IGNEOUS PETROLOGY
(Practical)

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Lab. 1

Diagnostic features of igneous minerals under the microscope

Felsic minerals

1. **Quartz SiO_2:** anhedral or subhedral, colorless and without pleochroism, without cleavage, low relief, parallel extinction, first order gray interference color, devoid of alteration.

2. **Orthoclase $KAlSi_3O_8$:** subhedral to anhedral, colorless but dusty result alteration to kaolinite and sericite, low relief, carlsbad twinning, first order gray to white interference color, parallel or oblique extinction.

3. **Microcline $KAlSi_3O_8$:** similar to orthoclase but distinguished from it by cross hatch twinning.

4. **Sanidine $(K, Na)AlSi_3O_8$:** similar to orthoclase in most of features (color, relief and interference color) but alteration less than it or devoid of alteration, distinguished by its tabular to elongated euhedral to subhedral crystals and transverse cracks.

5. **Plagioclase, Albite $NaAlSi_3O_8$ -----Anorthite $CaAl_2Si_2O_8$**: similar to orthoclase in most of features (color, interference color, alteration and sometimes medium relief), tabular to elongate euhedral or subhedral and sometimes anhedral crystals, oblique extinction.
   Distinguished by its polysynthetic twinning and sometimes zoning.

6. **Muscovite $KAl_3Si_3O_{10}(OH)_2$:** colorless or pale color and third to fourth order bright interference color, 1-set cleavage, parallel extinction.

Mafic minerals

7. **Biotite $K(Mg, Fe)_3(AlSi_3O_{10})(OH)_2$:** brown color and distinct pleochroism from light-brown to dark-brown, third order interference color but often mask interference color, medium relief, 1-set cleavage, parallel extinction, birds eye texture, it alters to chlorite mineral is green color.

8. **Hornblende $(Ca, Na)_{2-3}(Mg, Fe, Al)_5Si_6(Si, Al)_2O_{22}(OH)_2$:**
   Common Hornblende*:* green to yellowish-green, perfect cleavage 1-set or 2-set at angle of 56°-124°, medium relief, second order interference color, oblique extinction 10°-30° in prismatic sections and symmetrical extinction is split to cleavage angle in basal sections (perpendicular on C-axis), common hornblende occurs in plutonic igneous rocks.
   Basaltic Hornblende: brown color, high relief, perfect cleavage similar to common hornblende, often mask interference color, oblique extinction less than 10°, it alters to pyroxene and magnetite, basaltic hornblende occurs in volcanic igneous rocks.

9. **Pyroxene group XYZ_2O_6:** anhedral to subhedral in plutonic rocks and subhedral to euhedral in volcanic rocks, whereas euhedral in perpendicular sections on C-axes, pale color, 1-set cleavage in prismatic sections but 2-set cleavage in basal sections at angle 87°-93°.

   A. Orthopyroxene (Parallel Extinction):

   - **Enstatite:** colorless, first order gray interference color, good cleavage.
   - **Hypersthene:** light-brown or pink color, weak pleochroism.

   B. Clinopyroxene (Oblique Extinction):

   - **Aegirine:** dark-green color (grassy-green) with pleochroism, mask interference color, oblique extinction at angle 2°-10°.
   - **Aegirine-Augite:** light-green and pleochroism from light-green to yellowish-green, mask interference color, oblique extinction at angle 15°-38°.
   - **Augite , Ti-Augite:** light-brown color but Ti-Augite pale-pink depending on Ti, oblique extinction at angle 36°-57° (average 46°) , second order interference color.

- **Diopside:** light-green or colorless, second order interference color, oblique extinction at angle 36°-43°, diopside is similar to augite but distinguished from it by color and diopside occurs in ultrabasic igneous rocks.

10. **Olivine $(Mg, Fe)_2\ SiO_4$:** stumpy prismatic crystals, high relief, colorless, without cleavage but distinguished by its fracture, third order interference color, parallel extinction, alteration to Iddingsite is red color result to oxidation or Serpentine is green color result to hydration.

11. **Zircon $ZrSiO_4$:** small prismatic crystals, high relief with fracture, colorless surrounded it by chromatic aureoles, inclusion inside biotite.

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12. **Apatite $Ca_5(PO4)_3(F,Cl,OH)$:** small prismatic or equant hexagonal crystals**,** medium to high relief, colorless, first order gray interference color. Parallel extinction in prismatic sections and isotropic in hexagonal crystals (perpendicular on C-axis).

13. **Sphene $CaTiO(SiO_4)$:** wedge-shape, high relief**,** dusty color, White high order interference color.

14. **Spinel $MgAl_2O_4$:** green or yellow and sometimes black color, anhedral crystals, high relief, isotropic mineral.

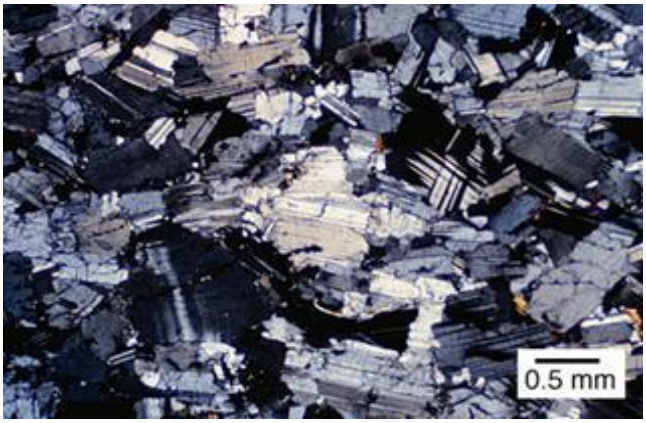
15. **Chromite $FeCr_2O_4$:** dark-red color similar to coffee, isotropic mineral.

Lab. 2
Textures of Igneous Rocks

Texture: refers to the way in which individual grains relate to grains surrounding them. Texture deals with small-scale features seen in hand specimen or under the microscope, such as the degree of crystallinity, grain size, grain shape, grain orientation, grain boundary relations and crystal intergrowths. Textures are useful indicators of cooling and crystallization rates and of phase relations between minerals and magma at the time of crystallization.

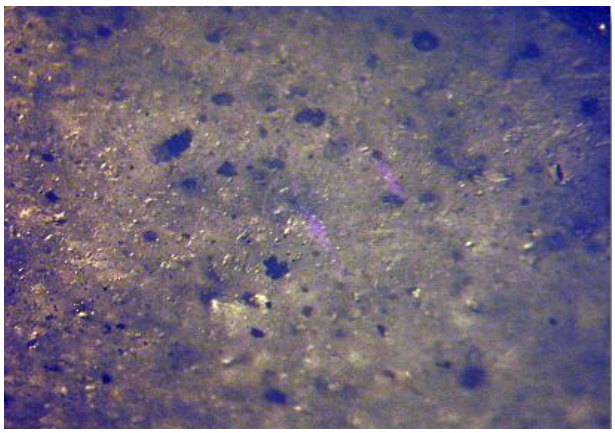
1. Texture referring to the crystallinity of an igneous rock

Holocrystalline: refers to a rock composed of entirely crystalline material.



