FUNDAMENTALS OF EARTH SCIENCES (ESO 213A)

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Magma and Igneous Rocks "Granites"

Previous Class: Divergent/Convergent/Transform Plate Boundaries

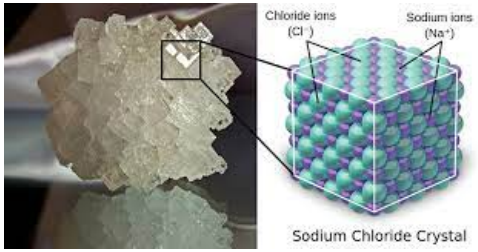
Last Class: Review

1. Convergent/Divergent/ Transform plate boundaries
2. Hot Spots and Mantle plume
3. Drivers of plate movement
4. How do we measure plate Movements
5. Features of continental margins and deep oceans
6. Effect of spreading rate

Minerals and Rocks

- Minerals:
  1. must be naturally formed
  2. must be inorganic
  3. must be a solid
  4. must have a specific chemical composition
  5. must have a characteristic crystal structure

Is ice a mineral??



Is salt a mineral??

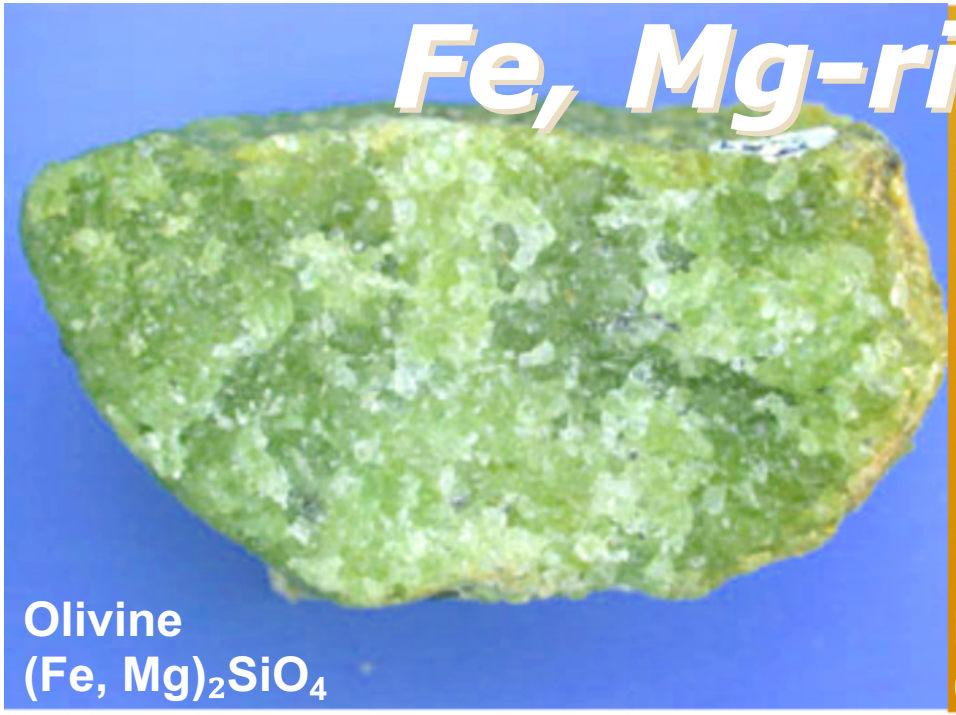
Rocks are mineral assemblages!

Is sugar a mineral??

Common rock forming minerals

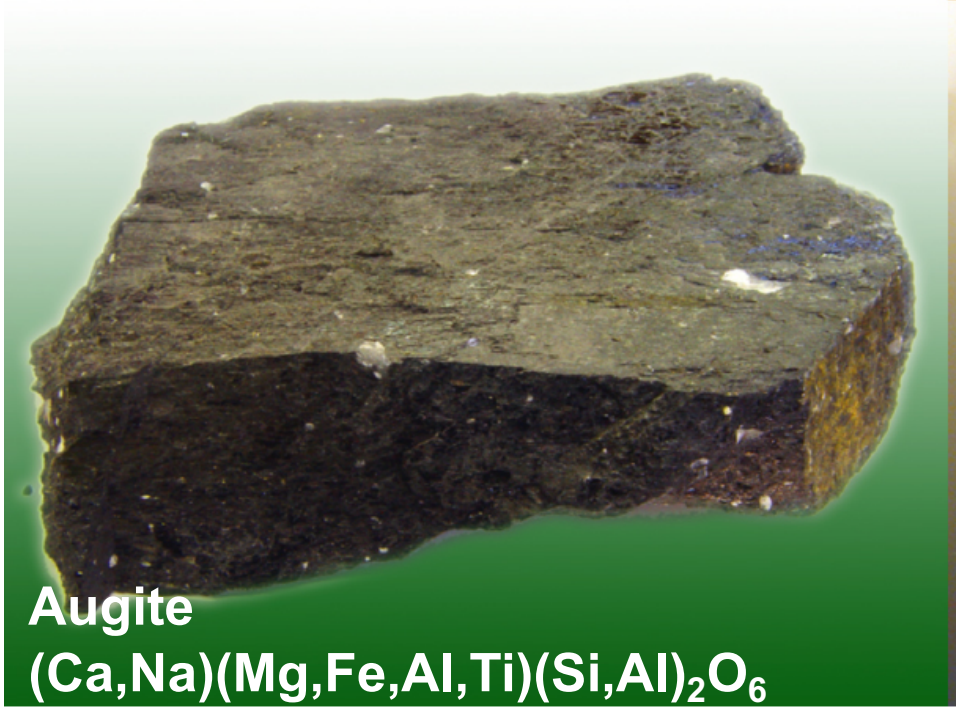
1. Silicates (~60% of crust)
-- all contain a $(SiO_4)^{4-}$ in single, chains or sheets or more complex form
-- e.g. Feldspar, Quartz (SiO_2), clay, Biotite, Muscovite
2. Oxides e.g. Hematite (Fe_2O_3), Magnetite (Fe_2O_4)
3. Carbonates e.g. Calcite ($CaCO_3$), Dolomite $(Ca,Mg)_2CO_3$, Aragonite ($CaCO_3$)
4. Sulfates e.g. Gypsum ($CaSO_4, 2H_2O$), Baryte ($BaSO_4$), Anhydrite ($CaSO_4$)
5. Sulfides e.g. Pyrite (FeS_2), Galena (PbS), Sphalerite ((Zn,Fe)S)

