Rock types
Igneous rocks

Velledits Felicitász

Rocks

Characteristics of rocks

- Mineral composition (most rocks are aggregates of minerals. The properties of rocks are determined by the chemical composition and crystalline structure of the minerals contained within them)
- Texture (size, shape, arrangement of grains)

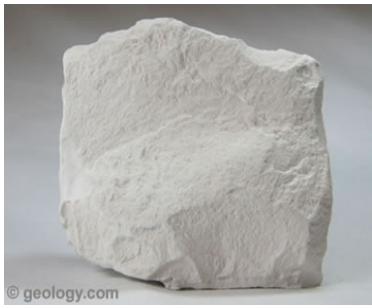




Formation of rocks

- Crystallization of magma (**igneous**)
- Accummulation of fragments or precipitated minerals (**sedimentary rocks**)
- Transformation by high pressure/temperature (**metamorphic rocks**)



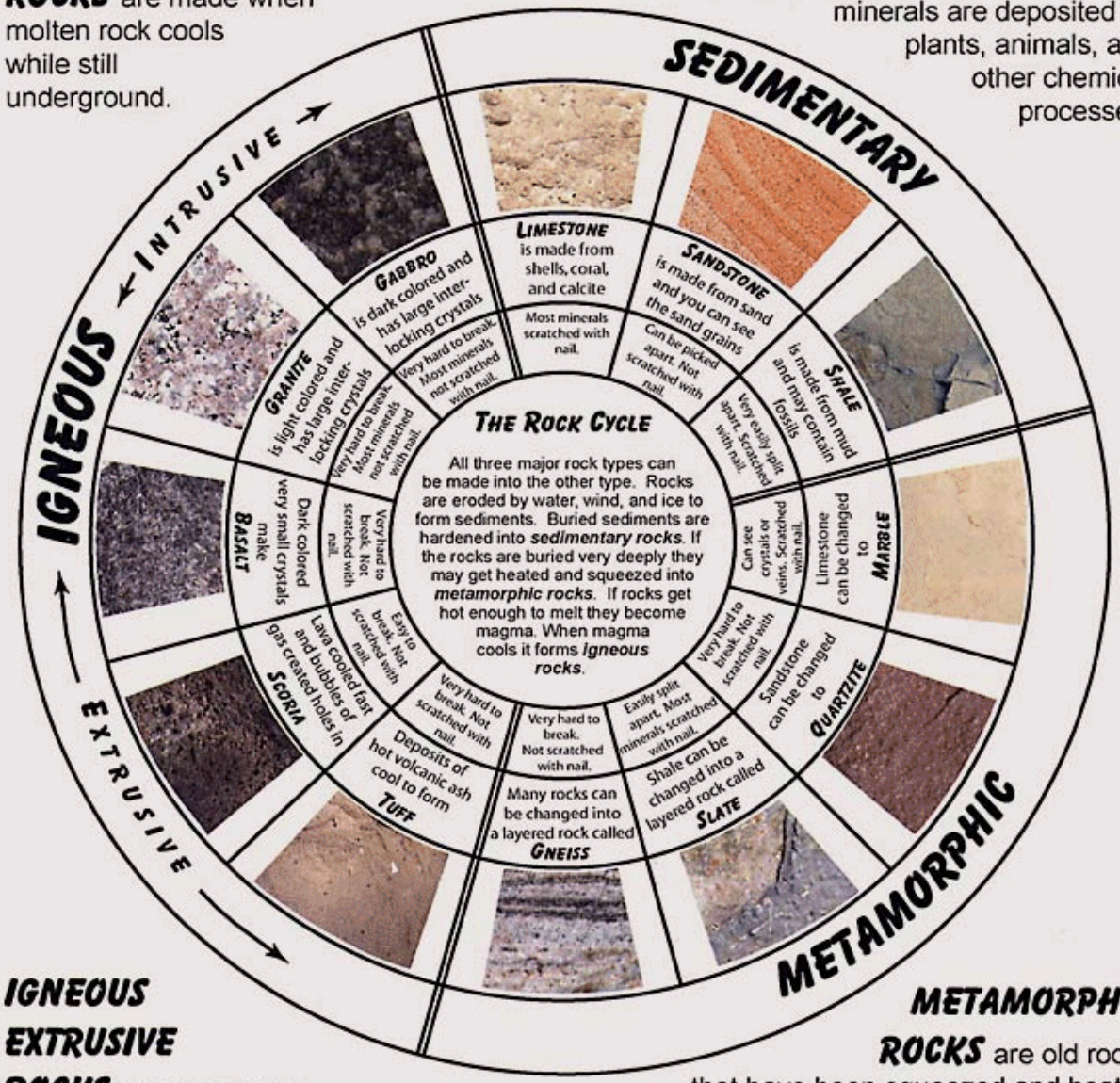






IGNEOUS INTRUSIVE ROCKS are made when molten rock cools while still underground.

SEDIMENTARY ROCKS are made when pieces of rocks settle from the water or when minerals are deposited by plants, animals, and other chemical processes.

