GLY 4310C
LAB 9

METAMORPHIC ROCKS, PART 1

LOWER-GRADE REGIONAL METAMORPHICS
Slate, Phyllite, "Greenstone", and Schist

The rocks in this week's laboratory are low-grade metamorphic rocks, predominantly formed as the result of regional metamorphism or metasomatism. The latter process may be associated with regional metamorphism. Regional metamorphism is the result of temperature, pressure, and stress (differential pressure). More information about these rocks is included in Chapter 28 of Moorhouse (on the bookshelf in SE 435 - DO NOT REMOVE). Metamorphic rocks may be classified by either grade or facies. The slates, phyllites, and greenstones belong to the chlorite and lower part of the biotite grade. In facies classification, they are part of the greenschist facies.

Slate - Slates are usually formed by the metamorphism of shale. They possess slaty (note spelling) cleavage and hence can be split into slabs and thin plates. Slates are usually named for their color in hand specimen. The colors are due to various impurities. Spotted slates are bumpy due to the formation of incipient porphyroblasts. Slates generally have a dull, earthy appearance in hand specimen.

Phyllite - Phyllites are metamorphic rocks intermediate in composition between slate and mica schist. Minute crystals of sericite and chlorite impart a silky sheen to the cleavage surface (or surface of schistoscity). Phyllites often exhibit corrugated cleavage surfaces. Spotted phyllites are bumpy due to the formation of incipient porphyroblasts.

Greenstone - The term "greenstone" has a variety of meanings in geology, and is frequently misused. In metamorphic petrology, the term has a fairly specific meaning. It is a field term applies to any compact dark-green altered or metamorphosed mafic igneous rock (basalt, diabase, gabbro, spilite) that owes its color to the presence of chlorite, actinolite, or epidote.

Schist - Schist is a strongly foliated crystalline rock which can be readily split into thin flakes or slabs due to the well developed parallelism of more than 50% of the minerals present. Schistosity is due to the parallel arrangement of platy or elongated minerals. Spotted schists are bumpy due to the formation of porphyroblasts. Schists must have megascopically visible crystals. In grade, schists range from biotite to sillimanite. They correspond to greenschist to amphibolite facies. Not all rocks associated with schists are schistose. Limestones, quartzites, intrusive rocks and some metasomatic rocks may be massive.

Schists are characterized by a high content of mica, chlorite, hornblende, or other flaky or acicular minerals. Quartz and feldspar are usually associated with these minerals. A large variety of other minerals occur in schists. It is on the basis of these other minerals that the rocks are assigned to various grades or facies.

Mica and actinolite schists are typical greenschist facies rocks. The muscovite of the mica schist is commonly found in metamorphosed sedimentary rocks. Graphite schists form as the result of metamorphism of organic matter. They are often recognizable because of the shiny luster of minute graphite grains. Actinolite is usually found in metamorphosed igneous rocks. Cummingtonite schist represents a slightly higher grade of metamorphism, the amphibolite facies.

Glaucophane schist is typical of moderate to high pressure rocks seen on the oceanic side of the eugeosyncline. Stilpnomelane schist probably formed in a similar environment. All of the specimens are part of the Franciscan formation. This formation contains sediments (and the metamorphic product of those sediments) from the floor of the Pacific, scrapped off as the Pacific was subducted. Stilpnomelane is usually regarded as a low-grade metamorphic mineral but here it occurs with garnet, sometimes regarded as a high-grade mineral. This is probably the result of high-pressure, low-temperature conditions.

TERMS:

The following list of terms are associated with rocks from this laboratory assignment. You will probably be familiar with some of these terms already. You should learn any terms that you are not familiar with as they may be tested on lab quizzes or the midterm. The list also includes a number of minerals which were not commonly seen in igneous rocks.

Actinolite - A bright to grayish-green mineral of the amphibole group. The more iron-rich members of the tremolite series are actinolites. Symbol: Ac. Formula: $Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$. May be asbest-iform, but often occurring as fibrous, radiated, or columnar forms in metamorphics rocks (usually schists) or altered igneous rocks.