Fe, Mg-rich Silicates

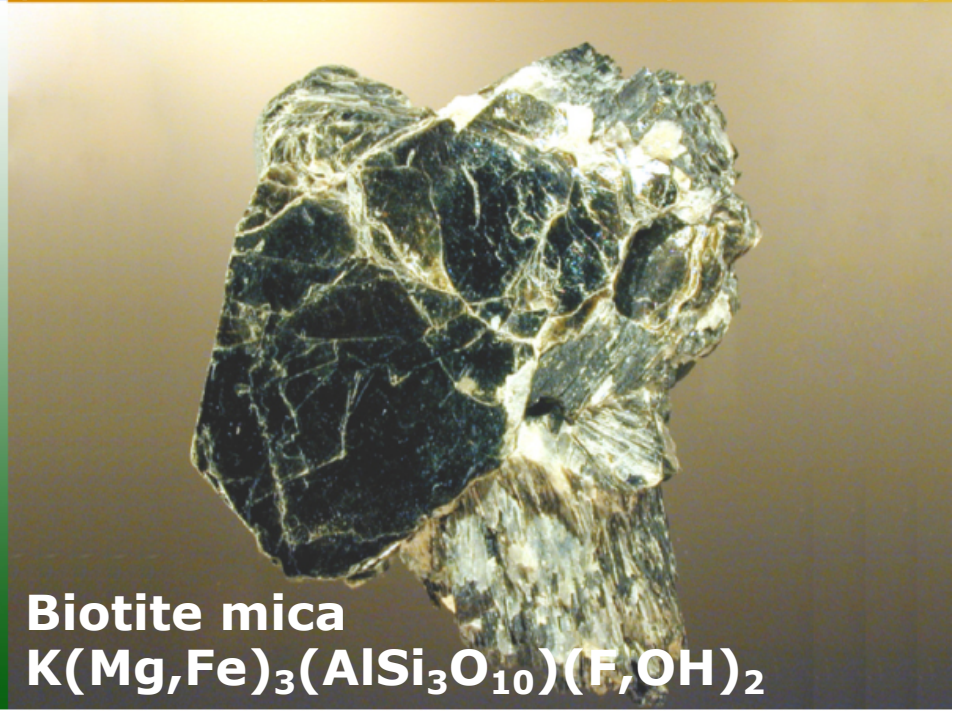


Olivine
$(Fe, Mg)_2SiO_4$

Hornblende
$(Ca, Na)_{2-3}(Mg, Fe, Al)_5(Al, Si)_8O_{22}(OH, F)_2$



Augite
$(Ca,Na)(Mg,Fe,Al,Ti)(Si,Al)_2O_6$

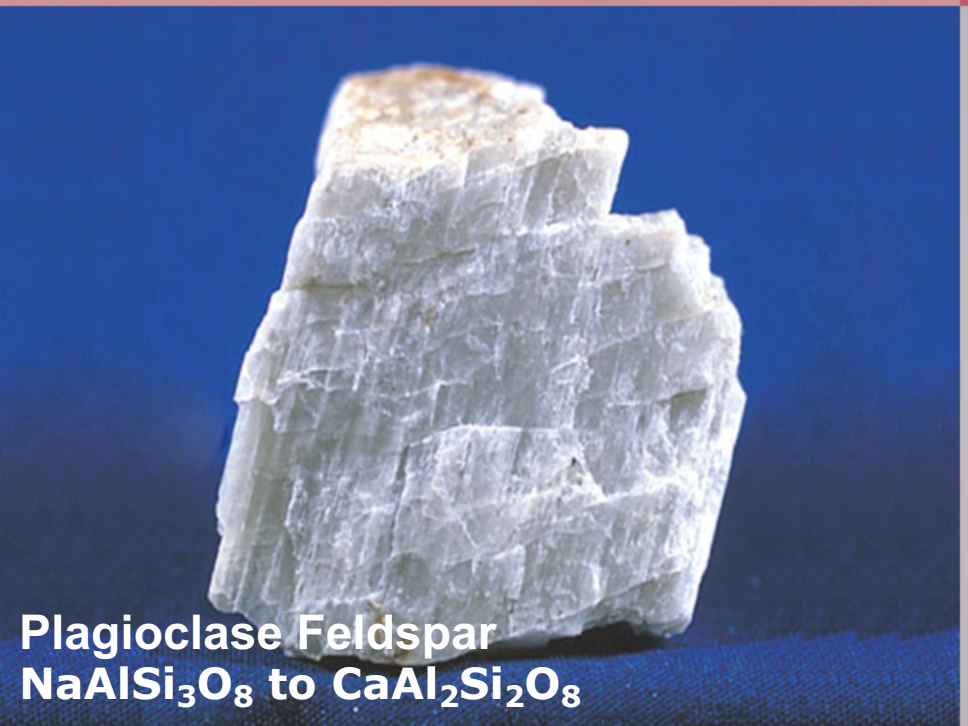


Biotite mica
$K(Mg,Fe)_3(AlSi_3O_{10})(F,OH)_2$

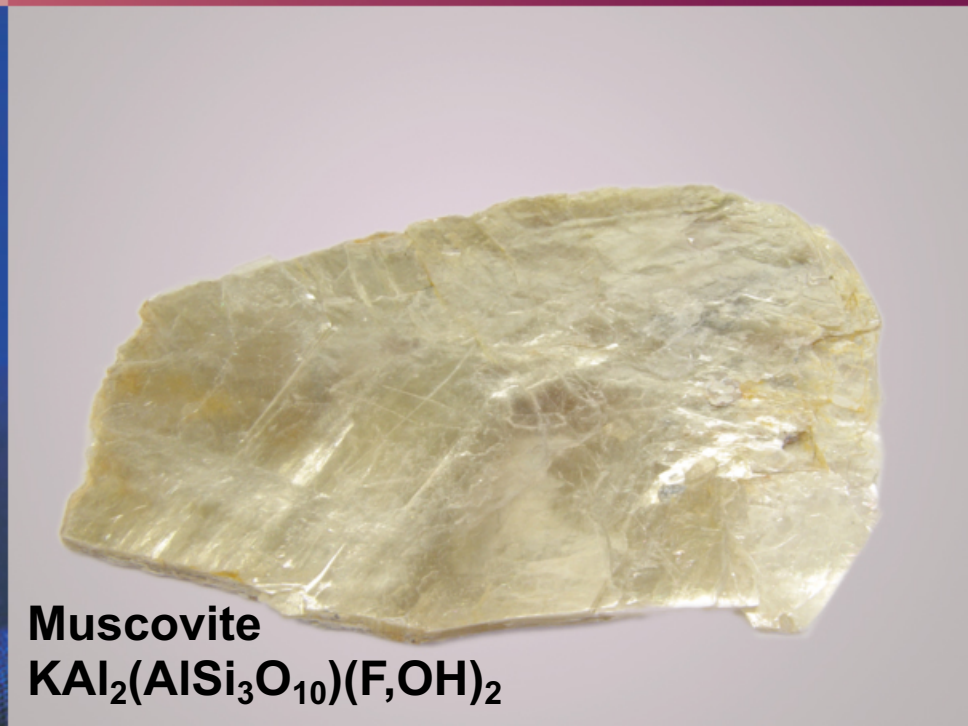
Quartz & Al-rich Silicates

Quartz
SiO_2

Potassium Feldspar (Orthoclase)
$KAlSi_3O_8$



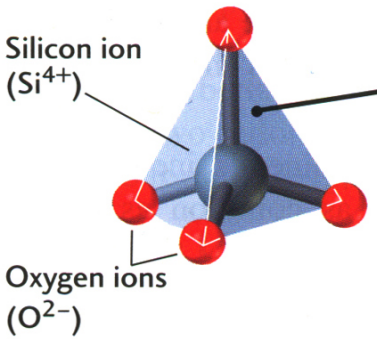
Plagioclase Feldspar
$NaAlSi_3O_8$ to $CaAl_2Si_2O_8$



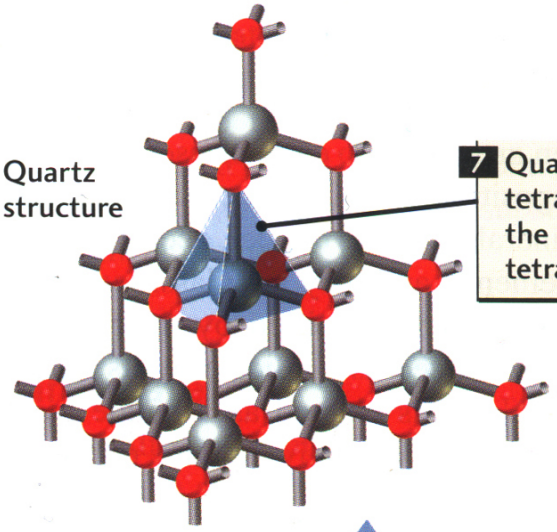
Muscovite
$KAl_2(AlSi_3O_{10})(F,OH)_2$

SILICATE AND SILICATE POLYMORPH MINERALS

(c) Silicate ion (SiO_4^{4-})



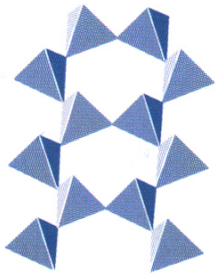
6 The silicate ion forms tetrahedra with a central silicon ion surrounded by four oxygen ions.

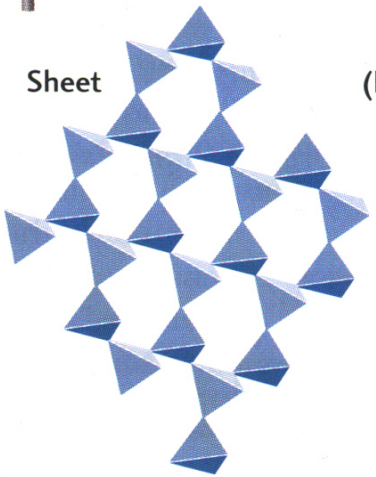


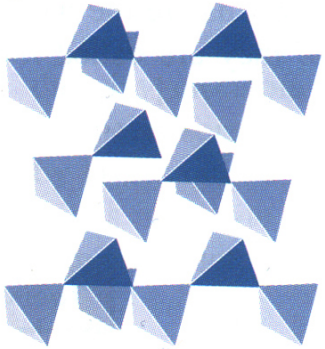
7 Quartz is made of silicate tetrahedra arranged in the same way as the tetrahedra in diamond.

