UNIT - 3

PETROLOGY

PETROLOGY

Define Petrology

Petrology means "STUDY OF ROCKS"

Petro = Rock

Logy = Study

The branch of geology deals with the various aspects of rocks such as, Origin, Association, Occurrence, Mineral composition, Chemical composition, Texture, Structure, Physical properties of rocks.

PETROLOGY

Define Rock

Rock or stone is a natural substance, a solid aggregate of one or more minerals combined together in an orderly manner.

Petrography deals with the descriptive part of rocks.

Petrogeny deals with the mode of formation of rocks.

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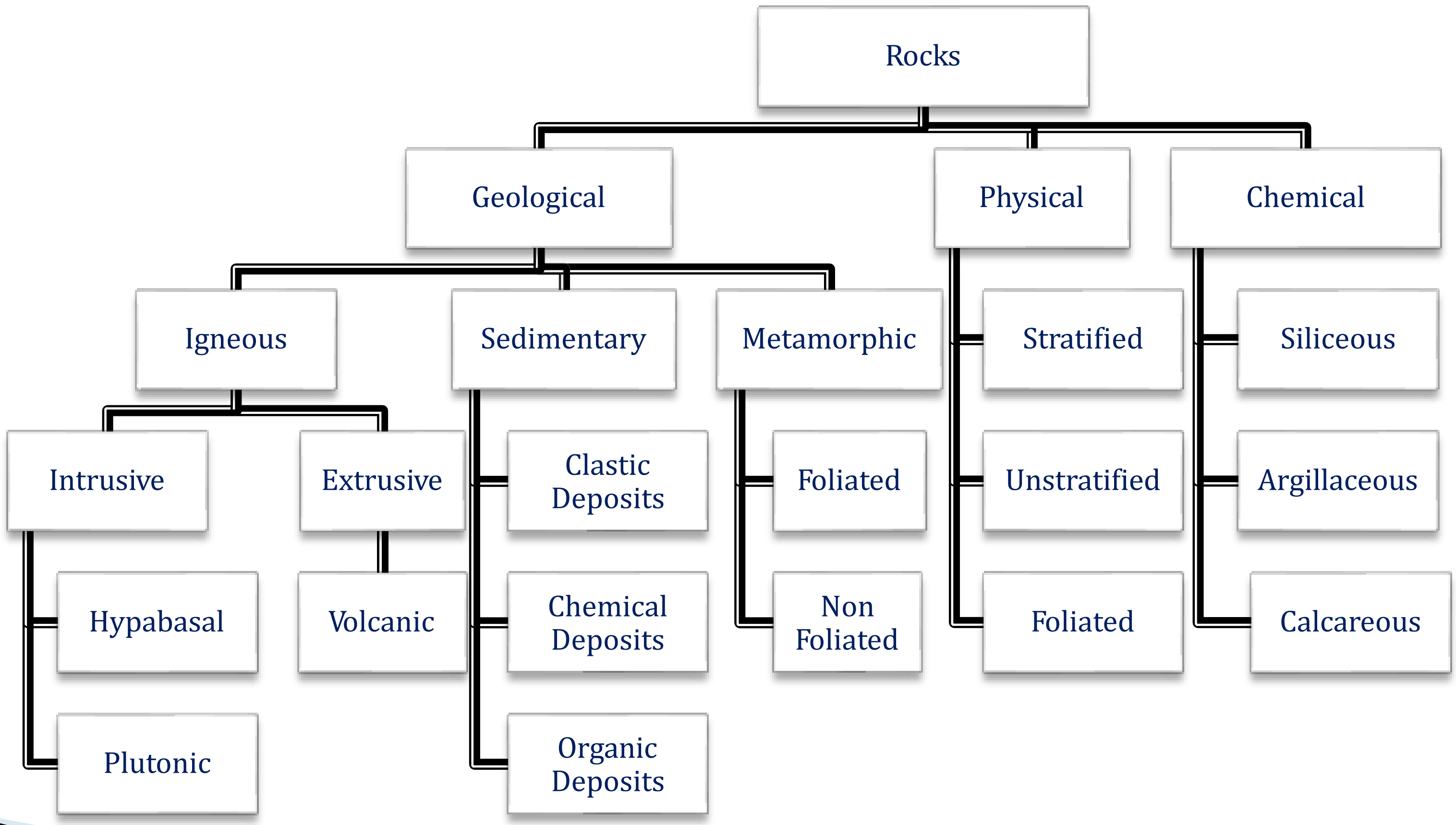
Classification of Rocks



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Igneous Rock

Igneous rocks are the primary rocks, which are formed due to cooling and solidification of magma.

Magma is a hot viscous, siliceous melt, containing water vapour and gases.

Magma comes out from the greater depth below the earth surface, such magma is called LAVA.

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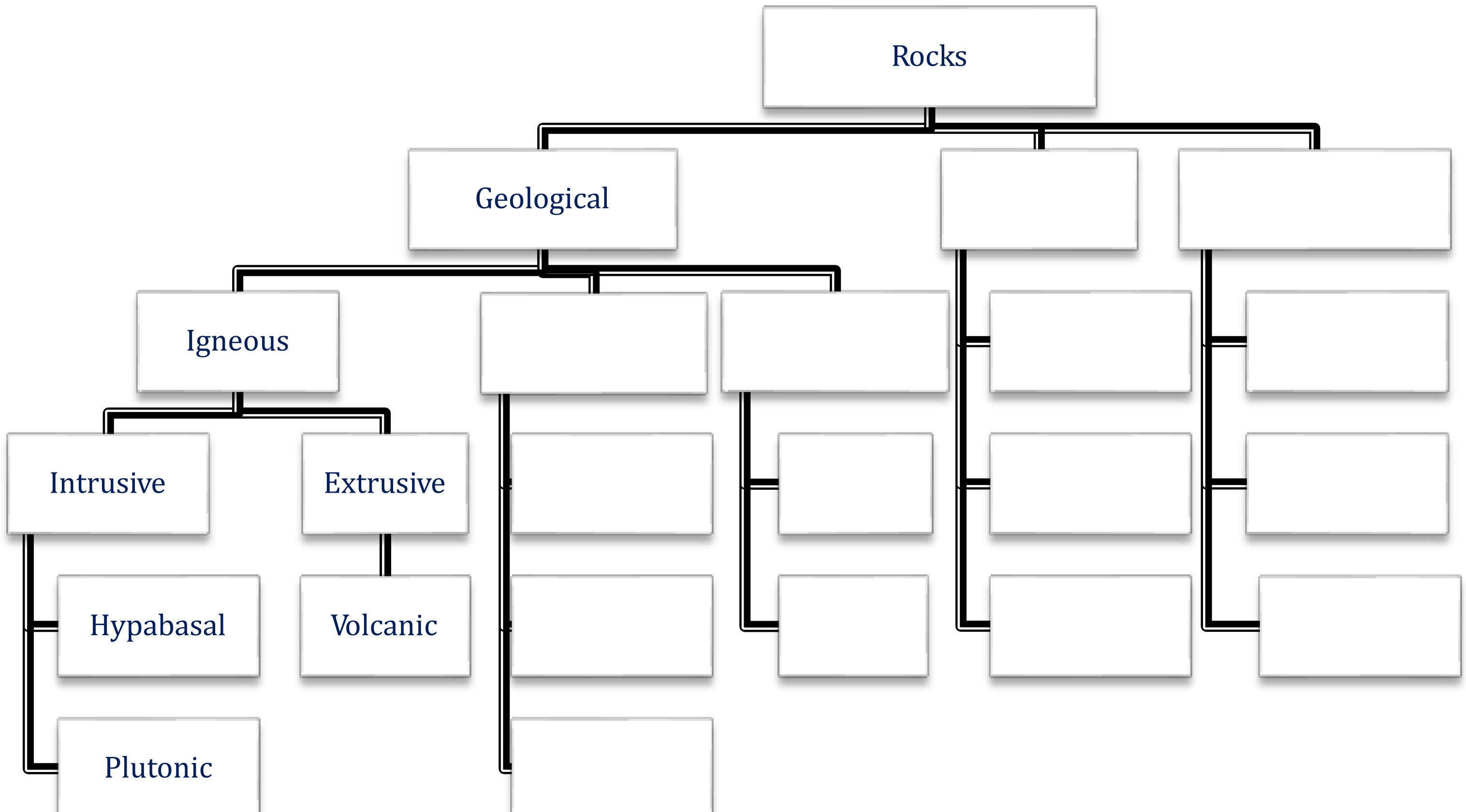
Classification of Igneous Rock



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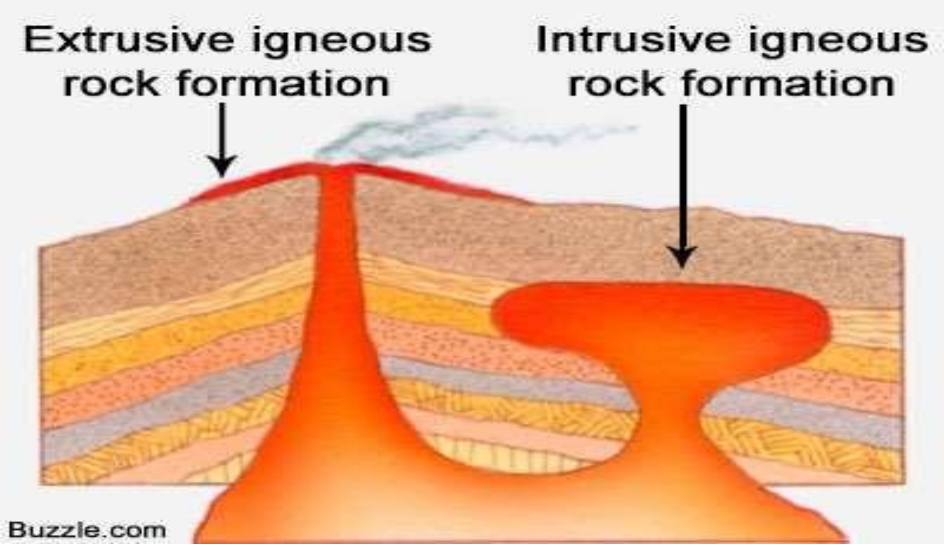

Igneous Rock

Intrusive igneous rocks

Intrusive igneous rocks are formed from magma that cools and solidifies within the crust of a planet, surrounded by pre-existing rock (called country rock).

The magma cools slowly and, as a result, these rocks are coarse-grained. The mineral grains in such rocks can generally be identified with the naked eye.

Intrusive Igneous Rock

Diorite

Granite

Intrusive Igneous Rock

Gabbro

Pegmatite

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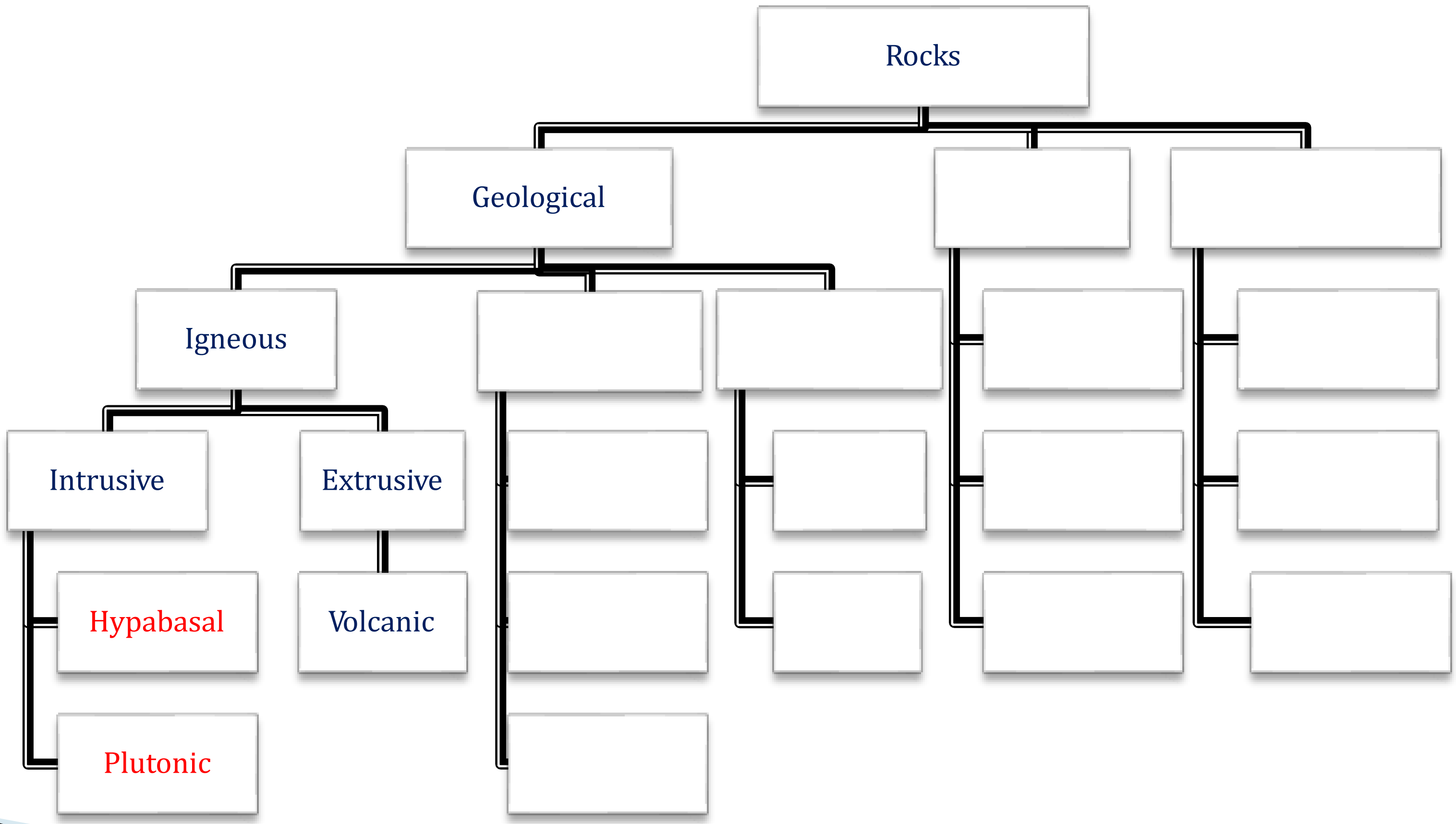
Classification of Igneous Rock



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Igneous Rock

Intrusive igneous rocks

Hypabasel Rock

These Rocks are formed at intermediate depth generally up to 2 km below the earth surface and exhibits mixed characteristics of volcanic and plutonic.

Intrusive Igneous Rock
Hypabasel Rock

Diorite

PETROLOGY

Igneous Rock

Intrusive igneous rocks

Plutonic Rock

These Rocks are formed at considerable depth generally up to 7-10 km below the earth surface. Because of very slow rate of cooling at these depth coarse grained rocks are formed.

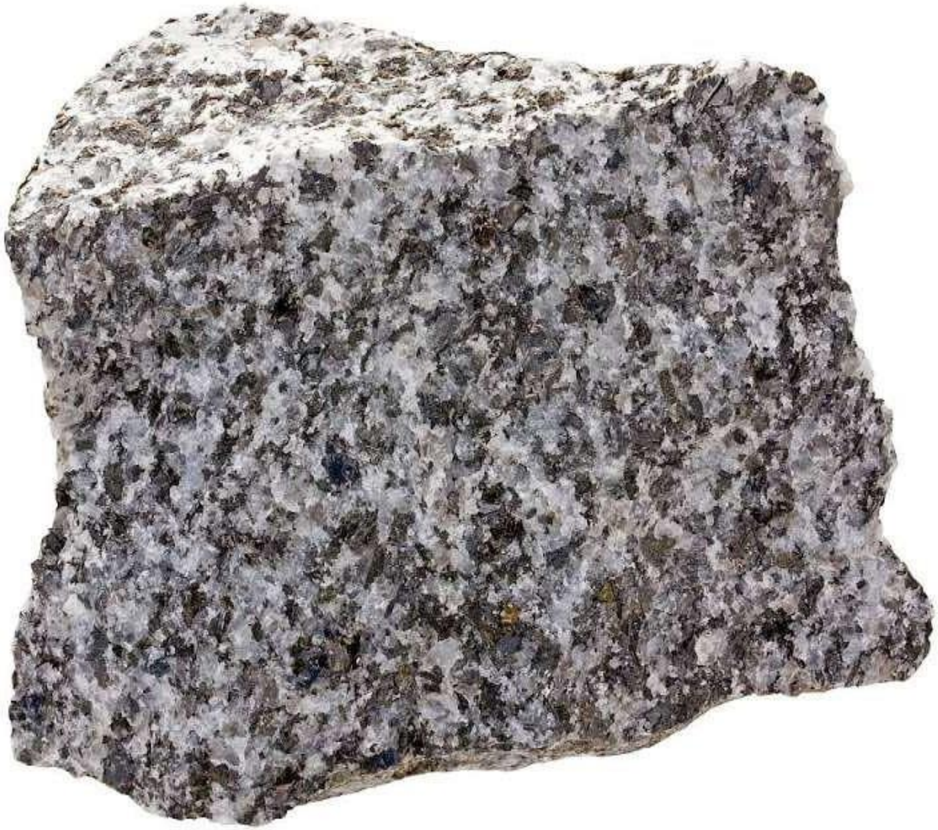
Intrusive Igneous Rock
Plutonic Rocks

Gabbro

Pegmatite

Intrusive Igneous Rock

Plutonic Rocks
Gabbro



Hypabasel Rock
Diorite

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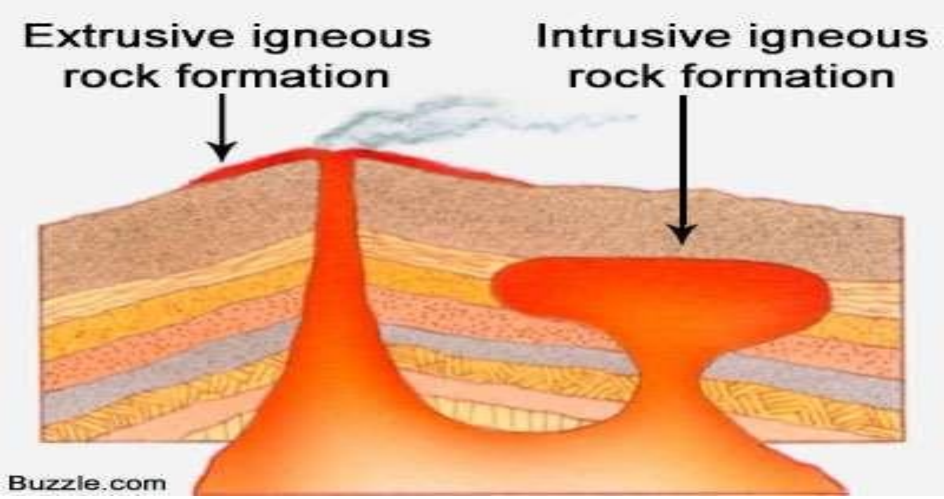

Igneous Rock

Extrusive igneous rocks

It is also called as volcanic rocks. These rocks are formed due to cooling and solidification of magma at the crust surface.

The magma, which is brought to the surface through fissures or volcanic eruptions, solidifies at a faster rate. Hence such rocks are smooth, crystalline and fine-grained.

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Igneous Rock

Extrusive igneous rocks

Volcanic Rocks

These rocks are formed due to cooling and solidification of lava erupted from volcanoes. since lava cools down very fast rate. The grain size of the crystal formed in these rock is fine.

Extrusive Igneous Rock
Volcanic Rock

Volcanic Rock

Extrusive Igneous Rock
Volcanic Rock

Basalt

Igneous Rock

Basalt

Diorite

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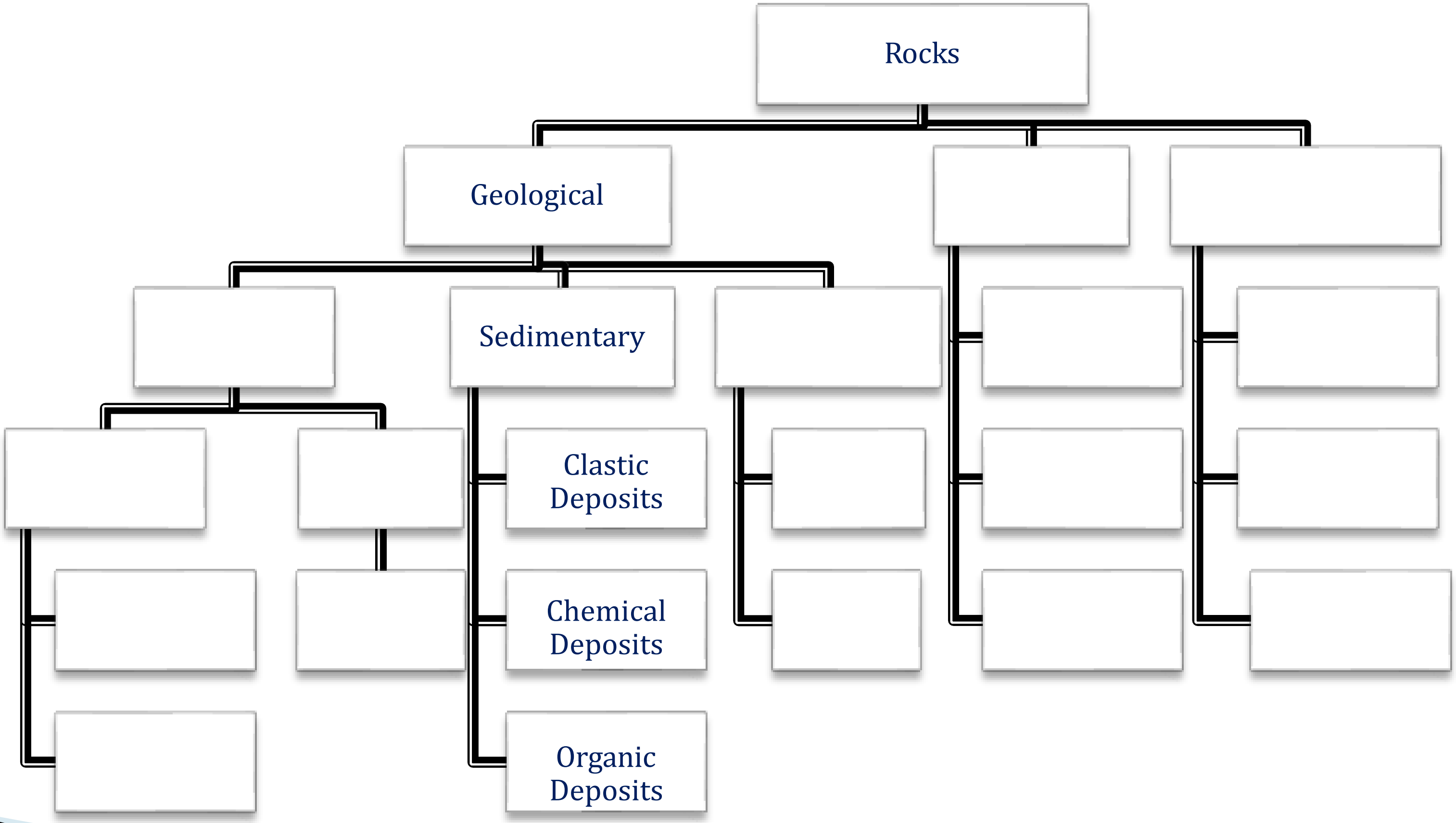
Classification of Rocks



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Sedimentary Rock

Sedimentary rocks are those, which are formed by the accumulation, compaction and consolidation of sediments. The sediments are the particles produced from the disintegration of pre-existing rocks (Igneous/metamorphic rocks) through the process of transportation and deposition by various natural agencies like wind, water and glaciers .

