

Lecture 5: Igneous Rocks

1. Big Island Field Trip. Sign-up by Friday Sept. 11
2. Extra credit



iClicker assignments – pick yours up

001 Abreu	013 Comilla	027 Higa	039 Lockett	067 Peahu
003 Agena	014 Cuadrado	028 Hipolito	040 Manion	068 Santiago
004 Albert	015 Dang	090 Inserra	041 McTigue	069 Shigemitsu
006 Araki	016 Duncan	031 Jadu	042 Meyers	070 Soares
091 Atiburcio	080 Fujihara	030 Johnsen	043 Mitamura	084 Teramura
008 Buck	018 Ganther	034 Kaaihue	044 Morikawa	086 Tomaszek
010 Byce	021 Guerrero	036 Keanini-White	047 Nassiri	073 Wu
011 Clements	022 Haupt	037 Kipi	048 Ota	074 Yamamoto
012 Colle	025 Hedden	089 Lee	088 Pavao	075 Yanagi
				077 Yokota
				079 Zoller

Learning Objectives (LO)

Lecture 5: Igneous Rocks

What we'll learn today:

1. Describe igneous rock
2. Identify the information revealed by igneous texture
3. Identify how igneous rock color relates to chemical composition
4. Describe the process of igneous evolution and the role of plate tectonics in it
5. Describe the environments where basalt accumulates



Quick Facts

- Earth's crust is 4/5 igneous rock
- Every igneous rock begins life as magma
- As magma migrates toward the surface, some of it chills & hardens underground into various types of igneous rocks
- Magma that makes it to the surface erupts in either flowing or *explosive* volcanoes, generating lava or *pyroclastic* debris

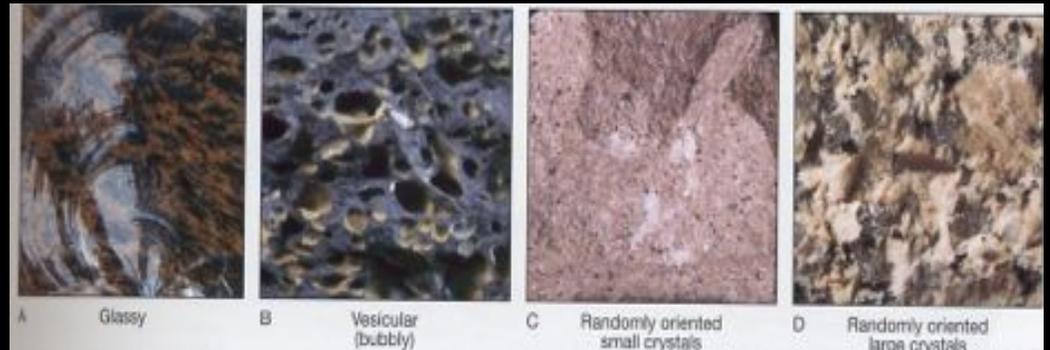
Kilauea lava flow, Aug 7, 2013

Igneous rock is formed when
molten, or partially molten,
rock solidifies.

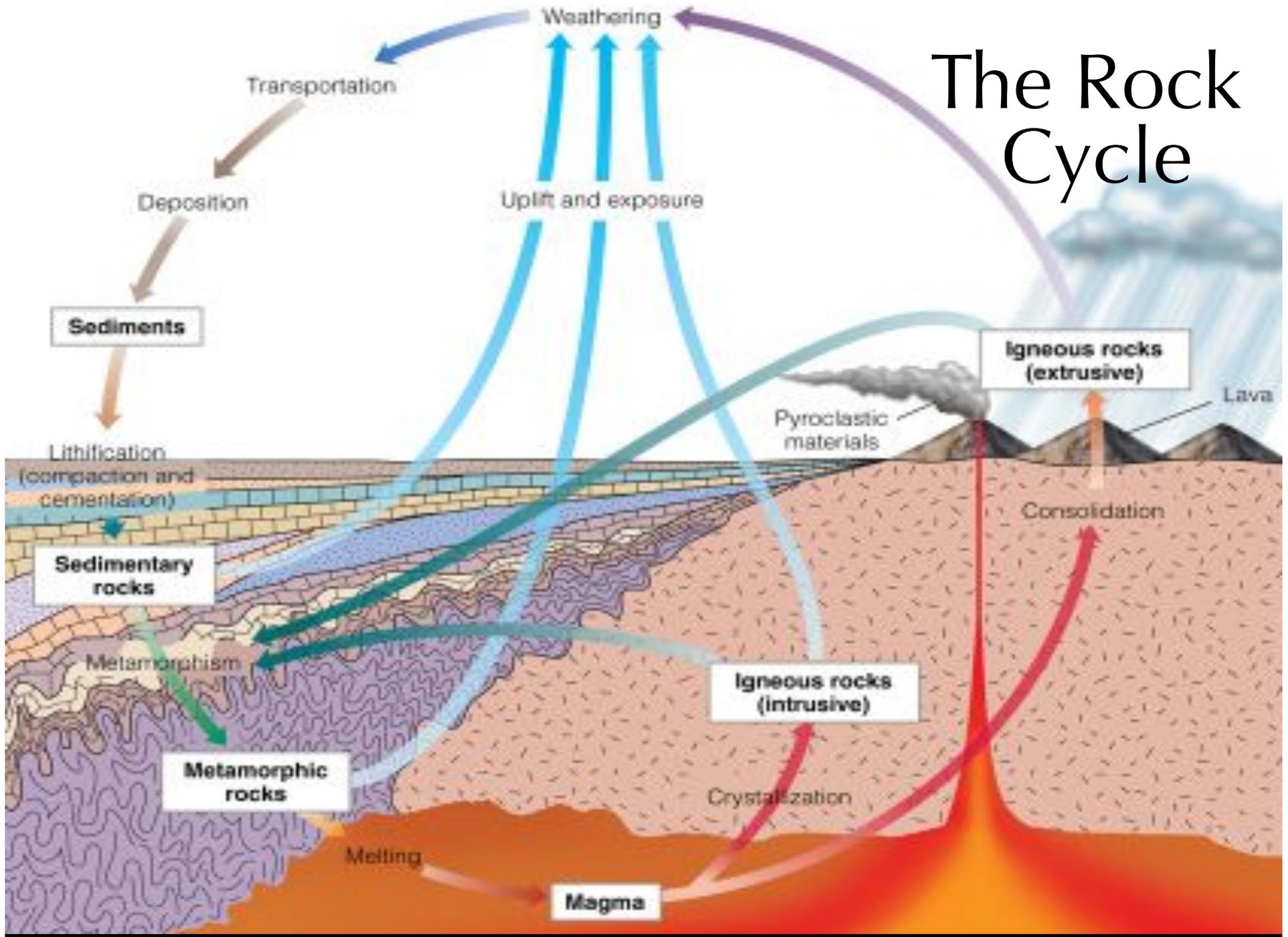


Fundamental Rock Types

- Igneous Rocks:
form when magma solidifies
- Sedimentary Rocks:
form when sediment becomes cemented into solid rock
- Metamorphic rocks:
form when heat, pressure, or hot water alter any preexisting rock

