Igneous petrology EOSC 321

Laboratory 2:

Determination of plagioclase composition. Mafic and intermediate plutonic rocks

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

- Determine plagioclase composition in a thin section
- Identify the key rock-forming minerals in mafic and intermediate rocks
- Name mafic and intermediate rocks based on their textures and mineral modes using triangle diagrams

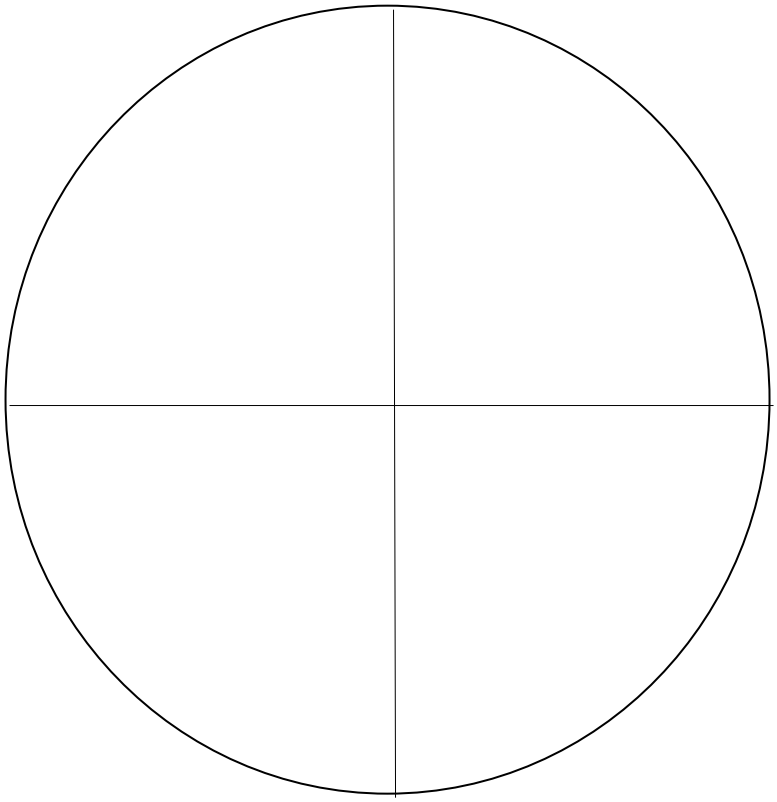
Material Needed: a) Microscope, b) Classification triangles and instructions on determination of plagioclase composition included with lab handout; d) a Manual on Optical Mineralogy (i.e. Minerals in Thin Section by Perkins and Henke)

Test. You will receive a thin section of an unknown ultramafic rock for your independent 30 minute examination. Draw a sketch of the key features of the rock and write its petrographic description finally give it a rock name. You may use your previous lab notes, textbooks etc., but NO ELECTRONIC DEVICES! Your petrographic report should be completed and handed to the TA by the end of the first 30 minutes of your Lab.

TEST 1 Ultramafic Rocks

Thin section _____
Magnification_____
Field of view width _____

Your Name:_____
Student ID:_____



Texture:

Description:

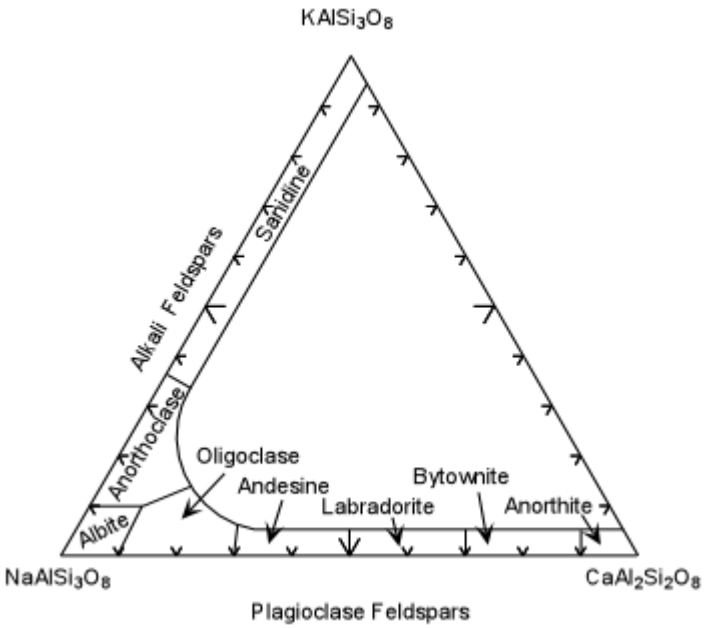
Rock name:

