
- D. Gneiss
- E. Marble
- F. Quartzite
- G. Anthracite
- H. Graphite
- I. Serpentine

46. Sample #10: What is the texture of this rock?

- A. Foliated
- B. Layered
- C. Nonfoliated

47. Sample #10: What major mineral(s)/material makes up this rock?

- A. Micas (muscovite, biotite, etc.)
- B. Feldspar, quartz, and hornblende
- C. Calcite
- D. Quartz
- E. Plant material (no minerals)
- F. Graphite
- G. Serpentine

48. Sample #10: Which of the following is an additional observation that best describes this rock?

- A. Dull appearance, similar to that of a chalkboard
- B. Has a sheen to it; has wavy, wrinkled surfaces
- C. Glittery appearance
- D. Minerals are separated into light and dark layers
- E. Fizzes in acid
- F. Has conchoidal fracture
- G. Black, low density, semi-metallic luster
- H. Writes on paper
- I. Waxy appearance, slippery feel.

49. Sample #10: What is the protolith for this rock?

- A. Shale
- B. Shale or granite
- C. Limestone
- D. Sandstone

- E. Bituminous Coal
- F. Basalt

50. Sample #10: What is the name of this rock?

- A. Slate
- B. Phyllite
- C. Schist
- D. Gneiss
- E. Marble
- F. Quartzite
- G. Anthracite
- H. Graphite
- I. Serpentinite