(d) Isolated tetrahedra (e) Single chains (f) Double chains (g) Sheet (h) Framework

8 Tetrahedra arranged in other ways are characteristic of other silicate minerals.

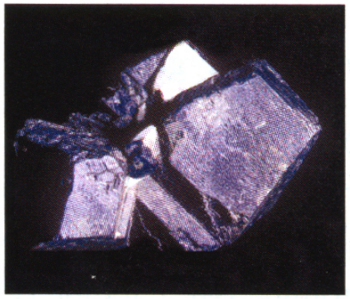






Olivine

Pyroxene



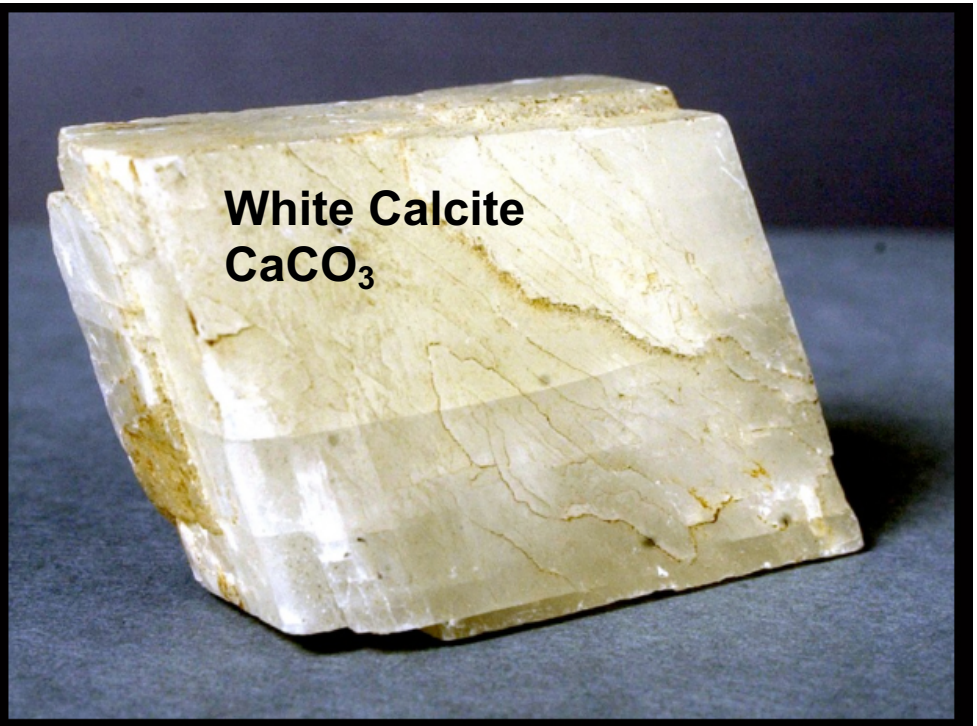
Amphibole

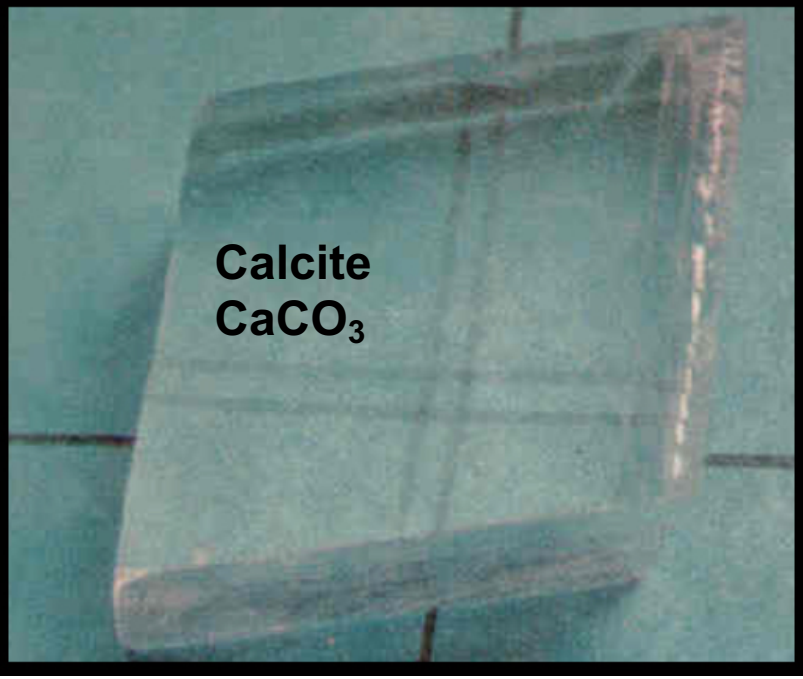
Muscovite

