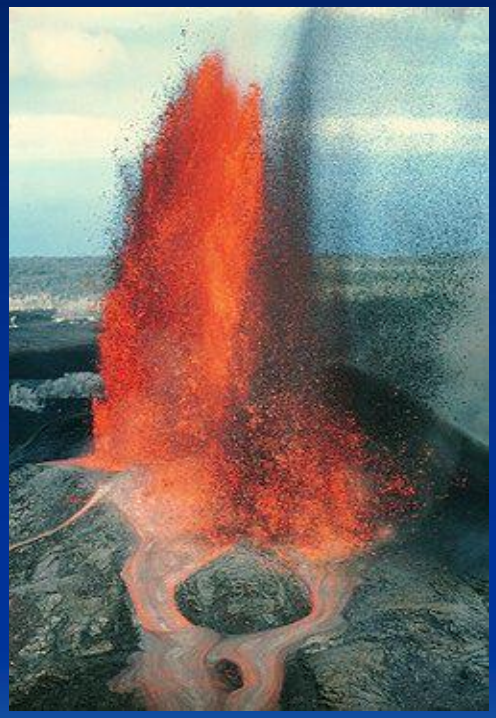
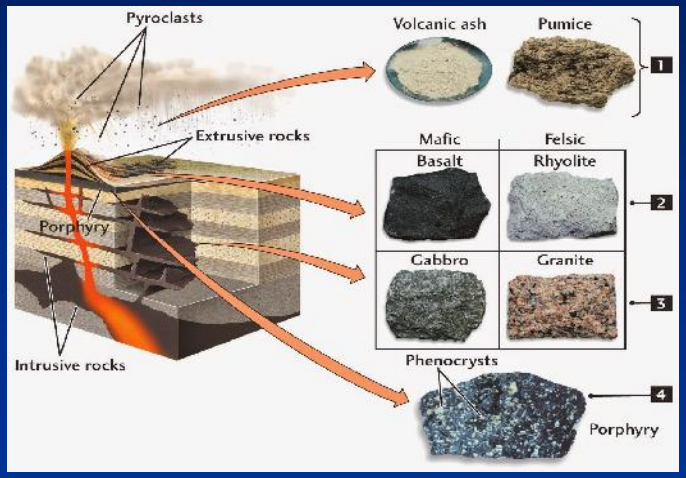
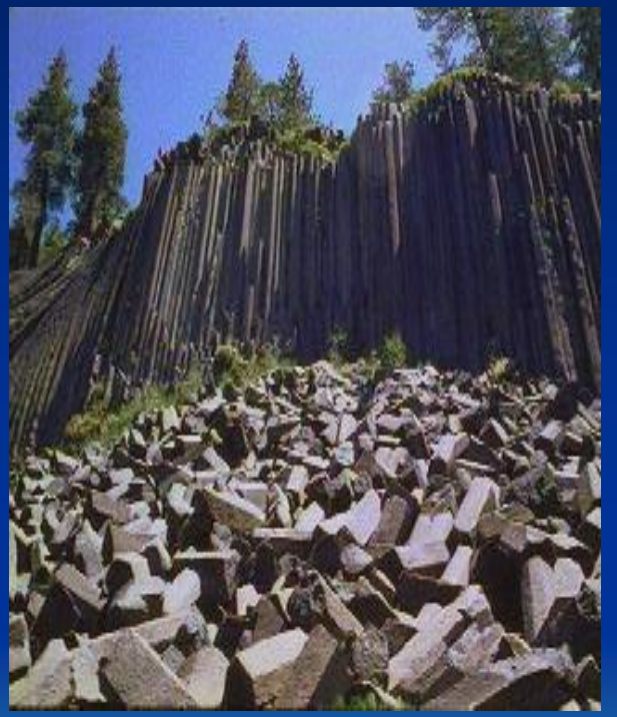
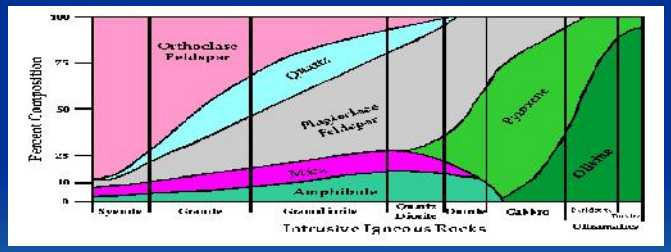
# Igneous Rock – Classification, Processes and Identification








## Physical Geology – GEOL 100

Ray Rector - Instructor

# Major Concepts

1) Igneous rocks form directly from the crystallization of a magma or lava
2) Three primary tectonic settings of global-scale magmatization are divergent boundaries, subduction-related convergent boundaries, and hot spots.
3) Tectonic environment controls the type of magmas generated, and hence the types of igneous rocks that form at each of the three tectonic settings.
4) Magma reaching the surface is termed lava, typically forming a volcano.
5) The type of igneous rock formed is controlled by two factors: magma composition and cooling history; also determines naming of igneous rocks
6) Magma compositions vary from mafic to intermediate to silicic-felsic.
7) Texture controlled by cooling history; Mineralogy by magma composition
8) Coarse-grained igneous rocks that cooled very slowly at depth are termed intrusive or plutonic
9) Fine-grained igneous rocks that cooled quickly at or near surface are termed extrusive or volcanic.
10) Identification of igneous rocks based on two criteria: texture and composition

