Igneous Rocks

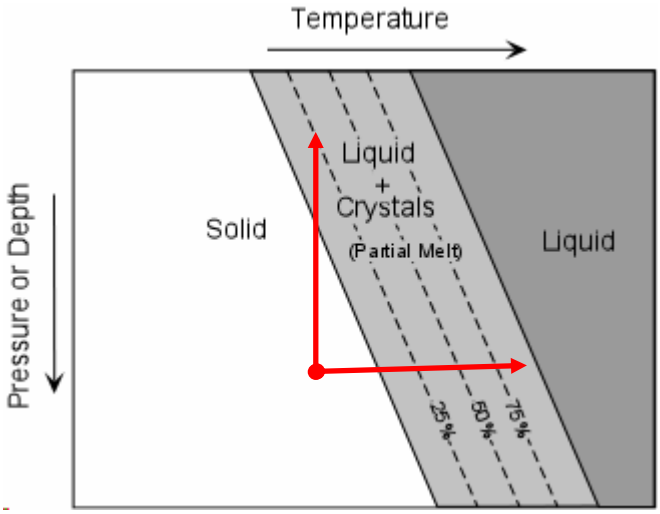
1) **Igneous** – crystallized (cooled) from a magma (like "ignite").

2) Melt (magma) ≡ mixture of melted minerals

   a) Different minerals melt at diff. temps. (800°C - 1300°C)

   b) ∴ Can get partial melting

   c) Melting temp.
      - increases with pressure
      - decreases with water



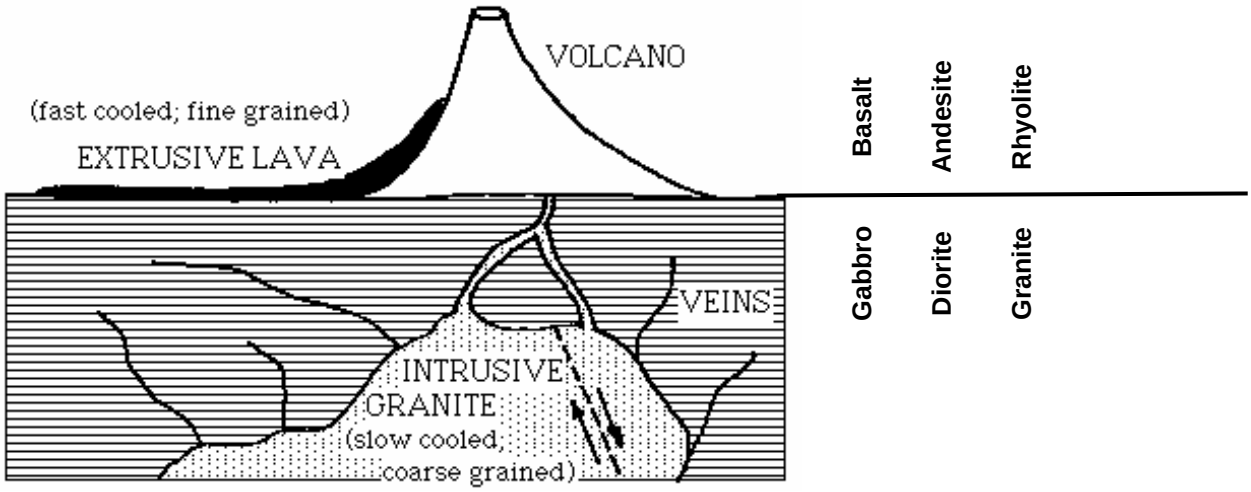
3) Three main compositions of magma

   a) <u>Basaltic</u> – from partial melting in the mantle (spreading centers)
      Mafic ~50% SiO_4

   b) <u>Andesitic</u> – partial melting with water present (subduction zones)
      Intermediate ~60% SiO_4

   c) <u>Rhyolitic</u> – melting of the continental crust w/ water present
      Silicic (felsic) ~75% SiO_4