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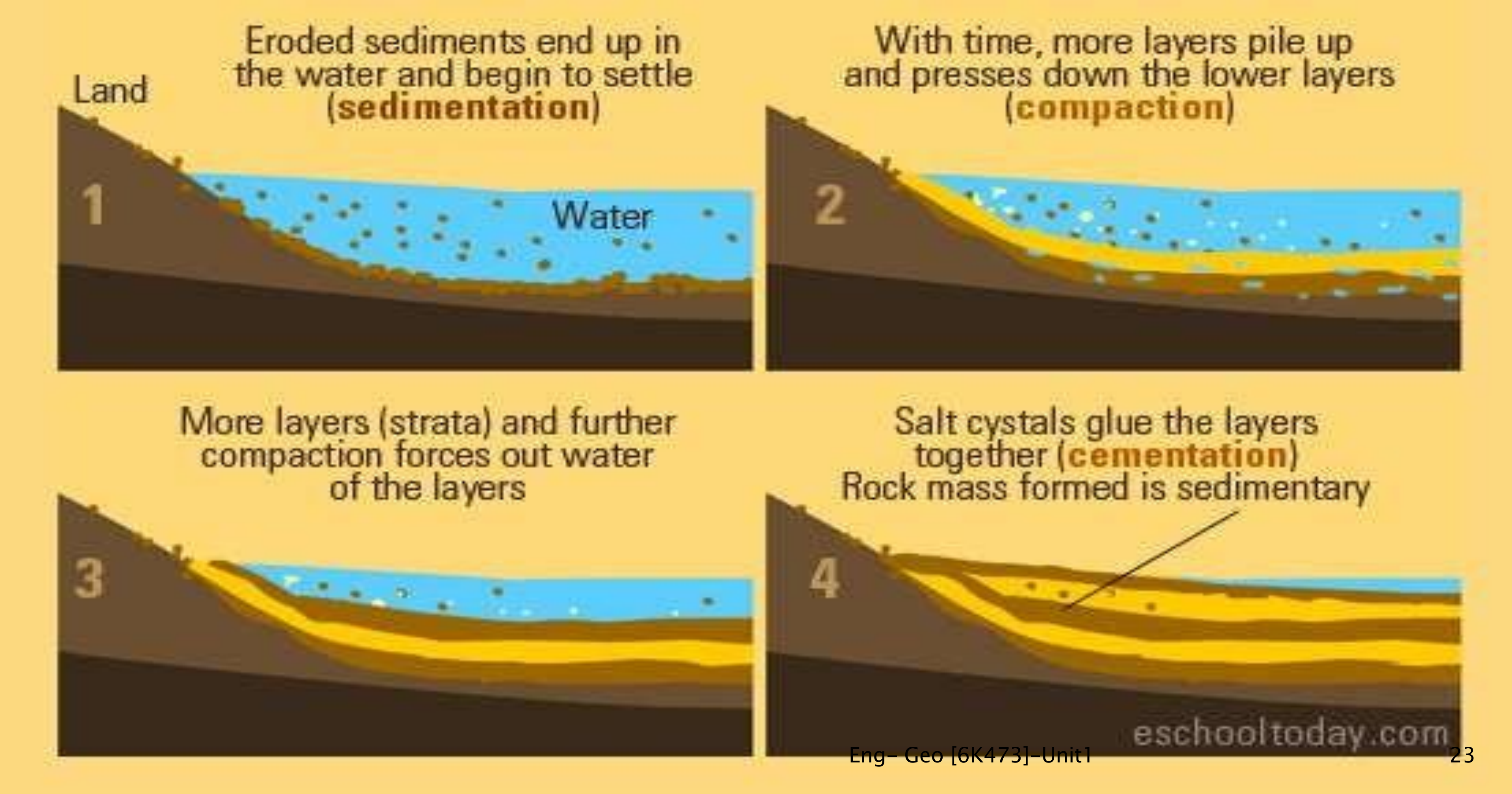
Sedimentary Rock



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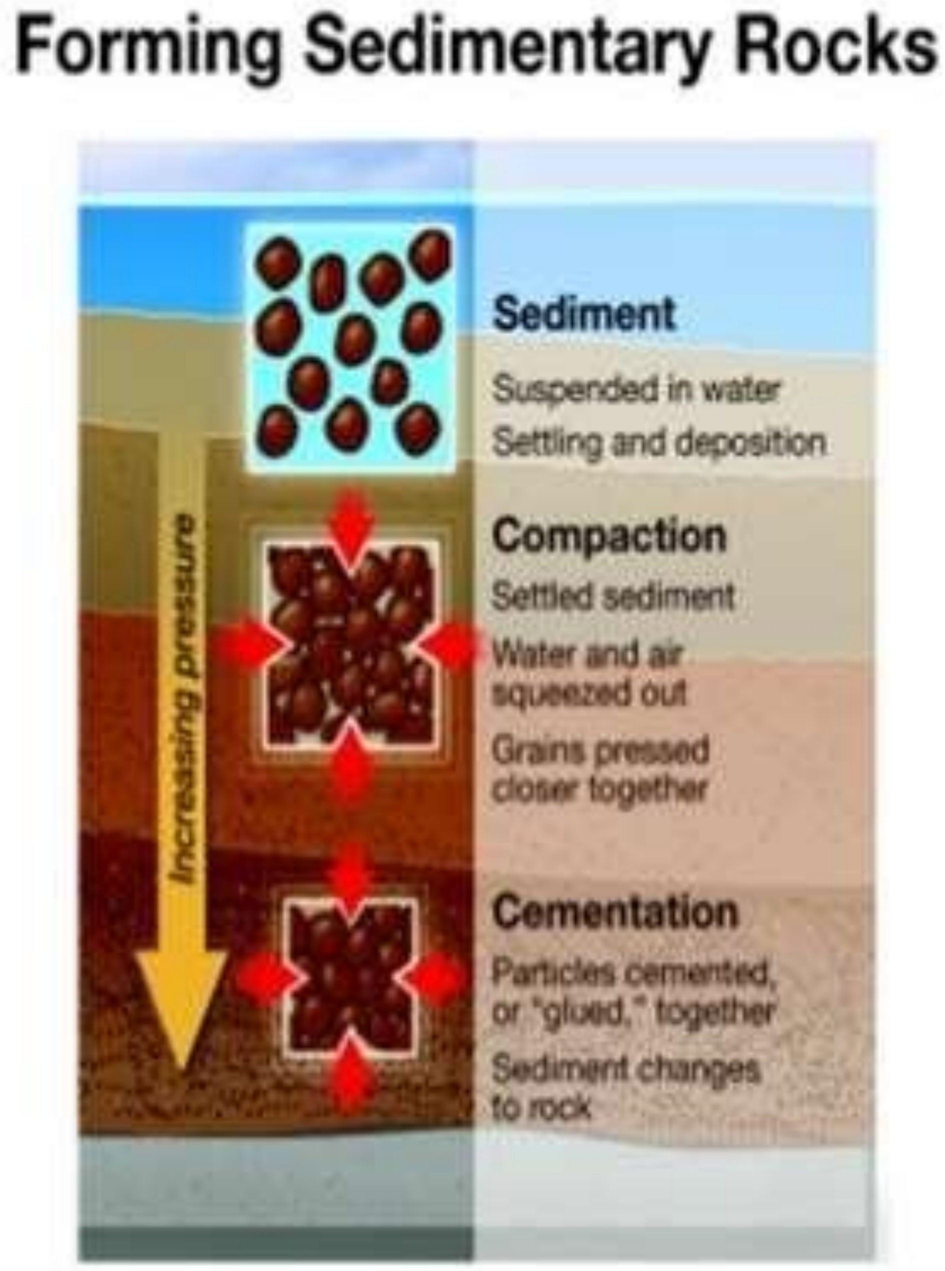
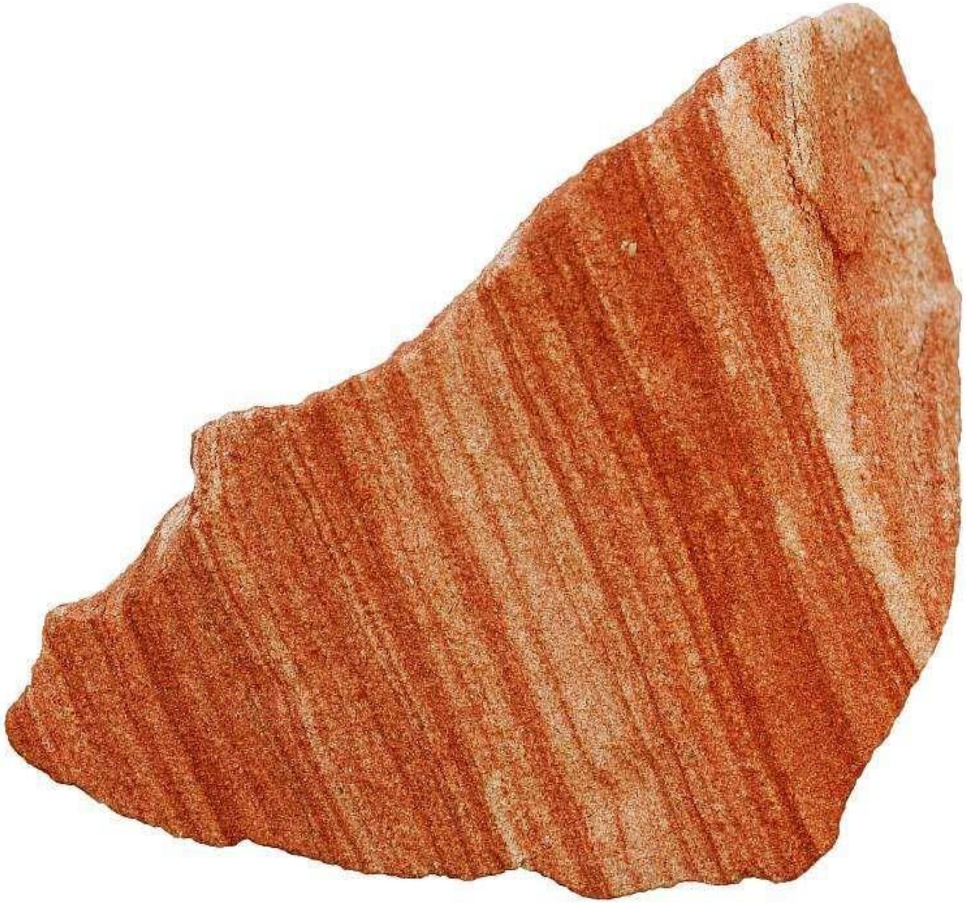
Sedimentary Rock



Sedimentary Rock



Sand Stone

Conglomerate

Sedimentary Rock

shale

Lime stone

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Sedimentary Rock

Clastic deposit rock

They are mechanically formed rocks. These are formed due to the process of weathering, erosion, transportation and deposition of pre-existing rocks.

Rudaceous rocks-If the grain size are more than 2 mm in dia,

Arenaceous rocks-If the grain size is in between 1 and 2 mm.

Argillaceous rocks-If the size of the particle is < 1mm in dia,

Sedimentary Rock

Clastic Deposit [Rudaceous rocks]

Conglomerate

Breccia

Sedimentary Rock

Clastic Deposit [Arenaceous rocks]

Quartz Sand stone

Grit

Sedimentary Rock

Clastic Deposit [Argillaceous rocks]

Shale and Mud stone

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Sedimentary Rock

Chemical deposit rock

They are formed by precipitation, evaporation or crystallization from natural aqueous solution.

When water is rich in dissolved salt evaporates and left behind minerals. (Halite)

Limestone can form when calcite minerals dissolved in lakes, sea and underground water comes out of solution and form crystal.

Sedimentary Rock
Chemical Deposit

Lime Stone

Halite

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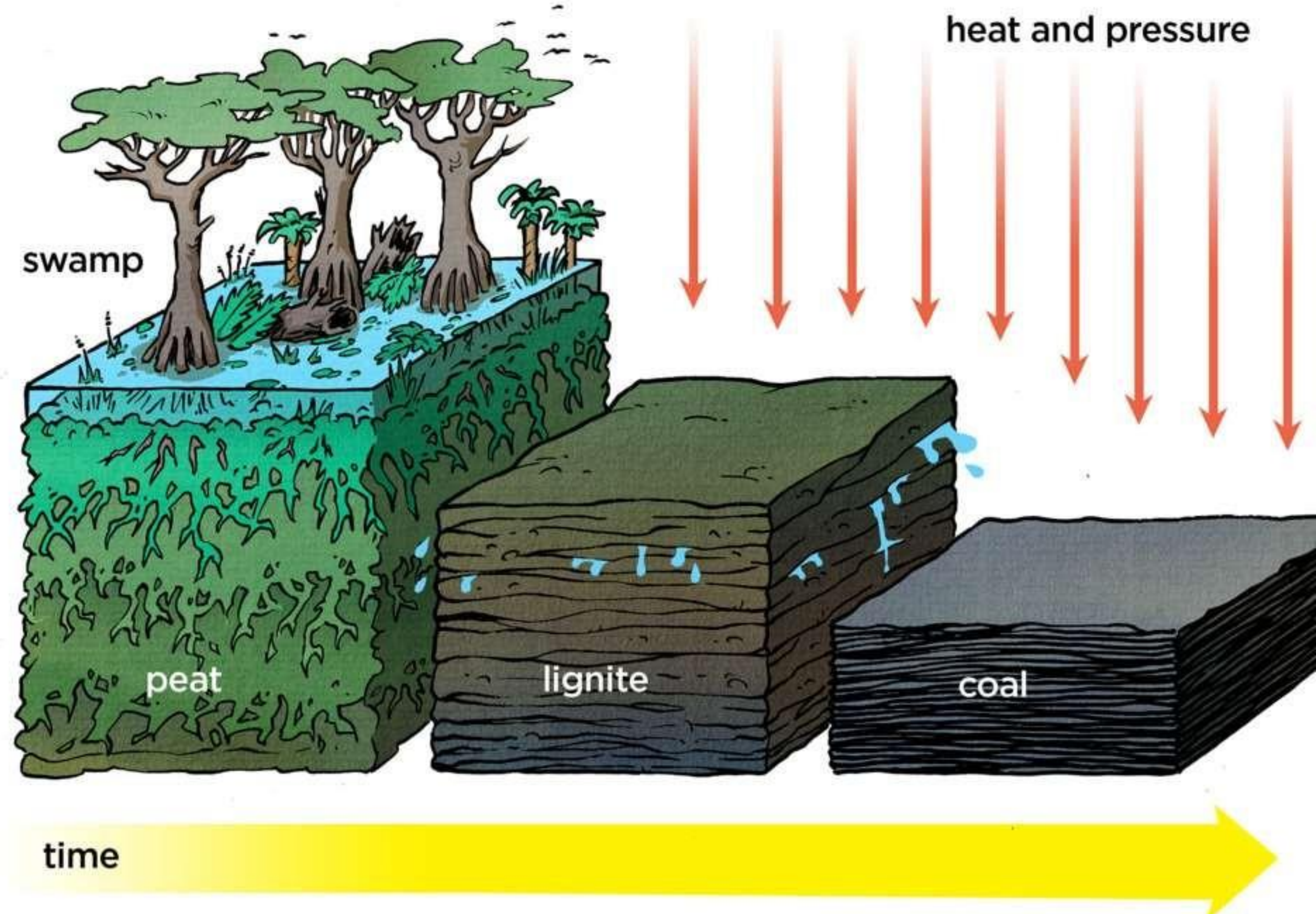
Sedimentary Rock

Organic deposit rock

Sedimentary rocks which are formed exclusively from remains of organisms like plant / animals deposited in a thick layer.


heat and pressure
swamp
peat
lignite
coal
time

Sedimentary Rock
Chemical Deposit

Coal

Lignite

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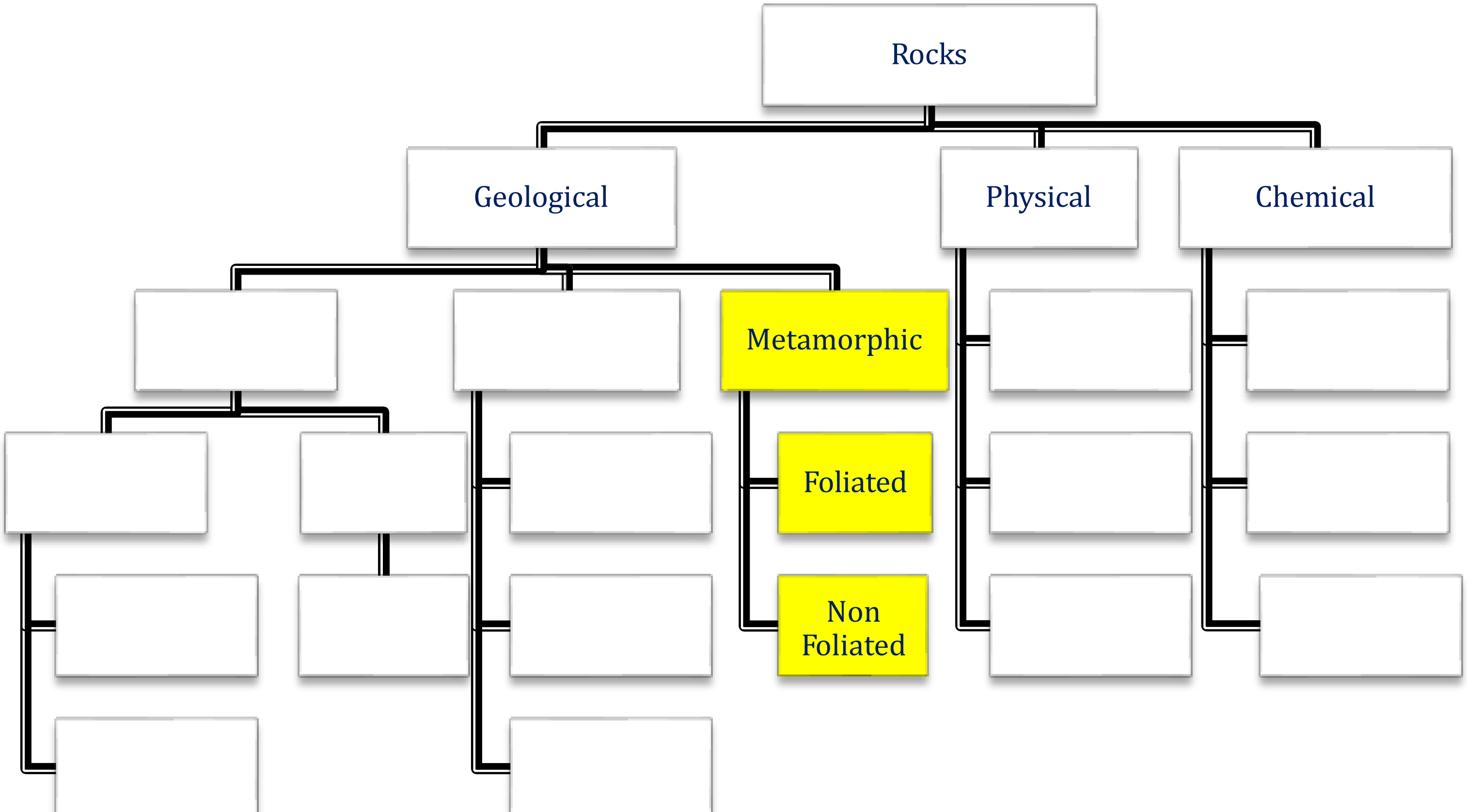
Classification of Rocks



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Metamorphic Rock

The word "Metamorphism" comes from the Greek: Meta = change, Morph = form, so metamorphism means to change form. Metamorphic rocks are those rocks that are formed as a result of transformation that takes place in the pre-existing rocks (Igneous/sedimentary rocks). When the pre-existing rocks are subjected to higher temperature, pressure and chemically active liquids and gases, the minerals present in the original rocks changes to new environmental condition.

Metamorphic Rock

Slate

Slate

Metamorphic Rock

Gneiss

Gneiss

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Metamorphic Rock

Foliated

When pressure squeezes the flat or elongate minerals within a rock so they become aligned. These rocks develop a **platy** or sheet-like structure that reflects the direction that pressure was applied in. **Slate**, **schist**, and **gneiss** are all foliated metamorphic rocks.

