GEPM 375

Geology and Geomorphology

Igneous Rocks

Igneous Rock Formations

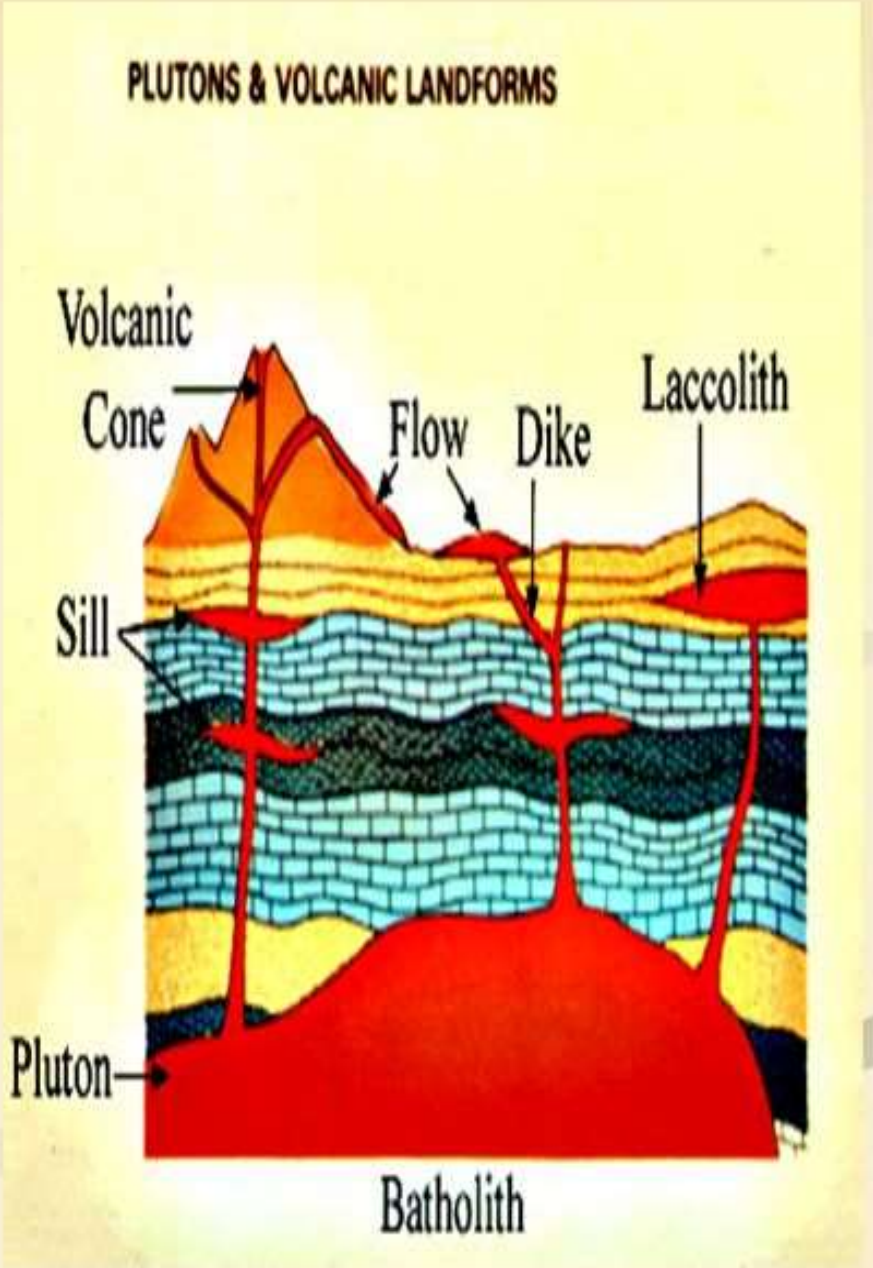
Extrusive Igneous Structues:

- volcanoes

Intrusive Igenous Structures:

- batholiths
- laccoliths
- sills
- dikes

- ❑ **Lopolith**
- ❑ **Stock**



Igneous Rocks

- Formation
- Process of Crystallization
- Bowen Reaction Principles and Reaction Series
- Extrusive and Intrusive Igneous Rocks