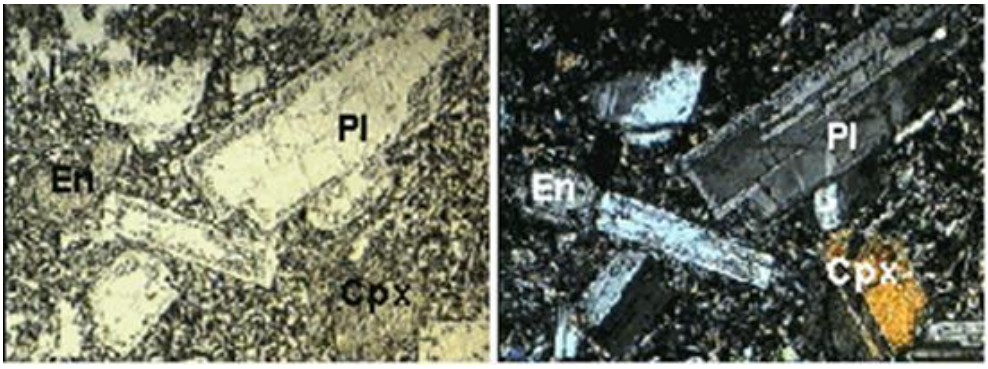
Anorthosite sample which is entirely composed of plagioclase crystals.

Holohyaline: refers to a rock composed of entirely glassy material.



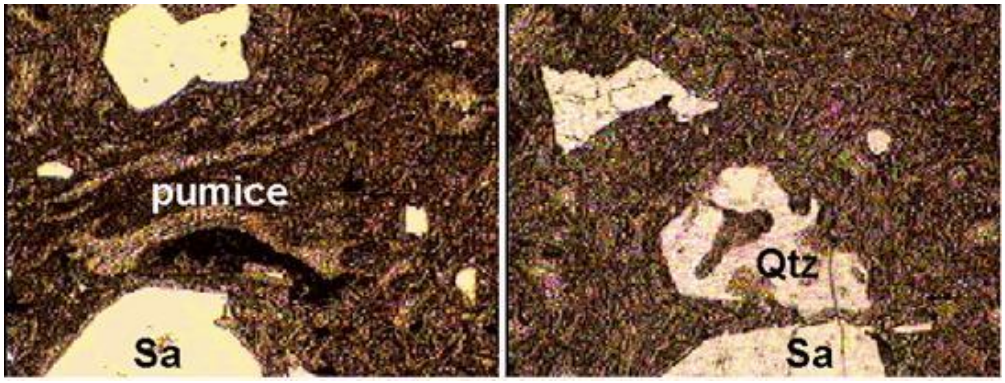
Obsidian sample (volcanic glass) which is entirely composed of siliceous glassy material.

Hypocrystalline: refers to a rock composed of both crystals and glassy material, but amount of crystals is greater than glassy material.



Andesite sample which is composed of both plagioclase (Pl) and clinopyroxene (Cpx) crystals with a fine grained groundmass. In this sample, amount of glassy material, which is essential component of the groundmass is less than the total amount of crystals.

Hypohyaline: refers to a rock composed of both crystals and glassy material, but amount of glass is greater than crystals.

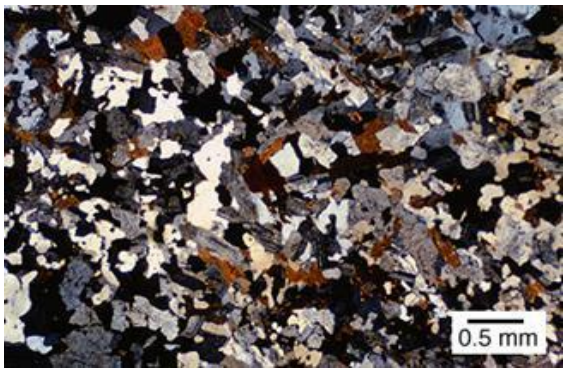


Rhyolite sample which is composed of volcanic glass shards, pumice fragments and free crystals (Qzt-quartz; Sa-sanidine). In this sample amount of volcanic glass material is higher than the amount free crystals.

2. Texture referring to the granularity of an igneous rock

The absolute crystal sizes:
Coarse-grained implies crystal size > 5 mm.
Medium-grained implies crystal size between 1-5 mm.
Fine-grained implies crystal size < 1 mm.

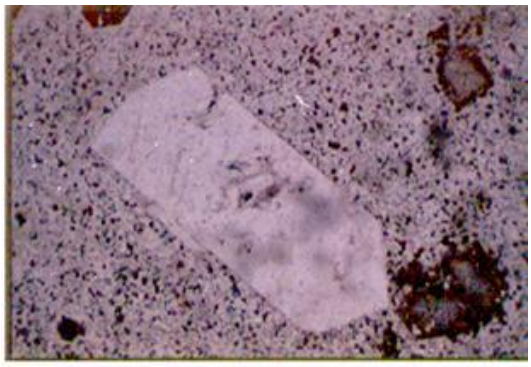
The relative crystal sizes:
Equigranular texture: refers to grains sizes are nearly equal; it is including an igneous rock texture, in which the diameters of component minerals are comparable.



Biotite granite sample which is composed of nearly equigranular crystals of quartz (white), K-feldspar (grayish), plagioclase (grayish with polysynthetic twining) and biotite (reddish brown) minerals.

Porphyritic texture: refers to minerals are large grains called phenocrysts surrounded by grains smaller size called groundmass from the same phenocrysts minerals, groundmass be formed from microlite and glass.

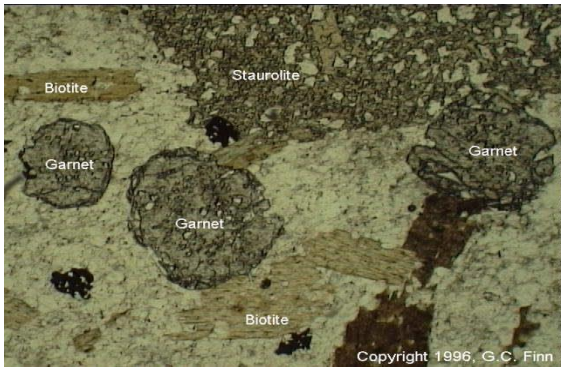
A porphyric rock which is composed of euhedral-subhedral feldspar phenocrysts in a fine grained groundmass



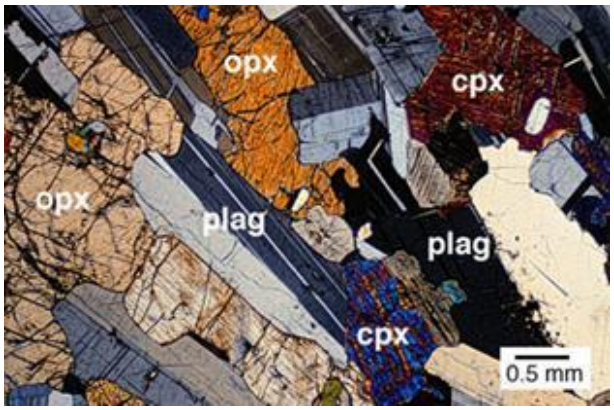
A porphyritic volcanic rock which is composed of euhedral sanidine, quartz (not visible) and some altered mafic (amphibole) minerals in groundmass.

3. Texture referring to the crystal shapes of an igneous rock

Allotriomorphic or Xenomorphic texture: the whole constituents are anhedral in shape.



Hypidiomorphic texture: refers to a texture, in which the grains of some mineral species are anhedral, those of others subhedral and those of some may even be euhedral. This texture is typical of granitic rocks in many of which quartz and orthoclase tend to be anhedral and plagioclase and biotite are subhedral to euhedral.

