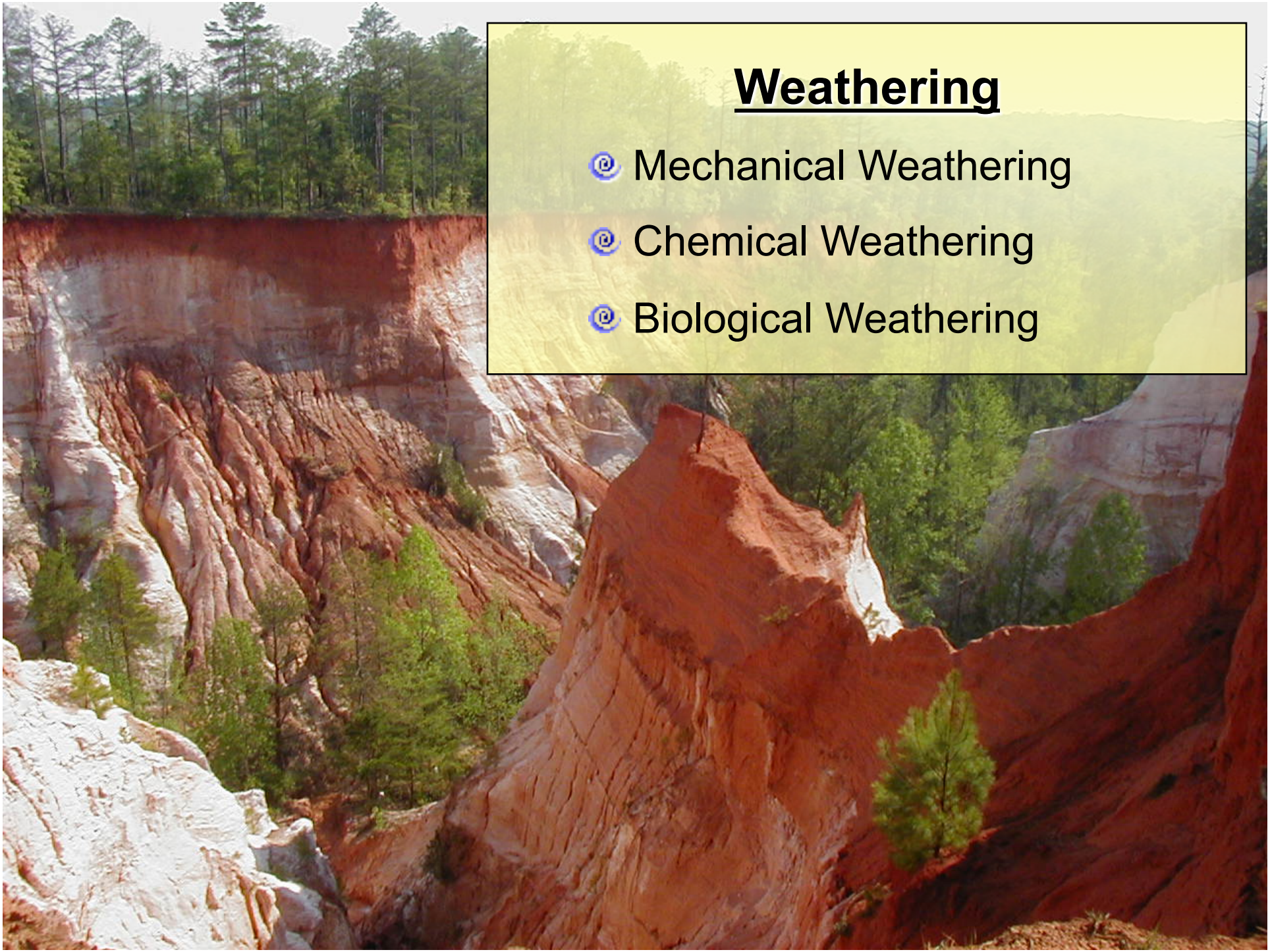


# Weathering

- Mechanical Weathering
- Chemical Weathering
- Biological Weathering

# Mechanical Weathering

Includes all processes that crack, abrade, crunch, and otherwise break rocks.