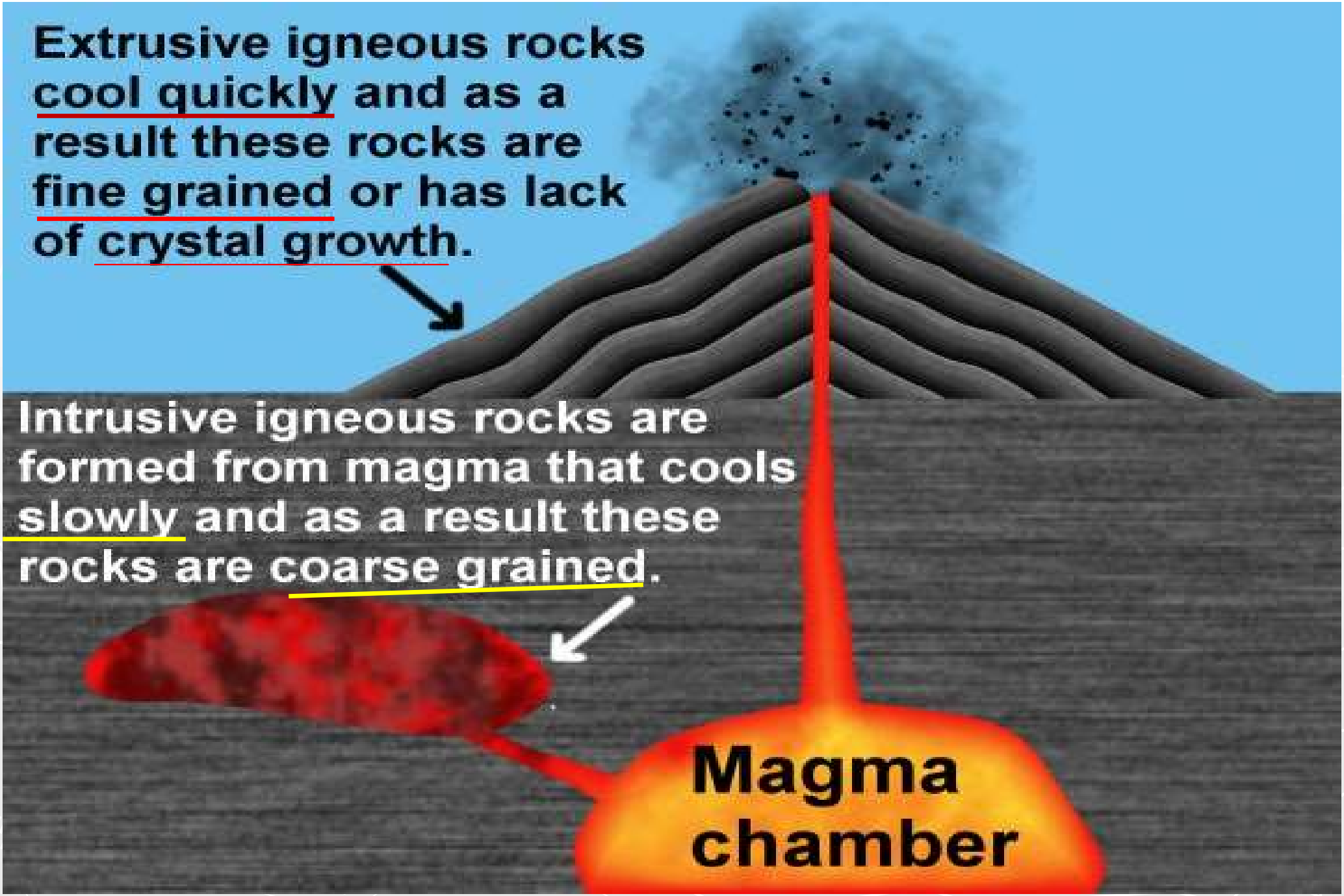
Igneous Rocks:

- Igneous rock, also known as **“fire rock”** (derived from the Latin “ignus”), these type of rock are the most common type of rock in the Earth’s surface.

- Combined with metaphoric rock, **igneous rock makes up 90 to 95% of all rock to a depth of 16 km** from the surface.

Formation of Igneous Rocks: All Igneous Rocks have been formed from **solidification of Magma**.

- Magma **extruded as lava at the surface**, cools comparatively rapidly and solidified.
- **Offshoots of magma** that work their ways into surrounding rocks **below the surface, cools more slowly and solidify.**
- Even **magma reservoir**, eventually cools and solidifies but it takes **much longer time** because it is a larger mass.