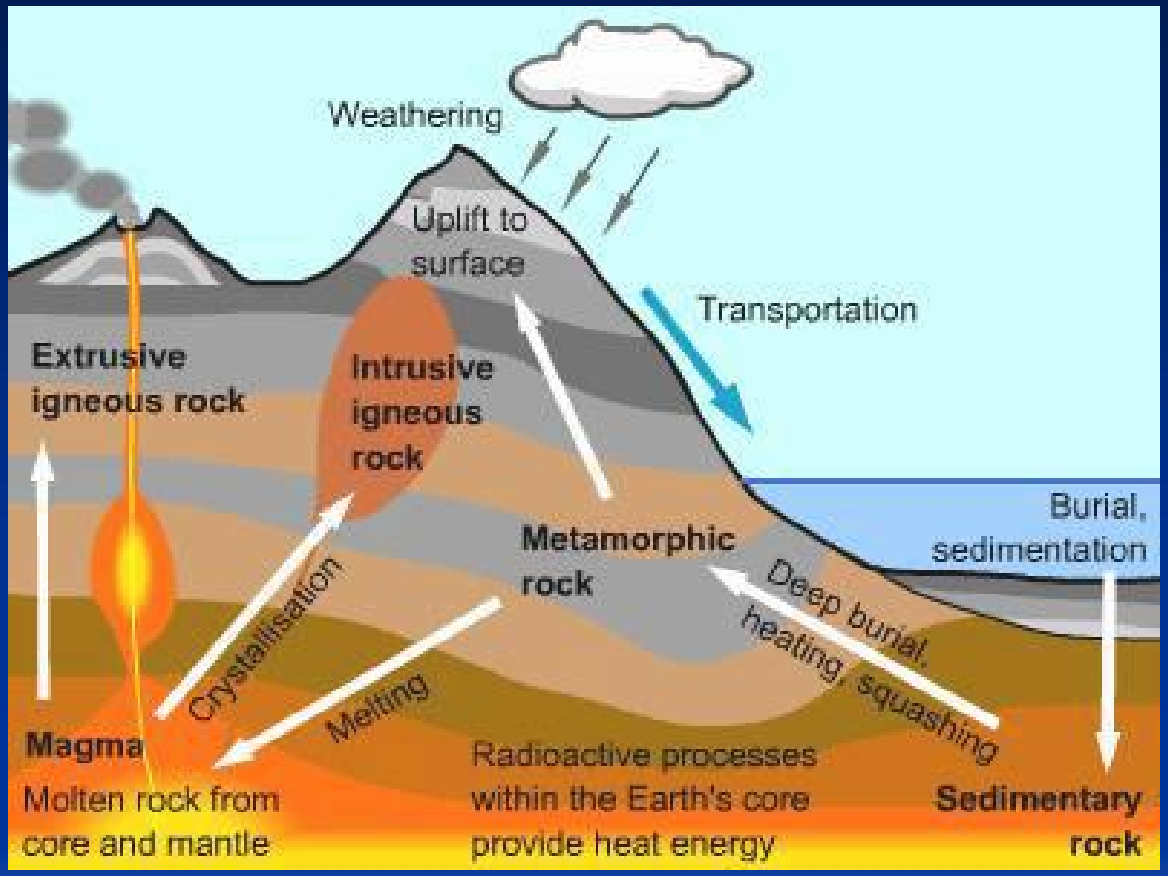
# The Rock Cycle

## Three Primary Rock Types

1) **Igneous**

2) **Metamorphic**

3) **Sedimentary**




**Key Concept:**

**The Rock Cycle is Perpetuated by Several Major Processes**

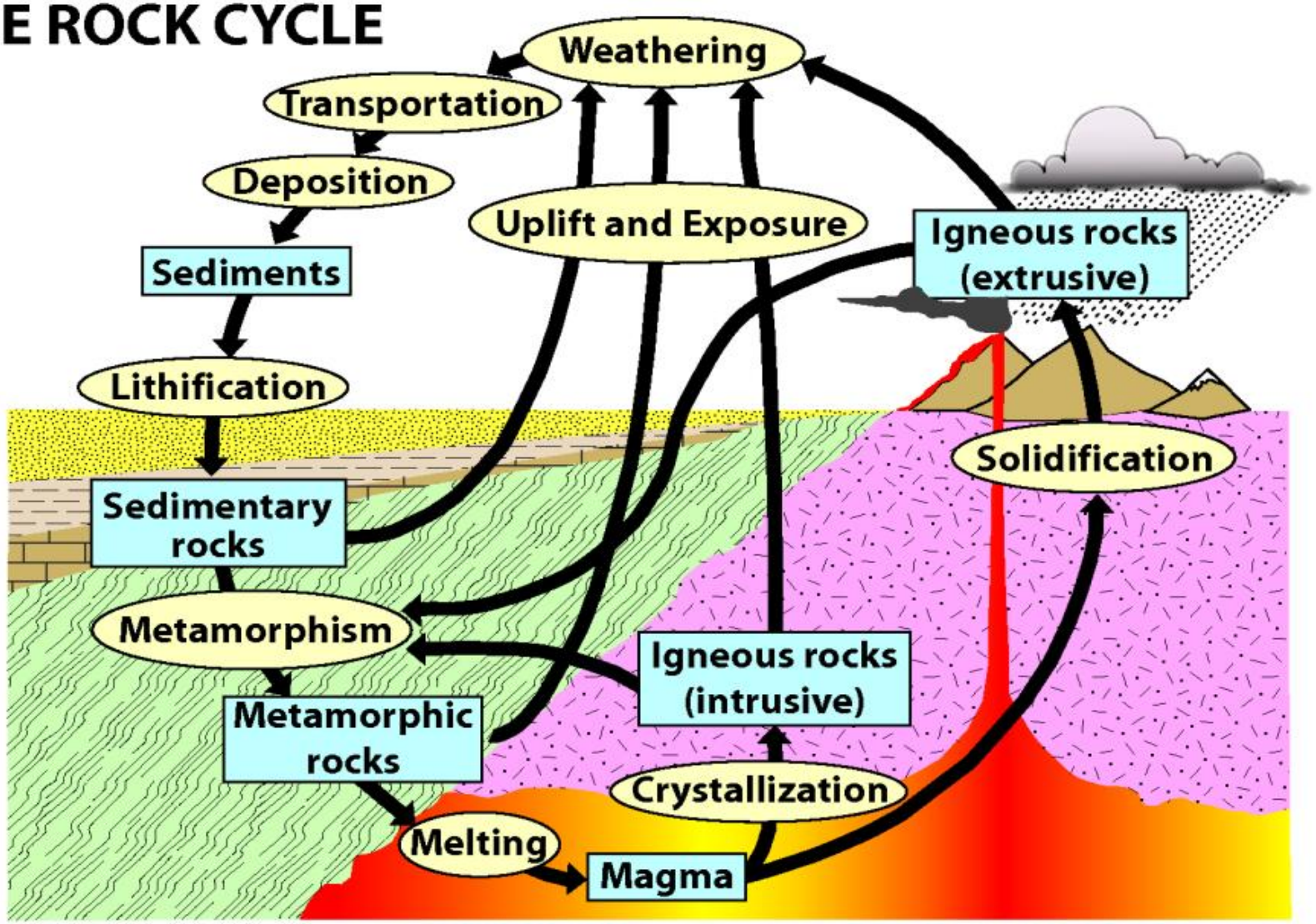
1) Magmatic Activity
2) Uplift and Mountain Building
3) Weathering, Erosion, Deposition, and Burial of Sediment

# 3 Major Rock Types

- Igneous
  - Formed from the solidification of molten rock (magmaor lava).
- Sedimentary
  - Formed at the Earth's surface from the accumulation and cementation of fragmented pieces of older rock produced by weathering.
- Metamorphic
  - Rocks that have undergone physical changes as a result of exposure to extreme pressure, temperature and fluids.


Minerals
Rocks
Quartz
Granite
Igneous
Feldspars
Sandstone
Orthoclase and Plagioclase
Sedimentary
Micas
Gneiss
Metamorphic
Muscovite and Biotite

# THE ROCK CYCLE




**Igneous Rocks -**
Rocks that form from the cooling of motlen rock (magma), Example: granite and basalt

**Sedimentary Rocks -**
Rocks that are fromed from pieces of other rocks, Example: sandstone, or that are deposited from the ocean by chemical processes, Example: limestone

**Metamorphic Rocks -**
Rocks that are changed by heat and pressure without melting, Example: gneiss

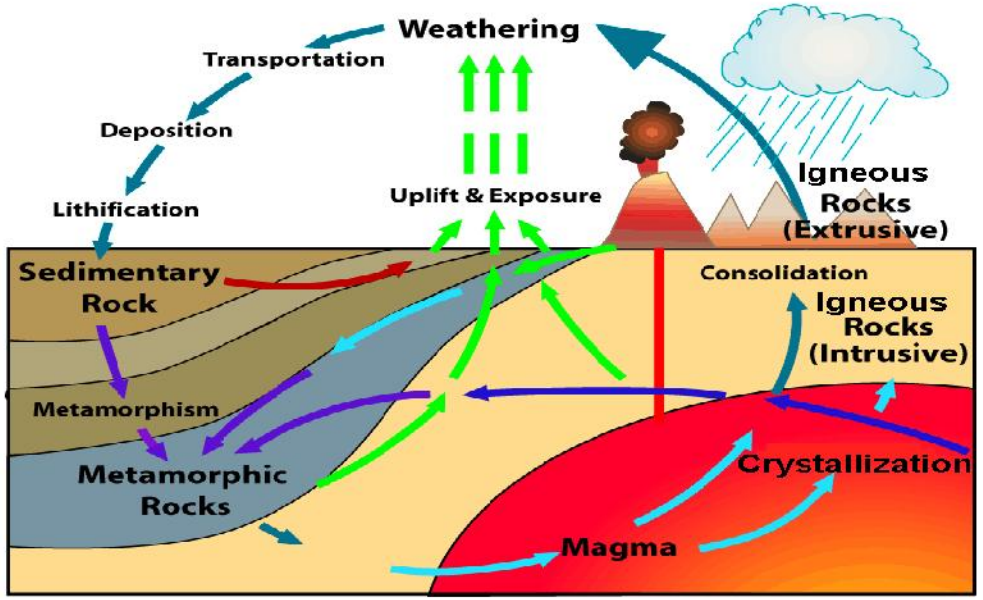
# The Rock Cycle

## Three Primary Rock Types

1) **Igneous**

2) **Metamorphic**

3) **Sedimentary**




Igneous rocks form by the *cooling* and *crystallization* of underground *magmas* and erupted *lavas*.

Igneous rocks are classified by two mineral criteria:

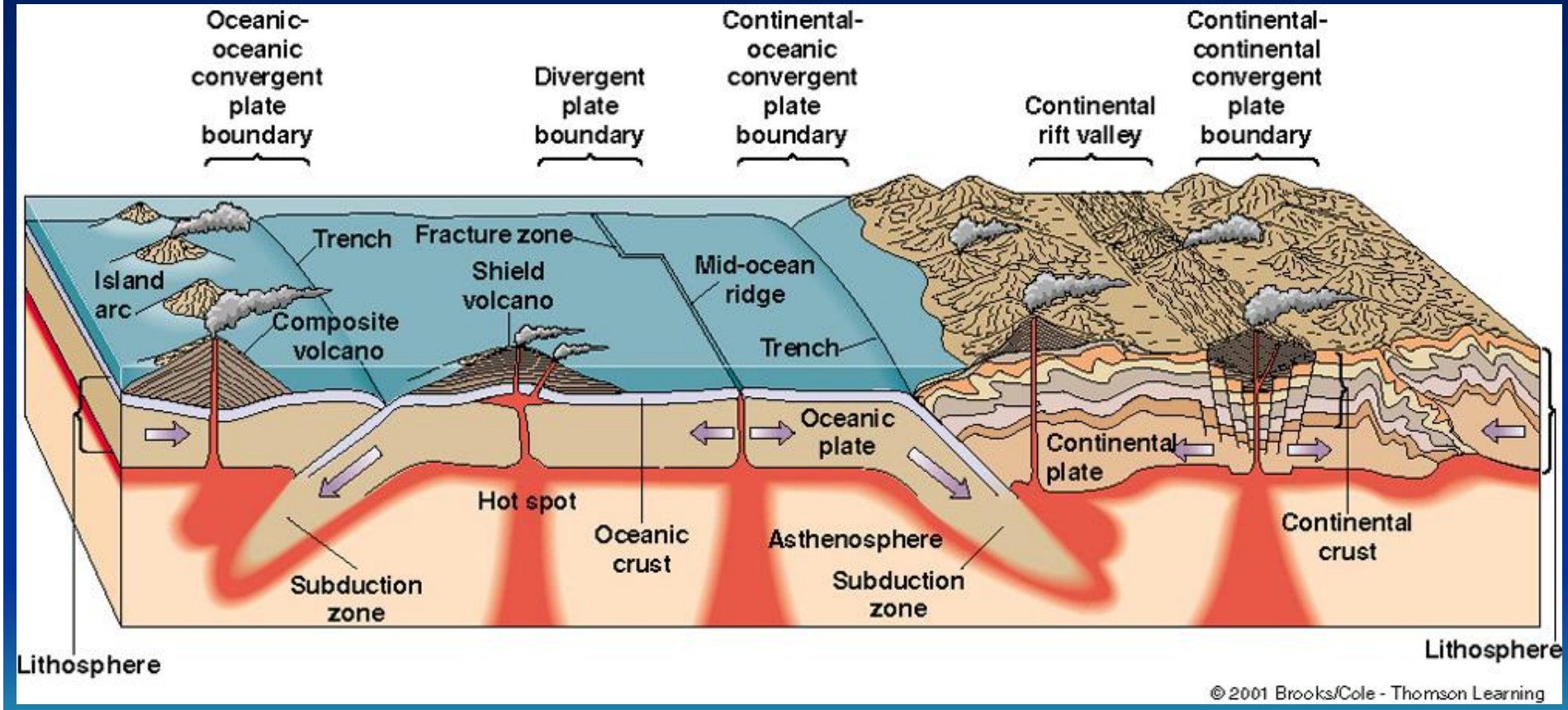
1) *Type and % of minerals* 2) *Crystal size & arrangement*