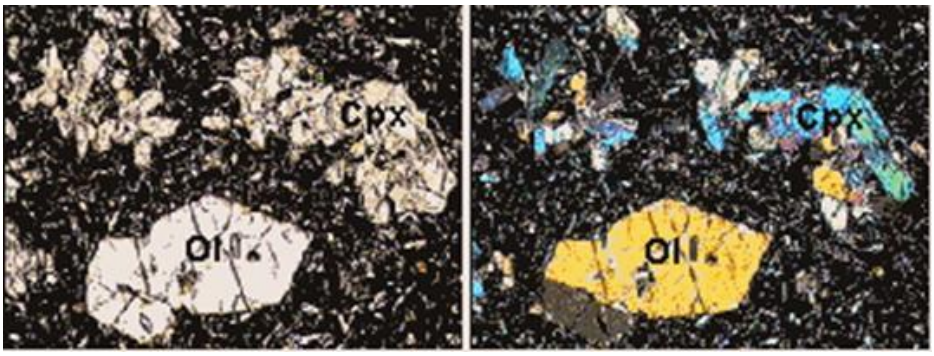


Norite sample which is composed of euhedral-subhedral and anhedral plagioclase minerals (Plag: gray-black colored minerals with polysynthetic twining) and subhedral-anhedral orthopyroxene (Opx) and clinopyroxene (Cpx) minerals.

Idiomorphic texture: the whole constituents are euhedral in shape.

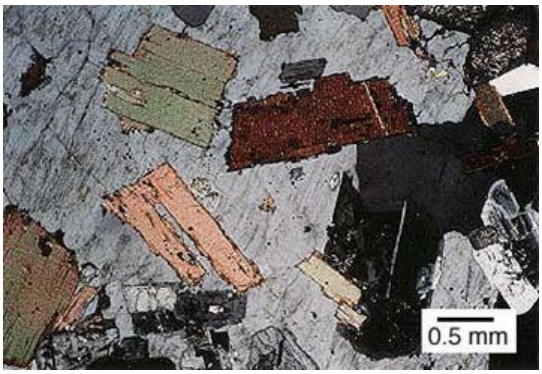
4. Texture referring to interrelations between the crystals

Glomeroporphyritic texture: results when phenocrysts aggregate in groups and it refers to porphyritic texture in which phenocrysts occur in clusters. This texture represents accumulations of fractionated crystals.



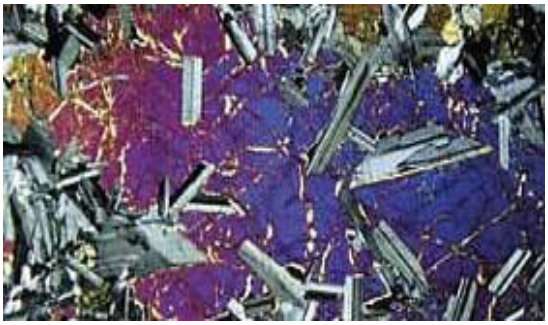
Olivine basalt sample which is composed of olivine (Ol), Clinopyroxene (Cpx) phenocrysts and plagioclase microphenocrysts (not seen) in a fine grained groundmass. Note that the aggregation of Clinopyroxene minerals as glomerocrysts.

Poikilitic texture: randomly oriented inclusions within large crystals (sieve like texture).



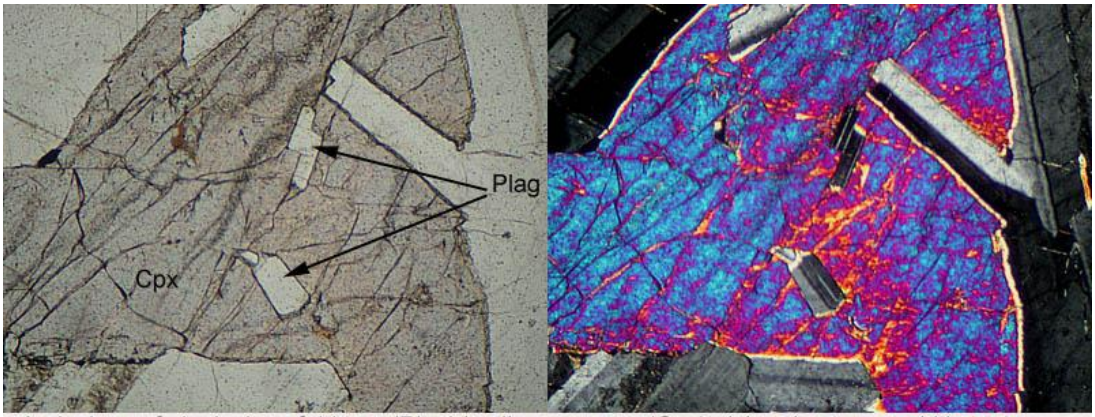
Biotite minerals (reddish-greenish-dark brown) poikilitically enclosed by a large K-feldspar mineral (light- gray).

Ophitic texture: is a term generally used for gabbroic rocks and refers to the augite crystals are larger than plagioclase, plagioclase (labradorite-bytownite) wholly enclosed within pyroxene (augite).



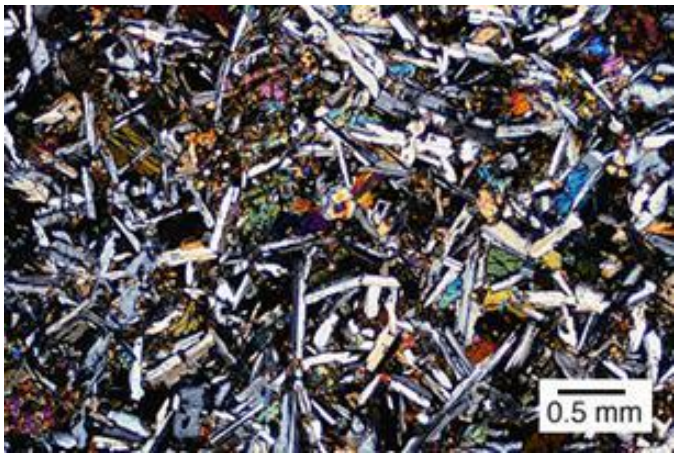
Gabbro sample that shows extremely large crystals of pyroxene surrounding smaller plagioclase crystals.

Sub-ophitic texture: is a term also used for gabbroic rocks and refers to a situation where the augite grains are somewhat smaller, and not much larger than the plagioclase; they will thus only partly enclose individual plagioclase.



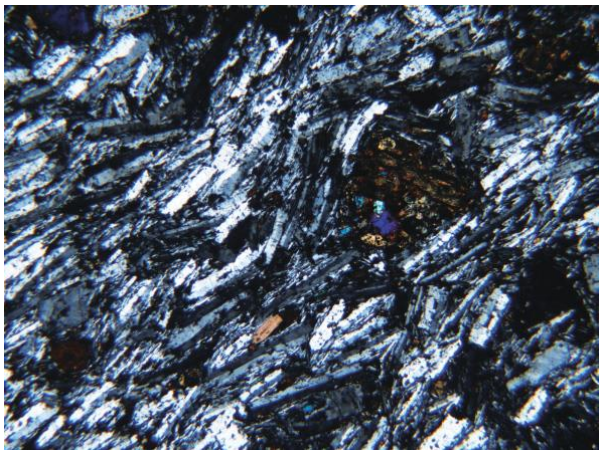
Inclusions of plagioclase feldspar (Plag) in clinopyroxene (Cpx) giving rise to an ophitic texture. Partial inclusion of Plag in Cpx results in a subophitic texture.

Intergranular or Diabasic texture: pyroxene (augite) or olivine minerals are enclosing by plagioclase (labradorite-bytownite).