Metamorphic Rock
Foliated Rock

Slate

Schist

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Metamorphic Rock

Non Foliated

Non foliated metamorphic rocks are formed around igneous intrusions where the temperatures are high but the pressures are relatively low and equal in all directions

Metamorphic Rock
Non Foliated Rock

White Marble

Marble

Metamorphic Rock

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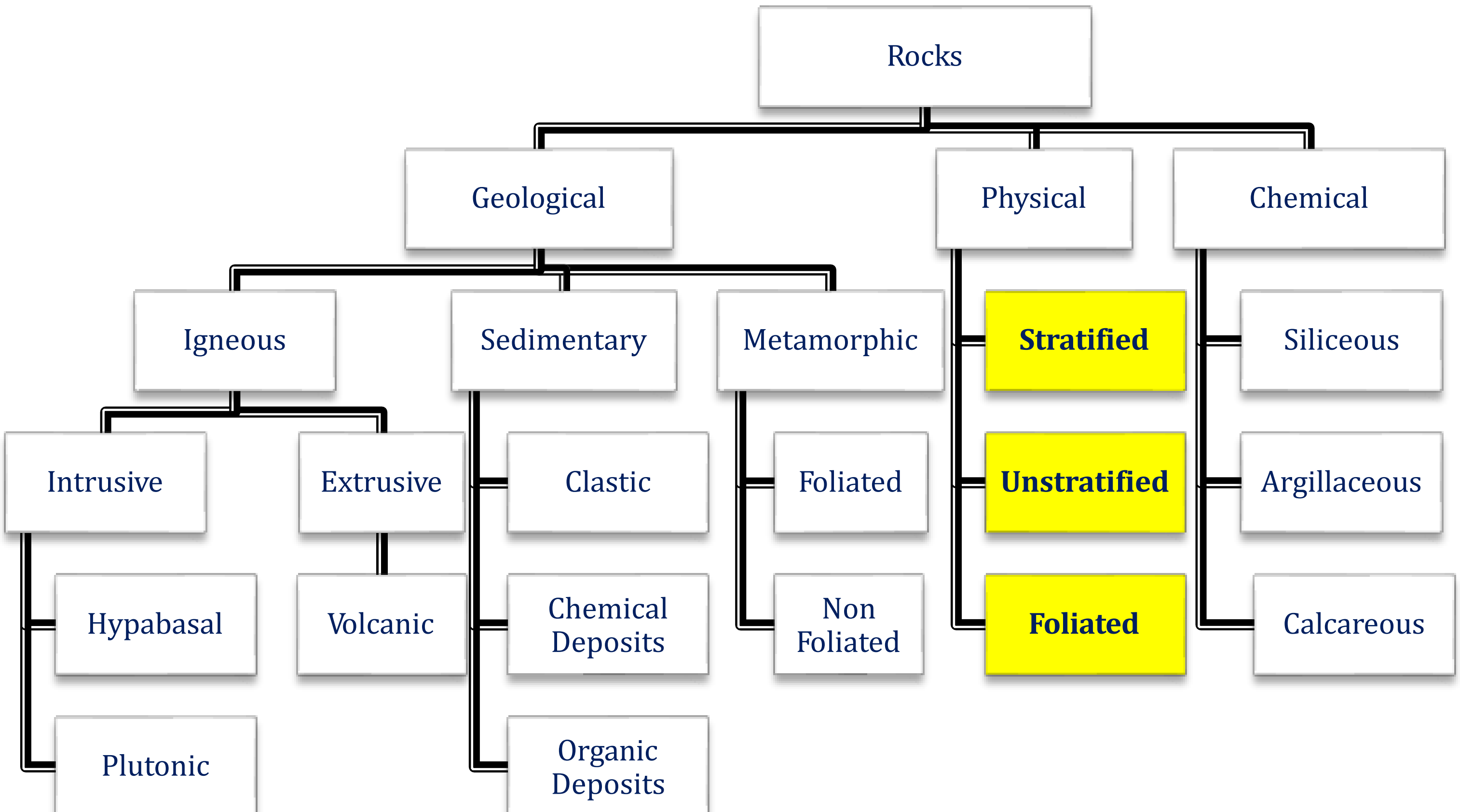
Classification of Rocks



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Physical Classification

Stratified rocks

These rocks are having **layered structure**. They possess planes of stratification or cleavage. They can be easily split along these planes.

Sand stones, lime stones, slate etc.

Physical Classification of Rocks

Stratified Rocks

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Physical Classification

Un-stratified rocks

These rocks are not stratified. They possess crystalline and compact grains. They cannot be split in to thin slab.

Granite, trap, marble etc. are the examples of this type of rocks.

Physical Classification of Rocks

Un Stratified Rocks

Granite

Marble

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Physical Classification

Foliated Rocks

These rocks have a tendency to split along a definite direction only. The direction need not be parallel to each other as in case of stratified rocks. This type of structure is very common in case of metamorphic rocks.

Physical Classification of Rocks

Foliated Rocks

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Chemical Classification

Siliceous rocks

These rocks which have silica as the main constituent.

The silica in the free state is called sand and in combined state is silicate.

Examples: Granite, Quartzite, Sandstone etc.

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Chemical Classification

Argillaceous rocks

These rocks which have clay or alumina as the main constituent.

Examples: Kaolin, Laterite, Slate etc.

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Chemical Classification

Calcareous rocks

These rocks which have calcium carbonate or lime as their leading constituent. These rocks are readily acted upon by even *dilute HCl*.

Examples: Limestone and Marble.

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Forms of Igneous Rock

- Igneous Rocks
  - Intrusive
    - Concordant
      - Sill
      - Phacolith
      - Lopolith
      - Laccolith
    - Discordant
      - Batholith
      - Dyke
      - Volcanic neck
  - Extrusive

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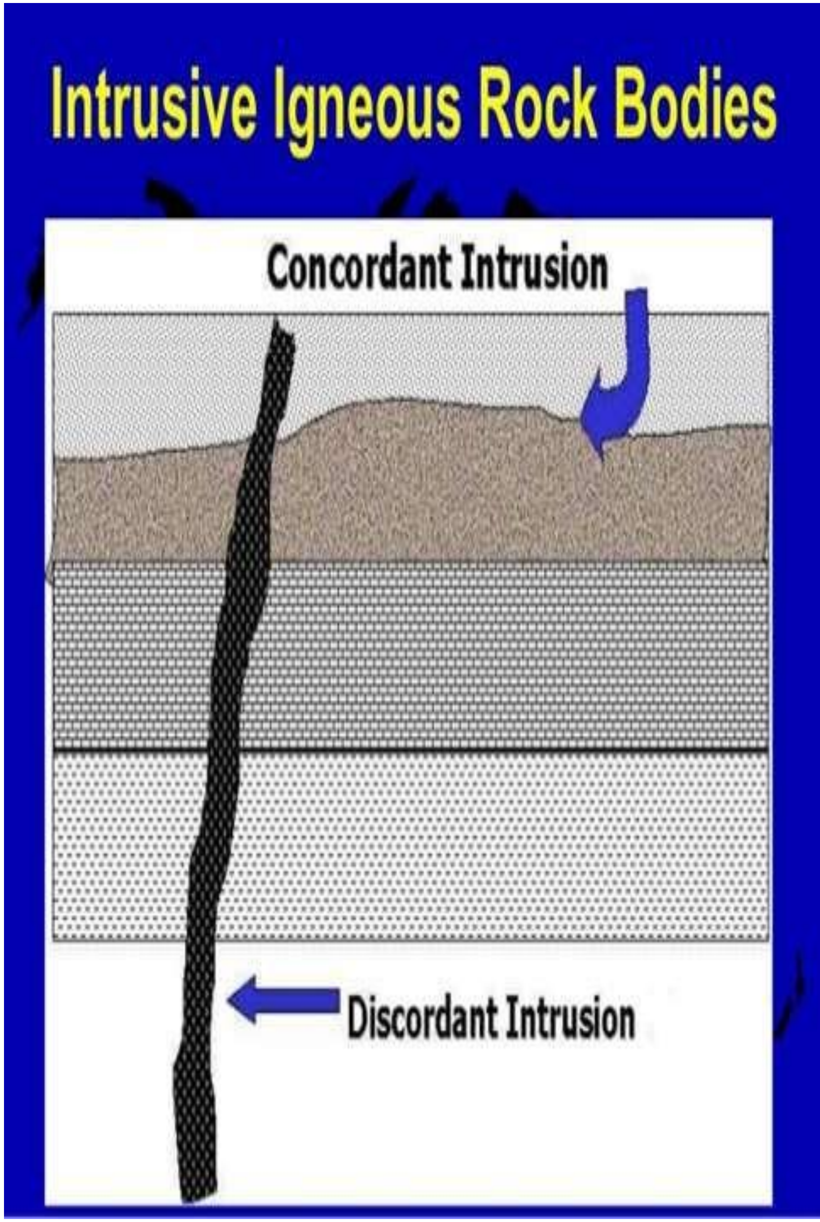
Forms of Igneous Rock

Concordant intrusive bodies

The magma intrusion is parallel to the structure of the country rock, they are called ‘Concordant intrusive bodies



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Forms of Igneous Rock

Concordant intrusive bodies

Sill

It is a concordant intrusive igneous bodies. Sills are formed due to the penetration of magma into bedding planes of enclosing sedimentary rock. Their spreading capacity is mainly depends upon viscosity of magma, its temperature and the weight of overlaying rocks. The thickness varies from few centimetres to several kilometres.

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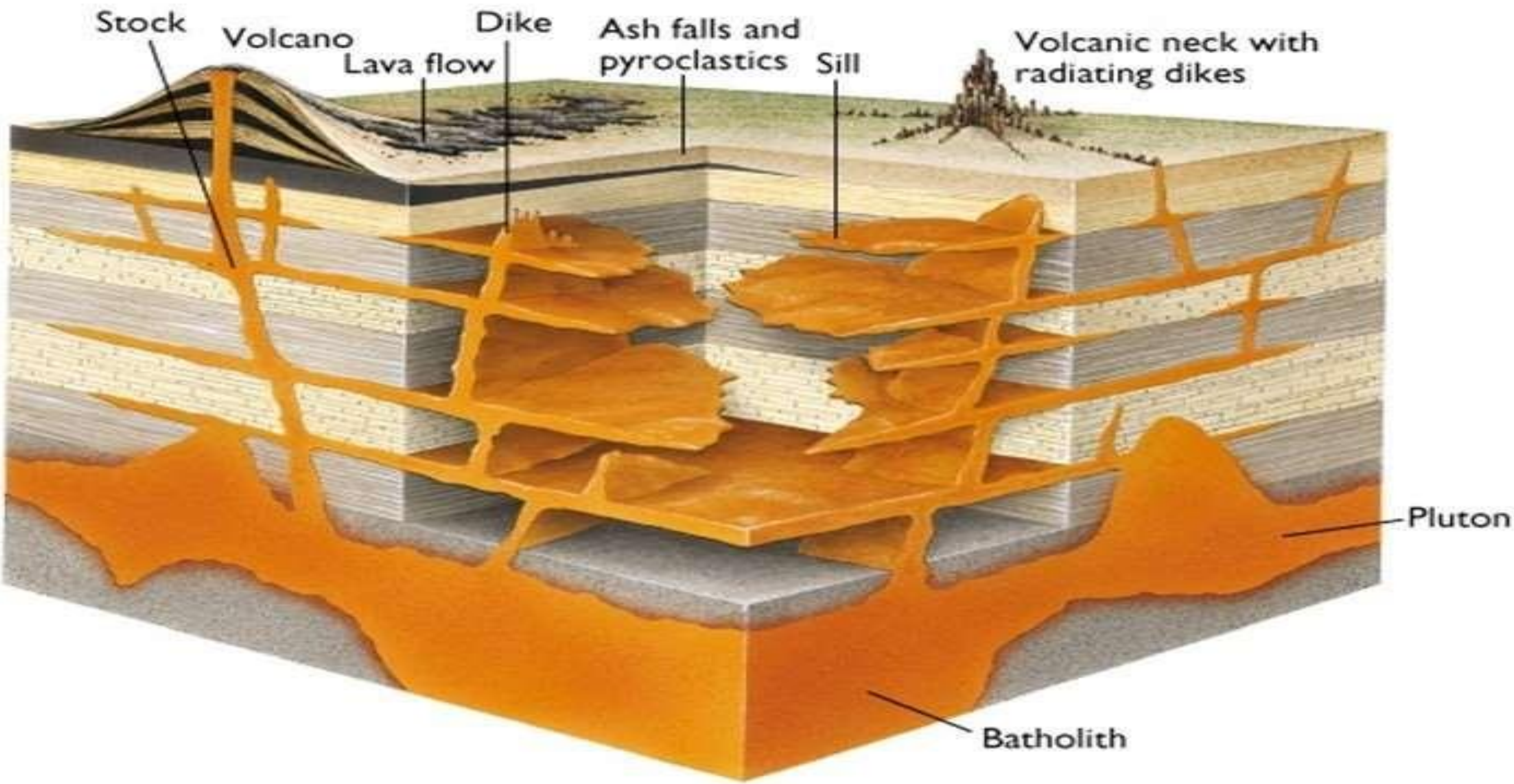
Sill



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Forms of Igneous Rock

Concordant intrusive bodies

Phacolith

When thick sedimentary strata are folded, along the crust and trough, some empty space occurs. These spaces are readily occupied if magmatic intrusion get access to them.

On solidification these appear as lens shaped across the axial plane.

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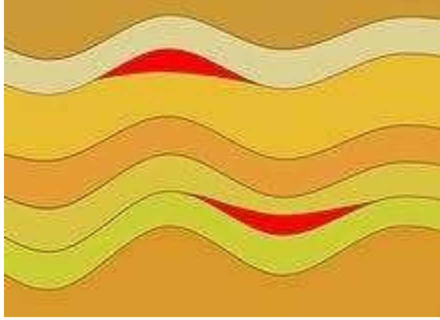
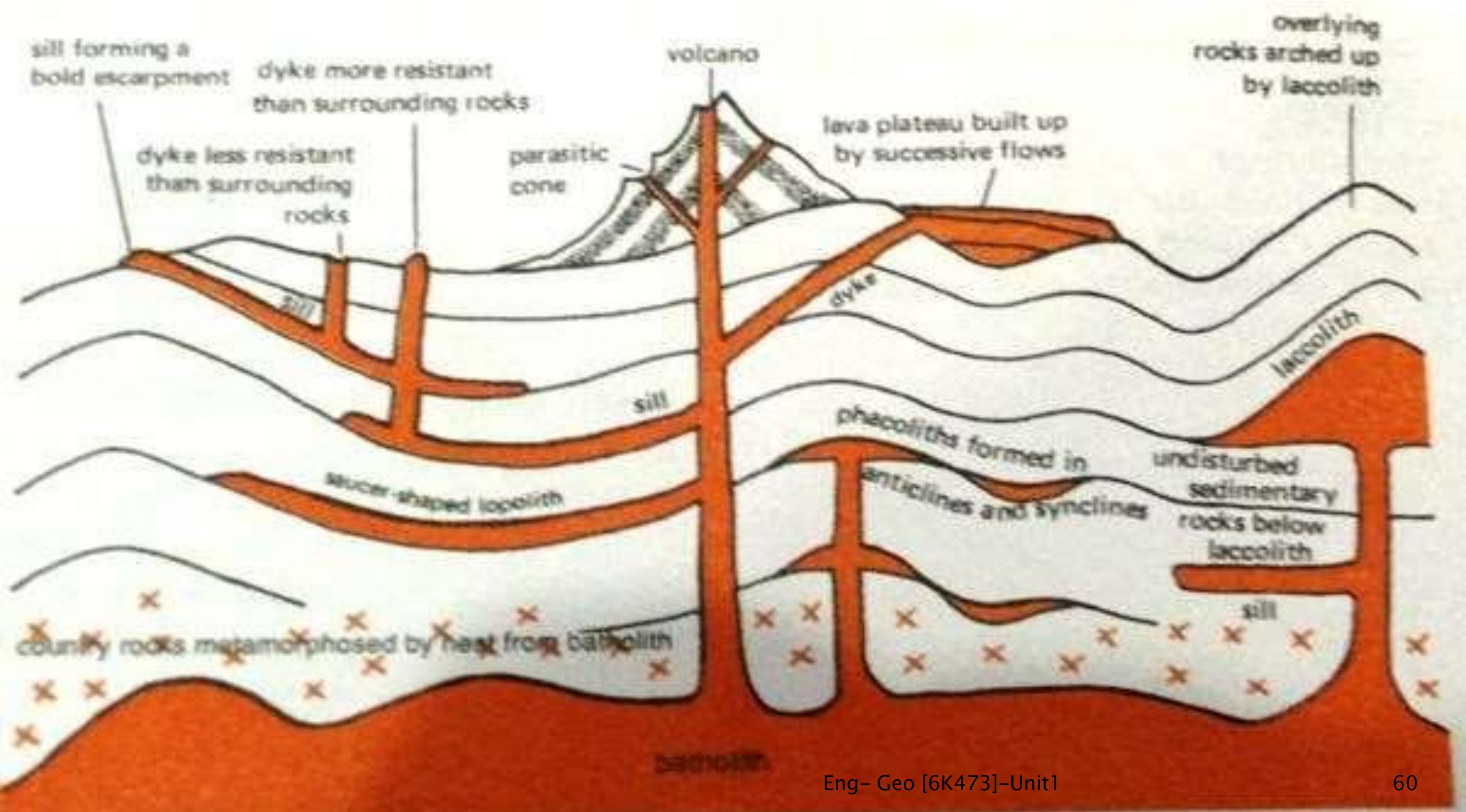


Phacolith



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Forms of Igneous Rock

Concordant intrusive bodies

Lopolith

This is basin or saucer shaped concordant intrusive igneous body of enormous size. Its top is nearly flat and bottom is convex downward bowl-like bodies, which are sagged downwards due to the weight of the intruded magma.

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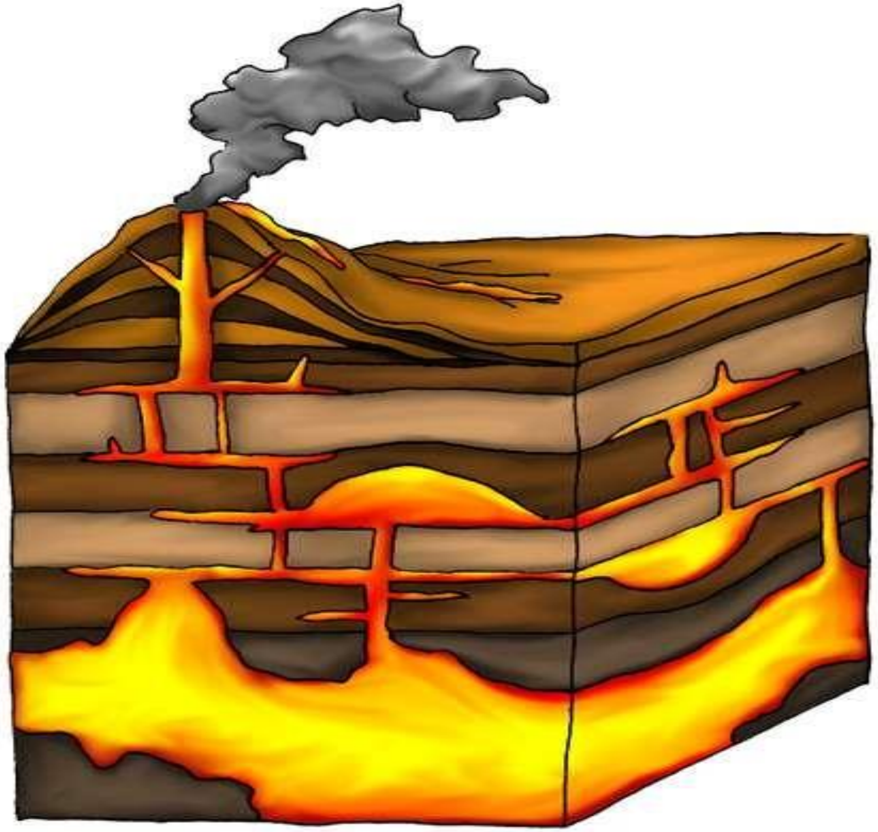
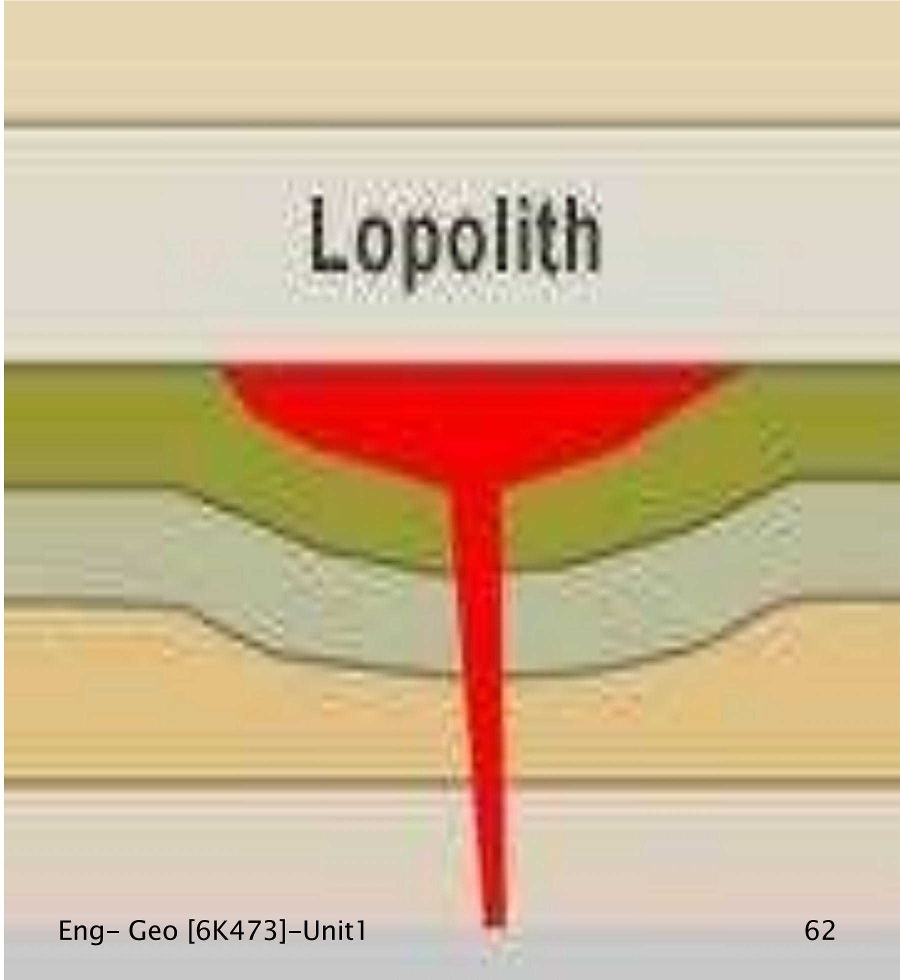
Lopolith





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Forms of Igneous Rock

Concordant intrusive bodies

Laccolith

This is a mushroom like concordant intrusive igneous bodies. It is nearly flat bottom but it is convex upward i.e. dome shaped. When viscous magma is injected along the bedding plane, as it cannot spread easily, it pushes up the overlaying rocks and piles up more at the place.