# Unloading Exfoliation

Expansion of igneous rock at surface pressures causes fracturing and shedding of outer layers

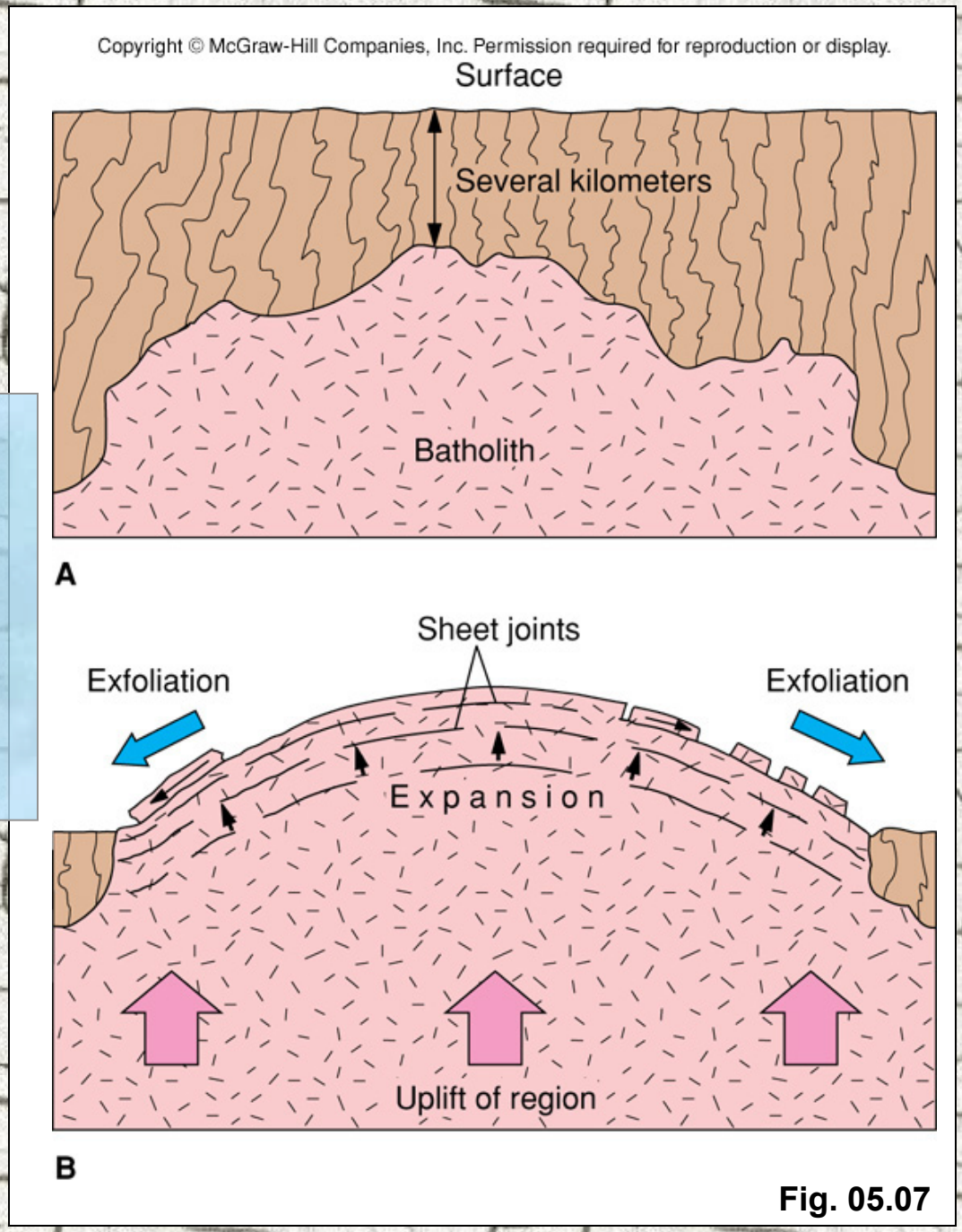
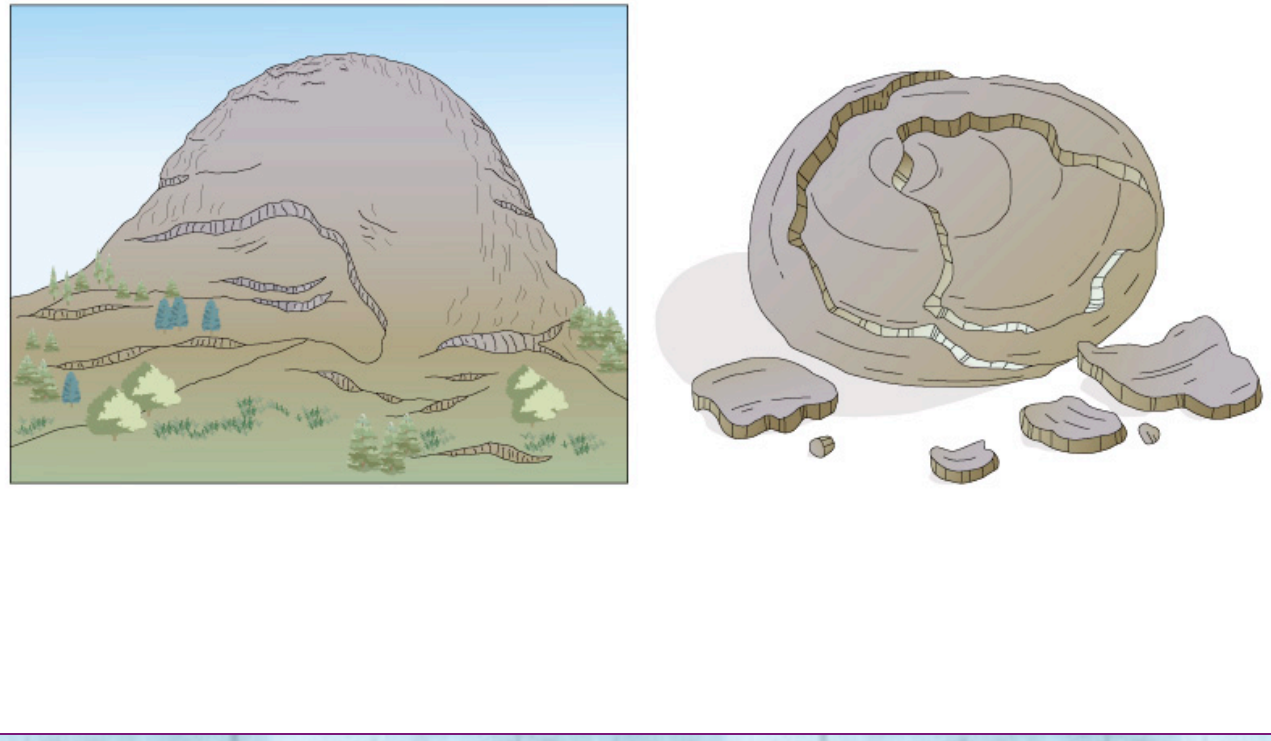