Activity II. The composition of plagioclase can help us to understand the crystallization history of the magma from which it crystallized. The composition of plagioclase can be used as an important diagnostic tool in igneous petrology. The optical orientation of plagioclase varies systematically with composition, this results in systematic changes in the extinction angle of twin lamellae as composition changes from the Albite to the Anorthite end members. We use the Michel Levy method to determine the composition of plagioclase in thin section.

The importance of this petrographic skill cannot be overestimated. The very classification of rocks depends on the correct determination of the composition of plagioclase. A coarse-grained clinopyroxene-plagioclase rock could be called gabbro if the plagioclase is Ca-rich or diorite if the plagioclase is more sodic (i.e. andesine). Even though rock descriptions in the reference collections do not include the plagioclase compositions, your rock descriptions done for independent assignments should always provide the plagioclase composition. From now on, this will be a routine part of the petrographic examination for you.

To practice the method, your TA will give you a thin section with the known composition of plagioclase. Listen to the TA's step-by-step instructions, repeat them on your microscope and thin section, measure the extinction angles for 3-5 grains and read the resulting plagioclase composition from the Michel-Levy plot. Check this value with your TA to ensure your plagioclase analysis is correct. If not, repeat the measurements until you arrive at the correct value.

See 'Instructions on determining plagioclase composition' on the course website for more information on the technique, and also pgs 46& 47 of Perkins and Henke.



Activity III

Mafic rocks consist mainly of clinopyroxene and plagioclase (labradorite) with accessory orthopyroxene, olivine, hornblende and biotite. Typical alteration products of these primary phases are chlorite, sericite (fine-grained muscovite), talc, serpentine, amphibole and mica. Mafic plutonic rocks include gabbro, norite, troctolite, anorthosite, and diabase. Diabase is the North American name used for medium-grained basic rocks (grains 1-3 mm) consisting essentially of labradorite, augite and ore minerals, i.e. equivalent of basalt and gabbro. The rest of the world uses the term Dolerite in preference to Diabase to denote the same rock. Diabase has smaller grains than other plutonic mafic rocks and often is formed in a hypabyssal environment. An abundant intermediate plutonic rock is diorite. This is a coarse-grained rock consisting of andesine plagioclase and one or more mafic minerals clino- and orthopyroxene, hornblende, and biotite. A little quartz, K-feldspar and olivine may be present. Diorite is a coarse-grained equivalent of andesite.

There are several hand specimens of mafic and intermediate plutonic rocks available in the lab. (P939, P1241, P2720, P2716, P2112, P722, P752, P872, P521, P271, P307, P18, P478, P572, P909, P1065). Examine all of them and answer the following questions:

What colour is the plagioclase in mafic rocks?

_____

What colour is olivine in mafic rocks?

_____

Activity IV. Now we will examine some mafic and intermediate plutonic rocks under the microscope comparing the thin sections with the reference petrographic descriptions. Please make sure you understand these and can find all of the minerals mentioned. You should also be able to understand why a rock is given a particular name.