# Magma and Lava = Mother Igneous

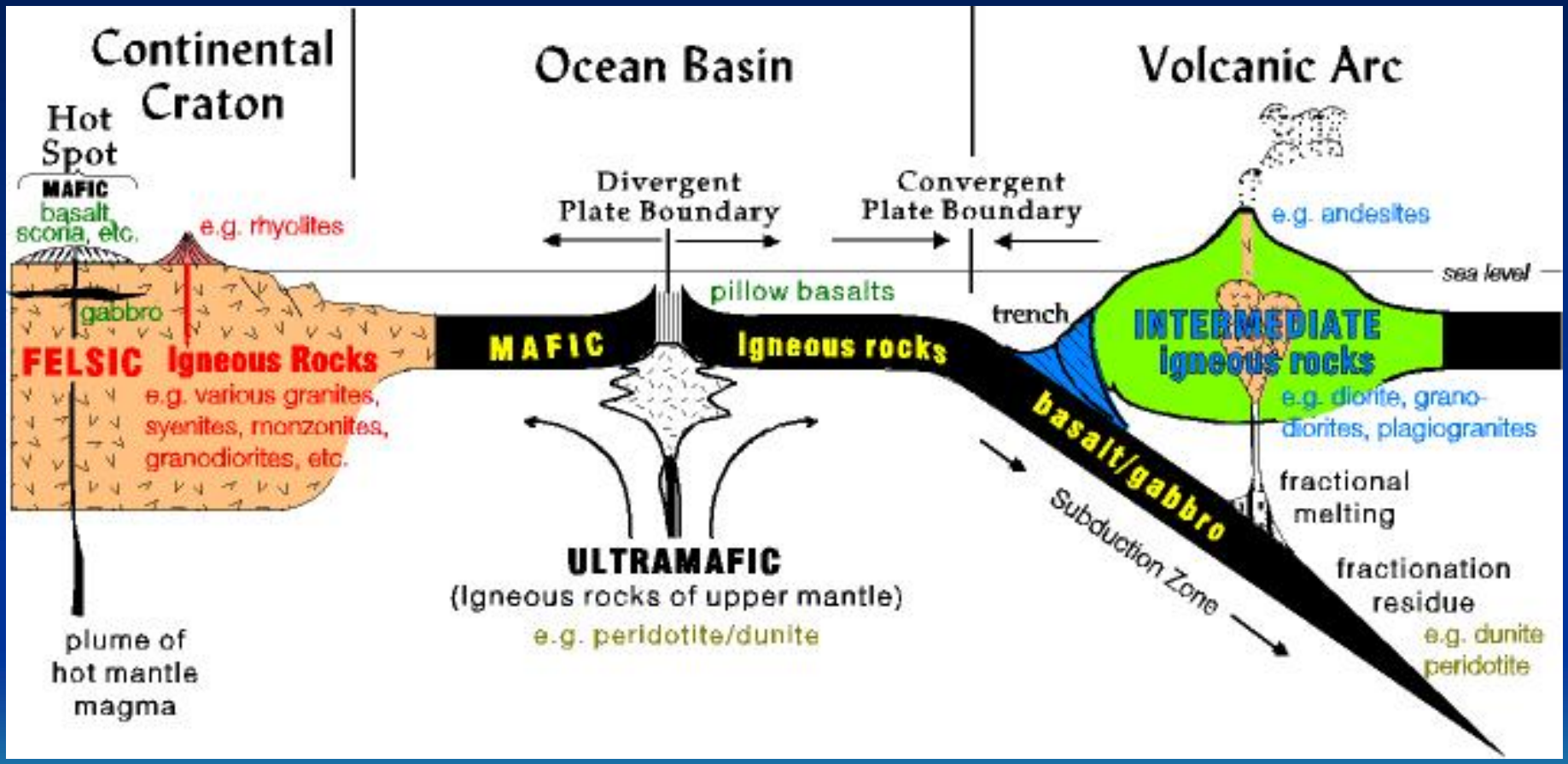
The mineralogy of an igneous rock is *primarily controlled* by the composition of the magma or lava that it cooled from.

The texture of an igneous rock is *primarily controlled* by the cooling rate of its parent crystallizing magma or lava.

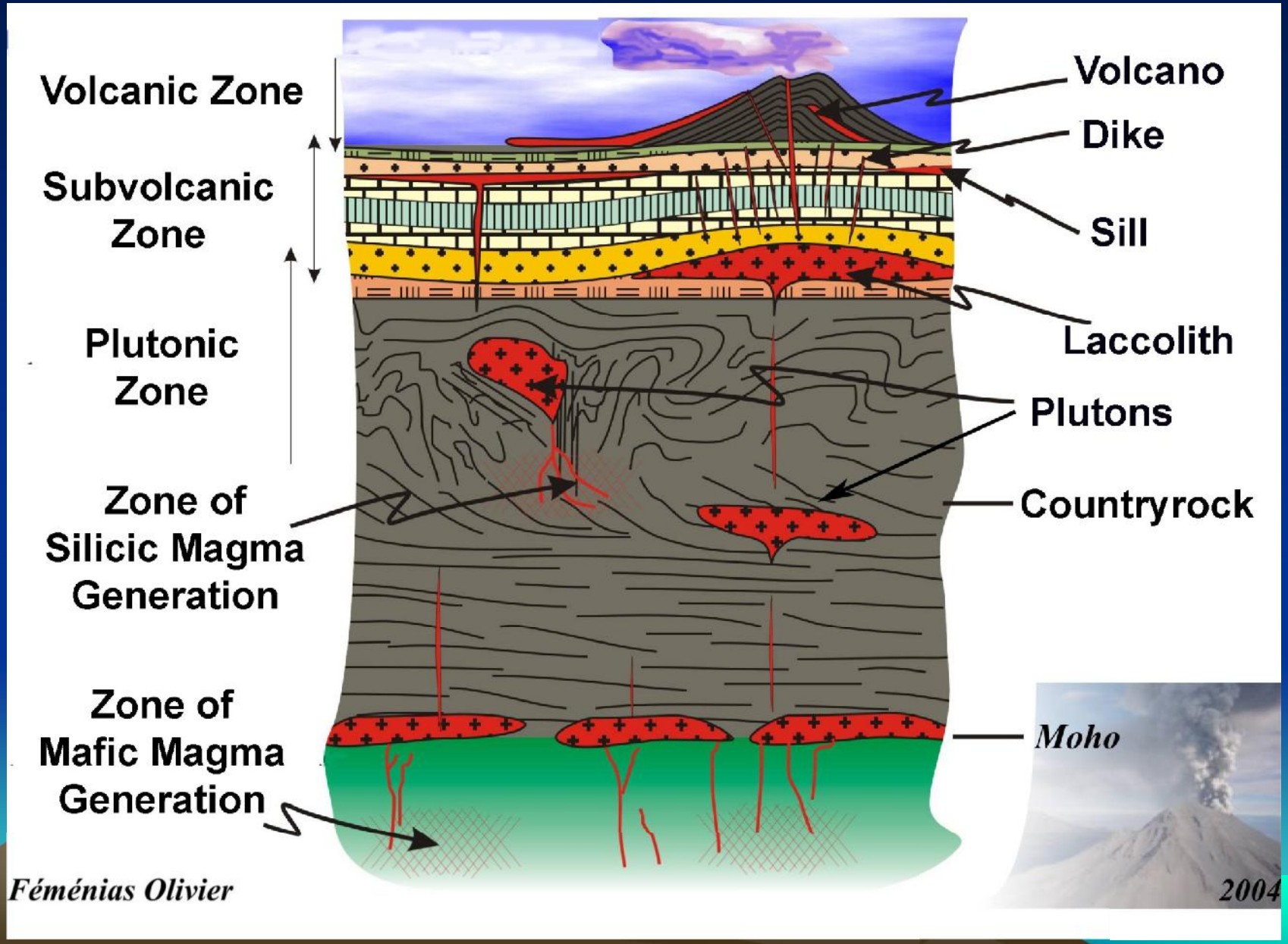
# Tectonic Environments for Magma Generation



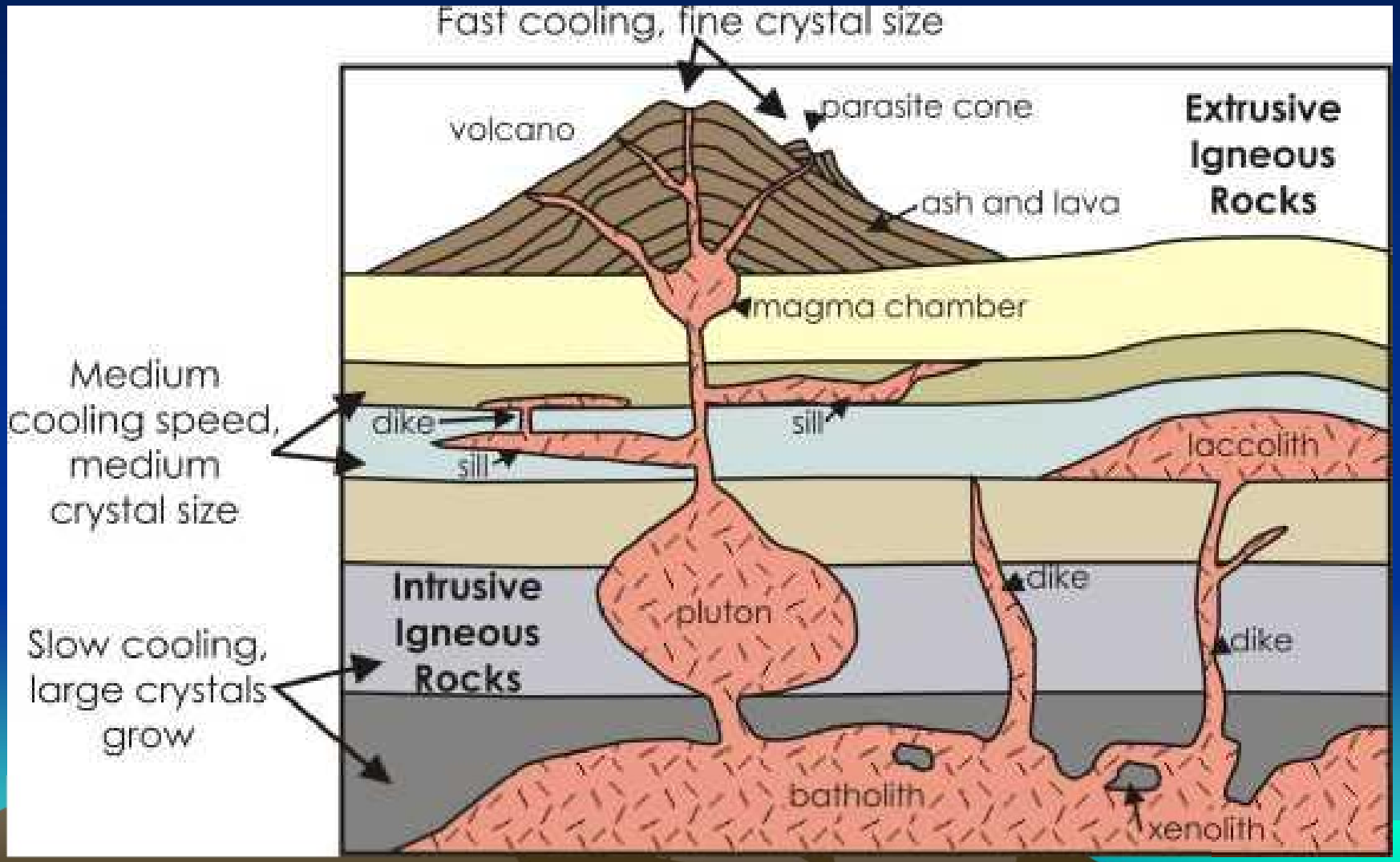
# Predominant Igneous Rock Types at Specific Tectonic Settings