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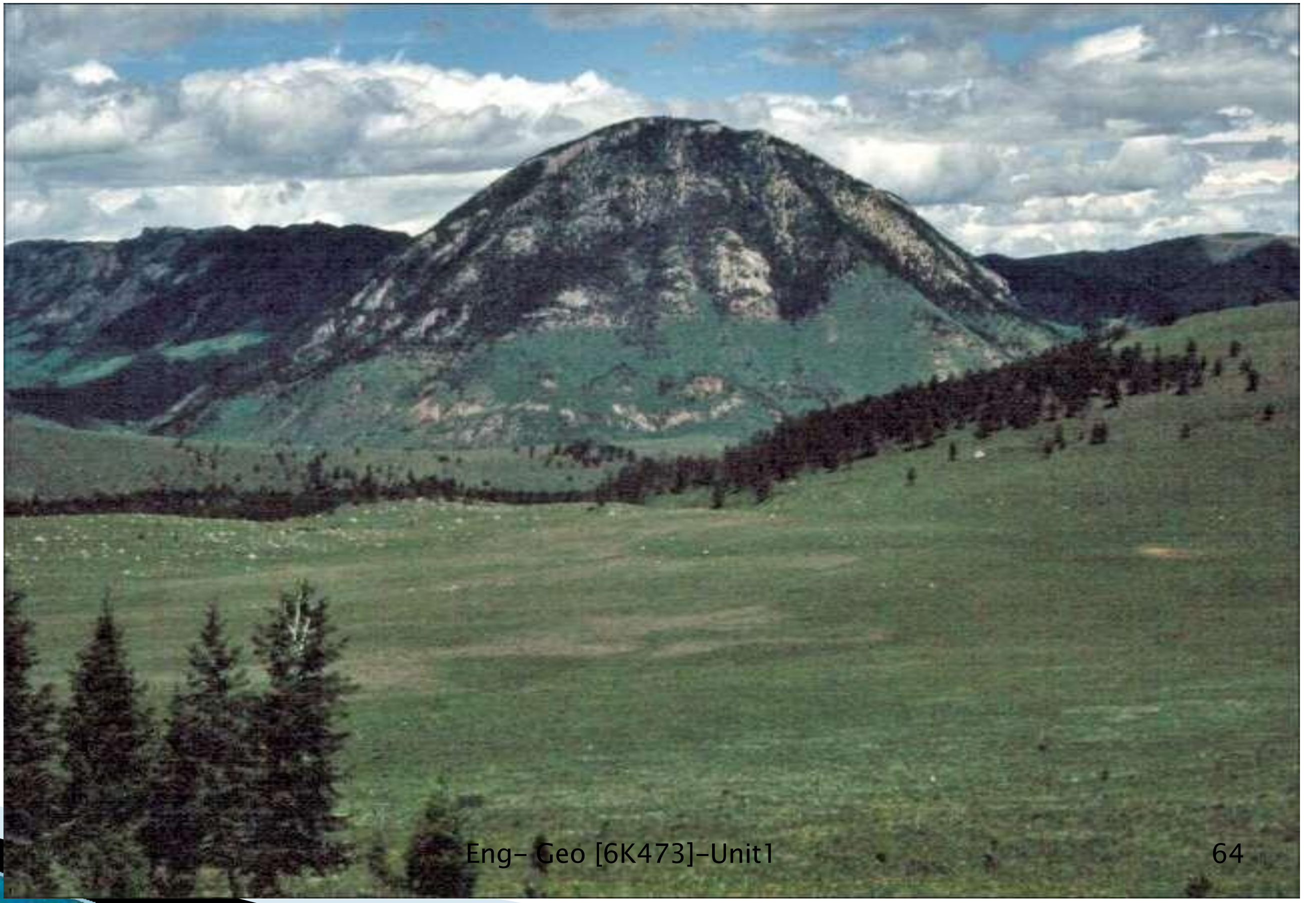
Forms of Igneous Rock

Concordant intrusive bodies

Laccolith



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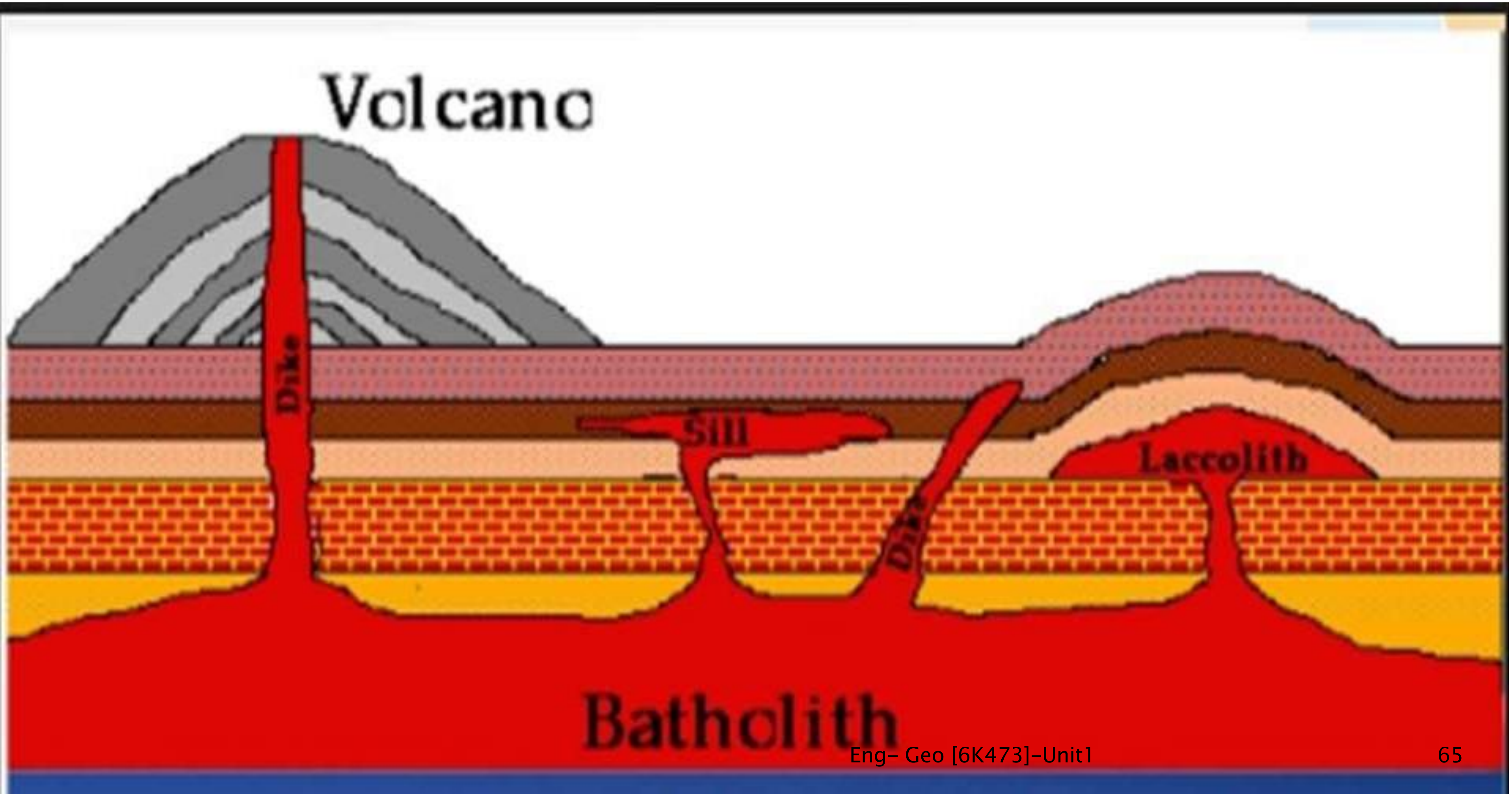
Laccolith



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Forms of Igneous Rock
Discordant intrusive bodies

Batholith

These are the largest known discordant intrusive igneous bodies mainly occurring in mountain ranges. Batholiths have side sloping away from each other which makes them larger and larger downwards and they have extended to very great depths covering several kilometres.

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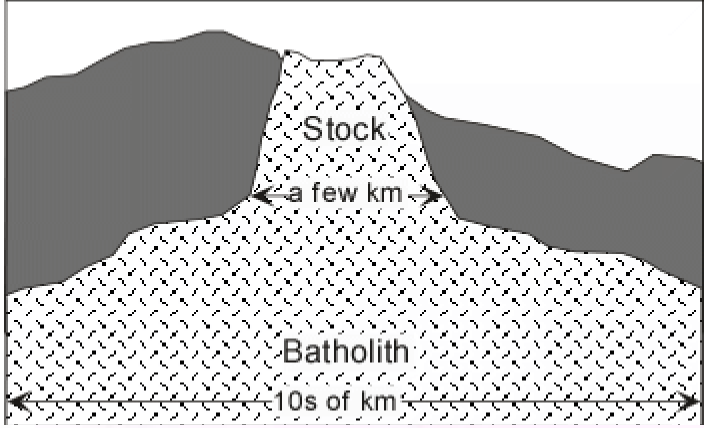
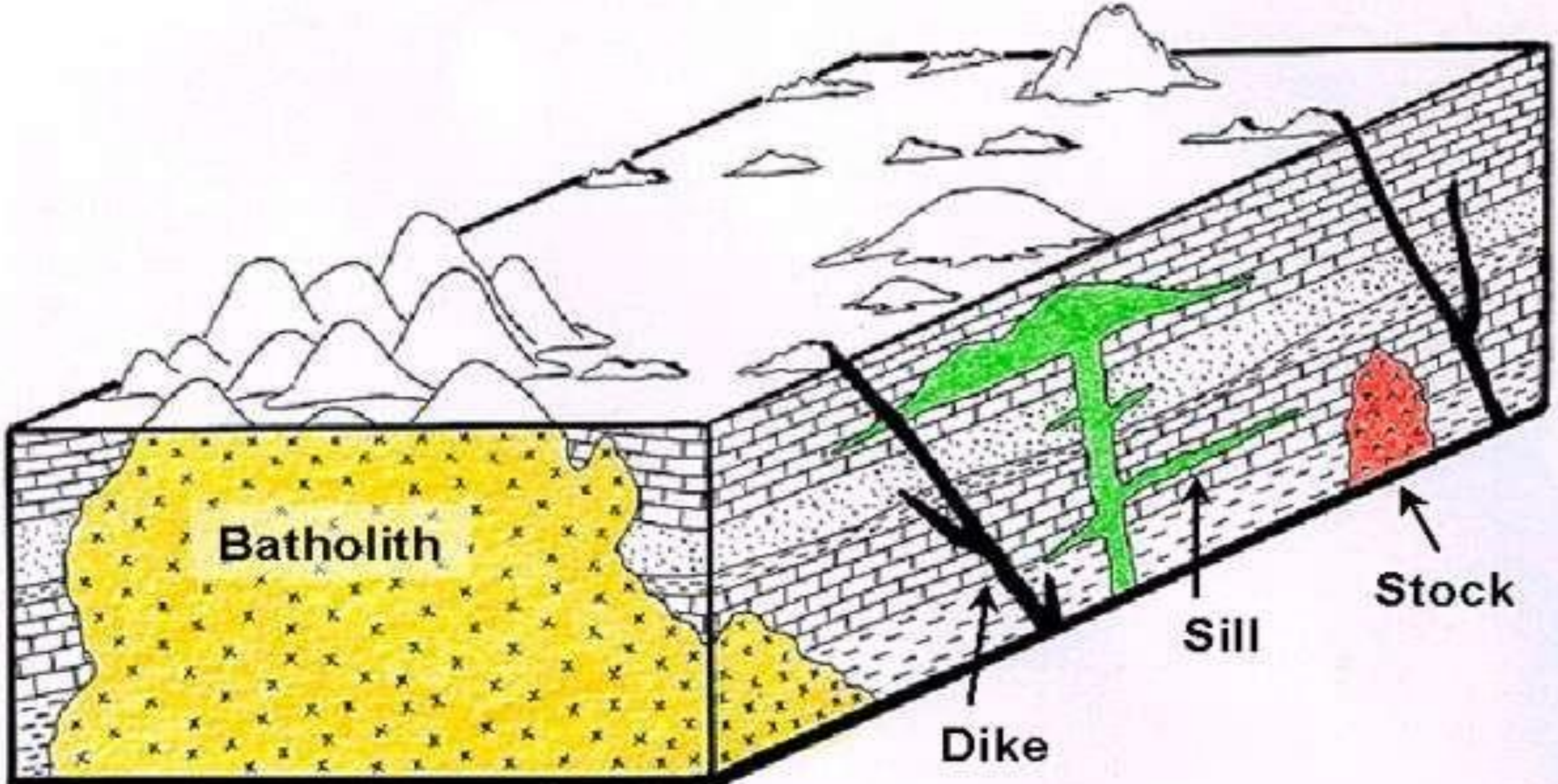
Batholith





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Forms of Igneous Rock
Discordant intrusive bodies

Dyke

Dykes are discordant igneous body of more or less tabular shape and exhibit a cross –cutting relationship with the country rocks they occur commonly n the forms of wall like masses of exactly or nearly vertical attitude. If the rocks constituting the dyke are hard and compact, they can resist weathering and Erosional process.

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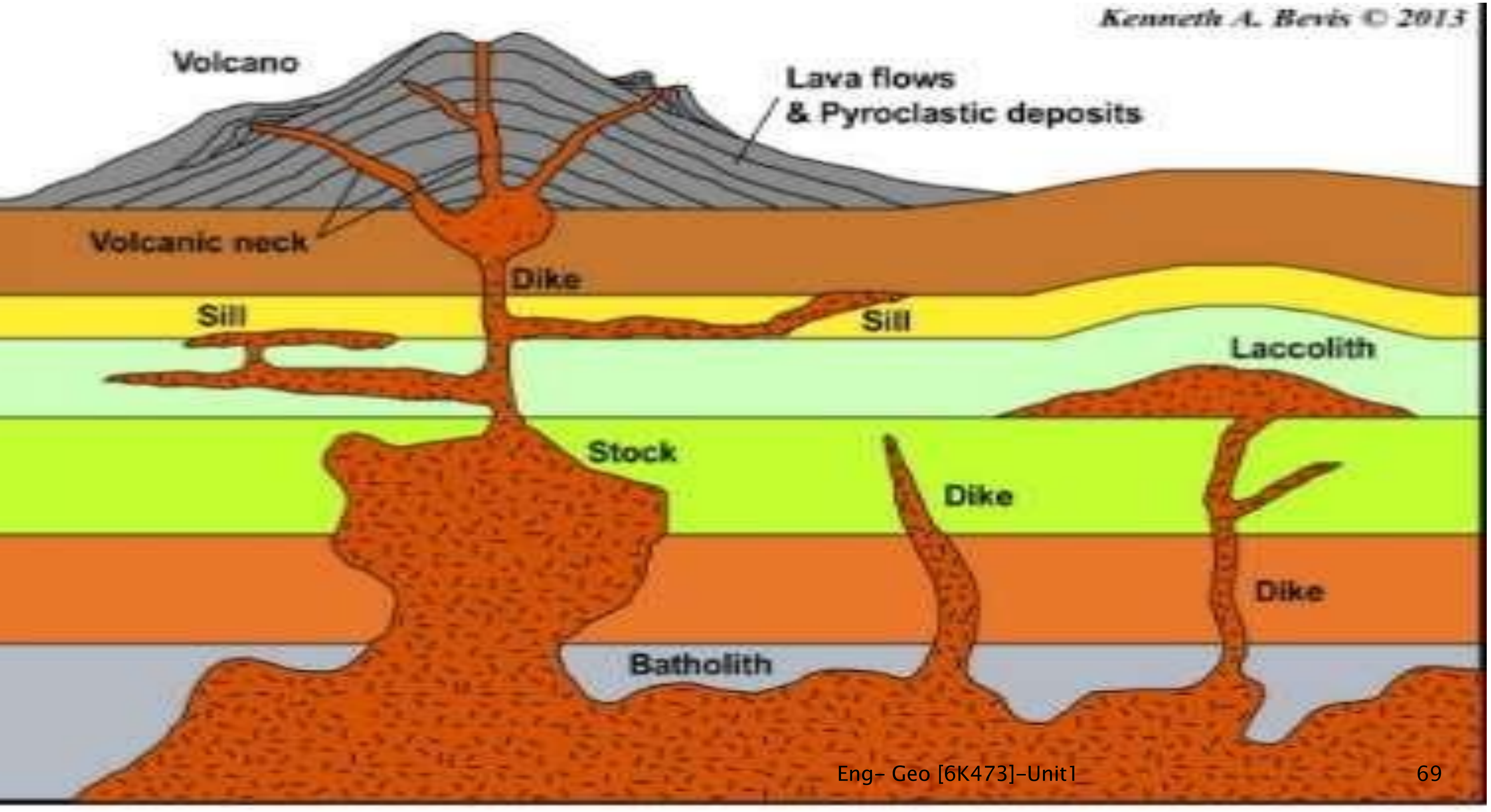
Dyke



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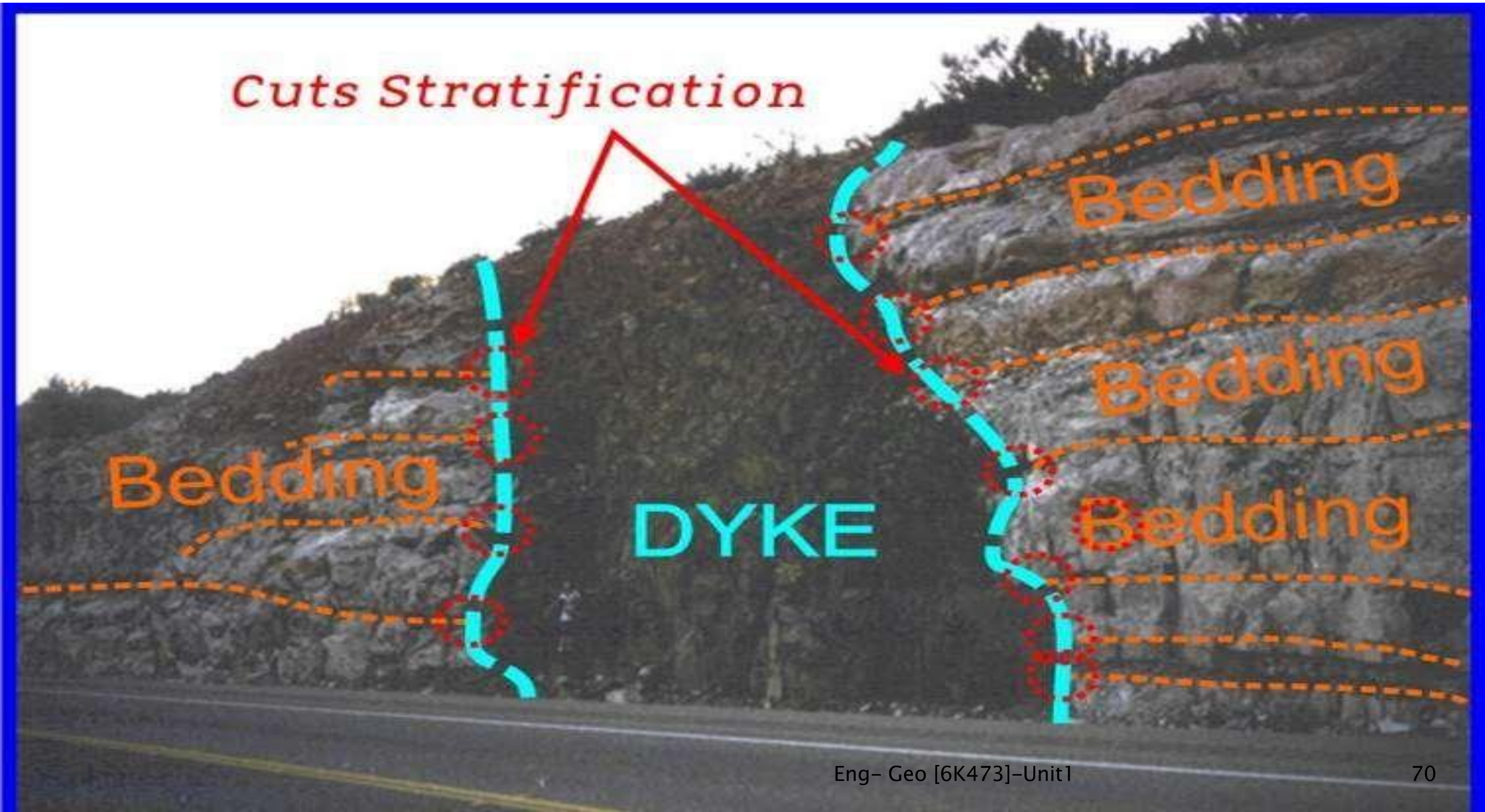
Dyke



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Forms of Igneous Rock
Discordant intrusive bodies

Volcanic neck

The vents of quiet volcanoes have become sealed with the igneous intrusions and is called volcanic necks/plugs. These forms may be circular, semi circular or irregular and in varying diameter.

