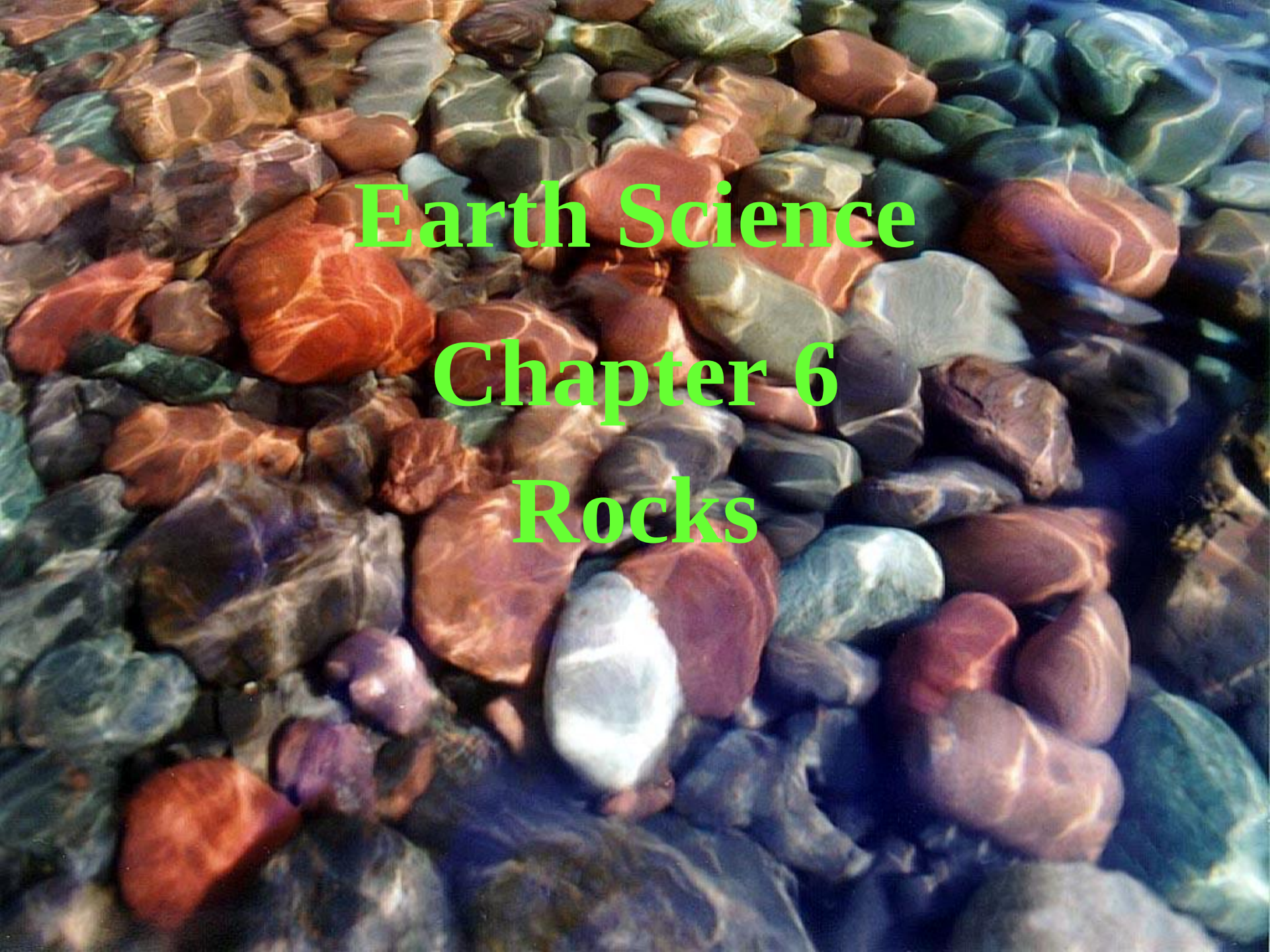


Earth Science
Chapter 6
Rocks

I. Rocks and the Rock Cycle

* **Material that makes up the solid part of the Earth.**
* **Made of a variety of different combinations of minerals and organic matter.**

A. Three Major Types of Rock

1. **Igneous rock –**

   formed when magma cools down and hardens.

2. **Sedimentary rock –**

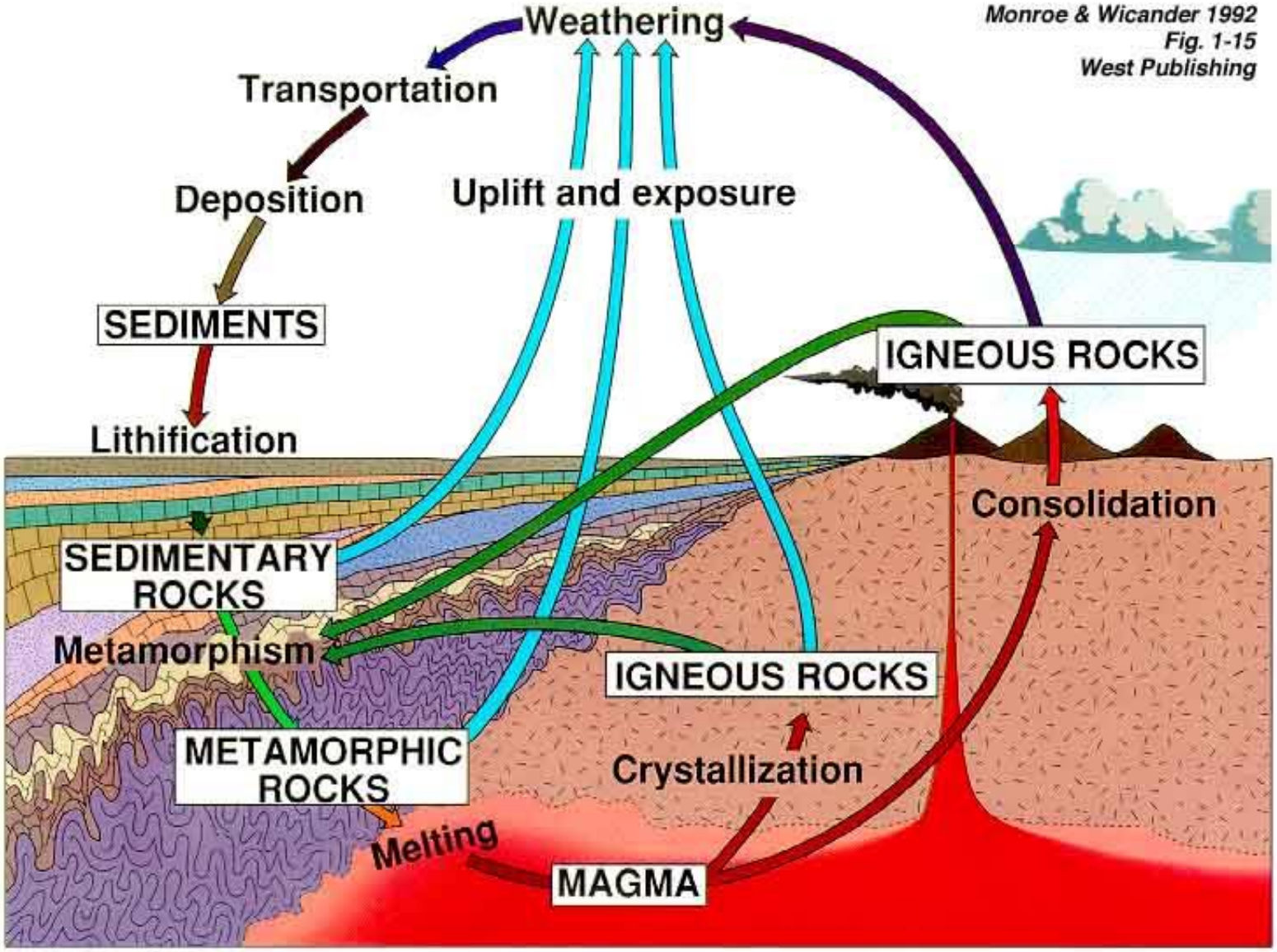
   formed when sediments are compressed or cemented together and harden.

3. **Metamorphic rock –**

   formed by changing existing rock through heat, pressure, or chemical action.

B. The Rock Cycle

Process by which rock is changed from one type to another



C. Properties of Rocks

1. Bowen's Reaction Series –

The order in which minerals crystallize from magma.

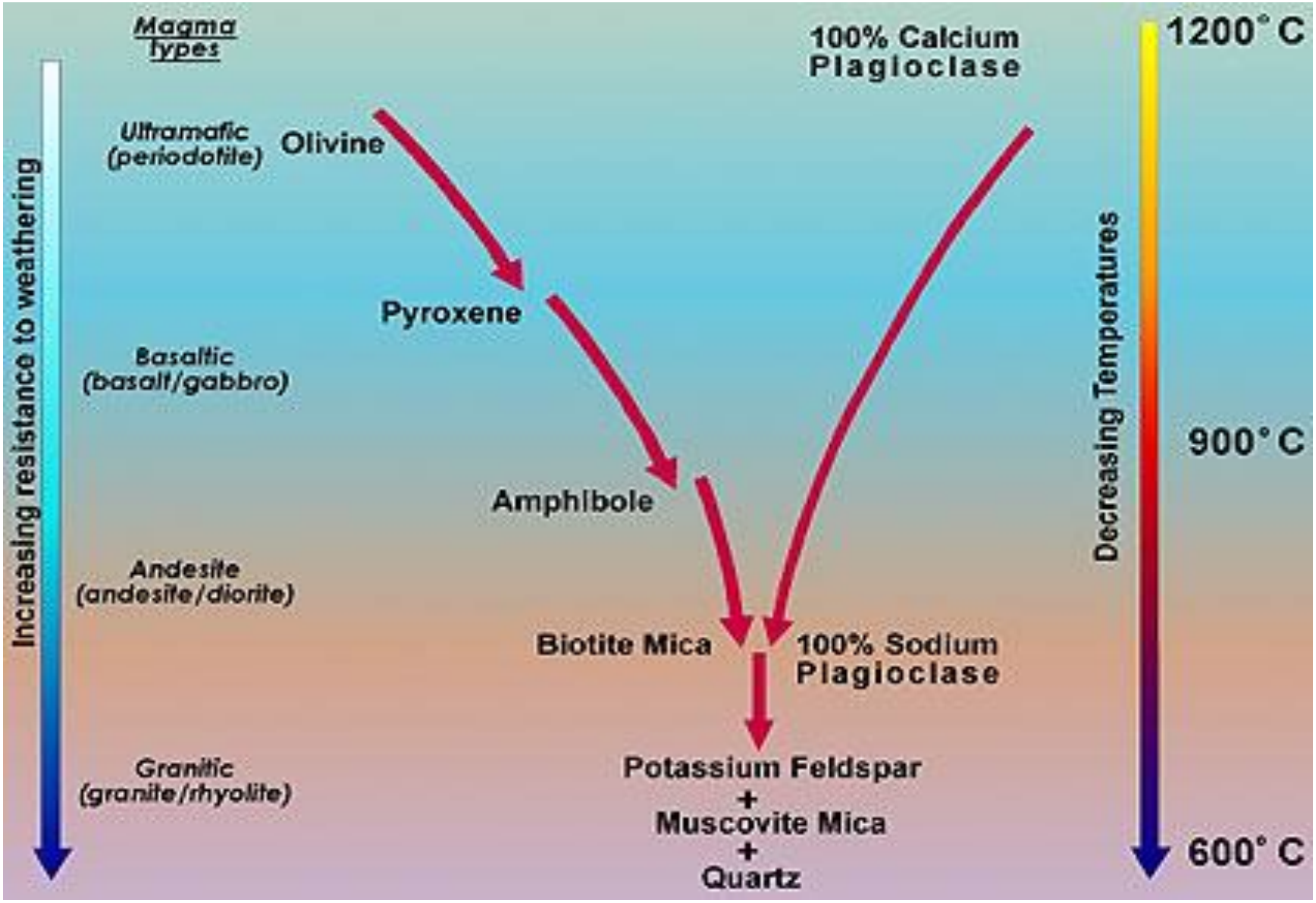
a. **First Way –**

   A gradual continuous formation of minerals that have similar composition.