# Igneous Environments



# Affects of Cooling Rates on Crystal Size in Various Igneous Environment



# Common Igneous Rock-Forming Minerals

1) Plagioclase
2) Potassium Feldspar
3) Quartz
4) Muscovite
9) Biotite
10) Hornblende
11) Augite (pyroxene)
12) Olivine
13) Tourmaline
14) Garnet
15) Magnetite

# Igneous Rock Classification

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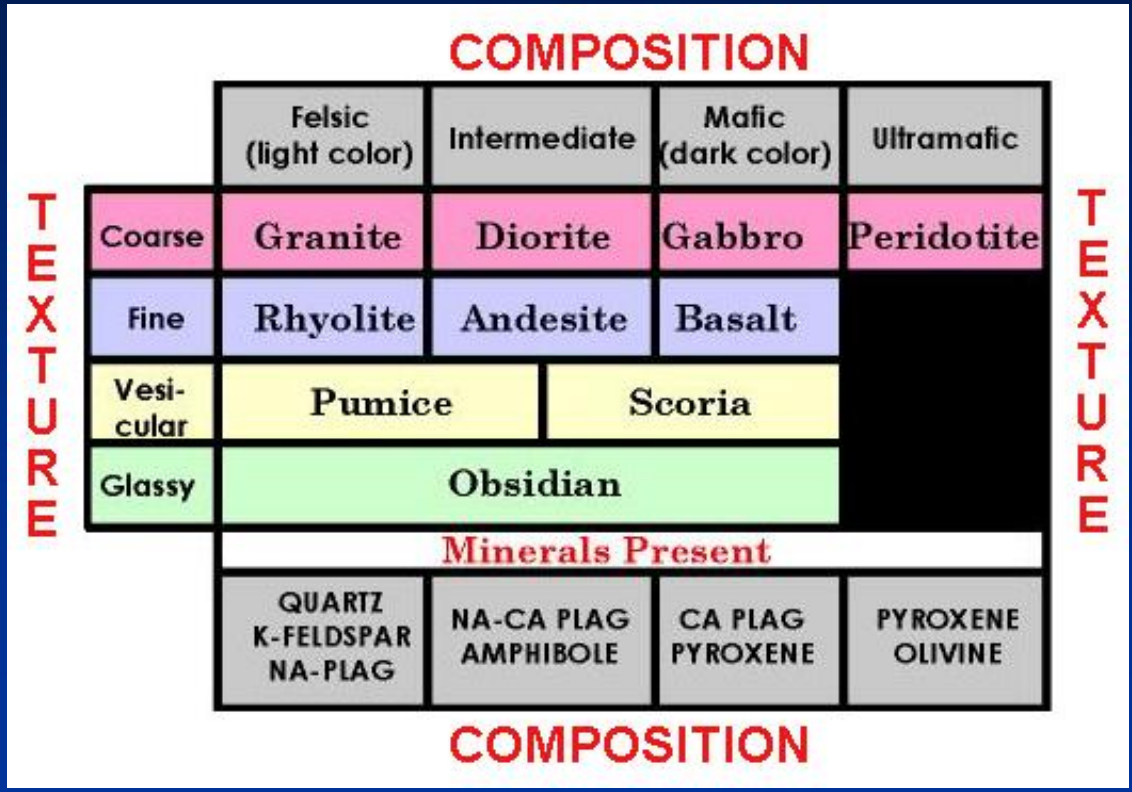



- http://geology.csupomona.edu/alert/igneous/igclass.htm

# Igneous Compositions

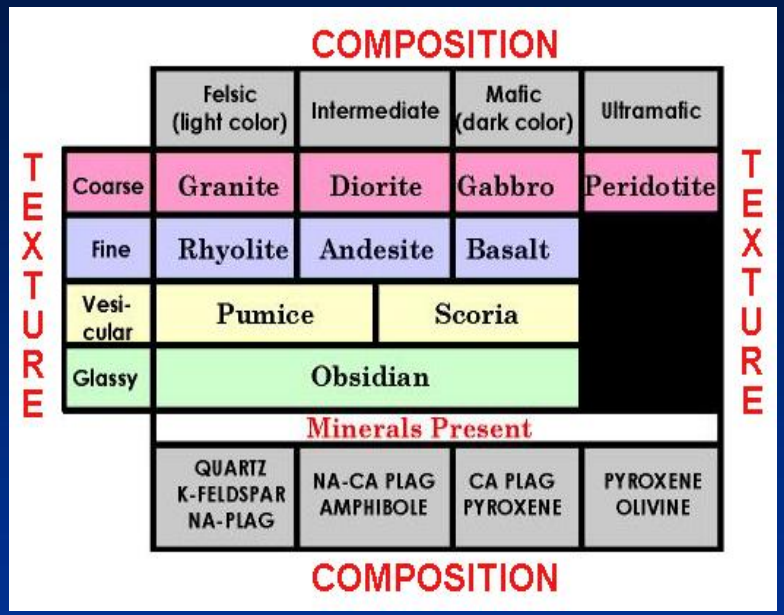
**Ultramafic:**
- ✓ Very Iron – Magnesium Rich
- ✓ Super undersaturated in silica
- ✓ Mantle rocks = **Peridotite**

**Mafic:**
- ✓ Iron–Magnesium-Calcium Rich
- ✓ Undersaturated in silica
- ✓ Oceanic rocks = **Gabbro** and **Basalt**

**Sub-Mafic:**
- ✓ Between Mafic and Sub-Felsic/Silicic
- ✓ Saturated in silica
- ✓ Volcanic Arc rocks = **Diorite** and **Andesite**

**Sub-Felsic/Silicic:**
- ✓ Between Sub-Mafic and Felsic/Silicic
- ✓ Saturated in silica
- ✓ Volcanic Arc rocks = **Granodiorite** and **Dacite**

**Felsic/Silicic:**
- ✓ Sodium – Potassium - Aluminum Rich
- ✓ Very Oversaturated in silica
- ✓ Continental rocks = **Granite** and **Rhyolite**

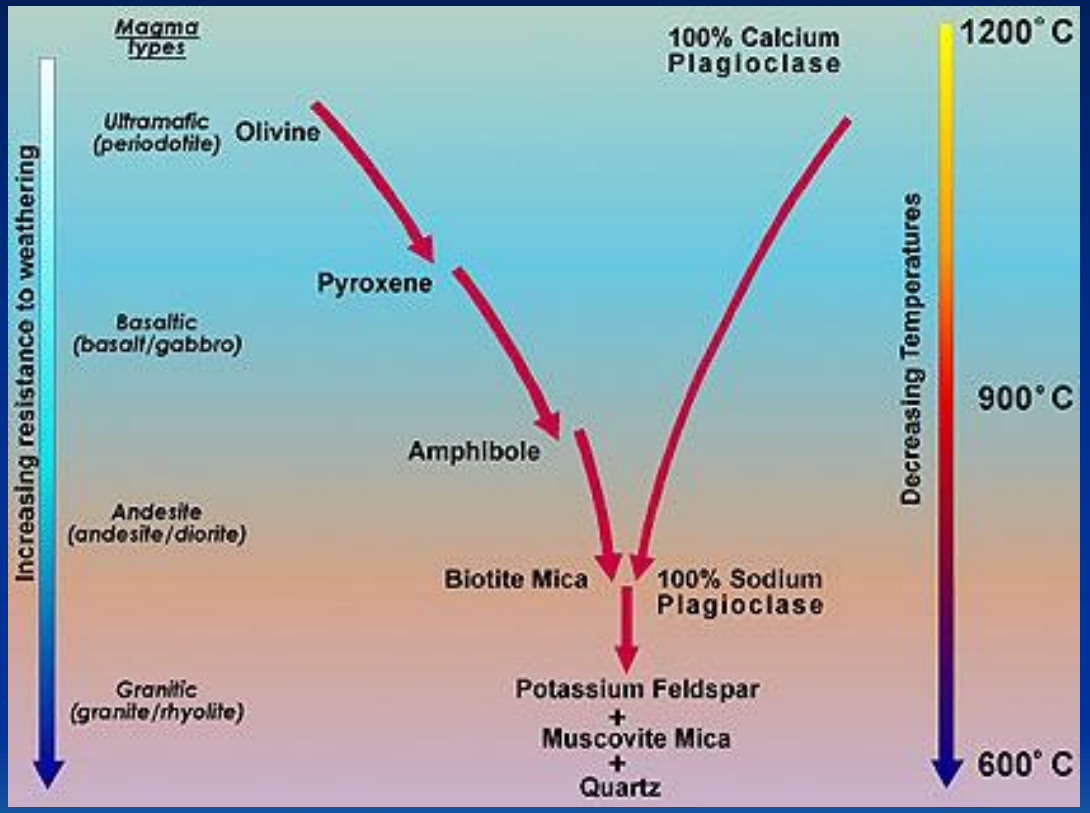



- http://www.rockhounds.com/rockshop/rockkey/index.ht

# Cooling and Crystallization of a Magma

## Bowen's Reaction Series

- ✓ Early forming minerals are Fe-Mg-Ca rich and silica poor @ high temps
- ✓ Later forming minerals become more richer in Na and silica @ mod temps
- ✓ Last forming minerals are most rich in K and silica @ low temps