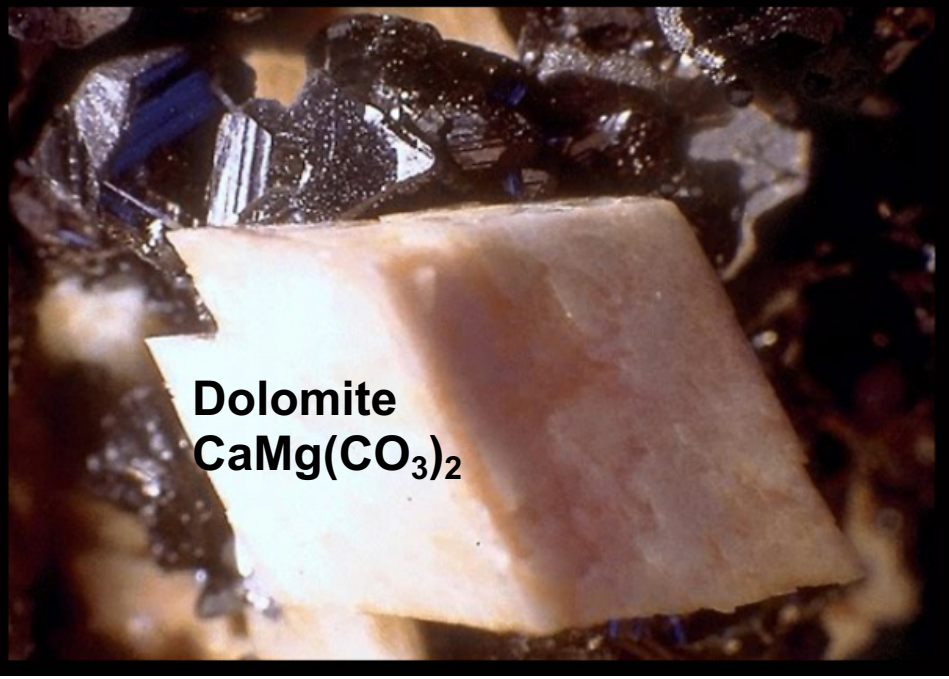
Feldspar

Carbonates

note rhombohedral cleavage in all three carbonate samples shown







Sulfides, Sulfates & Halides

Galena—
PbS

Forms of Gypsum
$CaSO_4.2H_2O$

Alabaster

Satin Spar

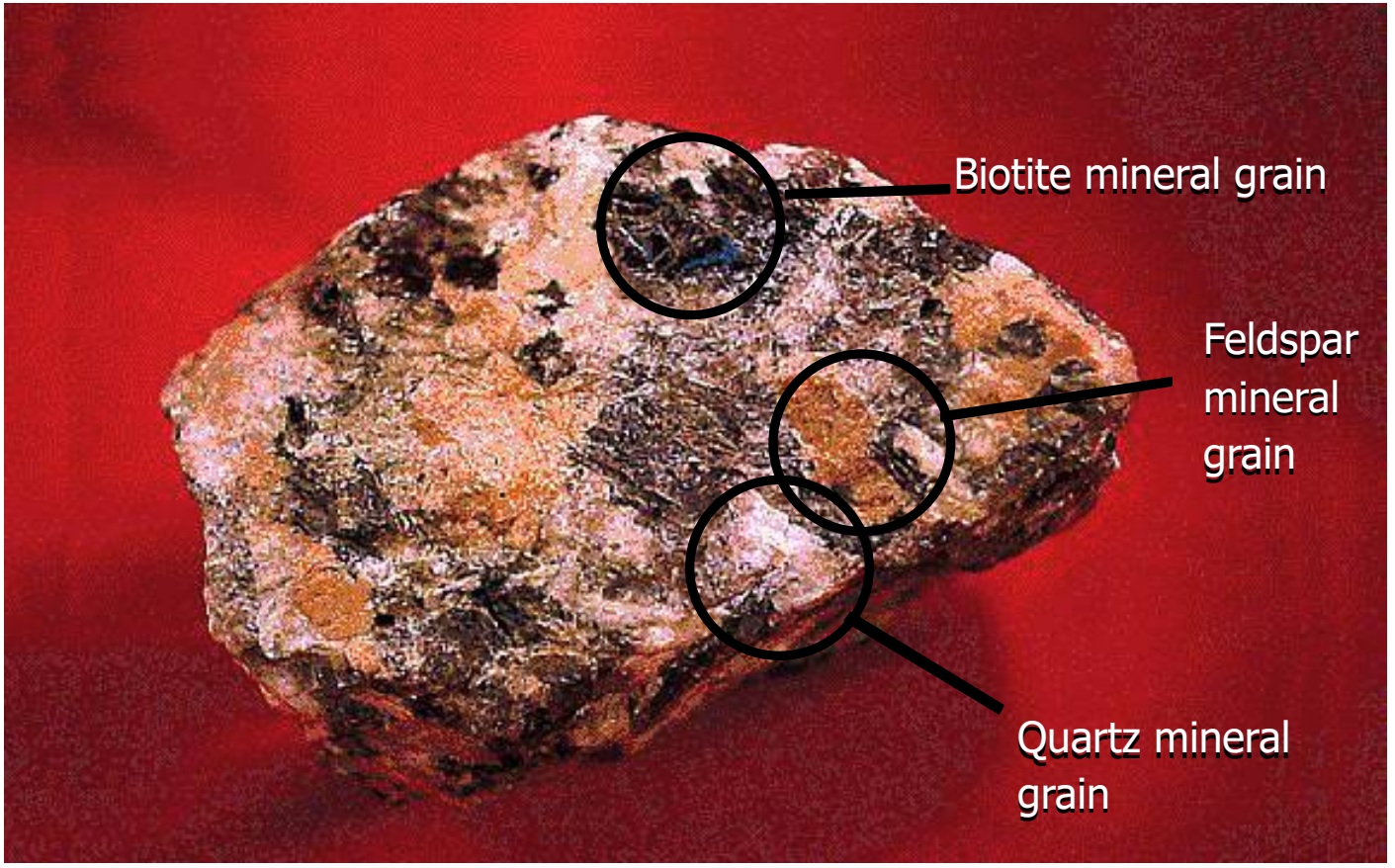
Halite

NaCl

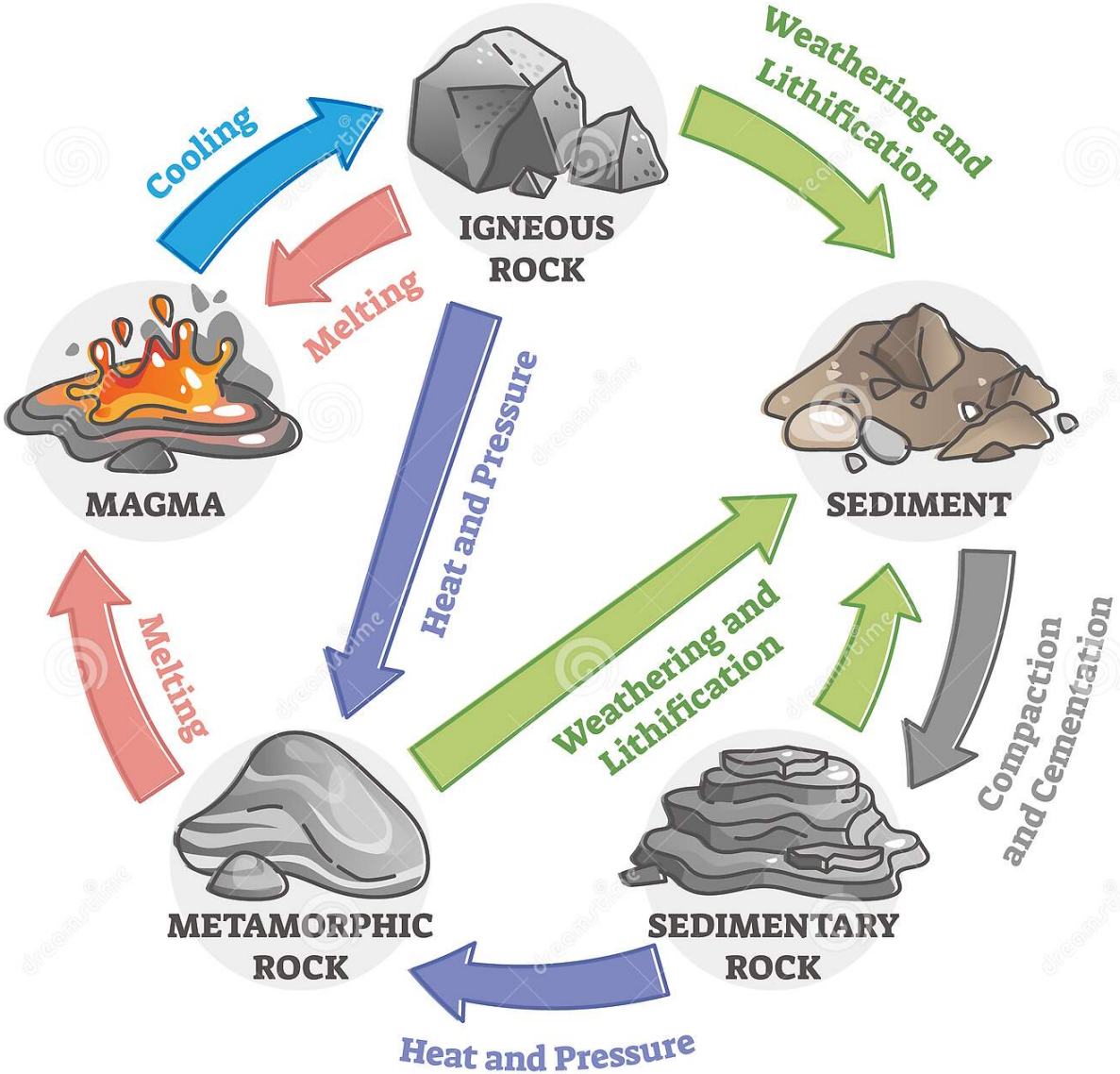
Salenite

Where do rocks come from?