Fig. 05.07

# Mechanical Weathering

## *Unloading Exfoliation*

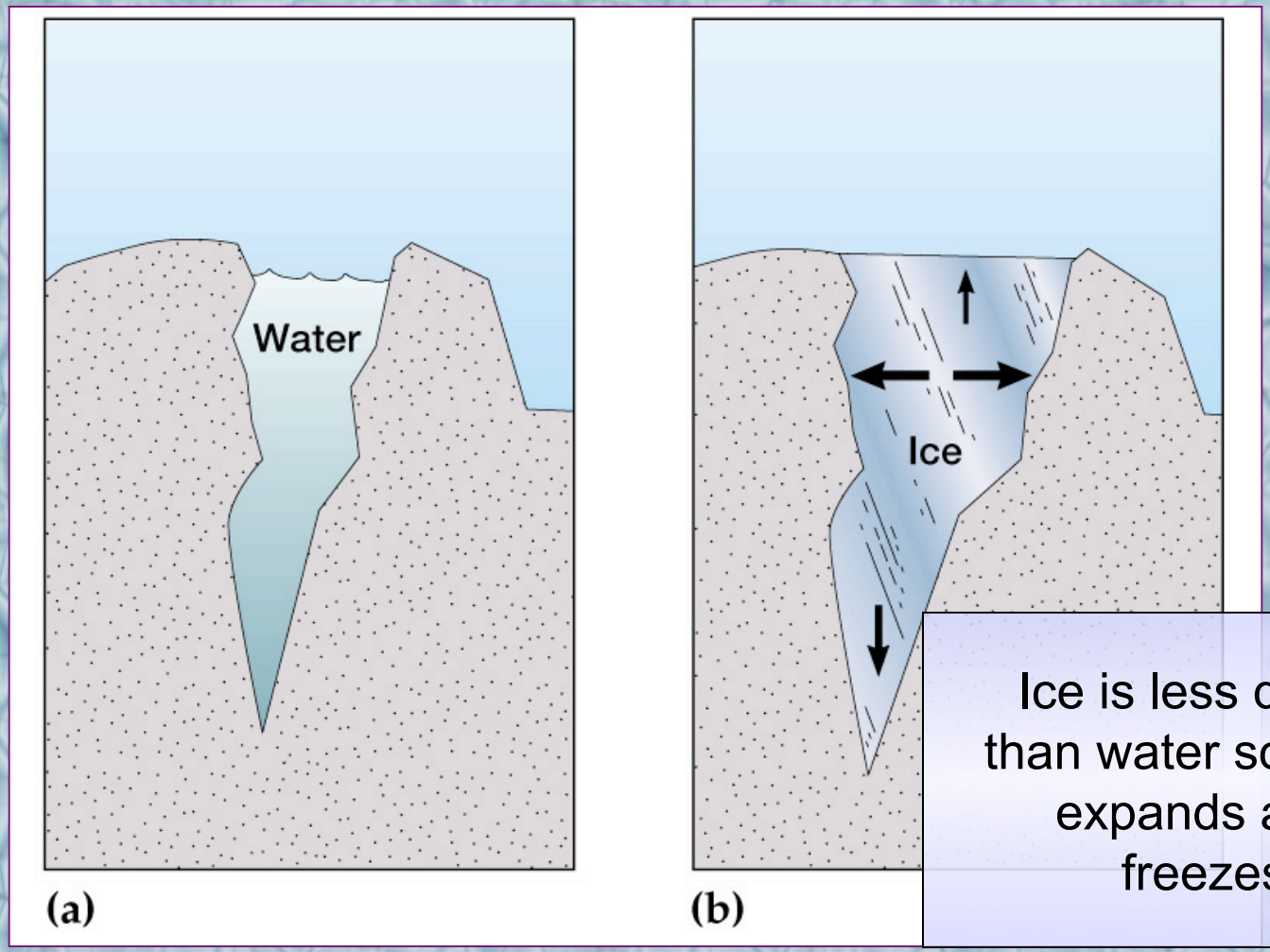


*http://www.utexas.edu/depts/grg/hudson/grg301c/hudson_grg_301c/schedule/4_water_geomorph_images/*

**Fig. 05.08**

Photo by David McGeary

# Mechanical Weathering
## Frost/Ice Wedging




Ice is less dense than water so water expands as it freezes.

