EESC 2100: Mineralogy

LAB 7: COMMON MINERALS IN METAMORPHIC ROCKS

Part 1: Minerals in Metabasites

Learning Objectives:

- Students will be able to identify the most common silicate minerals that occur in metabasites
- Students will be able to determine metamorphic facies from mineral assemblages present in metabasites

New Minerals: Natrolite, Prehnite, Epidote, Actinolite, Glaucophane, Chlorite, Titanite

Review Minerals: Quartz, Plagioclase, Biotite, Hornblende, Orthopyroxene, Clinopyroxene

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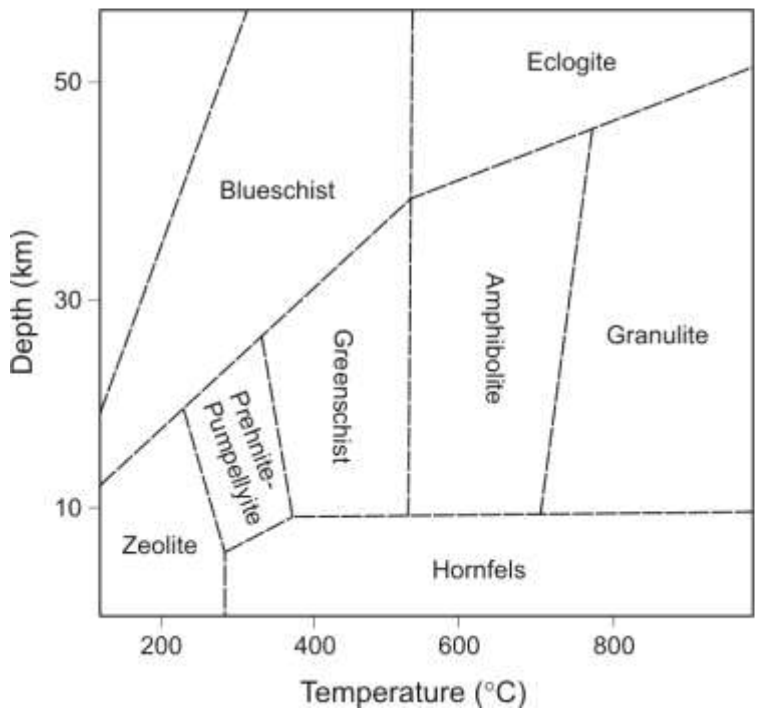
MINERALS IN METABASITES

As you learned in Lab 6, basalts and gabbros are composed of calcic plagioclase along with ferromagnesian minerals such as hornblende, augite, enstatite, and olivine. Thus mafic igneous rocks can be characterized chemically as combinations of the following cations: Si, Al, Ca, Fe, and Mg. When a mafic igneous rock is subjected to new pressure and temperature conditions during metamorphism, these chemical components will rearrange themselves to form new minerals. Which Fe-Mg-Ca-bearing silicates form depends on the specific pressure and temperature conditions, and so by identifying the minerals within a metabasite you can determine the approximate conditions under which the basalt or gabbro was metamorphosed.

Eskola (1915) devised a **metamorphic facies** scheme that linked specific minerals assemblages to corresponding pressure-temperature conditions. For example, the zeolite facies corresponds to a set of low-temperature and low-pressure conditions typified by the growth of zeolites, and the blueschist facies corresponds to a set of low-temperature high-pressure conditions typified by the growth of the amphibole glaucophane. (Note that the term facies is used in several other contexts in geology, most notably in sedimentology. In general a facies can be defined as the sum total of features that reflect the specific environmental conditions under which a given geological material was formed.)



Metamorphic Facies in Relation to Pressure and Temperature

Chlorite is a general name for several sheet-silicate minerals that are considered a subset of the group of clay minerals. The general formula for chlorite is $(Fe,Mg,Al)_6(Si,Al)_4O_{10}(OH)_8$. Like muscovite and biotite, chlorite has a well-developed basal cleavage. Chlorites typically form green, flaky microscopic crystals. The optical properties of chlorite vary systematically with the composition with respect to Fe and Mg. Fe-rich chlorites are optically negative, length slow, and exhibit anomalous blue and purple interference colors. Mg-rich chlorites are optically negative, length fast, and exhibit anomalous brown interference colors. Chlorites that contain approximately equal percentages of Fe and Mg exhibit grey interference colors.

Examine the hand sample of CHLORITE and document its physical properties.

Examine the thin-section of CHLORITE and document its optical properties.