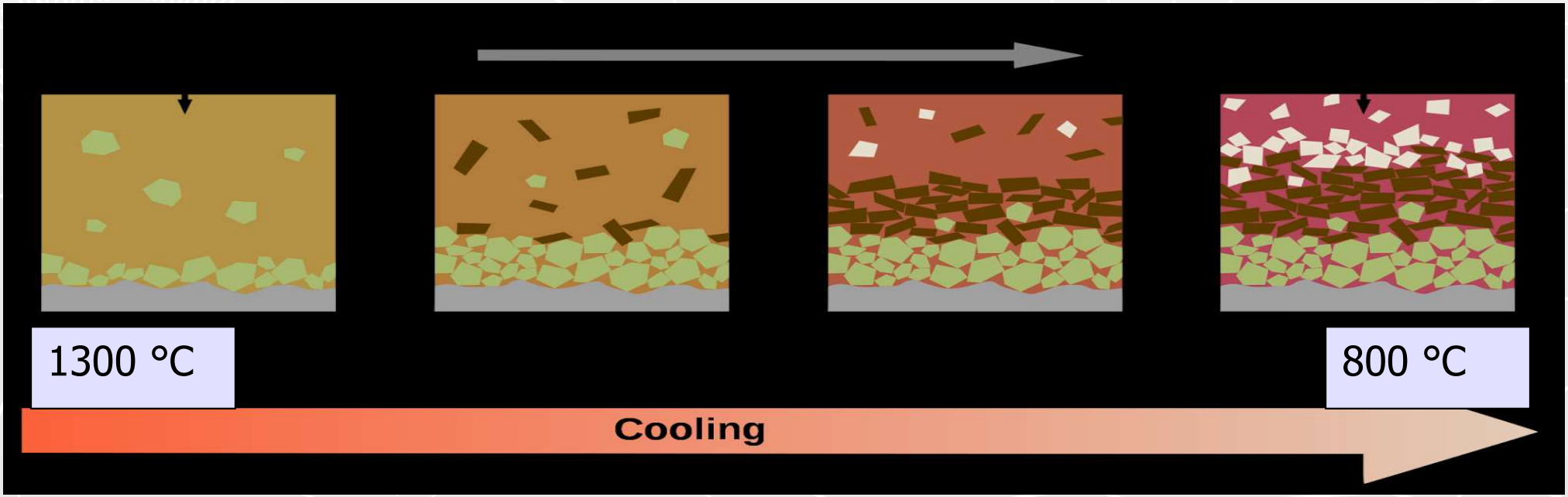

Extrusive igneous rocks cool quickly and as a result these rocks are fine grained or has lack of crystal growth.
Intrusive igneous rocks are formed from magma that cools slowly and as a result these rocks are coarse grained.
Magma chamber

Process of crystallization of magma:

- Magma **solidified through the crystallization**.

- As **decrease in temperature**, **magma starts to solidify**, mineral grains began to grow.

- As the **temperature continues to fall**, the **mixture solidifies** until the igneous rocks are formed.



Bowen's Reaction Principles:

- In 1922, **N L Bowen proposed that during crystallization,** the differences in **end product** depend

  -on the rate at which magma cools and

  -on whether **early formed minerals remain in or settle out** of the remaining liquid.

- **Called this process Reaction**.

What is Reaction Series?

Basing on the **laboratory experiment**, **Bowen was able to arrange the rock forming minerals of igneous rocks in reaction series.**

Explanation of Bowen's Reaction principles:

- An **important characteristics of silicate melts** is that,

-as **one mineral develops at a certain temperature, it will be converted upon further cooling in to different mineral by reaction with the liquid around it.**

Types of Reaction Series:

- Continuous Reaction Series
- Discontinuous Reaction Series.

Differences between Continuous and discontinuous series in Bowen reaction principles.

- **In continuous series**, some early formed minerals are converted in new minerals by **continuous changing their composition** but **not heir crystalline structure**.

- **In discontinuous reaction series**, some early formed minerals react with the melt to change to new minerals **with different composition** and **a different crystalline structure.**

Description of Bowen's reaction Series:

- Common minerals of igneous rocks can be arranged into two series, a **continuous reaction series** of the **feldspars**, and a **discontinuous reaction series** of the **ferromagnesian minerals** (olivine, pyroxene, hornblende, biotite)

- This reaction series implies that **from a single "parental magma"** all the **various kinds of igneous rocks** can be derived by **Magmatic Differentiation**