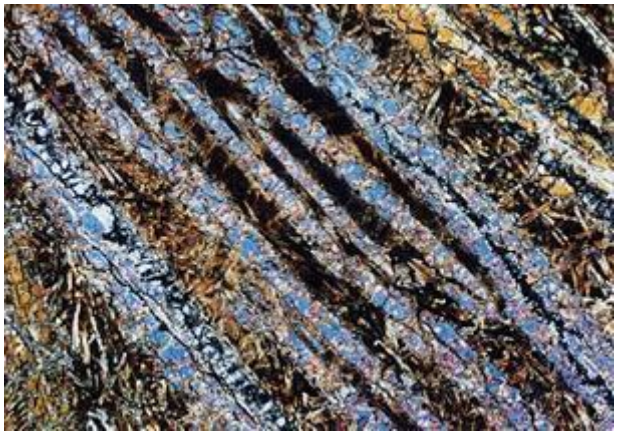
5. Texture referring to orientation and arrangement of the crystals

Trachytic or Flow texture: is result to lava flow on the earth surface, the groundmass is consisting of directivity microlites indicative of flowing.



Trachytic texture showing sub-parallel sanidine laths sweep around the larger crystal.

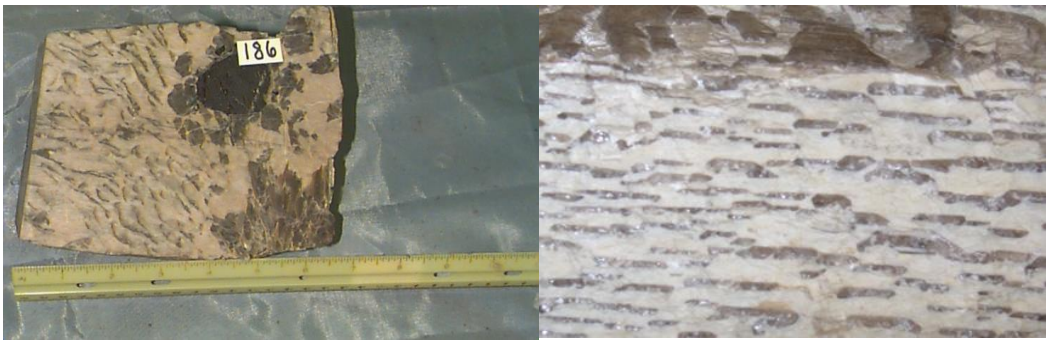
Parallel growth texture: refers to a single elongate skeletal crystal, which in thin section appears to consist of a clot of crystals having the same elongation direction. This texture result to quencher of minerals.



Komatiite sample that shows parallel growth of elongate quenched olivine crystals (blue colored).

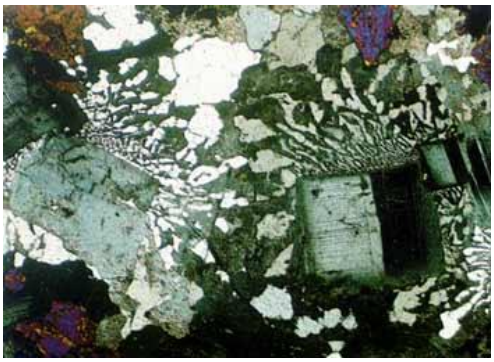
6. Texture referring to intergrowth of the crystals

Graphic texture: consists of a very large crystal of alkali feldspar enclosing smaller crystals of quartz in the letters-shaped.
This texture result to intergrowth between alkali feldspar and quartz at one time.



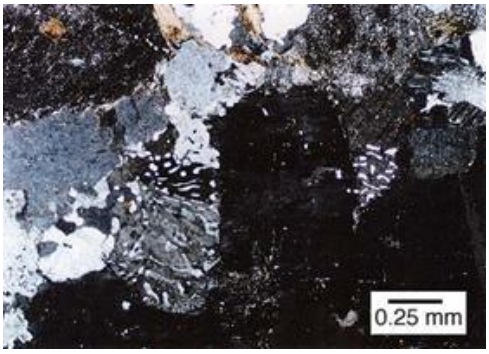
Intergrowth of quartz minerals in K-feldspar crystals to form graphic texture.

Granophyric texture: delicate intergrowths of quartz and alkali feldspar around alkali feldspar, often with an overall three-dimensional radiating habit.



Granophyric intergrowth of quartz grains in alkali feldspar.

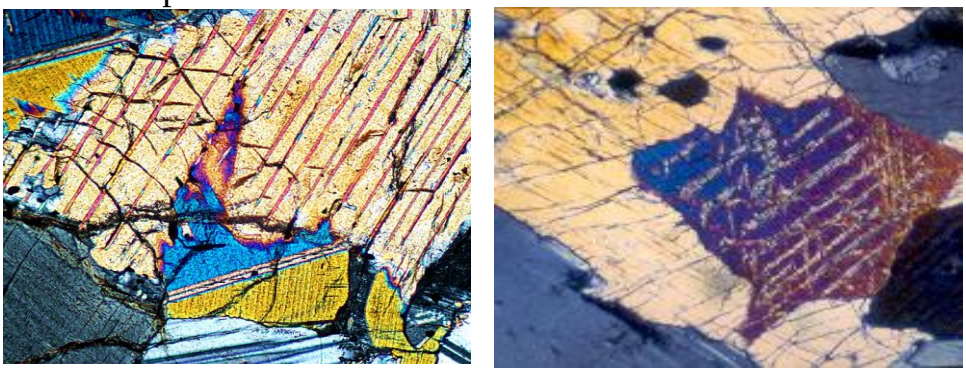
Myrmekitic texture: connotes of intergrowth of plagioclase and quartz occurring in small wormy or cauliflower-shaped embayment in or around plagioclase.
This texture result to quartz and plagioclase minerals growth together between slow and rapid cooling.



Myrmekitic texture defined by wormy (rounded) intergrowths of quartz and K-feldspar in plagioclase which is adjacent to K-feldspar.

Exsolution lamellae or **exsolution blebs:** refer to lamellar and bleb-like intergrowths is often attributed to exsolution of the lamellae and blebs of one component from the host crystal.

This texture occurs because the two pyroxenes cool slowly they become supersaturated with each other and they appear under microscopic exsolution lamellae.



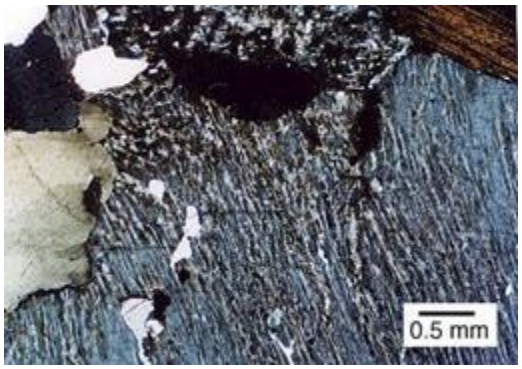
Exsolution lamellae of orthopyroxene in clinopyroxene mineral (blue-purple colored).

Perthite: is very common in igneous rocks and consists of intergrowth between minor lamellae or patches of albite within the host orthoclase or microcline.

This texture result to K-feldspar and albite crystallized at one temperature, (e.g. Granite and Syenite).

Exsolution of albite patches in microcline crystal to form perthitic texture.

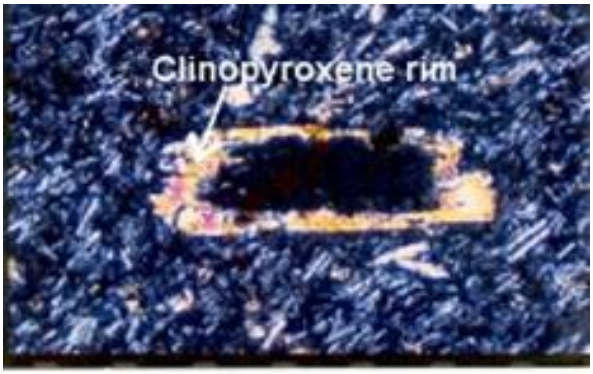
Microperthite: refers specifically to exsolution textures that are visible only on a microscopic scale.



