

Igneous petrology EOSC 321

Laboratory 4: **Mafic volcanic rocks**

Learning Goals. After this Lab, you should be able:

- Identify the key rock-forming minerals in mafic and intermediate volcanic rocks
- Identify textures of mafic volcanic rocks in thin sections
- Name mafic and intermediate rocks based on their textures and mineral modes using triangle diagrams

Material Needed: a) Microscope, b) Classification triangles and instructions on determination of plagioclase composition included with lab handout; d) a Manual on Optical Mineralogy (i.e. Minerals in Thin Section by Perkins and Henke)

Basalt is the most common terrestrial volcanic rock. Volcanic rocks classified in thin sections as basalts can have substantial variations in chemical compositions. Chemical analysis is absolutely necessary to distinguish, for example, between trachybasalt and basanite. Both of these chemical sub-types of basalt are comprised of plagioclase, augite, olivine and Fe-Ti oxide. Note that in the absence of chemical data we call all rocks in our reference thin sections "basalts". If basalt has olivine in the groundmass (not as phenocryst!), it should be called Olivine basalt. Olivine basalt is Si-undersaturated, alkaline in character. From textures and experiments on natural samples, the common crystallization sequence for basalts is olivine (\pm Mg-Spl) \Rightarrow Ol + Plag (\pm Mg-Spl) \Rightarrow Ol + Plag + Cpx. Thus, augite clinopyroxene is rare as a phenocrystal phase, but comprises up to 50% of the groundmass in basalts.

An important distinction between silica-saturated basalts and basalts of alkaline series can be made through petrographic observations. Alkali olivine basalt has olivine in the groundmass, but rarely has glass in the groundmass. Olivine phenocrysts tell us nothing about alkalinity.

Picrite is an olivine-rich basalt, and rocks with more than 20% of olivine could possibly be termed picrites or picro-basalts. However, a correct classification of a rock as picrite cannot be done petrographically and should be confirmed chemically.

Note that clinopyroxene-plagioclase fine-grained rocks are called basalts if the plagioclase is labradorite-anorthite, or andesites if the plagioclase is andesine.

Activity I

There are several hand specimens of mafic volcanic rocks available in the lab (P469, P64, P2613, P2612, P1737, P619, P1852, P999, P515, MU 72 9A, 935B 4A, MU 74).

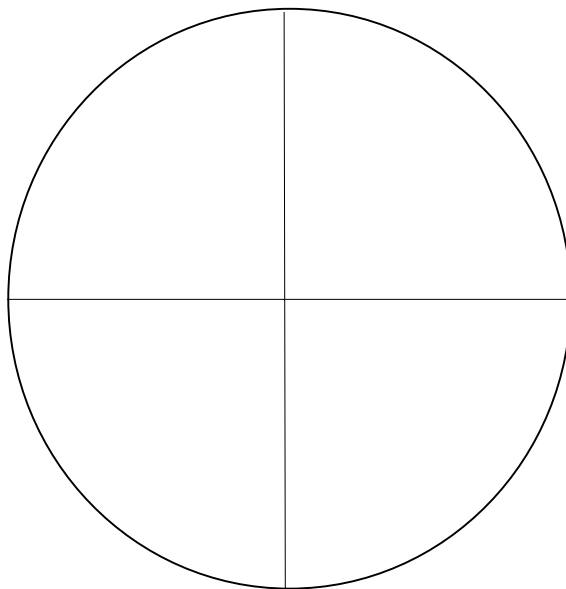
Examine all of them and discuss in a group

- Are mafic volcanics more likely to have porphyritic or aphanitic texture?
- Estimate the range of typical modal abundances (in vol. %) of vesicles in the rocks

Activity II

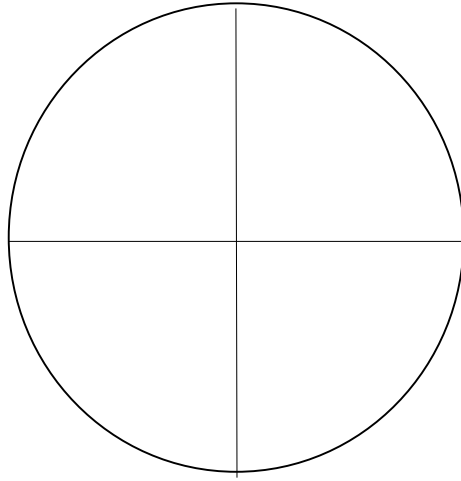
Now we will examine the same mafic volcanic rocks under the microscope. Sixteen microscope stations are prepared for you. Please move from one station to another, spending ~10 min on each short assignment and filling in the answers below. The TA will check the completion of all stations at the end of the Lab.