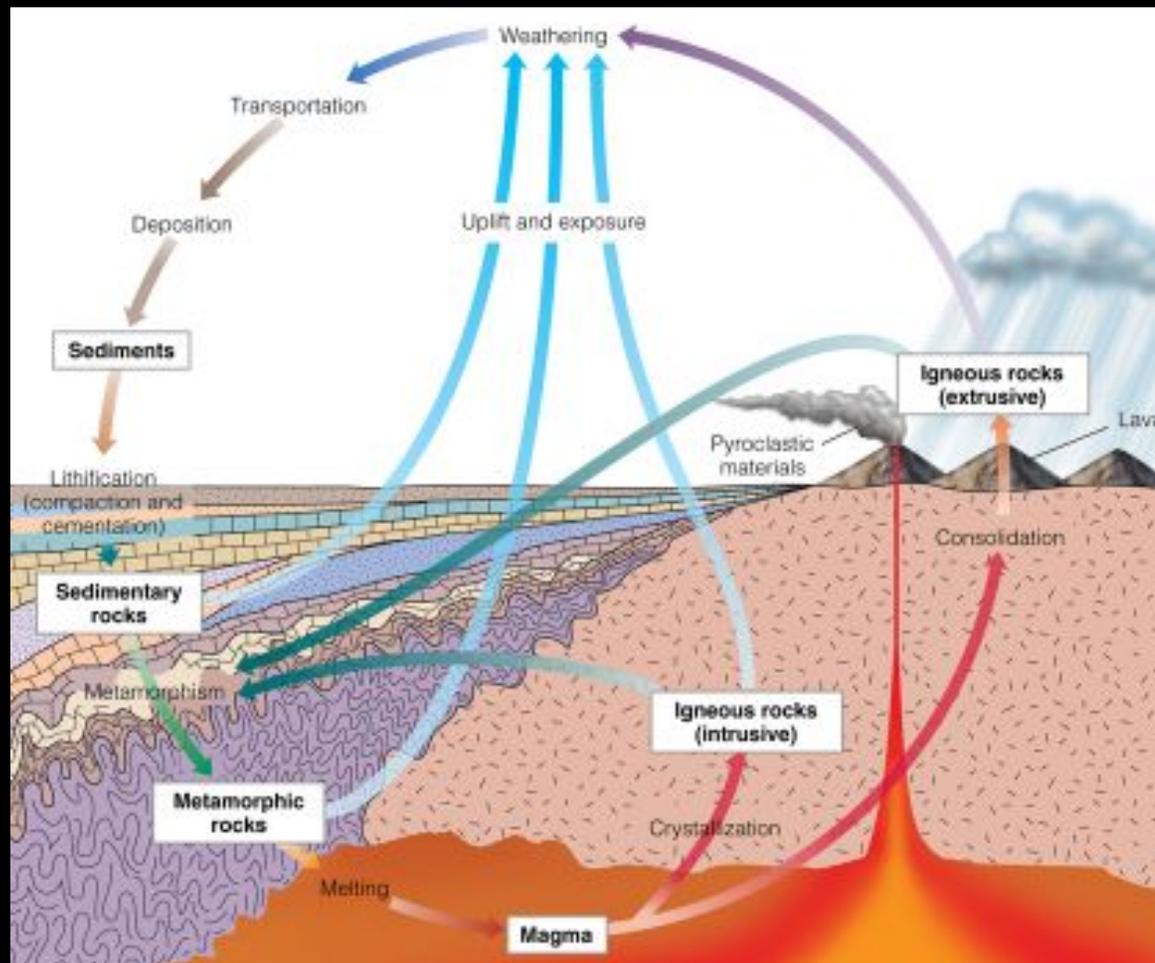


The Rock Cycle

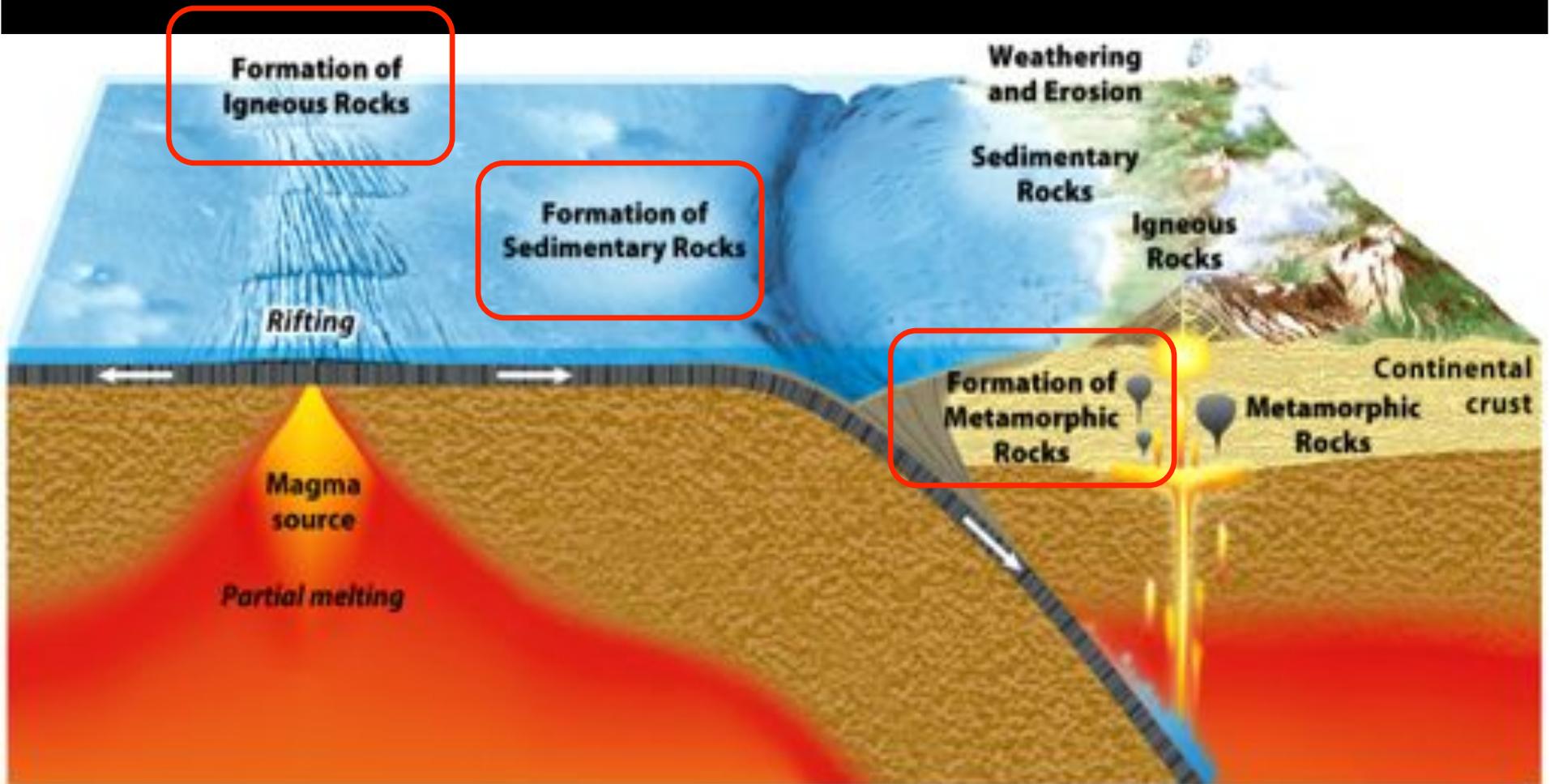


The Rock Cycle

- **Def.:** All rocks change slowly from 1 of 3 rock types to another
- Rocks are created, changed, and recycled

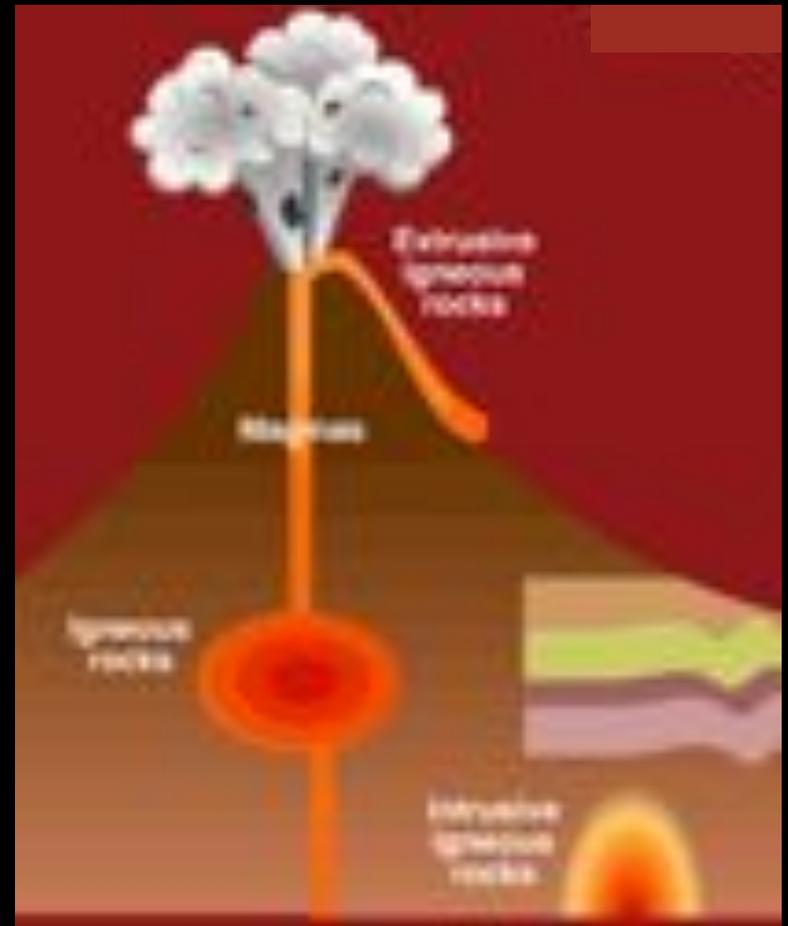
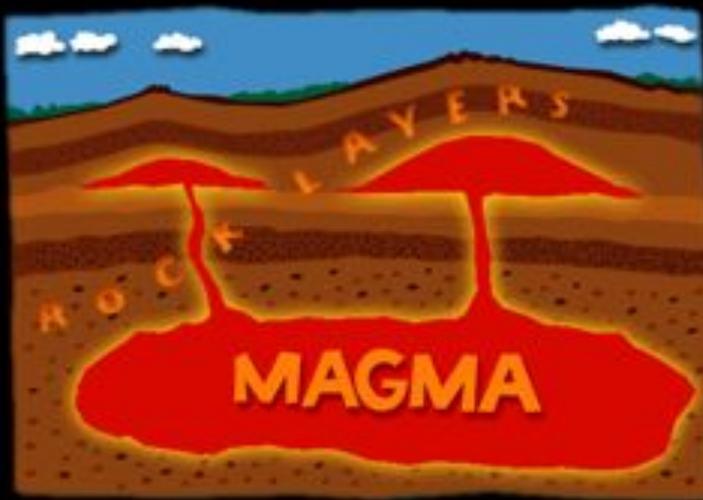