Andalusite - One of the three Al_2SiO_5 polymorphs. Occurs as thick, nearly square prisms in schists, gneisses, and hornfels. It forms at medium temperature and pressures of a regionally metamorphosed sequence (see Figure 1). Also characteristic of contact-metamorphosed argillaceous rocks. Color ranges: brown, green, red or gray.

Argillaceous - Pertaining to, largely composed of, or containing clay-sized particles or clay minerals.

Chiastolite - An opaque variety of andalusite containing black carbonaceous impurities arranges in a regular manner so that a section normal to the long axis of the crystal shows a black Maltese cross. The cross grows as the result of the crystal pushing the impurities aside as it grows in metamorphosed carbonaceous shales.

Chlorite - A group of platy, usually greenish minerals of the general formula (Mg, Fe^{2+}, Fe^{3+})$_6AlSi_3O_{10}(OH)_8$. Commonly found in low-grade metamorphic rocks, or as alteration products of ferromagnesian minerals. They may resemble micas, splitting into small, thin flakes. Chlorite is flexible, but not elastic like mica.

Cummingtonite - A brownish mineral of the amphibole group. Formula: $(Mg,Fe)_7Si_8O_{22}(OH)_2$. It contains more iron than anthophyllite and may contain zinc or manganese. There is a solid solution series between cummingtonite and the iron-rich variety grunerite. It often occurs in metamorphic rocks as lamellae or fibers.

Fibrolite - A synonym for fibrous sillimanite.

Graphite - A naturally occurring dimorph of diamond. It is lustrous, opaque, greasy feeling, and iron-black to steel-gray in color. In hand spec-imen it sometimes is detected by the marks it leaves on hands or paper. It occurs as crystals, flakes, scales, laminae, or grains in veins or bedded masses. In metamorphic rocks it occurs as disseminations formed from the metamorphosis of organic matter.

Kyanite - A blue to light-green trimorph of Al_2SiO_5. It occurs in long, thin, bladed crystals and crystalline aggregates in schists, gneisses, and granitic pegmatites. Kyanite is a metamorphic mineral formed during the regional metamorphism of pelitic rocks. It is the moderate to high-pressure, low to moderate temperature Al_2SiO_5 polymorph and is found in moderate-grade metamorphic rocks (see Figure 1). The presence of andalusite together with kyanite restricts the pressure to less than about 3.75 kbars.

Magnesite - A white to grayish, yellow, or brown mineral, $MgCO_3$. It is usually found as earthy masses or irregular veins resulting from the alteration of dolomitic rocks. It may also form by metasomatism of magnesium silicates.

Metabasalt Basalt that has undergone regional metamorphism in which amygdaloidal, columnar, or other structures are often preserved. The rocks may grade into greenshcist facies or, at higher pressures, into blue schist.

Metacryst - A synonym for porphyroblast, which is the preferred term.

Omphacite - A grass-green to pale-green granular aluminous clinopyroxene found as a common constituent in eclogite. Formula (ideally): $CaNaMgAlSi_4O_{12}$.

Pelite - A sediment or sedimentary rock composed of the finest detritus, clays or mud-size particles, or a calcareous sediment composed of clays and minute quartz particles. Often these sediments are aluminous. Pelite is sometimes used to mean the metamorphic equivalent of an argillaceous rock.

Poikiloblastic - A texture in which porphyroblasts contain inclusions of other minerals. The term is analogous to poikilitic in igneous rocks.

Porphyroblast - Large crystals that have grown in a finer-grained rock during metamorphism or metasomatism. They resemble phenocrysts in igneous rocks.

Psammite - A clastic sediment or sedimentary rock composed of sand-sized particles. A synonymous term is arenite. Sometimes called the metamorphic equivalent of arenite.

Relict - A term applied to minerals, textures, or structures inherited from unmetamorphosed rocks or from grades or facies of meta-morphism other than that now shown by the rock.

Sericite - A white, fine-grained potassium mica. It occurs as small flakes and scales formed by alteration of various aluminosilicate minerals. It has a silky luster. Found most often in phyllites and schists. It is either muscovite or close to muscovite in composition, and may include considerable illite.

Sillimanite - A brown, gray, pale-green, or white orthorhombic trimorph of Al_2SiO_5. Occurs in long, slender, needlelike crystals often found as fibrous aggregates in schists and gneisses. Sillimanite is the moderate to high-temperature, moderate to high pressure polymorph of Al_2SiO_5, and is common in high-grade regional and contact metamorphic rocks (see Figure 1). In contact-metamorphic rocks, it is characteristic of the innermost zone.