- **Building blocks of all rocks are minerals**
- **Some minerals form as molten rock cools**
- **Some minerals form as chemical precipitates**
- **Some are produced by chemical reactions (weathering)**
- **Some are "manufactured" by living things**



ROCK CYCLE



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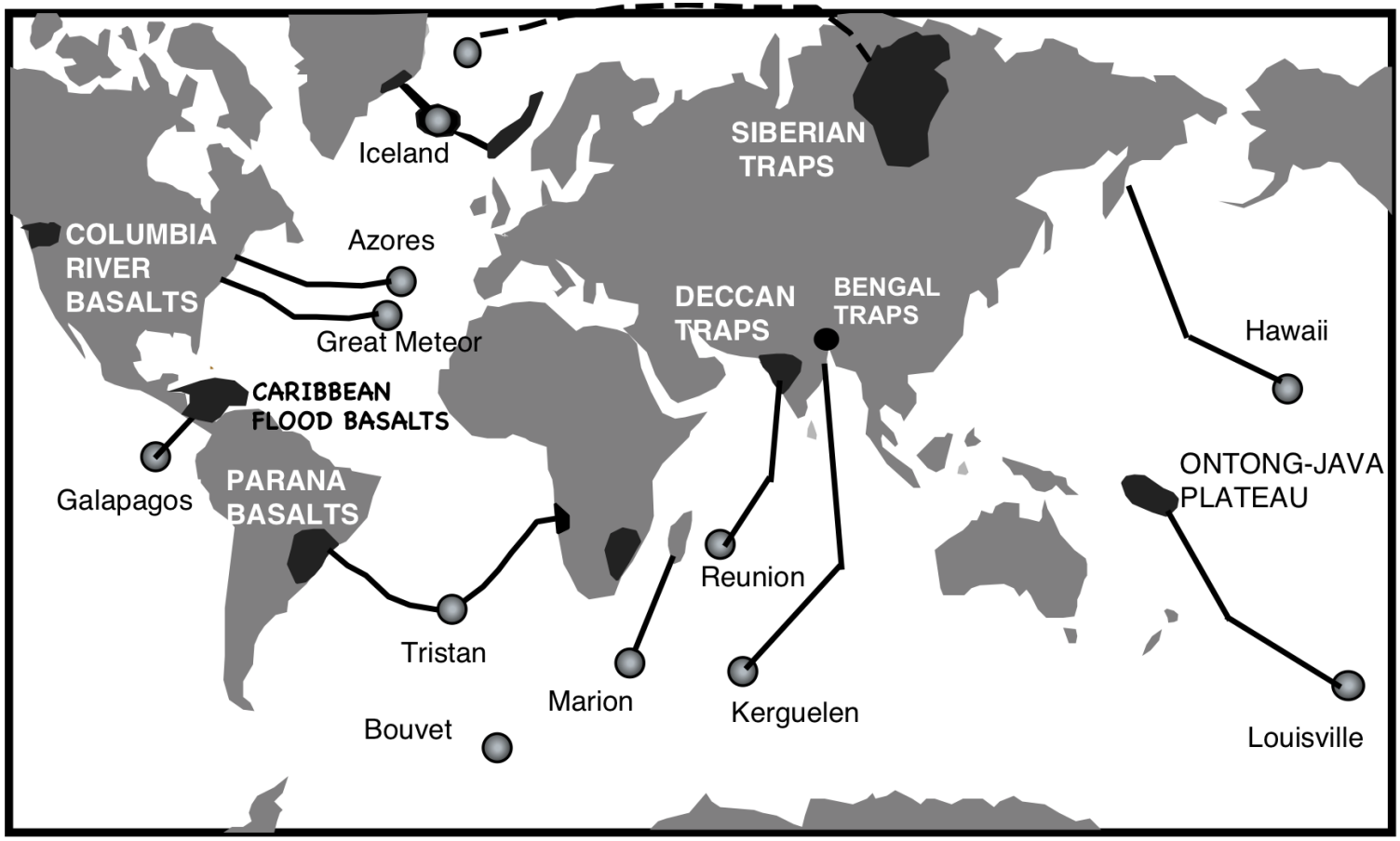
Igneous rocks

Throughout the earth's geologic past, there have been episodes of massive outpourings of basaltic lavas on the ocean floor and on continents. The large plateaus that were formed by such volcanism have been variously called *flood-basalt provinces* or *large igneous provinces* (LIP)



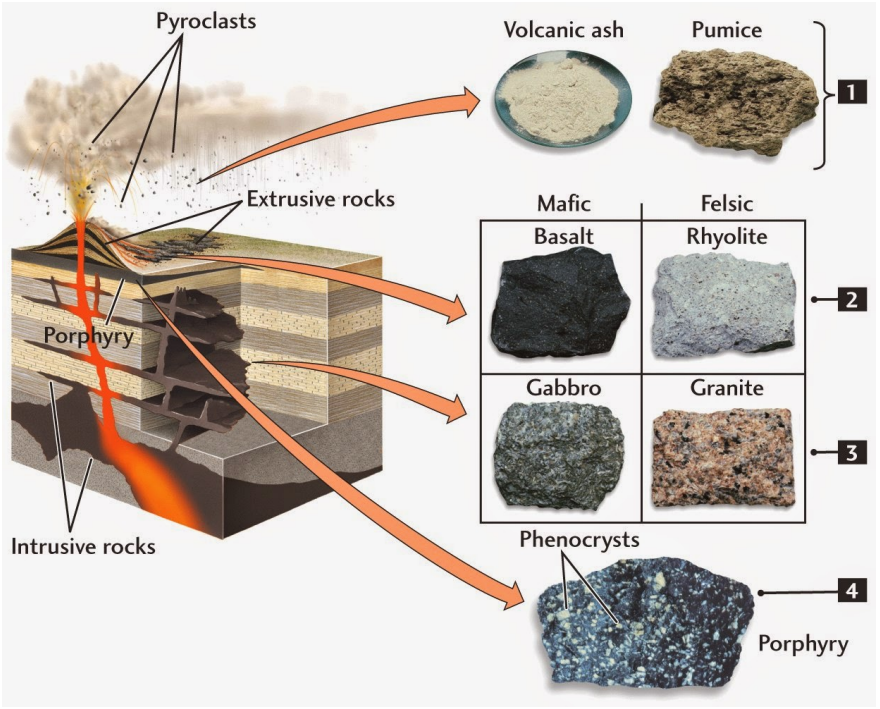
It is believed that episodically large plume "heads" rise from the deep mantle and melt when they reach the base of the lithosphere. Such melts or magmas give rise to large igneous provinces, such as the Deccan Traps of India.

General Characteristics of Magma

- Igneous rocks form as molten rock cools and solidifies.
- General characteristics of magma:

  (Parent material of igneous rocks)

  - Forms from partial melting of rocks inside Earth
  - Magma at surface is called **lava**.
  - Rocks formed from lava are **extrusive**, or **volcanic rocks**.
  - Rocks formed from magma at depth are **intrusive**, or **plutonic rocks**.



- The nature of magma
  - Consists of three components:
    1. Liquid portion = **melt (ions of Si, O, Al, Na, K, Ca, Mg, Fe etc)**
    2. Solids, if any, are silicate minerals.
    3. **Volatiles** are dissolved gases in the melt, including water vapor (H_2O), carbon dioxide (CO_2), and sulfur dioxide (SO_2).

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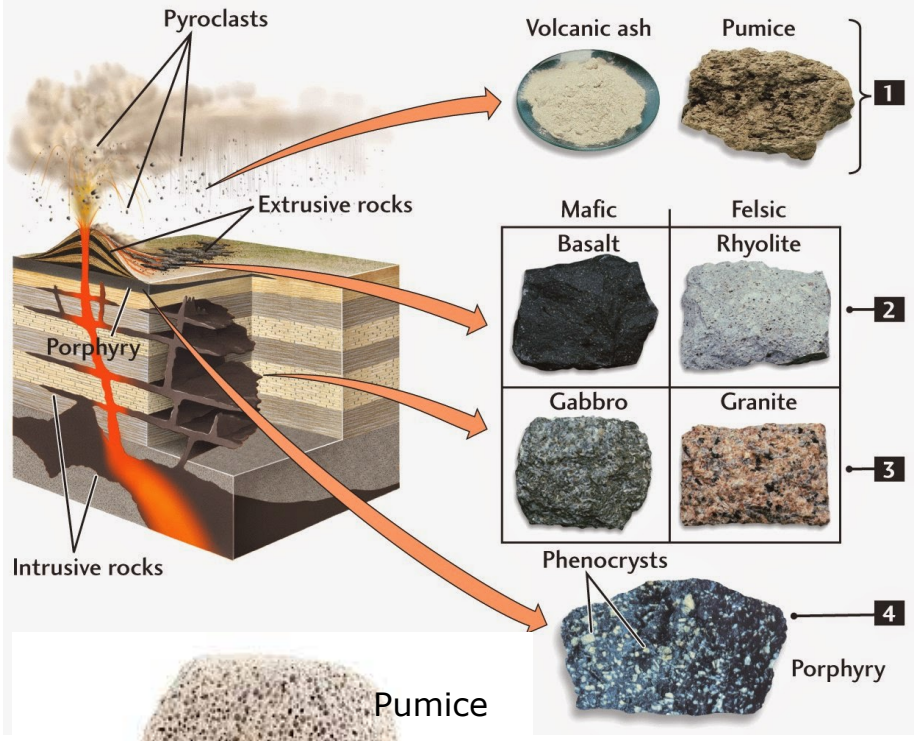
Igneous Textures