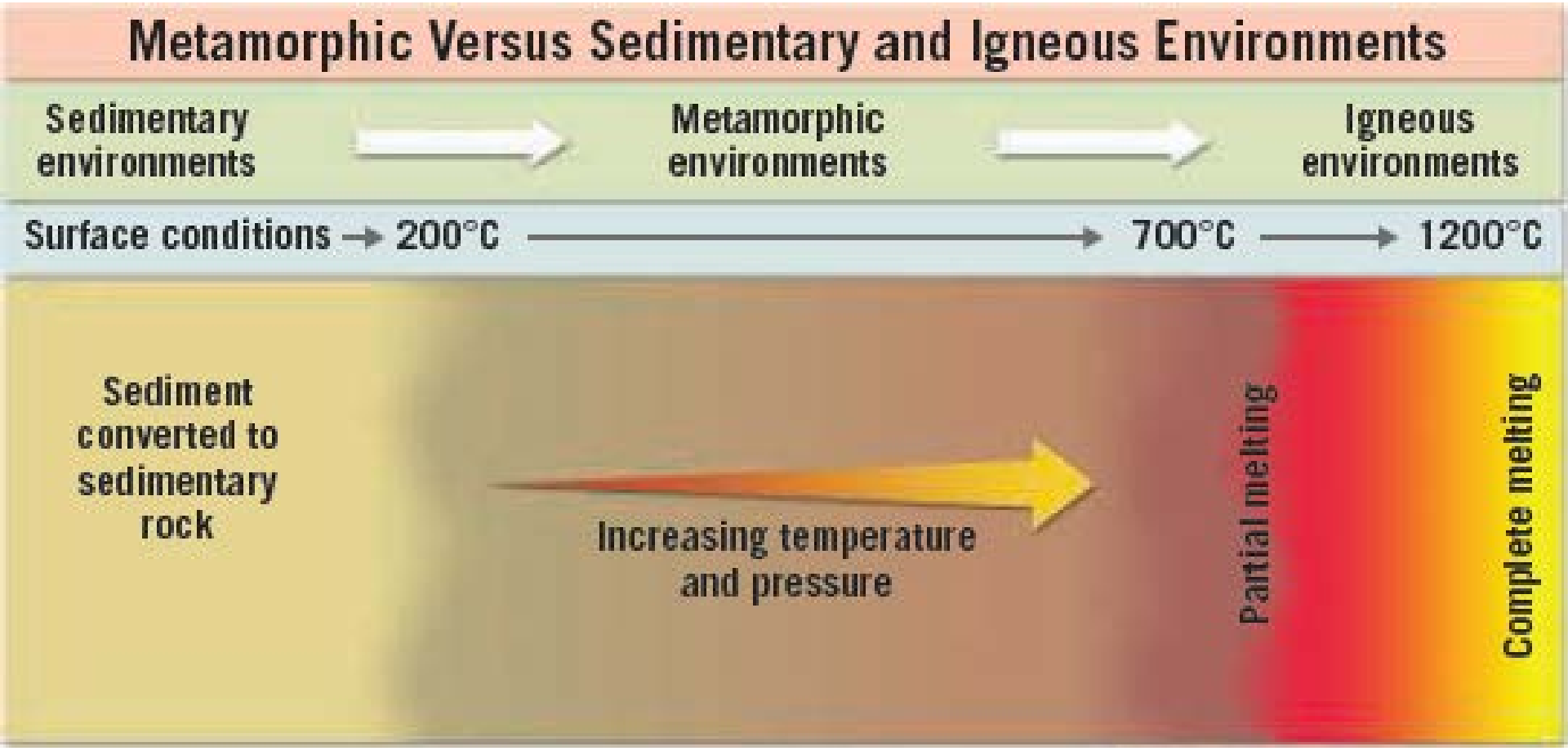


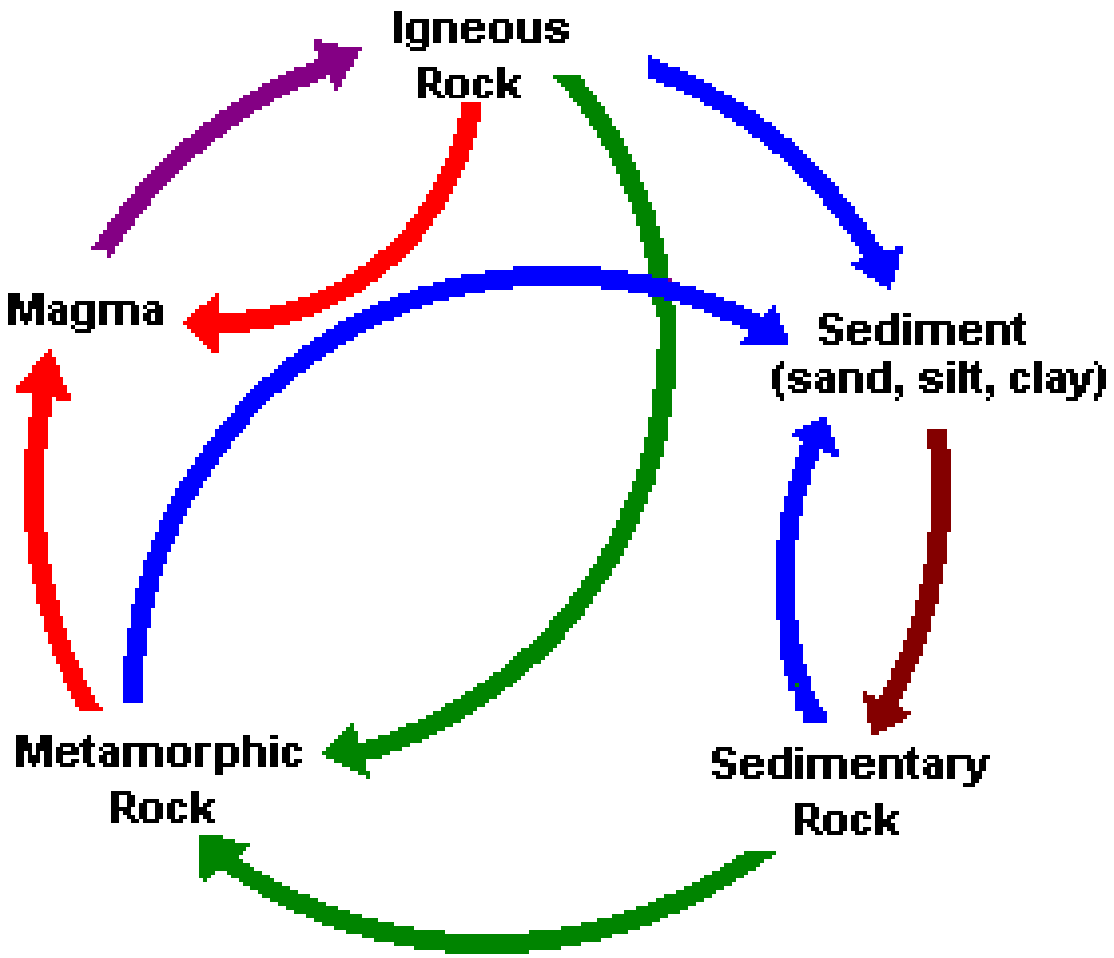
IGNEOUS EXTRUSIVE ROCKS are made when molten rock flows on the land surface or is thrown into the air and then is cooled into rock.

METAMORPHIC ROCKS are old rocks that have been squeezed and heated but not melted. What new rock is made depends on what the original rock was and on the amount of heat and pressure.

Source: Bill Langer, U.S. Geological Survey.

http://www.bedrockquarry.com/images/identify-rocks.jpg

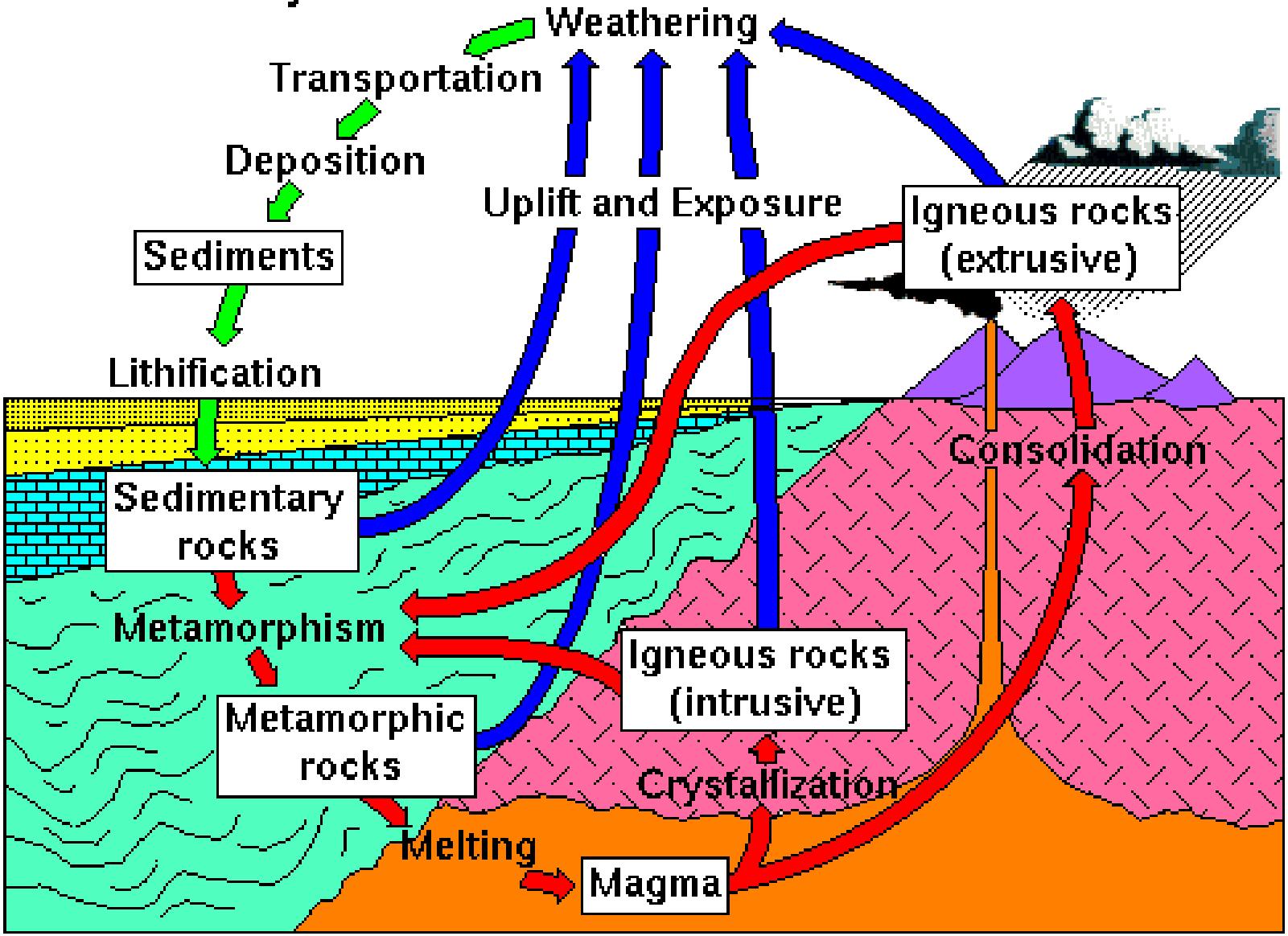

Metamorphic Versus Sedimentary and Igneous Environments
Sedimentary environments
Metamorphic environments
Igneous environments
Surface conditions
200°C
700°C
1200°C
Sediment converted to sedimentary rock
Increasing temperature and pressure
Partial melting
Complete melting

