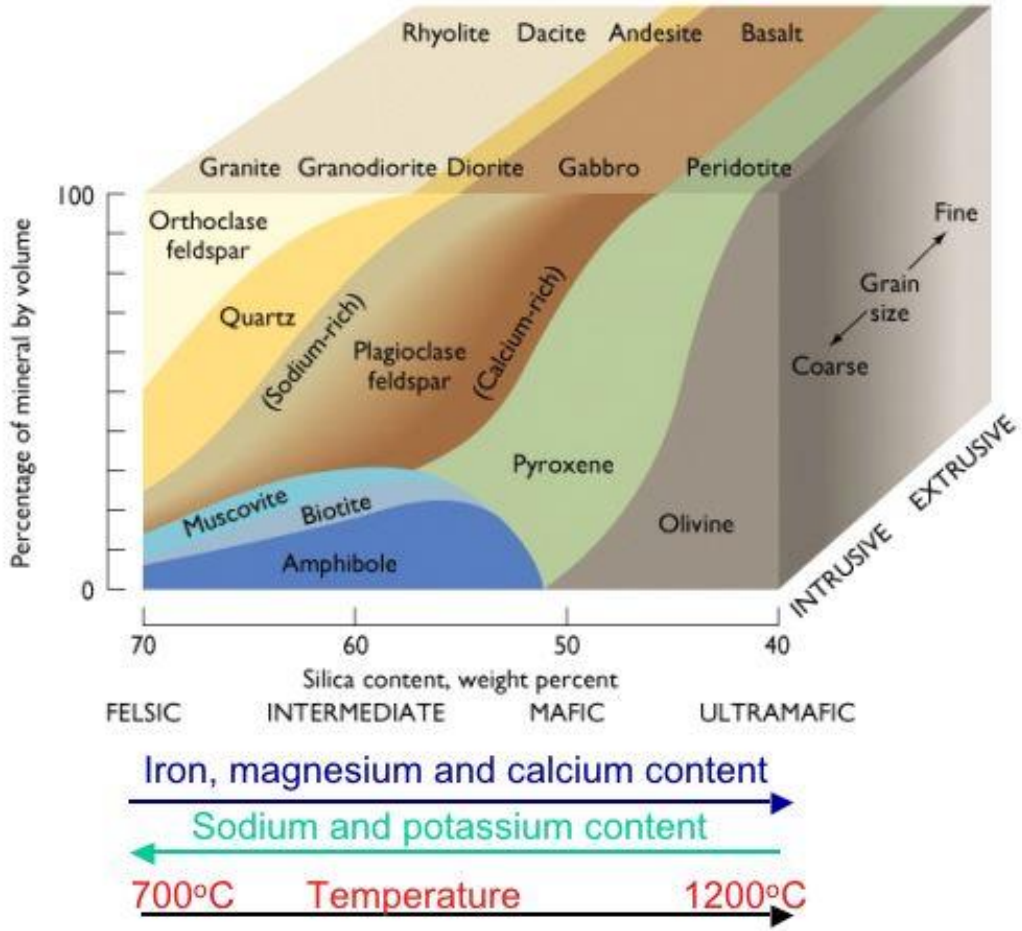
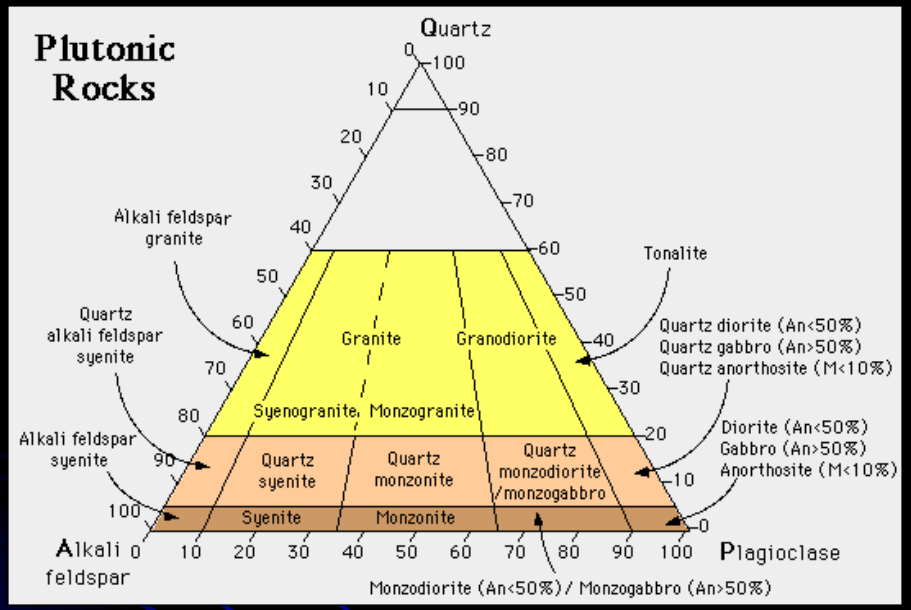
Igneous Rocks and Processes

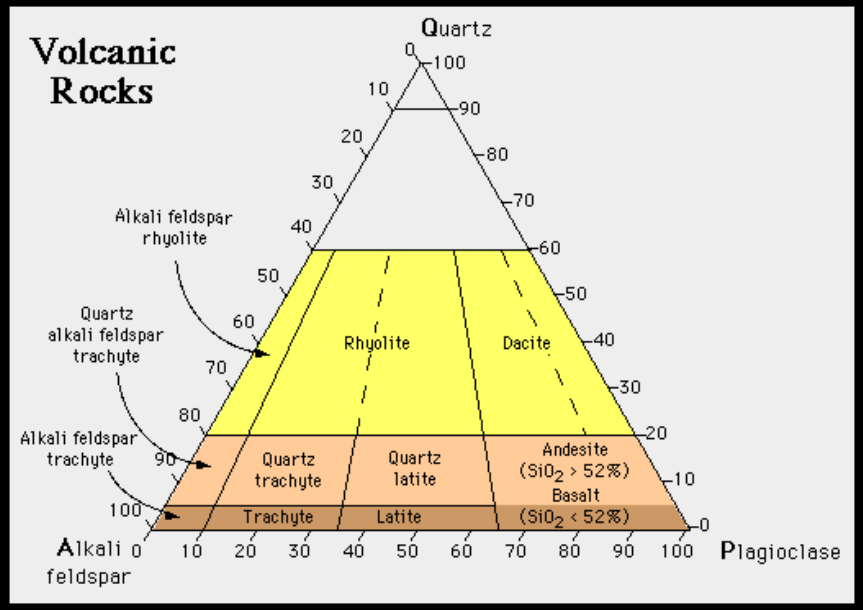
Classification of Igneous Rocks



Other minerals are important for the full description of igneous rocks: Olivine, Pyroxene, Hornblende, Biotite and Muscovite