b. **Second Way –**

   A sudden change in mineral types.

c. **The pattern depends upon the chemical composition of the magma**

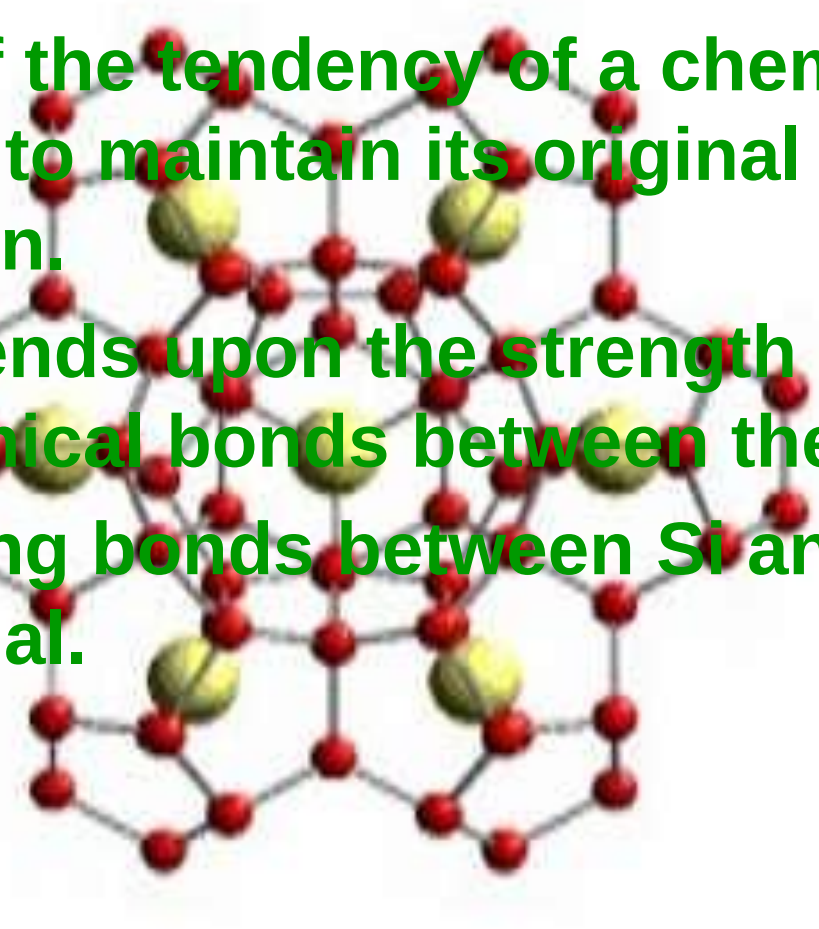

Magma types
Ultramafic (periodotite)
Olivine
Pyroxene
Basaltic (basalt/gabbro)
Amphibole
Andesite (andesite/diorite)
Biotite Mica
100% Calcium Plagioclase
100% Sodium Plagioclase
Granitic (granite/rhyolite)
Potassium Feldspar + Muscovite Mica + Quartz
Increasing resistance to weathering
Decreasing Temperatures
1200° C
900° C
600° C

2. Chemical Stability of Minerals

A measure of the tendency of a chemical compound to maintain its original chemical composition.

a. **Depends upon the strength of the chemical bonds between the atoms.**

b. **Strong bonds between Si and O are crucial.**

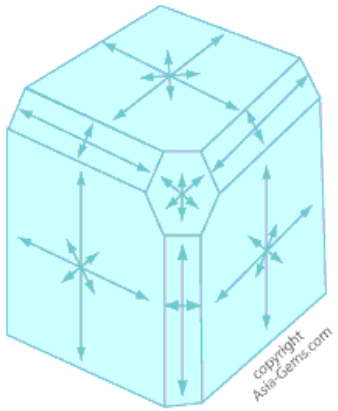


3. Physical Stability of Rocks

a. **Rocks have natural zones of weakness determined by how and where the rocks were formed.**

1. **Sedimentary rocks have layers where they break.**
2. **Metamorphic rocks also have layers.**
3. **Igneous rocks have zones of weakness called joints.**

Diamond Crystal
Showing Direction of Hardness



The arrows indicate the crystal's hardness in that particular direction on that plane.

The shorter the arrow, the harder it will be to cut the diamond in that direction.

II. Igneous Rock

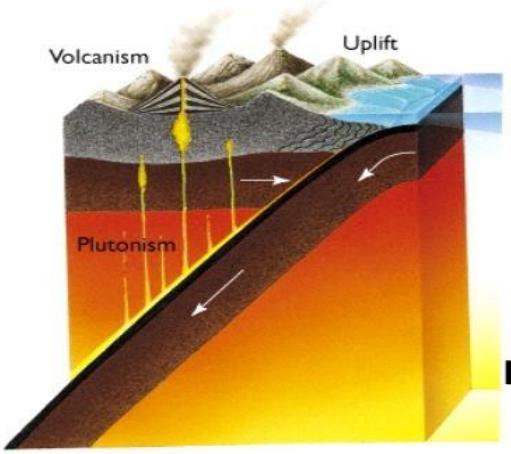
A. The formation of Magma

Rock melting under extreme heat and pressure.

Determined by chemical composition of the minerals in the magma.

1. Partial Melting –

   different minerals melting at different temperatures.

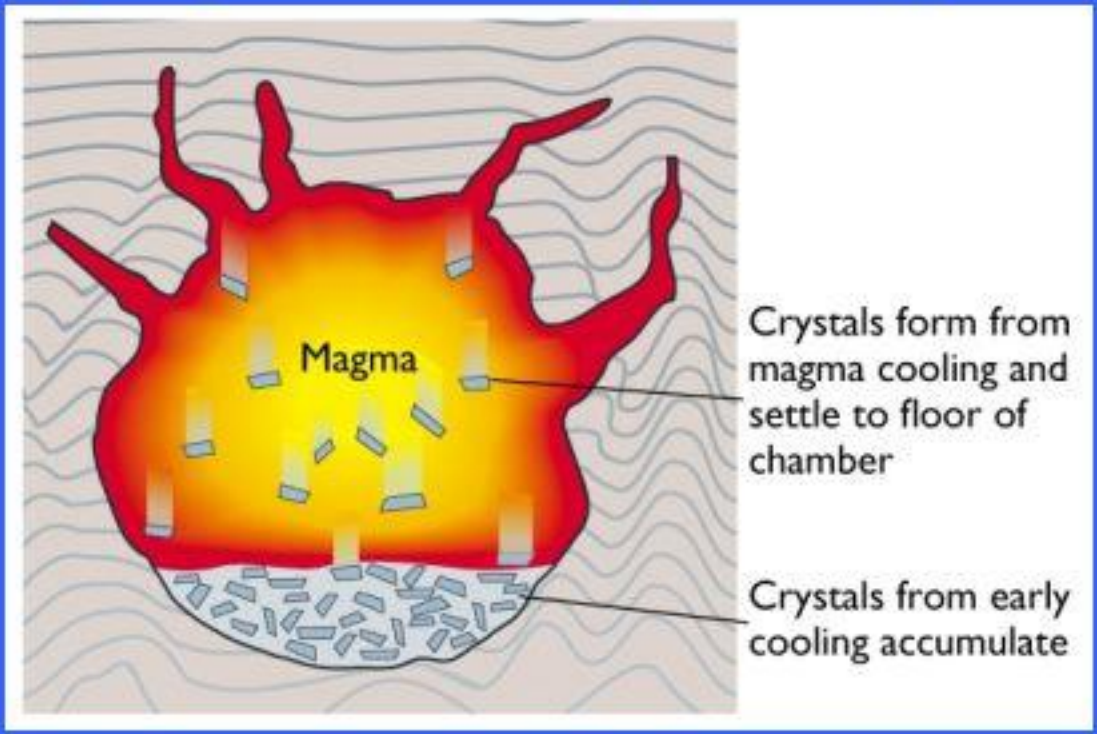


Subduction at convergent plate boundaries causes partial melting to form magma and resulting igneous rocks.

Fig. 3.11a

2. Fractional crystallization

- The process of crystallizing and removal of crystals from the magma
- Composition of crystals is different than magma
- Fractional crystallization results in chemical change in the magma
- High temperature minerals crystallize first (melt last)



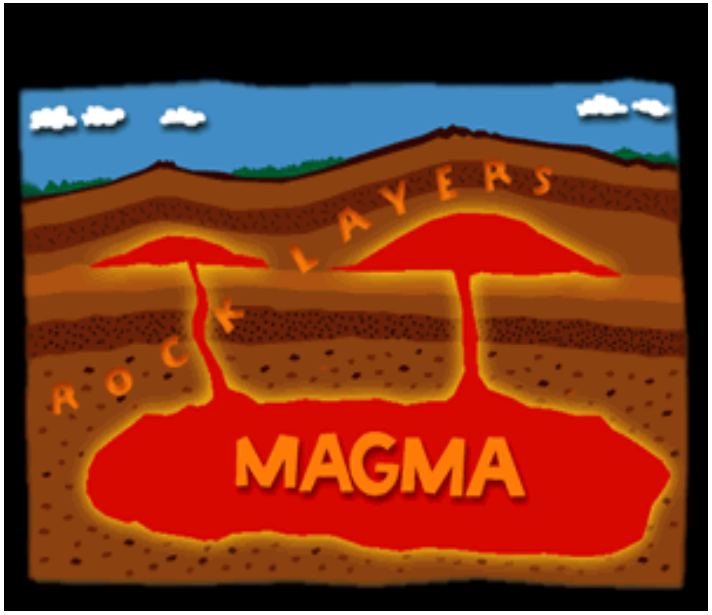
B. Texture of Igneous Rock

Intrusive Igneous Rock –

magma that cools deep inside the crust

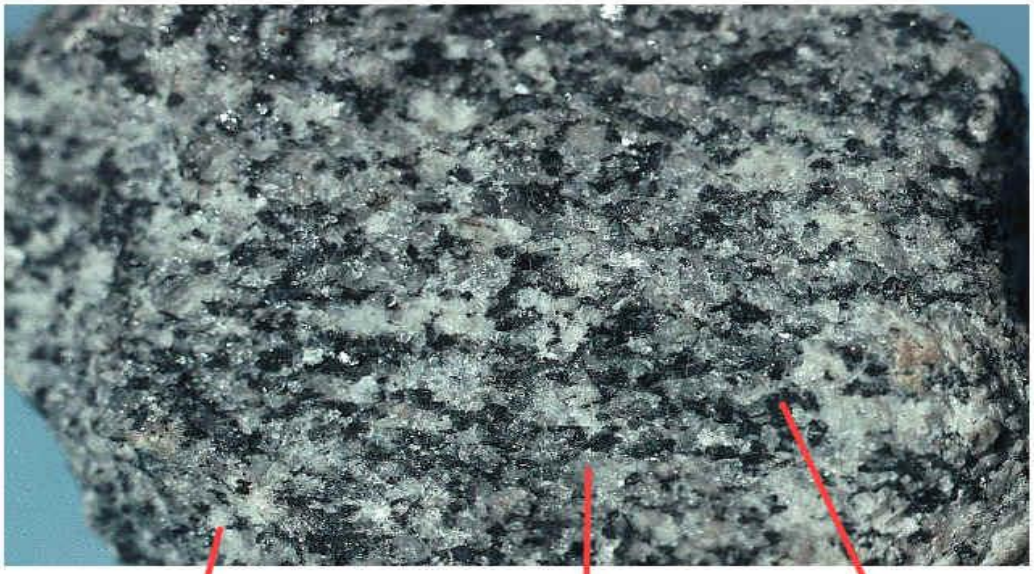
Extrusive Igneous Rock –

magma that cools on the Earth's surface.



