Rocks and Minerals
Lab 7: Metamorphic Rocks and Textures

DUE DATES
At the beginning of lab next week.

OBJECTIVES
 To recognize textures and minerals of common metamorphic rocks (refer to textural terms handout at end of this lab)
 To understand how mineralogy and grain size change with increasing P, T
 To understand basic relationships between protolith and the type of metamorphic rock
 To perfect hand sample description skills

ASSIGNMENT
REVIE W RELEVANT SECTIONS IN TEXT BOOK (CHAPTERS 17 AND 18).

ON SEPARATE SHEETS OF PAPER, ANSWER THE FOLLOWING:

1) Samples 1 through 4 represent the prograde sequence slate → phyllite → schist → gneiss. Do detailed and accurate hand sample descriptions of each sample, and identify any porphyroblasts. Describe the change in grain size, mineralogy (if minerals can be identified; if not make educated guesses based on the type of rock), and foliation in this sequence.

2) Sample #5: If this rock formed at a pressure of 7 kbar, what is the maximum temperature at which it formed? How do you know? If this rock ascends isothermally to 4.5 kbar, what mineral will the blue mineral turn into? Consult your book for help with this question.

3) What is the name of sample #6? Explain your reasoning for giving the rock this name.

4) Examine samples #7A, #9A and #12. All of these samples have a common texture. What is this texture called and how does it form? These three samples represent three distinct metamorphic rock types. For each sample, provide a metamorphic name (e.g., biotite schist, augen gneiss). For each of these samples, give a probable protolith name.

6) What is the primary mineral in sample #10? What is the name of this rock? What is the likely protolith? Where would you expect to find this rock?

7) Sample 11 is an eclogite. Identify the porphyroblasts and describe the P-T conditions required for formation of this rock.

8) Identify the two principal minerals in sample #13 and explain how you were able to identify them.
Hand sample description for metamorphic rocks

- **Presentation:** Descriptions should be well-organized, with the information presented in the same order. The descriptions should be written in the present tense, in full sentences and should use proper grammar and spelling.

- **Include description of:**
  - mineralogy (identify minerals when they are large enough)
  - porphyroblasts, if present (identify minerals, describe size and shape, see definitions below of idioblastic, hypidioblastic, xenoblastic)
  - poikiloblasts, if present
  - matrix (mineral identification, foliation present)
  - average crystal size (if rock is equigranular, describe the rock as granoblastic)
  - texture (is rock foliated?, which minerals define the foliation?, does it have cleavage or schistosity?)
  - alteration, if present

- **Provide a rock name (see attached classification) and if known, a protolith**

### Textural terms for metamorphic petrology

Where a mineral occurs as crystals distinctly larger than the matrix, the mineral is called a **porphyroblast**.

Where a metamorphic rock is equigranular, it is called **granoblastic**.

Porphyroblasts that contain numerous small inclusions are called **poikiloblasts**. Inclusions can be important because they in some cases represent minerals from a lower grade metamorphic event.

**Pseudomorphed** crystals are those that preserve the habit of a previous mineral, but are now a single new crystal or a number of new crystals. Typically, numerous small crystals occupy the original shape of the crystal.

**Idioblastic** refers to metamorphic mineral with well-formed crystal faces (equivalent to euhedral).

**Hypidioblastic** refers to metamorphic mineral with medium developed crystal faces (equivalent to subhedral).

**Xenoblastic** refers to metamorphic mineral with poorly formed crystal faces (equivalent to anhedral).

**Foliation** is a general term for pervasive planar structures. Typically the result of fine-scale compositional layering and alignment of minerals.

**Slaty cleavage** is cleavage characteristic of fine grained, low grade metamorphic rocks such as slate.

**Schistosity** is foliation defined by parallel, planar alignment of platy or prismatic minerals such that the rock tends to split parallel to the foliation. This is characteristic of medium to coarse grained, medium grade metamorphic rocks.

**Polygonal texture** is present in dominantly monomineralic rocks where crystals are five or six-sided and are characterized by abundant triple junctions.

