EESC 3000: Igneous and Metamorphic Petrology

MET LAB 2: DESCRIBING METAMORPHIC ROCKS

Learning Objectives:

- Students will be able to fully describe a metamorphic rock
- Students will be able to interpret relative timing of mineral growth in metamorphic rocks based on mineral textures

Key Minerals: To be determined

The lab activity this week will involve discussion in groups, and as a class. Please sit at a table with at least one other student, and have at least one copy of a mineral identification text per table.

The lab is designed to model the methodology involved in describing a metamorphic thin-section thoroughly, thereby allowing you to name rock and interpret its history or mineral growth (paragenetic sequence). Together, we will go through the following essential steps for a complete petrographic description of a metamorphic rock:

- Research the sample in order to short-list minerals and textures that are likely to be present in the study samples
- Review the optical properties of minerals that are likely to be present
- Identify the minerals in the sample
- Document the textural relationships of minerals in the sample
- Use textures to determine which minerals developed at peak metamorphic conditions, which minerals occur as relict grains from the prograde path, and which minerals formed as retrograde minerals

We will save the final steps of naming the rock, interpreting PT conditions and deducing the protolith for next week's lab.

STEP 1: Research

Is anything known about the rock? What about the location from which it was sampled? If so, then quick keyword searches may provide background information that will make your petrographic work easier; what is the general geological setting? What rocks are common in the area? What minerals have been documented previously in these rocks? Have any unusual minerals been documented in the area?

According to a note on the box that contained CAZ1, this sample came from Cazadero, California, and sample 670 was labeled "Eclogite, California". A search on "Cazadero and eclogite" in GeoRef returned 8 references; these references yielded keywords such as blueschist, Franciscan Complex, metabasalt, epidote, lawsonite, and glaucophane. An example of a downloadable abstract from one of these references (Mineralogy and Petrology, 1997) is attached to this assignment.

Read the attached abstract (Shibakusa and Maekawa, 1997) and determine the following:

What kind of rock is present in the Cazadero area?

_____

What minerals do Shibakusa and Maekawa (1997) document in Cazadero rocks?

_____ _____ _____
_____ _____ _____
_____ _____ _____
_____ _____ _____

Use Williams, Turner and Gilbert (WTG) to further research the minerals and textures that may be found in the dominant rock type of the Cazadero area. Are there any additional minerals noted in WTG? Are there any textural features or mineral assemblages that WTG have alerted you to look for? Note this additional information below.

_____
_____
_____
_____
_____
_____
_____

STEP 2: Review Mineral Properties

Use your optical mineralogy texts (Nesse, Perkins and Henke) to review the diagnostic properties of minerals that you are likely to see in the thin-section. Document the **diagnostic** properties of each of the minerals below:

_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____

Are there some minerals that are more problematic to identify? Can some minerals be confused easily with other minerals? Note these minerals below, and describe how they can be distinguished from similar minerals.

_____ _____
_____
_____

_____ _____
_____
_____

_____ _____
_____
_____

_____ _____
_____
_____

_____ _____
_____
_____

Group Report-Outs

STEP 3: Mineral Identification

Examine thin-section 670 and identify the minerals that are present within it. Record this information on the front page of the "Metamorphic Thin-Section Description" form, separating "major minerals" (>5% of the rock) and "accessory minerals" (<5% of the rock). Briefly note two or three of the most striking textural/physical features of each mineral (e.g., average size of crystals, habit of crystals, degree of alteration, occurrence only in veins, occurrence as inclusions, undulose extinction, twinning, etc.). Estimate the abundance of each mineral as a percent; note that for the naming of a metamorphic rock, relative abundance (e.g., % muscovite > % biotite > % garnet) is more important than absolute abundance (e.g., 35% muscovite, 20% biotite, 10% garnet).

Discuss your findings with your table-mates, and agree upon a list of minerals in order of decreasing abundance.

Group Report-Outs

STEP 4: Document Textural Relationships

Re-examine thin-section 670, this time focusing on the textural relationships between neighboring minerals. Use the following questions to guide you through your texturasl analysis:

General textures

- Are minerals segregated in pods or bands? (may indicate regional metamorphic textures such as schistosity and gneissosity; or primary compositional differences such as bedding or amygdales; or localized retrograde metamorphism due to restricted inflow of water)

Reaction-Related Textures

- Are certain minerals commonly in contact? (suggests equilibrium)
- Are certain minerals never in contact? (suggests disequilibrium)
- Are certain minerals commonly/always found as inclusions in another mineral? (possible indicator of prograde metamorphic assemblages and sequence of mineral growth).
- Do certain minerals exhibit complete or partial rims of another mineral? (evidence of mineral reaction, either incomplete prograde reaction or incomplete retrograde metamorphism)
- Are there depletion haloes around porphyroblasts? (evidence of reaction mechanisms)

