LAB 10: METAMORPHIC ROCKS IN THIN SECTION

**Symplectite of garnet and clinopyroxene in eclogite, Antarctica**

**Purpose:** This lab introduces you to some of the common textures and minerals in metamorphic rocks as seen in thin section. Unlike many igneous rocks, metamorphic rocks are often fine grained and it can be difficult to recognize key minerals (recall many of the rocks you saw in hand sample last week). Thin sections are critically important to understanding how metamorphic rocks form, particularly when trying to decipher the relationship between mineral growth (reflecting the P-T conditions) and fabric development (most commonly associated with deformation). By working out the relationship between minerals and fabrics, one can try to address the metamorphic history, especially as it relates to the tectonic movements associated with plate interactions and mountain belt evolution. Consult the handout provided for common terms used in naming and describing metamorphic rocks.

Also consider rock composition. The minerals in a metamorphic rock, like their igneous cousins, are the product of chemical reactions and therefore reflect the rock’s bulk composition. When looking at a metamorphic rock, always keep in the back of your mind the rock bulk composition, the appropriate mineral associations, the P-T conditions of metamorphism, and a likely protolith (precursor rock).

Study the thin sections provided for the samples listed below, and answer the questions. Careful observation will be most helpful.

12-2

a) What are the minerals in this rock?

b) The coarse yellow mineral in this rock is **staurolite**. List the optical properties that you see.

c) This rocks shows a good example of a penetrative schistosity. How is it expressed and how can you tell that it is very uniform in orientation?

d) What name do you give to the large crystals?

e) Name this rock.
12-17
a) What are the minerals in this rock?

b) What minerals make up the schistosity in this rock?

c) Note how minerals are concentrated in crenulation bands - did the band form at the same time the minerals grew, or before, or after? Why?

d) Name this rock.

12-10
a) What are the key or index metamorphic minerals?

b) How do the crenulations in this rock compare with 12-17?

c) What mineral has formed along the crenulations? What is its relative age compared to the other minerals? Sketch this relationship.

MRM-6-4
a) What is the coarse yellow-orange mineral?

b) What other minerals are present?

c) Note the mosaic texture of quartz, like small tiles of uniform size. These polygons are equant and commonly show grain-boundary junctions at ~120°, which is thought to form by equilibrium metamorphic growth of mineral grains in order to reduce surface energy. Because parts of the rock are essentially all quartz, these boundaries suggest thorough recrystallization during heating. The rock itself is a metamorphosed chert (Si-rich marine sediment of the deep sea-floor); its composition is not very revealing, but its texture reflects its thermal history.
MRM-7-2

a) The granular mineral is clinopyroxene. List the optical properties that you see.

b) The elongate, bladed mineral is grunerite (an orthoamphibole). List the optical properties that you see.

c) This rock probably represents a metamorphosed mafic igneous rock, or a siliceous carbonate (possibly a Mg-rich siliceous dolomite). Note that the so-called “mafic” minerals in this case are not dark as you expect to see in most igneous rocks.

SY-70

a) The coarse, pale-green mineral with anomalous birefringence and “hourglass” structure is chloritoid. List the optical properties that you see.

b) When did chloritoid form relative to foliation and folds of the layers? Provide textural evidence.

c) Make a careful, detailed sketch of this rock, showing the relationship between chloritoid crystals and the associated fabrics.

NM 16-3

a) What are the minerals in this rock?

b) What mineral forms the coarse porphyroblasts?

c) Note the “pressure shadows” around the equant, euhedral mineral. These look like augen - triangular regions on two sides of the main crystal that give the appearance of “eyes” - and are formed by deformation of a rigid crystal in a deforming matrix. In this case, the porphyroblast is stiff and resists stress applied to it (perpendicular to the foliation). In the low-stress areas (“shadows”) to either side and within the foliation plane, new mineral growth occurs. In some cases, the pressure shadow contains an interesting mineral that reveals something about the metamorphic conditions, but in this case it is mostly quartz.
d) Make a careful, detailed sketch of this rock, showing the pressure shadows and their relation to the penetrative foliation.

e) Name this rock.