Igneous rocks are the foundation of the **Rock Cycle**

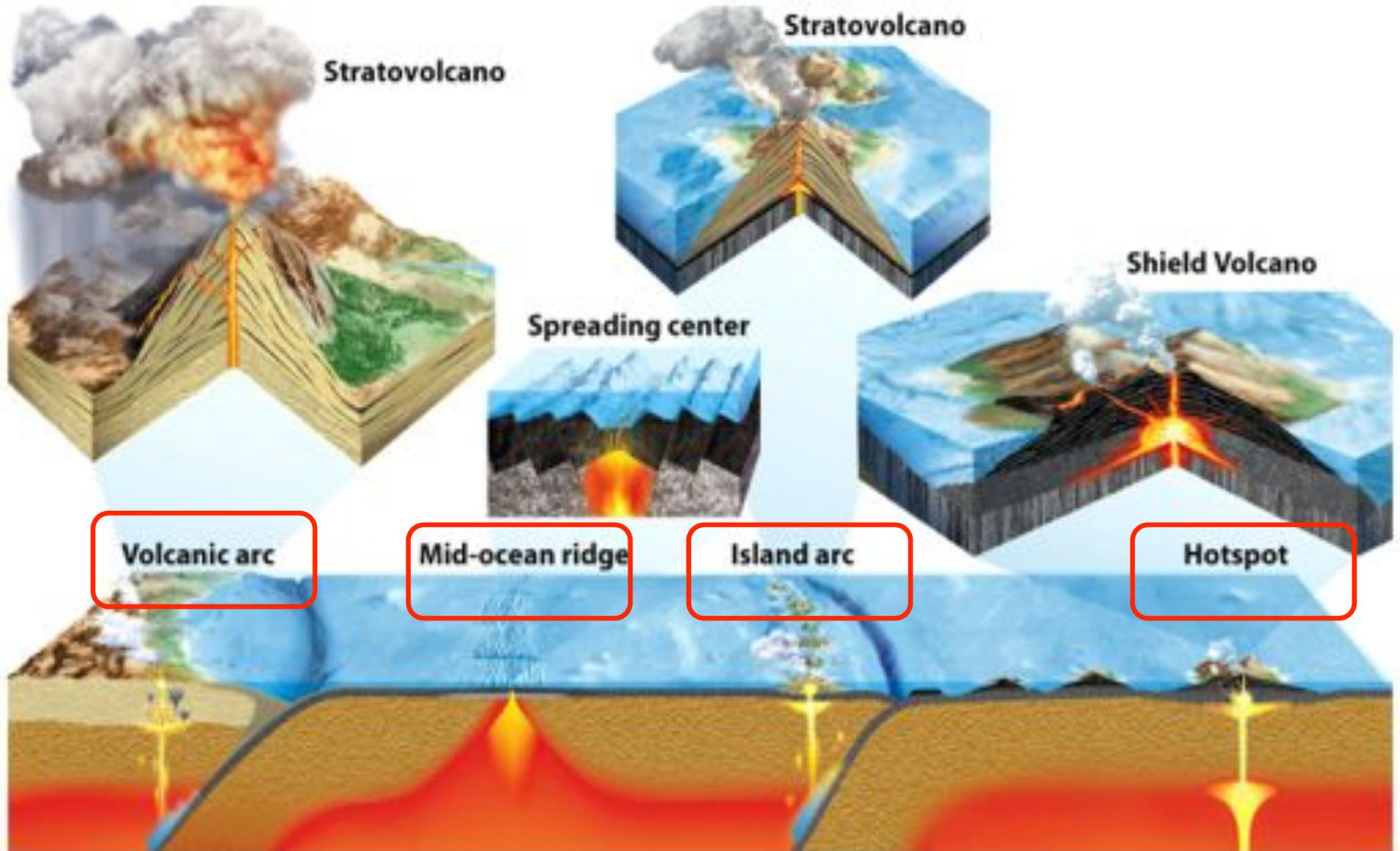


Igneous Rocks = Magma

- **Magma:** solid rock that is melted (high temperatures) to form molten liquid
- Magma rises toward Earth's surface & cools, solidifies



Igneous Rock-Forming Environments



Cooling of Magma

Size of Magma Body

Time for Cooling

extrusive
↑
↓
intrusive

1 mm

1 second

lava splatter

10 mm

1 minute

100 mm

1 hour

lava flow

1 m

5 days

10 m

1 year

magma chamber

100 m

100 years

1 km

10,000 years

pluton (deep)

10 km

1 Myr

100 km

100 Myr

oceanic lithosphere

Cooling is VERY SLOW for large magma bodies

Extrusive Igneous Rocks

- **Lava**: fluid magma that flows from a crack or volcano onto Earth's surface
- Magma cools **quickly** = **less time** for **crystals** to form
- Ex.: Basalt - common volcanic rock, ocean crust, few crystals

Lava



Basalt



Rhyolite



Porphyritic rock



Obsidian

Intrusive Igneous Rocks

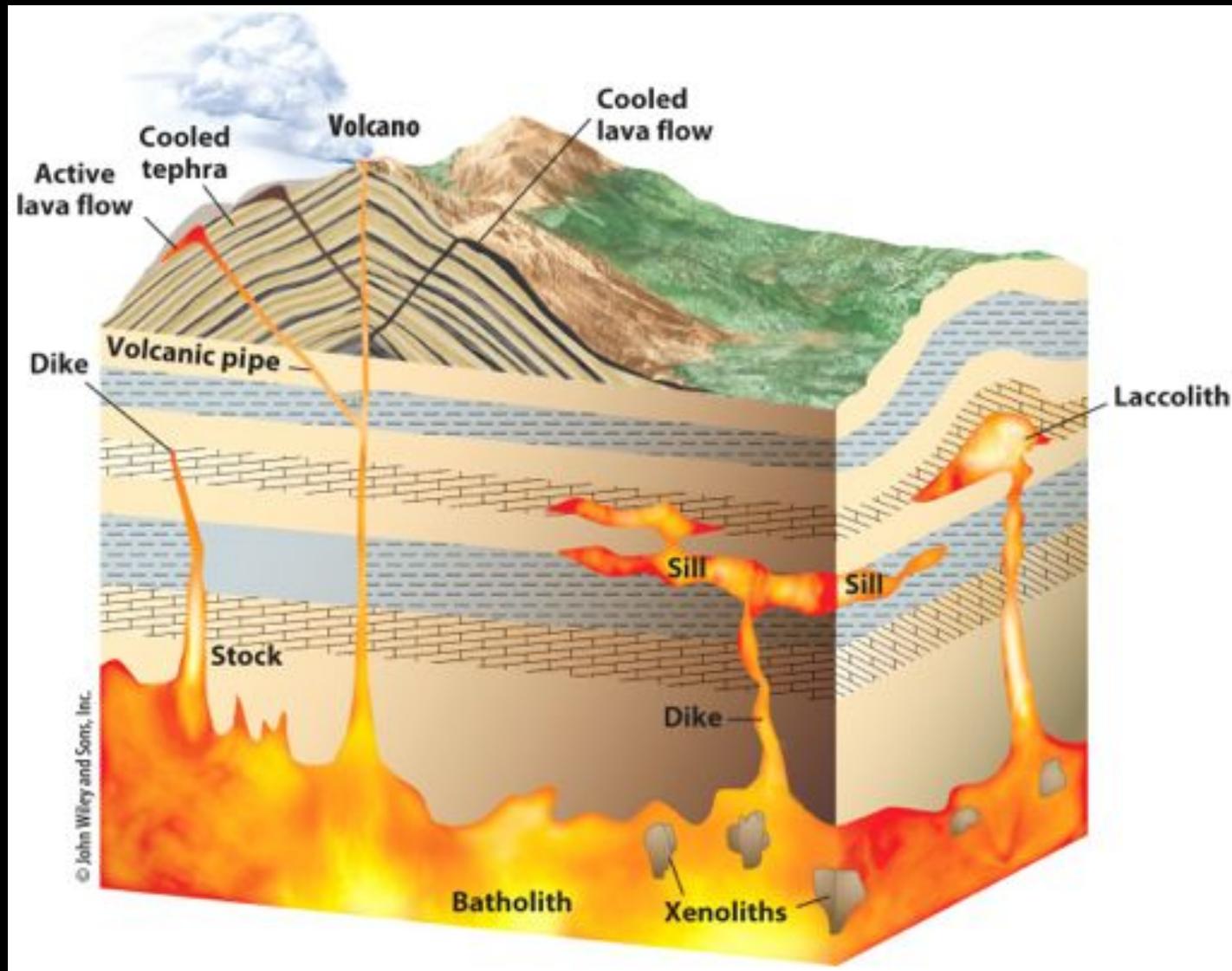
- Magma cools **slowly, more time** for **crystals** to form
- Ex. Granite: most abundant rock in continental crust
medium- to coarse-grained crystals

