Name: _____ **Grade:** ___

GEOL 101 - Physical Geology Laboratory
METAMORPHIC ROCK CLASSIFICATION AND IDENTIFICATION

Introduction & Purpose: The purpose of this laboratory exercise is to become familiar with identifying common metamorphic rocks and understanding their depositional origin. In this lab you will learn to identify metamorphic rocks in hand samples from their physical properties. You will become familiar with the common metamorphic rock-forming minerals and processes. The nature and origin of metamorphic rocks, the major types of metamorphic rocks, and their structures, and the connection between plate tectonics and metamorphic rocks in the rock cycle will be explored.

LAB PREPARATION SECTION – To be completed during lab lecture:

PART I. General Overview and Classification of Metamorphic Rocks

A. Defining Metamorphism:

Directions: Answer the following (from lecture and lab text: see page 133):

1) Define "metamorphism" _____

2) Every metamorphic rock has a _____ rock (or protolith) - the original rock type that was metamorphosed into the resultant metamorphic rock, i.e. the source rock.

B. Conditions of Metamorphism:

Metamorphic rocks form as a result of changing crustal conditions, e.g. increasing pressures and/or temperatures, that are between that of igneous and sedimentary rock-forming environments.

1). The four major agents of change that cause rocks to metamorphose (see page 133):

a) _____ , b) _____ , c) _____ , and/or d) _____

C. Processes of Metamorphism:

Metamorphic processes that are forming the metamorphic rocks occur at various scales within the Earth, and the type of internal earth agents involved is used to define the type of metamorphism. One type is related to magmatism, and the other type is related to faulting and mountain building.

1) The two major types of metamorphism that are agent-dependent (page 134):

a) _____ , and b) _____

2) Question: Very briefly describe the differences between these two types of metamorphism:

_____

D. Classification and Identification of Metamorphic Rocks

1) Classification and identification of metamorphic rocks are based upon two major physical criteria:

a) _____ , and b) _____

2) Metamorphic rocks are divided into two major groups based on whether the rock has a *layered* versus *non-layered* texture. See Figure 7.4, page 136. Special alternative names for these are:

a) Layered = _____ and b) Non-layered = _____

E. Foliated Metamorphic Rocks

1) Metamorphic rocks that possess a layered or ***foliated*** crystalline grain fabric consisting of elongate and/or platy crystals that all share a ***preferred orientation*** within the rock. Metamorphic rocks that have foliated/layered fabrics originated in two types of metamorphic environments that featured directed or deviatoric crustal stresses (like being placed in a vice) during metamorphism: Regional Metamorphism (RM) and Dynamic Metamorphism (DM).

2) There are four common types of metamorphic rocks that have foliated-layered textures. Each type of foliation is unique and represents a progressive increasing scale of intensity of regional metamorphism as go from slate to phyllite to schist to gneiss. The textural character of foliated and/or layered metamorphic rock can vary greatly as a function of 1) grain size, 2) degree of preferred grain orientation of the rock's mineral crystals, and 3) degree of layered segregation of light minerals from dark minerals.

3) The foliated/layered metamorphic rocks are classified primarily upon texture, with mineralogy a secondary criterion. There are four visually distinctive types of foliated rocks (listed below).

Below are the general textural and mineralogic characteristics of the four foliated rock types (see Figure 7.15)

Rock Name	***Grain Size and Layering Features***	***Rock Mineralogy***
1. **Slate**	Very fine-grained; slaty cleavage; breaks into hard, flat sheets	Clay, Micas, and Quartz
2. **Phyllite**	Fine-grained with sheen; phyllitic cleavage; tight wavy sheets	Micas, and Quartz
3. **Schist**	Medium- to coarse-grained; schistosic cleavage; broad wavy sheets	Micas, Quartz, Feldspars, Amphiboles, Garnet
4. **Gneiss**	Medium- to coarse-grained; gneissic cleavage; light-dark layers	Micas, Quartz, Feldspars, Amphiboles, Pyroxenes

Please note: There are infinite shades of gray between these four foliated types – no sharp divisions

F. Non-Foliated-Non-Layered Metamorphic Rocks

1) Metamorphic rocks that have non-foliated (non-layered) textures originate in two types of metamorphic environments: regional metamorphism (RM) and contact metamorphism (CM). **Note** that the nonfoliated metamorphic rocks that form by regional metamorphism RM are mostly *mono-mineralic (mostly of one mineral type)*, having mineral crystals that are neither platy nor tabular, such as quartz and calcite. Note that amphibolite and serpentinite may exhibit foliation.