1. Coarse-Grained Igneous Rock

a. Intrusive
b. Slow cooling, large crystals
c. granite



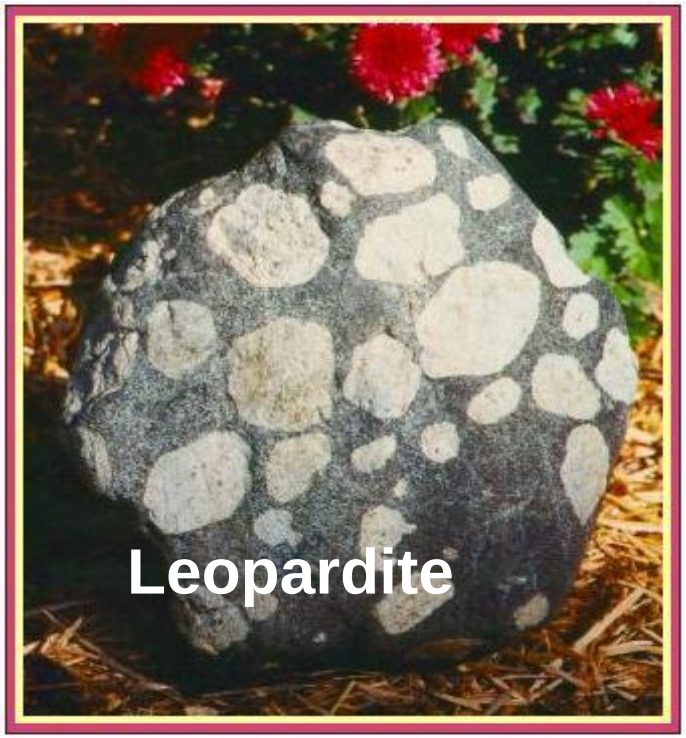
2. Fine-Grained Igneous Rock

a. Extrusive
b. Rapid cooling, small crystals
c. basalt

3. Other Igneous Rock Textures

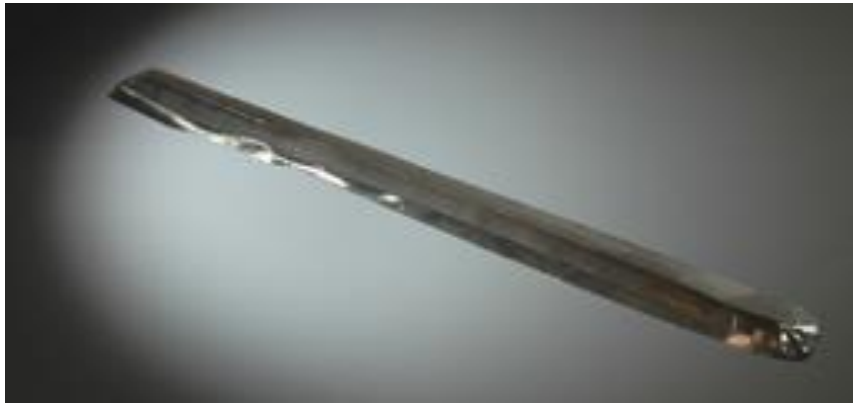
a. Porphyritic –

1. combination of slow and rapid cooling.
2. both small and large crystals.



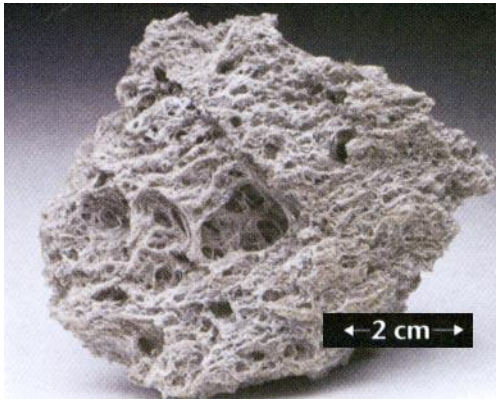
b. Glassy -

1. **Quick cooling, few crystals**
2. **Contains little gas**
3. **Obsidian**



c. Vesicular -

1. quick cooling, few crystals
2. large % of gas
3. Bubbles form, rock has holes
4. Pumice



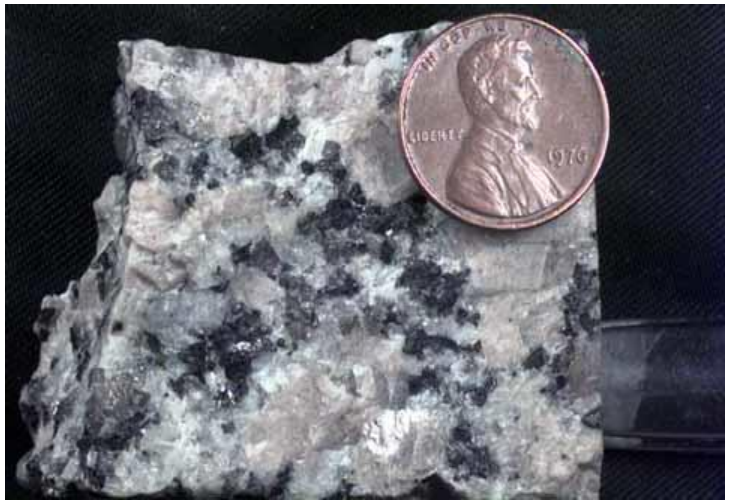
C. Composition of Igneous Rock

Determined by the chemical composition of the magma

1. Felsic Rock – large proportion of Si

Felsic Magma

Common Minerals:	Quartz, ortho, Na Plag	**Typical Rocks:**	Granite & Rhyolite
Silica Content:	> 63 %	**Sample Locations**	Sample Locations
Color:	Light	**Magma Behavior**	Tends to be explosive
Location:	Volcanic arcs & continents		



2. Mafic Rock – low in Si, rich in Fe, Mg

Mafic Magma

Common Minerals:	Pyroxene & Ca Plagio.	Typical Rocks:	Basalt & Gabbro
Silica Content:	45 - 52 %	Sample Locations	Sample Locations
Color:	Dark Gray	Magma Behavior	Tends to be hot & fluid
Location:	Ocean basins/hot spots		

3. Intermediate Rock

a. Contains Si between Mafic and Felsic.

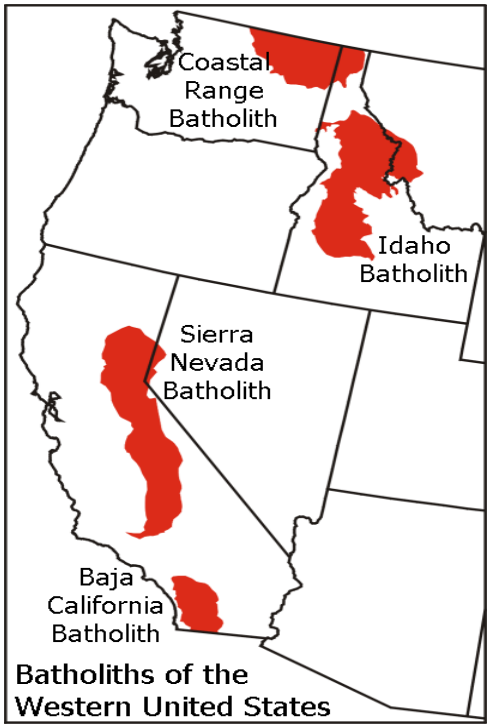
Intermediate Magma

Common Minerals:	Amphibole Ca/Na Plagio.	Typical Rocks:	Diorite & Andesite
Silica Content:	57 - 63 %	Sample Locations	Sample Locations
Color:	Intermediate	Magma Behavior	Tends to be explosive
Location:	Volcanic arcs/convergent boundaries		

D. Intrusive Igneous Rock Structures

Igneous rock structures that form underground

1. **Batholith –**
   a. **Largest of all intrusions**
   b. **Spread over 100 km^2**
   c. **Forms cores of many mountain ranges.**



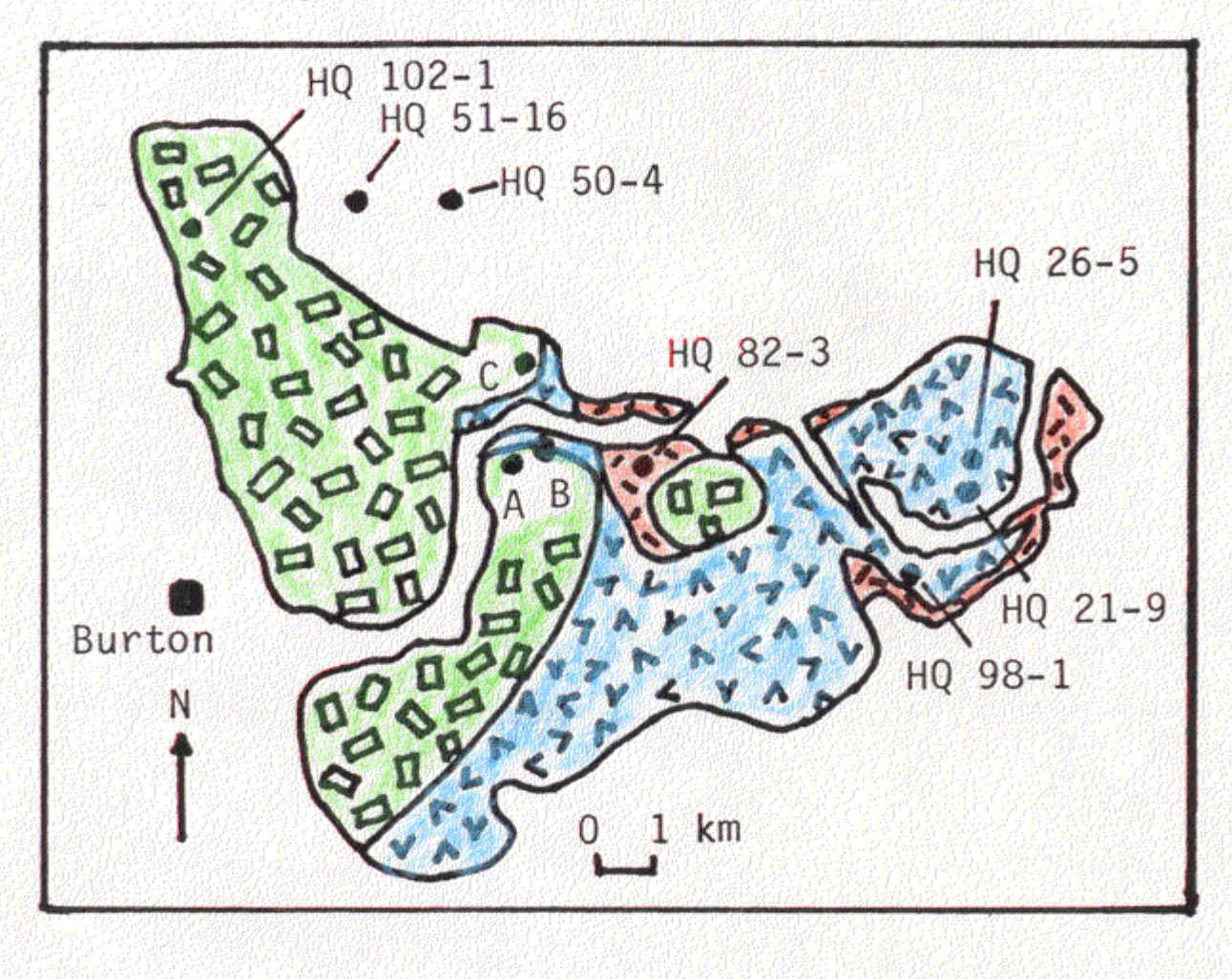
Batholiths of the Western United States


Castle Peak

2. **Stock -**

   a. **Same as a Batholith but not as large.**

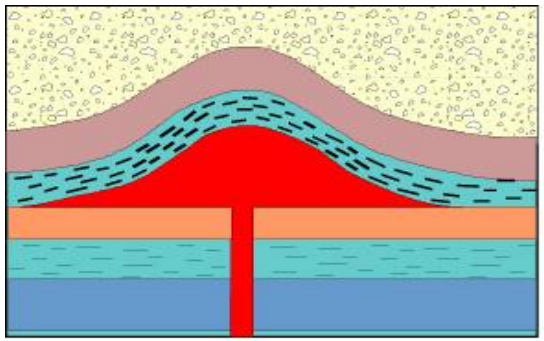
   b. **Less than 100 km^2**



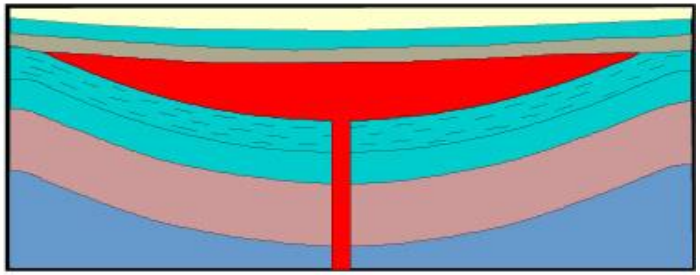
3. Laccoliths -

Dome shaped underground magma intrusion.