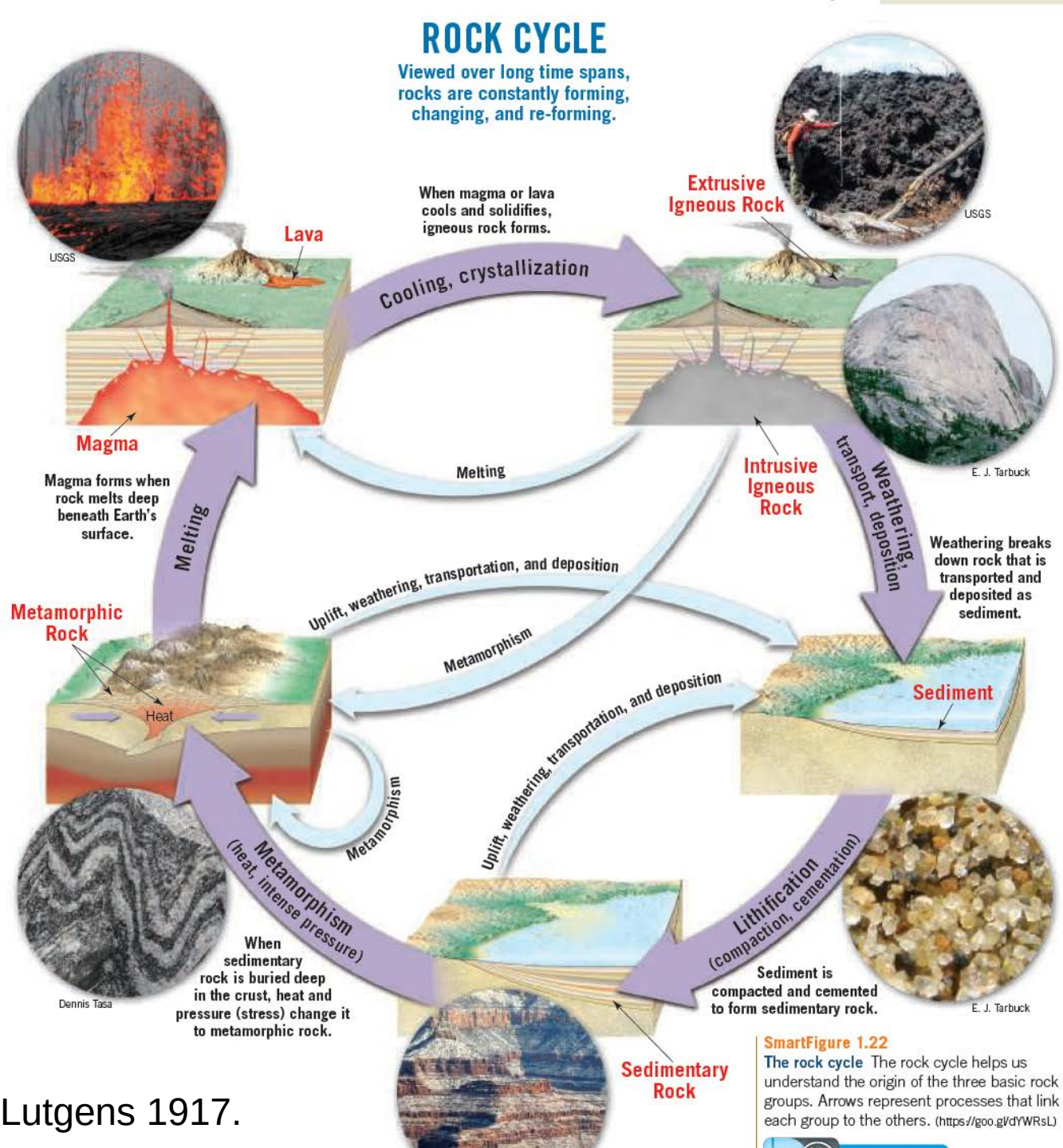


Key To Processes

- Melting
- Crystallizing
- Weathering
- Metamorphosing
- Compaction & Cementing

The Rock Cycle





SmartFigure 1.22
The rock cycle The rock cycle helps us understand the origin of the three basic rock groups. Arrows represent processes that link each group to the others. (https://goo.gl/dYWRsL)

Tarbuck & Lutgens 1917.

Rock classification

- **Magmatic rocks**
  - Intrusive (gabbro, diorite, granite)
  - Volcanic (basalt, andesite, rhyolite)

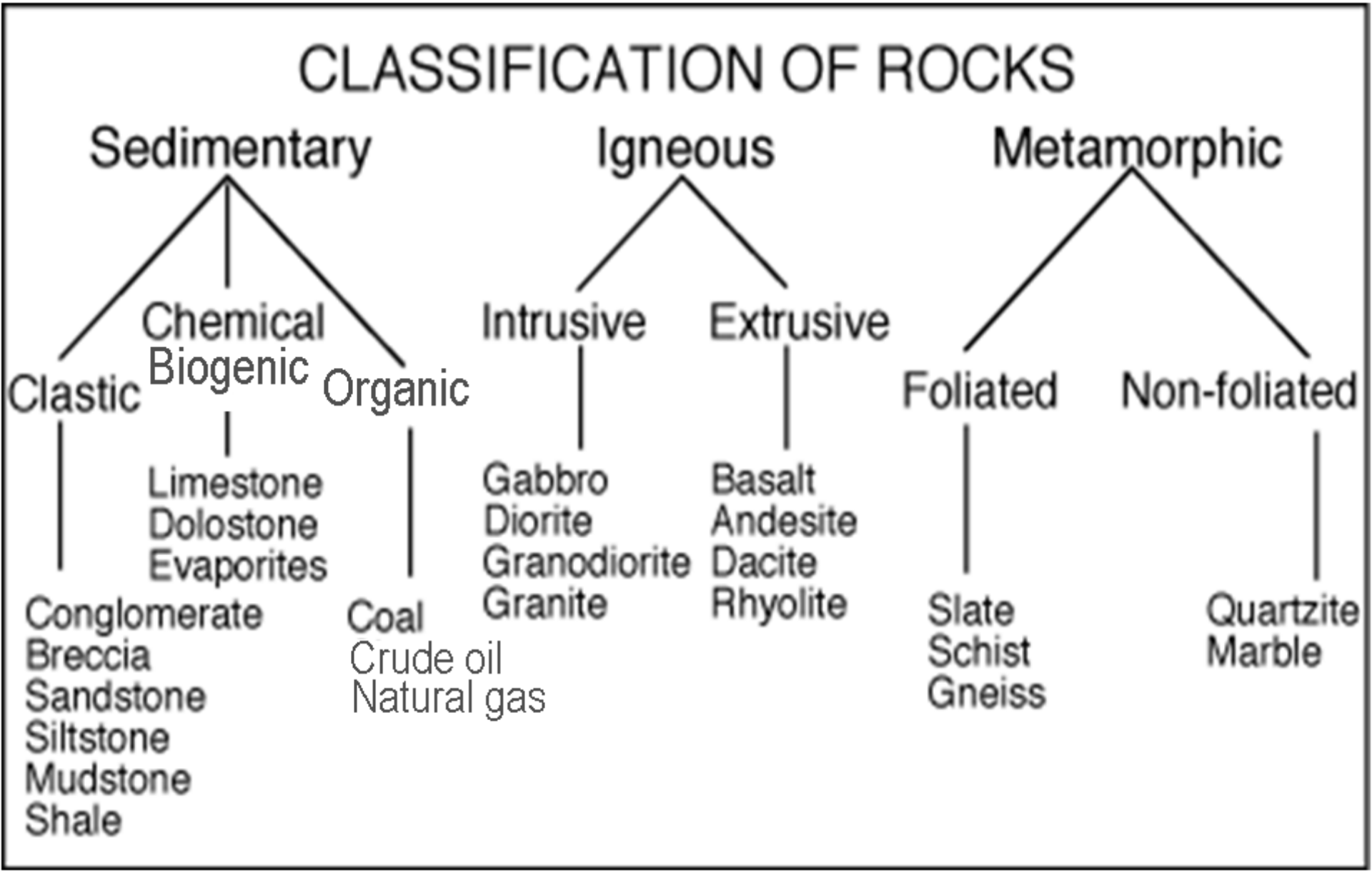


- **Sedimentary rocks**
  - Clastic (conglomerate, sandstone, siltstone, mudstone /shale)
  - Chemical and biogenic (limestone, dolomite, evaporite manganese rocks)
  - Organic (coal, crude oil, natural gas)



