Metamorphic Rock Lab: Identifying Unknown Rocks

You will need:

- Metamorphic rock samples
- Hardness kit
- Dilute HCl acid

Recall:
Metamorphic rocks form when pre-existing rocks (called the **protolith**) are subjected to a combination of increased temperature and pressure that results in changes in the texture, mineral content, or even chemical composition of the original rock.

Learn:
Metamorphic Environments
These changes usually occur as the protolith is buried, either by sequential deposition of sediment on top of the original rock (**regional metamorphism**) or by tectonic processes at convergent plate boundaries, like folding, thrust-faulting, and subduction (**dynamic metamorphism**). Metamorphism also occurs next to magma chambers and in association with superheated waters at mid-ocean ridges (**contact metamorphism**).

Metamorphic Grades
Metamorphism occurs at temperatures above 200°C. Metamorphic change that occurs at relatively low temperatures or pressures is referred to as **low-grade metamorphism**, while relatively high temperatures or pressures result in **high-grade metamorphism**. As soon as the temperature is high enough to cause partial melting of the metamorphic rock, it is characterized as a metamorphic and igneous rock called a migmatite.

Some minerals are considered index minerals to help define metamorphic grades. They form as minerals in the protolith become unstable at higher temperatures and pressures and react with each other form new minerals. These new minerals are more stable at a specific range of higher temperature and pressure.

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          Low Grade                    Intermediate Grade                 High Grade
----------Chlorite-----------
          ---------------------Muscovite---------------------
                    ---------------------------Biotite----------------------------
                                 -------------------Garnet-------------------
                                               -------Staurolite-------
                                                     ------------Kyanite------------
                                                                    --------Sillimanite-------
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Chlorite, muscovite, and biotite are all sheet silicates (recall: micas) that will re-orient themselves under increased pressure, resulting in alignment of their flat, vitreous cleavage faces. This will result in shiny metamorphic rocks, displaying a characteristic called **schistosity**.

Metamorphic Classification
Metamorphic rocks can either be classified based on their metamorphic grade and resulting texture (**foliated metamorphic rocks**) or based on the mineral composition of the protolith (for **non-foliated metamorphic rocks**). As rocks are buried and experience more stress in some directions than other (differential stress), they form distinctively metamorphic layers called **foliation**.

FOLIATED METAMORPHIC ROCKS

Shale is a very common sedimentary rock and so is a very common protolith for metamorphic rocks. As shale undergoes increasing grades of metamorphism, different metamorphic rocks form.

Slate: Forms when shale undergoes low-grade metamorphism. The clay minerals in shale break down and re-form into microscopic crystals of micas (biotite, muscovite, and chlorite). The microcrystalline structure gives slate a dull appearance. The micas are aligned in foliation planes perpendicular to the direction of compression. Slate breaks into flat cleavage planes (**slatey cleavage**).

Phyllite: Forms at higher temperatures than slate. Mica crystals grow larger than in slate but are still microscopic; the larger crystals result in a satin-y sheen and wavy cleavage.

Schist: Formed when rock that was originally shale undergoes intermediate-grade metamorphism. The mica crystals are larger than in phyllite and easily visible, giving schist a glittery appearance. The mica crystals are aligned in schistose foliation layers that give schist blocky cleavage. Schists are frequently characterized by their dominant minerals (e.g. a light-green schist primarily composed of muscovite is called a ***Muscovite Schist***; a dark-colored schist primarily composed of biotite is called a ***Biotite Schist***.) Schists may also grow garnet crystals at higher grades of schist metamorphism.

Gneiss: Formed when rock that was originally shale undergoes high-grade metamorphism. Micas have broken down and recombined to form feldspars and other minerals. Characteristically, the minerals arrange themselves in alternating bands of light-colored minerals and dark-colored minerals, forming a type of foliation called **gneissic banding**. Gneiss can also form from the metamorphism of the common continental igneous rock, granite.

NONFOLIATED METAMORPHIC ROCKS

Marble: Forms when limestone or dolostone is metamorphosed, usually under intermediate-grade conditions. Marble is composed of interlocking calcite crystals and will therefore fizz in contact with weak acid. Marble may or may not exhibit layering, which is either relict sedimentary bedding planes or true metamorphic foliation.

Quartzite: Forms when sandstone undergoes low to high grade metamorphism. The quartz grains in the sandstone recrystallize to form interlocking crystals of quartz; it will not fizz in contact with acid. Quartzite is hard and durable, occurring in as many colors as sandstone. It may or may not be layered, either preserving sedimentary bedding planes or displaying true metamorphic foliation.

Soapstone: Composed of the mineral talc, possibly with some minor carbonate minerals (so, may weakly fizz in contact with acid). Soapstone forms when igneous rocks are altered in contact with superheated waters (**hydrothermal alteration**) at mid-ocean ridges or at subduction zones. Is very soft and historically has been used for sculpting.

Serpentinite: Formed when ultramafic or mafic igneous rocks undergo hydrothermal alteration at mid-ocean ridges. Composed of green serpentine minerals like lizardite, antigorite, and chrysotile. Named for its characteristic waxy snake-skin texture and greenish appearance.

Anthracite Coal: Formed from the intermediate-grade metamorphism of bituminous coal (a sedimentary rock). Harder and denser than bituminous coal with a semi-metallic luster, higher carbon content, and lower moisture content.