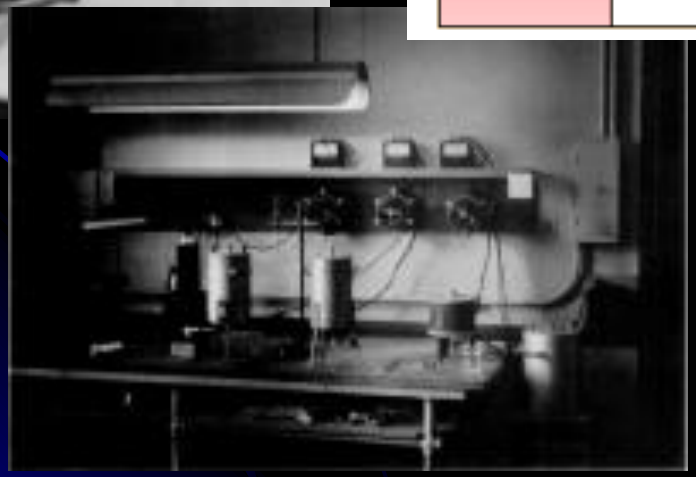
Classification of Igneous Rocks

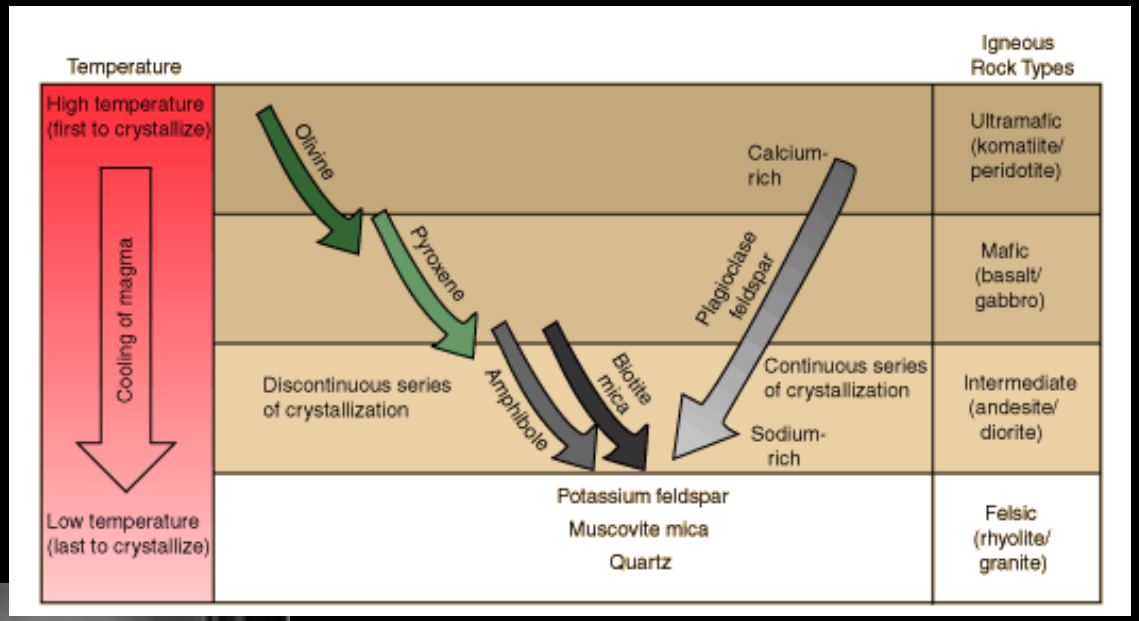




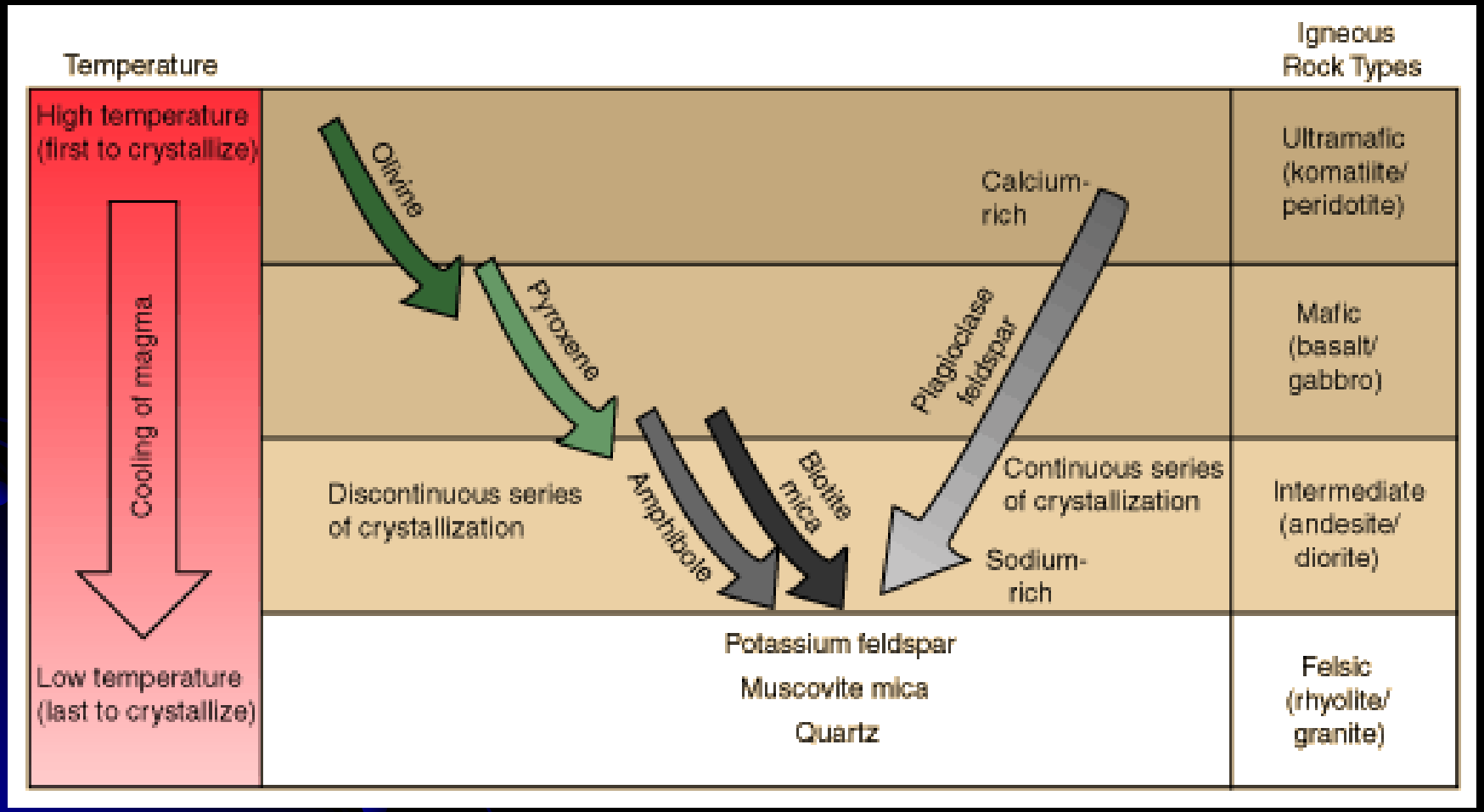
Streckheisen classification is based on only three minerals:
Quartz, Plagioclase, Potassium Feldspar