- **Metamorphic rocks**
  - Very low grade (shale)
  - Low grade (phyllite, serpentinite)
  - Medium grade (schist, amhibolite, marble, quartzite)
  - High grade (gneiss, eclogite)




CLASSIFICATION OF ROCKS
Sedimentary
Igneous
Metamorphic
Clastic
Chemical
Biogenic
Organic
Intrusive
Extrusive
Foliated
Non-foliated
Limestone
Dolostone
Evaporites
Gabbro
Diorite
Granodiorite
Granite
Basalt
Andesite
Dacite
Rhyolite
Conglomerate
Breccia
Sandstone
Siltstone
Mudstone
Shale
Coal
Crude oil
Natural gas
Slate
Schist
Gneiss
Quartzite
Marble

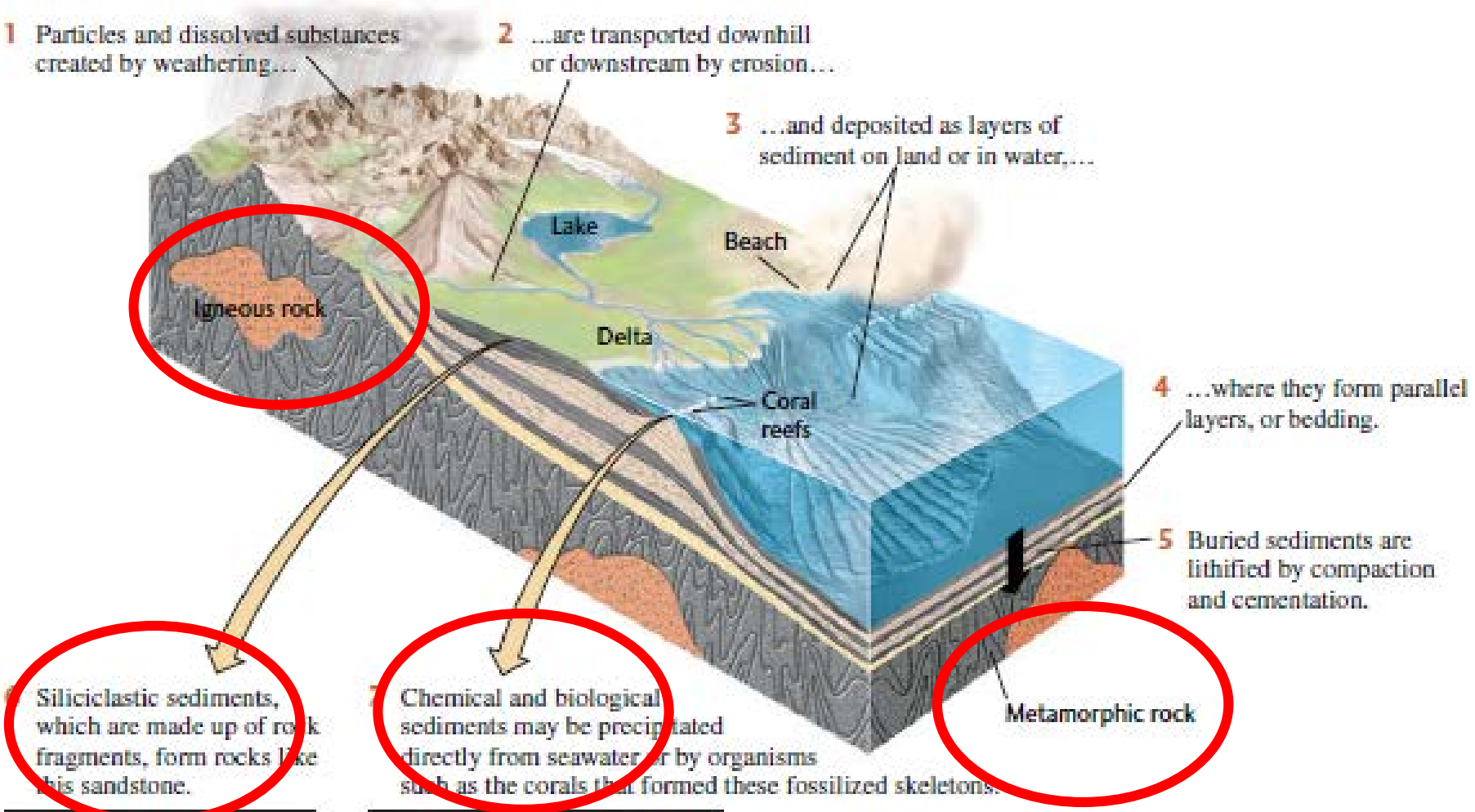


FIGURE 3.26 ■ Sedimentary rocks are formed from particles of other rocks. [Photos by John Grotzinger/Ramón Rivera-Moret/MIT.]

Remember it well!!

Rocks contain information about the

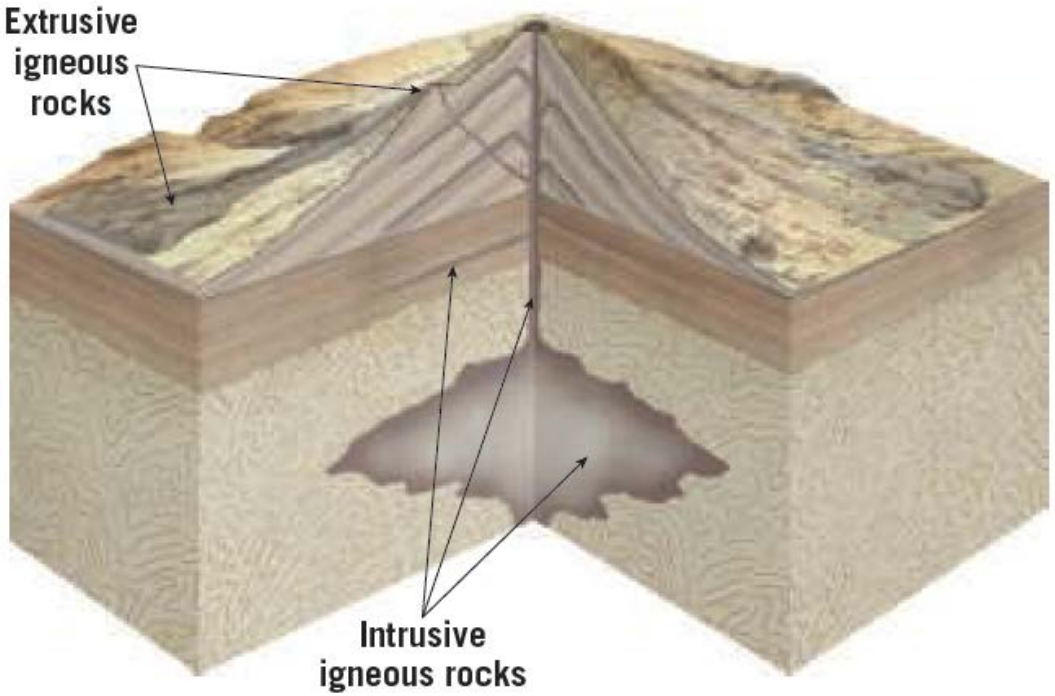
- 1) processes that produced them,
- 2) about the environment in which they were formed.

Igneous rocks are classified on the basis of their texture and mineral composition.

- The **texture** result mainly from different cooling histories,
- the **mineral composition** of an igneous rocks depends on the chemical makeup of its parent magma.

Igneous rock

- **Igneous rocks** (*ignis:* fire) form as molten rock cools and solidifies. They form in two basic settings:



B. When magma crystallizes at depth, intrusive igneous rocks form. When magma solidifies on Earth's surface, extrusive igneous rocks form.