2) As noted above, the non-foliated (non-layered) metamorphic rocks consist of equant shaped mineral crystals that have no preferred orientation or arrangement. These rocks have a massive, homogenous "crystalline" texture, much like that of either, *phaneritic* granite, or *aphanitic* basalt. The non-foliated metamorphic rocks are classified primarily upon mineral composition.

3) There are four common types of metamorphic rock s that have non-foliated/ non-layered fabrics:

Below are the general textural and mineralogic characteristics of the eight most common non-foliated rock types (see Figure 7.15)

Rock Name	***Textural Features***	***Rock Mineralogy***
1. **Quartzite**	Medium to coarse -grained; sugary, granular texture; hard	Quartz
2. **Marble**	Medium to coarse -grained; sugary, granular texture; soft	Calcite or Dolomite
3. **Amphibolite**	Medium to coarse-grained; blade-like xtals non-layered or layered	Amphibole, Plagioclase
4. **Hornfels**	Fine-grained to microcrystalline; non-layered; hard; dark-colored	Dark minerals, Feldspar, Quartz
5. **Serpentinite**	Fine-grained to microcrystalline; wavy surfaces; green-colored	Serpentine
6. **Soapstone**	Microcrystalline; wavy surfaces; light-colored; soft; low density	Talc
7. **Anthracite**	Microcrystalline; black shiny surfaces; conchoidal fracture	Solid, tar-like organic make-up
8. **Meta-conglomerate**	Conglomerate-like; crystalline; breaks across pebbles	Meta-rock fragments; Quartz

PART II. METAMORPHIC ROCK EXAMINATION AND IDENTIFICATION ACTIVITIES

A. Examination of the Foliated Metamorphic Reference Rocks

Exercise 1 - **Samples M1 through M4** are representative hand samples of each of the **foliated** rock types. Study each sample carefully and make some brief descriptions of the rock's character (texture, layered (foliated) fabric & minerals). Carefully study lab manual for reference.

	Observed *Grain Size and Layering Features*	***Identified Rock Mineralogy***
Sample # M1 = Slate	_____	_____
Sample # M2 =Phyllite	_____	_____
Sample # M3 = Schist	_____	_____
Sample # M4 = Gneiss	_____	_____

Exercise 2 – Compare and contrast the foliated metamorphic rocks.

1. Question: How does the slate differ from the phyllite, in terms of texture?

2. Question: How does the phyllite differ from the schist, in terms of texture?

3. Question: How does the gneiss differ from the other three foliated rocks, in terms of texture?

4. Question: How does the gneiss differ from the schists, in terms of mineralogy?

5. Question: What are the main criteria that you used to distinguish between these four rock types?

B. Examination of the Non-Foliated Metamorphic Reference Rocks

Exercise 1 - **Samples M5 through M10** are representative hand samples of the **non-foliated** rock types. For each hand sample, briefly describe the rock's character (texture and minerals)

Rock Sample #/Name	**Observed *Grain Size and Layering Features***	***Identified Minerals***
Sample # M5 = Amphibolite	_____	_____
Sample # M6 = Serpentinite	_____	_____
Sample # M7 = Quartzite	_____	_____
Sample # M8 = Marble	_____	_____
Sample # M9 = Hornfels	_____	_____
Sample # M10 = Anthracite	_____	_____

Exercise 2 – Compare and contrast non-foliated metamorphic rocks.

1. Question: How does quartzite differ from marble? How are they similar?

2. Question: How does amphibolite differ from serpentinite? How are they similar?

3. Question: What is the main criteria you use to distinguish between these four rock types?

C. Procedure for Describing and Identifying Metamorphic Rocks:

Directions: Four-Step chart for the analysis and classification of metamorphic rocks is found in lab manual. Use this chart, and the additional directions found in the lab manual to help you learn to identify metamorphic rocks. Make sure to use the microscope for examining the ten unknown lab rock samples.

The Four-step Meta-Rock Identification Procedure - A brief description of the four determinant steps:

Step 1: Texture = a) Foliated or Non-Foliated? **AND** b) Coarse-, medium-, or fine-grained?
Step 2: Rock Composition = Identifiable Minerals?
Step 3: Name the Rock.
Step 4: Name the Most Likely Parent Rock (protolith)

D. Examination and Identification of 10 Unknown Metamorphic Hand Samples

Directions: **Sample Collection "MU"** (in the clear plastic tub) has ten unknown metamorphic rock samples. Use the 4-step procedure outlined above to help in identifying the rocks. Complete the worksheet chart below for all ten unknown samples. Be sure to circle only the appropriate texture and mineralogy. List rock name and parent rock.