Work through the list below and check that you have seen the following:

- ✓ *Ophitic or subophitic texture of mafic rocks. This very common texture is created by euhedral plagioclase and anhedral pyroxene and olivine. Can be observed in T/s's 1349, 1367, 1685, 1689, 1690, 960, 1349, 1217, 1268, 1019, 691, 1312*

- ✓ *Gabbronorite. Can be observed in T/s's 1349, 1367, 1019, 691*

- ✓ *Gabbro. Can be observed in T/s's 1685, 1689, 169, 960*

- ✓ *Anorthosite. Can be observed in T/s's 1173*

- ✓ *Diabase (dolerite). Can be observed in T/s's 1268, 1312, 339*

- ✓ *Diorite – Intermediate rock with plagioclase An<50. Can be observed in T/s's 1446, 1459*

- ✓ *Late crystallization of hornblende replacing orthopyroxene. This can be a result of a primary magmatic, deuteric, or secondary process. Can be observed in T/s's 1367, 1019, 691*

- ✓ *Late crystallization of deuteric biotite around orthopyroxene and an opaque mineral. Can be observed in T/s's 438*

- ✓ *Bowen's reaction series illustrated by a single rock. Clinopyroxene crystallizes after and around olivine. The clinopyroxene, in turn, is replaced by hornblende. Can be observed in T/s's 1019, 691*

- ✓ *Granophyric intergrowths of quartz and alkali feldspar in interstices of diabase. Can be observed in T/s's 339*

- ✓ *Difference between anhedral, interstitial quartz and euhedral, altered plagioclase. Can be observed in T/s's 1446, 1459*

Reference collection: Mafic and intermediate plutonic rocks

Thin Section: 1685 (2 T/s), 1689, 1690
Sample: P 2720, feeder plug, P2716, P2112
Rock Type: Olivine gabbro
Location: Bonaparte Area

Thin Section Description:

Texture: Subophitic, typical of mafic intrusive rocks. It is created by elongate chadacrysts of Plag enclosed by oikocrysts of Px. In gabbros, chadacrysts of plagioclase are partially enclosed by oikocrysts of pyroxene and olivine.

83% Plagioclase, euhedral to subhedral.

10% Olivine, euhedral . Can be recognized by the extinction parallel to the elongation, and the absence of cleavage.

7% Clinopyroxene. Smaller grains, anhedral to subhedral, grey-greenish in colour, with cleavage.

1% Opaque mineral, anhedral to euhedral

traces of apatite – in small euhedral grains with hexagonal cross-sections, high relief and very low birefringence.

Thin Section: 960 !! Thicker than normal thin section as evidenced by the yellow interference colour of plagioclase 14
Sample: P478
Rock Type: Gabbro
Location:

Thin Section Description:

Texture: Subophitic

50% Plagioclase, euhedral

50% Clinopyroxene, grey-greenish, anhedral

Thin Section: 1349
Sample: P 1241
Rock Type: Olivine gabbronorite
Location:

Thin Section Description:

Texture: Subophitic, typical of mafic intrusive rocks. It is created by elongate chadacrysts of Plag enclosed by oikocrysts of Px. In gabbros, chadacrysts of plagioclase are partially enclosed by oikocrysts of pyroxene and olivine.

70% Plagioclase, euhedral to subhedral. Combined Carlsbad-Albite twins give extinction angles of 20 and 31 => An_{61}

15% Clinopyroxene. Anhedral

8% Olivine in subhedral grains now almost totally replaced by a secondary aggregate of serpentine, fine-grained black opaque hematite and talc.

4% Orthopyroxene. Anhedral to subhedral shapes. Slightly pleochroic

1% Opaque mineral, anhedral

Thin Section: 1367
Sample: P 939
Rock Type: Pyroxene Hornblende Gabbronorite
Location: Ruskin Dam, W.H.M

Thin Section Description:

Texture: Hypidiomorphic

60% Plagioclase. Euhedral to subhedral shapes, An_{60} , but zoned!

15% Orthopyroxene. Euhedral to subhedral shapes. Shows lamellae. Low birefringence, parallel extinction. Rimmed by late amphibole

5% Clinopyroxene. Euhedral to subhedral shapes, inclined extinction. Rimmed by late amphibole

10% Amphibole, pleochroic from darker to lighter green (Hornblende?)

2% Opaque mineral, anhedral

Comments: Amphibole is late magmatic (deuteric?) or secondary

Thin Section: 1173
Sample: P722
Caution: Thin section is thicker than normal and plagioclases appear yellow in cross polarized light!