Norman Bowen (1887-1956)
Father of Experimental Petrology





Bowen's Reaction Series



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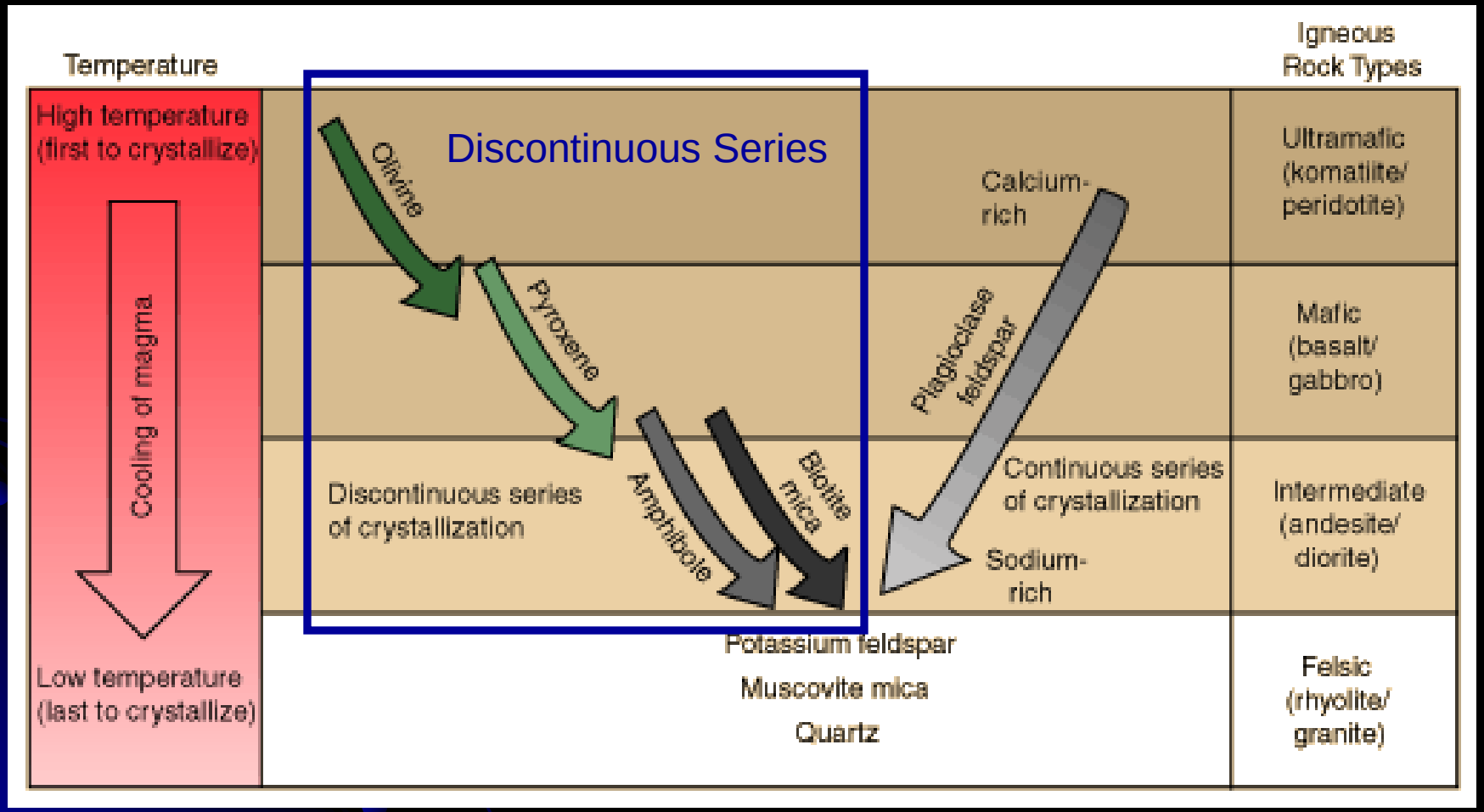
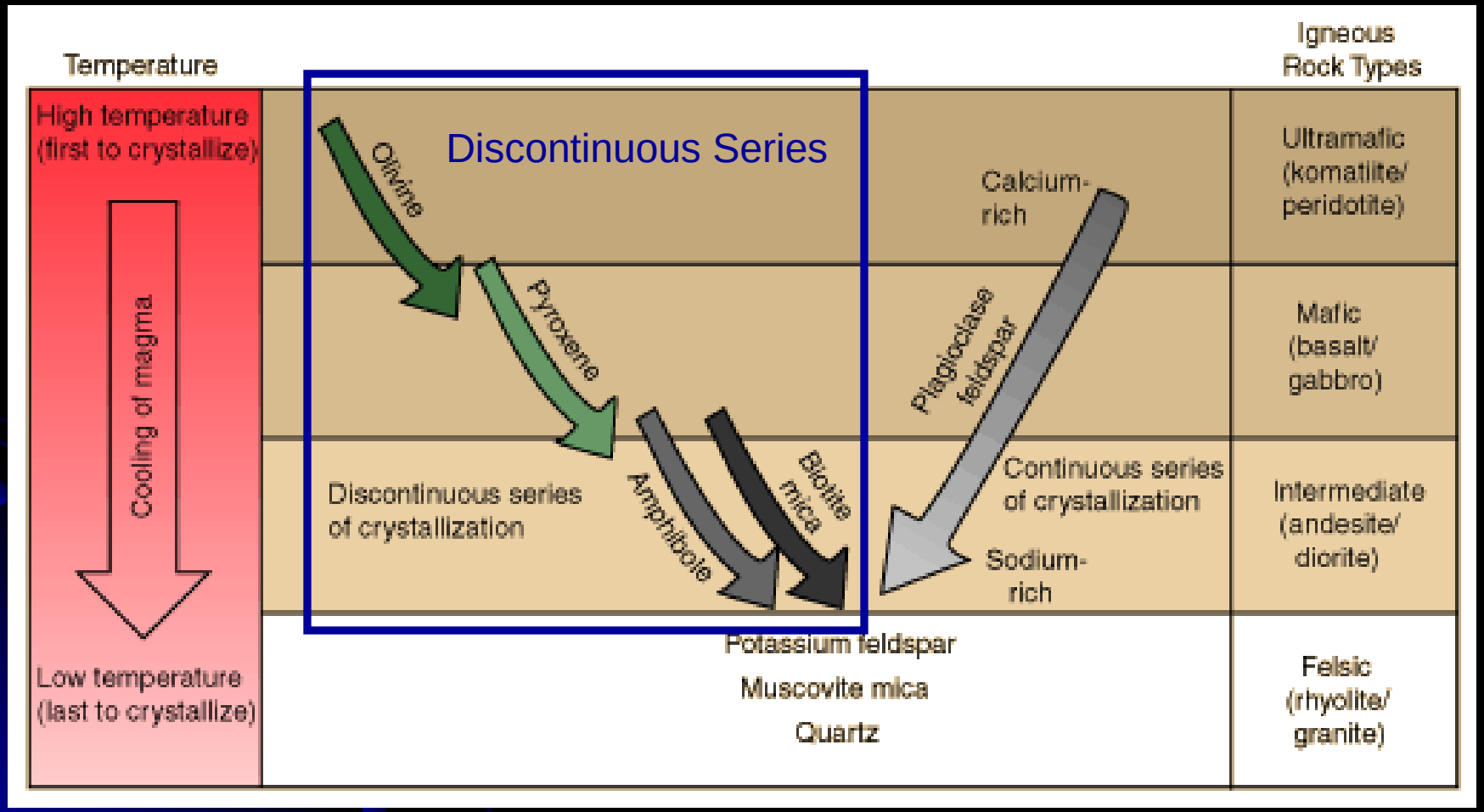