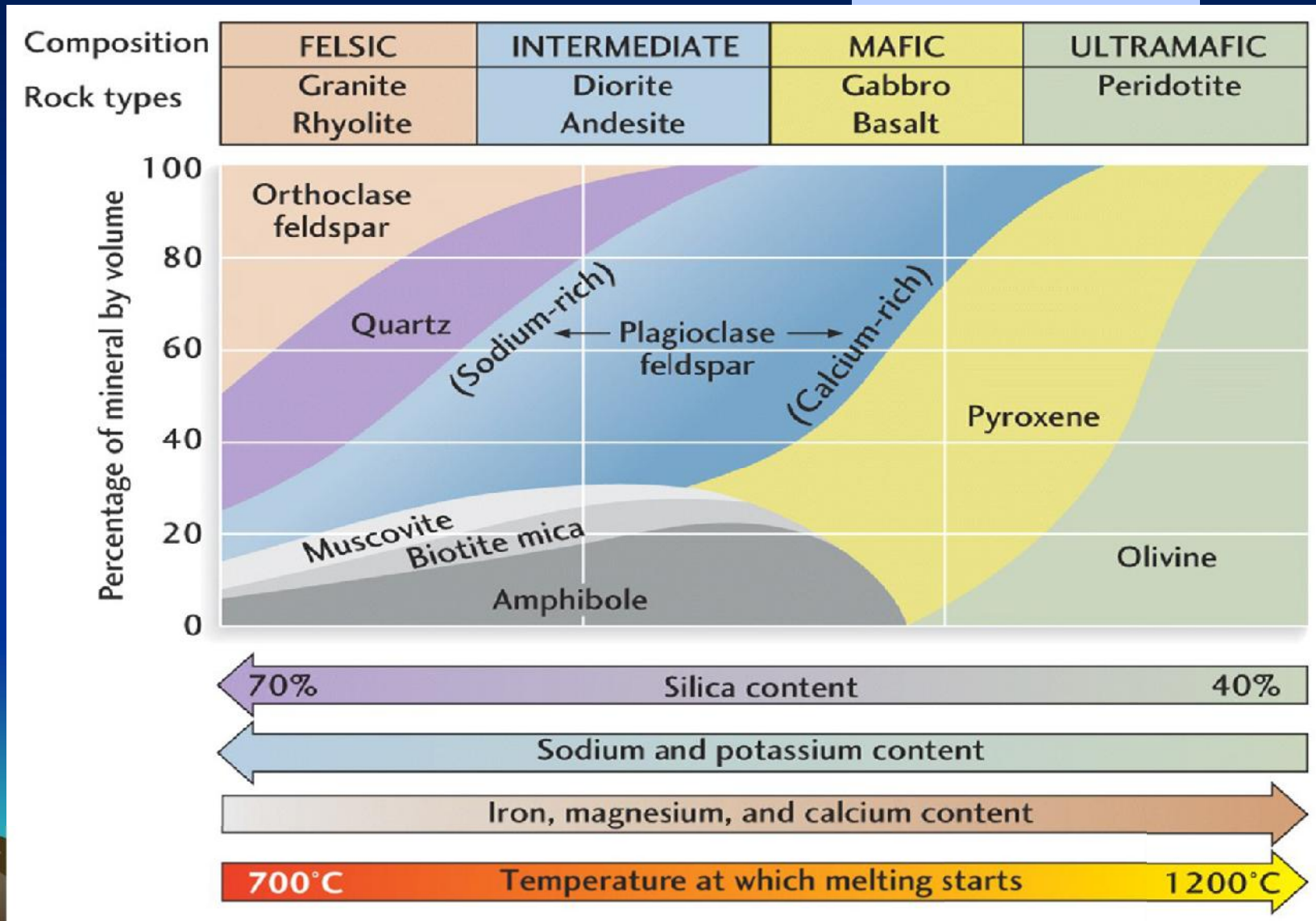

- ✓ Final rock type depends mostly on initial magma composition
- ✓ Crystal fractionation processes can also affect magma comp.

- http://www.rockhounds.com/rockshop/rockkey/index.html

# Mineral Assemblages of Igneous Rock

Light-Colored

Dark-Colored



# Igneous Rock Textures

## Phaneritic Texture:

- ✓ **Coarse Grain Size =** Slow Cooling
- ✓ **Plutonic Rocks** = Coarse-grained

## Aphanitic Texture:

- ✓ **Fine Grain Size =** Fast Cooling
- ✓ **Volcanic Rocks** = Fine-grained

## Porphyritic Texture:

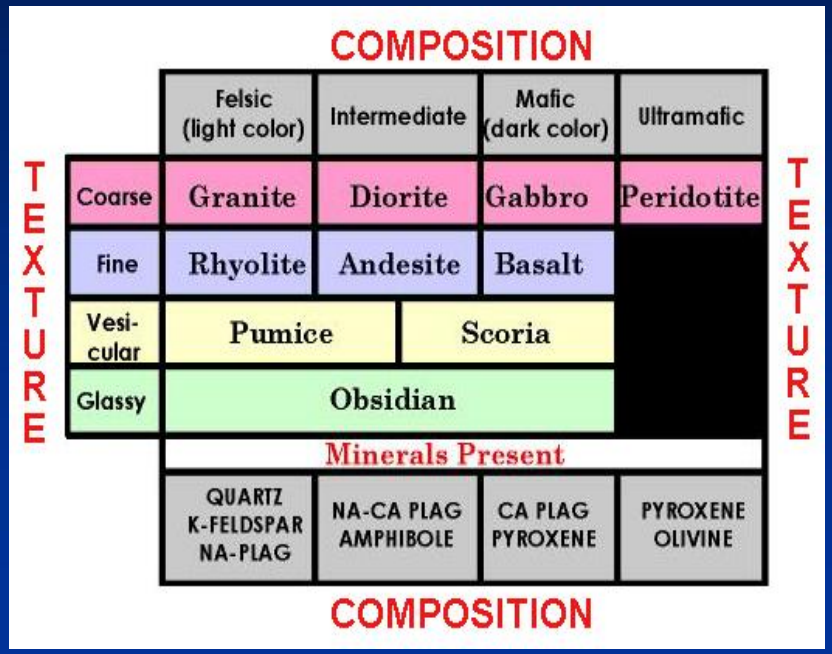
- ✓ Large crystals in aphanitic groundmass = slow cooling followed by rapid cooling
- ✓ **Porphyry Rocks** = Mixed-grain

## Vesicular Texture:

- ✓ Fine-grained to glassy with Cavities
- ✓ Lots of tiny vesicles = pumice
- ✓ Fewer larger vesicles = scoria

## Glassy Texture:

- ✓ Little to no crystals = natural glass
- ✓ Super rapid cooling
- ✓ Obsidian is dark in color
- ✓ Pumice is light in color




- http://www.rockhounds.com/rockshop/rockkey/index.html

# Igneous Rock Pairs

**Classification by texture**

| *Extrusive* | *Intrusive* |
|---|---|
| *Fine grained* | *Coarse grained* |
| Basalt | gabbro |
| Andesite | diorite |
| Rhyolite | granite |