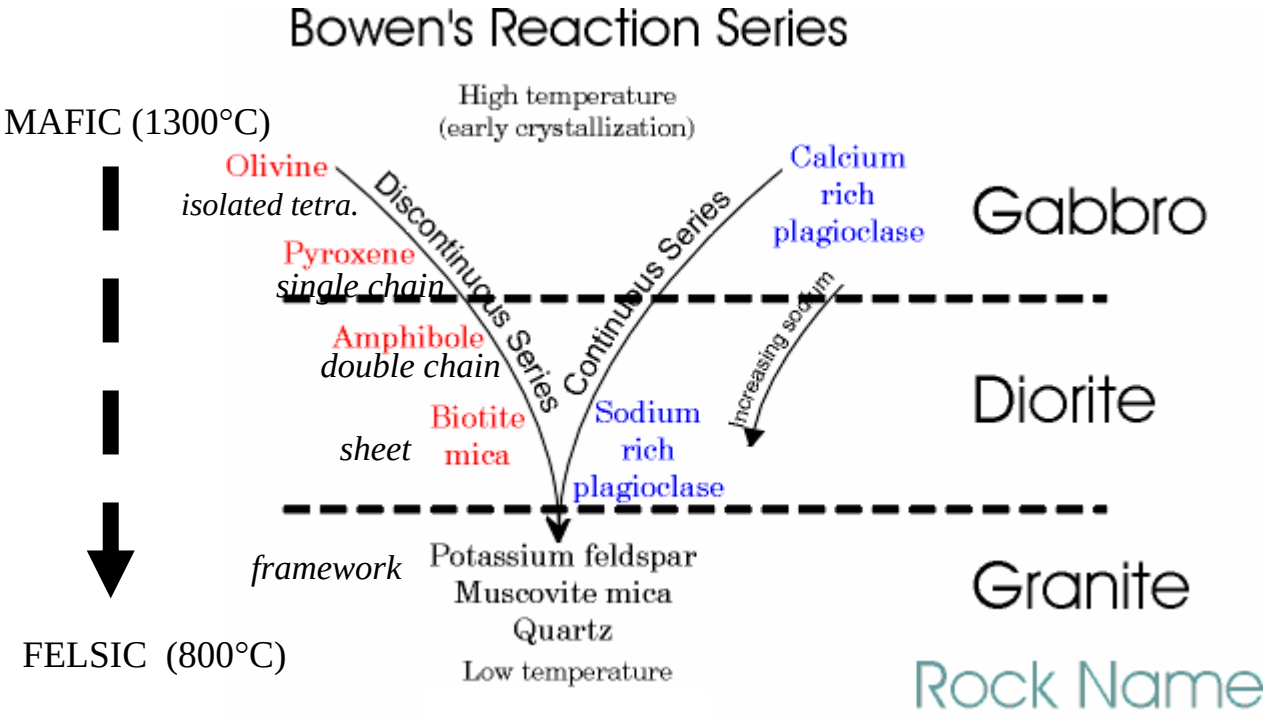
   All contain gasses: water vapor & CO_2 (<3%)



Sequence of Crystallization

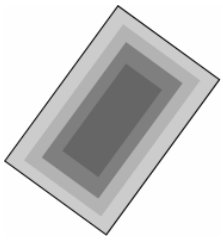
1) Minerals melt (and xlize) at different temps
   ∴ melt and xtalize in a particular ORDER as the rock heats or cools

2) Described in Bowen's Reaction Series (Norman L. Bowen ~1925)