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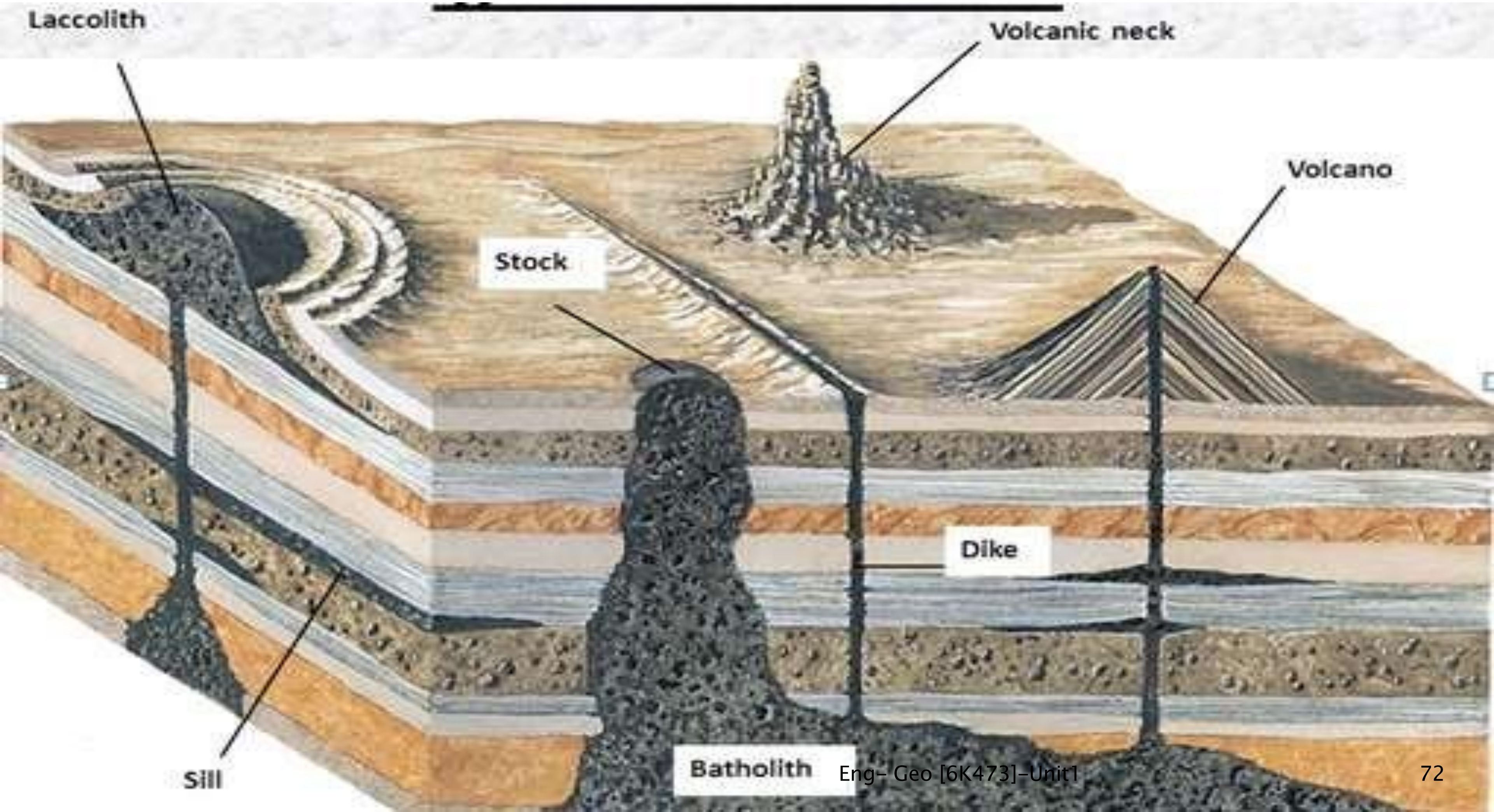
Volcanic neck



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Structure

Structure are physical features associated with the rocks. They are primary in nature they occurs along with the formation of rocks

- Structure contribute the strength and weakness of the rock.
- Structure helps to distinguishing features of rock group.
- Structure reveals the mode of formation.

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Structure of Igneous Rock

Vesicular Structure

- Structure is porous in nature.
- Commonly observed in Volcanic rocks.
- Magma is a mixture of rock melts and volatiles, (Gases).
- The gases present in the magma are lighter and escape into atmosphere.
- Empty cavity of various sizes and shapes are formed on surface. These cavity called **Vesicles.**

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Structure of Igneous Rock

Vesicular Structure

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Structure of Igneous Rock

Amygdaloidal Structure

- The empty vesicles in the vesicular structure are filled by surface water or under ground water or sediments.
- The in filled cavity are called **Amygdales.**
- When empty cavities are filled with amygdales that structure is called **Amygdaloidal Structure**

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Structure of Igneous Rock

Amygdaloidal Structure


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Structure of Igneous Rock

Columnar Structure

The volcanic igneous rock appears to be made up of numerous parallel polygon prismatic column bundled together. This results of the contraction of lava during cooling.

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Structure of Igneous Rock

Columnar Structure

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Structure of Igneous Rock

Sheet Structure

The rocks appears to be made up of a number of sheets, because of the development of nearly horizontal crack .

Plutonic rocks are formed at a great depth which means under the great pressures. When erosion takes place in the over laying strata gradually dis appear ultimately exposing of plutonic rock in the form sheet.

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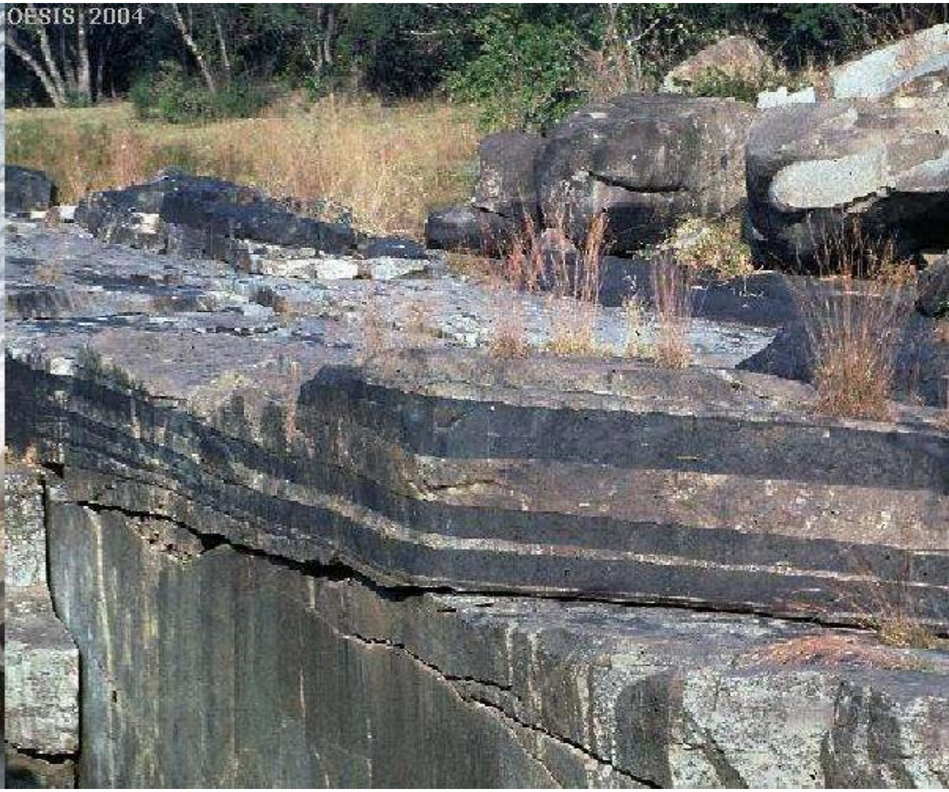
Structure of Igneous Rock

Sheet Structure



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Structure of Igneous Rock

Flow Structure

These structures are linear and nearly parallel features occurring in volcanic rocks which develops as a consequence of the flow of lava.

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Structure of Igneous Rock

Flow Structure

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Structure of Igneous Rock

Pillow Structure

The Volcanic igneous body appears as a pile of numerous overlapping pillows.

It occurs only in soda rich basalt rock.

The pillows are generally interconnected vesicular and glassy tops.

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Structure of Igneous Rock

Pillow Structure

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Textures of Igneous Rock

Texture mainly refers to Mutual relationship with constituent minerals of rocks in addition to crystallinity, granularity and shape of minerals in the rocks.

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Textures of Igneous Rock

Equigranular Texture

In this type, the mineral grains are all of approximately same size. This is because all the minerals are simultaneously get consolidated. Ex: Granite, Basalt

PETROLOGY

Textures of Igneous Rock

Equigranular Texture

Granite

Basalt

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Textures of Igneous Rock

In Equigranular Texture

In this type, the mineral grains show marked difference in their grain size. This is because different mineral grains consolidate at different level and hence different minerals exhibit different sizes.

Ex: Syenite

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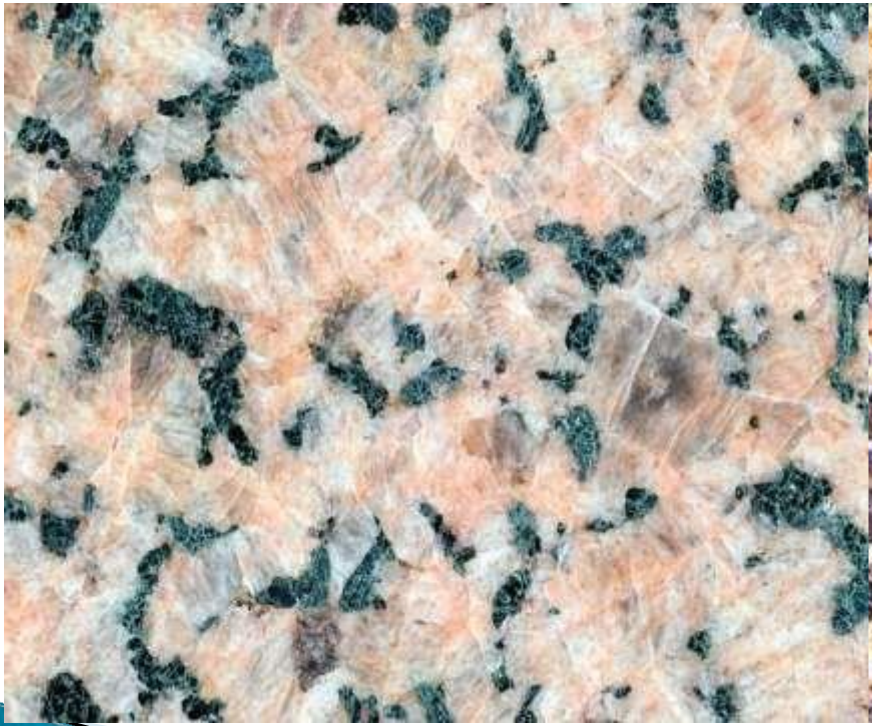
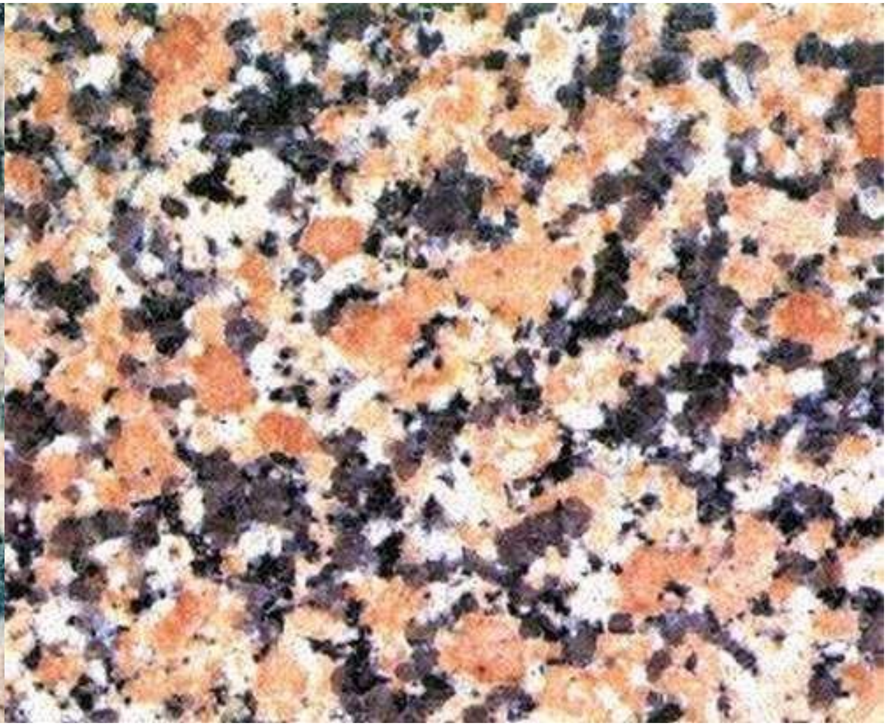
Textures of Igneous Rock

In Equigranular Texture



Syenite



Basalt

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Textures of Igneous Rock

Porphyritic texture

It is a type of inequigranular texture, where tabular or large sized minerals called **phenocrysts** are fully embedded within the fine grained minerals known as matrix

Ex: Syenite Porphyry

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Textures of Igneous Rock

Porphyritic texture

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Textures of Igneous Rock

Poikilitic texture:

This is the converse of porphyritic texture, which is characterized by the presence of fine grained crystals within the body of large sized crystals. Ex: Peridotite

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Textures of Igneous Rock

Poikilitic texture

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Textures of Igneous Rock

Ophitic texture

This is similar to porphyritic texture, which shows the phenocrysts are partially embedded within the matrix. This is observed in dolerite rock whose lath shaped of mineral Augite enclosed within small Plagioclase mineral.

Ex: Dolerite

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Textures of Igneous Rock

Ophitic texture

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Textures of Igneous Rock

Pegmatitic / intergrowth texture

Two or more minerals crystallize simultaneously in a limited space. Here one crystal intrudes another. An alternate bands of dark and light coloured minerals are seen (quartz and feldspar).

Ex: Pegmatite

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Textures of Igneous Rock

Pegmatitic / Intergrowth texture

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Textures of Igneous Rock

Vesicular Texture

Most lavas are heavily charged with gas which escapes as soon as it comes in contact with Earth's atmosphere. The escape of these gases leads to the formation of different sizes / shapes of holes in the cooled volcanic rocks.

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Textures of Igneous Rock

Vesicular Texture

PETROLOGY

Structure of Sedimentary Rock

Stratification and Lamination

The sedimentary rocks are bedded in nature. A bed is called stratum and a number of beds are called Strata.

A bed is generally homogeneous in composition, texture and colour. These are called Bedding planes. The different layers of beds may vary in grain size, mineral composition, colour, texture etc., depending upon the environment and formation. This feature is called stratification.

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Structure of Sedimentary Rock

Stratification and Lamination

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Structure of Sedimentary Rock

Graded Bedding

In some beds at the bottom, there will be bigger particles and very fine particles at the top. There is a gradual decrease in the size of the particles from bottom to top. This phenomenon is called Graded bedding. Here individual layer is said to be graded with different particle size.

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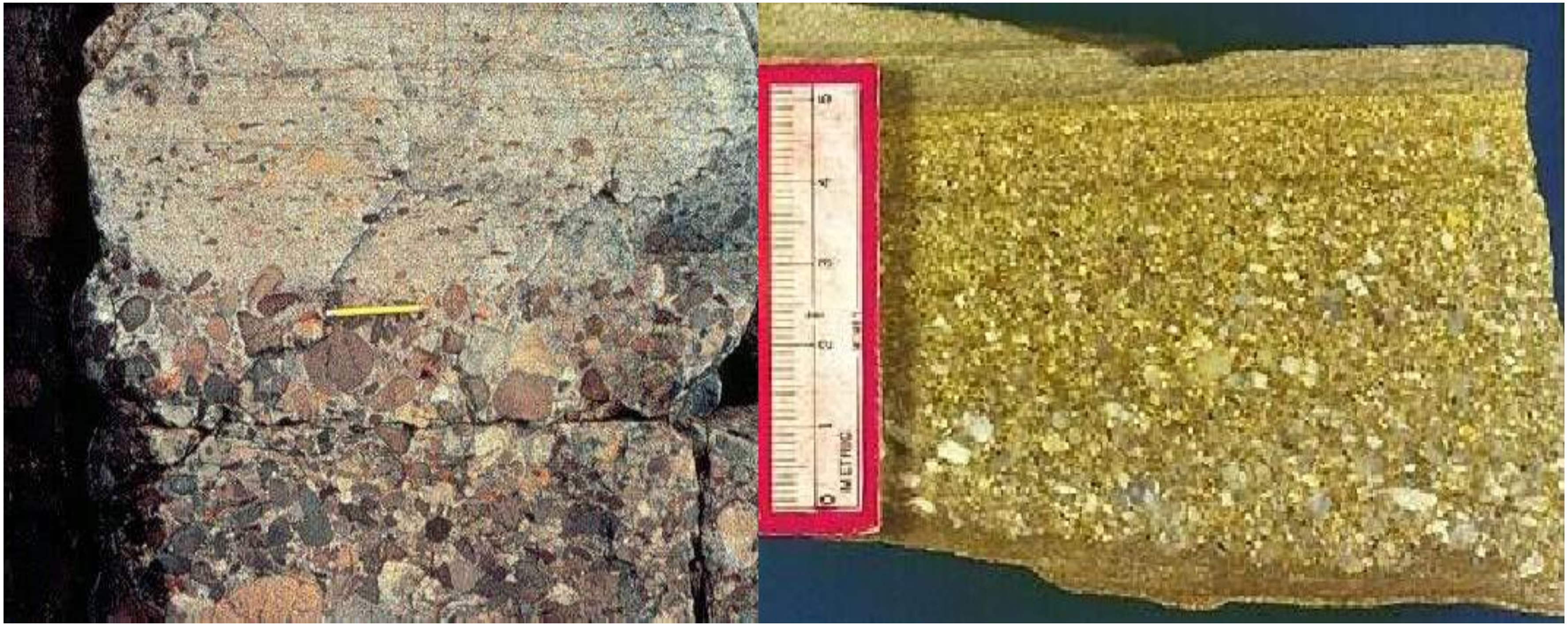
Structure of Sedimentary Rock

Graded Bedding



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Structure of Sedimentary Rock

Current Bedding

Generally, the sedimentary beds are parallel to one another. Some times the beds are deposited slightly inclined to the major bedding plane because of change in the velocity and direction of flow of stream. This structure is known as Current Bedding.

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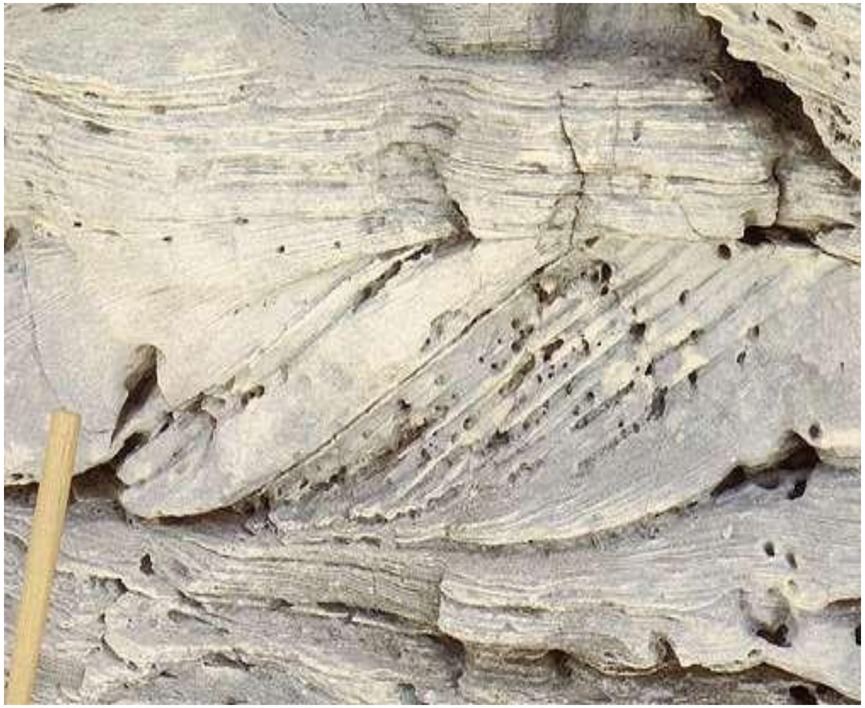
Structure of Sedimentary Rock

Current Bedding



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Structure of Sedimentary Rock

Ripple Marks

This is a minor structure in sedimentary rocks formed due to mechanical origin. They are the undulations structure formed on the surface of loose sediments due to action of wind in a shallow water body. It is also called wave marks. If the ripple marks are formed by stagnant water then the feature will be symmetrical and if they are formed by moving water then they are asymmetrical.

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Structure of Sedimentary Rock

Ripple Marks

PETROLOGY

Structure of Sedimentary Rock

Mud Cracks

These are common structural features of fine grained sedimentary rocks. The development of mud cracks is because of the drying of huge masses of fine grained sediments under sub-aerial condition. It is also called Sun cracks since they are formed due to the effect of solar heat.

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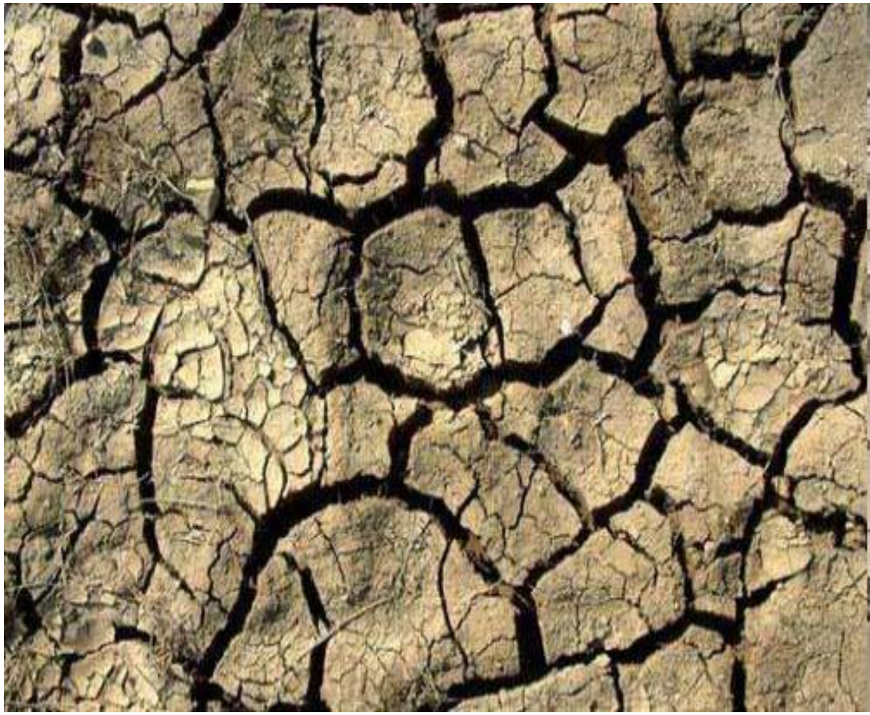
Structure of Sedimentary Rock

Mud Cracks



PETROLOGY

Structure of Sedimentary Rock

‘Tracks and Trails, Rain Prints

The movement of organisms on the surface of loose sediments develops a marking or impression and is called ‘tracks and trails’. On the other hand ‘Rain prints’ are formed on the top surface of loose sediments due to impact of ‘drops’ of rainwater.