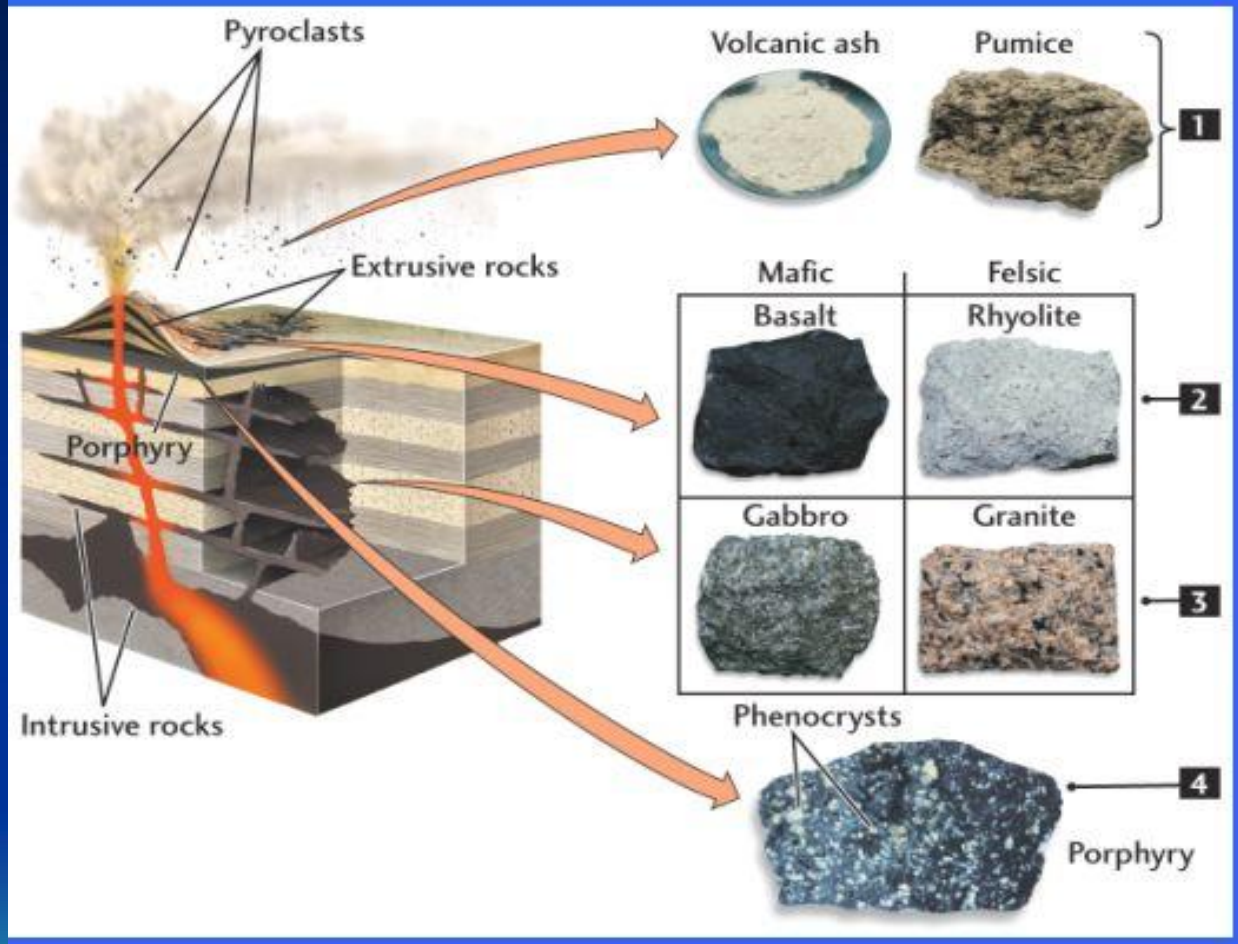
**Classification by composition**

- magnesium (Mg) + iron (Fe) = mafic
- feldspar + quartz (Si) = felsic

Fast Cooling


Slow Cooling

# Formation and texture



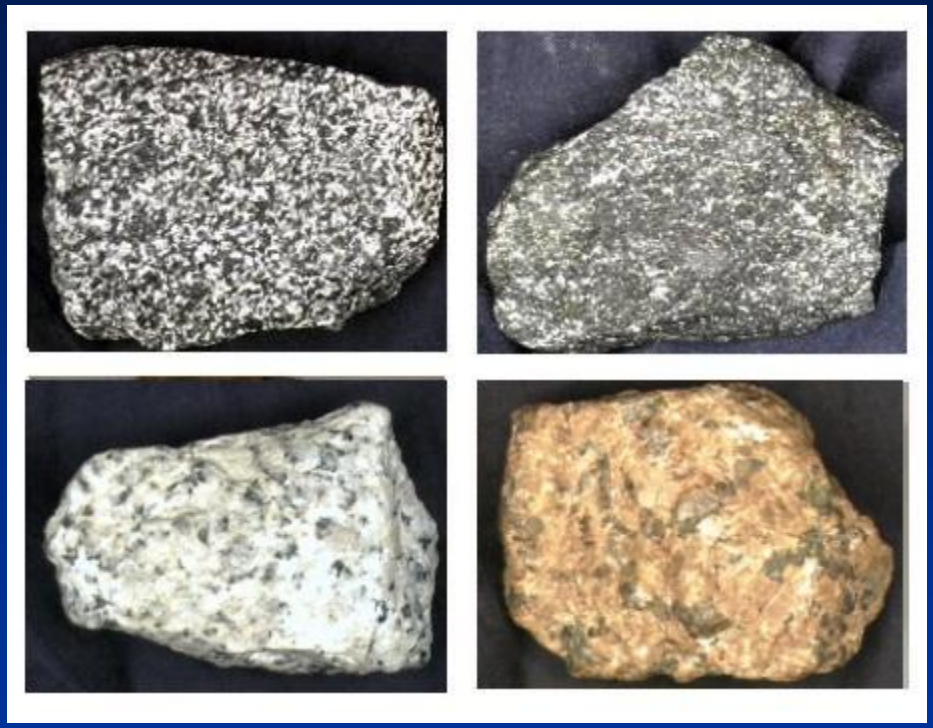

1. **Pyroclasts** form from airborne lava in violent eruption

2. **Extrusive igneous rocks**. Cool rapidly on the Earth's surface

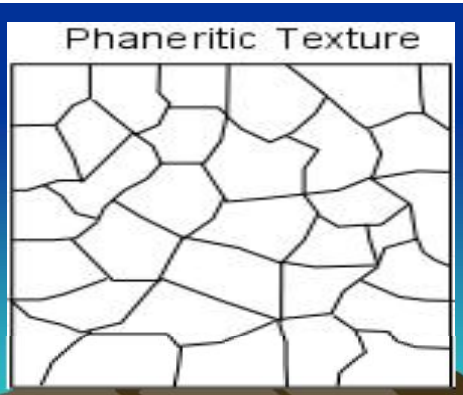
3. **Intrusive igneous rocks**. Cool slowly in the Earth's interior allowing large crystals to form

4. **Porphyry** starts to grow below the surface but before solidification is brought to the surface

# Plutonic Rock Textures



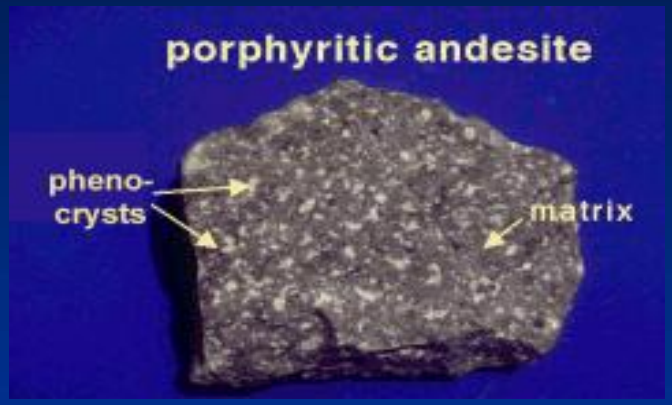
Field Outcrops of Plutonic Rocks



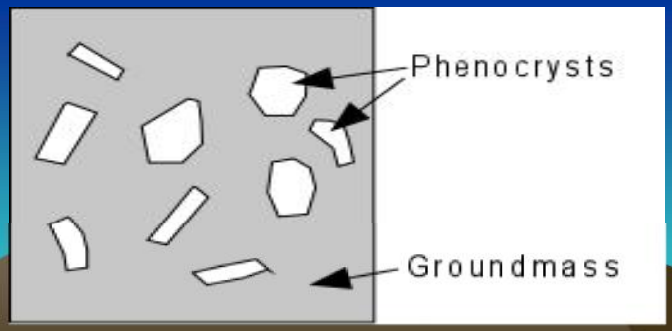

- ✓ Intrusive -Plutonic
- ✓ Coarse-grained
- ✓ Cooled Slowly

# Volcanic Rock Textures

## Porphyritic

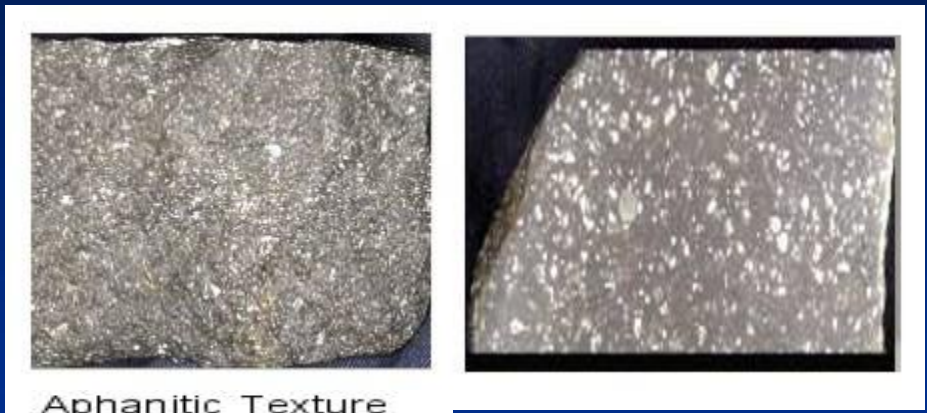


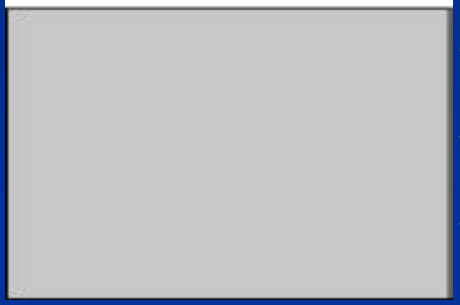





- ✓ Combo Plutonic -Volcanic
- ✓ Coarse-grained phenocrysts in a fine-grained groundmass
- ✓ First cooled Slow, then Fast