Staurolite - A brown to black mineral, $(Fe,Mg)_2Al_9Si_4O_{23}(OH)$. Twinned crystals often resemble a cross. The cross may occur at 60° or 90°. Crystals are often six-sided prisms, although the mineral is orthorhombic, not hexagonal. A common constituent in mica schists and gneisses that have undergone medium-grade regional metamorphism.

Stilpnomelane - A black to greenish-black mineral of approximate composition $K_{0.6}(Fe^{2+},Fe^{3+},Al)_6Si_8Al(O,OH)_{27}\cdot 2\text{-}4\ H_2O$. It may occur as mica-like plates, fibers, or velvety bronze-colored incrustations. Typically found in low-grade, regionally metamorphosed schists, of blueschist facies metamorphic rocks, and of unmetamorphosed Precambrian banded-iron formations. Very difficult to distinguish in hand-specimen from biotite mica.

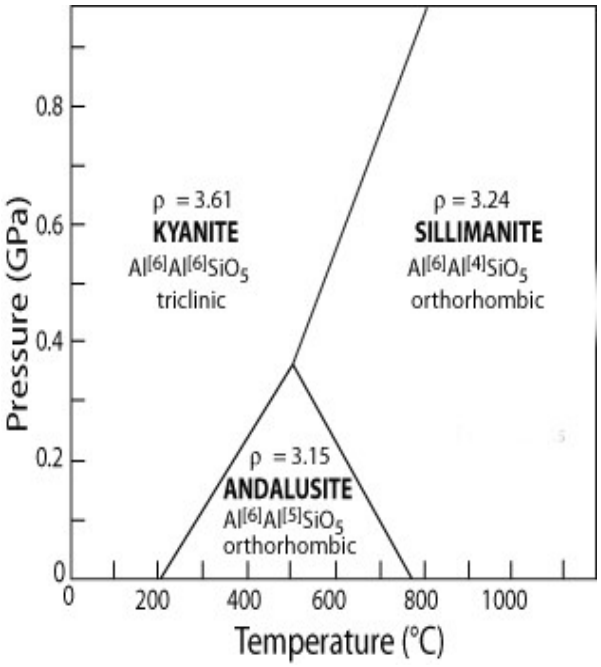
Tremolite - A white to gray clinoamphibole. Formula: $Ca_2Mg_2Si_8O_{22}(OH)_2$. It can contain varying amounts of iron, and forms a solid solution series with actinolite. It may also contain manganese or chromium. The habit is long blade-shaped or short stout prismatic crystals. It may also occur in fibrous, columnar, or granular masses. Typically found in dolomitic limestones and talc schists.

Wollastonite - A pyroxenoid mineral of composition $CaSiO_3$. It occurs in cleavable masses in contact-metamorphosed limestones or as tabular crystals. Color ranges from white to gray, brown, red, or yellow. Symbol: Wo

Assignment:

1. Examine any two of rocks number 79, 81, 93, 94, or 96 in thin section. Prepare a labeled sketch of two thin sections, being sure to label the sketch with magnification and either CN or PP. Identify the major minerals, and write a concise description of the petrography of the rock. This will be handed in at the beginning of the lab 10.

77 Gray slate
Purple Slate
78 Phyllite
79 Mica schist
81 Stilpnomelane schist
84 Andalusite (chiastolite) slate
93 Actinolite schist
94 Cummingtonite schist
96 Glaucophane schist



2. **Examine all of the rocks in hand specimen. The rocks (numbered) from Wards North American Rock Set are particularly good type examples. Also examine the following rocks:**

Kyanite Schist
Tourmaline-Mica Schist
Anthracite-Graphite Schist

3. Examine at least one interference figure from a mineral in this weeks lab. Determine the optical class and sign. If biaxial, estimate 2V. If uniaxial, determine whether the figure is centered or not. If it is not centered, approximately how far off the C axis are you viewing the figure? Prepare a labeled sketch of the figure, including the mineral name. Show the figure to the GTA. Do a different mineral each week.

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