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Structure of Sedimentary Rock

Tracks and Trails, Rain Prints

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Texture of Sedimentary Rock

Clastic Texture

Grains do not interlock but rather are piled together and cemented. Boundaries of individual grains may be another grain, cement or empty pore space. Overall rock is generally porous and not very dense. Because Clastic are only cemented together, grains are relatively easy to “scrape off" using a rock hammer point or metal nail.

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Texture of Sedimentary Rock

Clastic Texture

www.alamy.com - JD42BY

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Texture of Sedimentary Rock

Microclastic texture

This texture is the same as the Clastic texture except that the clasts are not visible to the eye. Because the grains are invisible, examining the ease in which grains (silt or clay) may be knocked off is the best test to perform.

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Texture of Sedimentary Rock

Microclastic texture


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Texture of Sedimentary Rock

Bioclastic texture

The texture is similar to Clastic texture except that all of the clasts or grains are fossils.

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Texture of Sedimentary Rock

Bioclastic texture

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Texture of Sedimentary Rock

Crystalline texture

Crystals are visible and form an interlocking network. Unlike igneous crystalline textures, however, sedimentary crystalline textures are typically formed from one mineral throughout the entire rock.

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Texture of Sedimentary Rock

Crystalline texture

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Texture of Sedimentary Rock

Microcrystalline texture

No crystals are visible but the rock is composed of interlocking microscopic crystals. Such rocks are dense and typically nonporous. Microcrystalline rocks break with a characteristic Conchoidal fracture. That is, the broken surface may smooth concentric lines resembling the inside of an oyster shell or broken glass.

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Texture of Sedimentary Rock

Microcrystalline texture

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Structure of Metamorphic Rock

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Structure of Metamorphic Rock

Porphyroclastic Structure

It is produced under stress and in absence of high temperature, where by rocks are subjected to shearing and fragmentation. Only the durable mineral partly survive the crushing force and the less durable ones are powdered. Thus, when resistant minerals and rock fragments stand out in a pseudo porphyritic manner in the finer materials, it is known as 'porphyroclastic' structure.

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Structure of Metamorphic Rock

Porphyroclastic Structure

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Structure of Metamorphic Rock

Maculose structure

It is produced by thermal metamorphism of argillaceous rocks like shale. Here, larger crystals of cordierite and biotite are sometimes well developed giving a spotted appearance to the rocks. The well developed crystals are known as 'porphyroblasts' with increasing degree of metamorphism, the spotted slates pass into extremely fine grained granular rock known as Hornfels.

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Structure of Metamorphic Rock

Maculose structure

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Structure of Metamorphic Rock

Schistose structure

Here the platy or flaky minerals like the micas and other Inequidimensional minerals show a preferred orientation along parallel planes, under the effect of the stress dominating during metamorphism. The longer directions are parallel to the direction of maximum stress. Schistosity is the property or tendency of a foliated rock, whereby it can be readily split along foliation plane.

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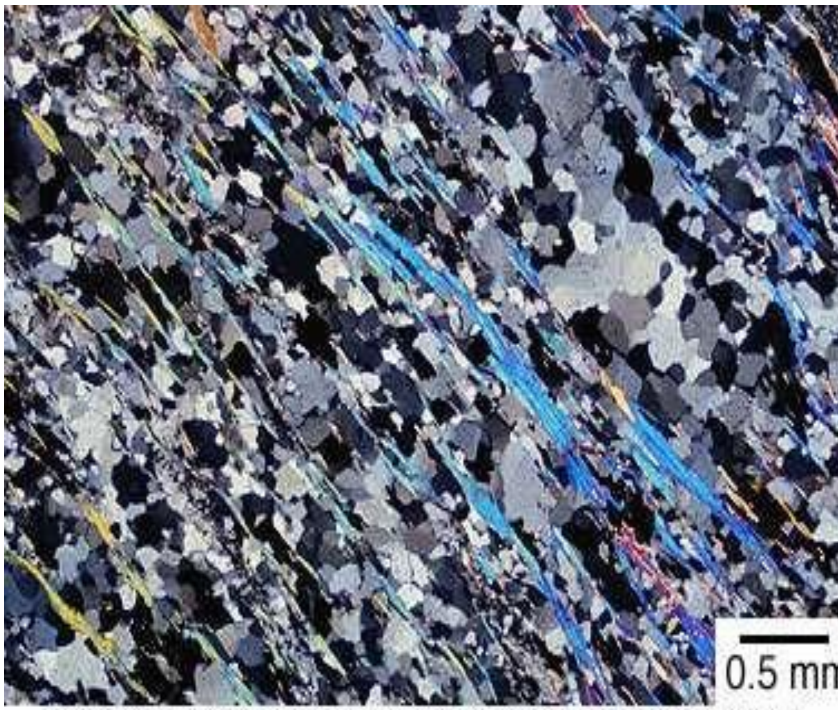
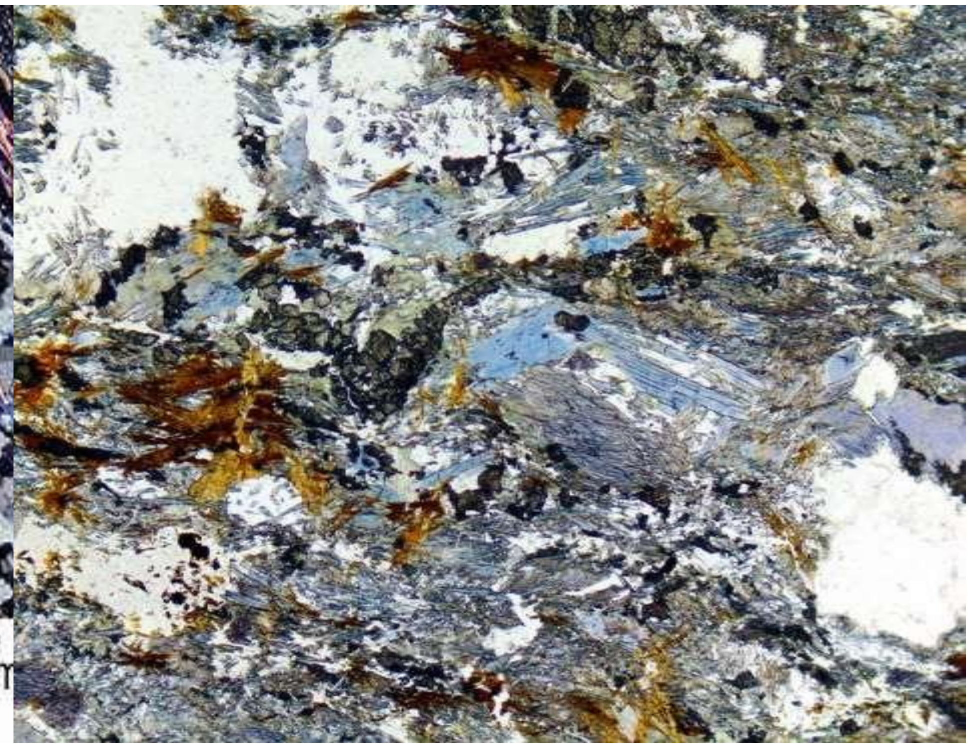
Structure of Metamorphic Rock

Schistose structure



(from http://www.geolab.unc.edu/Petunia/IgMetAtlas/mainmenu.html)



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Structure of Metamorphic Rock

Granulose structure

This is found in the rocks composed of equidimensional minerals like quartz, feldspar and pyroxenes. They are formed by the recrystallization of pre-existing rocks, under uniform pressure and great heat. The typical texture is coarsely granoblastic. These structures are also known as

Quartzite's and marbles are typical examples of this structure.

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Structure of Metamorphic Rock

Granulose structure

PETROLOGY

Structure of Metamorphic Rock

Gneissose structure

It is a banded structure due to alter nation of schistose (dark coloured) and granulose (light coloured) bands and is produced by highest grade of metamorphism, typically by regional metamorphism. The bands differ from are another in colour, texture and mineral composition.

Gneisses typically show this type of structure, hence the name.

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Structure of Metamorphic Rock

Gneissose structure

PETROLOGY

Texture of Metamorphic Rock

Gneissose structure

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Structure of Metamorphic Rock

Gneissose structure

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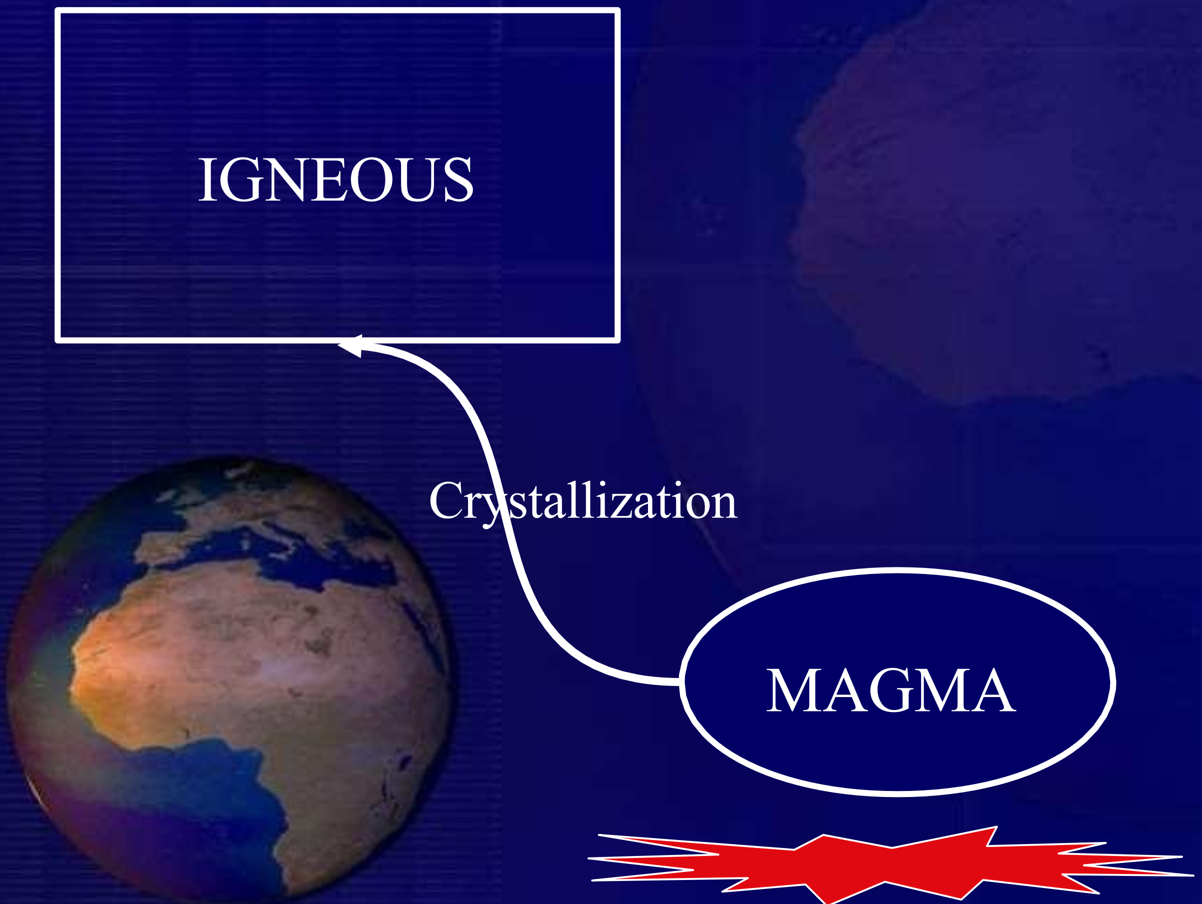
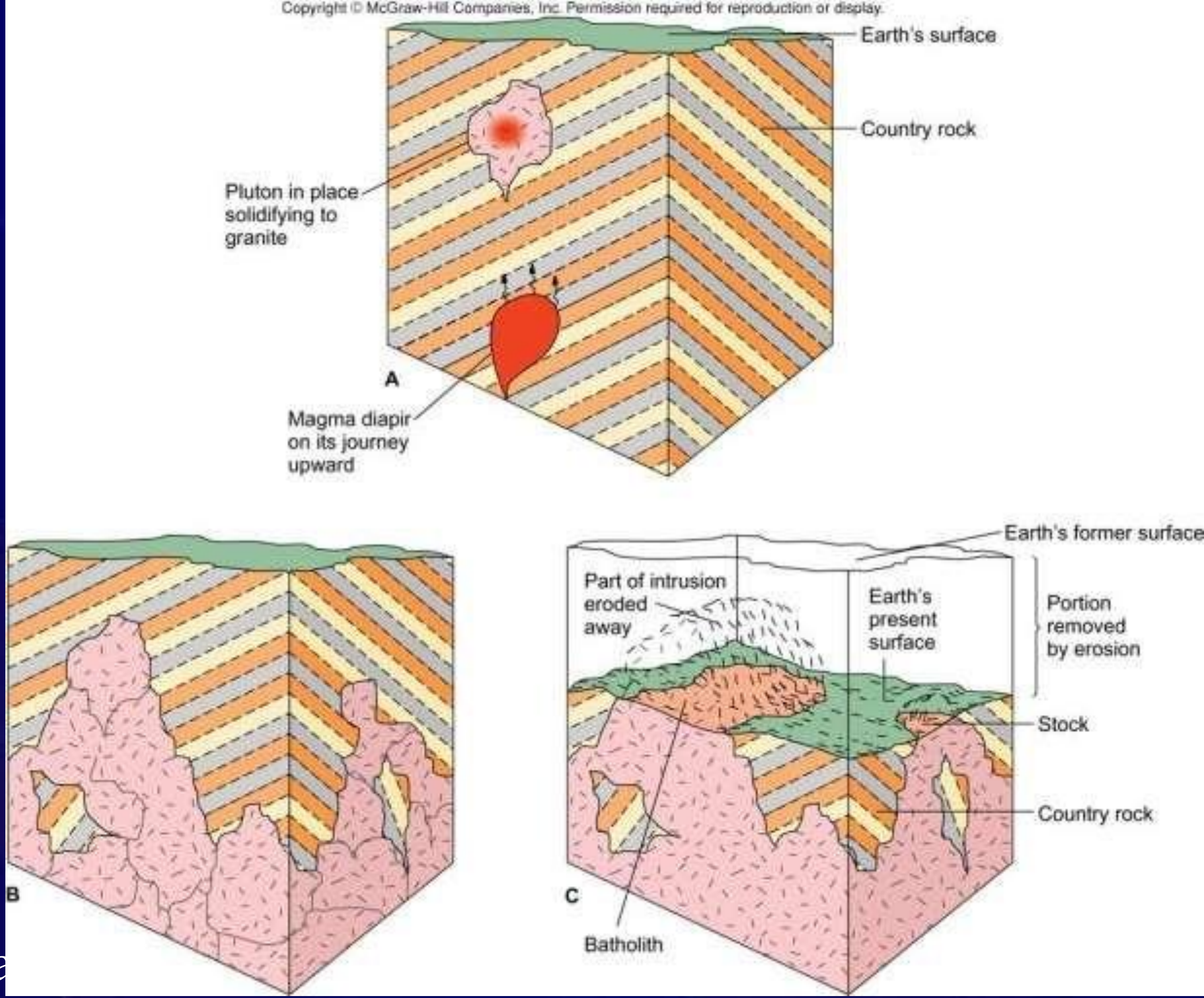
ROCK CYCLE


IGNEOUS
Crystallization
MAGMA

IGNEOUS

Plutonic



Crystalliza

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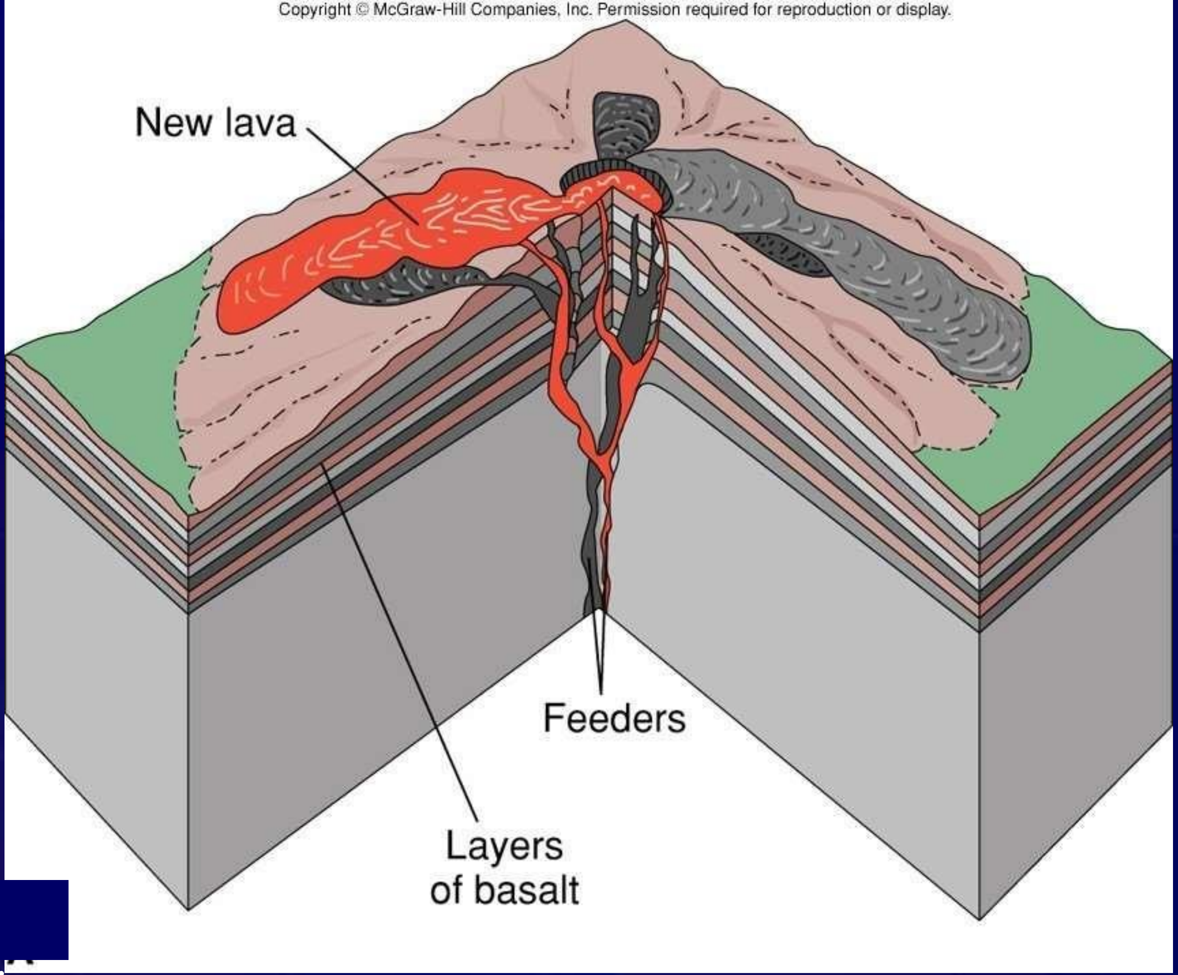
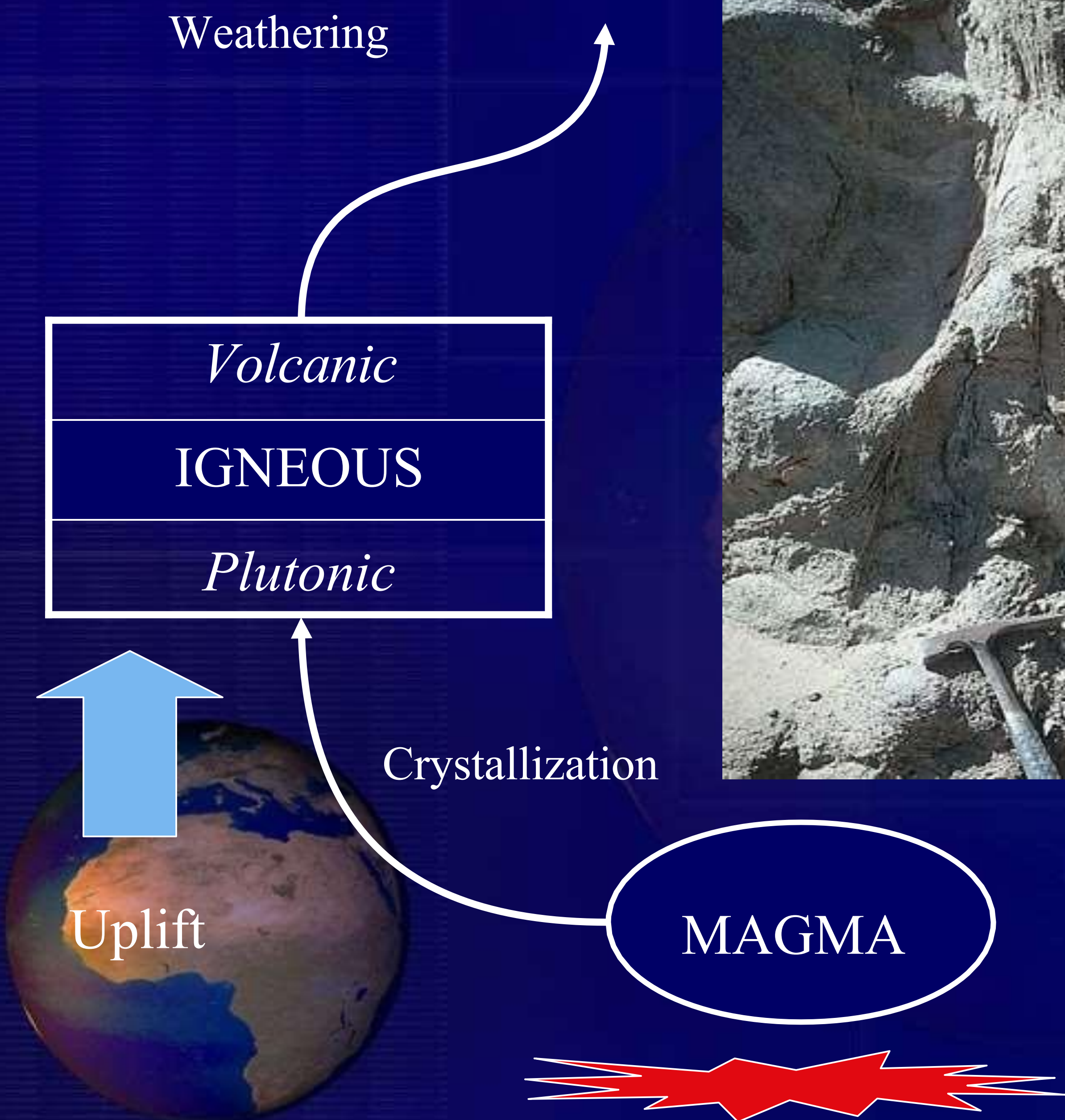
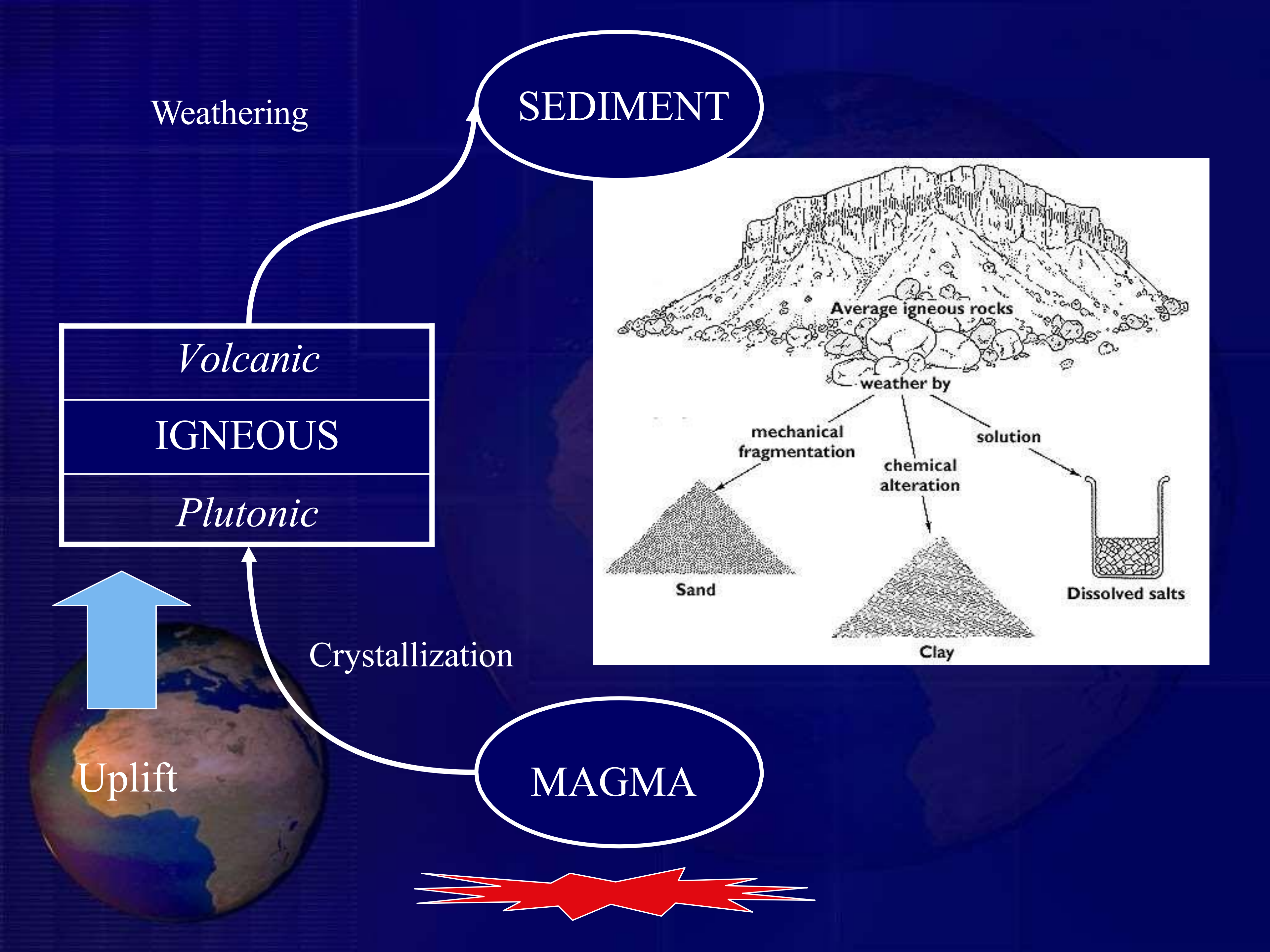