## Aphanitic

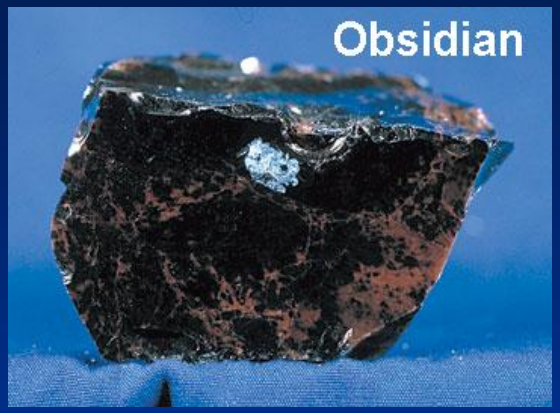


- ✓ Extrusive -Volcanic
- ✓ Fine-grained
- ✓ Cooled Rapidly

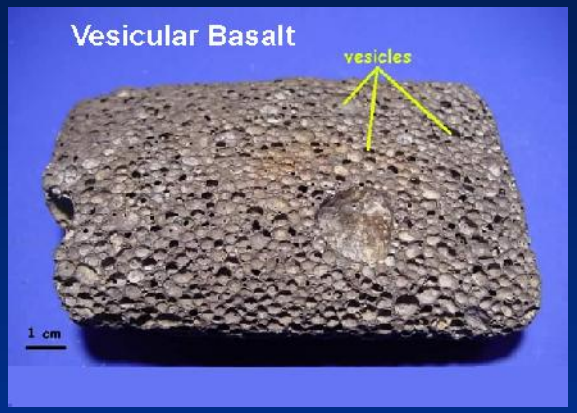
# Other Volcanic Rock Textures

## Glassy

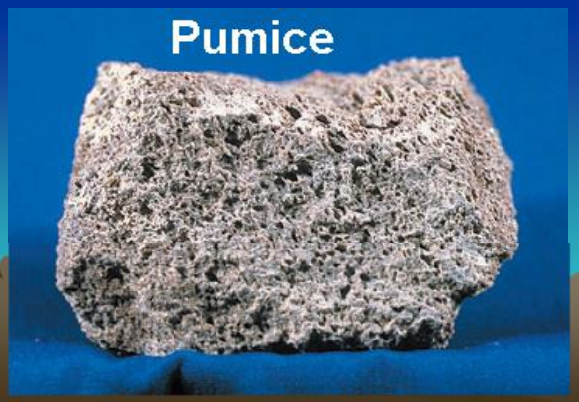




## Vesicular








## Fragmental

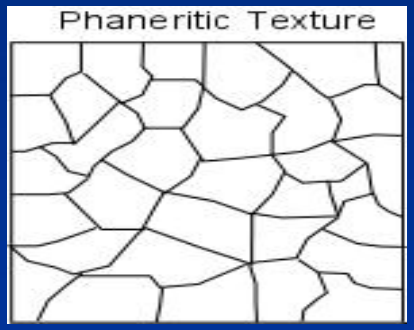


# Igneous Rocks Under a Microscope

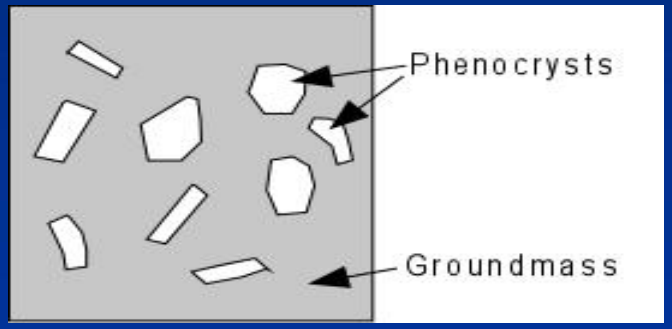
Granite

Rhyolite

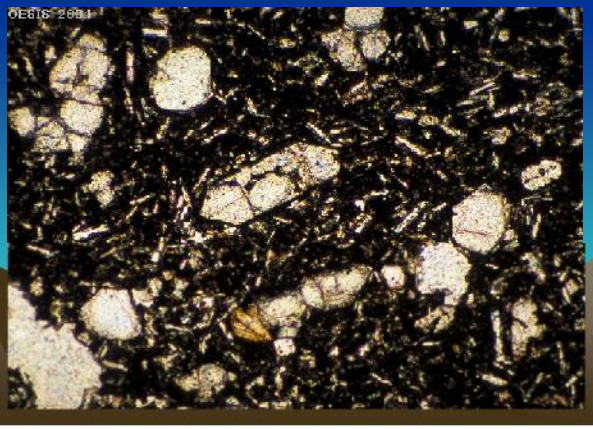
Obsidian

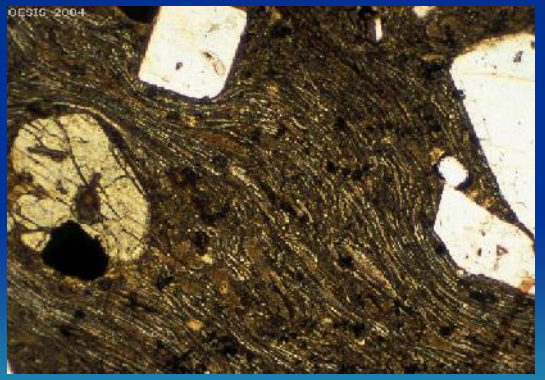



Gabbro




Basalt

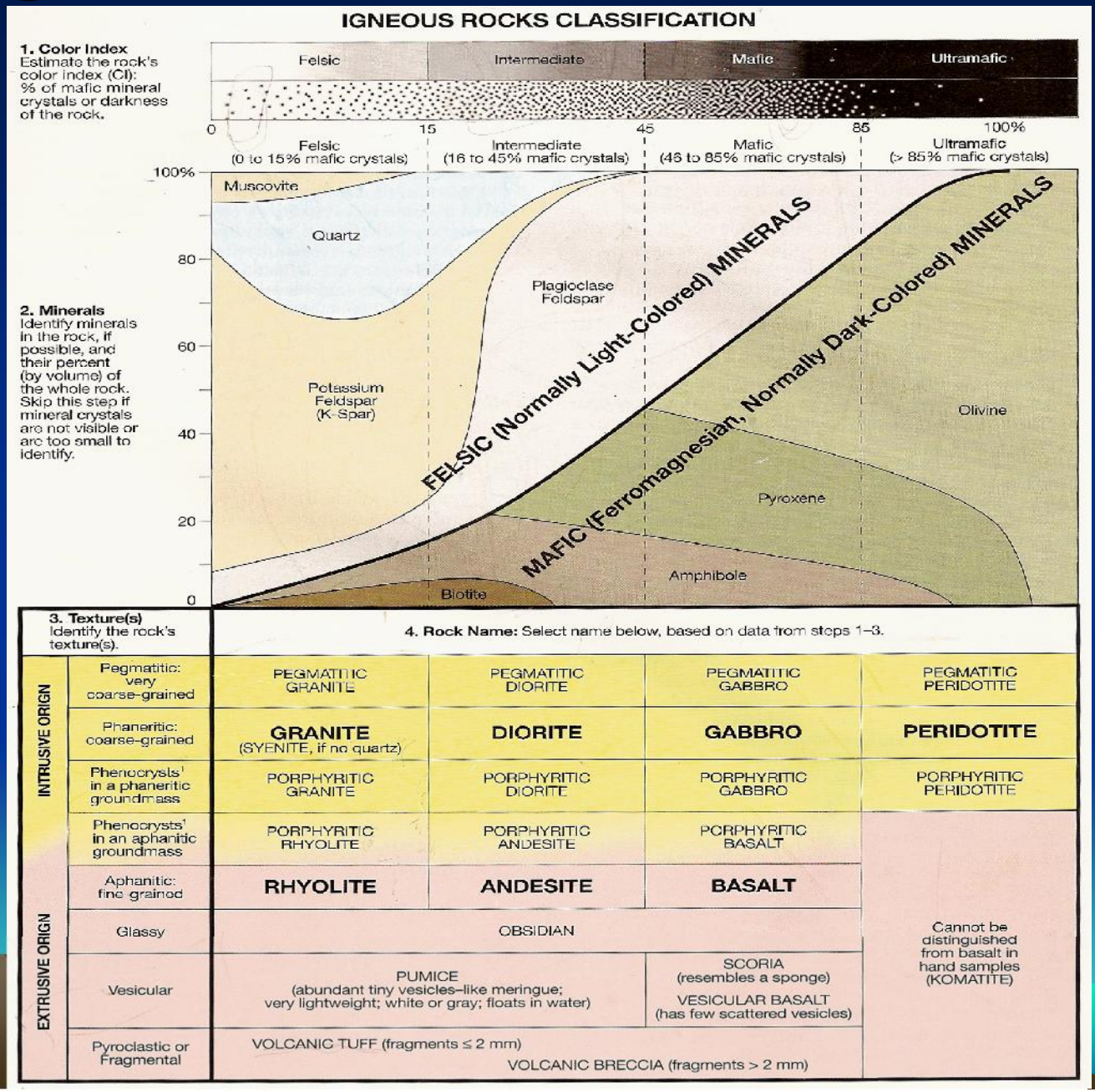




Welded Tuff

# Color Index of Plutonic Rocks

# Igneous Rock Classification



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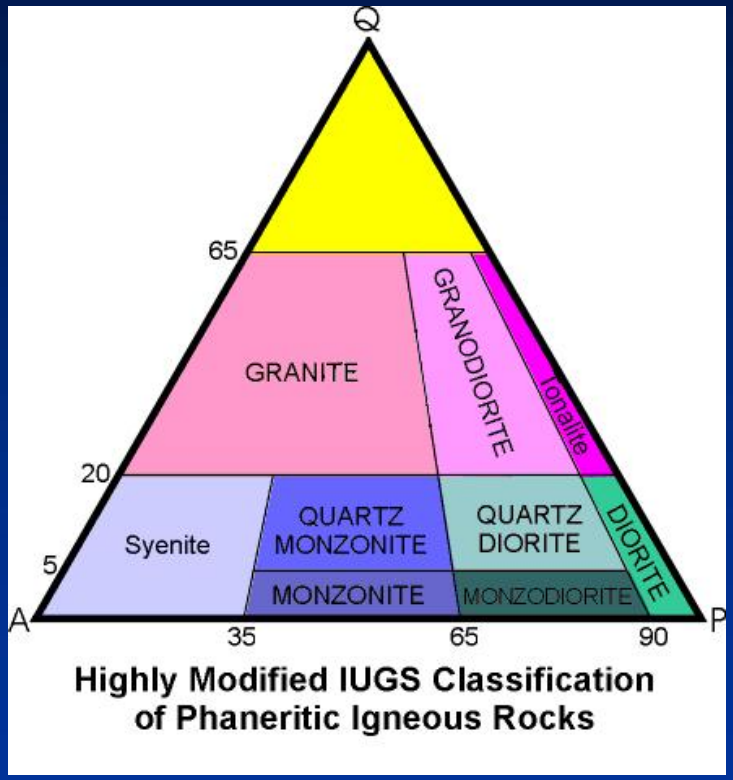
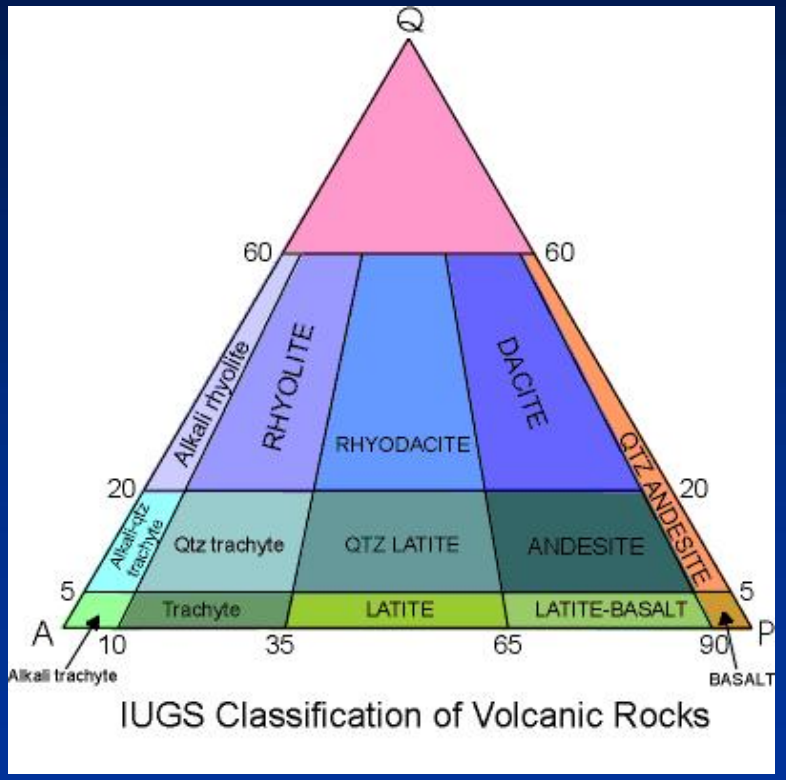



**Granitic Plutonic Rocks**




**Volcanic Rocks**

## Ternary Diagrams:

1)Top corner = quartz;  Bottom L. corner = K-spar;  Bottom R. corner = Plag

2)Fields indicate  tri-mineral proportions in terms of percentages totally 100%

# Igneous Rock Classification

A Three Step Process

## 1) Determine Composition

- ✓ Color Index (plutonic only)
- ✓ Color darkness (volcanic)
- ✓ Mineralogy (observable)