Bowen's Reaction Series

What is the trend in silicate structures? Why?



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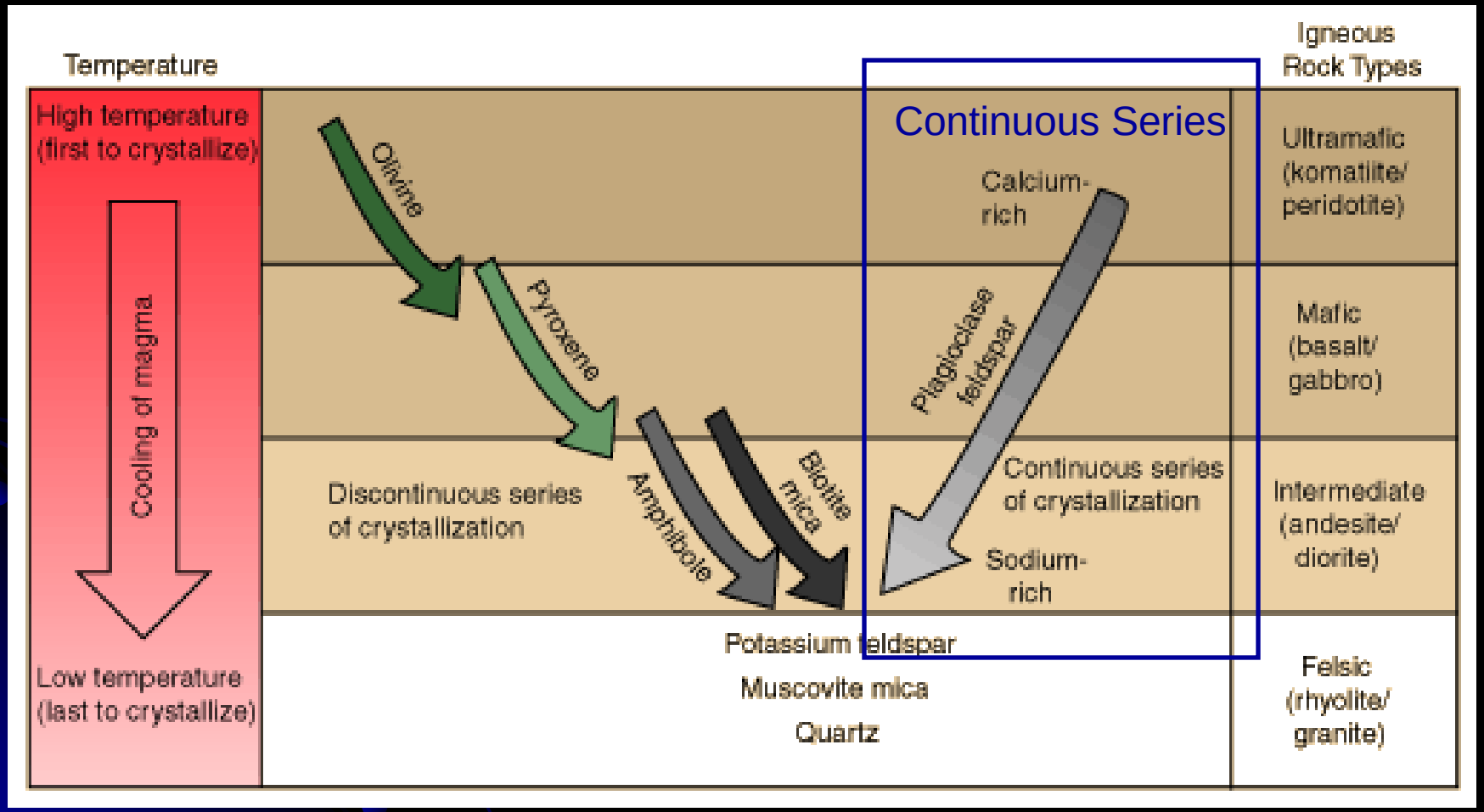
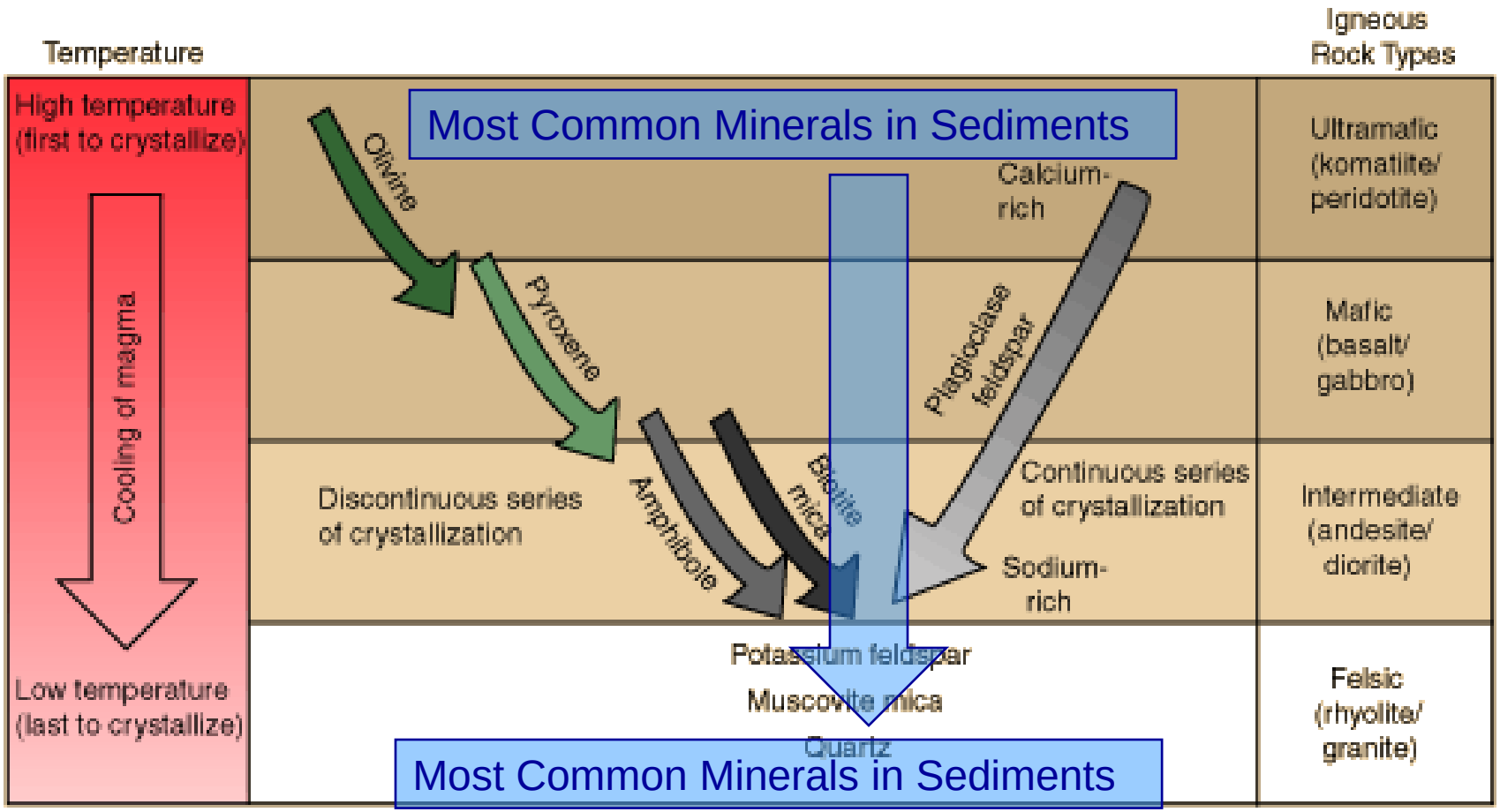
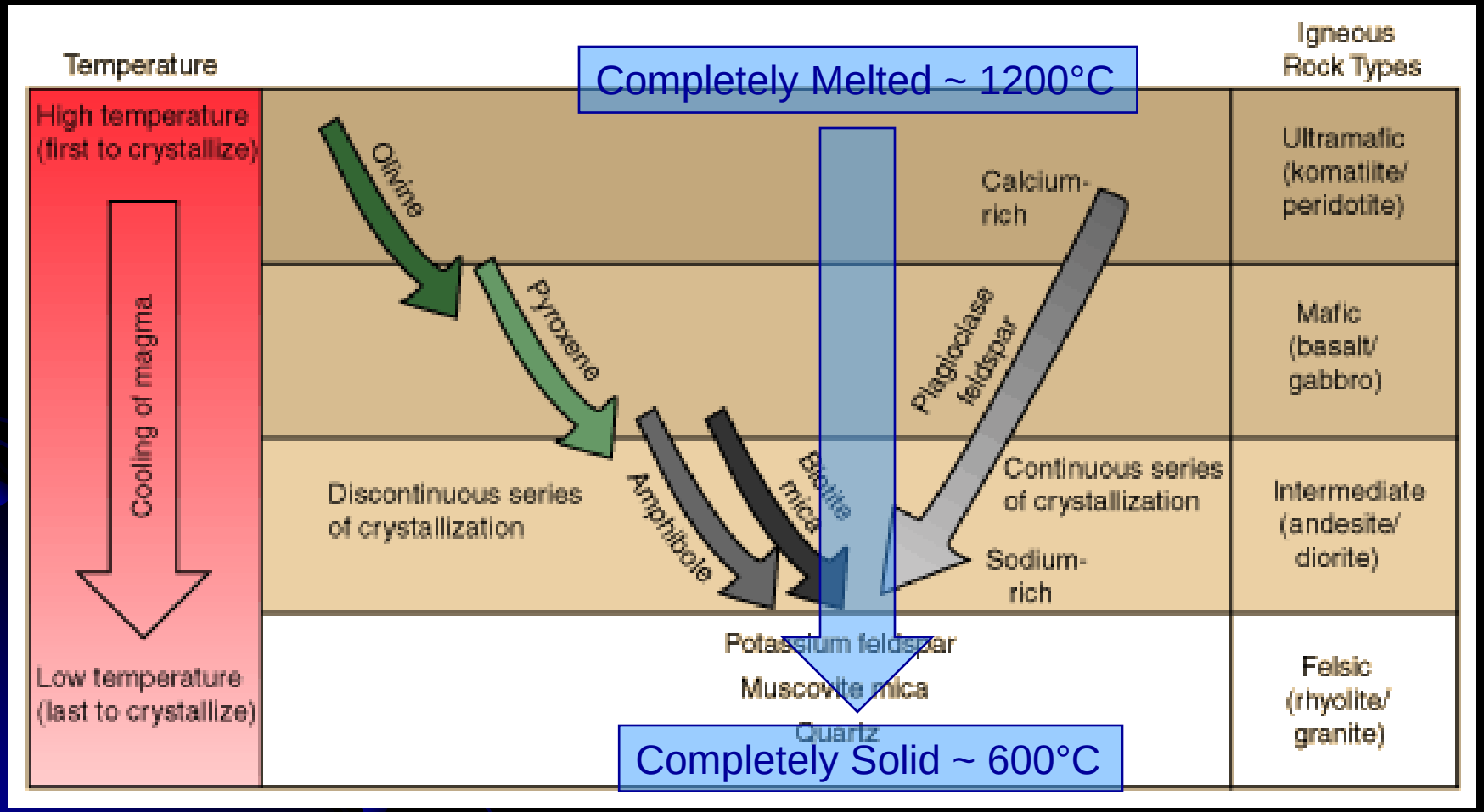