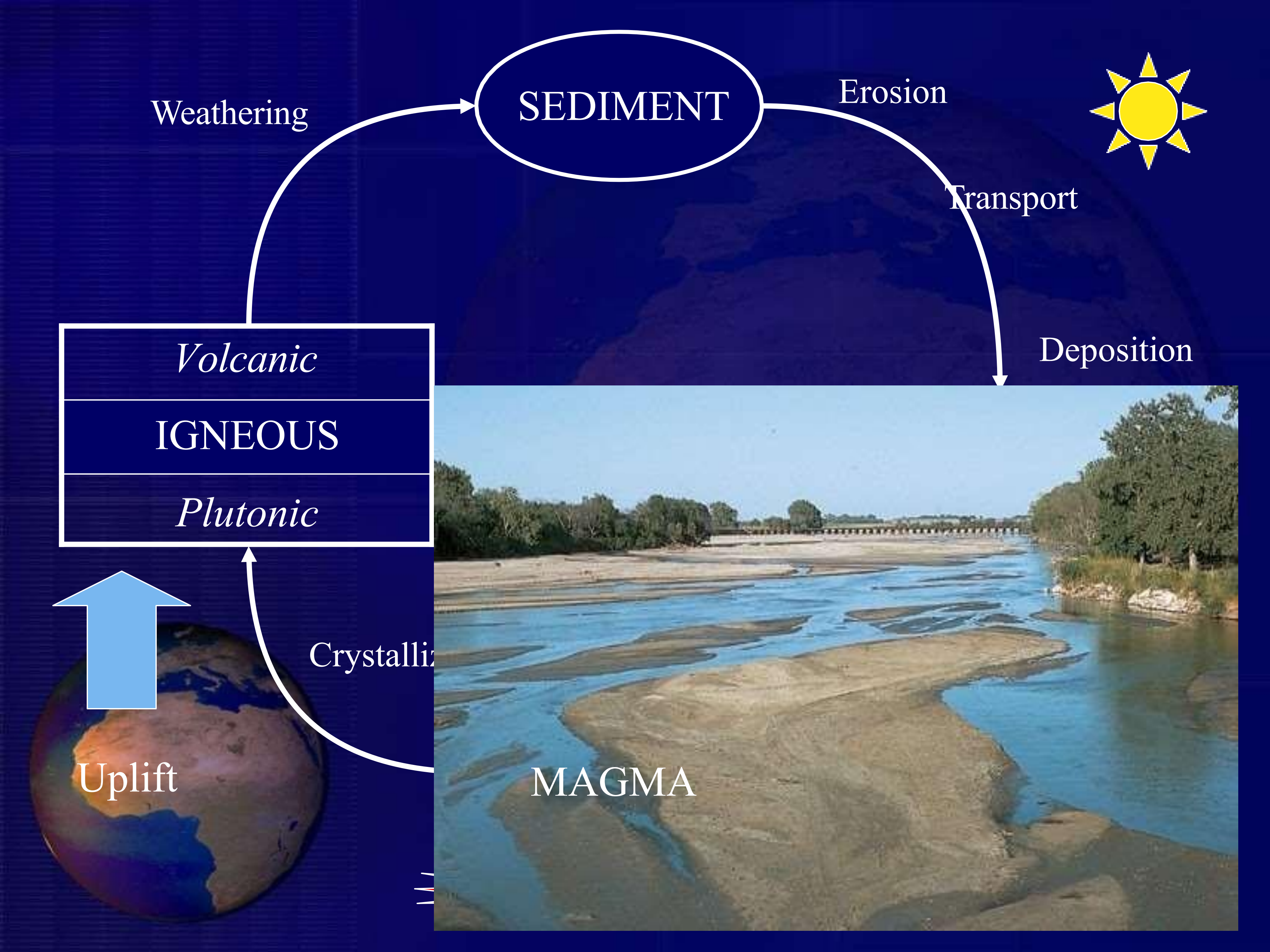
Volcanic
IGNEOUS
Plutonic

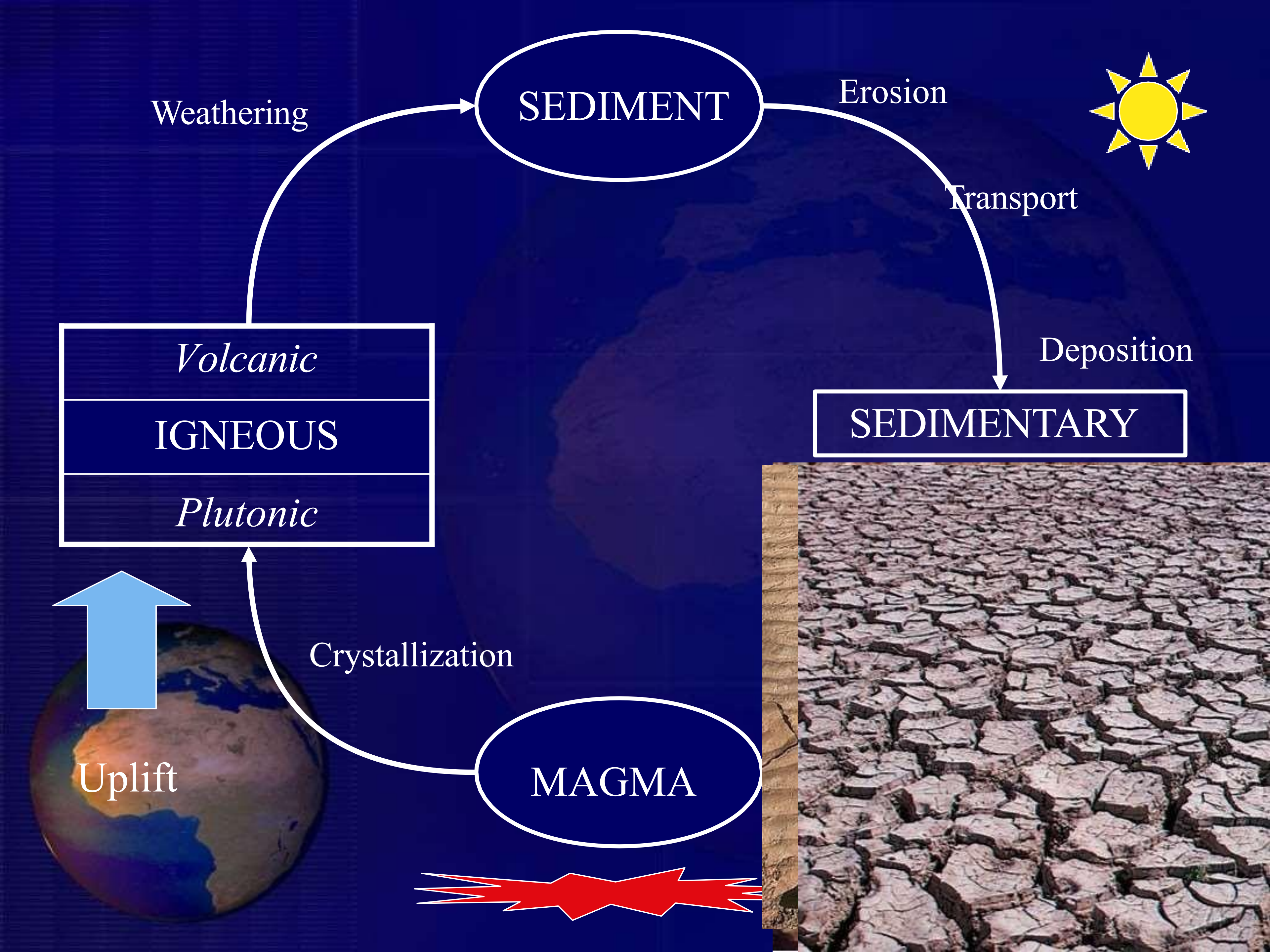
Crystallization

MAGMA

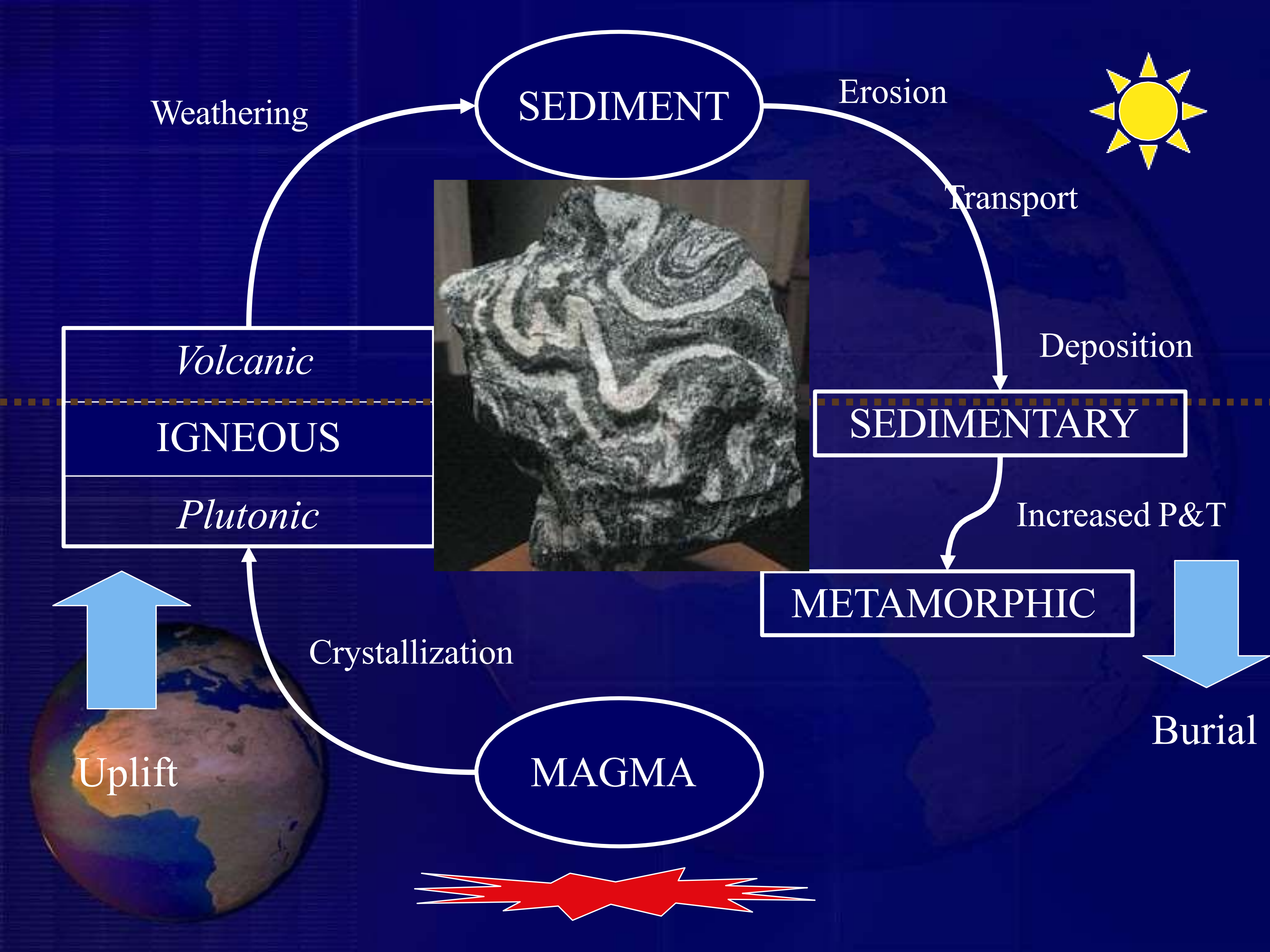

Weathering
Volcanic
IGNEOUS
Plutonic
Crystallization
Uplift
MAGMA


Weathering
SEDIMENT
Volcanic
IGNEOUS
Plutonic
Crystallization
Uplift
MAGMA
Average igneous rocks
weather by
mechanical fragmentation
chemical alteration
solution
Sand
Clay
Dissolved salts

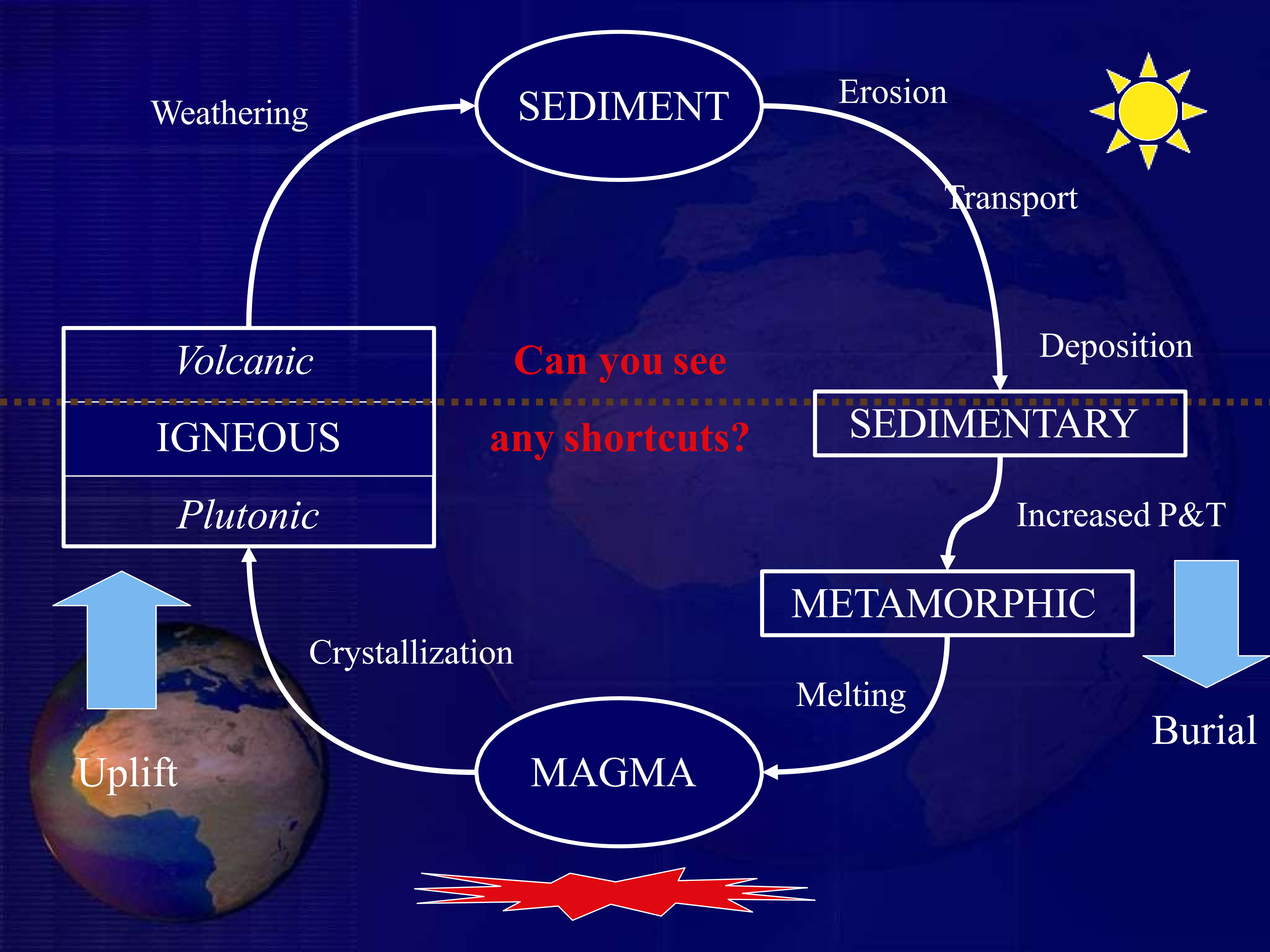

Weathering
SEDIMENT
Erosion
Transport
Deposition
Volcanic
IGNEOUS
Plutonic
Crystalliz
Uplift
MAGMA