- Texture is the overall appearance of a rock based on the size, shape, and arrangement of interlocking minerals.
- Factors affecting crystal size:
  - Rate of cooling
    - Slow rate = fewer but larger crystals
    - Fast rate = many small crystals
    - Very fast rate forms glass.
- Types of igneous textures
  - Aphanitic (fine-grained) texture
    - Rapid rate of cooling
    - Microscopic crystals
    - May contain vesicles (holes from gas
  - Phaneritic (coarse-grained) texture
    - Slow cooling
    - Large, visible crystals
  - Porphyritic texture (slowly rise before eruption)
  - Vesicular texture (holes/pores due to gas expansion)
  - Glassy texture (Due to very fast cooling)



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Texture examples

Texture	Composition		
	Felsic (Granitic)	**Intermediate** (Andesitic)	**Mafic** (Basaltic)
Phaneritic (course-grained)	 Granite	 Diorite	 Gabbro
Aphanitic (fine-grained)	 Rhyolite	 Andesite	 Basalt

Porphyritic granite

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Igneous Compositions

- **Igneous rocks are composed primarily of silicate minerals.**
  - **Dark (or ferromagnesian) silicates**
    - **Olivine, pyroxene, amphibole, and biotite mica**
  - **Light (or nonferromagnesian) silicates**
    - **Quartz, muscovite mica, and feldspars**

Granite

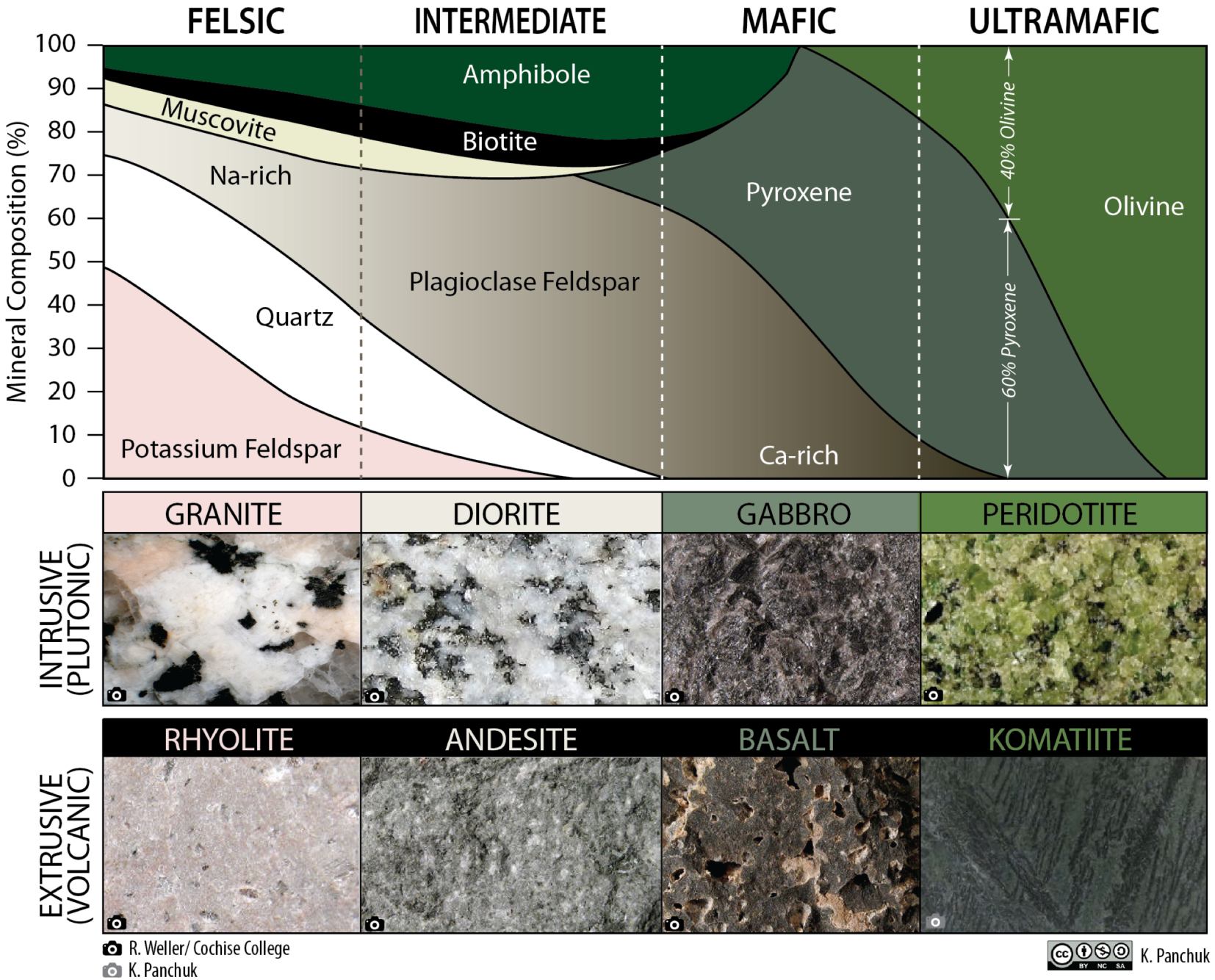
- **Granitic composition**
  - **Light-colored silicates**
  - **Termed felsic (*fel*dspar and *si*lic*a*) in composition**
  - **High silica (SiO_2) content**
  - **Major constituent of continental crust**

Basaltic composition

Dark silicates and calcium-rich feldspar
Termed mafic (*ma*gnesium and *fe*rrum, for iron) in composition
Higher density than granitic rocks
Comprise the ocean floor and many volcanic islands