1) **At depth *intrusive*** igneous rocks/plutonic rocks. (After Pluto, the god of the underworld in classical mythology.)
2) **At the surface: *extrusive*** igneous rocks, or volcanic rocks. (After Vulcan, the Roman fire god.)

Tarbuck & Lutgens 1917.

Composition of Igneous rock

Most abundant constituents of igneous rocks are:

- Silicon (Si) and oxygen (O).
- Si+O and other ions, like aluminum (Al), calcium (Ca), sodium (Na), potassium (K), magnesium (Mg), and iron (Fe), make up roughly 98 percent, by weight, of most magmas.

- Magma contains small amounts of titanium (Ti) manganese (Mg), and trace amounts of rare elements, such as gold, silver, and uranium.

As magma cools and solidifies, these elements combine to form **two major groups** of silicate minerals.

- 1)The ***dark* (or *ferromagnesian*) *silicates*** are rich in iron and/or magnesium and low in silica.
- *Olivine* $(Mg,Fe)_2SiO_4$
- *Pyroxene*, $(Mg,Fe)_2Si_2O_6$
- *Amphibole (pl.*$Ca_2(Mg, Fe, Al)_5 (Al, Si)_8O_{22}(OH)_2$
- *Biotite* $K(Mg, Fe^{2+})_3(Al, Fe^{3+})Si_3O_{10}(OH, F)_2$

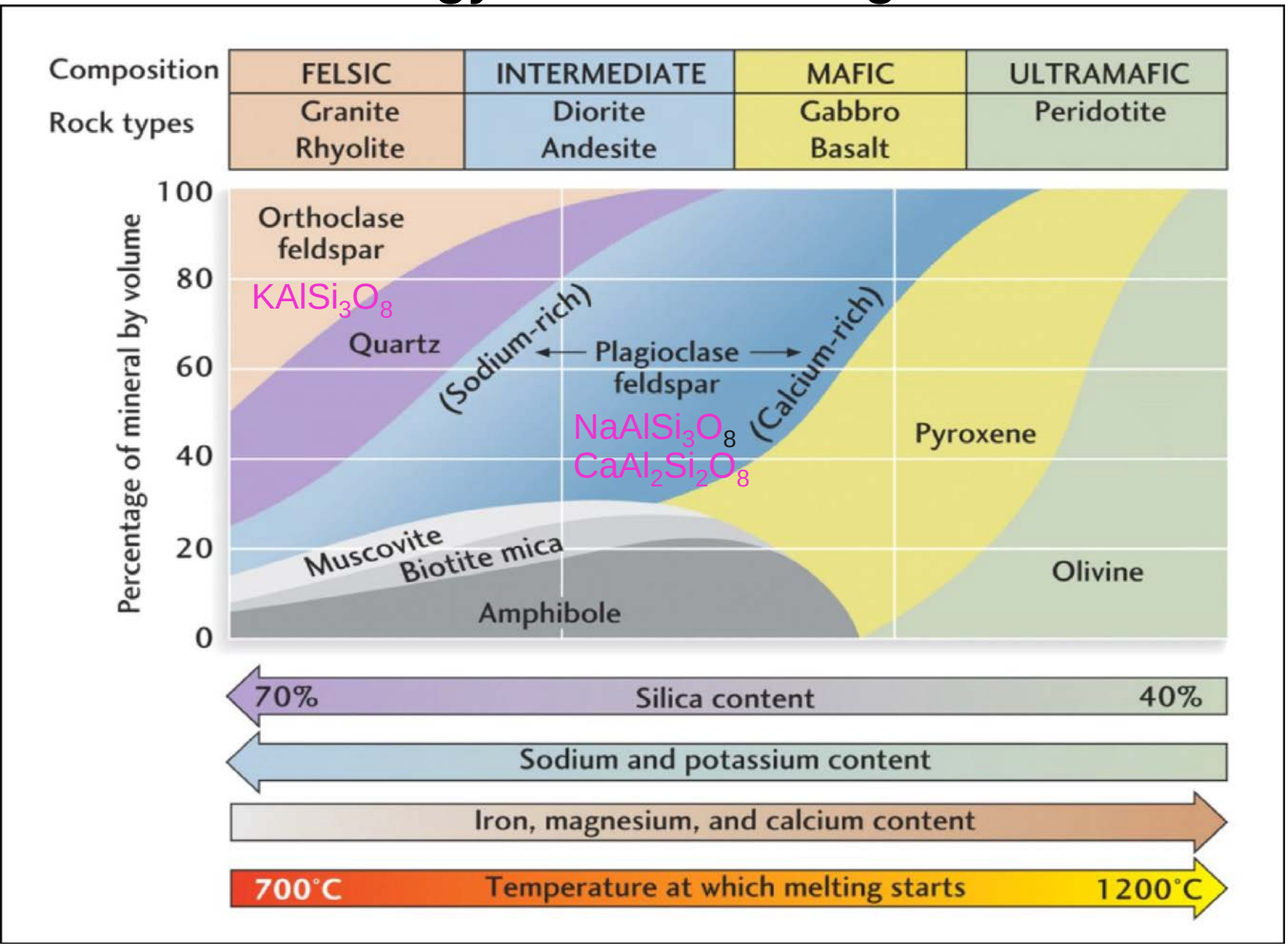
1) The ***light*** **(or *nonferromagnesian*)** ***silicates*** contain greater amounts of potassium (K), sodium (Na), and calcium (Ca) rather than iron (Fe) and magnesium (Mg). The light silicate minerals, including:

- *Quartz (*SiO_2*)*,
- *Muscovite mica* $(KAl_2)(F,OH)_2$, or $(KF)_2(Al_2O_3)_3(SiO_2)6(H_2O)$
- *Feldspars* $NaAlSi_3O_8$-$KAlSi_3O_8$-$CaAl_2Si_2O_8$

The light silicates **are richer in silica than the**

dark silicates.

Mineralogy of common igneous rocks



Tarbuck & Lutgens 1917.

1) Granitic (felsic) composition

Composed almost entirely of light-colored silicates: quartz and potassium feldspar. Other name is: **felsic** a term derived from ***fel***dspar and ***si***lica (quartz).

In addition to quartz and feldspar, contains about 10 percent dark silicate minerals, usually biotite mica and amphibole.

Granitic rocks are rich in silica (about 70 %) and are major constituents of the continental crust.

2) Basaltic composition

Contain at least 45 percent dark silicate minerals and calcium-rich plagioclase feldspar (but no quartz), and high percentage of ferromagnesian minerals.

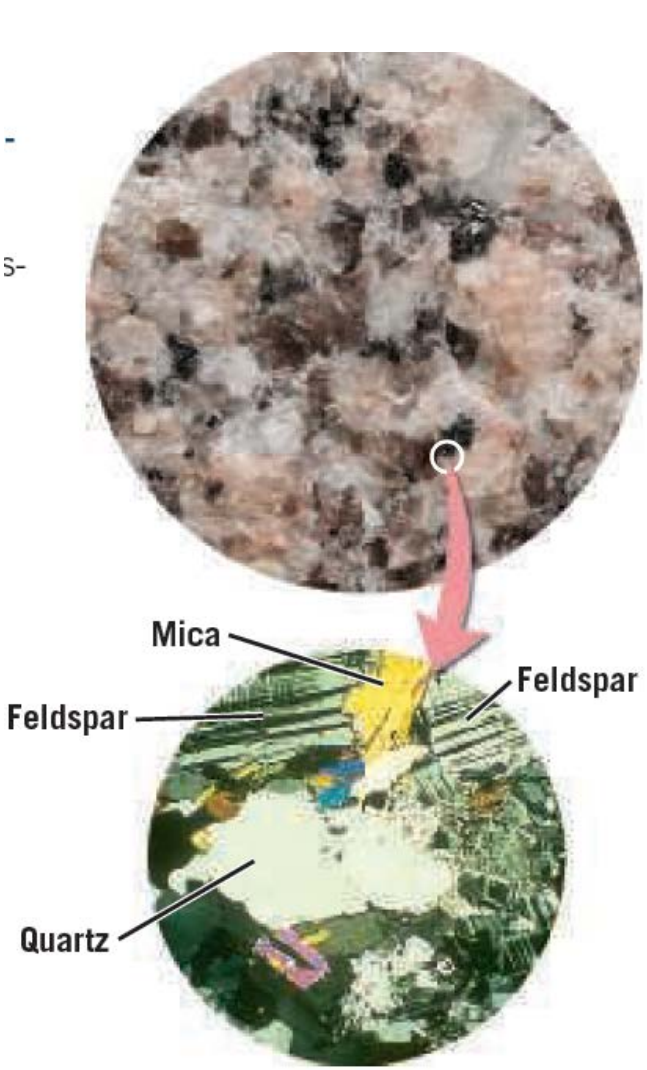
Other name: mafic (from *ma*gnesium and *fe*rrum, the Latin name for iron).