1. Thin section P469. This rock illustrates how secondary alteration could help in mineral identification. Many phenocryst grains are replaced by bright yellow serpentine along margins and carbonate in the core. The serpentine is fibrous, with radial orientation crudely perpendicular to grain outlines. Note that small Cpx grains in the groundmass are fresh. Therefore, a mineral replaced by yellow serpentine cannot be CPx. We tentatively identify the replaced mineral as Ol based on 1) its general commonality in basalts; 2) its typical alteration to Serp; 3) its shape. Most likely, small mineral grains in the groundmass pseudomorphed by yellow serpentine were also olivines.
2. Thin section 974 P64. This thin section shows glass inclusions in plagioclase phenocrysts. The inclusions were once melt trapped by growing plagioclase. Draw the distribution of glass inclusions in the phenocrysts.



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3. Thin section P2722 1114. This thin section hosts rare cristobalite. This polymorph of SiO_2 is characterized by moderate negative relief and is present in fibrous yellowish mantles and in spherulites. Find it and draw its textural position in the groundmass.



4. Thin section 732 P2613. This is the typical alkali basalt containing olivine in the groundmass. Olivine is replaced by an aggregate of secondary minerals called iddingsite. It is fine-grained reddish- or yellowish-brown material that consists of goetite, clay, chlorite, quartz, talc, and other minerals. Iddingsite alteration in response to higher oxygen fugacity and lower volatile content in quenched lavas. What is the modal proportion of olivine in the groundmass of this rock?
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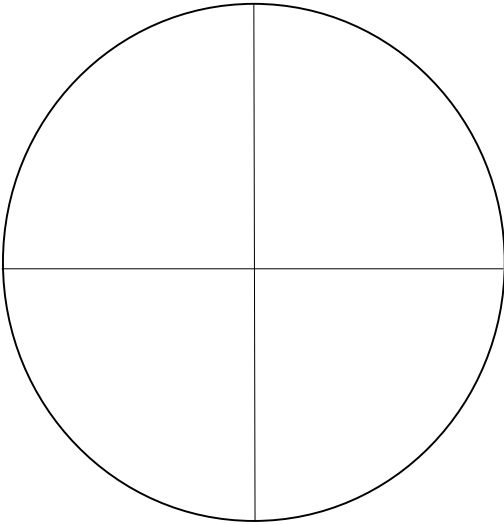
5. Thin section P2612 728. This alkali basalt has vesicular texture. Draw shapes of the vesicles

6. Thin section P1737 871. This basalt has porphyritic overall texture, with trachitic texture of the groundmass. Observe the trachitic texture in the thin section, find the definition of the texture in the list of igneous terms (2 pages from the Winter textbook enclosed with Lab 1) and copy it below.
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7. Thin section 597. This rock has vesicular, porphyritic hypohyaline texture. Examine the thin section and define the term “hypohyaline”. For a hint, find other igneous textural terms that use the same Greek roots in Table 3-1 (enclosed as Reference Material with Lab 1)
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8. Thin section P999 659. Draw the intergranular texture how you see it expressed in this thin section



Copy the definition of this texture from Table 3-1 (enclosed as Reference Material with Lab 1)

9. Thin section 1257 P515. What is the length of the largest clinopyroxene phenocryst in the rock?

What is the length of the largest plagioclase phenocryst in the rock?

10. Thin section A (4 t/s's available). Call up the TA and show him (her)

* Zoning in a mafic mineral

* Glomeroporphyric intergrowth

11. Thin section WT-85-9 (4 t/s's). Draw shapes of individual glassy particles in this pyroclastic rock.

How should we call the rock based on the sizes of the tephra particles? Consult with classification triangles on Fig. 2-5 (enclosed as Reference Material with Lab 1)

12. Thin section WT-85-10 (4 t/s's). Examine the thin section and explain why the rocks shows oriented (planar or linear) texture.

