Activity 25: Metamorphic Rock Identification

Maine Geological Survey

Objectives:

To have students develop skill in the visual identification of metamorphic rock species; to also have students conceptualize the relationships between non-metamorphosed species and their metamorphic counterparts.

Time:

This activity is designed to last one class period.

Background:

Metamorphism has played a major role in creating the bedrock geology of Maine. From the magnificent phyllite exposures at Two Lights State Park, to the "country rock" surrounding the gem-bearing pegmatites, to the andalusite-rich Smalls Falls Formation, metamorphism is evident in every corner of the state. Often of no commercial value, metamorphic rocks provide tremendous scientific insight into diverse topics ranging from crystal chemistry phase relations to the mechanics of plate tectonics.

In practice, metamorphism results when pressure, temperature, and introduced chemical fluids cause a previously existing rock to be transformed into a new rock species, with, almost always, a new assemblage of minerals. The extent to which a metamorphic rock differs from the original rock species is known as the metamorphic grade of the rock. Grade increases as a direct result of increasing the temperature, pressure and, to a lesser degree, the fluid parameters of the metamorphism. Shale, for example, can undergo a number of changes in grade as follows:

SHALE→PHYLLITE→STAUROLITE MICA SCHIST→GARNET SILLIMANITE SCHIST→GNEISS

Notice the use of specific mineral names, staurolite, sillimanite, and garnet, in the above examples. These specific minerals are known as geothermometers. That is, they define a certain minimum temperature that the rock must have achieved during the metamorphism process. Mapping mineral geothermometers allows geologists to define specific zones of intensity (isograds) in the metamorphism of a region.

Metamorphic rocks are identified based on grain size, mineral composition, and texture (see the accompanying chart). In this activity, students will be asked to identify a number of common metamorphic rocks using the enclosed sheets.

Materials:

Students should work in groups of two or three, each group will need:

- Numbered metamorphic rocks preferably from Maine locations including the following: slate, phyllite, schist (possibly two types), gneiss, quartzite, and marble
- 2 non-metamorphic rocks - granite and basalt
- Hand lens
- Metamorphic rock identification sheet
- Pens and notebooks

Procedure:

PART I. Students should use the hand lens to examine the metamorphic rocks and make observations about grain size, foliation, and so forth. Then, using the above data, they take the classification sheet and identify the rocks. Circulate freely among the students, asking questions and reinforcing correct identifications.

PART II. In this part, using the attached sheets and the non-metamorphic rocks, students should write statements such as:

Granite, sample number 9, will metamorphose to schist, sample number 1.

After writing the statement, have the students set the granite next to the schist sample and attempt to "visualize" the granite being metamorphosed to the schist.

Follow-Up:

An interesting follow-up to a unit on metamorphism is to have students write an essay. They are to pretend they are a mineral grain in an igneous rock that is undergoing metamorphism. Stress the use of factual material as well as the personification aspects of the essay. Creative students really enjoy this. One of the big issues in areas with a large number of granite bodies in areas of high-grade metamorphism is that of igneous versus metasomatic granite. Many introductory geology texts (*Physical Geology*, by Judson and Kauffman, for example) do an excellent job of presenting both sides of the issue. Research this topic and then visit a local granite quarry and see if your class can determine the nature of the granite. See the CREST Field Trip Guide. This activity is especially valid in the western part of the state where the metamorphic grade is high and some quarries show metamorphic rocks and textures grading into igneous ones.

References:

There are a number of excellent books that deal with various aspects of the metamorphic process. The following ones can be very useful in introducing these topics to teachers.

Metamorphic Textures, Alan Spry, Pergammon Press, New York, 1970.

An Introduction to Metamorphic Petrology, Bruce Yardley, John Wiley and Sons, New York, 1989.

Physical Geology, Sheldon Judson and Marvin E. Kauffman, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1990 (8th edition).

Activity developed by Duane Leavitt.

Name___________________________

Activity 25: Metamorphic Rock Identification

Maine Geological Survey

Student Sheet

Purpose:

In this first part of the activity, you will identify a number of metamorphic rocks that are commonly found in the state of Maine. You will also identify some igneous rocks which give rise to certain metamorphic counterparts.

Materials:

Students should work in groups of two or three as directed by the instructor. Each group will need a numbered set of variably metamorphosed rocks of several different compositions, two numbered igneous rocks, a hand lens, and the metamorphic rock identification sheet. Each student will need their pens and notebook.

PART I:

You should examine each rock with the hand lens, as well as macroscopically, and record your observations. When you have examined ALL the metamorphic rocks, take your metamorphic rock classification chart and use this to help you identify each specimen observed. Your teacher will tell you if a species is present more than once in your set of specimens.

Specimen	Observations with and without a hand lens	Species Name

PART II:

Before continuing, be certain that you have correctly identified the specimens listed in Part 1 above. Next, using the accompanying chart entitled Generalized Results of the Metamorphic Process, take your two igneous rock samples and match them up with the correct metamorphic counterpart. Write descriptive statements such as: *granite will metamorphose into schist*. Place each rock and its metamorphic counterpart next to each other and try to visualize what the conversion process must involve.