Because of their iron content, mafic rocks are typically **darker** and **denser** than granitic rocks.

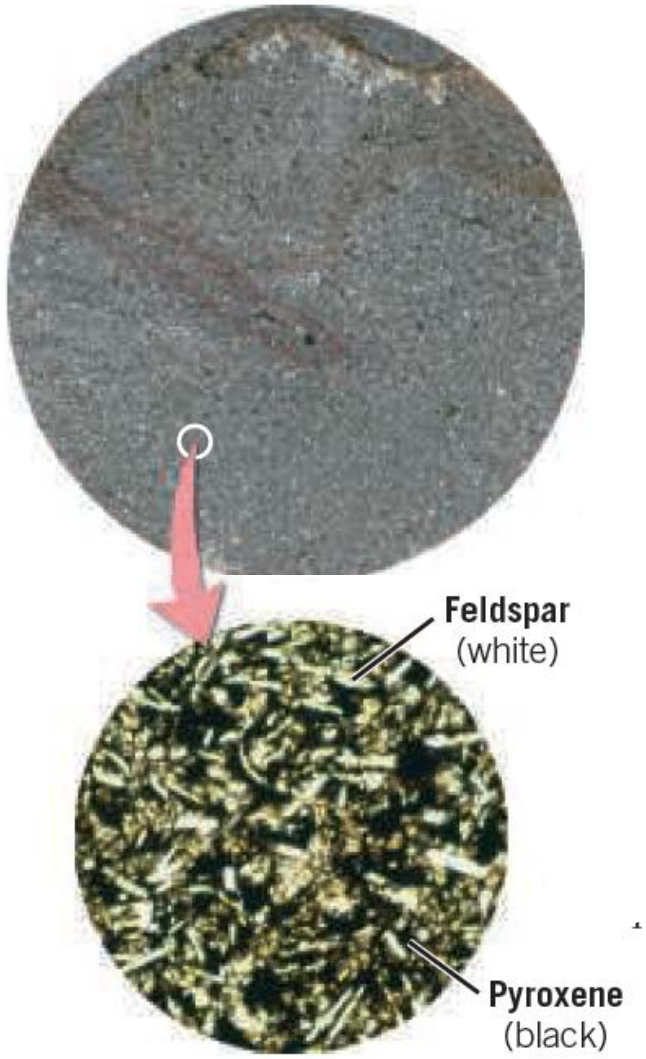
Basaltic rocks *make up the ocean floor* as well as many of the *volcanic islands* located within the ocean basins.

Basalt also forms *extensive lava flows on the continents.*

Granitic (felsic) versus basaltic (mafic) compositions



A. Granite is a felsic, coarse-grained igneous rock composed of light-colored silicates—quartz and potassium feldspar.



B. Basalt is a fine-grained mafic igneous rock containing substantial amounts of dark colored silicates and plagioclase feldspar.

Tarbuck & Lutgens 1917.

Andesitic, or **intermediate composition**,

Rocks with a composition between granitic and basaltic rocks.

Contain at least 25 percent dark silicate minerals, mainly amphibole, pyroxene, and biotite mica, with the other dominant mineral being plagioclase feldspar.

Is often associated with volcanic activity on the seaward margins of the continents and

on volcanic island arcs.

Ultramafic rocks (peridotit)

Contains mostly olivine and pyroxene and thus falls on the opposite side of the compositional spectrum from granitic rocks.

Although ultramafic rocks are rare at Earth's surface, peridotite is the main constituent of the upper mantle.

Igneous Textures: What Can They Tell Us?

Texture: the overall appearance of a rock based on the *size, shape, and arrangement* of its mineral grains.

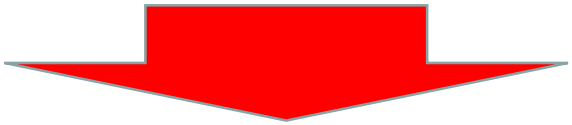
- Texture reveals a great deal about the *environment in which the rock formed.*
- **Three factors influence the textures of igneous rocks**:

1) the dominant factor: the rate at which molten rock cools.

2) The amount of silica present in the magma

3) The amount of dissolved gases in the magma.

A very large magma body located many kilometers beneath Earth's surface **will cool very slowly** over a period of perhaps tens of thousands to millions of years.
Initially, relatively few crystal nuclei form. Slow cooling permits ions to migrate freely until they eventually join one of the existing crystals.



Consequently, **slow cooling promotes the growth of fewer but larger crystals.**

When cooling occurs **rapidly** the ions quickly lose their mobility and readily combine to form crystals.
Numerous embryonic nuclei develops, all of which compete for the available ions.



The result is **a solid mass of many tiny intergrown crystals.**

Aphanitic texture

- (*a:* not, *phaner:* visible).
- The crystals are so small that individual minerals can be distinguished only with the aid of a microscope.



Phaneritic (Coarse-Grained) Texture

When magma slowly crystallize at great depth, the igneous rocks exhibit a **coarse-grained texture** described as **phaneritic** (*phaner:* visible).

Coarse-grained rocks consist of a mass of intergrown crystals that are roughly equal in size and large enough to distinguish the individual minerals without the aid of a microscope.



Porphyritic Texture

Different minerals crystallize under different temperatures and pressure. It is possible for crystals of one mineral to become quite large before others even begin to form.

If molten rock containing some large crystals moves to a different environment (by erupting at the surface) the remaining liquid portion of the lava cools more quickly. The resulting rock, which has large crystals embedded in a matrix of smaller crystals.

The large crystals in porphyritic rocks are referred to as **phenocrysts** (*pheno:* show, *crys* whereas the matrix of smaller crystals is called **groundmass**.

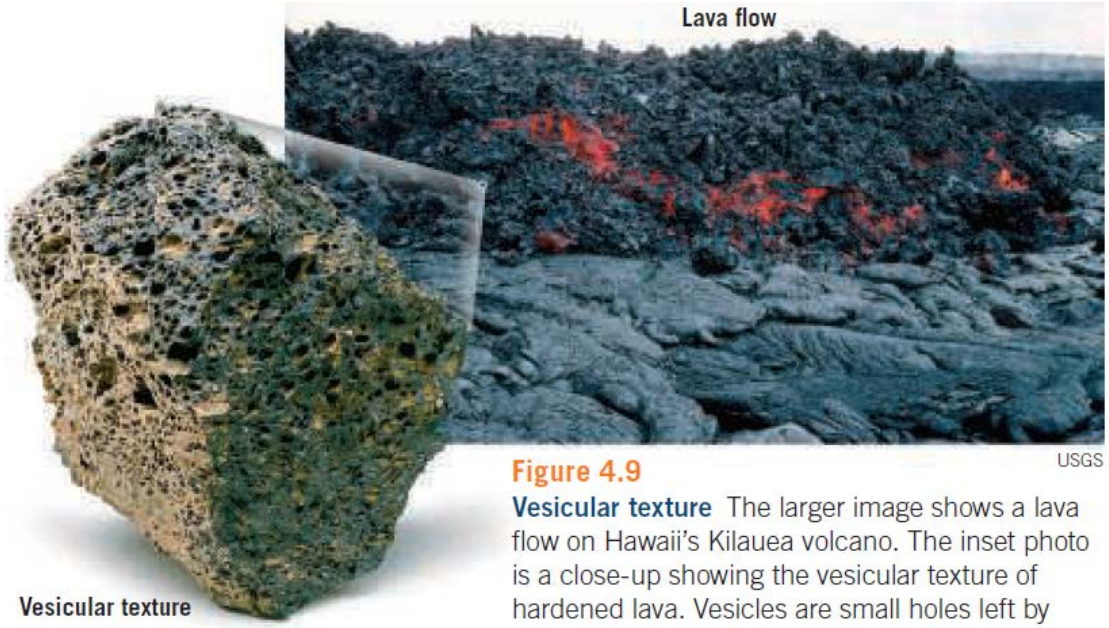


Vesicular Texture

Common features of many extrusive rocks are the voids left by gas bubbles that escape as lava solidifies.