**Triple junction** is where three crystals comes together, and the grain boundaries intersect at 120° angles.
Classifying Metamorphic Rocks

This system comes from the IUGS Subcommission on the Systematics of Metamorphic Rocks (SCMR). While it retains many aspects of the traditional classification system, there are some new rules, especially as concerns the terms schist, gneiss and granofels. (Full information at http://www.bgs.ac.uk/SCMR/)

Note that these are root names, not extended names. To find the correct root name, you should go through the following list, choosing the first category that fits your rock.

Protolith name
- If the rock's texture and mineralogy clearly indicate the protolith, then you should name it as a meta-[protolith].
- Metamorphic rock names are almost never used as protoliths (e.g., no meta-eclogite allowed)
- The hyphen is often omitted, especially before a consonant.
- Examples: metagabbro, meta-arkose, meta-quartz diorite.

Mineral name
- If the rock is composed of more than 75% one mineral (by volume) then you should name it as a [mineral]ite.
- Examples: garnetite, biotitite.

Specific name
- If the mineralogy and texture matches a specific name in the attached list, then that is the root name.
- Relict or retrograde minerals should be ignored in choosing a root name.
- This is preferred over the systematic (textural) name (e.g., marble is better than calcite granofels).

Systematic (Textural) Name
If none of the above names applies, then you must use one of the three texture-based systematic root names.
- Granofels: Displays no schistosity, either because no inequant grains are present or because the inequant grains are randomly oriented.
- Schist: Displays a well-developed schistosity such that the rock will split on a scale < 1 centimeter.
- Gneiss: Displays a poorly-developed schistosity or a well-developed schistosity that is present in spaced zones so that the rock will split on a scale > 1 centimeter.

Naming Metamorphic Rocks

Once a root name is selected, then it may be prefixed by one or more modifiers to provide more information to the reader.

Mineral prefixes
- First choose a general rock name using the guide above.
- Prefix this name with those minerals not implied by the root name. Minor minerals (<5%) are optional as prefixes and should be added with “-bearing” (e.g., “rutile-bearing serpentininte”)
  - If you wish to specify the composition of a mineral that is implied by the root name, you may (e.g., “oligoclase amphibolite”)
  - Those minerals that convey information about the conditions of metamorphism must be included.
- Mineral prefixes should increase in abundance as you read the name. The syntax for these uses hyphens and ±, so a garnet - biotite - plagioclase ± muscovite schist unit would have a more biotite than garnet and more plagioclase than biotite, and muscovite would occur sporadically in the outcrop.

Textural prefixes
- Optionally, add textural prefixes (e.g., a schistose garnet amphibolite).
List of Common Specific Names

This list represents the most common specific rock names, but it is not meant to be comprehensive; there are others as well. Mineral abbreviations are given in: Kretz (1983) Symbols for Rock-forming minerals, American Mineralogist v. 68 p. 277-279.