Bowen's Reaction Series

Why would aspects of this igneous concept apply to sedimentary rocks as well?

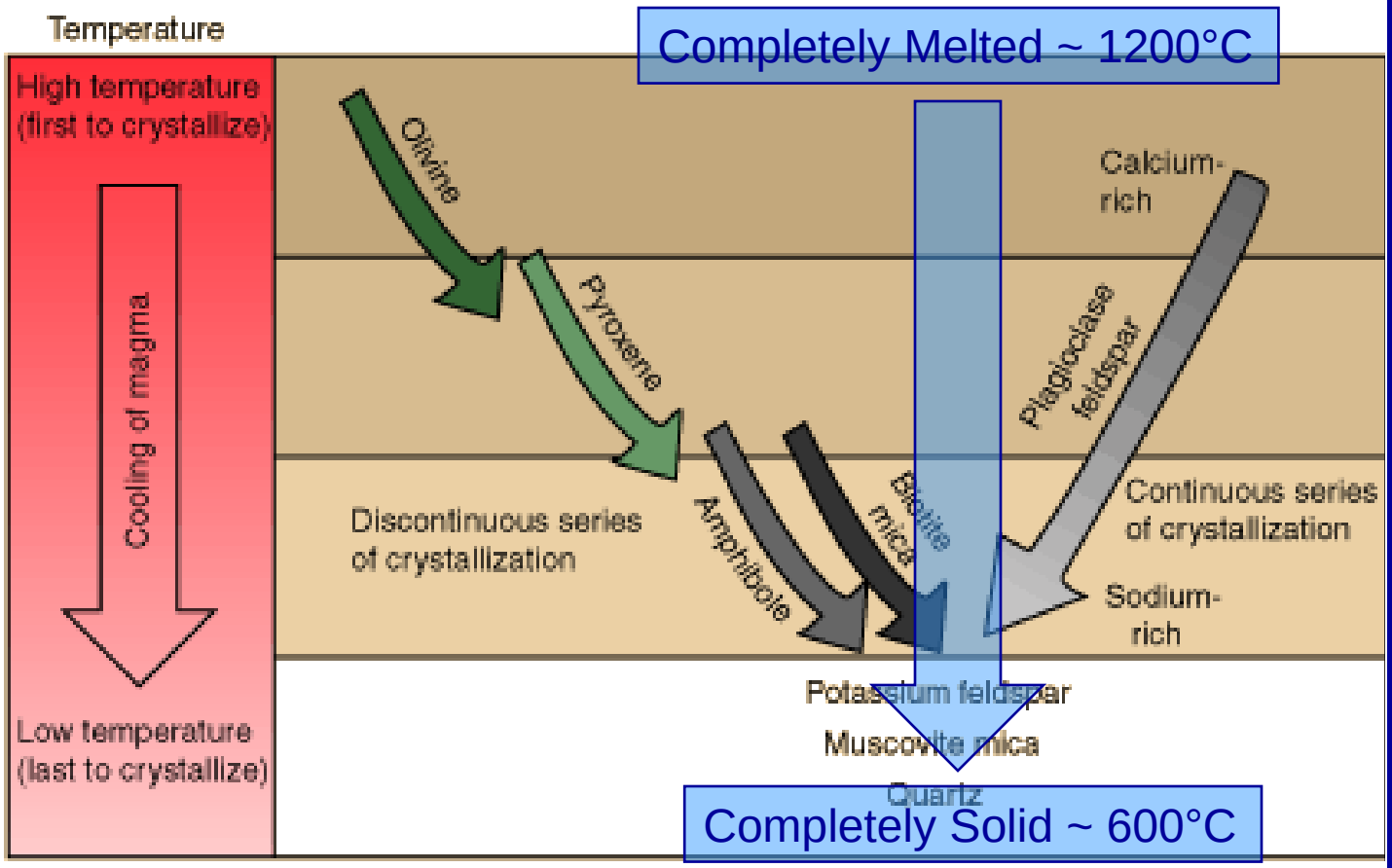


Bowen's Reaction Series



Bowen's Reaction Series

Rock melting temperatures are inconsistent with mineral melting temperatures



Mineral Melting Temp

Olivine: 1800°C

Ca-Feld: 1500°C

Pyroxene: 1400°C

Na-Feld: 1100°C

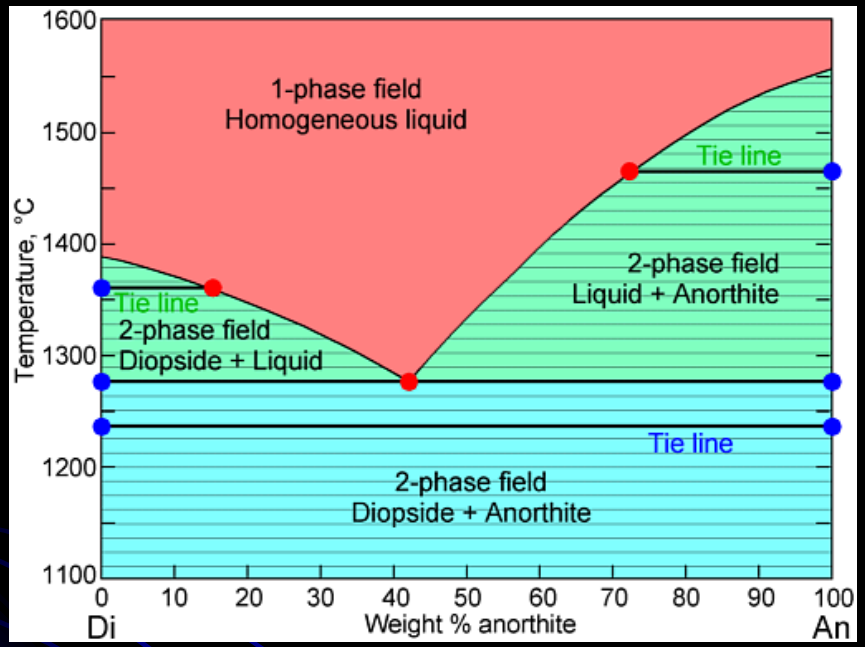
K-Feld: 1250°C

Quartz: 1650°C

- Minerals are chemical compounds
  - Freshwater (a compound): Freezing/Melting point = 0°C
- Rocks are chemical mixtures
  - Seawater (a mixture): Freezing/Melting point = -2°C

- Mixtures have lower melting points
  - Rocks have lower freezing/melting temperatures than the individual minerals that they contain