Basalt

Mineralogy of common igneous rocks



R. Weller/ Cochise College
K. Panchuk

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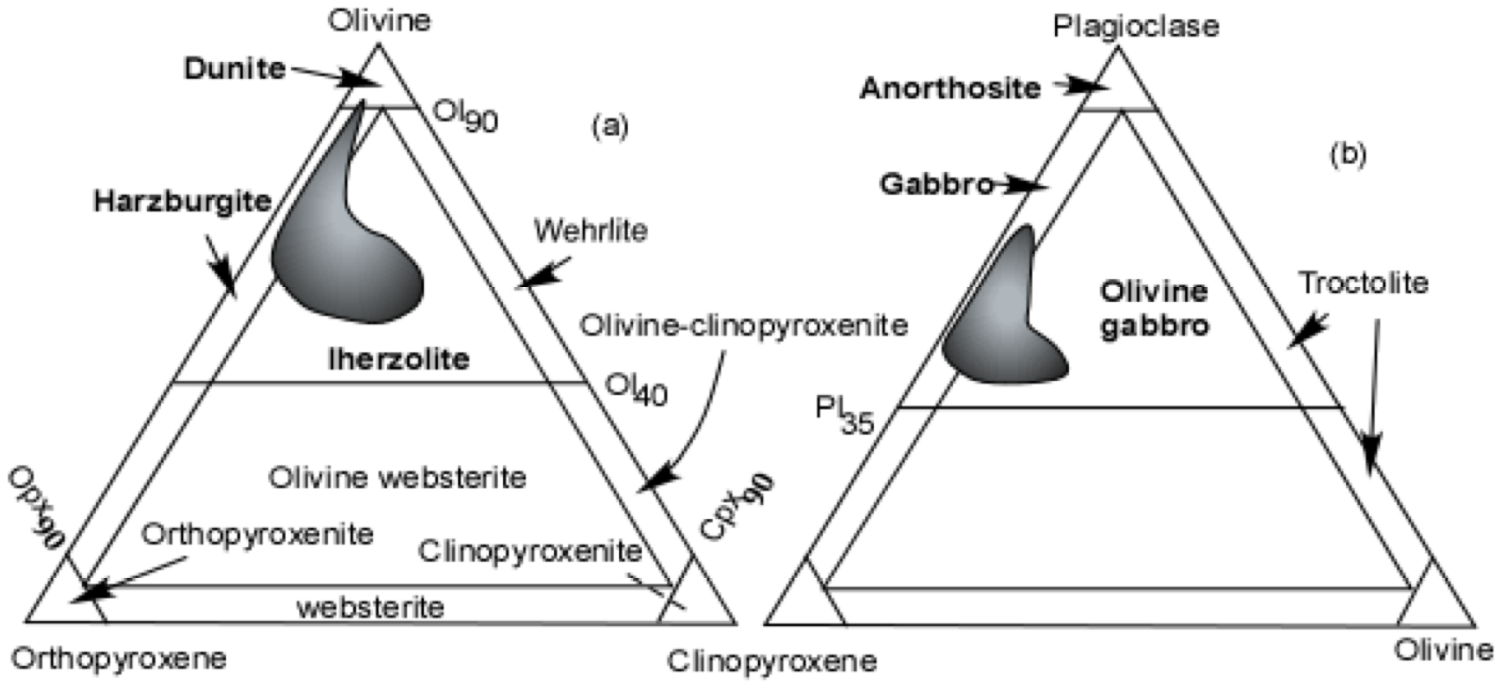
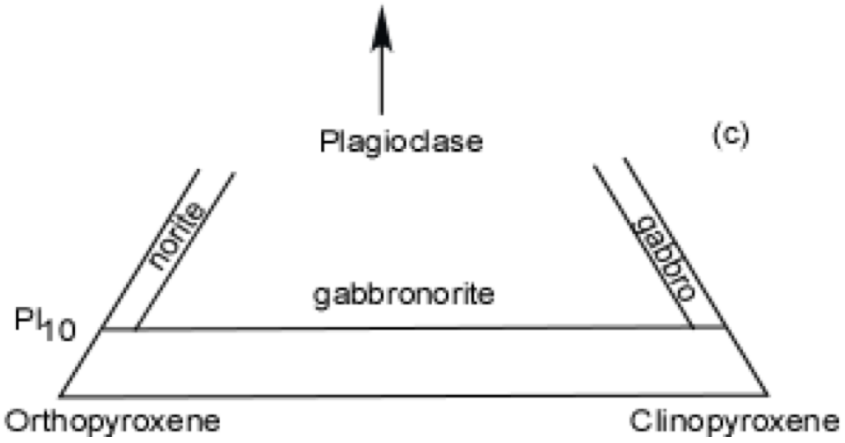
Classifications of Igneous Rocks : Plutonic rocks are classified on the basis of mineralogy and texture

Classification of Mafic and Ultramafic rocks.



Basalt

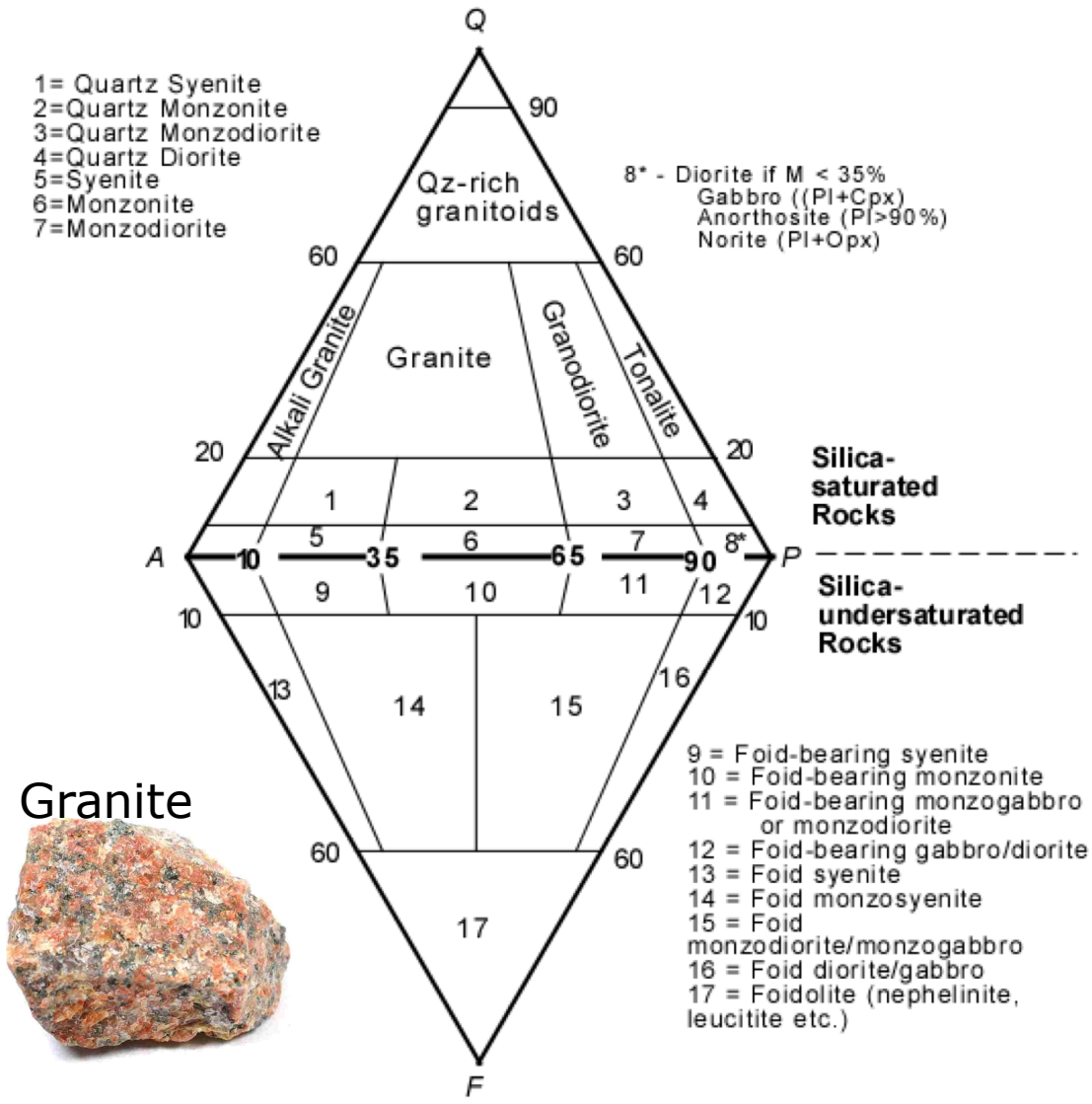


Based on IUGS classification

1. Determine percentage of mineral from a rock

2. Plot mineral percentage and name the rock

QAPF classification of felsic plutonic rocks (Phaneritic rocks)



Granite

Q = Quartz, A = Alkali feldspar and albitic plagioclase,
P = Plagioclase
F = Feldspathoids (Foid), M = Mafic minerals

This classification scheme is for plutonic rocks containing <90% M.
For rocks with >90%M, the classification for ultramafic rocks should be used.