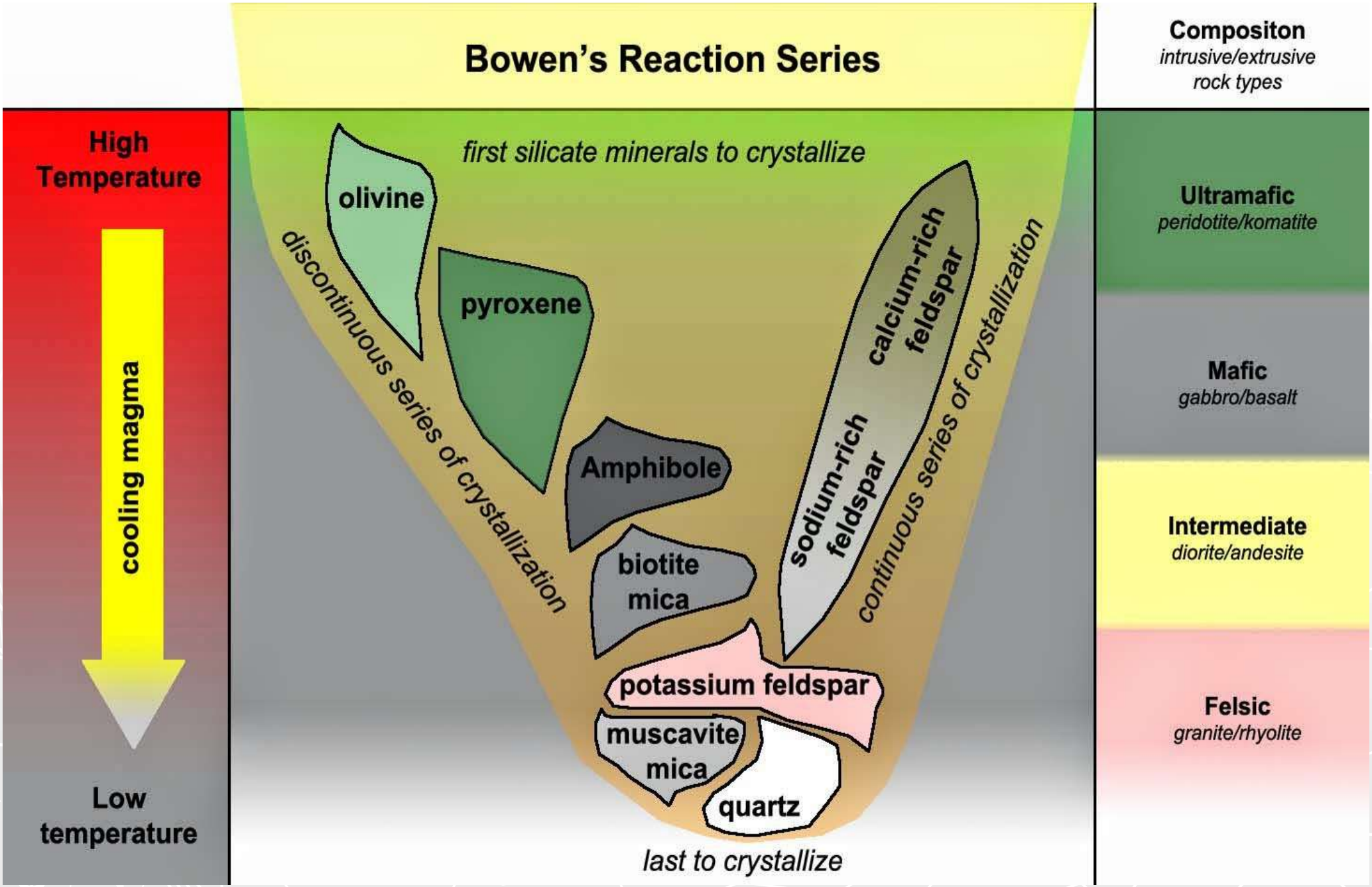
- As magma cools, **Olivine and Anorthite** (Ca-Felspar) are the first minerals to form.

- **Some early formed minerals are settled out**, called **Fractionation**, remaining minerals react with the remaining melts.

- **Augite becomes Hornblende**, and **Anorthite** (Ca-Feldspar) **becomes Albite** (Na- Feldspar)

- **Fractional crystallization** can **lead to the formation of successively more Siliceous rocks** until Quartz mineral is reached.

- **Rocks formed depend** on the extent of which **the early formed minerals were removed** from the further reaction with the melt and on the **rate of cooling**.


Bowen's Reaction Series
Compositon
intrusive/extrusive
rock types
High
Temperature
cooling magma
Low
temperature
first silicate minerals to crystallize
olivine
pyroxene
Amphibole
biotite
mica
potassium feldspar
muscavite
mica
quartz
last to crystallize
discontinuous series of crystallization
continuous series of crystallization
calcium-rich
feldspar
sodium-rich
feldspar
Ultramafic
peridotite/komatite
Mafic
gabbro/basalt
Intermediate
diorite/andesite
Felsic
granite/rhyolite

Texture of Igneous Rocks:

- Latin ‘texere’ meaning **weave.**
- General appearance of rocks
- Texture of IG Rocks means, size, shape and arrangement of their interlocking mineral grains.