Antiperthite: is not commonly seen in igneous rocks, This texture consists of orthoclase within the host plagioclase.

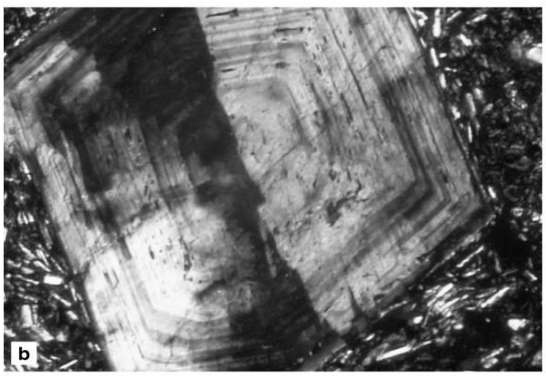
7. Texture referring to overgrowth of the crystals

Corona or **Reactionary texture:** refers to a situation where a crystal one mineral is surrounded by a rim of one or more crystals of another mineral (olivine surrounded by orthopyroxene or biotite surrounding hornblende). This texture results from incomplete reaction of the inner mineral with melt or fluid to produce the reaction rim or reaction corona.



Basalt sample containing composite pyroxene. Subhedral orthopyroxene phenocrysts with rounded margins (inner part), is surrounded by clinopyroxene rim (reddish-yellow colored) due to reaction with the melt.

Zoning: systematic pattern of chemical variation within a solid solution mineral is called zoning. It is a record of incomplete reaction relations between a melt and the crystallizing solid solution. In plagioclase, zoning is concentric to the exterior grain margin and plagioclase zoning from calcic cores to more sodic rims.

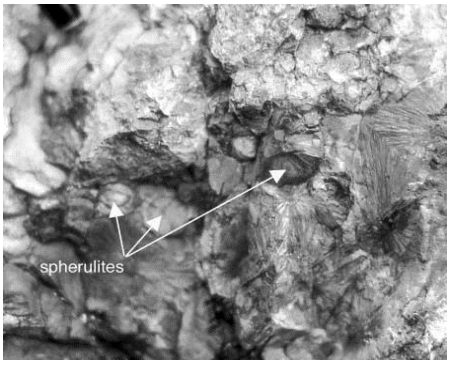


Plagioclase phenocryst displaying zoning.

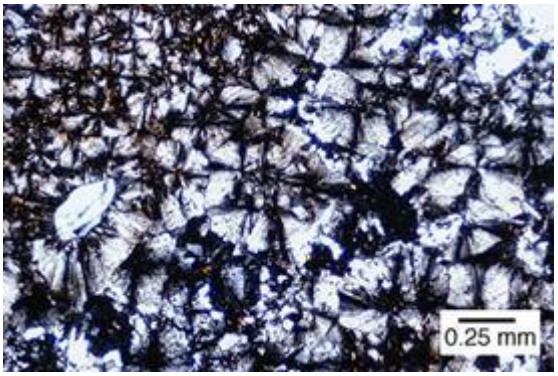
8. Texture referring to radial arrangement of the crystals

Spherulitic texture: is composed of an aggregate of fibrous crystals of one or more minerals radiating from a nucleus. The most common occurrence of spherulitic texture is a radiate aggregate of acicular alkali-feldspars with glass or intergrowth between alkali-feldspar and quartz.

This texture result to crystals or glass recrystallizes around nucleus.



Spherulites in basaltic glass. (Field photo)



Spherulites are radiating masses of fibrous crystals in a glassy matrix. These spherulites are probably composed of alkali feldspars and some polymorph of SiO_2, and in this cross-polarized, appear as round objects with dark crosses.

9. Texture referring to banding of the crystals

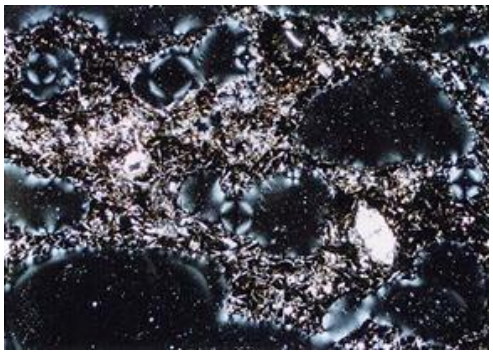
Comb layering: refers to elongate, possibly curved, branching crystals sharing the same direction of elongation. The crystals typically form a band, layer, or fringe.

Comb layering

10. Texture referring to cavity fillings of the crystals

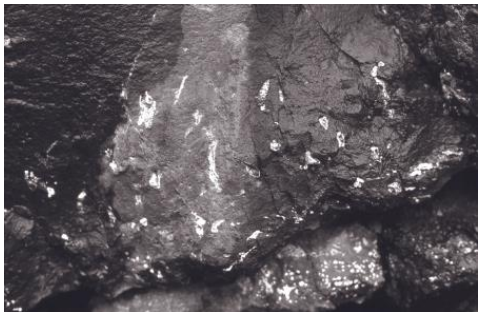
Vesicular texture: refers to a round, ovoid or elongates irregular holes (vesicles) formed by expansion of gas in magma.
This texture result to vapors and gases are escape during the melt rise to the surface for change of temperature and pressure (e.g. Basalt rock).

Vesicles in basalt lava. (Field photo)

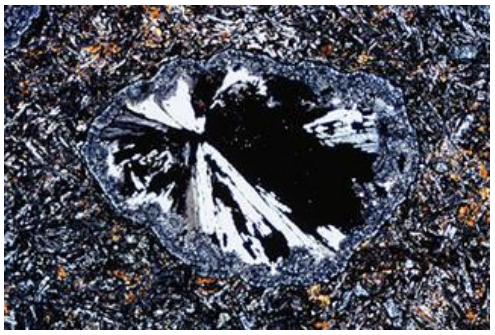


Scoria sample containing ovoidal vesicles (dark regions).

Amygdaloidal texture: refers to former vesicles which are occupied, or partially occupied by secondary minerals, such as, carbonate, quartz, chalcedony, chlorite and/or rarely, glass or fine groundmass. The filled holes are known as "*amygdales*" or "*amygdules*".



Pipe amygdales at the base of basalt lava. (Field photo)



The oval feature in this photomicrograph is an amygdule: a formerly open vesicle which has been filled with a secondary mineral precipitated from low-T ground waters which have penetrated into the rock.

Lab. 3

Classification of Igneous Rocks

Igneous rocks can be classified according to chemical or mineral composition.

1. **Chemical classification:** depending on chemical composition of igneous rock.

   Silica content is used to classify igneous rocks as follows:

Rock type		Silica content Wt%	Example	
			Plutonic	Volcanic
1.	Acidic	> 66 %	Granite	Rhyolite
2.	Intermediate	52-66 %	Syenite	Trachyte
3.	Basic	45-52 %	Gabbro	Basalt
4.	Ultrabasic	< 45 %	Peridotite	Kimberlite

2. **Mineral classification:** depending on mineral composition of igneous rock, (relative abundance of Quartz, Feldspar, Feldspathoid, Olivine and mafic minerals).
   As a result minerals are divided to

A) Primary minerals

1. Essential minerals: important in nomenclature (e.g. Quartz and Orthoclase) and characteristic (e.g. Biotite and Hornblende) of igneous rocks.
2. Accessory minerals: not exceeding proportion 1 % from igneous contents (e.g. Apatite, Zircon, Sphene, and Iron oxides).