Rock Type: Anorthosite
Location: Troodos, Cyprus

Thin Section Description:

Texture: Allotriomorphic: all minerals are anhedral

96% Plagioclase, anhedral to subhedral

3% Olivine, anhedral, interstitial

1% Amphibole, forms rims on olivine, pleochroic from light to dark green, cleavage at 60^{o} (hornblende?)

few grains of black opaque minerals

Secondary Minerals: Epidote or clinozoisite, characterized by moderate relief, anomalous blue interference colour and twinning. Found in large auhedral elongate laths, after Plag or Px?

Thin Section: 1217
Sample: P752
Rock Type: Fine-grained diorite
Location: ?

Thin Section Description:

Texture: Subophitic

73% Plagioclase- Euhedral, ~An_{42}. based on albite twins.
10% Clinopyroxene, grey, from subhedral to anhedral, often twinned.
7% Opaque mineral or minerals. Some grains are euhedral elongate (Ilmenite?), some are anhedral.
5% Hornblende, pleochroic from dark to light khaki, with cleavage at 60o
4% Apatite in small euhedral crystals hexagonal or elongate.
1% Quartz

Secondary Minerals: Biotite, chlorite

Thin Section: 1268
Sample: P872
Rock Type: Diabase
Location: Sooke

Thin Section Description:

Texture: Subophitic

70% Plagioclase- Euhedral to subhedral, ~An_{87}. based on albite twins.
27% Clinopyroxene, grey, subhedral
3% Olivine, subhedral, one grain is surrounded by a reaction rim made of orthopyroxene. Another grain is replaced by green serpentine
1% Quartz

Secondary Minerals: Talc after Cpx, Serp after Ol

Thin Section: 339
Sample: P 521
Rock Type: Diabase with granophyric intergrowths
Location: Salem, Mass.

Thin Section Description:

Texture: Subophitic, with granophyric intergrowths. Granophyric texrure is defined as radiate intergrowths of quartz and alkali feldspar.

50% Clinopyroxene, grey, subhedral to anhedral. Zoned!
49% Plagioclase, euhedral to subhedral, ~An_{55}. Most of grains are altered into -grained muscovite called sericite.
<1% Granophyric intergrowths of quartz and alkali feldspar present in interstices.

Secondary Minerals: Sericite after Plag and Fsp.

Thin Section: 1019
Sample: P271
Rock Type: Olivine gabbronorite
Location: Sooke

Thin Section Description:

Texture: Subophitic in T/s 1019 and ophitic in T/s 691. In ophitic texture, large pyroxene grains enclose small random plagioclase laths.

65-70% Plagioclase, subhedral, zoned, based on complex Carlsbad-Albite twinning its composition is An_{84}-An_{81}

20-30% Clinopyroxene, grey-greenish, anhedral, sometime has lamellar structures (Twinning? Exsolution lamellae?), altered along fractures and rims into amphibole

5-7% Olivine, subhedral, often is surrounded by clinopyroxene and an opaque mineral.

Secondary minerals:

5% Amphibole, pleochroic from light green to light brown (hornblende?), replaces Cpx

1% powder of fine hematite (?) is present on Ol rims

Comment: grain sizes of the rocks vary in thin sections; parts of T/s 691 are medium- to fine-grained and could be classified as diabase.

Thin Section: 691
Sample: P307
Rock Type: Olivine gabbronorite
Location: Sooke

Thin Section Description:

Texture: Subophitic in T/s 1019 and ophitic in T/s 691. In ophitic texture, large pyroxene grains enclose small random plagioclase laths.

65-70% Plagioclase, subhedral, zoned, based on complex Carlsbad-Albite twinning its composition is An_{84}-An_{81}

20-30% Clinopyroxene, grey-greenish, anhedral, sometime has lamellar structures (Twinning? Exsolution lamellae?), altered along fractures and rims into amphibole

5-7% Olivine, subhedral, often is surrounded by clinopyroxene and an opaque mineral.

Secondary minerals:

5% Amphibole, pleochroic from light green to light brown (hornblende?), replaces Cpx

1% powder of fine hematite (?) is present on Ol rims

Comment: grain sizes of the rocks vary in thin sections; parts of T/s 691 are medium- to fine-grained and could be classified as diabase.