Granite



Gabbro

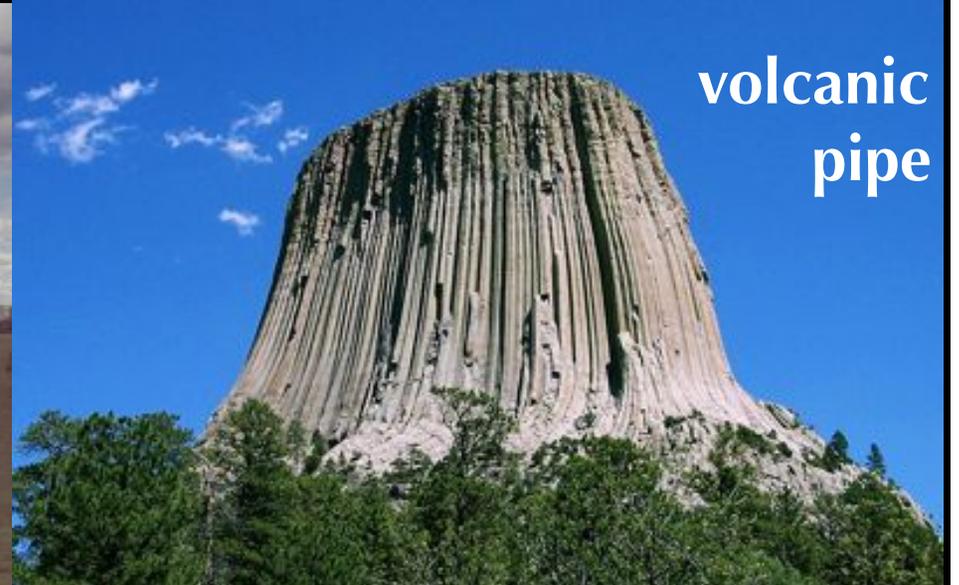
Igneous intrusions occur in a variety of shapes and sizes



Igneous intrusions occur in a variety of shapes and sizes



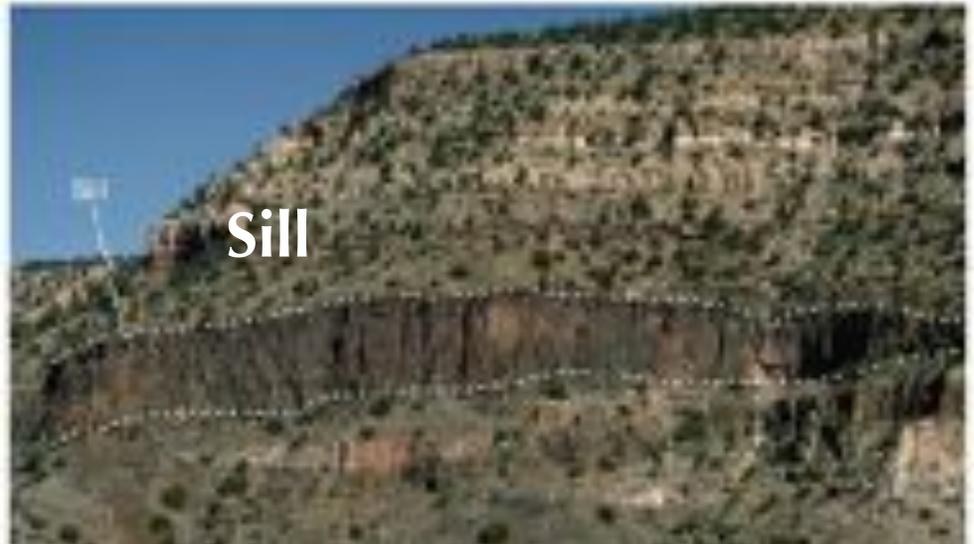
laccolith



volcanic
pipe



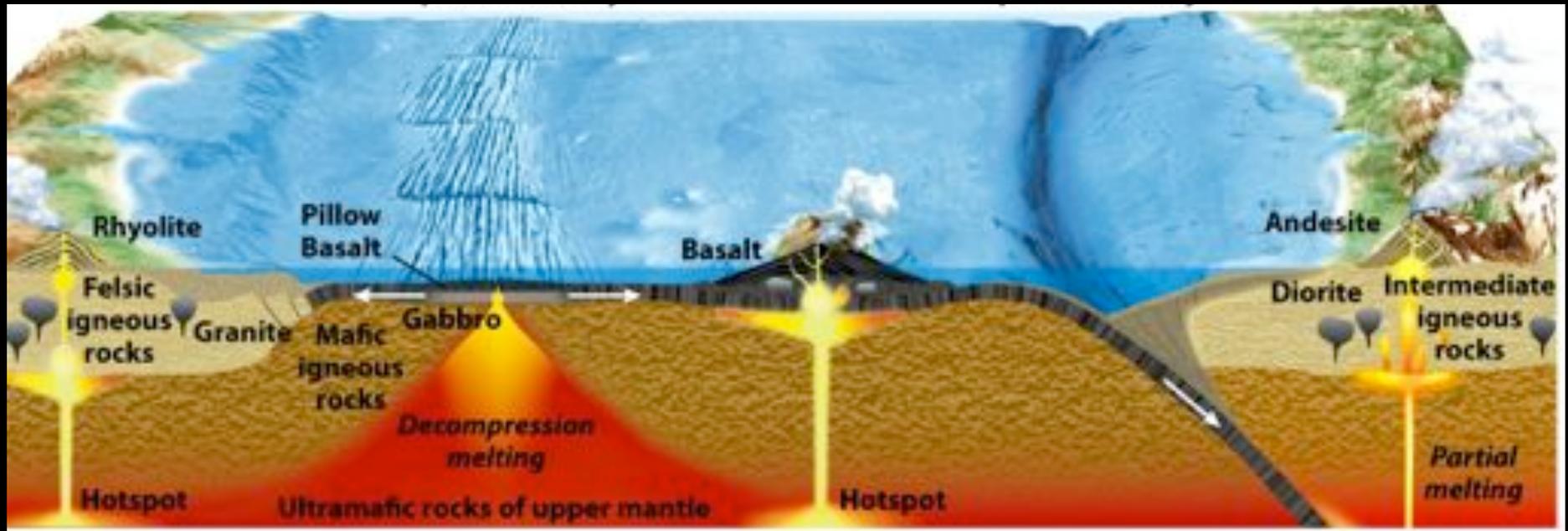
dike



Sill

Basalt forms at spreading centers & hotspots

Spreading centers

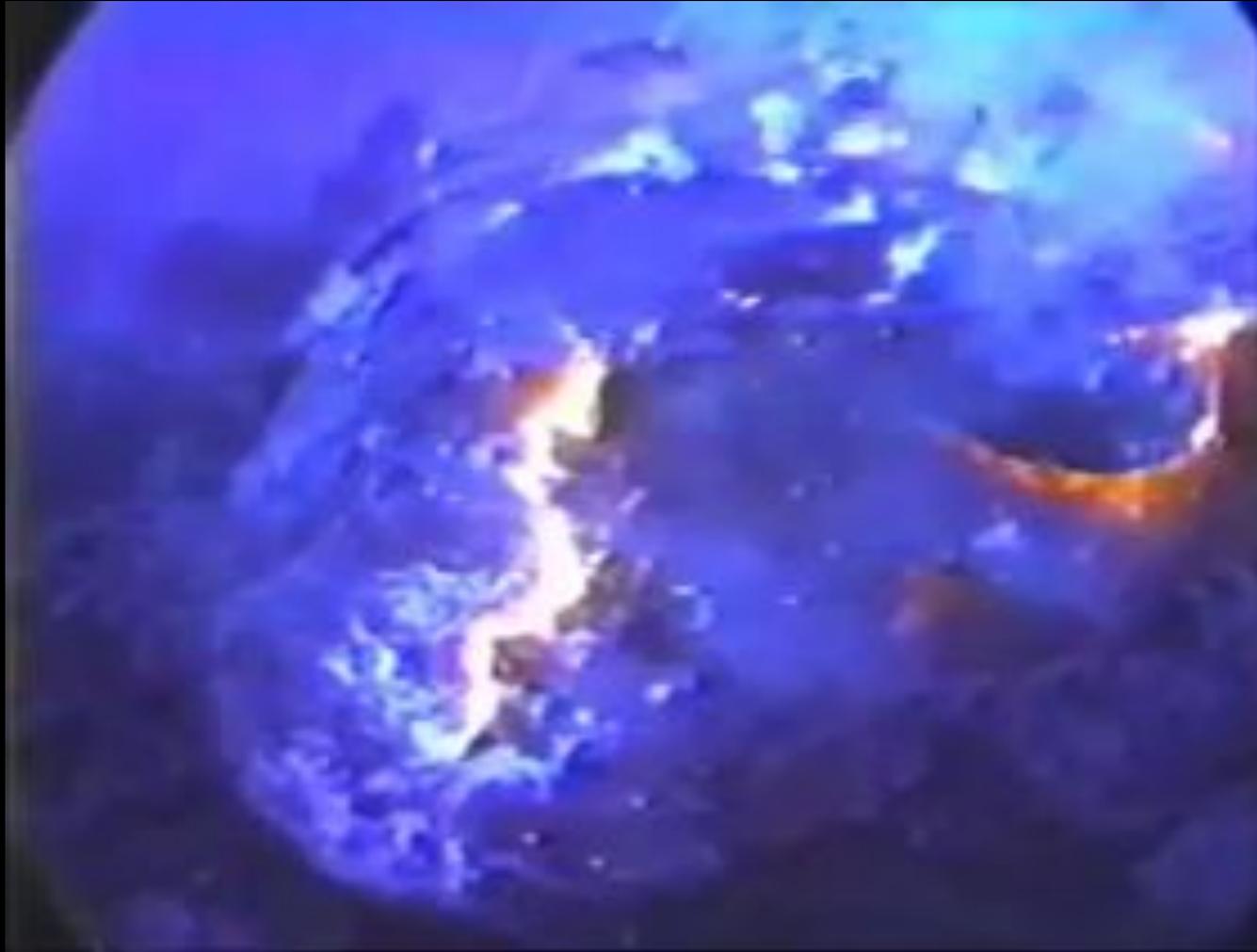


hotspots

Pillow basalts



Pillow lavas form where erupting lava interacts with water



[http://www.youtube.com/watch v=DdIUuUY0L9c](http://www.youtube.com/watch?v=DdIUuUY0L9c)

Subglacial Volcanos: Eruption Beneath ice

Lava erupting beneath
ice forms volcanoes with
flat tops and steep sides

Called a "Tuva"



Herðubreið, Iceland

What Happens When Lava Meets Ice?