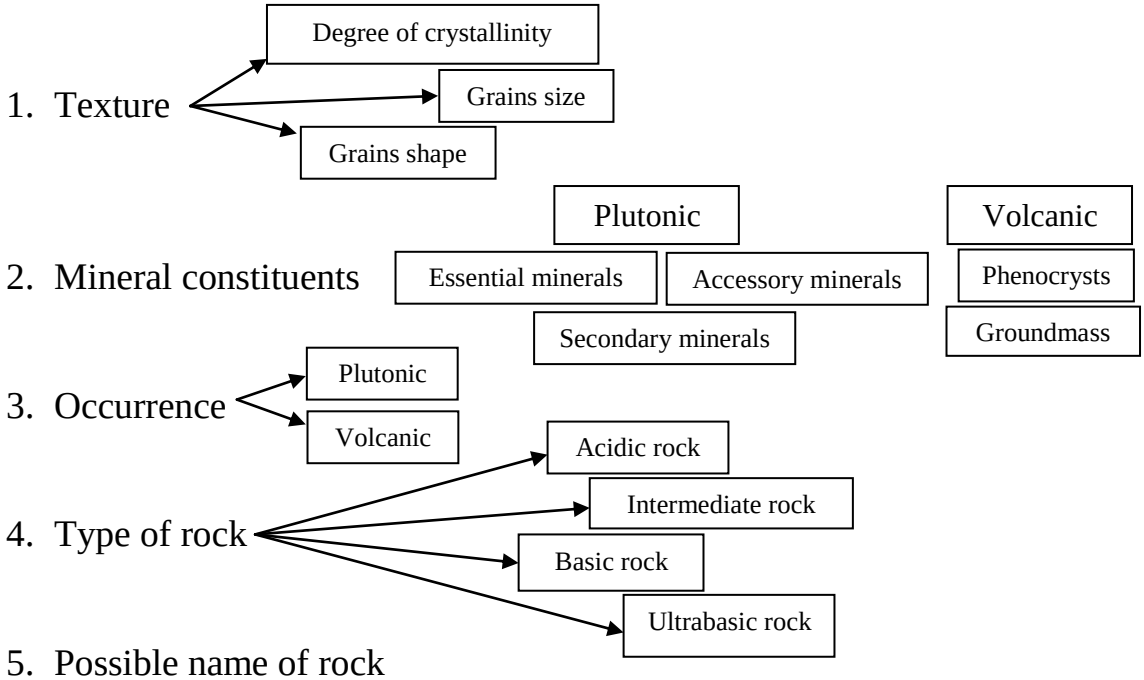
   Primary minerals are resulted to melt crystallized.

B) Secondary minerals: result from primary minerals alteration after rocks crystallized (e.g. Feldspars alteration to kaolinite and sericite, Biotite alteration to chlorite).

3. **Texture classification:** depending on
   A. Degree of crystallinity.
   B. Grains size.
   C. Grains shape.
   D. Interrelations between the crystals.

   Depending on texture classification, igneous rocks divided to ***Plutonic*** and ***Volcanic rocks***.

Description of Igneous Rocks:



Example 1:
Granite rock (Plutonic)

1. Texture
   - Degree of crystallinity: Holocrystalline.
   - Grains size: Equigranular.
   - Grains shape: Hypidiomorphic (variant grains shape; generally are most of subhedral).
     Therefore the texture of rock calls hypidiomorphic granular texture.
   - Textures are between minerals.
2. Mineral constituents

   A) Primary minerals

   1) Essential minerals:

   Quartz: anhedral, colorless and without pleochroism, without cleavage, low relief, parallel extinction, first order gray interference color, devoid of alteration.

   Orthoclase: subhedral to anhedral, colorless but dusty result to alteration, low relief, carlsbad twinning, first order gray to white interference color.

   In this rock, quartz and orthoclase are calling determinative minerals. Orth > Plag (Granite), Orth < Plag (Granodiorite).

   Plagioclase: colorless but dusty result alteration to sericite, low relief in this rock, subhedral crystals, oblique extinction,

distinguished by its polysynthetic twinning. In this rock, plagioclase calls assistant mineral.

Biotite: brown color and distinct pleochroism from light-brown to dark-brown, mask interference color, medium relief, 1-set cleavage, parallel extinction, birds eye texture, it alters to chlorite. In this rock, biotite calls characteristic mineral.

2) Accessory minerals:

Zircon: small prismatic crystals, high relief with fracture, colorless surrounded it by chromatic aureoles result to isotope crashed, inclusion inside biotite.

Apatite: small prismatic or equant hexagonal crystals**,** medium to high relief, colorless, first order gray interference color. Parallel extinction in prismatic sections and isotropic in hexagonal crystals (perpendicular on C-axis).

Iron oxides: black color, isotropic.

B) Secondary minerals:

Sericite and clay minerals: distinguish small grains and bright color; they are result from the feldspar alteration (orthoclase and plagioclase but plagioclase alteration more than orthoclase).

Chlorite: green color, low to medium relief and pleochroism from light-green to dark-green, mask first order interference, parallel extinction, and result from biotite alteration.

3. Occurrence: plutonic rock because it is holocrystalline (entirely crystallinity).
4. Type of rock: acidic igneous rock (felsic minerals > mafic minerals and abundance quartz)
5. Possible name of rock: Granite (Alkali-feldspar > Plagioclase).

Example 2:

Rhyolite rock (Volcanic)

1. Texture: deficient crystallinity and this rock contains minerals are large grains called phenocrysts surrounded by smaller size grains called groundmass from same phenocrysts minerals be formed from microlite and may be with glass; therefore texture of rock called porphyritic texture.
2. Mineral constituents

   Phenocrysts:

   Quartz: euhedral in this rock, colorless and without pleochroism, without cleavage, low relief, first order gray interference color, devoid of alteration.

Sanidine: distinguish by its tabular crystals, carlsbad twinning and transverse cracks.

Plagioclase: colorless but dusty result alteration, often euhedral in this rock, polysynthetic twinning.

Biotite: brown color and pleochroism, mask interference color, medium relief, 1-set cleavage, parallel extinction.

Biotite is surrounded by iron oxides; sometimes iron oxides replace completely biotite in process called Magmatic Corrosion result to reaction of hydroxyl minerals (biotite, amphibole) with atmosphere during melt is climb to surface.

Phenocrysts minerals were formed 50% from a rock.

Groundmass: consists of microlite and glass which often similar to phenocrysts minerals. May be groundmass consist of microlite, only glass or together.

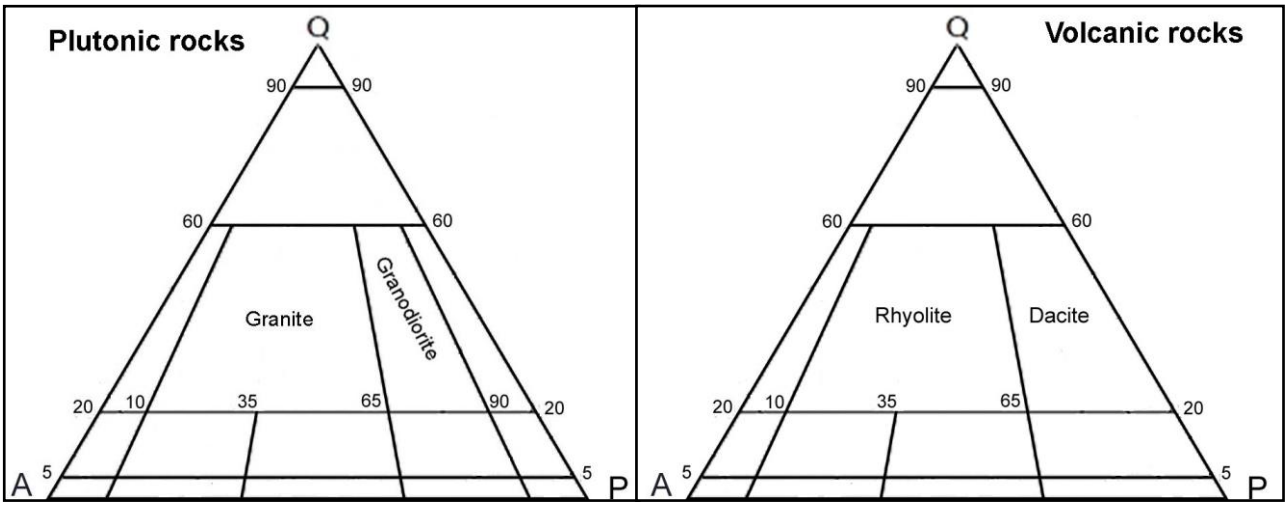
3. Occurrence: volcanic because it is porphyritic texture (depending on texture)
4. Type of rock: acidic igneous rock (felsic minerals > mafic minerals and abundance quartz)
5. Possible name of rock: Rhyolite (Alkali-feldspar > Plagioclase)