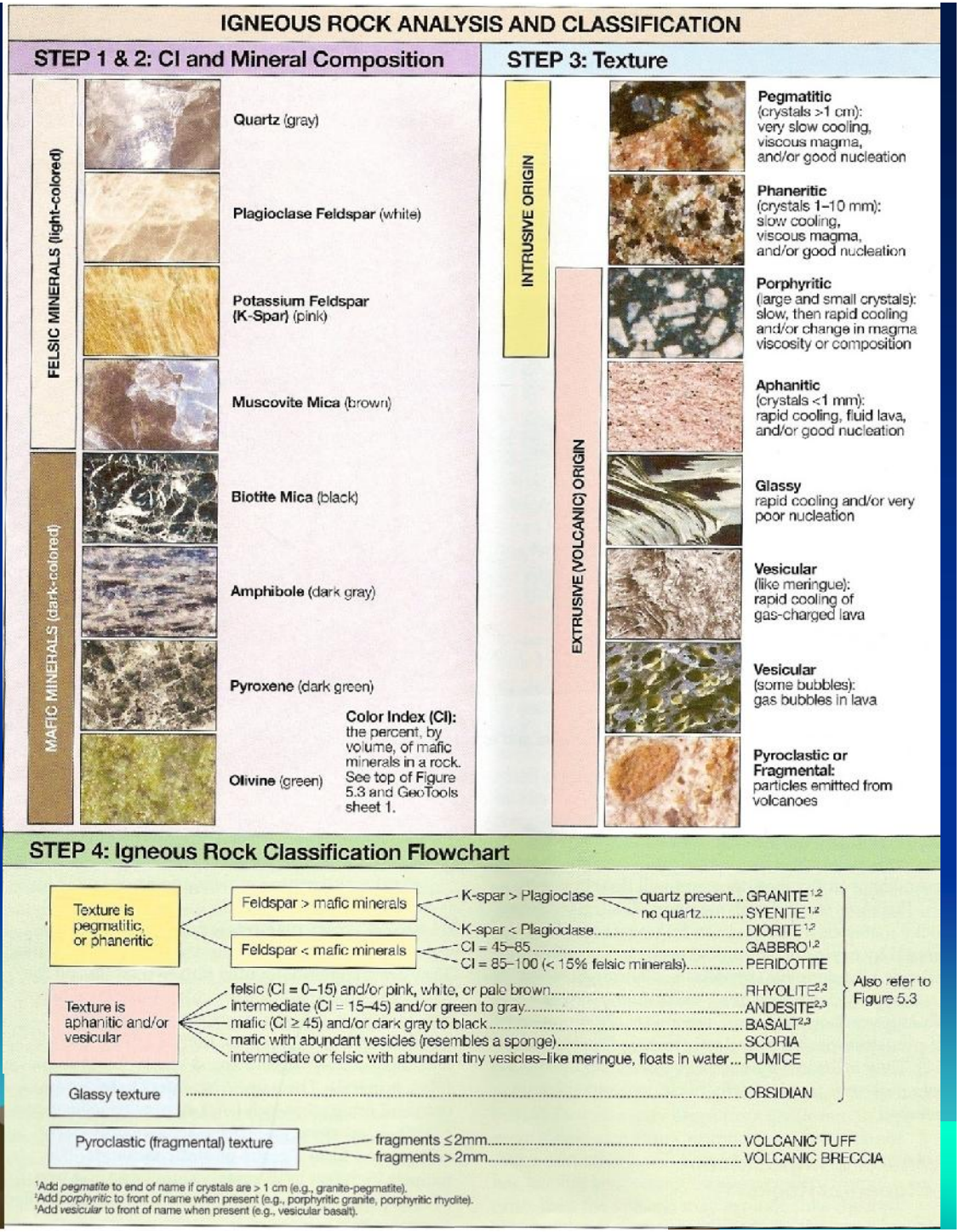
## 2) Determine Texture

- ✓ Specific intrusive texture?
- ✓ Specific extrusive texture?

## 3) Name the Rock

- ✓ Use Flowchart

**Practical Use for Rock?**



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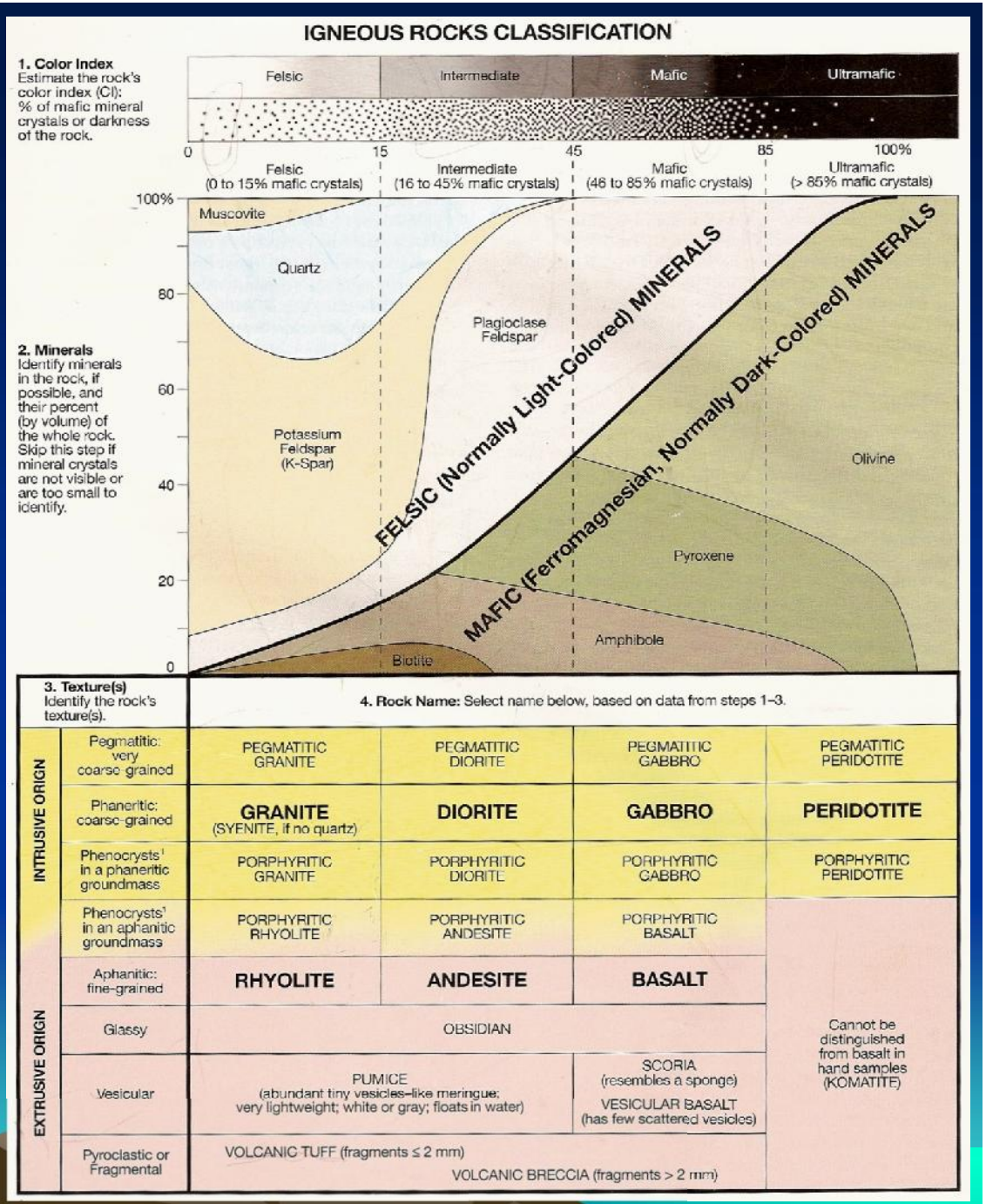


# Igneous Rock Identification Procedure

**Step 1:** Observe and record the rock's **TEXTURE**

- ✓ Pegmatitic
- ✓ Phaneritic
- ✓ Aphanitic
- ✓ Porphyritic
- ✓ Fragmental
- ✓ Others = vesicular or glassy

**Step 2:** IF ***Phaneritic*** **or** ***Pegmatitic*-** Identify and record the minerals and the volume % of dark minerals = ***COLOR INDEX***.

**Note:** **Color index** applicable for **course-grained rocks** **ONLY!** **OR**

IF ***Aphanitic*** or ***Porphyritic*** = no to some observable minerals, then estimate composition by the **OVERALL ROCK COLOR**.

**Note:** ("light" = felsic/silisic, "medium" = intermediate, and "dark" = mafic).

**Step 3:** **NAME the ROCK** – **based on texture/composition combo**

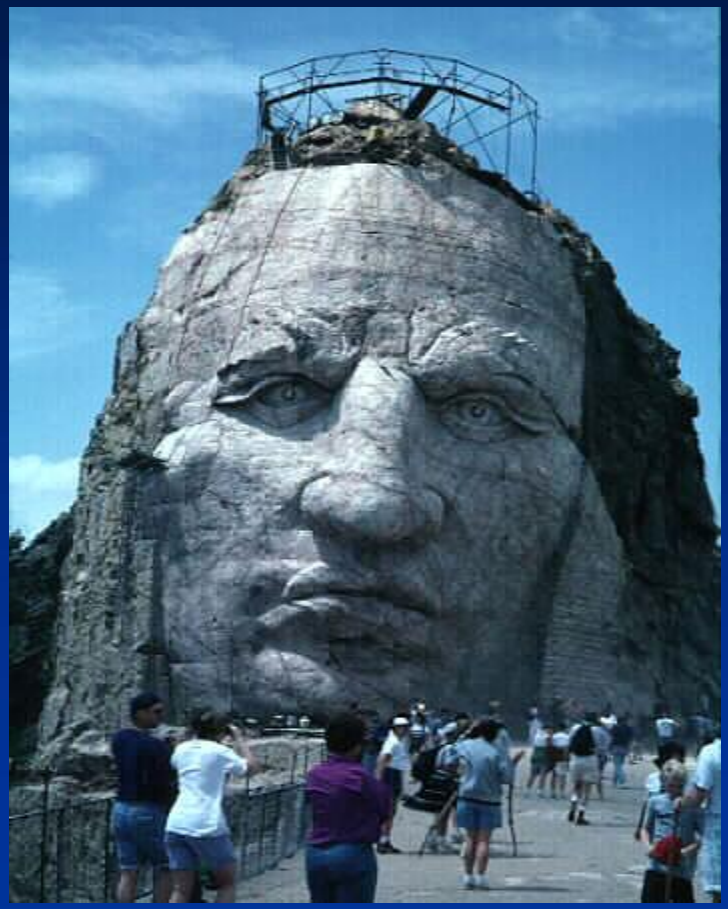
# Building Applications

Granite, Diorite and Gabbro - used for flooring, countertops, walls, steps, cobblestone paving, gravestones, and various landscaping applications

Volcanic Rock - used for various landscaping applications

http://www.stonecontact.com/library.asp

# Igneous Rock References



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