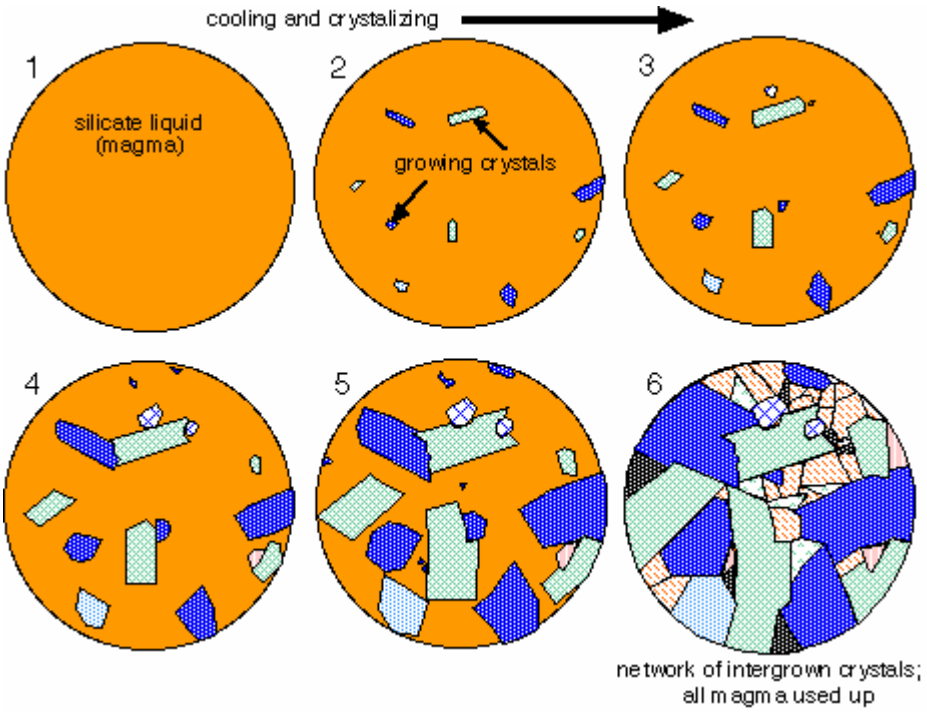
a. Shows order of crystallization as melt cools
b. Mafic → intermediate → felsic (silicic) minerals
c. Generally dark colored → lighter colored

d. Continuous series (feldspars) – early xlized minerals remove (mafic) atoms from the melt so composition of melt changes as cooling continues.
   i. Composition changes as xl grows=**Zoned xl**



e. Discontinuous series (mafic minerals) – as melt cools first xlized minerals become unstable and react with the melt & are converted to new minerals… Olivine → pyroxene

:. Olivine rarely found with other minerals



3) As minerals Xlize they intergrow

   a. Earliest growing xls are larger & better formed
   b. Longer to cool = larger xls
      May take 1,000's of years

4) ∴ Can interpret "**Cooling history"**

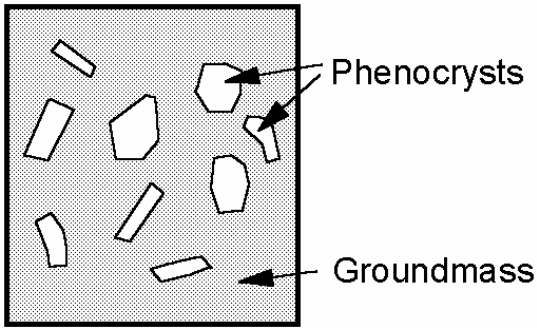
   a. Glass = Very fast
      i. No xtls (viscous liquid)

   b. Aphanitic = extrusive
      i. Fast = small xls

   c. Phaneritic = intrusive
      i. Slow = lg. Xls (phaneritic)

   d. Porphyritic texture = both small & lg xls.
      i. Cooling slow at first then fast
      ii. Phenocrysts / groundmass