Types of Texture of IG Rocks:

- Granular
- Aphanitic
- Glassy
- Porphyritic





Types of Texture of IG Rocks:

- Granular- A rock texture resulting from the aggregation of mineral grains of **approx. equal size** whose particles range in diameter from 0.05 to 10 mm.



Types of Texture of IG Rocks:

- **Aphanitic** - Igneous rocks that form on the earth's surface have **very fine-grained texture** because the crystals are too small to see without magnification.



Types of Texture of IG Rocks:

- Glassy or vitreous- **occur during some volcanic eruptions when the lava is quenched so rapidly that crystallization cannot occur**.
- Result is a natural amorphous glass with few or no crystals.



Types of Texture of IG Rocks:

- Porphyritic-in which **large crystals are set in a finer-grained or glassy groundmass**.
- Porphyritic textures occur in coarse, medium and fine-grained igneous rocks.



Types of IG Rocks as per color:

- Light colored - **Granite**
- Dark colored - **Gabbro**
- Intermediate - **Andesite**

Pegmatite

- Solutions develop late in cooling magma is called **hydrothermal**, which crystalizes into an **exceptional granular** igneous rocks, called Pegmatite.

- **Pegmatite** = **Quartz** + **Orthoclase Feldspar** + small amount of **Mica**.



Types of Igneous Rocks as per Origin of magma/lava:

Extrusive igneous rocks:

- **Erupt** onto the surface, where they cool quickly to form small crystals.
- Some cool so quickly that they form an **amorphous glass**.
- These rocks: include **andesite**, **basalt**, **obsidian**, **pumice** etc.

What is Andesite?

- Andesite is the name used for a **family of fine-grained, extrusive igneous rocks** that are usually **light to dark gray** in color

- Have a **mineral composition** that is intermediate between granite and basalt.
- Named after the **Andes Mountains**, in South America.



- Andesite is **rich in plagioclase feldspar** minerals and may contain biotite, pyroxenes, or amphiboles.



What is Basalt?

- Basalt is a **dark-colored**, **fine-grained** igneous rock.
- Composed mainly, **plagioclase and pyroxene minerals**.
- Most commonly forms as an **extrusive rock**, such as a lava flow, but can also form in small **intrusive bodies**, such as an igneous **dike** or a thin **sill**.



Basalt

What is Obsidian?

- An igneous rock that forms when molten rock material **cools so rapidly** that atoms are **unable to arrange themselves** into a crystalline structure.
- An amorphous material known as a "**mineraloid.**"
- Result is a **volcanic glass** with a smooth uniform texture that breaks with a **conchoidal fracture**.





What is Pumice?

- A **light-colored**, **extremely porous igneous** rock that forms during **explosive volcanic eruptions**.

- Used as **aggregate in lightweight concrete**, as **landscaping** aggregate, and as an **abrasive** in a variety of industrial and consumer products.



Intrusive igneous rocks

- **Crystallize below Earth's surface**, and the **slow cooling** that occurs there **allows large crystals** to form.

- Examples of intrusive igneous rocks are **gabbro**, **granite**, **pegmatite**, etc.

What is Gabbro?

- A **coarse-grained**, **black or dark green colored**, **intrusive igneous** rock.
- Composed mainly of the minerals **plagioclase and augite**.
- Most abundant rock in the **deep oceanic crust**.
- Used for everything from **crushed stone** base materials at construction sites **to polished stone** counter tops and floor tiles in construction industry.





Gabbro

What is Granite?

- A **light-colored igneous rock** with **grains large enough** to be visible with the unaided eye.
- Forms from the **slow crystallization of magma** below Earth's surface.
- Composed mainly of **quartz and feldspar** with minor amounts of **mica**, **amphiboles**, and **other minerals**.
- Usually gives granite a **red, pink, gray, or white** color with dark mineral grains visible throughout the rock.





Granite in Yosemite Valley, California

Uses of Granite

- Most often quarried as a "**dimension stone**".
- Granite is hard enough to **resist abrasion**, **strong** enough to **bear significant weight**, **inert enough** to resist weathering, and it **accepts** a **brilliant polish**.
- These characteristics make it a very **desirable and useful dimension stone.**





What is Pegmatite?

- Pegmatite is **extreme** **igneous rocks** that **form** during the **final stage of a magma's crystallization**.

- They are extreme because they **contain** **exceptionally large crystals** and they sometimes **contain** **minerals that are rarely found** in other types of rocks.



Thanks