Acidic Igneous Rocks

Grain size	Alkali-feldspar > Plagioclase (Albite)	Alkali-feldspar < Plagioclase (Oligoclase)
Plutonic	**Granite** Quartz + Orthoclase + Albite + Biotite ± Hornblende ± Muscovite	**Granodiorite** Quartz + Oligoclase + Orthoclase + Biotite ± Hornblende ± Muscovite
Volcanic	**Rhyolite** Quartz + Sanidine + Albite + Biotite ± Hornblende	**Dacite** Quartz + Oligoclase + Sanidine + Biotite ± Hornblende

Acidic igneous rocks consist of silica content > 66% and these rocks distinct abundance quartz > 20%

Generally, texture of plutonic rocks is hypidiomorphic granular and texture of volcanic rocks is porphyritic.



Lab. 4
Intermediate Igneous Rocks

Grain size	Alkali-feldspar > Plagioclase (Oligoclase)	Alkali-feldspar < Plagioclase (Andesine)
Plutonic	**Syenite** Orthoclase + Oligoclase + Common hornblende ± Quartz ± Biotite	**Diorite** Andesine + Common hornblende + Orthoclase ± Quartz ± Biotite
Volcanic	**Trachyte** Sanidine + Oligoclase + Basaltic hornblende ± Quartz ± Na-Pyroxene ± Biotite	**Andesite** Andesine + Basaltic hornblende + Pyroxene (Hypersthene, Augite) ± Biotite

Intermediate igneous rocks consist of silica content 52-66% and these rocks distinct absence quartz or less than acid rocks; therefor intermediate rocks divided to:

1- Oversaturated rocks: describe a rock or melt composition whose contains quartz between 5-20% for example Quartz syenite.

2- Saturated rocks: contain or not contain quartz 0-5% for example Syenite.

3- Undersaturated rocks: contain feldspathoid minerals (e.g. Nepheline, Leucite) for example Nepheline syenite

Description of intermediate igneous rocks:

1) Texture:

Generally, texture of plutonic rock is hypidiomorphic granular texture (subhedral shape) or xenomorphic granular texture (anhedral shape, while texture of volcanic rock is porphyritic texture.

2) Mineral constituents:

A) Feldspars

1. Alkali feldspar includes orthoclase, microcline in plutonic and sanidine in volcanic.
2. Plagioclase between oligoclase-andesine.

B) Hornblende: this mineral considers characteristic mineral in the intermediate igneous rocks and its two types:

1. Common hornblende occurs in plutonic rocks.
2. Basaltic hornblende occurs in volcanic rocks.

C) Na-pyroxene: mafic mineral may be observed in trachyte rocks and its two types:

1. Aegirine
2. Aegirine-augite

While hypersthene and augite are occurred in Andesite rock.

Distinction between Common hornblende and Basaltic hornblende

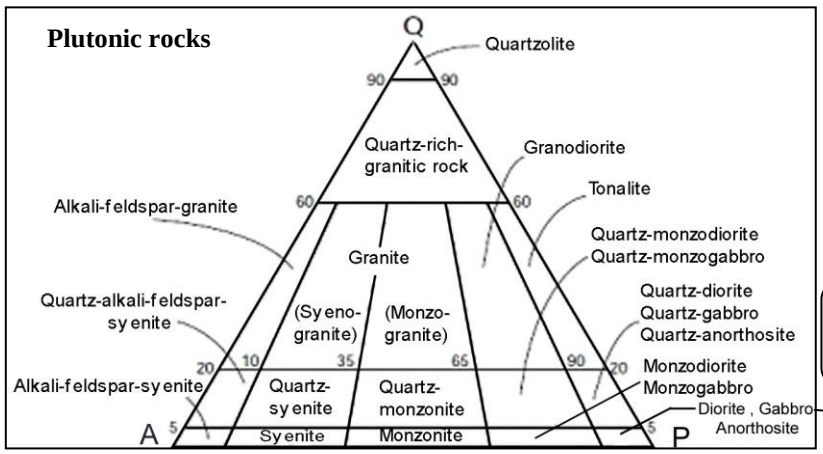
Common hornblende	Basaltic hornblende
Green color	Brown color
Extinction angle more than 10°	Extinction angle less than 10°
Occurs in plutonic rocks	Occurs in volcanic rocks

Distinction between Hypersthene and Augite

Hypersthene	Augite
Pale color and color increase result to iron increases	Pale color and becomes fleshy or pale-pink color result to titanium increases
Prismatic section gives parallel extinction	Prismatic section gives oblique extinction more than 40°
first order interference color (gray, dark-red, dark- orange)	second order interference color (bright colors)

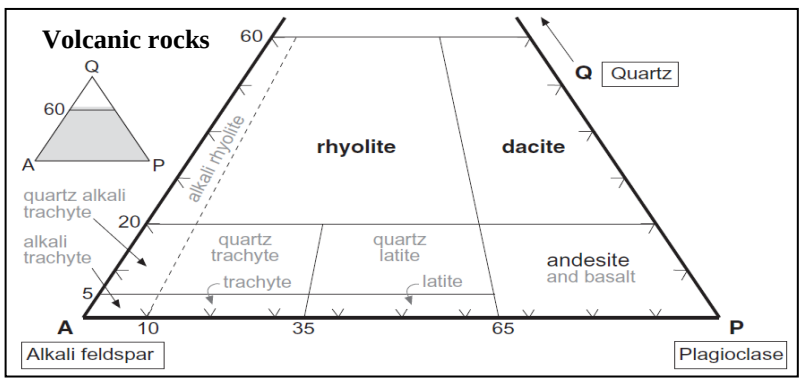
Distinction between Aegirine and Aegirine-augite

Aegirine	Aegirine-augite
Dark-green color (grassy)	Light-green
Extinction angle less than 10°	Extinction angle more than 10°



QAP diagram

Diorite: Plagioclase type is andesine
Gabbro: Plagioclase type is labradorite



Lab. 5
Basic Igneous Rocks

Plutonic	**1**	**Gabbro :** Ca-plagioclase + Augite ± Hypersthene ± Olivine ± Hornblende
	2	**Norite:** Ca-plagioclase + Hypersthene ± Olivine ± Hornblende
Location intermediate	**3**	**Diabase:** Ca-plagioclase + Augite ± Olivine ± Hornblende
Volcanic	**4**	**Basalt:** Ca-plagioclase + Olivine + Augite

Note: Diabase alternatively called dolerite.

Basic igneous rocks are distinct of silica content 45-52% and consist of following minerals:

1) Calcic-plagioclase: fluctuates between An_{50-90} (Labradorite An_{50-70} - Bytownite An_{70-90}).

Chemical analysis is the best of method to knowledge plagioclase composition through account Ca in mineral, for estimating the composition of plagioclase crystals in thin section under the microscope depending on measurement extinction angle and may be observe twining which is width increase result to Ca increase.