DT-13

a) What are the minerals in this rock?

b) Note the “snowball” garnet – crystal porphyroblasts with curving trails of solid mineral inclusions. From your observations and reading in the text, when did these garnets form relative to the timing of deformation – that is, are they pre-, syn- or post-tectonic (where “tectonic” refers to movement)? What is the textural basis for this interpretation?

c) Make a careful, detailed sketch of this rock, showing the snowball garnets and their relation to the inclusion trails.

d) Under low power, get a sense of how big and how common are the garnet porphyroblasts. Also look for staurolite. Both minerals are partly to completely replaced by secondary minerals (in this case Grt \(\rightarrow\) Chl and Sta \(\rightarrow\) Ms) that form patches in the rock about the same size and shape of the original porphyroblasts of garnet and staurolite. This type of replacement of one mineral by another, preserving the shape of the original, is known as a \("pseudomorph"\) [meaning “false shape”].

e) Name this rock.
NM 12-14
a) What are the minerals in this rock?

b) Put the major metamorphic minerals in a relative time sequence, from oldest to youngest. Some may be of equivocal age. Describe textural evidence to support your interpretation.

c) Name this rock.

CM-1A and CM-1B (look at either one)
a) What are the minerals in these rocks?

b) These rocks are strongly deformed metarhyolites. The large feldspars are relict phenocrysts in a rhyolite tuff – now they are porphyroclasts in a ductile matrix of other minerals. In this case, the feldspars are relatively rigid (not as strong as garnet, however), and float in a matrix dominated by quartz. Note the evidence of shear, including “tails” around the porphyroclasts, ribbons of fine-grained quartz, strong foliation of micas, and broken and rotated feldspars

c) This rock could be called a mylonitic metarhyolite. Make a careful, detailed sketch of this rock, showing the feldspar porphyroclasts and their relation to the surrounding matrix.

d) Note the fine-grained mosaics of quartz grains in the narrow ribbons. As you saw in an earlier sample, these grains are small equant polygons with 120° grain boundaries, indicating equilibrium recrystallization to reduce surface energy. Insert the gypsum plate with crossed polars. As you rotate the stage, you should see most of the grains colored blue or yellow, depending on position. What do the uniform interference colors, highlighted by the gypsum plate, tell you about the lattice preferred orientation of quartz in these samples?
87NS-2

a) What are the minerals in this rock?

b) Based on textural evidence, describe a crystallization sequence for this rock.

c) Give this rock a name.
To help you become more familiar with pelitic rocks (Al-rich metashales), key metamorphic minerals, and the concept of metamorphic facies, examine the suite of metamorphic rocks from the Picuris Range of northern New Mexico. These rocks are part of a Proterozoic metasedimentary assemblage now exposed in the southern Rocky Mountains that record a major orogenic metamorphism about 1,700 million years ago. These samples come from a single outcrop area exposing interlayered quartzites and schists, presumably interbedded sandstones and shales originally, so we assume they experienced the same metamorphic P-T conditions (that is, they are isofacial). Mineral assemblages and mineral compositions indicate these rocks were metamorphosed in the amphibolite facies at about 530 °C and 3.8 kbar.

In the samples provided:

a) Identify the minerals indicated
b) Look for textural evidence of growth sequence and syn-metamorphic deformation

c) Consider differences in rock bulk composition indicated by the mineral assemblages (note that even rocks representing metamorphosed shales have slightly different mineral assemblages that reflect subtle differences in composition)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Rock type</th>
<th>Protolith</th>
<th>Mineral assemblage</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR-100A</td>
<td>quartzite</td>
<td>sandstone</td>
<td>Qtz+Sil+Ms</td>
</tr>
<tr>
<td>CR-100B</td>
<td>Al-rich quartzite</td>
<td>lateritic soil</td>
<td>Qtz+St+Ms+Tur+Oxide</td>
</tr>
<tr>
<td>CR-101B</td>
<td>pelitic schist</td>
<td>shale</td>
<td>Qtz+Ms+Grt</td>
</tr>
<tr>
<td>CR-104 &amp; CR-105</td>
<td>pelitic schist</td>
<td>shale</td>
<td>Qtz+Ms+Grt+St+Chl+Oxide</td>
</tr>
<tr>
<td>CR-106B &amp; CR-109</td>
<td>pelitic schist</td>
<td>shale</td>
<td>Qtz+Ms+Grt+St+Oxide</td>
</tr>
<tr>
<td>CR-108</td>
<td>pelitic schist</td>
<td>shale</td>
<td>Qtz+Ms+Bt+St+Oxide</td>
</tr>
</tbody>
</table>

Qtz = quartz  
Ms = muscovite  
Bt = biotite  
Chl = chlorite  
Sil = sillimanite  
St = staurolite  
Grt = garnet  
Tur = tourmaline  
Oxide = Fe-Ti oxide

On the AFM phase diagram to the right (Winter, Fig. 28-11), plot and label the rock composition for each sample in an appropriate place based on the mineral assemblage given above. The field for common pelitic rocks is shown by the shaded oval, including some example compositions (dots). Also note that the A corner can be represented by any of the Al-silicate minerals (Ky, Sil or And).