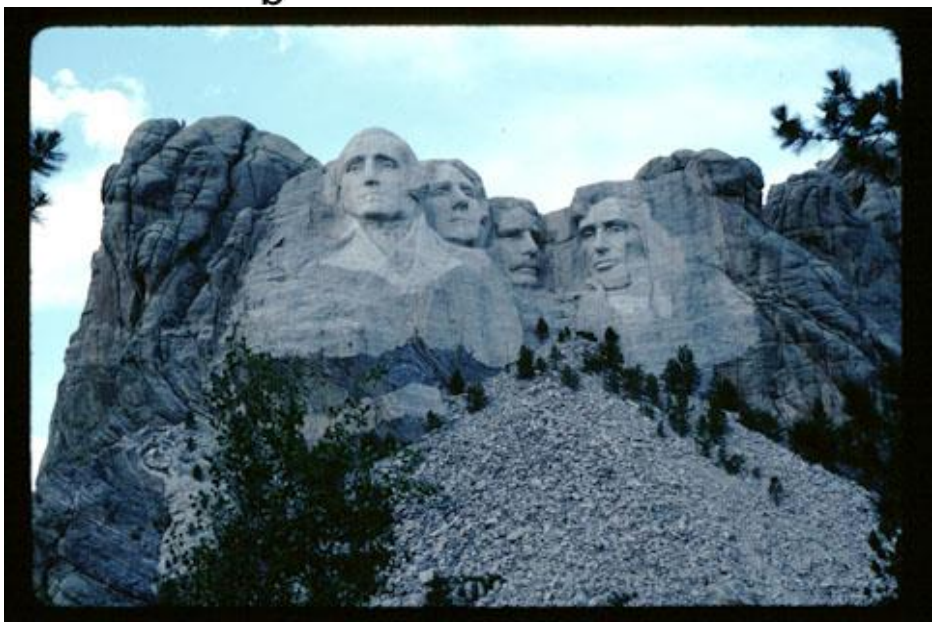
Usually occur in groups.

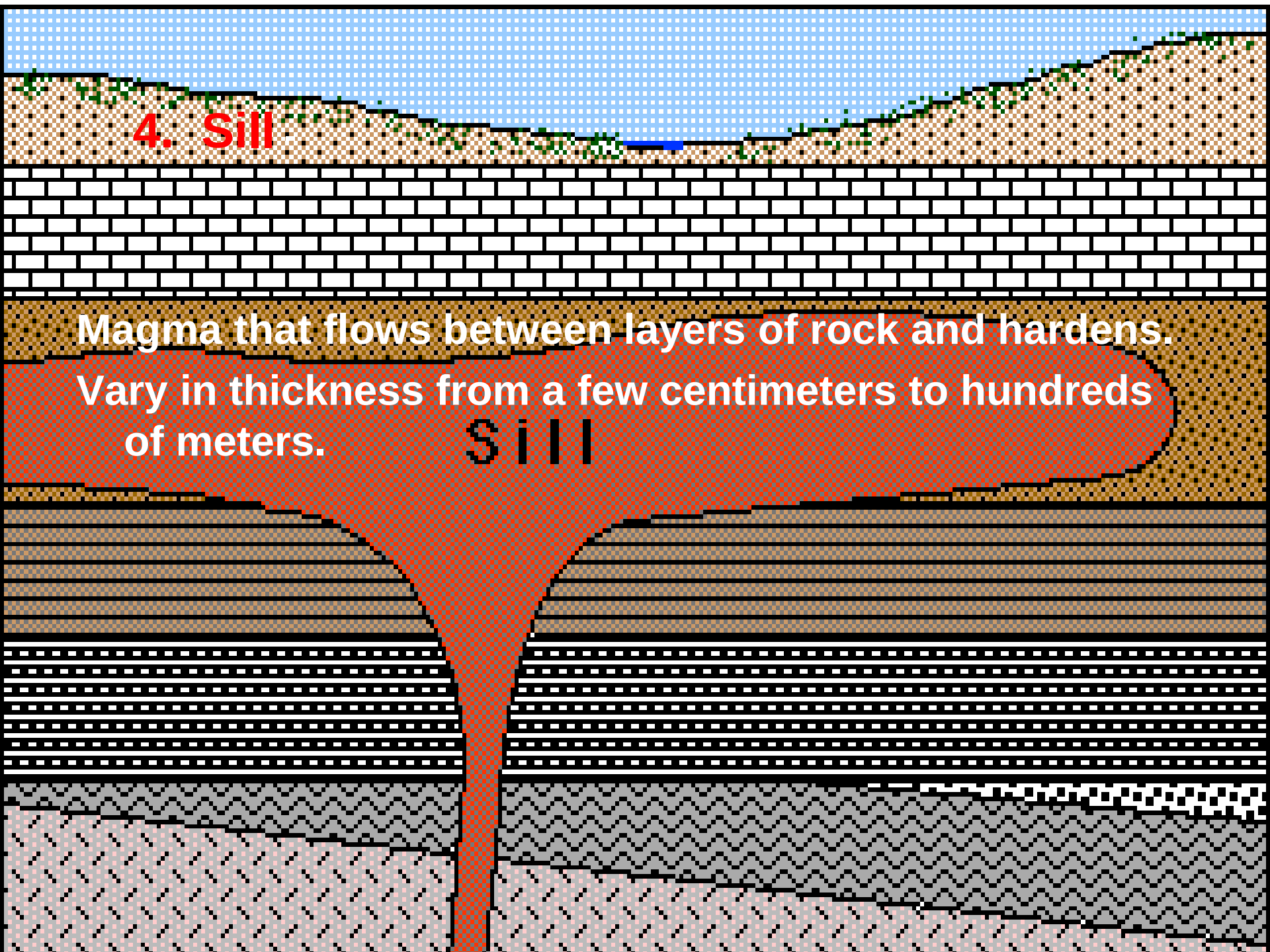


a



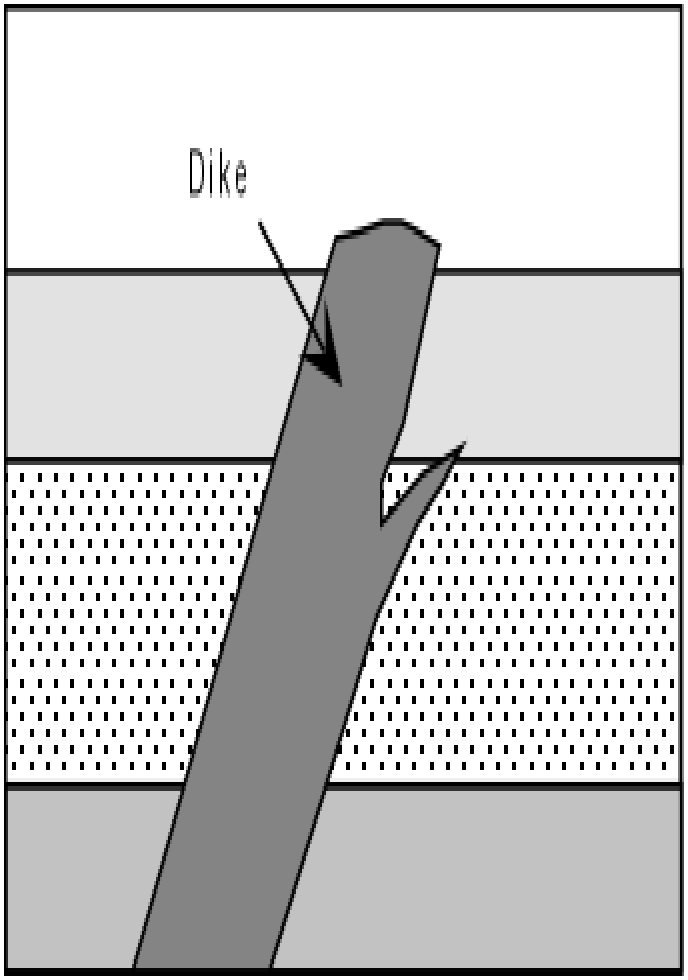
b




4. Sill
Magma that flows between layers of rock and hardens.
Vary in thickness from a few centimeters to hundreds of meters.
Sill

5. Dikes -

Magma that flows through vertical fractures and hardens.

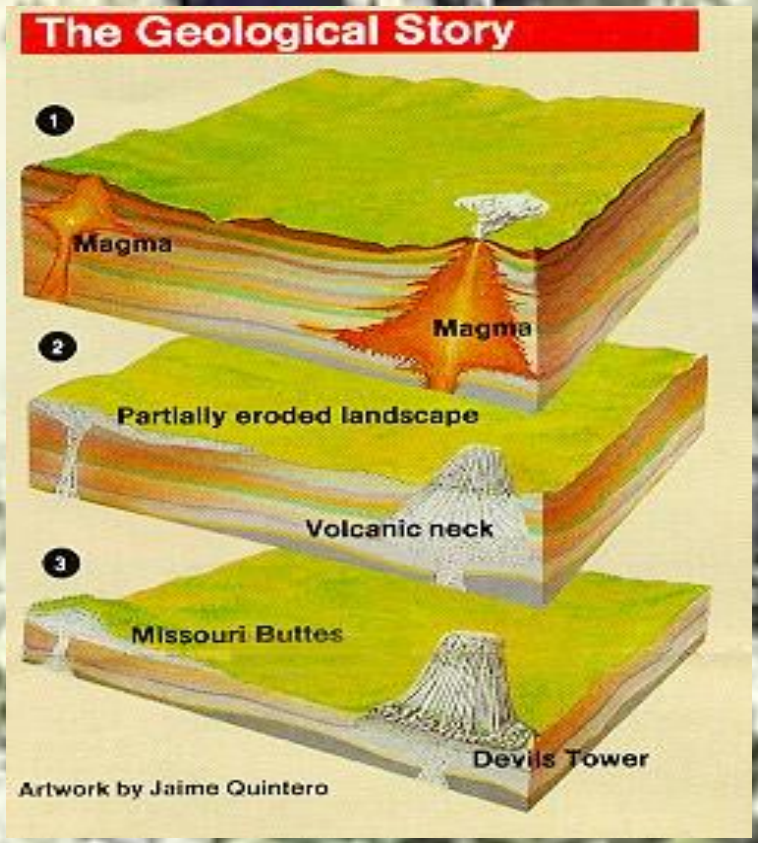


E. Extrusive Igneous Rock Structures

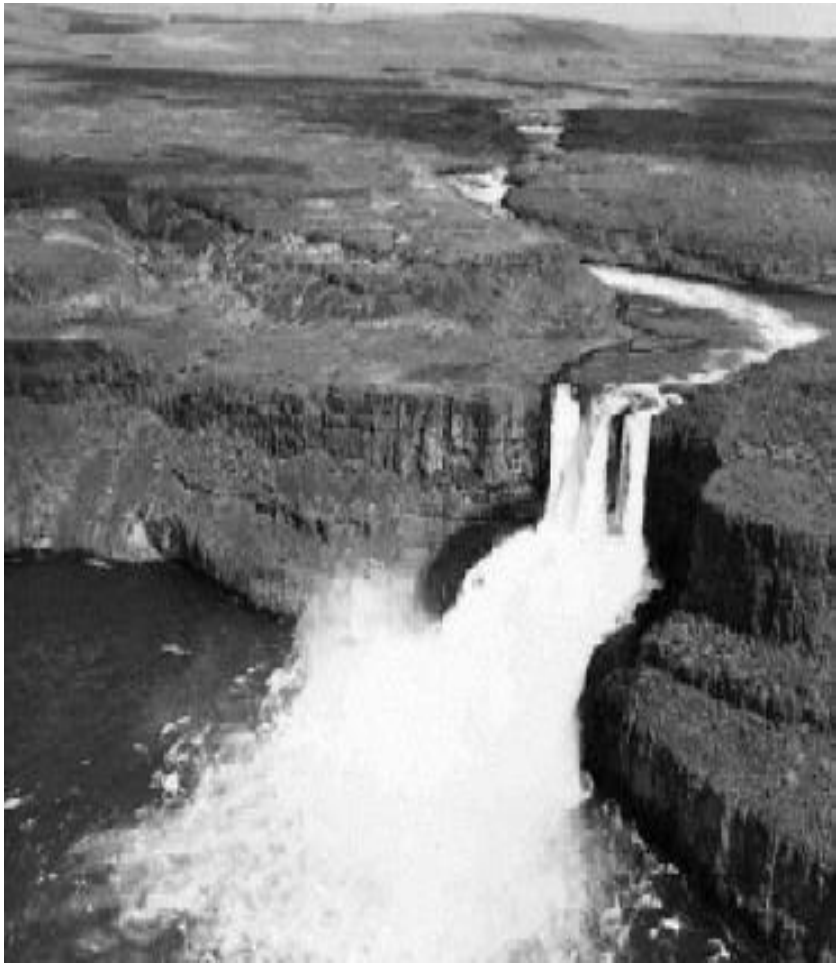
Igneous rock masses that form on the Earth's Surface

1. Volcanic neck –

   Solidified central vent of an extinct volcano



2. Lava Flows



Lava Plateau

3. Tuff

Volcanic Ash Deposits

◀ **FIGURE 4.16**
The Pinnacles, Crater Lake National Park. Striking erosional forms developed in the thick tephra blanket left by the catastrophic eruption of Mount Mazama 6600 years ago.