Thin Section: 1446
Sample: P1065
Rock Type: Quartz Diorite
Location: Craigmore, Scotland

Thin Section Description:

Texture: Intergranular. In this texture the spaces between plagioclase laths are occupied by one or more grains of anhedral minerals, where adjacent interstices are not in optical continuity.

60% Plagioclase. Euhedral large grains, Altered to sericite. An $_{8,5?}$
Intergrown with vermicular quartz at the margin of Plag crystals forming myrmekitic texture

10% Quartz, anhedral, interstitial, not altered, unlike other minerals

15% Hornblende. Subhedral, pleochroic from brown to yellow, with cleavage at 60^{o}. Altered to chlorite.

5% Biotite. Subhedral, pleochroic from dark brown to colourless. Altered to chlorite.

0.5% Apatite in tiny hexagonal euhedral crystals with very low birefringence

few grains of black opaque minerals (Magnetite?)

few grains of Zircon – very high relief and birefringence, euhedral

Secondary Minerals:

10% Chlorite. Green-blue colour, with low relief, weakly pleochroic.

Epidote, Carbonate

Thin Section: 1459
Sample: P909
Rock Type: Diorite
Location: N of Leavenworth

Thin Section Description:

Texture: Hypidiomorphic, all minerals are subhedral.

~84% Plagioclase, subhedral to euhedral. ~An_{43}
Plag grains ideal for determination of its composition in complex Carlsbad-Albite twins are marked.

7% Hornblende, subhedral, pleochroic from green to yellow-green, with cleavage at 60^{o}.

3% Biotite. Subhedral, pleochroic from dark brown to colourless.

3% Orthopyroxene. Euhedral, (-) 2V~60^{o}, weakly pleochroic.

3% Quartz, anhedral interstitial

0.5% Apatite in tiny hexagonal euhedral crystals with very low birefringence
Commonly enclosed by hornblende.

few grains of Zircon or Sphene– very high relief and birefringence, euhedral

Thin Section: 1312
Sample: P 18
Rock Type: Diabase
Location: Palisades, Jergen Hill, N.J.

Thin Section Description:

Texture: Ophitic

35% Clinopyroxene, grey, subhedral to anhedral. Often twinned
64% Plagioclase- Euhedral to subhedral, rarely sericitized.
<1% Biotite, pleochroic from dark brown to colourless
<1% Opaque, in elongate grains

Secondary Minerals: Sericite after Plag.

Thin Section: 438 !! Thicker than normal thin section as evidenced by the yellow interference colour of quartz
Sample: P 572
Rock Type: Quartz Norite
Location:

Thin Section Description:

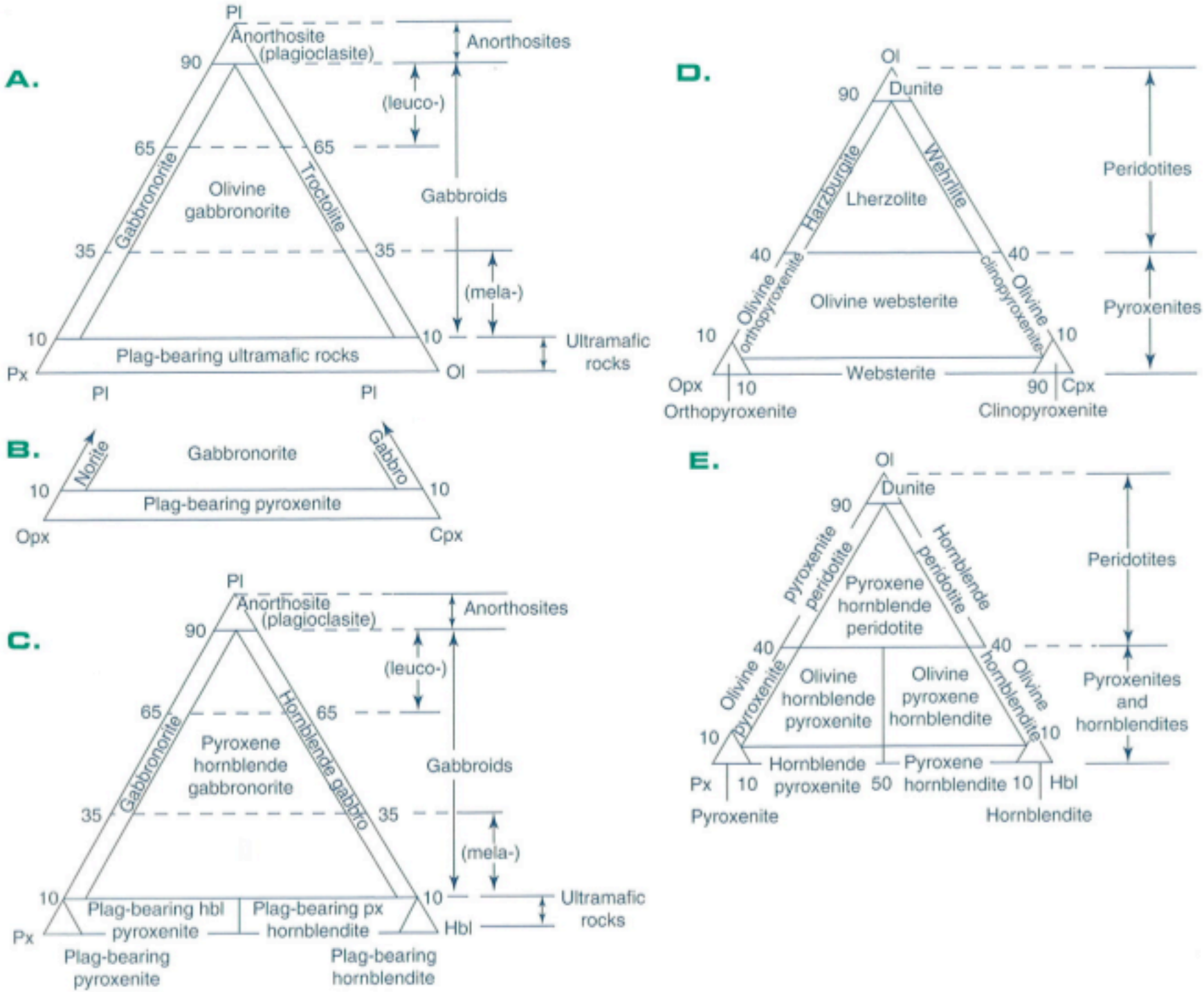
Texture: Hypidiomorphic

64% Plagioclase- Labradorite, euhedral to subhedral, always sericitized.
30% Opx, grey, subhedral, rectangular, Often twinned
5% Qz, interstitial, easily recognized due to lack of alteration
3% Biotite, pleochroic from dark brown to colourless, develops deuterically around Opx and opaque mineral
1% Opaque mineral

Single grain - microcline

Secondary Minerals: Sericite after Plag,

Deuteric chlorite around Opx, pleochroic from light green to light blue


A.
Pl
Anorthosite
(plagioclasite)
90
Anorthosites
(leuco-)
65
65
Gabbronorite
Troctolite
Olivine
gabbronorite
Gabbroids
35
35
(mela-)
10
10
Plag-bearing ultramafic rocks
Ultramafic
rocks
Px
Ol
Pl
Pl
B.
Norite
Gabbronorite
Gabbro
10
10
Plag-bearing pyroxenite
Opx
Cpx
C.
Pl
Anorthosite
(plagioclasite)
Anorthosites
90
(leuco-)
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65
Gabbronorite
Hornblende gabbro
Pyroxene
hornblende
gabbronorite
Gabbroids
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Plag-bearing hbl
pyroxenite
Plag-bearing px
hornblendite
Ultramafic
rocks
Px
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pyroxenite
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hornblendite
D.
Ol
90
Dunite
Harzburgite
Wehrlite
Lherzolite
Peridotites
40
40
Olivine
orthopyroxenite
Olivine
clinopyroxenite
Olivine websterite
Pyroxenites
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10
Websterite
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90
Cpx
Orthopyroxenite
Clinopyroxenite
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pyroxenite
peridotite
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Pyroxene
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Pyroxenite
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