<https://www.youtube.com/watch?v=yvSmPqqZB3Q>

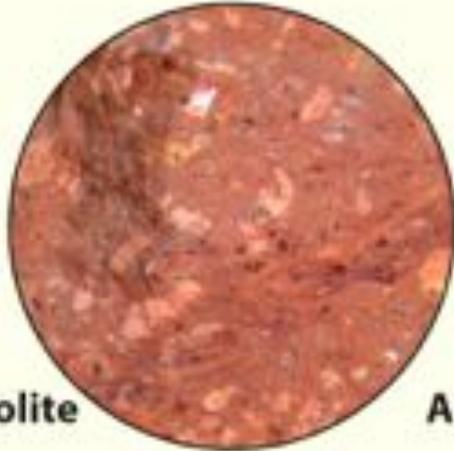
Igneous rocks are classified based on their composition and texture

Composition: **assemblage** of minerals (Si vs. Mg)

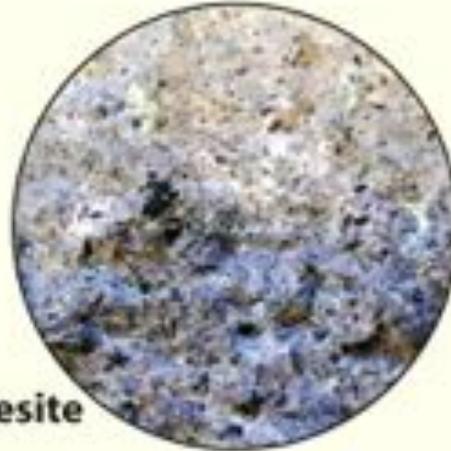
Texture: **size and arrangement** of crystals (cooling history)



The Major 7 Types of Igneous Rocks



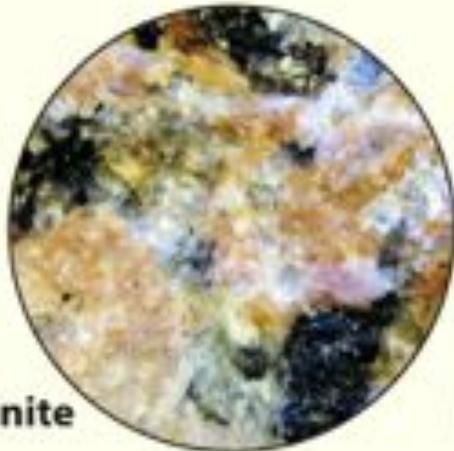
Rhyolite



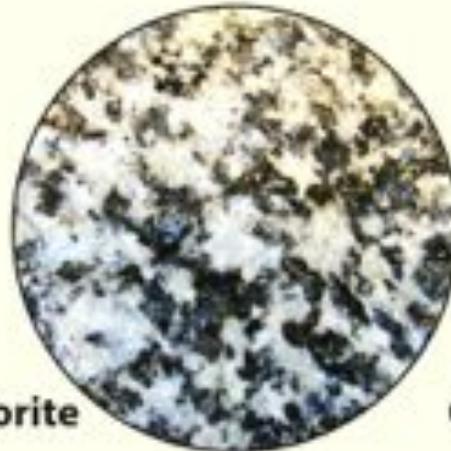
Andesite



Basalt



Granite



Diorite



Gabbro

+ Peridotite



Composition Types

- **Felsic:** Feldspar & Silica
Granite (large grains), Rhyolite (small)
- **Mafic:** Magnesium & Iron (Fe)
Gabbro (large), Basalt (small)
- **Ultramafic:** High Mg & Fe
Peridotite (mantle material, rare)
- **Intermediate:**
Andesite