Pompeii

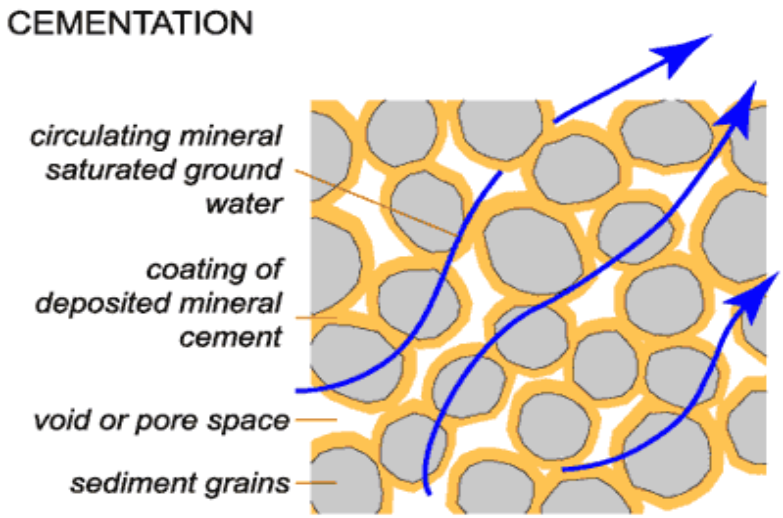
III Sedimentary Rock

A. Formation of Sedimentary Rock

* Sediments form from erosion
* Sediment composition determined by source
* Sediment is broken down or chemically altered
* Sediment is deposited.
* Compaction –

  Sediment is squeezed by weight and pressure
* Cementation –

  Sediments are glued together by minerals deposited by water.



From Weathering to Sedimentary Rock

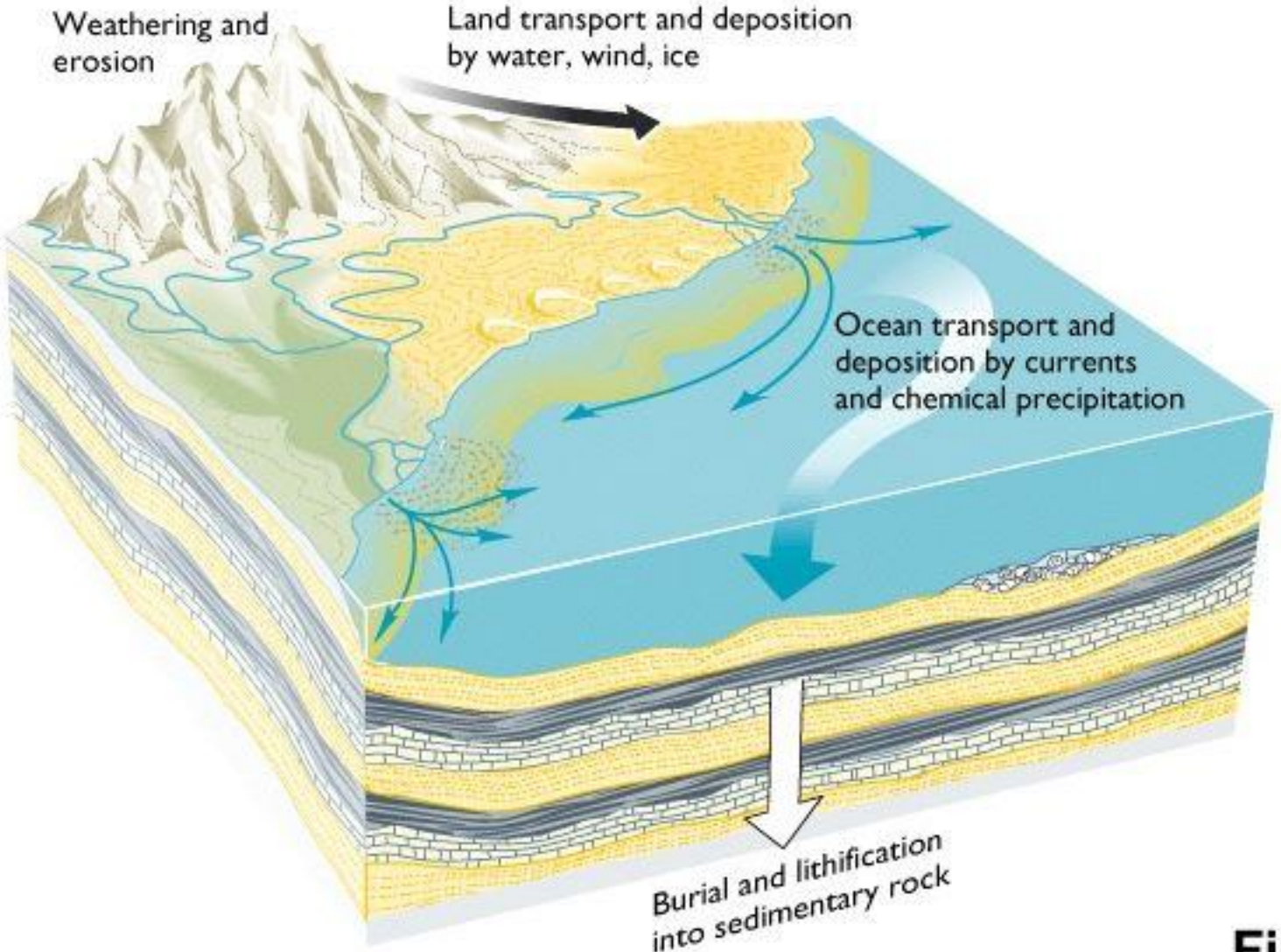
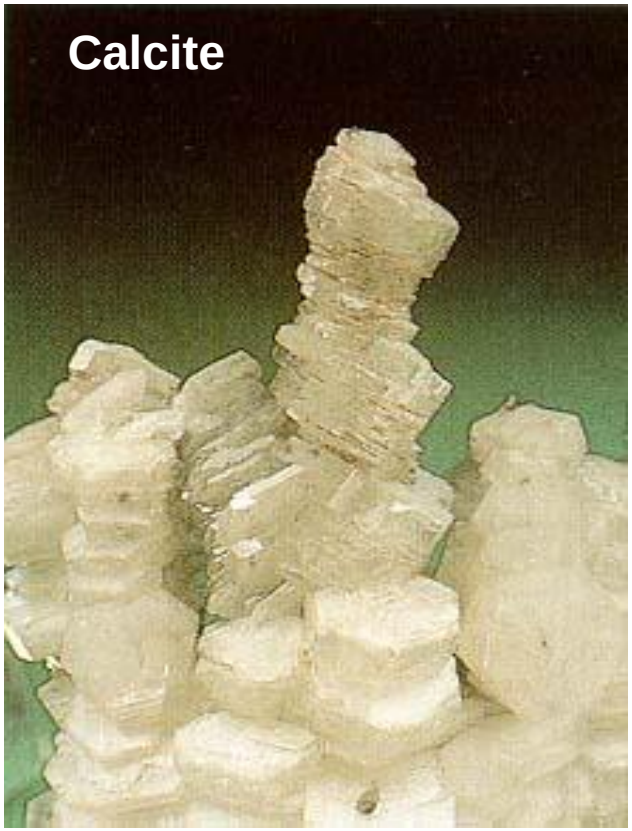


Fig. 3.3

1. Chemical Sedimentary Rock

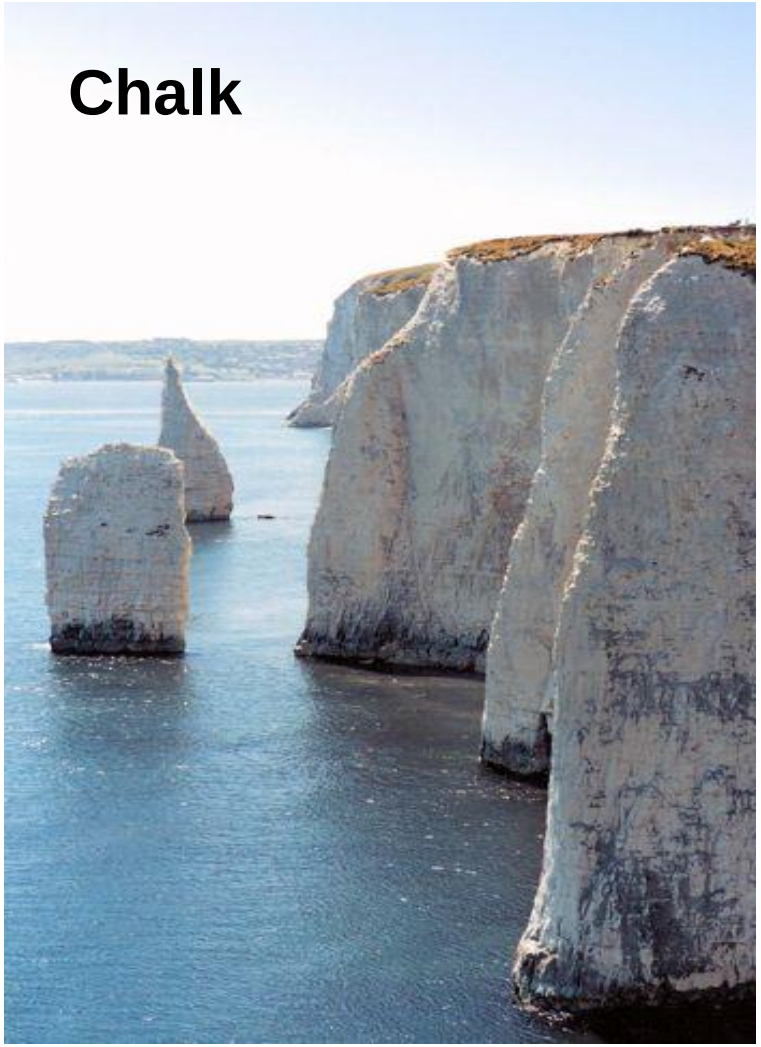
Formed from minerals that were once dissolved in water and then precipitated due to the evaporation of the water.



How they are formed
When water washes over and through rocks, some of the minerals from the rocks are dissolved and carried in the water. When the water evaporates or the minerals precipitate out of it the chemical sediment (the previously dissolved minerals) are deposited. These sediments go through the same lithification process as detrital sedimentary rocks.