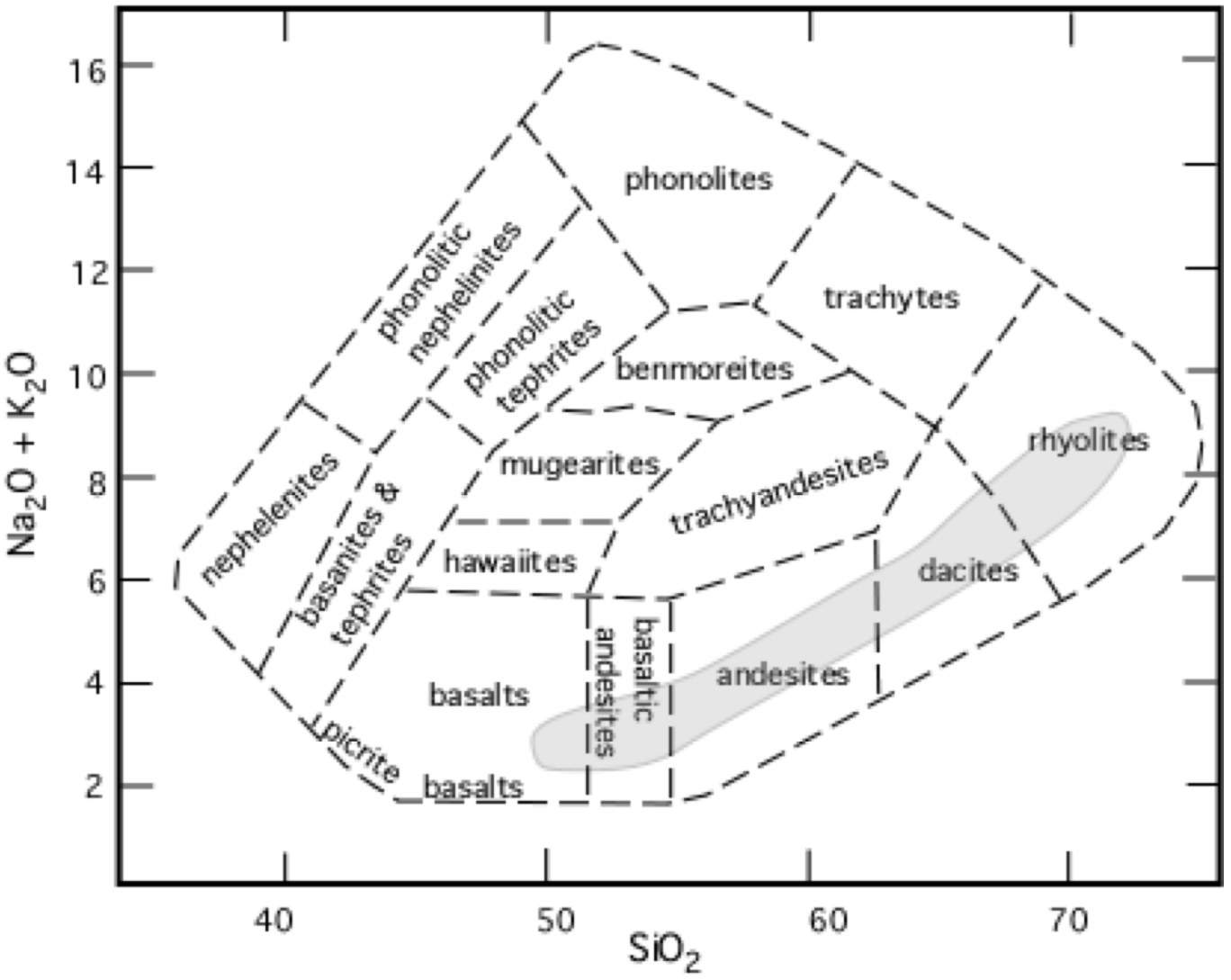
Rocks never contain both Q and F; so they are classified In terms of QAP or FAP

Based on IUGS classification

1. Determine percentage of mineral from a rock

2. Plot mineral percentage On a QAFP diagram to Name the rock

Question: If a rock contains 27% Quartz, 33 % Plagioclase and 20% Alkali feldspar, what will be the name of the rock?



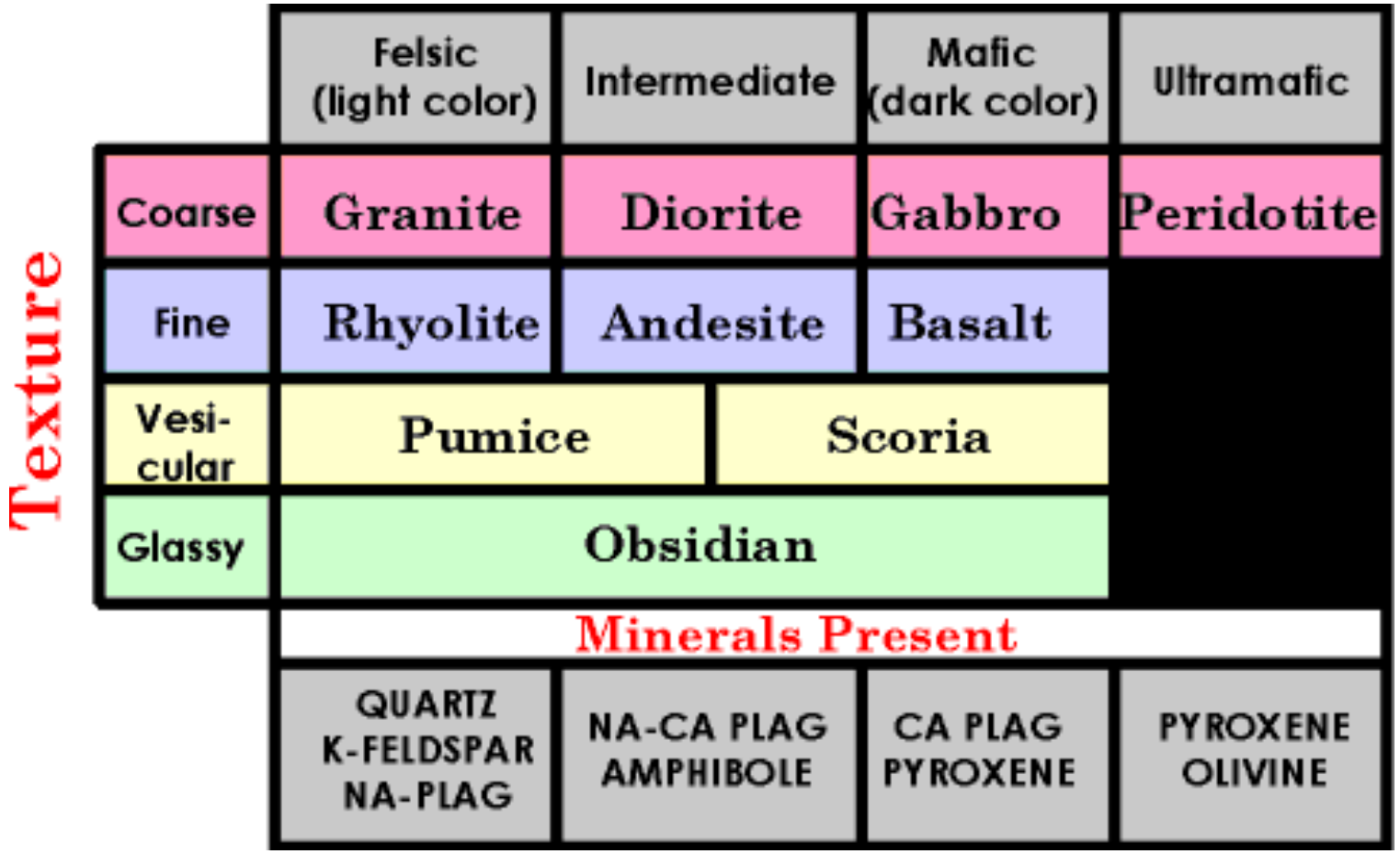
Volcanic rocks can be very fine grained and difficult to classify Using QAPF diagram

Then Geochemical analysis is done keeping alkali % in Y-axis and Silica % in X-axis

If silica % increases Mafic → felsic

Volcanic rocks are classified on the basis of their major element chemistry

Remember!!!!!



Density →

← Viscosity

Questions

Q1: Lava flows are typically finer grained than intrusive igneous rocks. Why?
(a) Intrusive magma is cooler because it is well insulated by the surrounding rock.
(b) Intrusive magma flows onto the Earth's surface and cools very slowly, allowing many small mineral grains to grow.
(c) The extrusive magma cools quickly so the mineral grains do not have time to grow.
(d) The extrusive magma, because it is deep below the surface, cools very slowly, producing very small mineral grains.

Q2: Which of the following rocks is likely to have the most quartz within it and why?
(a) Granite; intrusive rock that formed from cooling of relatively high silica magma.
(b) Rhyolite; extrusive rock that formed from cooling of relatively low silica magma.
(c) Diorite; intrusive rock that formed from the cooling of relatively intermediate silica magma.
(d) Basalt; extrusive rock that formed from cooling of relatively low silica lava.

Q3: Igneous rocks are produced largely by ____.
(a) the changing of a rock from one set of minerals to another
(b) the compaction of metamorphic rocks
(c) the melting of sedimentary rocks
(d) the cooling of magma

Q4: Glassy igneous rocks form when the magma _____.
(a) cools so fast that mineral grains cannot crystallize and grow
(b) cools so slowly that only one mineral is formed
(c) is composed of basalt
(d) cools at an extremely high temperature