Deformation-Related Textures

- Is there undulose extinction or deformation twinning? (evidence of deformation)
- Are platy or tabular minerals aligned? (evidence of regional directed pressure)
- Do porphyroblasts exhibit evidence of rotation? (record of deformational history)
- Is there a crenulation? (evidence of multiple episodes of deformation)
- Are some minerals deformed, whereas others are not? Or do some minerals overprint a foliation? (evidence for timing of deformation)

Group Report-Outs

STEP 5: Determine Relative Timing of Mineral Growth

In your group, attempt to interpret the textural data in order to determine the relative order of mineral growth. Which minerals occur only as shielded inclusions, and so may be interpreted as relict prograde minerals? Which minerals display textural equilibrium with each other and the metamorphic fabric, and so may indicate the peak metamorphic assemblage? Which minerals overprint peak metamorphic minerals, or are a rehydration product of other metamorphic minerals, and so may indicate retrograde development?

Group Report-Outs

Thin-section CAZ-1 comes from the same general area as 670, and so the background research that you did to understand 670 can be applied to the study of CAZ-1.

Alone, or in your group examine thin-section CAZ-1 and proceed through Steps 3, 4 and 5. Prepare a thin-section description of this rock. We will discuss your results at the beginning of next week's lab.

Lawsonite-bearing eclogitic metabasites in the Cazadero area, northern California

H. Shibakusa and H. Maekawa

Mineralogy and Petrology, Volume 61, Numbers 1-4 / March, 1997

In the Cazadero area, northern California, Lawsonite-bearing eclogitic metabasites occur in association with glaucophane schists. Lawsonite-bearing eclogitic metabasites are coarse-grained, and characteristically lack albite. Representative mineral assemblages are; (1) garnet + omphacite + Lawsonite + epidote + glaucophane + chlorite + quartz, (2) garnet -F- omphacite + Lawsonite + pumpellyite + glaucophane + actinolite + quartz, (3) garnet + omphacite + Lawsonite + pumpellyite + epidote + glaucophane + quartz. They can be represented on an $A1_2O_3$-Fe_2O_3-MgO-Na_2O diagram in which all minerals are projected from quartz, Lawsonite, almandine garnet, and H_2O-predominant fluid. On the basis of the garnet-clinopyroxene geothermometry and phase relations, the metamorphic conditions for the formation of Lawsonite-bearing eclogitic metabasites are estimated at 360-445 °C and more than 9 ± 1 kbar. Lawsonite-bearing eclogitic metabasites formed near the univariant curve albite = jadeite +quartz. A petrogenetic grid constructed by Schreinemakers' method shows that the Lawsonite-bearing eclogitic metabasites in the Cazadero area formed under transitional P-T conditions between those of the garnet-bearing glaucophane schists in New Caledonia and lawsonitebearing eclogitic metabasites in Corsica.

Metamorphic Thin-Section Description

Sample #: _____ Petrographer: _____

Major Minerals (>5%)	**%**	**Brief Description** (e.g., size, habit, occurrence)

Accessory Minerals	**%**	**Brief Description** (e.g., size, habit, occurrence)

Textural Description:

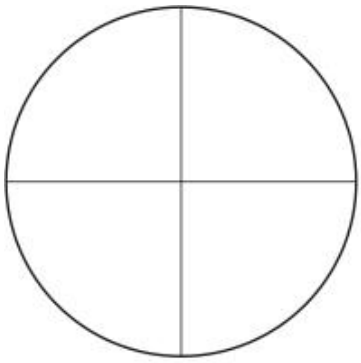

Fig.1 _____

FOV: _____mm

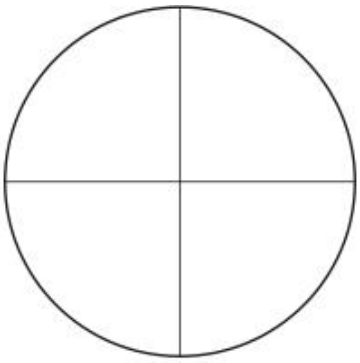

Fig.2 _____

FOV: _____mm

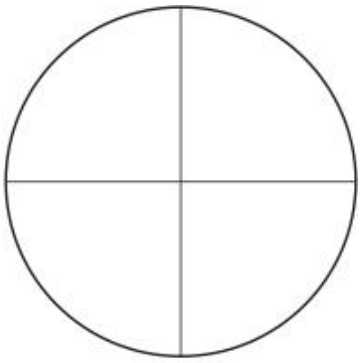

Fig.3 _____

FOV: _____mm

Petrogenetic Interpretation:

Peak Metamorphic Assemblage: _____

Retrograde Minerals: _____

Relict Minerals: _____

Protolith: _____ Main Textural Descriptor: _____

PT Constraints: _____

Metamorphic Rock Name: _____