2. Organic Sedimentary Rock

Forms from the remains of once living things



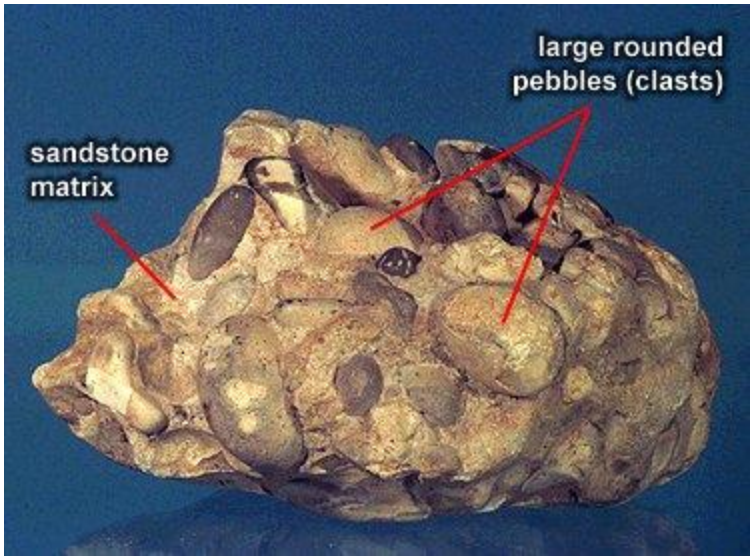
3. Clastic Sedimentary Rock -

Formed from fragments of rock moved from their original source by erosion and deposited in other areas.

Classified by the size of the particles in the sediments.

a. Conglomerate –

rounded fragments from sand grains to boulders.

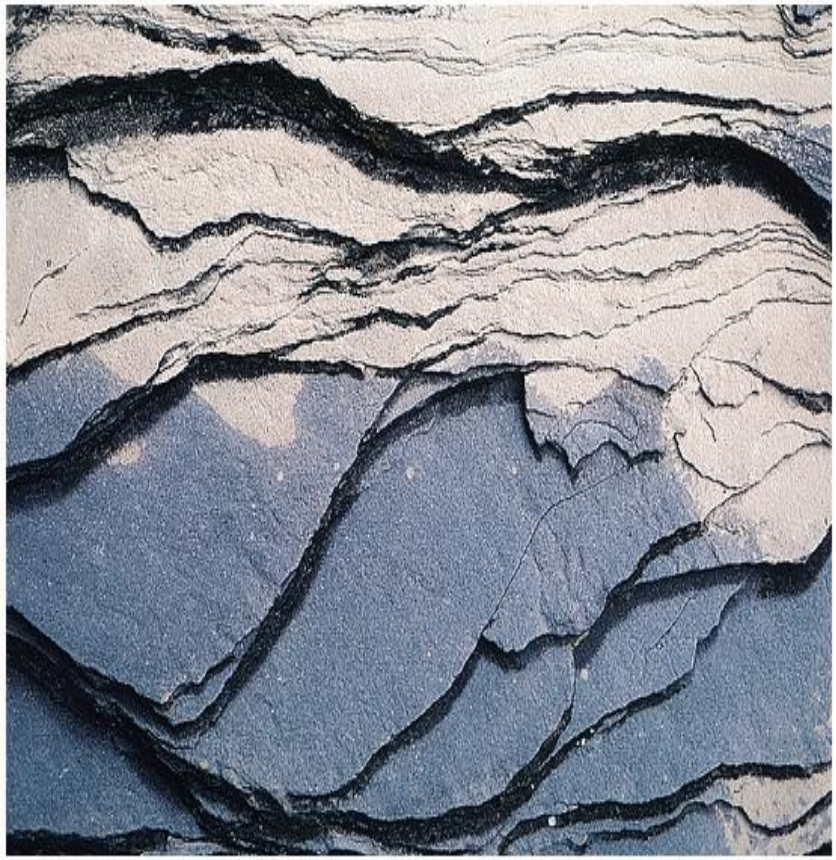


b. Sandstone -

Sand-sized grains cemented together, fluids and gases can move between the grains.

c. Shale -

Clay sized particles cemented together into flat layers that easily split apart.



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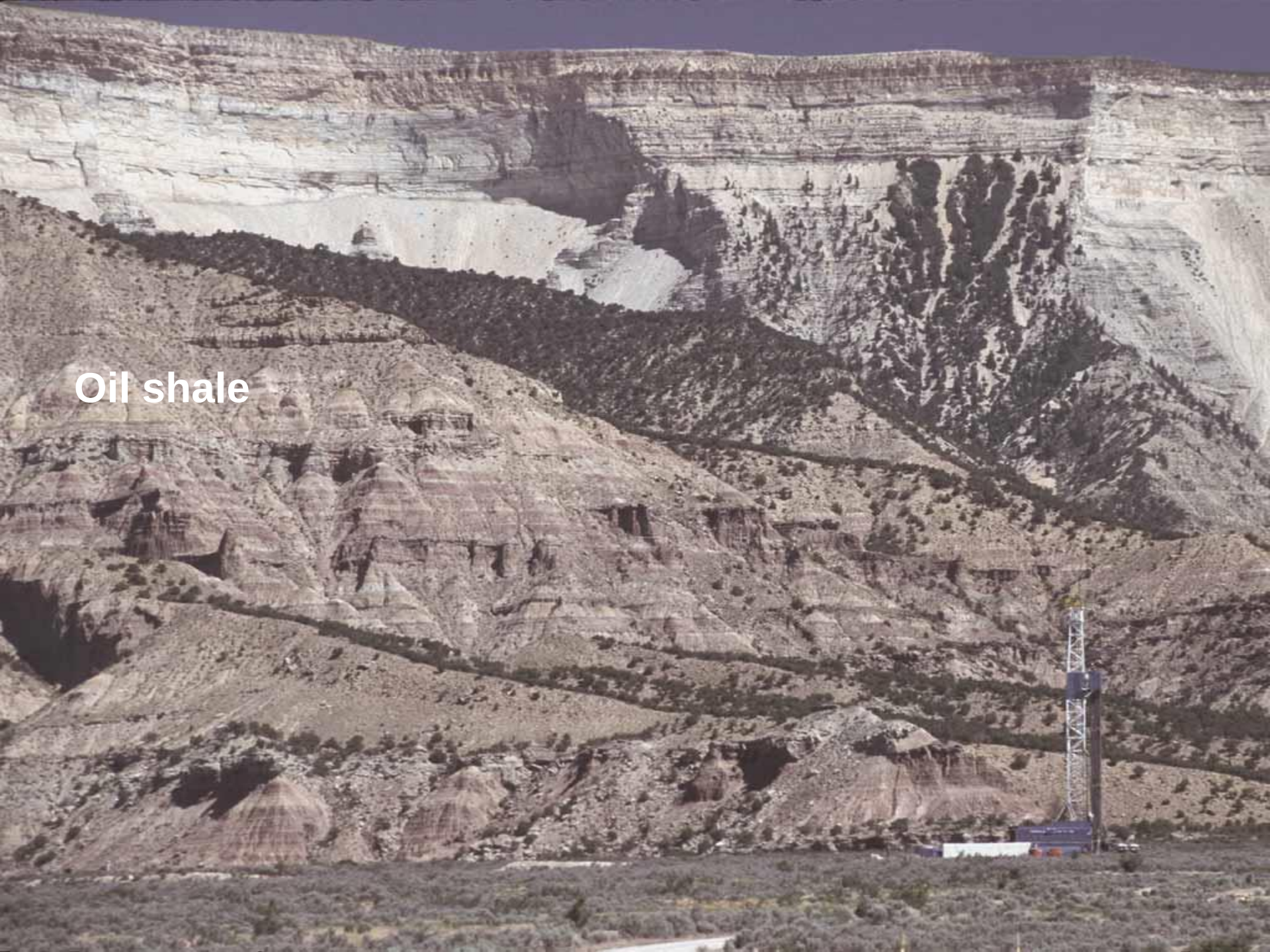
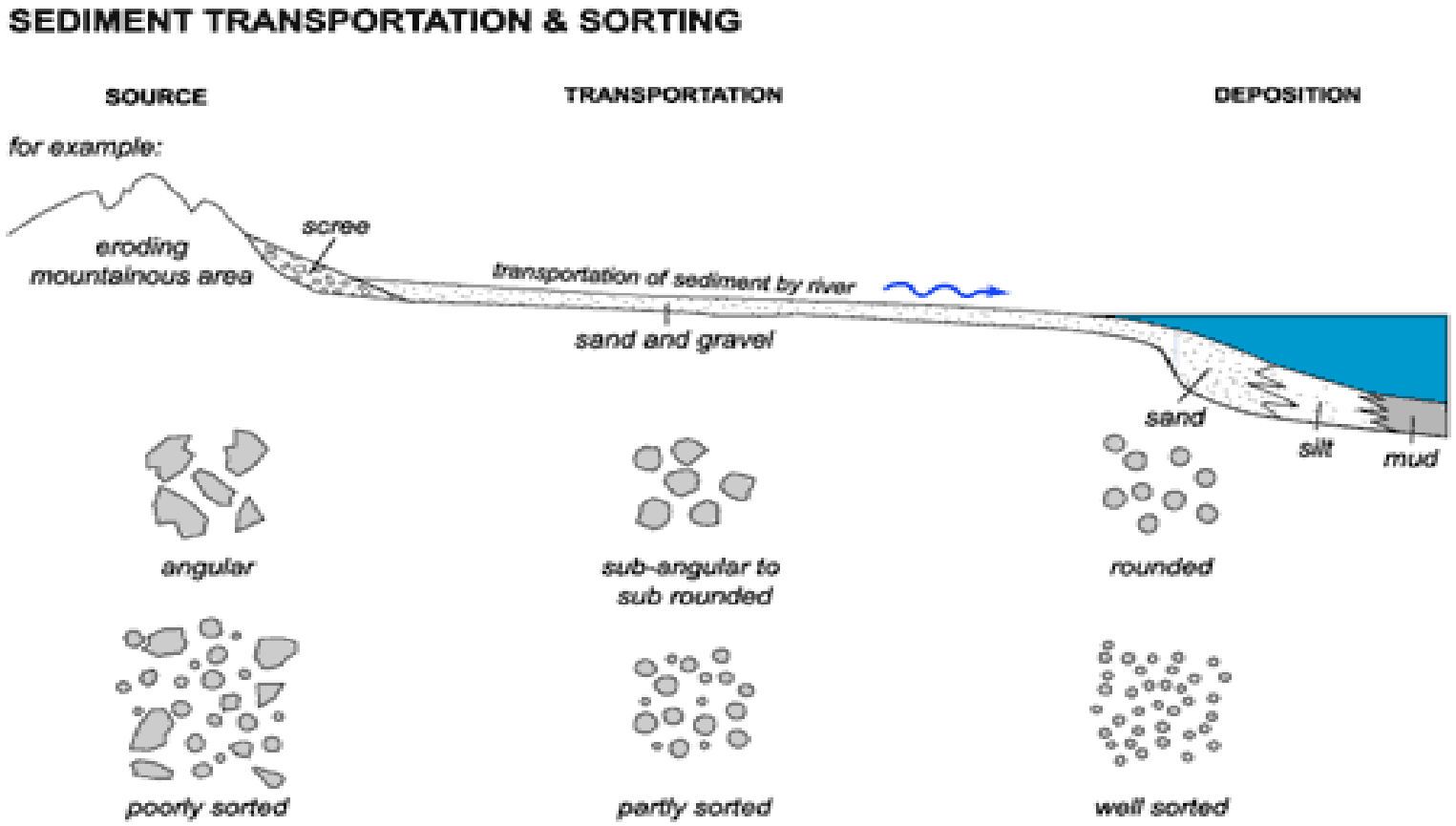

Oil shale

4. Characteristics of Clastic Sediments

a. Sorting –

1. separating sediments according to size.
2. result of changes in speed of the agent moving the sediment.



b. Angularity -

Change in shape of particles as they collide with other particles in their path.