13. Thin section KAS14A. Fill in the table below with information on phenocrysts:

<i>Phenocrystal Mineral</i>	<i>Euhedral or anhedral, describe the shape</i>	<i>Mode (vol.%)</i>
<i>Fill in the name</i>		
<i>Fill in the name</i>		

14. Thin section KAS10. How do you call the texture of the groundmass in this rock?

Sketch shapes of skeletal crystals of phenocrystal olivine in this thin section

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15. Thin section KAS2. Find an amygdale in thin thin section and determine what secondary mineral fills in the original volcanic pore. Amygdale is a vesicle partially or completely filled with secondary minerals

16. Thin section MU74 1A. Observe devitrificatipn of volcanic glass, i.e. secondary crystallization of glass to fine-grained mineral aggregates. Basaltic glass may be replaced by brown, optically isotropic oxidation-hydration products known as palagonite.

Reference collection: Mafic volcanic rocks

Thin Section: 953
Sample: P 469
Rock Type: Olivine Basalt
Location: Stanford, California

Thin Section Description:

Texture: Porphyritic. The groundmass has domains of intersertal texture (glass occupies the wedge-shaped interstices between Plag laths), intergranular texture (the spaces between Plag laths are occupied by one or more grains of Px) and ophitic texture.

- 11% Phenocrysts of plagioclase (7%) and serpentinized olivine (4%).
The Plag phenocrysts are corroded and embayed, have a speckled center with a thin rim of clear feldspar. The speckled core contains numerous inclusions of glass that were originally trapped as melt. This Plag grew partly as a skeletal crystal. The olivine phenocrysts are identified by euhedral shapes and the distinct type of Serp-carbonate alteration.
- 89% Groundmass:
- 36% Plagioclase. Euhedral to subhedral shapes, An₆₈
- 26% Clinopyroxene. Subhedral to anhedral shapes, forms small crystals and larger poikilocrystals enclosing Plag. Partly replaced by yellow Chl.
- 27% Glass, black, N<N balsam

Secondary Minerals: Serpentine after Ol, yellow, has crude radiate to aggregate structure. Carbonate also replaces parts of original olivine grains and is associated with serpentine.

Comment: Note that small Cpx grains in the groundmass are fresh. Therefore, a mineral replaced by yellow serpentine cannot be CPx. We tentatively identify the replaced mineral as Ol based on 1) its general commonality in basalts; 2) its typical alteration to Serp; 3) its shape. Most likely, small mineral grains in the groundmass pseudomorphed by yellow serpentine were also olivines

Thin Section: 974
Sample: P 64
Rock Type: Basalt

Thin Section Description:

Texture: Porphyritic with intergranular groundmass.

- 3% Phenocrysts of zoned Plag with glass inclusions. The amount of Plag phenocrysts is lower than the cut-off for the porphyritic texture (5%).
- 97% Groundmass:
- 65% Plagioclase. Euhedral to subhedral shapes, An₆₀
- 30% Clinopyroxene. Euhedral rhombic to anhedral shapes, partly altered to green Chl.
- 5% Magnetite, euhedral, with red thin rims of secondary hematite.

Secondary Minerals: Chlorite after Cpx, green
Hematite after magnetite

Sample: P 2722
Thin Section: 1114
Rock Type: Basalt with Crystobalite
Location:

Thin Section Description:

Texture: Vesicular (about 10-15% pore space), intergranular to ophitic

63%	Plagioclase, euhedral
25%	Clinopyroxene, anhedral
5%	Opaque mineral forms euhedral triangular crystals surrounded sometime by “atoll” rims of another opaque mineral
3%	Hypersthene
1%	Crystobalite. Characterized by moderate negative relief, uniaxial negative. Present in fibrous yellowish mantles on plagioclase and in spherulites.
3%	High relief, brown-red Mineral (Pseudobrookite? Rutile? Ilmenite? Fe oxide mineral?)

Comments: coarse –grained patches alternate with patches with smaller grain sizes.

Sample: P 2613-2612
Thin Section: 732, 728
Rock Type: Vesicular Olivine Basalt (alkaline)
Location: Quilchena Creek

Thin Section Description:

Texture: Vesicular (30-50% vesicles), aphanitic with sub-ophitic groundmass

Groundmass:

5-10%	Ol, euhedral. Larger crystals have reddish rims of iddingsite formed by oxidation in the process of extrusion and final quenching.
25-40%	Plagioclase, euhedral, An ₆₆ .
18-28%	Cpx, anhedral
2%	Glass, brown, interstitial
1%	Opaque mineral in rod-like grains (ilmenite?)