Felsic

Mafic



Ultramafic

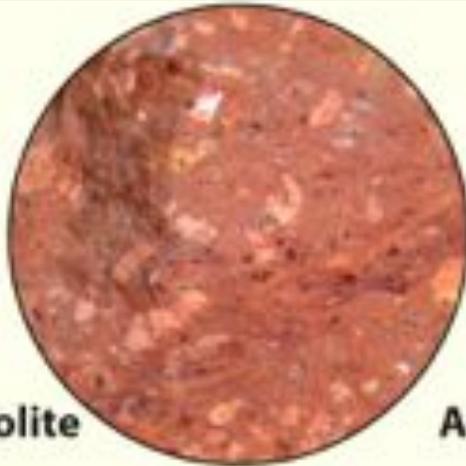


Andesite

Felsic

Intermediate

Mafic



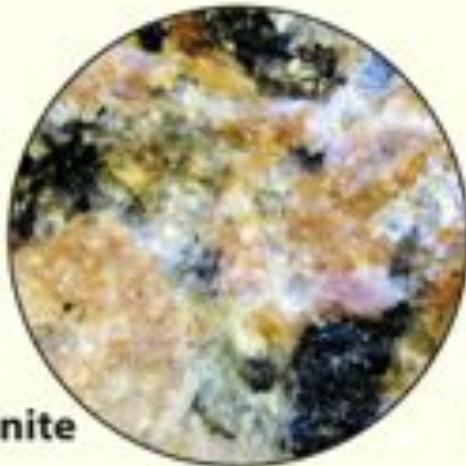
Rhyolite



Andesite



Basalt



Granite



Diorite



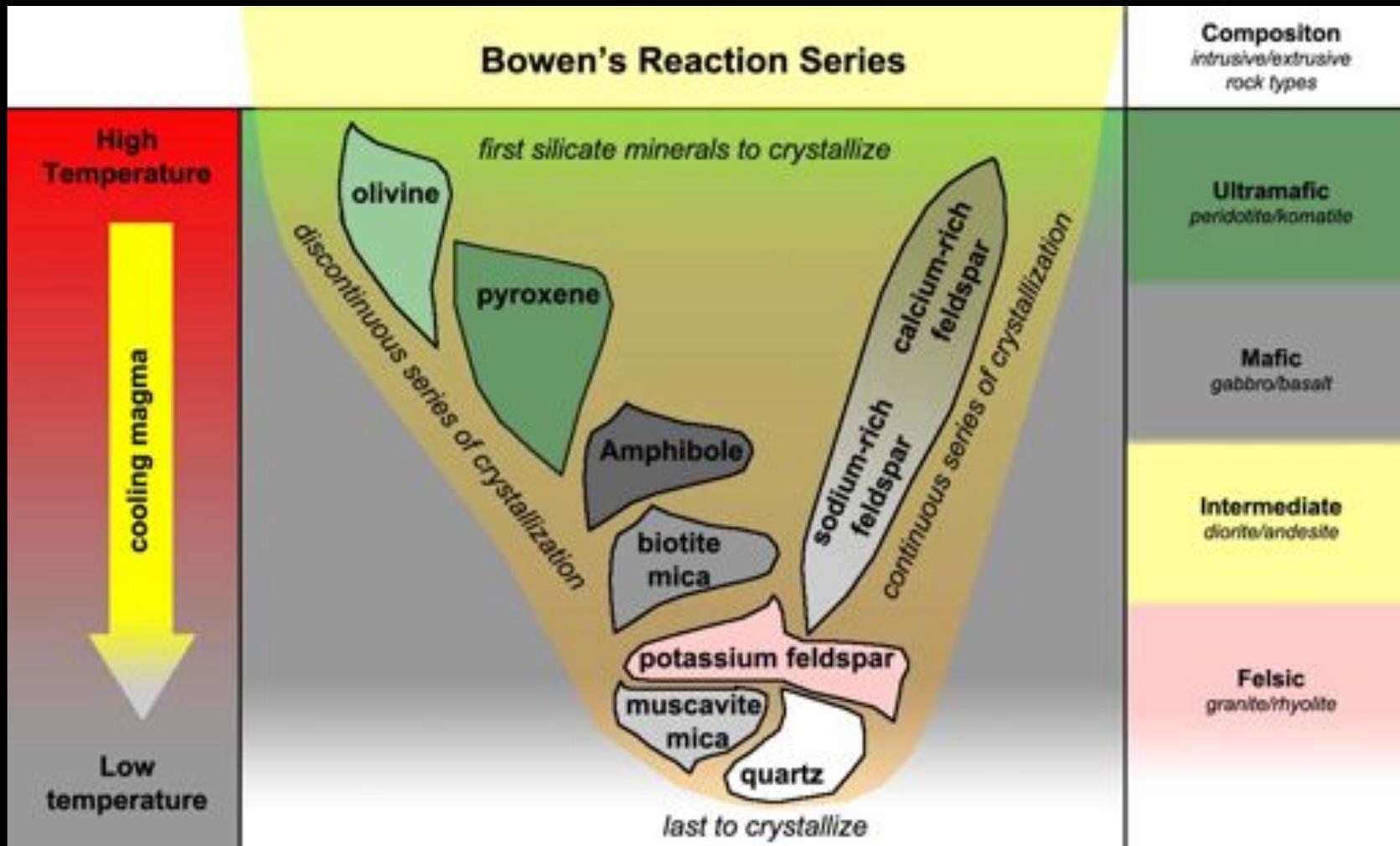
Gabbro

+ Peridotite



Ultramafic

Bowen's Reaction Series Describes the Crystallization of Magma

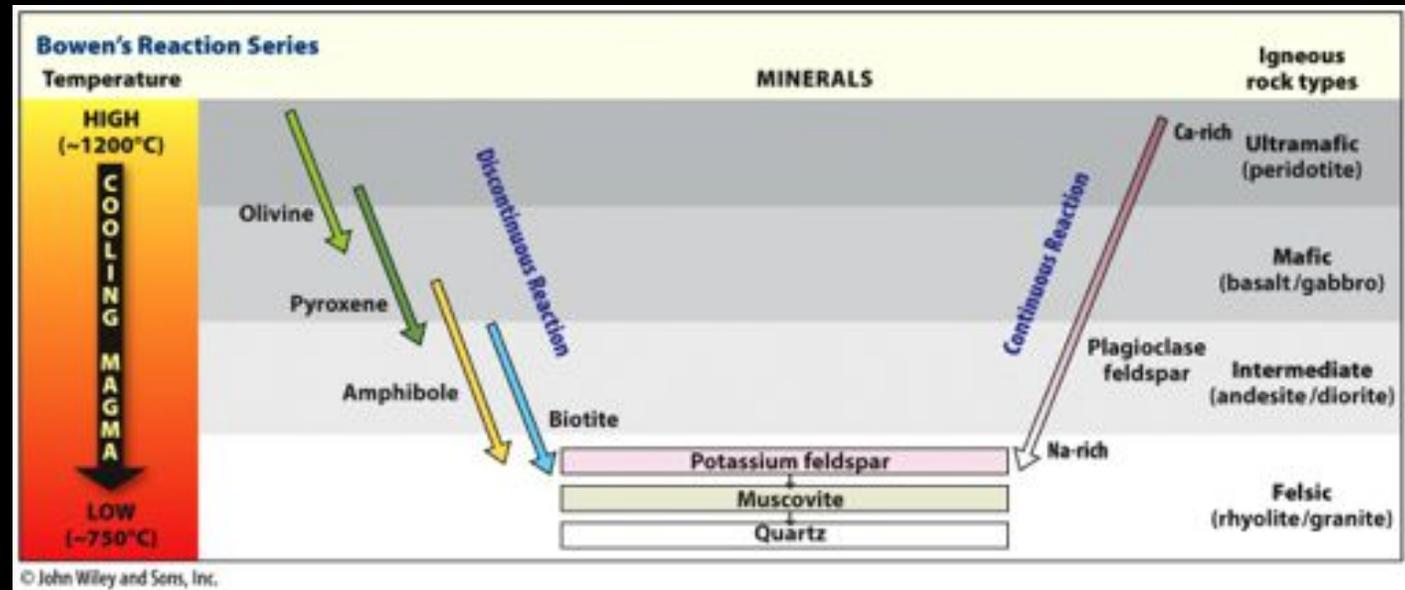


As magma crystallizes, a network of interlocking minerals forms

Mafic minerals crystallize early and Felsic minerals crystallize late in magma

Minerals at the TOP of the series:

- *Dark in color*
- *Mafic to ultramafic*
- *Fe & Mg*



Minerals at the BOTTOM of the series:

- *Light in color*
- *Felsic*
- *Na & K*

Composition vs. Color

Igneous color (gray scale) is used to estimate chemical composition



less
more

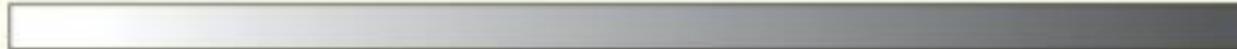
Mg/Fe content
Si/O content

more
less

Using visual color to estimate composition can be misleading.

Igneous Rock Color Index Guide

Color



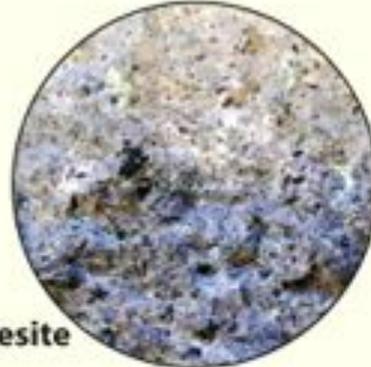
Felsic

Intermediate

Mafic



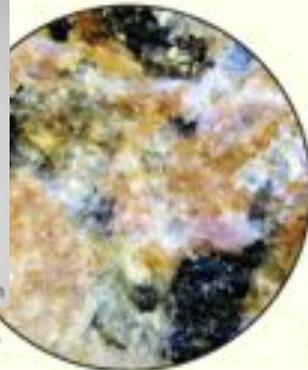
Rhyolite



Andesite



Basalt



Granite



Diorite



Gabbro

Obsidian
is Felsic!



© geology.com

Igneous rocks are classified based on their composition and texture

Composition: The assemblage of minerals (Si vs. Mg)

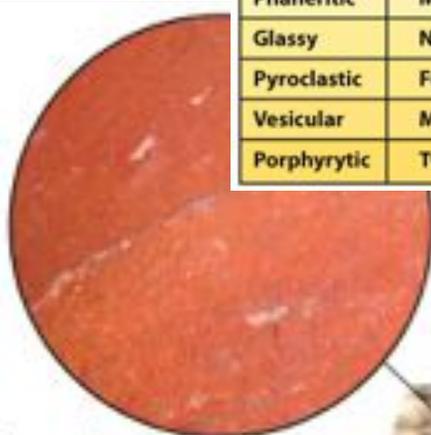
Texture: the **size and arrangement** of minerals (cooling history)



Texture is a Record of the Crystallization History

TABLE 5.2 Common Igneous Textures

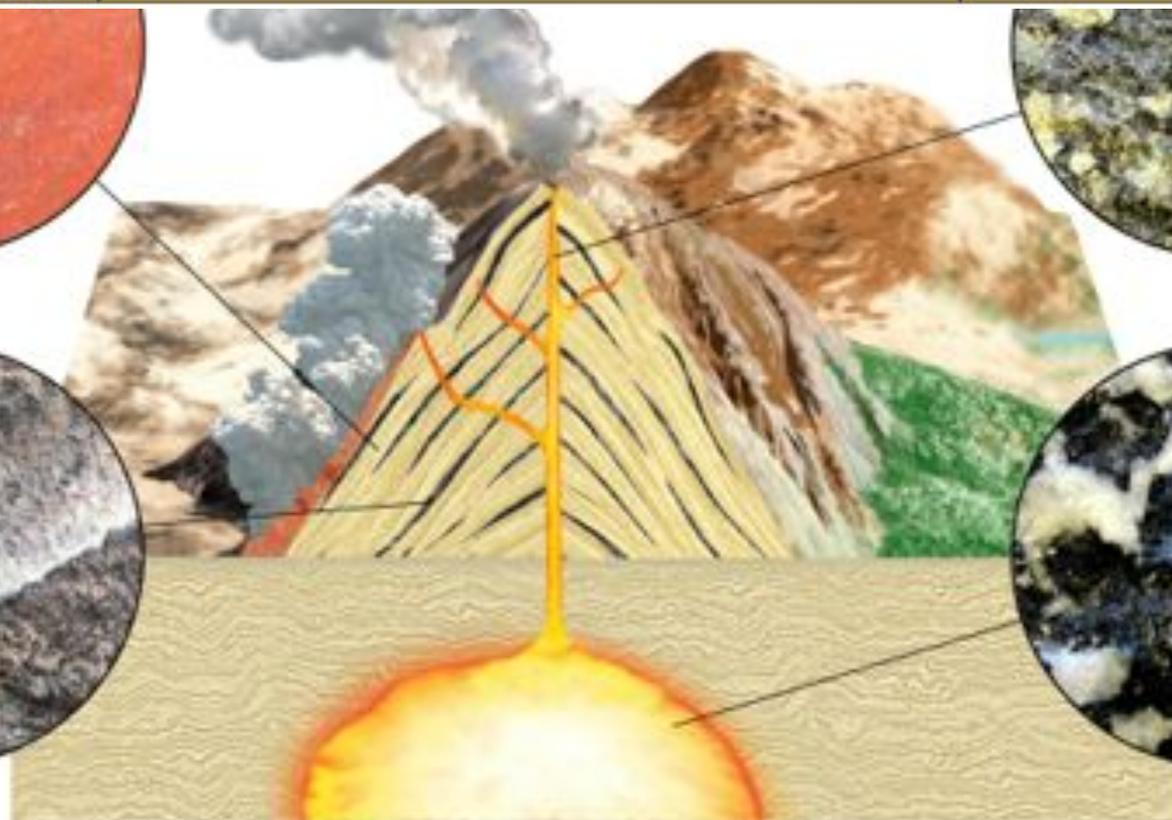
Texture	Definition	Example
Aphanitic	Minerals too small to see	Rhyolite
Phaneritic	Minerals large enough to see with unaided eye	Granite
Glassy	No obvious minerals	Obsidian
Pyroclastic	Fused, glassy volcanic rock fragments and ash from explosive volcanic eruption	Tuff
Vesicular	Many holes or pits in rock surface caused by escaping gas	Vesicular Basalt
Porphyritic	Two distinct mineral sizes	Porphyritic Basalt



Pyroclastic texture



Aphanitic texture



Porphyritic texture



Phaneritic texture

Texture Styles

Phaneritic:

- Slow cooling, larger crystals
- Coarse texture
- Intrusive or plutonic

Aphanitic:

- Rapid cooling, smaller crystals
- Finer texture
- Extrusive or volcanic

Other textures are **glassy, pyroclastic, vesicular, and porphyritic**



Volcanic bomb - aphanitic



Texture

Phaneritic

large minerals

Large crystals had a long time to crystallize.