Sample# MU1

a) Texture: Foliated or Non-foliated? ***AND*** Fine-Grained. or Medium-Gr. or Coarse-Gr.?

b) Mineralogy: Quartz; Feldspar; Mica; Amphibole; Calcite/Dolomite; Garnet; Serpentine; None Observ.

c) Other distinctive features = _____

d) Rock name _____

e) Most likely parent (protolith) rock _____

Sample# MU2

a) Texture: Foliated or Non-foliated? ***AND*** Fine-Grained. or Medium-Gr. or Coarse-Gr.?

b) Mineralogy: Quartz; Feldspar; Mica; Amphibole; Calcite/Dolomite; Garnet; Serpentine; None Observ.

c) Other distinctive features = _____

d) Rock name _____

e) Most likely parent (protolith) rock _____

Sample# MU3

a) Texture: Foliated or Non-foliated? ***AND*** Fine-Grained. or Medium-Gr. or Coarse-Gr.?

b) Mineralogy: Quartz; Feldspar; Mica; Amphibole; Calcite/Dolomite; Garnet; Serpentine; None Observ

c) Other distinctive features = _____

d) Rock name _____

e) Most likely parent (protolith) rock _____

Sample# MU4

a) Texture: Foliated or Non-foliated? ***AND*** Fine-Grained. or Medium-Gr. or Coarse-Gr.?

b) Mineralogy: Quartz; Feldspar; Mica; Amphibole; Calcite/Dolomite; Garnet; Serpentine; None Observ.

c) Other distinctive features = _____

d) Rock name _____

e) Most likely parent (protolith) rock _____

Sample# MU5

a) Texture: Foliated or Non-foliated? ***AND*** Fine-Grained. or Medium-Gr. or Coarse-Gr.?

b) Mineralogy: Quartz; Feldspar; Mica; Amphibole; Calcite/Dolomite; Garnet; Serpentine; None Observ.

c) Other distinctive features = _____

d) Rock name _____

e) Most likely parent (protolith) rock _____

Sample# MU6

a) Texture: Foliated or Non-foliated? ***AND*** Fine-Grained. or Medium-Gr. or Coarse-Gr.?

b) Mineralogy: Quartz; Feldspar; Mica; Amphibole; Calcite/Dolomite; Garnet; Serpentine; None Observ.

c) Other distinctive features = _____

d) Rock name _____

e) Most likely parent (protolith) rock _____

Sample# MU7

a) Texture: Foliated or Non-foliated? ***AND*** Fine-Grained. or Medium-Gr. or Coarse-Gr.?

b) Mineralogy: Quartz; Feldspar; Mica; Amphibole; Calcite/Dolomite; Garnet; Serpentine; None Observ.

c) Other distinctive features = _____

d) Rock name _____

e) Most likely parent (protolith) rock _____

Sample# MU8

a) Texture: Foliated or Non-foliated? ***AND*** Fine-Grained. or Medium-Gr. or Coarse-Gr.?

b) Mineralogy: Quartz; Feldspar; Mica; Amphibole; Calcite/Dolomite; Garnet; Serpentine; None Observ.

c) Other distinctive features = _____

d) Rock name _____

e) Most likely parent (protolith) rock _____

Sample# MU9

a) Texture: Foliated or Non-foliated? ***AND*** Fine-Grained. or Medium-Gr. or Coarse-Gr.?

b) Mineralogy: Quartz; Feldspar; Mica; Amphibole; Calcite/Dolomite; Garnet; Serpentine; None Observ.

c) Other distinctive features = _____

d) Rock name _____

e) Most likely parent (protolith) rock _____

Sample# MU10

a) Texture: Foliated or Non-foliated? ***AND*** Fine-Grained. or Medium-Gr. or Coarse-Gr.?

b) Mineralogy: Quartz; Feldspar; Mica; Amphibole; Calcite/Dolomite; Garnet; Serpentine; None Observ.

c) Other distinctive features = _____

d) Rock name _____

e) Most likely parent (protolith) rock _____

VI. METAMORPHIC ROCK LABORATORY REFLECTION

Directions: Write a 3-paragraph reflection of the lab activity, explaining its purpose, the methods used, the results obtained, and a brief personal reflection of what you enjoyed and learned about doing this metamorphic rock lab (*3 points possible*).

1) *What was the purpose of this lab? What did you actually discover and learn during this lab?*

_____

_____

_____

2) *What did you enjoy most about this lab? Also, what was challenging or thought-provoking?*

_____

_____

_____

3) *What are your constructive comments about the design and execution of this lab? What's good? What's bad? Offer suggestions for making the lab better.*

_____

_____

_____