Calcic-plagioclase in the basic rocks may be exposes to Saussurization process, Calcic-plagioclase alters to secondary albite, epidote and ± calcite result to this process.

2) Pyroxene:

A) Hypersthene

B) Augite

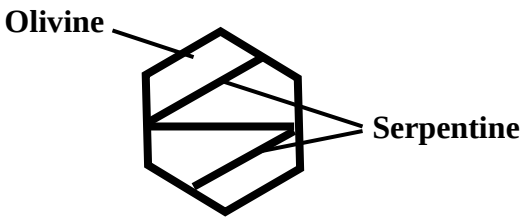
Generally, pyroxene mineral and specially augite alters to secondary amphibole (either as a single crystal or as a fibrous aggregate) result to Uralitisation process, if augite is entire alteration this mineral called Uralite.

Sometimes, pyroxene alters to chlorite in process calls Chloritisation and amphibole may be alters to chlorite.

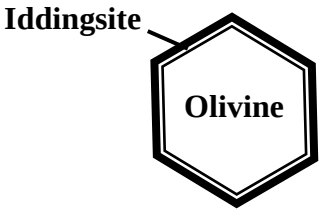
(Distinction between secondary amphibole and chlorite depended on extinction, secondary amphibole has oblique extinction at angle >10° and secondary chlorite has parallel extinction).

3) Olivine: stumpy prismatic crystals, high relief, colorless, without cleavage but distinguished by its fracture, third order interference color, parallel extinction, alteration to Serpentine is green color result to hydration or Iddingsite is red color result to oxidation.
Serpentine fills olivine fractures; while iddingsite occurs on olivine rims and sometimes olivine is entire alteration to iddingsite.

Olivine $\xrightarrow{\text{Hydration}}$ **Serpentine + Iron oxide**



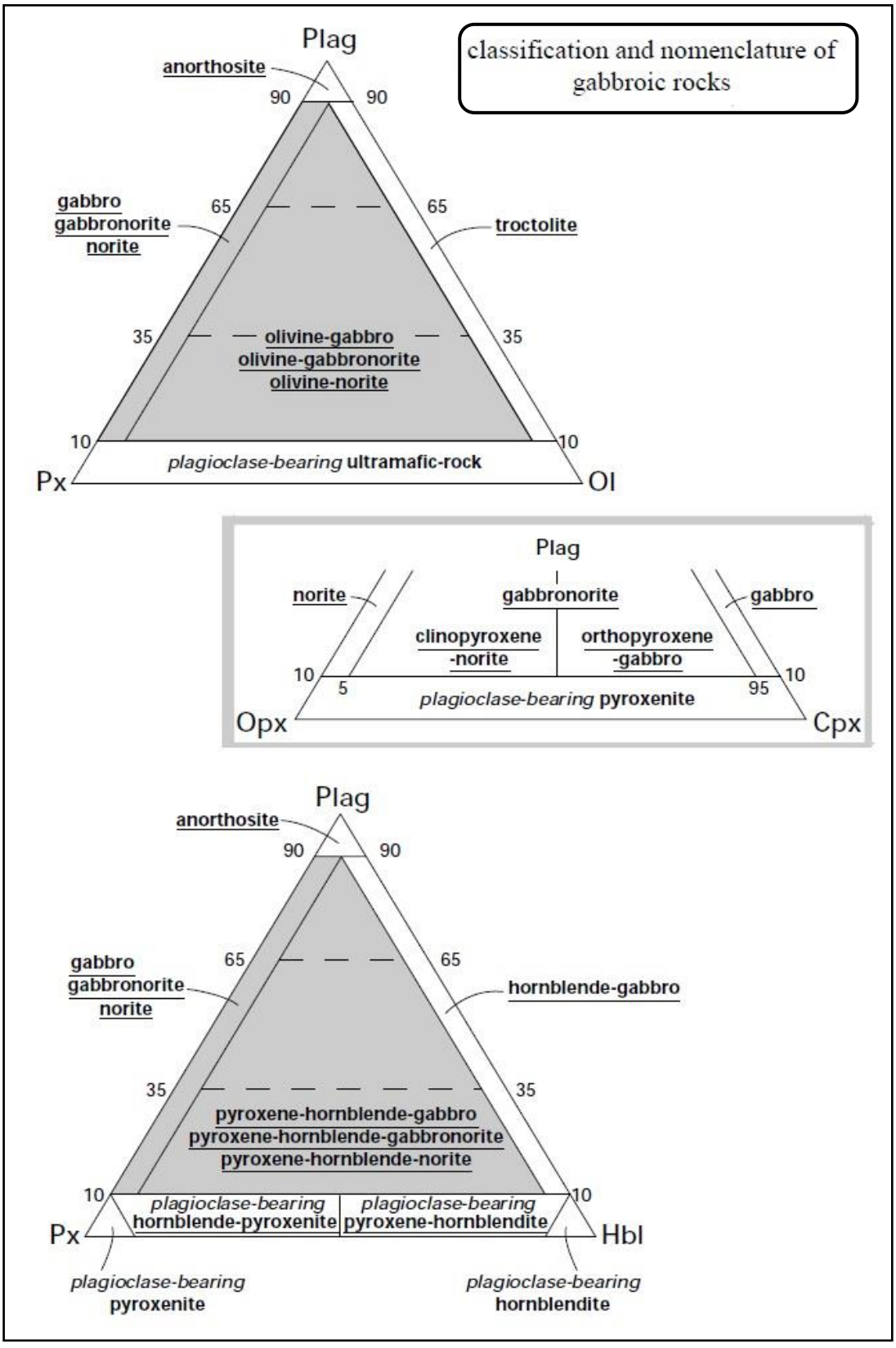
Olivine $\xrightarrow{\text{Oxidation}}$ **Iddingsite**



4) Hornblende (Barkevikite): basic rocks and specially gabbro are containing primary amphibole distinguished by its brown color with pleochroism and oblique extinction at angle less than 10° in prismatic sections.
Basic rocks are include accessory minerals (Apatite, Iron ore)

Common textures in Basic igneous rocks
Plutonic rocks:
1) Hypidiomorphic granular texture (grains shape subhedral).
2) Xenomorphic granular texture (grains shape anhedral).
Basic rocks are include characteristic textures:
1) Ophitic texture: refers to plagioclase tablets wholly enclosed within grain of augite, sometime plagioclase partly enclosed within augite this situation calls Subophitic texture.
2) Intergranular texture: refers to augite encloses by plagioclase and this texture common in Diabase or Dolerite rock is location intermediate.

Texture in volcanic rocks is porphyritic texture and amygdaloidal texture may be observes.



Lab. 6
Ultrabasic Igneous Rocks

A) Peridotite
1. Dunite: Olivine + Minor pyroxene + Chromite
2. Harzburgite: Olivine + Enstatite + Chromite or Spinel
3. Lherzolite: Olivine + Enstatite + Diopside + Spinel

B) Pyroxenite: Enstatite + Diopside + Olivine

Note: Peridotite contains of olivine > 4o%; while Pyroxenite < 4o%.
Ultrabasic igneous rocks have special textures:
1- Equigranular texture: grains size is equant.
2- Inequigranular texture: grains size is unequant.

Tectonite or Alpine peridotite	Cumulative peridotite
Refers to deformation texture which results to uplift the solid or semisolid rocks.	Result to magmatic differentiation.
Proofs of tectonite: 1) Wavy extinction 2) Banding 3) Strain lamellae 4) King banding	Proofs of cumulative: Poikilitic texture

Therefore textures of ultrabasic rocks are call equigranular tectonite texture or Inequigranular tectonite texture.