Therefore, this is an intrusive rock

Example: Granite

Texture

Aphanitic

mineral grains too small to see with the unaided eye

Small crystals had a **short time** to crystallize.

Therefore, this is an **extrusive** rock

Example: Basalt





Texture

Vesicular

many pits from gas
escape

Extrusive rock

Example: Basalt



Texture

Glassy

no obvious
minerals

No crystals.

This is an **extrusive** rock
that cooled
VERY quickly

Example: Obsidian

Glass Formation



<https://www.youtube.com/watch?v=eVk5Gbn1ePU>



Texture

Pyroclastic

Fused rock fragments & ash from an **explosive** eruption

Extrusive rock
(made during an eruption)

Example: Tuff



Texture

Porphyritic

2 distinct grain sizes,
large & small

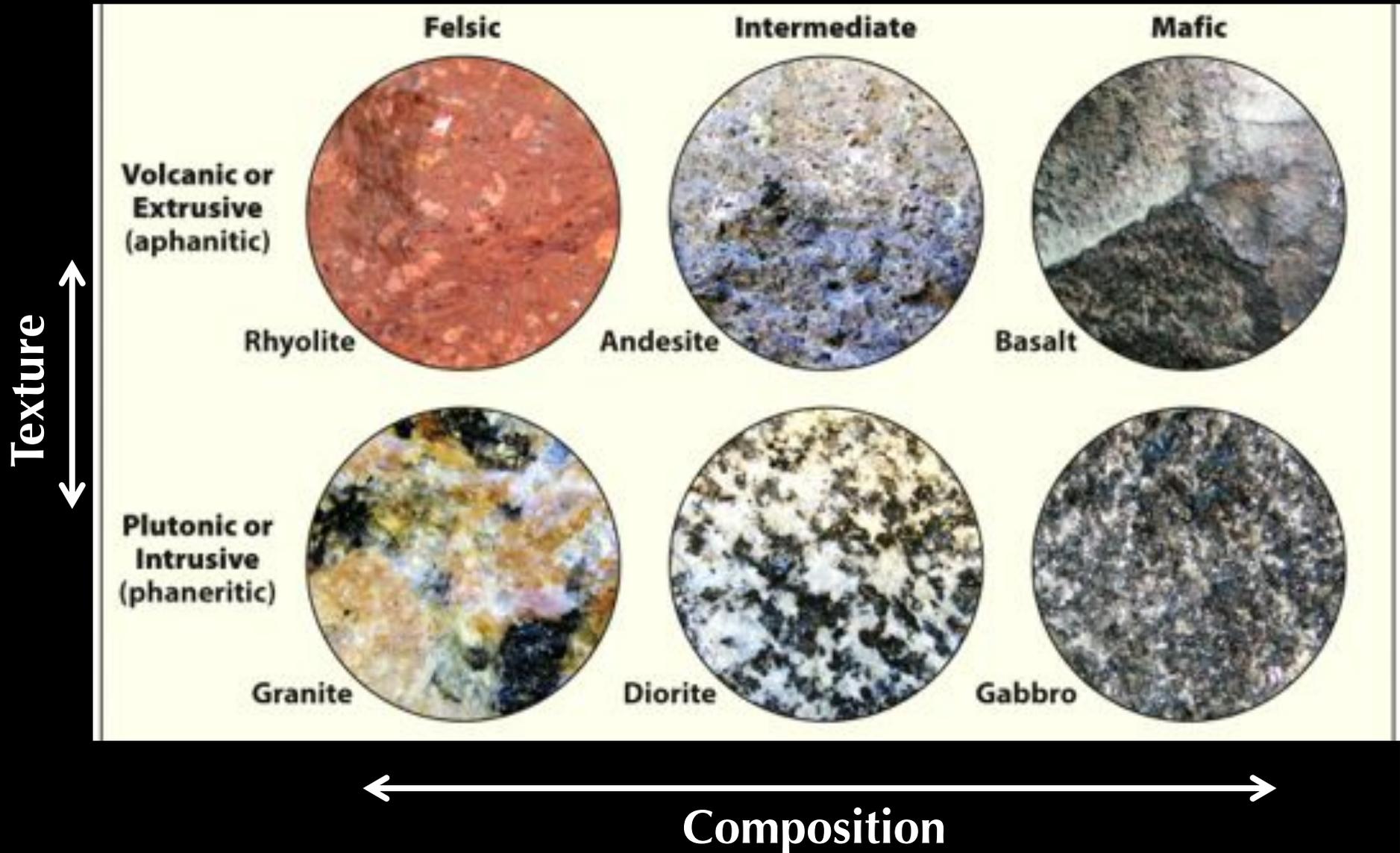
Two phases of cooling:

Intrusive phase: **large** crystals

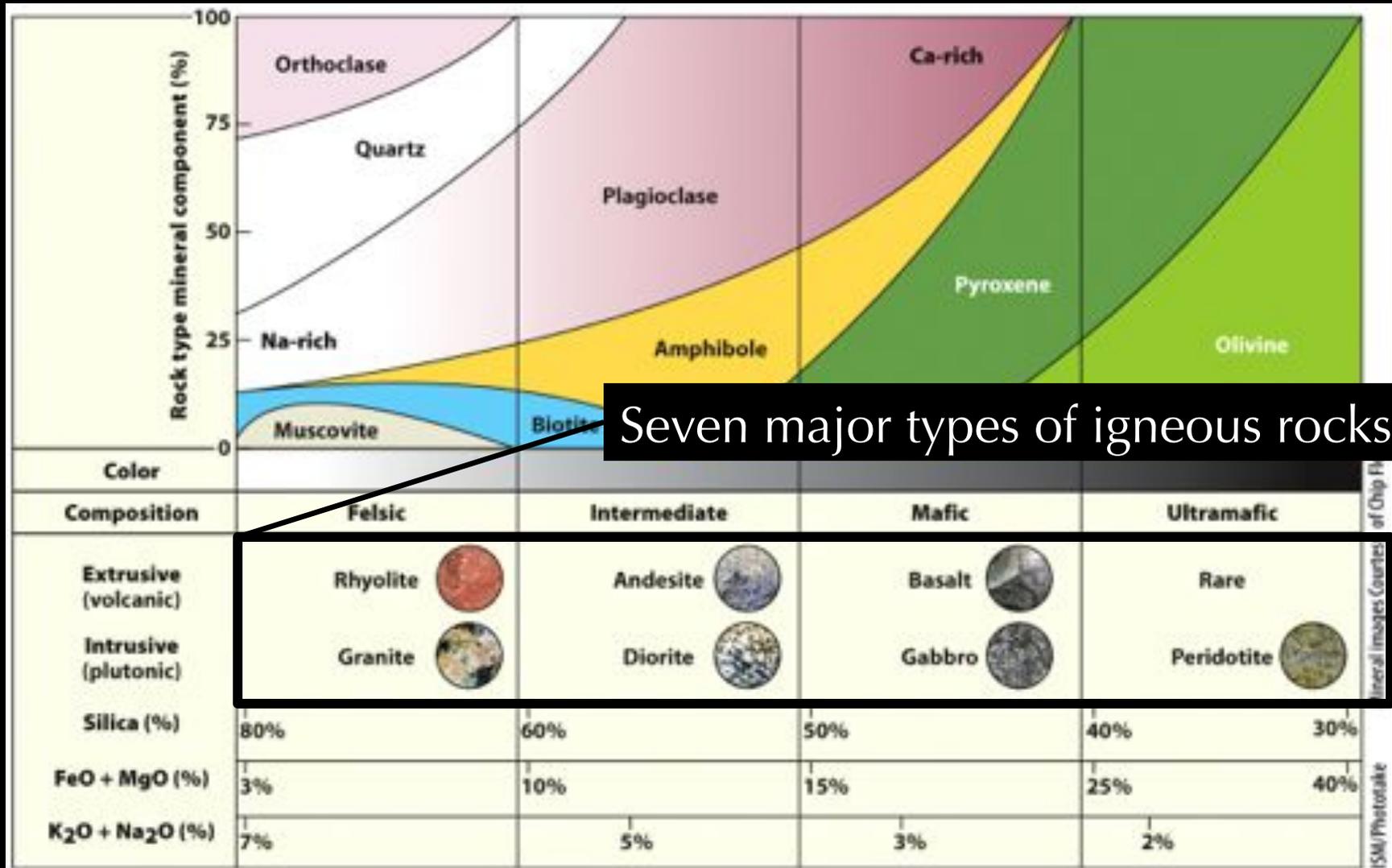
Extrusive phase: **fine** crystals

Example: Andesite

The Major 7 Types of Igneous Rocks



Igneous rocks are named based on their texture & composition



iClicker Question

Green Sand Beach, Big Island is made of Olivine.



True or false?

Olivine is also the most common mineral in the upper mantle.