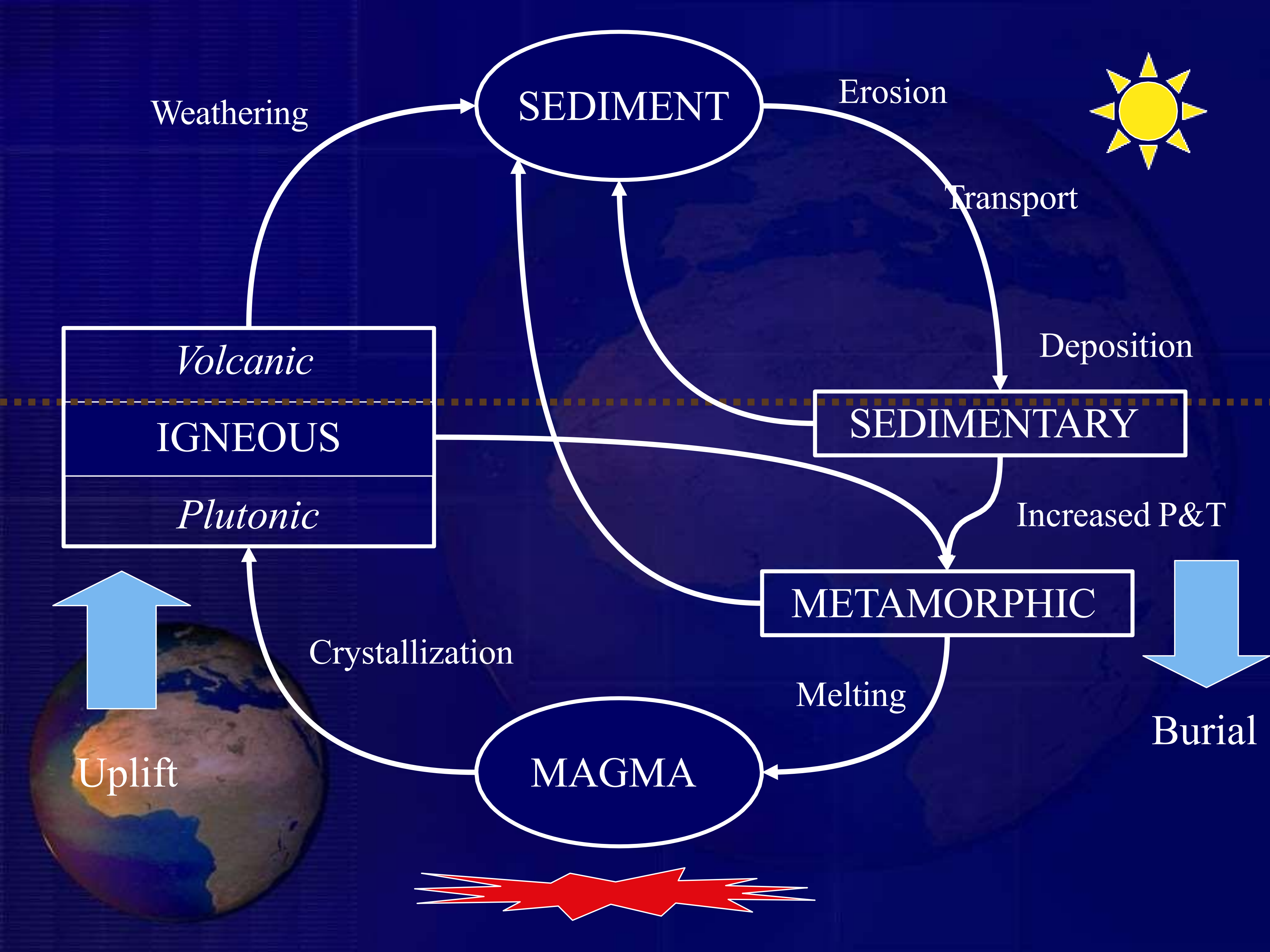


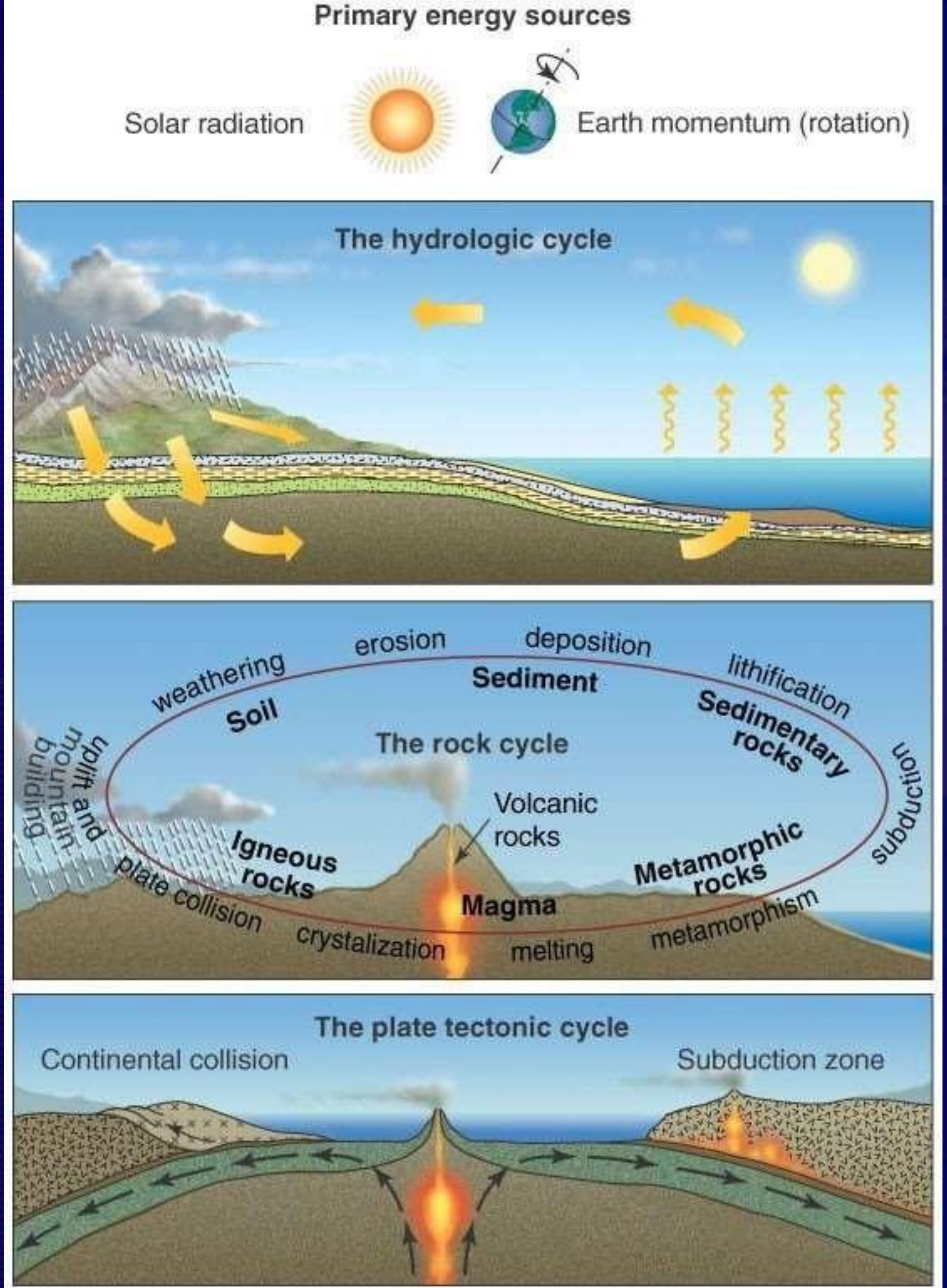
SEDIMENT
Weathering
Erosion
Transport
Deposition
SEDIMENTARY
Volcanic
IGNEOUS
Plutonic
Crystallization
MAGMA
Uplift



Weathering
SEDIMENT
Erosion
Transport
Deposition
SEDIMENTARY
Increased P&T
METAMORPHIC
Burial
Volcanic
IGNEOUS
Plutonic
Crystallization
MAGMA
Uplift

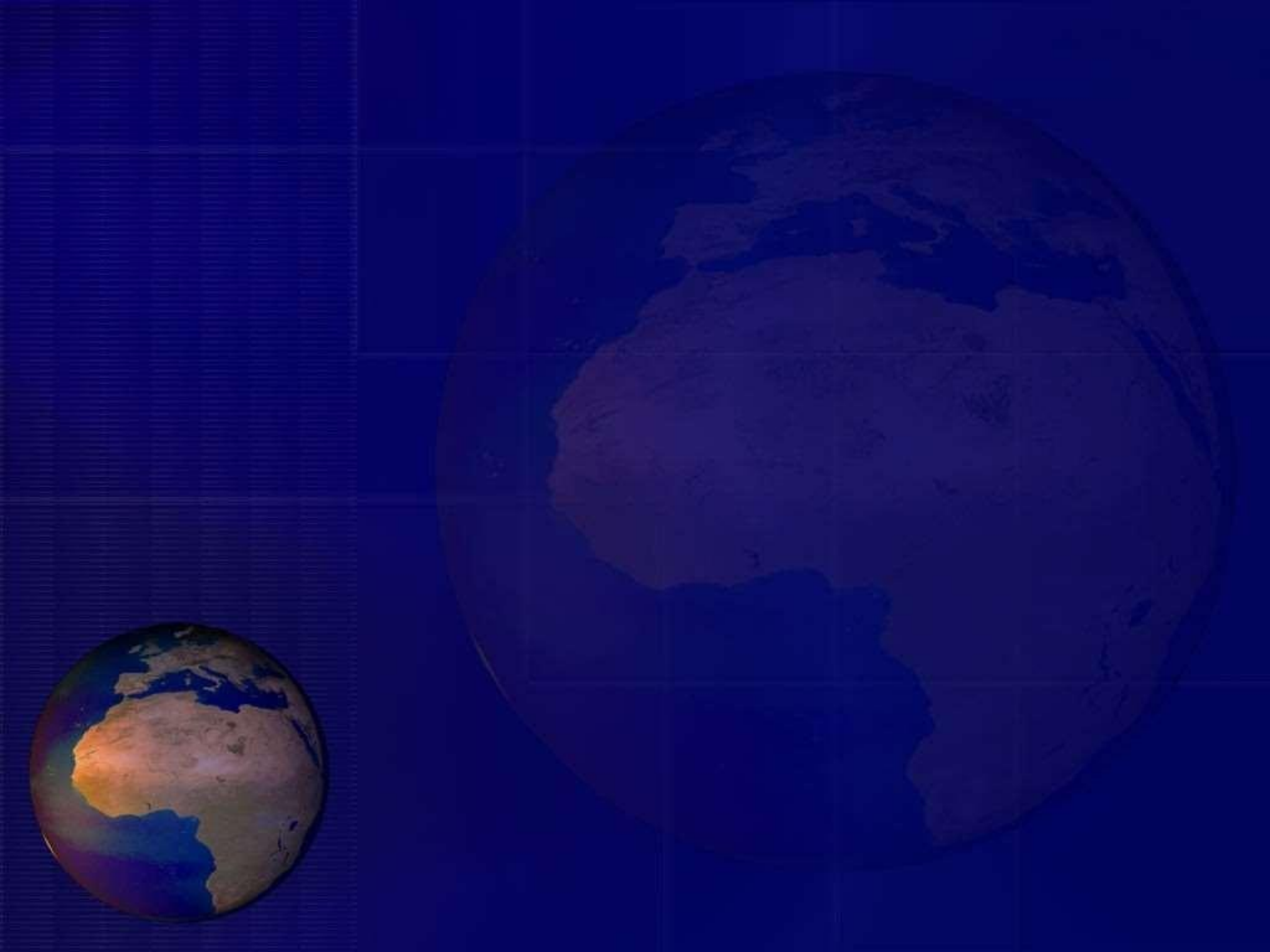

SEDIMENT
Weathering
Erosion
Transport
Deposition
Volcanic
IGNEOUS
Plutonic
Can you see
any shortcuts?
SEDIMENTARY
Increased P&T
METAMORPHIC
Burial
Uplift
Crystallization
Melting
MAGMA

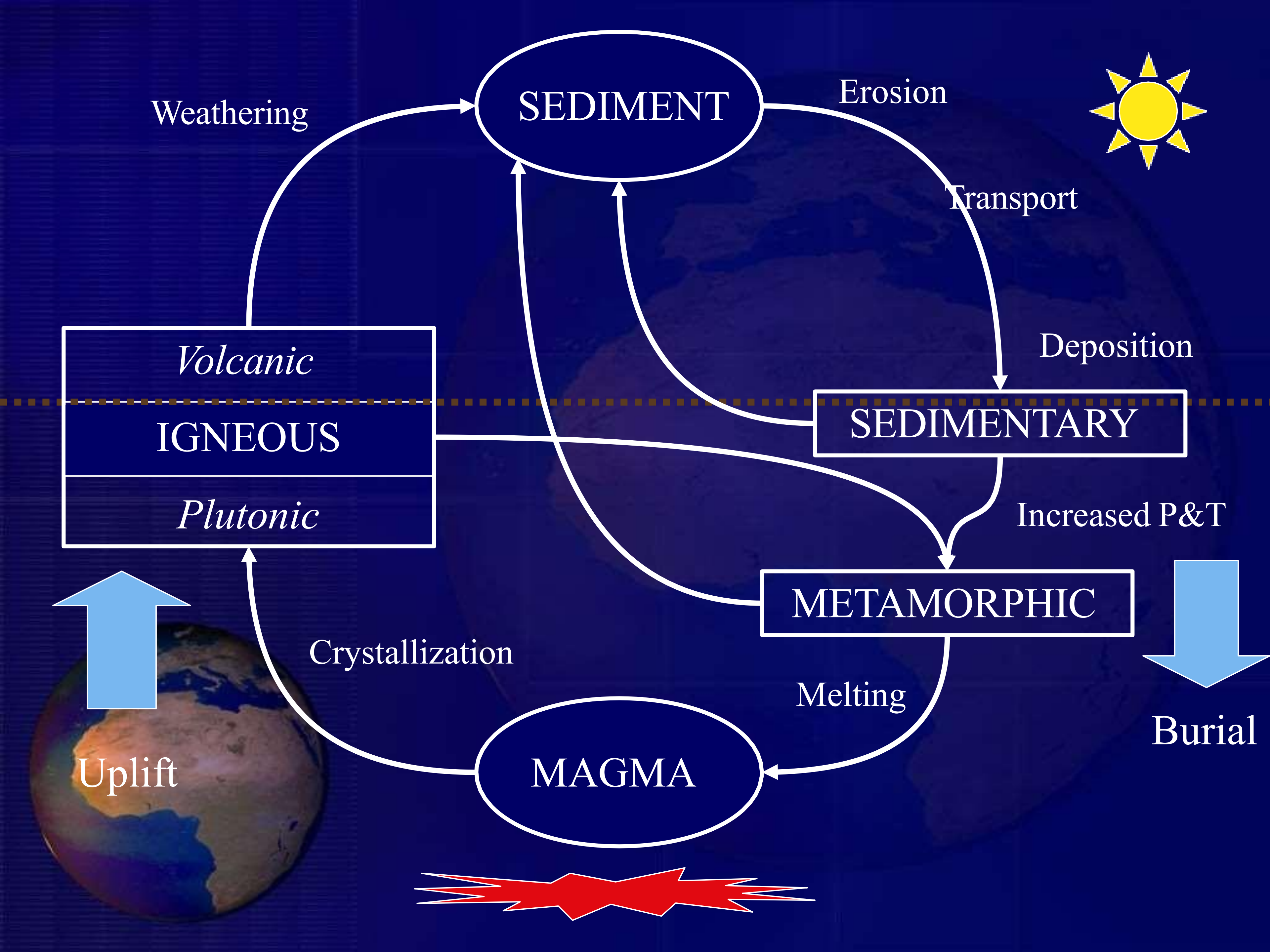

SEDIMENT
Weathering
Erosion
Transport
Deposition
Volcanic
IGNEOUS
Plutonic
SEDIMENTARY
Increased P&T
METAMORPHIC
Burial
Uplift
Crystallization
Melting
MAGMA



In Conclusion…

- The rock cycle demonstrates the relationships among the three major rock groups
- It is powered by the interior heat of the Earth
- As well as earth's momentum and…
- The energy from the sun
- It involves processes on the Earth's surface as well as the Earth's interior
- It connects the "hydrologic cycle" with the "tectonic cycle".




SEDIMENT
Weathering
Erosion
Transport
Deposition
Volcanic
IGNEOUS
Plutonic
SEDIMENTARY
Increased P&T
METAMORPHIC
Burial
Uplift
Crystallization
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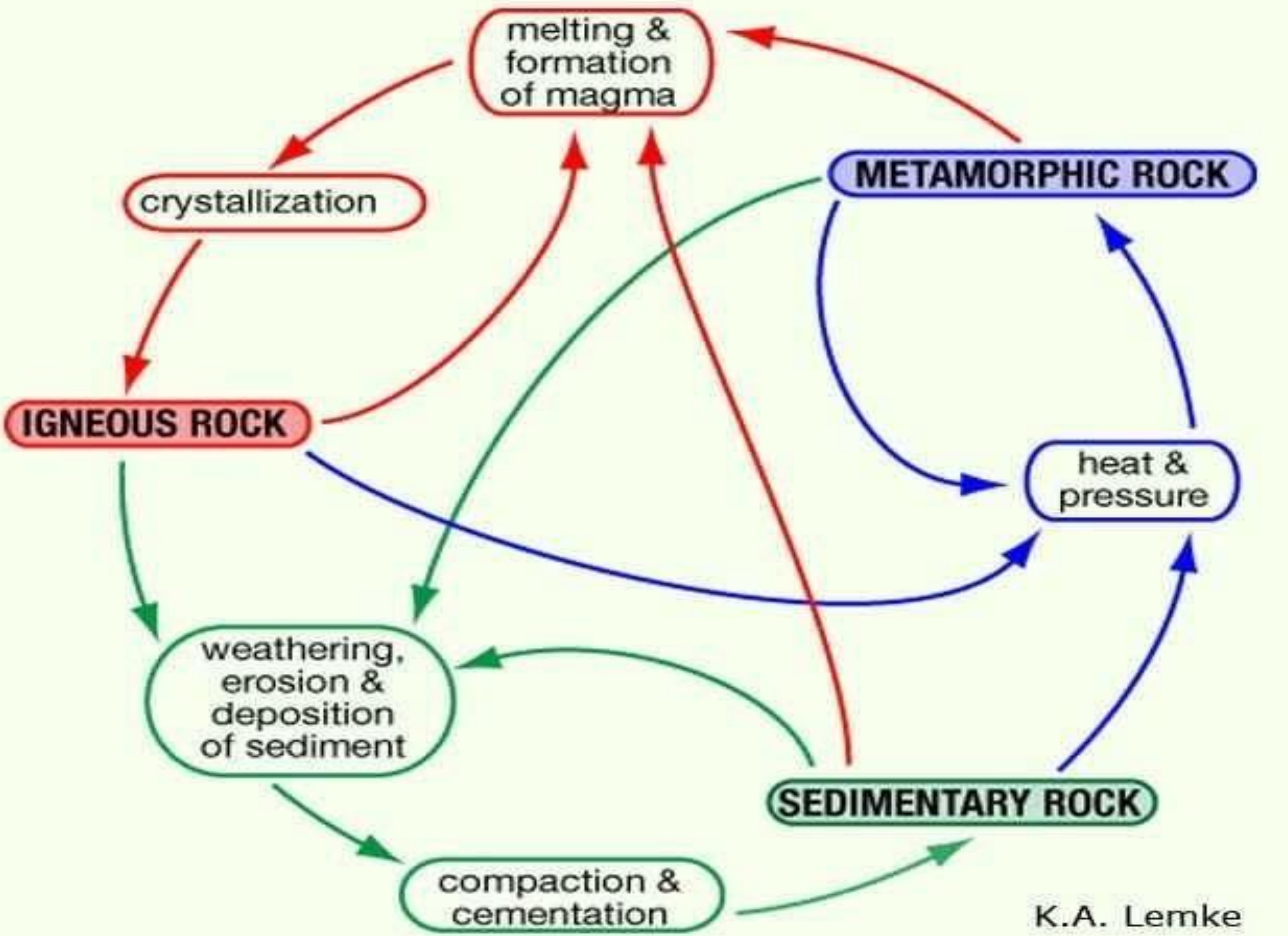
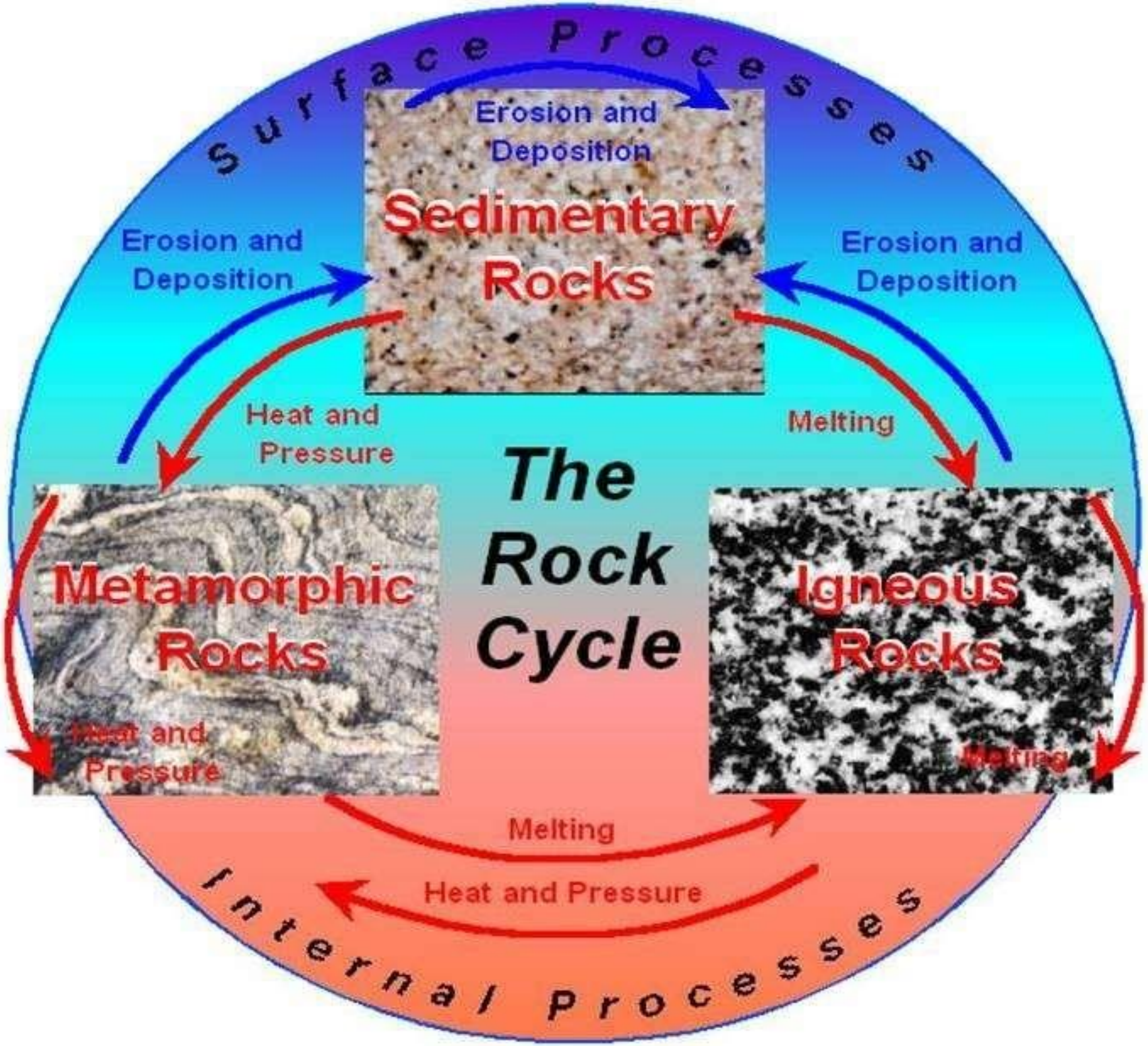
MAGMA


melting & formation of magma
crystallization
METAMORPHIC ROCK
IGNEOUS ROCK
heat & pressure
weathering, erosion & deposition of sediment
SEDIMENTARY ROCK
compaction & cementation
K.A. Lemke


Surface Processes
Erosion and Deposition
Sedimentary Rocks
Erosion and Deposition
Erosion and Deposition
Heat and Pressure
Melting
The Rock Cycle
Metamorphic Rocks
Igneous Rocks
Heat and Pressure
Melting
Melting
Heat and Pressure
Internal Processes