Porphyritic Texture

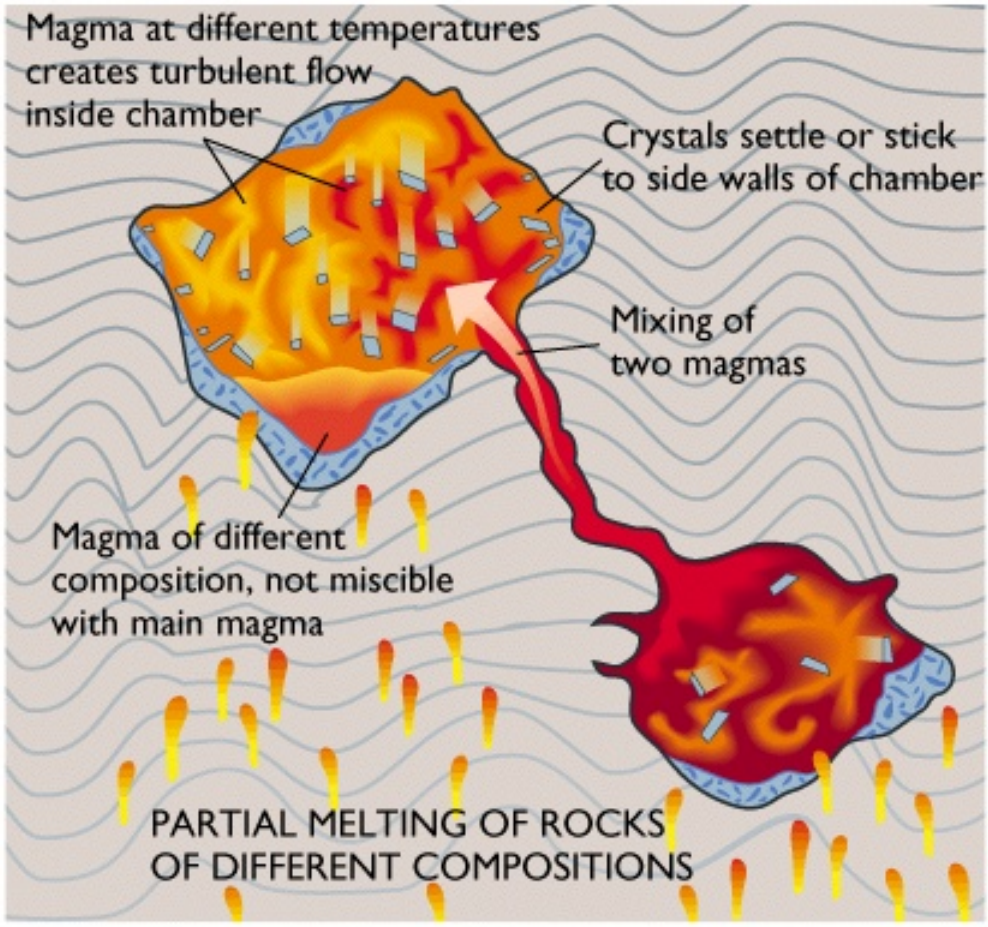


Magmatic differentiation – Melt of one composition can produce rocks of different compositions (depending on cooling history and fractionation)

1. **Fractional crystallization** – as Bowen's series proceeds composition of magma changes

2. **Gravity differentiation** – sinking or floating of xls in magma chamber

3. **Flow segregation** – remaining, more felsic melt may flow into another pluton, leaving xls behind.



Identification of Igneous Rocks

1) Identified by <u>texture</u> & <u>composition</u>

   a) <u>Texture</u> -- tells you about cooling history, depth of burial, etc.

      i) **Glass** – no xls (technically a very viscous liquid or "mineraloid")

      ii) **Aphanitic** – xls invisible to eye but visible in microscope
         (1) indicates rapid cooling, shallow burial or at surface
         (2) extrusive (volcanic)

      iii) **Phaneritic** – xls visible to the naked eye (Gk *phanero* = visible)
         (1) indicates slower cooling, deeper burial – time for xls to grow
         (2) intrusive (plutonic)

      iv) **Seriate –** xls of all sizes

      v) **Porphyritic** – (Gk = *purple*) larger xls (phenocrysts) in an aphanitic matrix. Indicates two phases of cooling: first phase xls form then lava erupts "freezing" the rest.

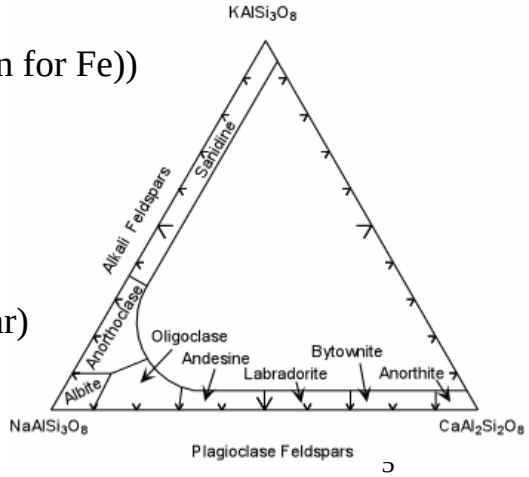
      vi) **Pegmatitic** – Huge xls (>2cm) late-stage, v. slow cooling

      vii) **Pyroclastic** (fire – chunks) heat welded tephra (lapilli to "ash")

   b) <u>Composition</u>

      i) Range from
         (1) **felsic** (***fel***dspar & ***si***lica) [O, Si, Al, K, Na] to
            Generally lighter in color
         (2) **mafic** (***ma***gnesium & "***fe***rrium" (Latin for Fe))
            [Fe, Ma, Ca]
            Generally darker in color

      ii) Feldspars mixture of Ca, Na, K
         Ca → Na → K
         plagioclase → albite → orthoclase (k-spar)