1. **Long distance – fine and round**
2. **Short distance – larger, rougher.**

5. Sedimentary Rock Features

a. Stratification –

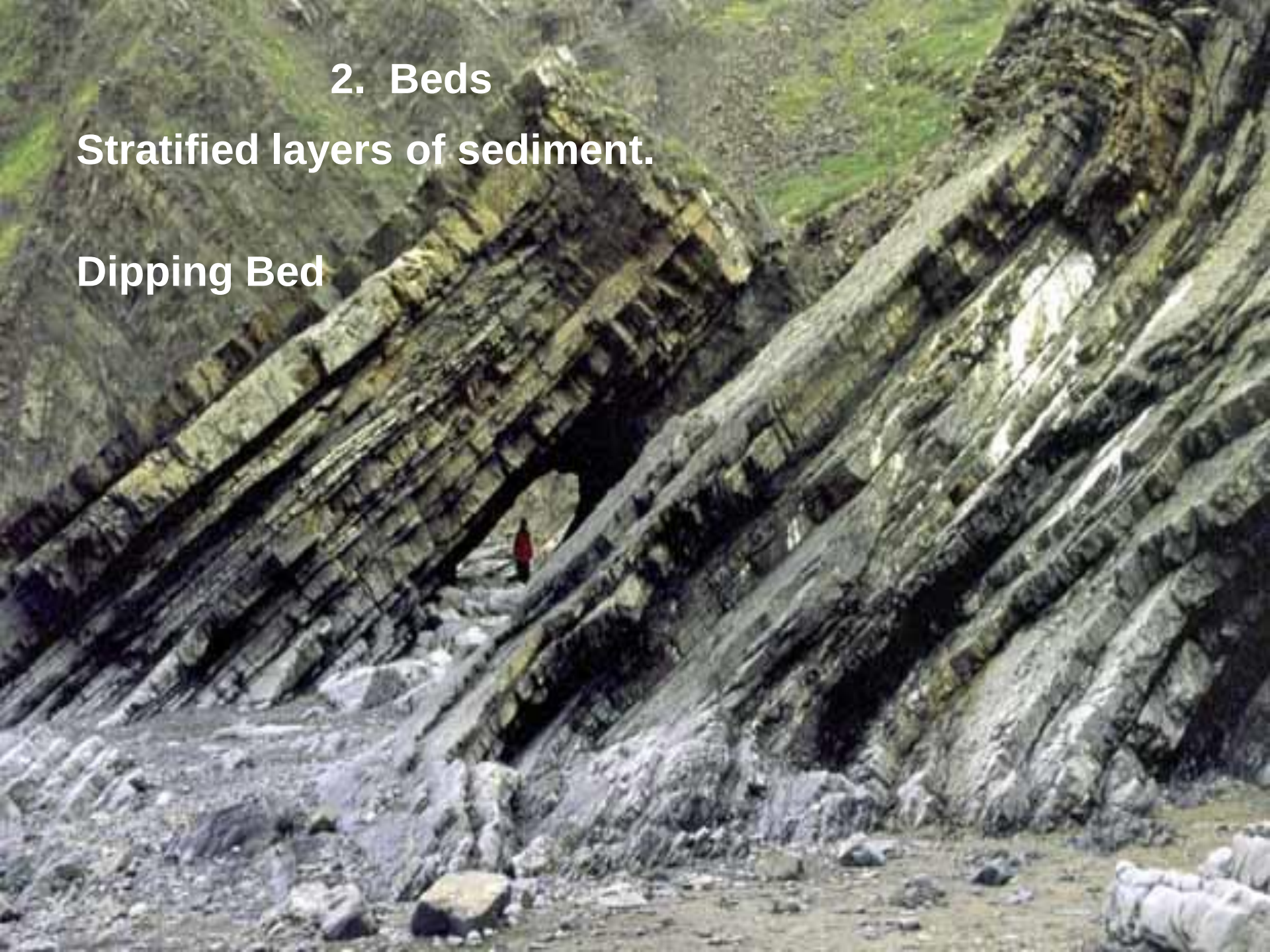
Layering of Sedimentary Rock

1. caused by changes in deposition conditions.
    a. Change in sediment type
    b. Change in physical environment.

2. Beds

Stratified layers of sediment.

Dipping Bed

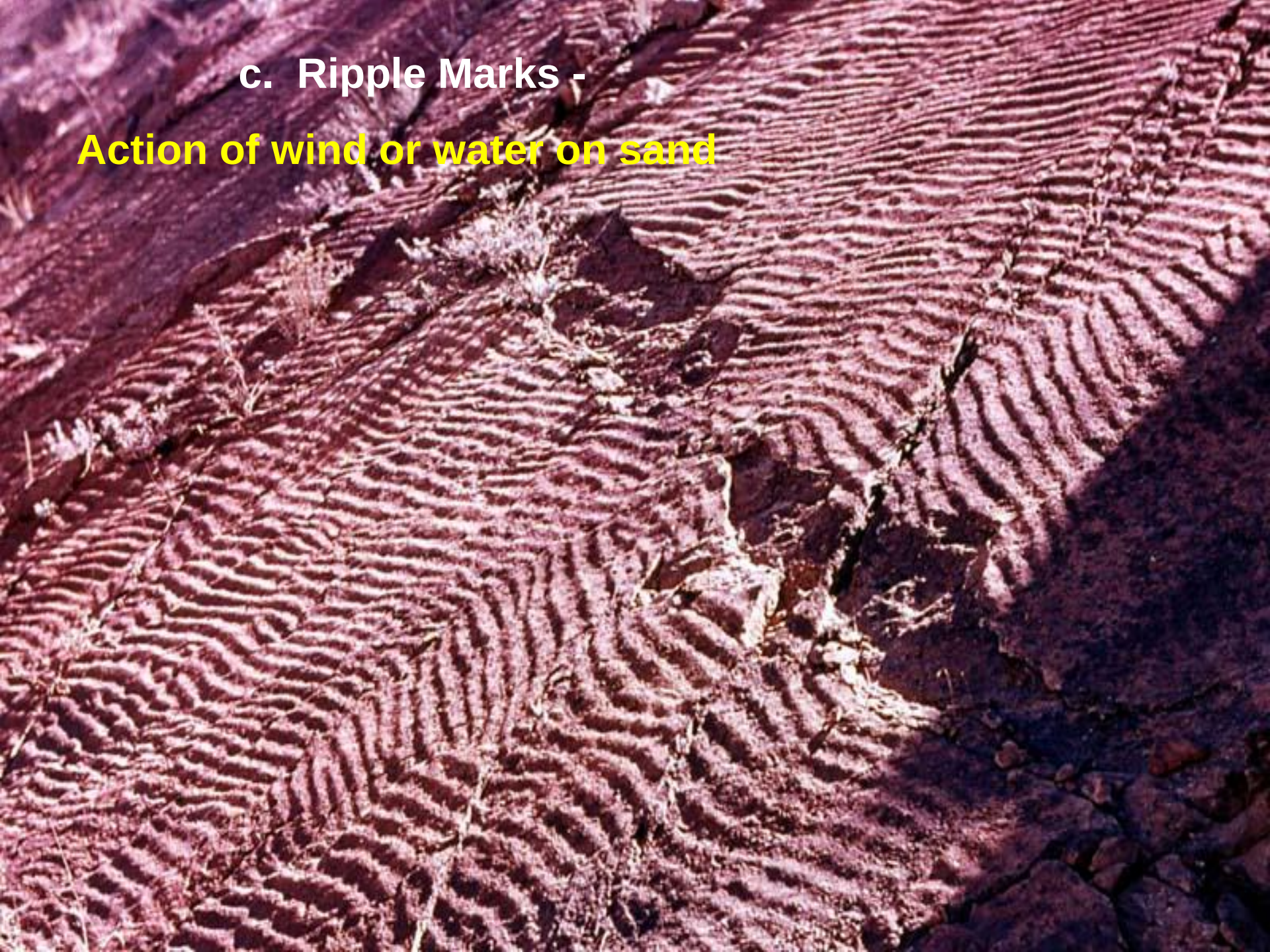


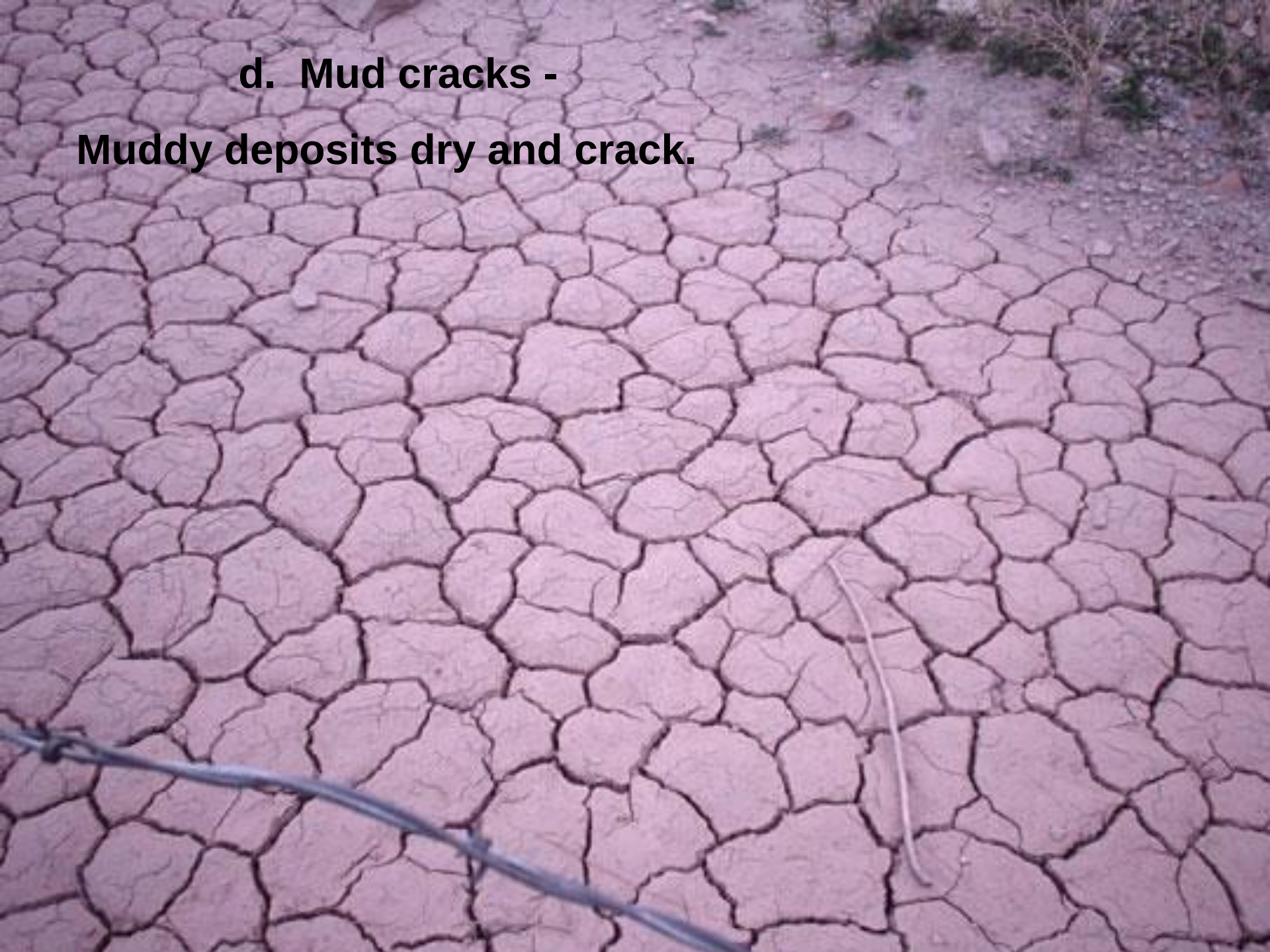
b. Cross-Beds and Graded Bedding

1. **Cross-Beds are slanted layers that form within beds.**
2. **Graded beds are sediments of different sizes being deposited largest on bottom, smallest on top.**

Vasquez Formation, Transverse Ranges, CA

Note the sharp contact between the underlying shale and the overlying coarse, graded bed. Faint cross stratification is present in the coarser bed and overlying sand. This style of deposition is consistent with fluvial deposition, which is the broader interpretation of the Vasquez Formation.


c. Ripple Marks -
Action of wind or water on sand



d. Mud cracks -

Muddy deposits dry and crack.

e. Fossils and concretions

1. Fossils –

remains or traces of ancient plants and animals.