1.____

2.____

3.____

Questions:

1. Do metamorphic rocks seem to have any common characteristics? If so, describe them and list the species that display these characteristics.

2. Referring to the diagrams included in this exercise, explain how two different non-metamorphic "parent" rocks can both end up being the same species of metamorphic rock; cite an example.

3. What will eventually happen during the metamorphic process if the rock temperature continues to rise (see Figure 1)?

Metamorphic Rock Identification Sheet

Maine Geological Survey

CLASSIFICATION OF METAMORPHIC ROCK SPECIES			
Mineral Composition	Texture	Grain Size	Species Name
Clays, mica family	Schistose*	Microscopic, not visible with hand lens	SLATE
Clays, mica family	Schistose	Fine-grained, some visible with hand lens	PHYLLITE
Mica family, quartz, garnet**	Schistose	Medium-grained to slightly coarse	SCHIST
Quartz, mica, feldspars, amphiboles, pyroxenes	Foliated	Coarse, light and dark interlayered bands	GNEISS
Amphiboles, usually hornblende, plagioclase feldspar	Foliated	Coarse, banded	BANDED AMPHIBOLITE
Quartz	Homogenous	Fine to medium	QUARTZITE
Calcite	Varies	Microscopic to medium	MARBLE
Amphiboles usually hornblende, plagioclase feldspar	Non-foliated	Fine to medium	AMPHIBOLITE
Rounded rock fragments in groundmass	Non-foliated	Coarse	META-CONGLOMERATE

*Schistose refers to the property of the rock displaying subparallel orientation of the micaceous and platy mineral grains. The rock SCHIST best displays the property of schistose texture.

**May also contain varying amounts of staurolite, kyanite, sillimanite, and andalusite.

GENERALIZED RESULTS OF THE METAMORPHIC PROCESS

ORIGINAL ROCK →	METAMORPHIC ROCK (Increasing metamorphism→)
SHALE	→Slate → Phyllite → Schist → Gniess
RHYOLITE →	Gneiss
GRANITE →	Gneiss
BASALT →	Schist → Gneiss
LIMESTONE →	Marble
SANDSTONE →	Quartzite

It should be noted that some rocks may have been metamorphosed and NOT fit neatly into the above classification scheme. These are often generally referred to as metasediments, the prefix "meta" designating metamorphic origin.

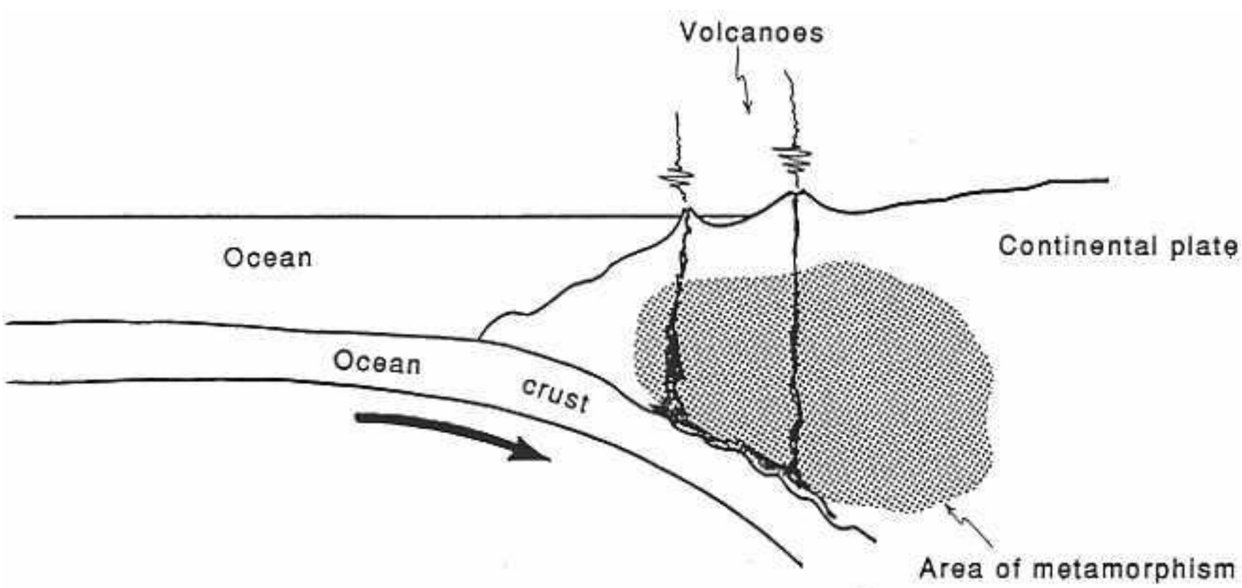

Figure 1. Diagram of a subduction zone.