Igneous Rock Chart (see Lab 4, pgs. 10 & 11)

Texture					
Aphanitic	rhyolite	dacite	andesite	basalt	*komatiite (rare)*
Phaneritic	granite	granodiorite	diorite	gabbro	peridotite
	quartz K-spar some mafic	quartz Na feldspar more mafic	little quartz Na-Ca feldspar more mafic	Ca feldspar pyroxene olivine	 olivine Ca feldspar

2.65 g/cm3 <---------- denser ----------> 3.3g/cm3

----------more mafic (darker) ----------→

600 C <---------- higher xtlization temp ---------- 1300 C

←---------- More viscous ←----------

Plagioclase Series

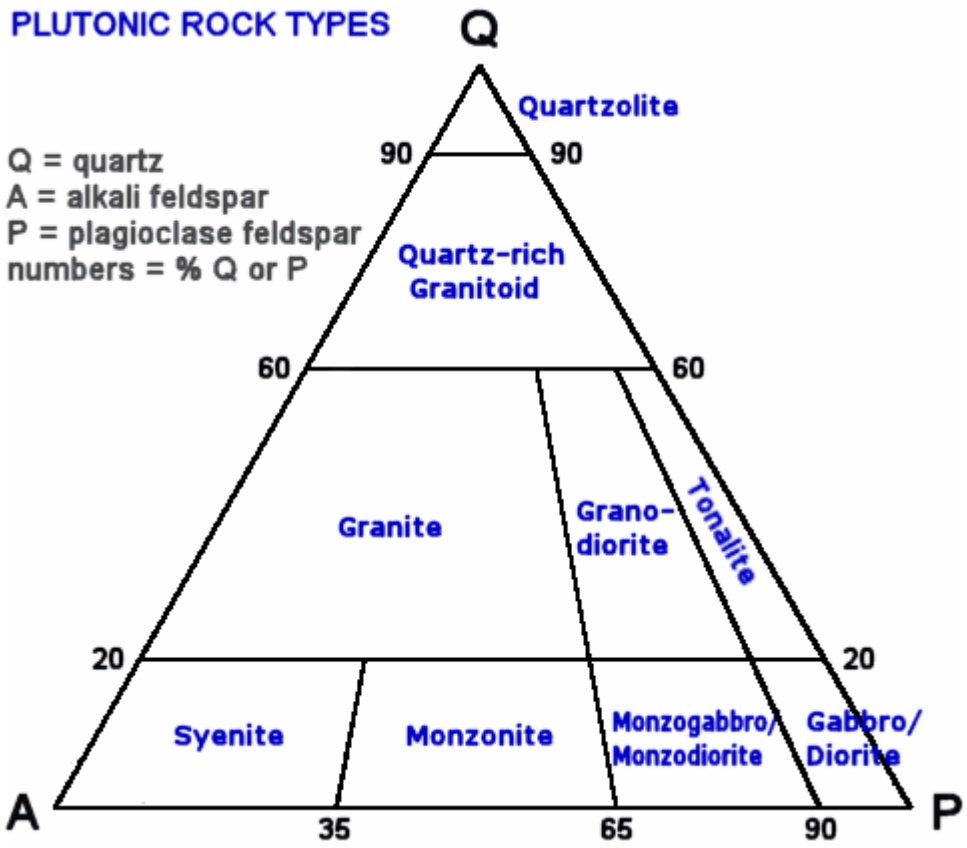
$(Na,Ca)Al_{1-2}Si_{3-2}O_8$

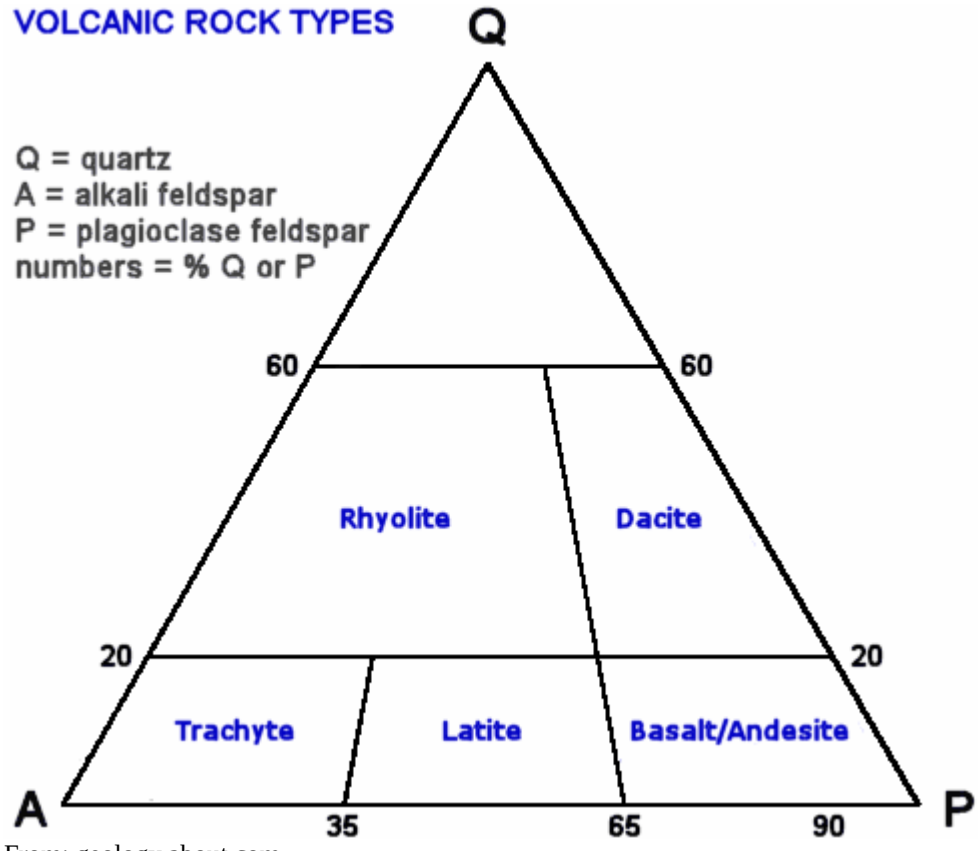
Variations in the amount of sodium and calcium; and aluminum and silicon, form different minerals in this series:

	Amount of sodium and calcium	*Percentage of Albite* (**Ab**) *and Anorthite* (**An**)