- A. True
- B. False



Many Uses of Igneous Rocks



walls of
lava rock



building
materials

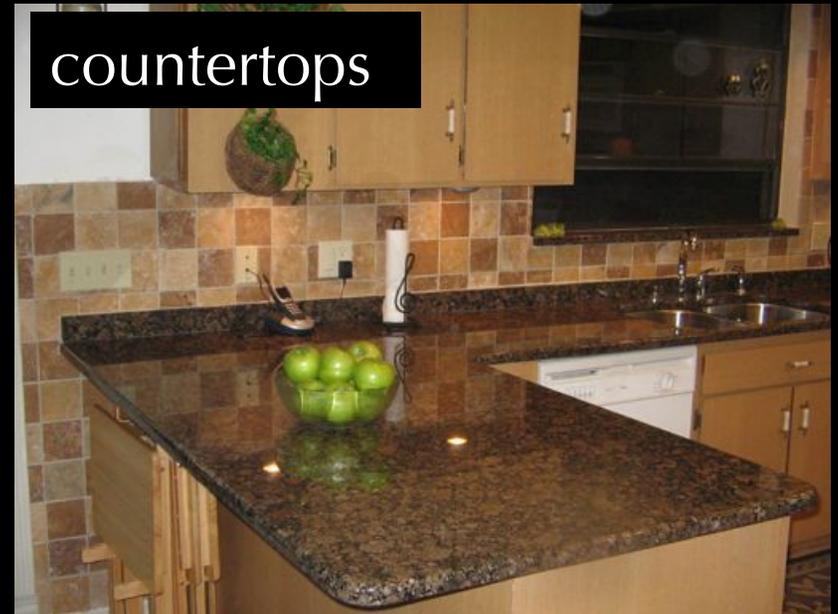


pumice
stone

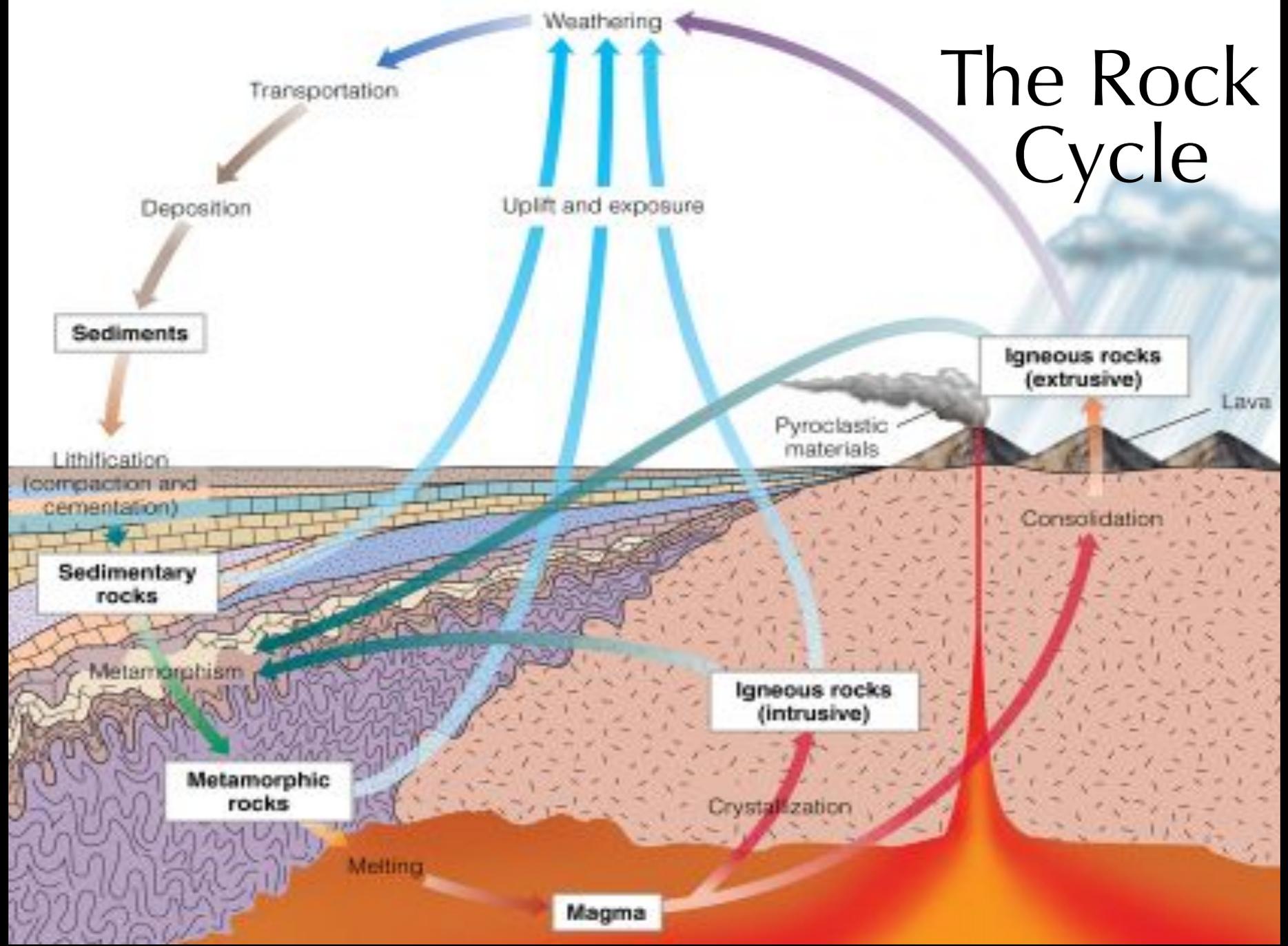
arrowheads



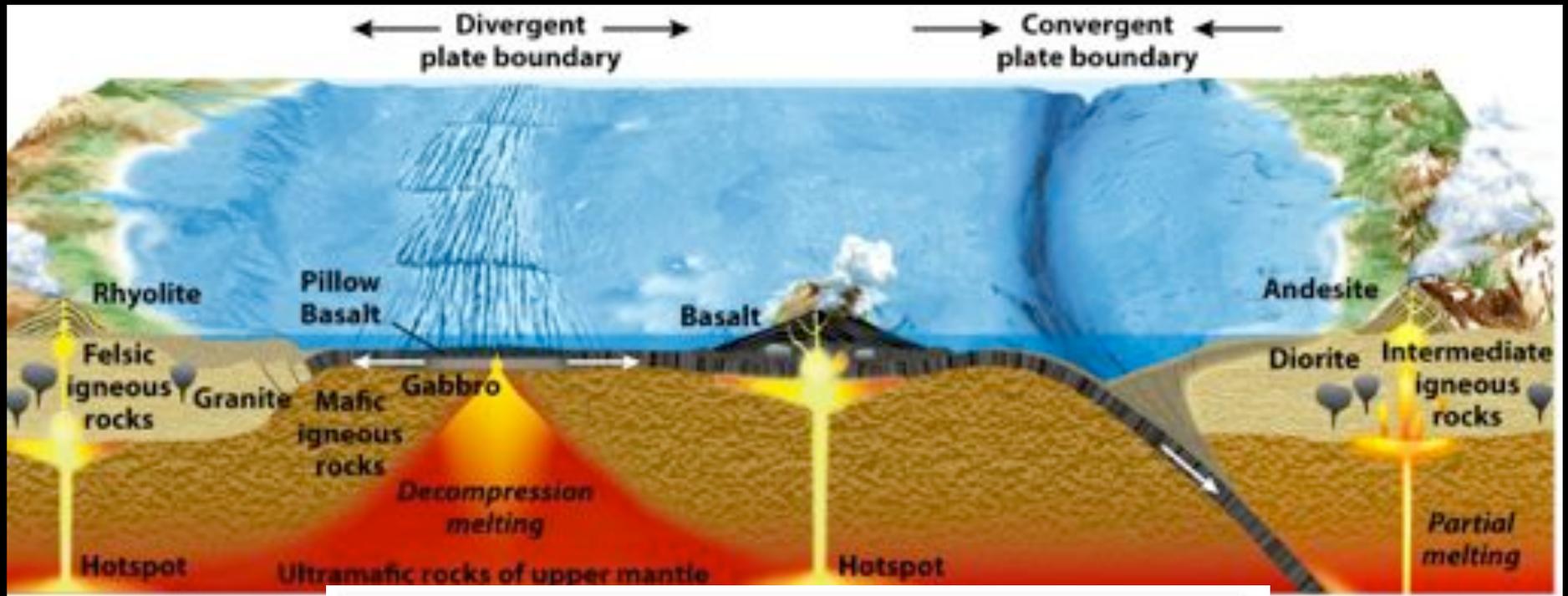
countertops



The Rock Cycle



Igneous rock is a ubiquitous component of Earth's crust because it evolves as a product of tectonic processes.



u·biq·ui·tous

/yoo'biqwədəs/

adjective

present, appearing, or found everywhere.

"his ubiquitous influence was felt by all the family"

synonyms: **omnipresent**, ever-present, **everywhere**, all over the place, **pervasive**, universal, worldwide, global; [More](#)

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Coke and Lava

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Action Items for Thursday, Sept. 10

1. Read Chapter 5
2. Complete homework assignment #5

What you should know from today:

1. Describe igneous rock
2. Identify the information revealed by igneous texture
3. Identify how igneous rock color relates to chemical composition
4. Describe the process of igneous evolution and the role of plate tectonics in it
5. Describe the environments where basalt accumulates