Determine the general composition of the chlorite in CHLORITE thin-section:

Fe-rich Intermediate Mg-rich (circle one)

Several **amphiboles** are common in metabasites. You are already familiar with **Hornblende** ($Ca_2[Mg,Fe,Al]_5$ $[Al,Si]_8O_{22}[OH]_2$) which is a common constituent of metabasites of the amphibolite and granulite facies. Metamorphic hornblende tends to exhibit deep green color in contrast with igneous hornblende which tends to be brown.

Actinolite [$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$] is another green amphibole, although in thin-section the green color is much paler than that of hornblende. It may also be distinguished from hornblende by a lower extinction angle (typically around 15°). Actinolite is common in greenschist-facies metabasites, and along with two other green minerals (epidote and chlorite).

Glaucophane [$Na_2(Mg,Fe)_3Al_2Si_8O_{22}(OH)_2$] is a sodic amphibole that characterizes the subduction-related blue-schist facies. The blue color blueschists is due to the presence of this blue amphibole. In thin-section, glaucophane is distinct due to its purple-blue-yellow trichroism.

Examine the hand sample ACTINOLITE and document its physical properties.

Examine the thin sections ACTINOLITE and GLAUCOPHANE and document their optical properties.

How can actinolite be distinguished from hornblende in hand-sample?

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How can actinolite be distinguished from hornblende in thin-section?

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Epidote [$Ca_2(Al,Fe)Al_2O(SiO_4)(Si_2O_7)(OH)$] is a structurally complex mineral that has both single and double silicate tetrahedrons. These tetrahedral connect parallel chains of octahedrally coordinated Al, resulting in a generally prismatic habit. Its unique green color which is often described as "pistachio", is quite striking in Fe-rich specimens. Low birefringent epidote grains may exhibit anomalous blue interference colors. Epidote is a common mineral in greenschist and amphibolite facies metabasites.

Examine the hand sample EPIDOTE and document its physical properties.

Examine the thin section EPIDOTE and document its optical properties.

How can epidote be distinguished from olivine in hand-sample?

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How can epidote be distinguished from olivine in thin-section?

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Zeolites are a group of minerals that typically form in cavities within volcanic rocks, due to very low grade metamorphism. The zeolites are hydrated framework silicates that consist of interlocking tetrahedrons of SiO_4 and AlO_4. In order to be a zeolite the ratio (Si+Al)/O must equal 1/2. Unlike most other tectosilicates, zeolites have large vacant spaces that allow space for large cations such as sodium, potassium, barium and calcium and even relatively large molecules and cation groups such as water, ammonia, carbonate ions and nitrate ions. These cations and molecules are weakly bonded to the negatively charged Si and Al tetrahedral. The large channels explain the consistent low specific gravity of zeolites, and there use in processes that involve ion exchange, filtering, odor removal, and gas absorption. All zeolites have negative relief and low birefringence.

Examine the hand samples NATROLITE and document their physical properties.

Examine the thin section of NATROLITE and document its optical properties.

Prehnite [$Ca_2Al_2Si_3O_{10}(OH)_2$] is a low-temperature sheet silicate that is a common constituent of zeolite and prehnite-pumpellyite facies metabasites. Like zeolites, prehnite commonly occurs in cavities.

Examine the hand sample PREHNITE and document its physical properties.

Examine the thin section of PREHNITE and document its optical properties.

Titanite ($CaTiSiO_5$) is a common accessory mineral in medium to high-grade metabasites. Also known as sphene, this mineral's high relief and diamond-shaped cross-sections are distinct.

Examine the thin section of TITANITE and document its optical properties.

CLASSIFYING METABASITES

Metabasites are classified by their metamorphic facies, that is, the mineral assemblages that are characteristic of specific ranges of pressure and temperature.

Metamorphic Facies	**Characteristic Mineral Assemblages in Metabasites**
Zeolite	Zeolites (e.g., natrolite)
Prehnite-Pumpellyite	Prehnite, Pumpellyite, Epidote, Chlorite
Greenschist	Actinolite, Epidote, Chlorite, Albite
Amphibolite	Hornblende, Plagioclase (An >20)
Granulite	Clinopyroxene, Orthopyroxene, Hornblende, Plagioclase
Blueschist	Glaucophane

Review the physical and optical properties of biotite, hornblende, clinopyroxene, and orthopyroxene. Examine thin-sections METABASITE 1 and METABASITE 2, and hand-samples METABASITE A and METABASITE B. Document the minerals present in each of the slides/samples. Using this data and the table above, determine to which metamorphic facies these rocks belong.

METABASITE 1

Minerals Present: ____

Metamorphic Facies: __________________________

METABASITE 2

Minerals Present: ____

Metamorphic Facies: __________________________

METABASITE A

Minerals Present: ____

Metamorphic Facies: __________________________

METABASITE B

Minerals Present: ____

Metamorphic Facies: __________________________