Secondary Minerals: Iddingsite aggregate. i.e. fine-grained reddish- or yellowish-brown material that consists of goetite, clay, chlorite, quartz, talc, and other minerals. It is a characteristic alteration of olivine phenocrysts in response to higher oxygen fugacity and lower volatile content in quenched lavas.

Thin Section: 871

Sample: P 1737

Rock Type: Basalt

Location: Porcupine Mt., N.W. of Big Bar

Thin Section Description:

Texture: Porphyritic with trachytic groundmass

Phenocrysts:

5% Olivine, subhedral. Rims are altered to iddingsite, i.e. fine-grained reddish- or yellowish-brown material that consists of goetite, clay, chlorite, quartz, talc, and other minerals.

95% Groundmass

70% Plagioclase- Euhedral to subhedral, ~An₆₃₋₆₆.

17% Clinopyroxene, anhedral

5% Orthopyroxene, anhedral

3% Opaque mineral, euhedral, rhombic (magnetite?)

Few grains of K-Fsp

Thin Section: 924

Sample: P 619

Rock Type: Altered andesite

Location: Boulder, Montana

Thin Section Description:

Texture: Aphanitic, hypidiomorphic, as all minerals are subhedral

Phenocrysts: Few grains of plagioclase

Groundmass:

55% Secondary fibrous green amphibole, probably after clinopyroxene.

35% Plagioclase, An 35

5% Biotite, brown

5% Opaque mineral, euhedral identified as pyrite in a polished thin section

Secondary minerals:

55% Amphibole, fine-grained, fibrous, light-coloured green. It is called uralite when it replaces Cpx

Chlorite after uralitic amphibole.

Thin Section: 597

Sample: P 1852

Rock Type: Vesicular Olivine Basalt (alkaline)

Location: Snake River, Ropy lava, Devil's Ranch

Thin Section Description:

Texture: Vesicular (30% vesicles), hypohyaline, microporphyritic

Phenocrysts:

1-4% euhedral olivines ½-1mm, rhombic or skeletal, often with iddingsite yellow rims

Groundmass:

3% euhedral olivines, sometime skeletal

10% Plagioclase An 56-67 in T/s 597

0-3% Brown glass, n>balsam.

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0-1% Cpx, subhedral

80% Black opaque glass

Secondary Minerals: Iddingsite after Olivine

Thin Section: 659

Sample: P 999

Rock Type: Vesicular Basalt

Location: Near Risk Creek, Chilcotin

Thin Section Description:

Texture: Vesicular (10% vesicles), porphyritic, intergranular

Phenocrysts: 4% euhedral olivines always with iddingsite yellow rims

Groundmass (96%):

64% Plagioclase, euhedral, An₆₄

30% Clinopyroxene, subhedral, round

2% Opaque anhedral and elongate mineral (ilmenite?)

Secondary Minerals: reddish- yellow iddingsite after Olivine

Thin Section: 1257

Sample: P515

Rock Type: Basalt

Location: Jamestown, California

Thin Section Description:

Texture: Porphyritic with intersertal groundmass

Phenocrysts: 25%

20% Plagioclase, with numerous glass inclusions, euhedral, An₅₀

4% Olivine.

1% Clinopyroxene,. Brownish

Few grains of Orthopyroxene. Low birefringence, surrounded by clinopyroxene.

75% groundmass:

40% brown glass. Glass filled with scattered speckled globulites

30% Plagioclase, euhedral laths

5% Ol + clinopyroxene

1% Opaque mineral in triangular grains and in rods

Secondary Minerals: Talc (?) in fractures in Px and Ol

Homework assignment

EOS Mining, a mineral exploration company, has hired you and your colleague to stake a new ground with sulfide deposits. In the area of interest, these deposits are associated with mafic dykes that host mantle xenoliths. There is a known, cross-cutting, NW-SE trending strike-slip fault dividing the area. Previous mapping work of field crews has identified three distinct dykes (A, B, C) to the west of the fault, with one of them containing the sulfide deposit. To the east of the fault, there is little exposure due to heavy vegetation. Your job is to determine the exact location of the mineralized dyke continuation to be staked out for a new mine in this vegetated area, based on thin sections and bulk chemical analyses given to you by the TA. The Lab assignment should be completed and handed to your TA IN TWO WEEKS during your regular Lab hours. There will no Lab next week due to the Thanksgiving holiday.