Binary Phase Diagrams

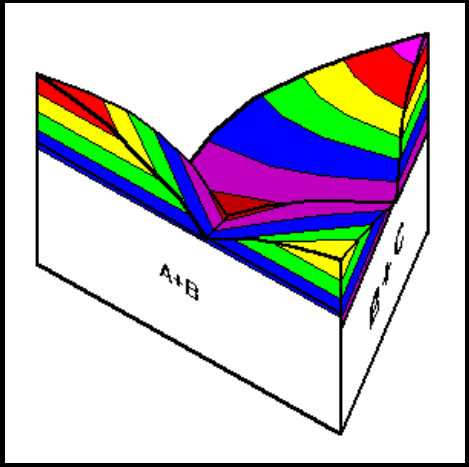


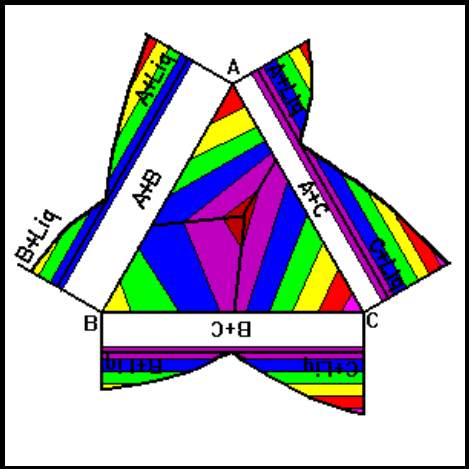
- Show the melting/crystallization relationships between mixes of two components
- The lowest melting temperature is called the EUTECTIC

- Geochemists and petrologists experiment with rocks to understand magmas
  - How do they form?
  - How do they cool?
- Add different chemicals (fluxes) to powdered rocks, heat them in a furnace, and see how they behave
  - Does it melt?
  - What minerals form?

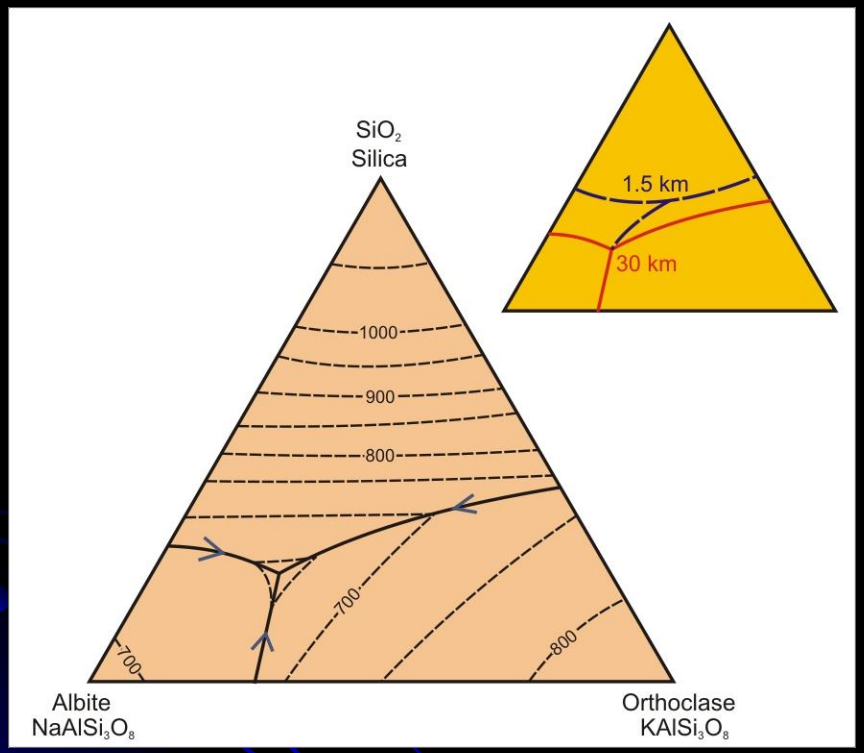
Ternary Phase Diagrams

- Show melting/crystallization relationships between mixes of three components
- Combination of 3 binary diagrams
- Used extensively to understand igneous rock processes