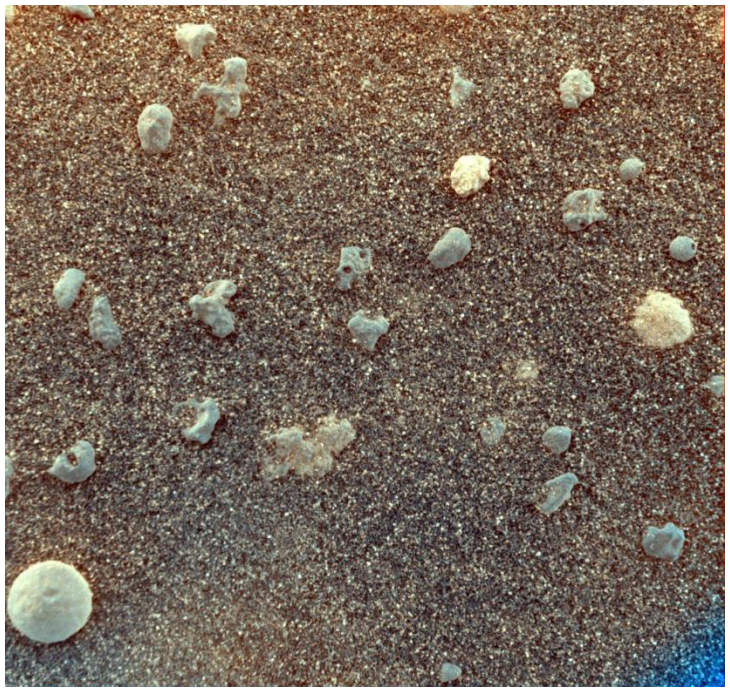
2. Concretion -

Lumps of rock in sediments that have a composition different from the main rock body.

Precipitation of minerals from fluids around a nucleus.

a. Geode –

minerals deposited inside cavaties in sedimentary rock.



III. Metamorphic Rock

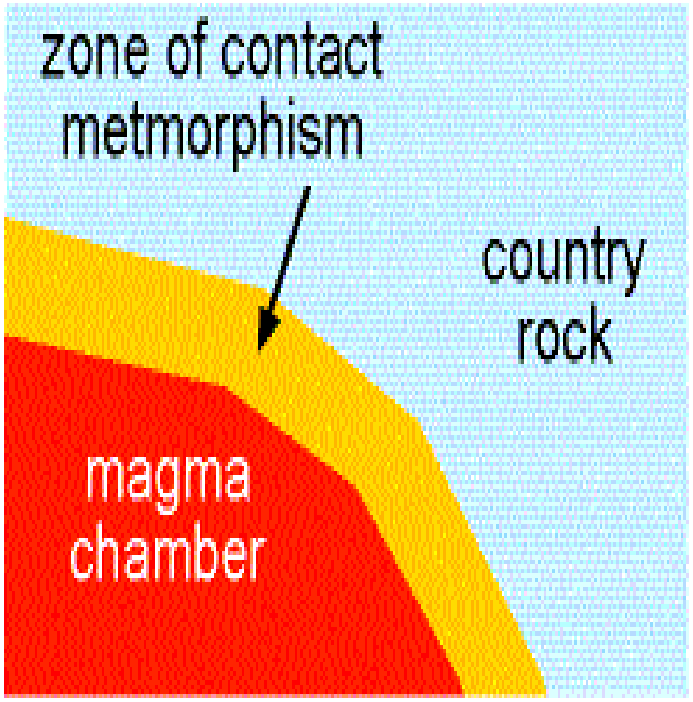
A. Formation of Metamorphic Rock

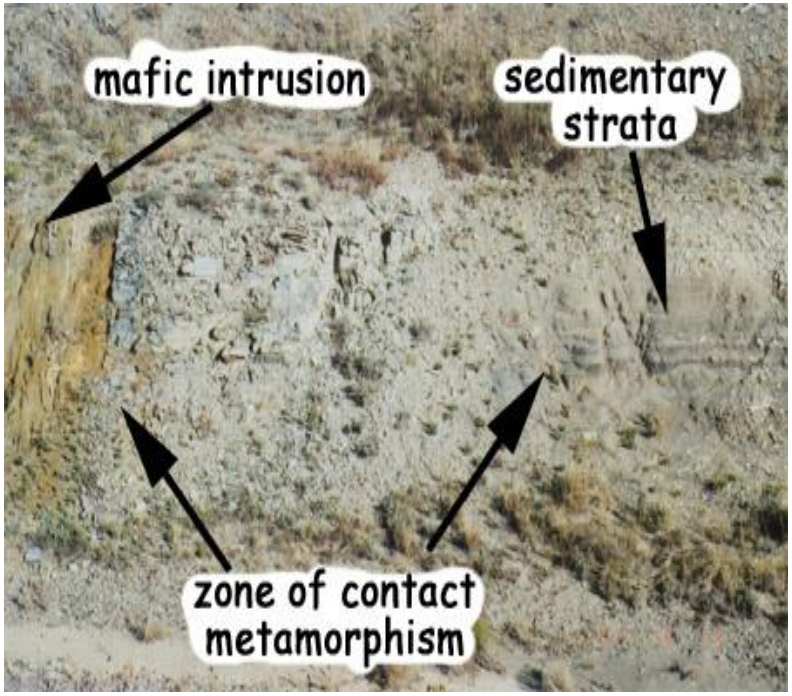
Heat, pressure, hot fluids cause some minerals to change into other minerals.

The amount of heat, pressure and the chemical composition of the rock will determine what combinations of minerals will form.

1. Contact Metamorphism

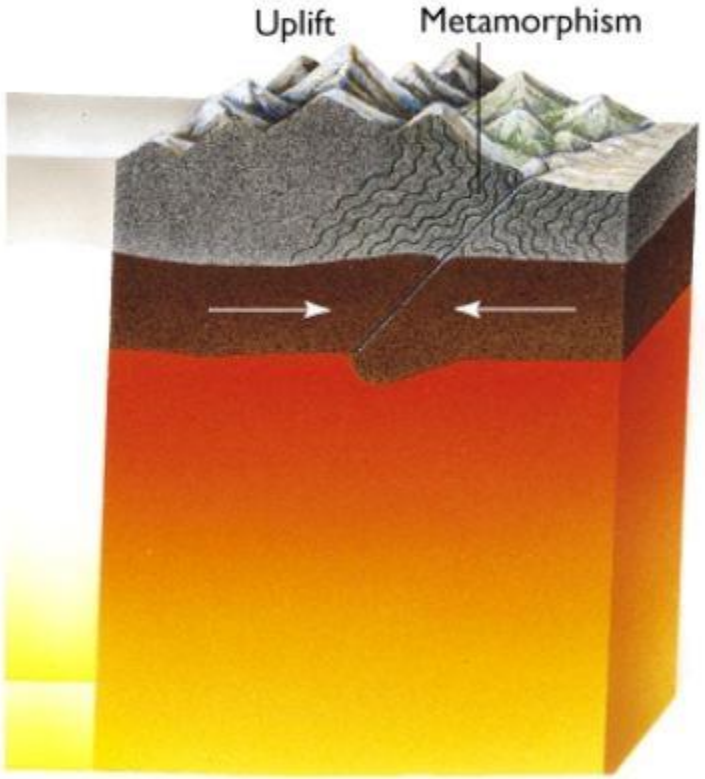
Small areas of rock that surround hot magma is changed by the magma's heat.





2. Regional Metamorphism -

Occurs over a large area during periods of high tectonic activity.



Convergence of plates causes deformation, uplift, and regional metamorphism.

B. Classification of Metamorphic Rocks

1. Foliated Rocks –

Texture in which minerals are arranged in planes or bands.

Caused by extreme heat and pressure to minerals that have different composition.

slate, schist, gneiss

a. shale → low heat, low pressure → slate

b. Slate → med heat, med pressure → schist

c. Schist → high heat, high pressure → gneiss


Shale


Slate


Schist
Sparkles and
glitters


Schist
Sparkles and
glitters

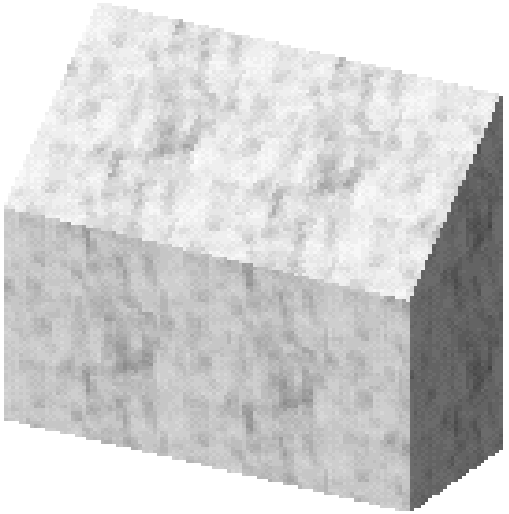

gneiss

2. Non-foliated Rock

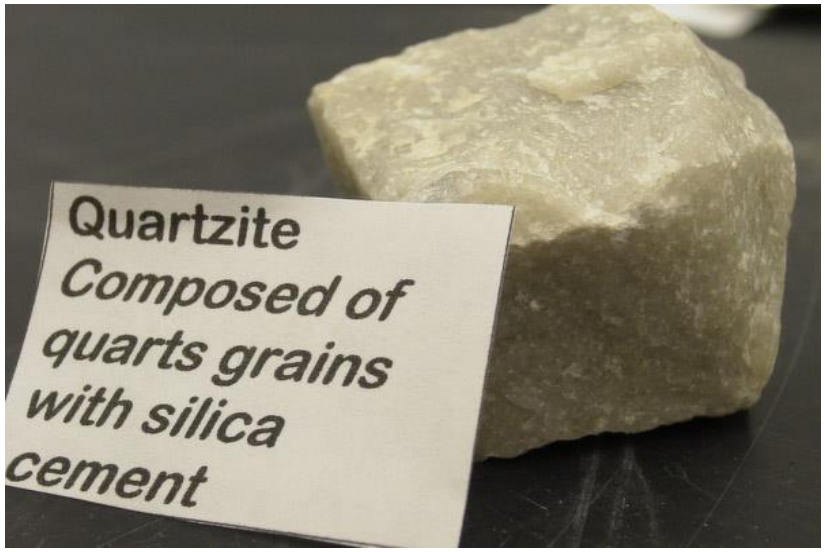
Do not have bands or aligned minerals.

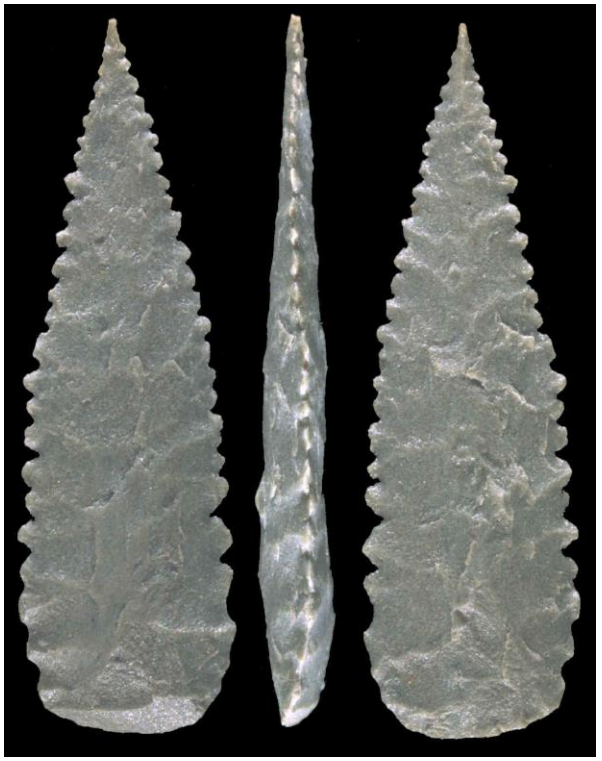
a. **Composed of one kind of mineral.**
b. **Composed of round or square grains that do not change position.**
c. **marble**

→



Quartzite



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