These nearly spherical openings are called *vesicles.*

Rocks that exhibit a vesicular texture often form in the upper zone of a lava flow, where cooling occurs rapidly enough to preserve the openings produced by the expandin



USGS

Figure 4.9
Vesicular texture The larger image shows a lava flow on Hawaii's Kilauea volcano. The inset photo is a close-up showing the vesicular texture of hardened lava. Vesicles are small holes left by escaping gas bubbles. (Inset photo by E. J. Tarbuck)





The vesicular (and also glassy) igneous rock floats in water because they contain numerous vesicles.

Glassy Texture

During some volcanic eruptions, molten rock is ejected into the atmosphere, where it cools very quickly. Rapid cooling of this type may generate rocks having a **glassy texture**. Glass results when unordered ions are “frozen in place” before they are able to unite into an orderly crystalline structure.

Obsidian, a common type of natural glass.





Pyroclastic (Fragmental) Texture

Is formed from the consolidation of individual rock fragments ejected during explosive volcanic.

Because pyroclastic rocks are made of individual particles or fragments rather than interlocking crystals, their textures often resemble those exhibited by sedimentary rocks rather than those associated with igneous rocks.

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Formation of pyroclastic rocks



Pyroclastic rocks are the product of explosive eruptions. These volcanic fragments may eventually consolidate to become rocks displaying a pyroclastic texture.

Pegmatitic Texture

Exceptionally coarse-grained igneous rocks. Most of the crystals **are larger than 1 centimeter** in diameter.

They occur as small masses around the margins of large intrusive igneous bodies.

Form late in the crystallization of a magma, when water and carbon dioxide, chlorine, and fluorine, make up an unusually high percentage of the melt. Because ion migration is enhanced in these **fluid-rich environments**, the crystals that form are abnormally large.

The large crystals in pegmatites do not result from inordinately long cooling histories; rather, they are the consequence of a fluid-rich environment that enhances crystallization.



Magmatic rocks



Gabbro



Diorite



Granite

INTRUSIVE ROCKS



Basalt



Andesite



Rhyolite

VOLCANIC (EXTRUSIVE) ROCKS

What Textures Can They Tell Us?



A. Glassy texture
Composed of unordered atoms and resembles dark manufactured glass. (Obsidian is a natural glass that usually forms when highly silica-rich magmas solidify.)



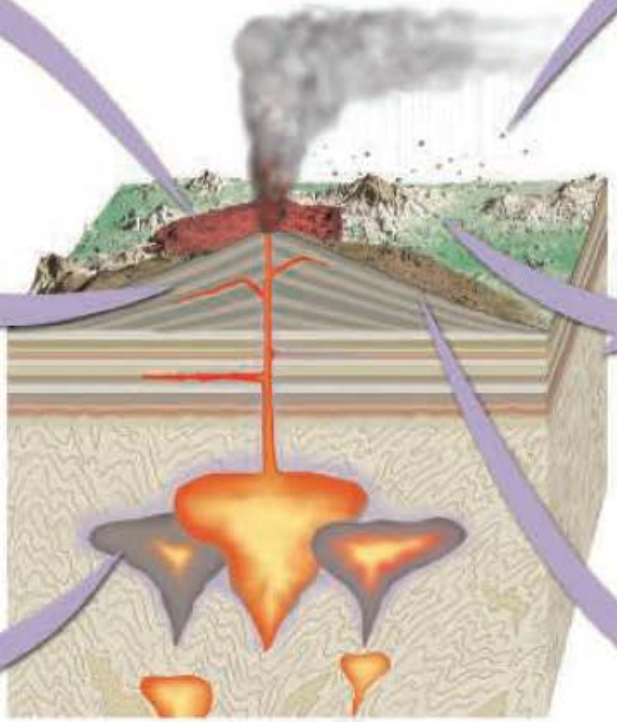
D. Vesicular texture
Extrusive rock containing voids left by gas bubbles that escape as lava solidifies. (Pumice is a frothy volcanic glass that displays a vesicular texture.)



B. Porphyritic texture
Composed of two distinctly different crystal sizes.



E. Pyroclastic (fragmental) texture
Produced by the consolidation of fragments that may include ash, once molten blobs, or large angular blocks that were ejected during an explosive volcanic eruption.

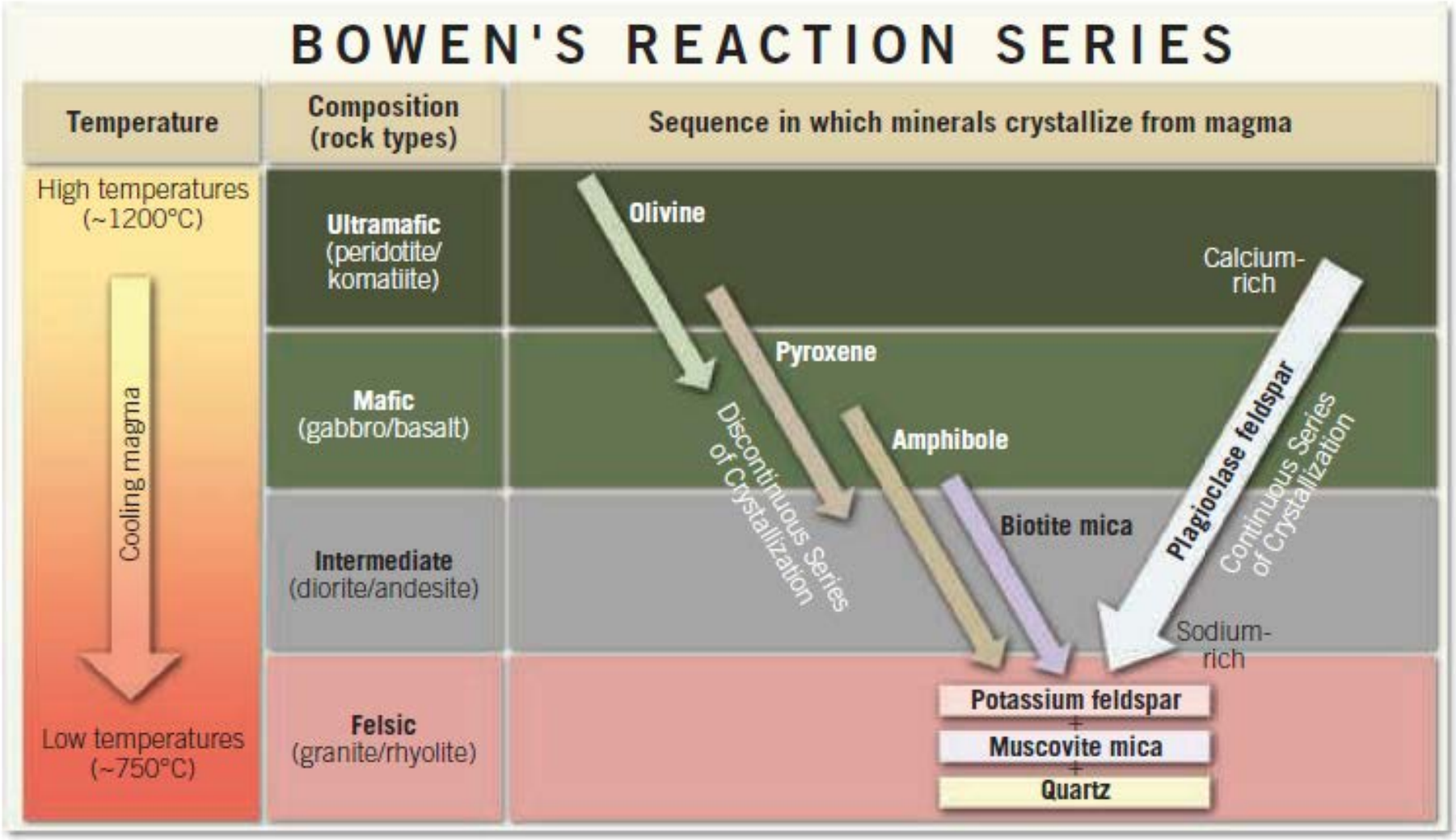




C. Phaneritic (coarse-grained) texture
Composed of mineral grains that are large enough to be identified without a microscope.