<table>
<thead>
<tr>
<th>Rock Name</th>
<th>Mineralogy</th>
<th>Texture &amp; Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amphibolite</td>
<td>Hbl + Pl ± Qtz ± Bt ± Ms ± Grt</td>
<td>Schistose or granofelsic. If granofelsic, may be impossible to distinguish from diorite.</td>
</tr>
<tr>
<td>Blueschist</td>
<td>Glc + Ab ± Lws ± Ep</td>
<td>Often schistose, but may be granofelsic.</td>
</tr>
<tr>
<td>Calc-silicate rock</td>
<td>Variable, but often: Grs, Ep, Di, Vsv, Tlc, Wo, Tr, Cal, Dol (&lt;5% carbonates)</td>
<td>Generally granofelsic, but often layered.</td>
</tr>
<tr>
<td>Carbonate-silicate rock</td>
<td>Variable, but often: Grs, Ep, Di, Vsv, Tlc, Wo, Tr, Cal, Dol (5-50% carbonates)</td>
<td>Generally granofelsic, but often layered.</td>
</tr>
<tr>
<td>Cataclasite</td>
<td>Any</td>
<td>A fault rock, schistosity poorly developed or absent, with angular crystals and rock fragments.</td>
</tr>
<tr>
<td>Eclogite</td>
<td>Grt + omphacite (Na-cpx) ± Ky ± Rut ± Qtz</td>
<td>May be schistose or granofelsic.</td>
</tr>
<tr>
<td>Granulite</td>
<td>Variable, with mostly OH-free minerals: Fsp ± Opx ± Cpx ± Crd ± Sil</td>
<td>May be schistose or granofelsic. Very high grade rock.</td>
</tr>
<tr>
<td>Greenschist</td>
<td>Ab + Chl + Ep + Act ± Qtz</td>
<td>Schistose, generally foliated. Visible minerals are not required, nor is it required to fit the definition of schist below.</td>
</tr>
<tr>
<td>Greenstone</td>
<td>Ab + Chl + Ep + Act ± Qtz</td>
<td>Granofelsic, generally fine-grained.</td>
</tr>
<tr>
<td>Hornfels</td>
<td>Variable, and generally too fine-grained to see in hand specimen</td>
<td>Granofelsic on the microscopic scale. Fine-grained, hard, homogeneous, breaking along curved fractures.</td>
</tr>
<tr>
<td>Marble</td>
<td>Dominated by carbonates (&gt; 50%), but may also have: Qtz, Grs, Ep, Di, Vsv, Tlc, Wo, Tr, others</td>
<td>Usually granofelsic but may be layered, or have foliation defined by stretched carbonate grains or aligned inequant minerals, if present.</td>
</tr>
<tr>
<td>Migmatite</td>
<td>Typically a combination of mica schist minerals and granitoid minerals.</td>
<td>Separate, irregularly distributed domains of mica schist rock and granitic rock.</td>
</tr>
<tr>
<td>Mylonite</td>
<td>Any</td>
<td>A sheared rock, with plastically deformed mineral grains defining a foliation</td>
</tr>
<tr>
<td>Phyllite</td>
<td>Ms (or other white mica) + Chl / Bt ± Fsp ± Qtz</td>
<td>Foliated, with fine-grained matrix coarse enough to provide a “sheen” to the rock.</td>
</tr>
<tr>
<td>Quartzite</td>
<td>Qtz (&gt; 75%) ± Bt ± Ms ± Grt ± Als</td>
<td>Granofelsic unless inequant minerals present.</td>
</tr>
<tr>
<td>Serpentinite</td>
<td>Srp (&gt;50%) ± Mag/Chr</td>
<td>Often schistose and generally fine grained</td>
</tr>
<tr>
<td>Skarn (=Tactite)</td>
<td>Variable, but often: Grs, Ep, Di, Vsv, Tlc, Wo, Tr, Cal, Dol</td>
<td>Hydrothermal rock, so generally layered; often coarse with euhedral crystals.</td>
</tr>
<tr>
<td>Slate</td>
<td>Too fine to discern in hand specimen, but may have pyrite porphyroblasts.</td>
<td>Fine grained to cryptocrystalline, with slate cleavage. Dull surface (cf. phyllite)</td>
</tr>
<tr>
<td>Soapstone</td>
<td>Tlc ± Srp ± Mag</td>
<td>Generally schistose</td>
</tr>
</tbody>
</table>

Mineral Abbreviations

A subset of those given in Kretz (1983), with a few additions.

Ab - Albite
Chl - Chlorite
Dol - Dolomite
Grt - Garnet
Ms - Muscovite
Srp - Serpentine
Wl - Wollastonite

Act - Actinolite
Cpx - Clinopyroxene
Ep - Epidote
Hbl - Hornblende
Opx - Orthopyroxene
Sil - Sillimanite
Tlc - Talc

Als - Aluminum Silicate
Bt - Biotite
Crd - Cordierite
Fsp - Feldspar
Ky - Kyanite
Pl - Plagioclase
Tr - Tremolite

Cal - Calcite
Di - Diopside
Grs - Grossular
Glc - Glaucophane
Lws - Lawsonite
Mag - Magnetite
Rut - Rutile
Vsv - Vesuvianite

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