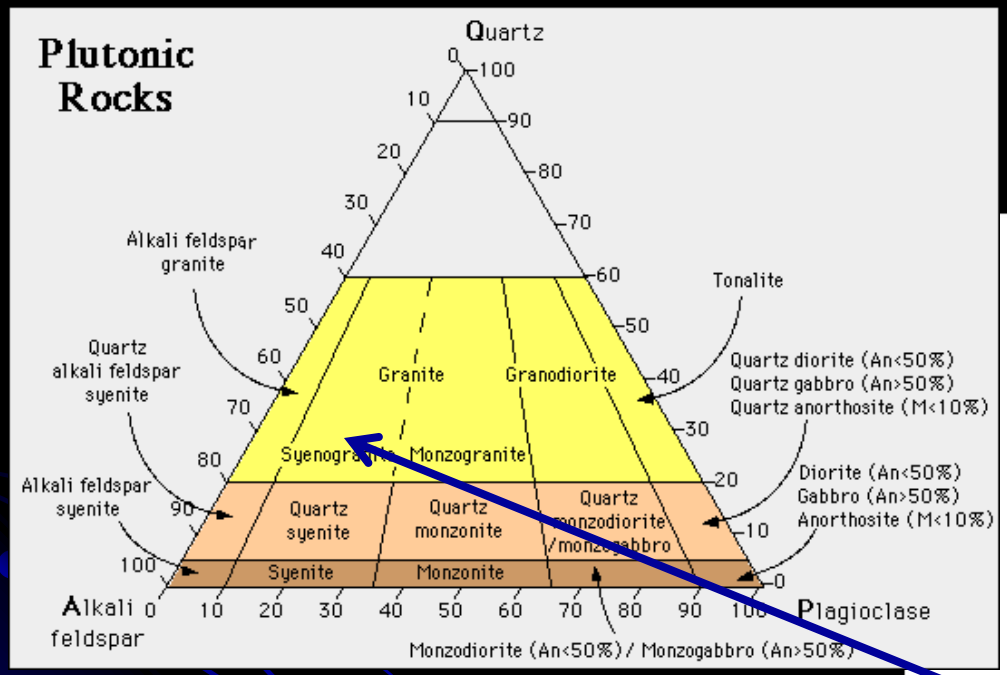


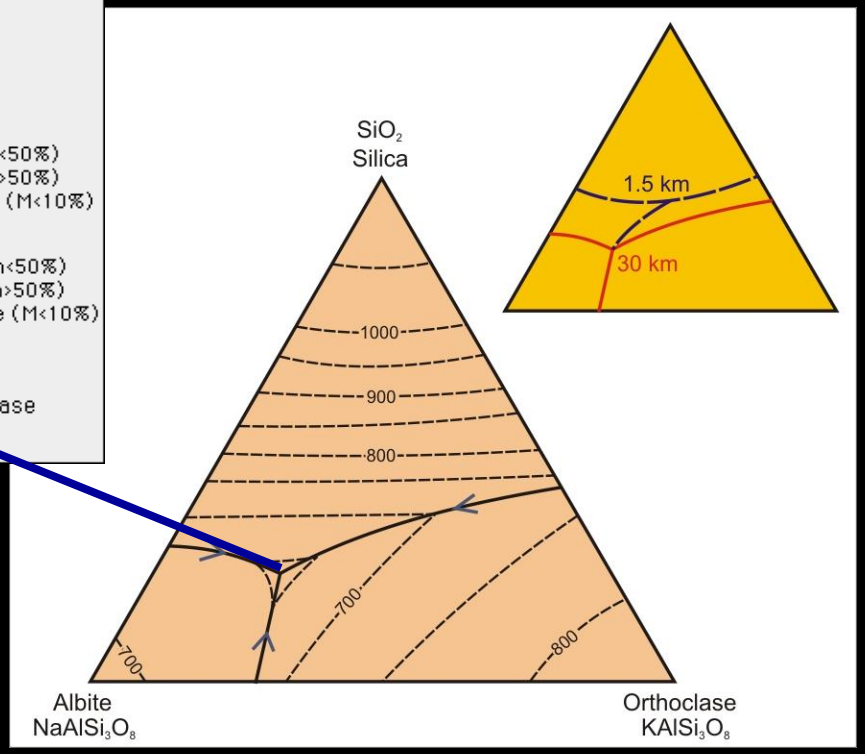
Si-Ab-Or Ternary Diagram:
Felsic and Intermediate Rocks



- Used for rocks that contain a mixture of quartz and feldspars
- What is the composition of the first magma to form?

Granite: A Eutectic Composition





Petrologists and Potters:
Shared Methods and Equipment

Experimental Petrologist

Potter

Glazes as Igneous Rocks

- A ceramic glaze is a glass
  - Glass is a solid without an ordered atomic structure that forms from rapidly cooling a silicate melt
  - OBSIDIAN is a natural silicate glass (igneous rock)

- The ideal glaze would be made of pure silica glass (molten quartz) but the melting temperature of quartz (1650°C) is higher than the firing temperature of a potter's kiln

- Potters experiment to find glazes that work
- Add fluxes powdered quartz in different proportions to find the ideal percentages to make a shiny glass
- Add transition metals to color the glaze

Components of Glazes

- Potters consider glazes to be composed of three components
  - Silica: the glass former (quartz or flint)
  - Flux: materials that make the glaze melt at kiln temperatures (e.g. feldspar, calcite, dolomite, talc)
  - Amphoteric: binds the glaze to the clay pot (e.g., clay minerals such as kaolin, bentonite)

Feldspar as a Glaze

- Feldpars can act as glazes by themselves for stoneware
  - Albite: $NaAlSi_3O_8$
  - K-Feldspar: $KAlSi_3O_8$

- They contain all three components:
  - SiO_2 (silica)
  - Al_2O_3 (amphoteric)
  - Na_2O/K_2O (Flux)

Feldspar as a Glaze

- Feldpars can act as glazes by themselves for stoneware
  - Typical stoneware firing is around 1200°C
  - Albite: $NaAlSi_3O_8$
    Melting T = 1100
  - Microcline: $KAlSi_3O_8$
    Melting T = 1250
  - Mixing ~ 70% Albite with 30% K-Feldspar will produce a glaze that melts at 1050