Albite	(**Na** $_{100\%}$, **Ca** $_{0\%}$) **Al Si** $_3$ **O** $_8$	90-100% **Ab** ; 0-10% **An**
Oligoclase	(**Na** $_{90\%}$, **Ca** $_{10\%}$) **Al** $_{1-2}$ **Si** $_{3-2}$ **O** $_8$	70-90% **Ab** ; 10-30% **An**
Andesine	(**Na** $_{70\%}$, **Ca** $_{30\%}$) **Al** $_{1-2}$ **Si** $_{3-2}$ **O** $_8$	50-70% **Ab** ; 30-50% **An**
Labradorite	(**Na** $_{30\%}$, **Ca** $_{70\%}$) **Al** $_{1-2}$ **Si** $_{3-2}$ **O** $_8$	30-50% **Ab** ; 70-50% **An**
Bytownite	(**Na** $_{10\%}$, **Ca** $_{90\%}$) **Al** $_{1-2}$ **Si** $_{3-2}$ **O** $_8$	10-30% **Ab** ; 70-90% **An**
Anorthite	(**Na** $_{0\%}$, **Ca** $_{100\%}$) **Al** $_2$ **Si** $_2$ **O** $_8$	0-10% **Ab** ; 90-100% **An**

Actual formula of end members are:

Albite	**Na Al Si** $_3$ **O** $_8$
Anorthite	**Ca Al** $_2$ **Si** $_2$ **O** $_8$





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