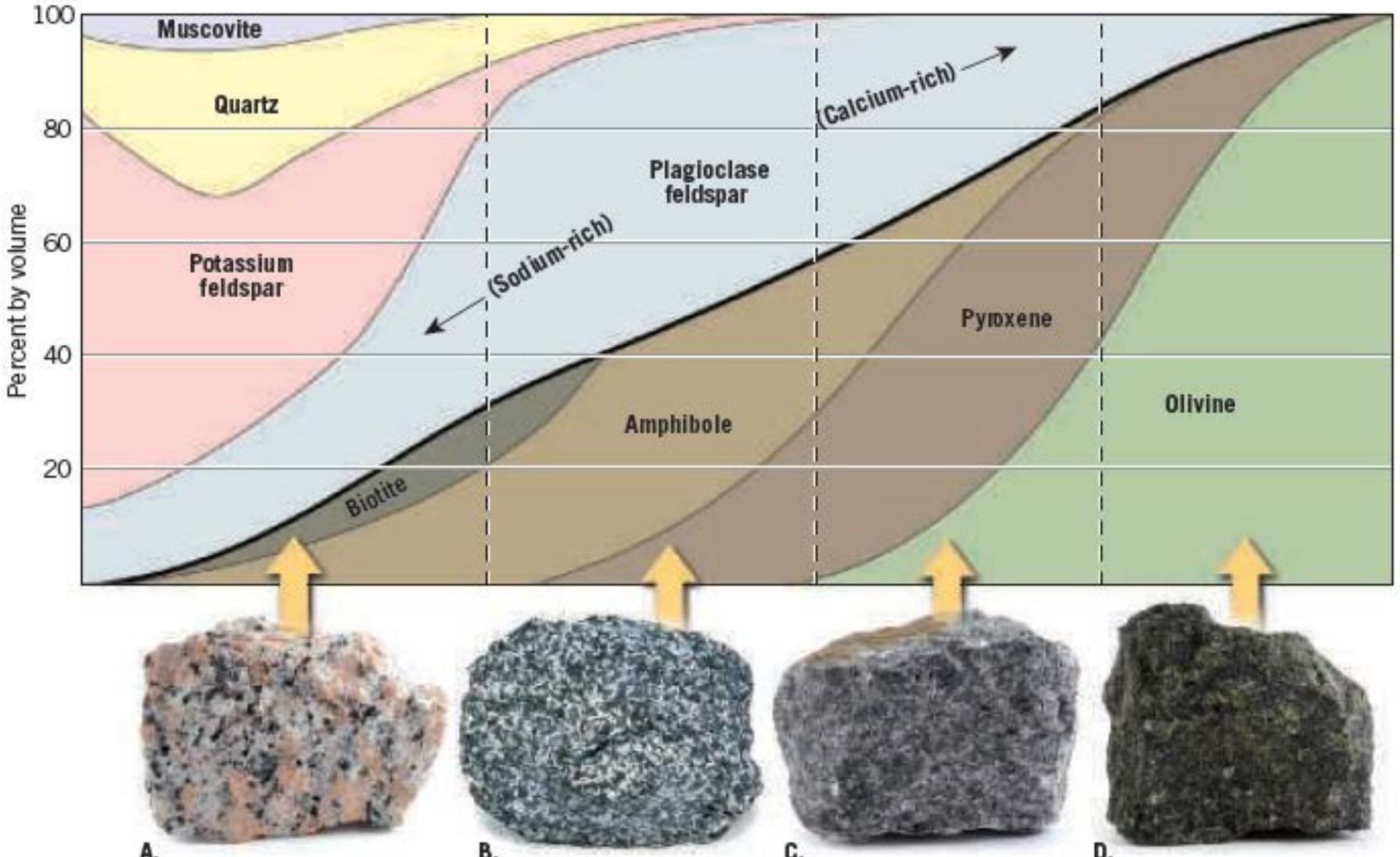
F. Aphanitic (fine-grained) texture
Composed of crystals that are too small for the individual minerals to be identified without a microscope.



This diagram shows the sequence in which minerals crystallize from a mafic magma.

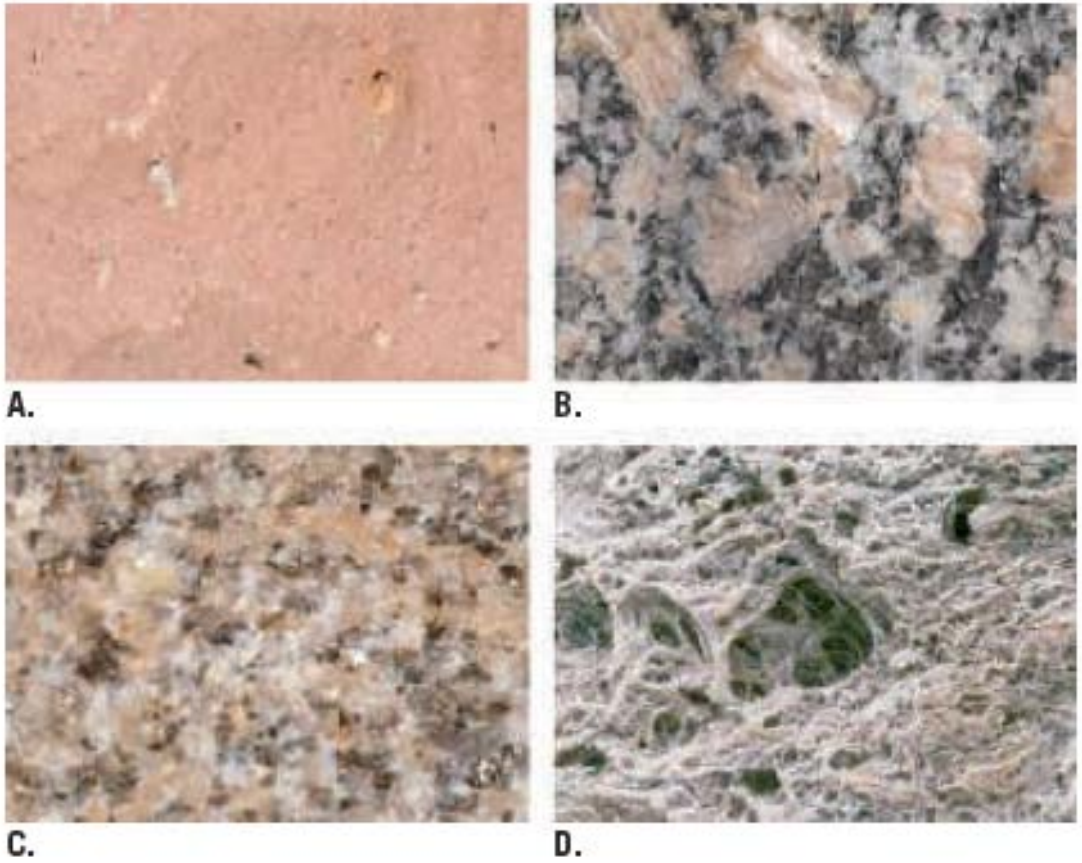
Each rock group consists of minerals that crystallize in the same temperature range.

Questions



Describe igneous rocks having the compositions of samples A and D, using terms such as mafic, felsic, etc. Would you ever expect to find quartz and olivine in the same rock? Why or why not?

Task



Apply your understanding of igneous rock textures to describe the cooling history of each of the igneous rocks pictured here.

Identify the igneous rock textures described by each of the following statements!

- **a.** Openings produced by escaping gases
- **b.** The texture of obsidian
- **c.** A matrix of fine crystals surrounding phenocrysts
- **d.** Consists of crystals that are too small to be seen without a
- microscope
- **e.** A texture characterized by rock fragments welded together
- **f.** Coarse grained, with crystals of roughly equal size
- **g.** Exceptionally large crystals, most exceeding 1 centimeter in
- diameter