*http://www.utexas.edu/depts/grg/hudson/grg301c/hudson_grg_301c/schedule/4_water_geomorph_images/*

# Mechanical Weathering

## Frost/Ice Wedging

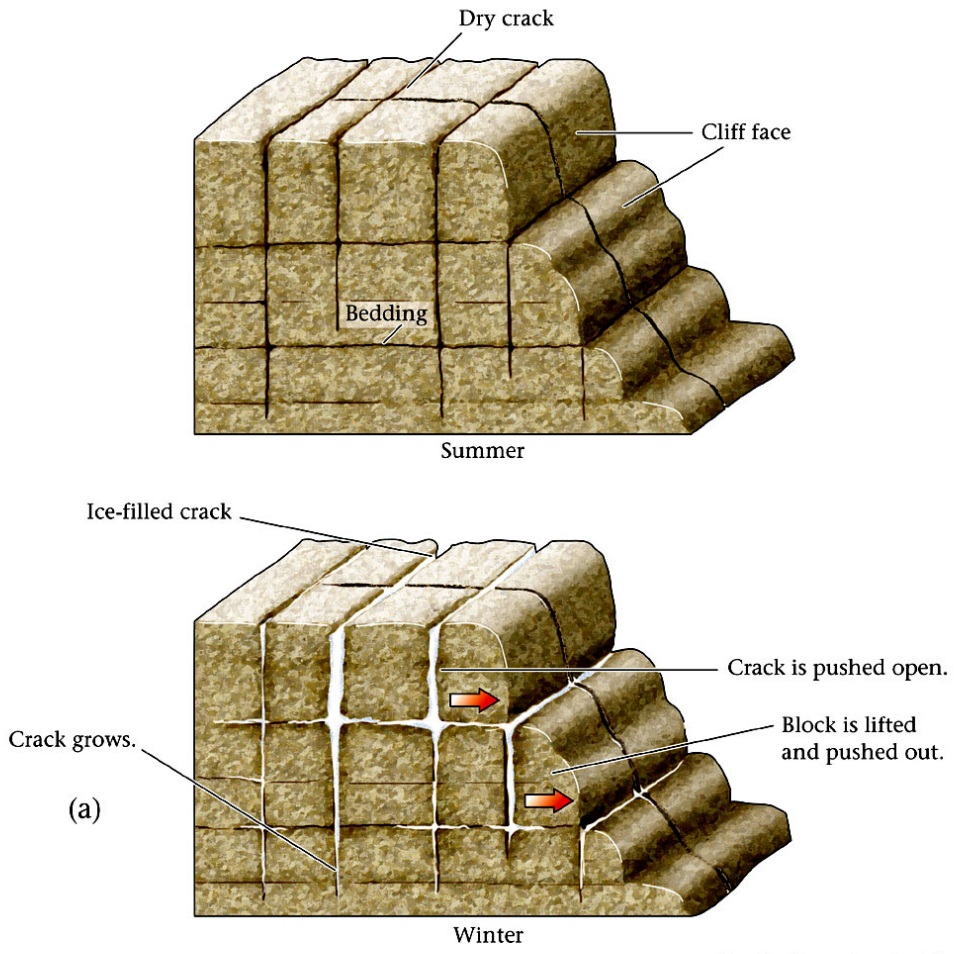



FIGURE 7.6

*Earth: Portrait of a Planet*, 2nd Edition

# Mechanical Weathering

## Frost/Ice Wedging

# Mechanical Weathering

## Abrasion

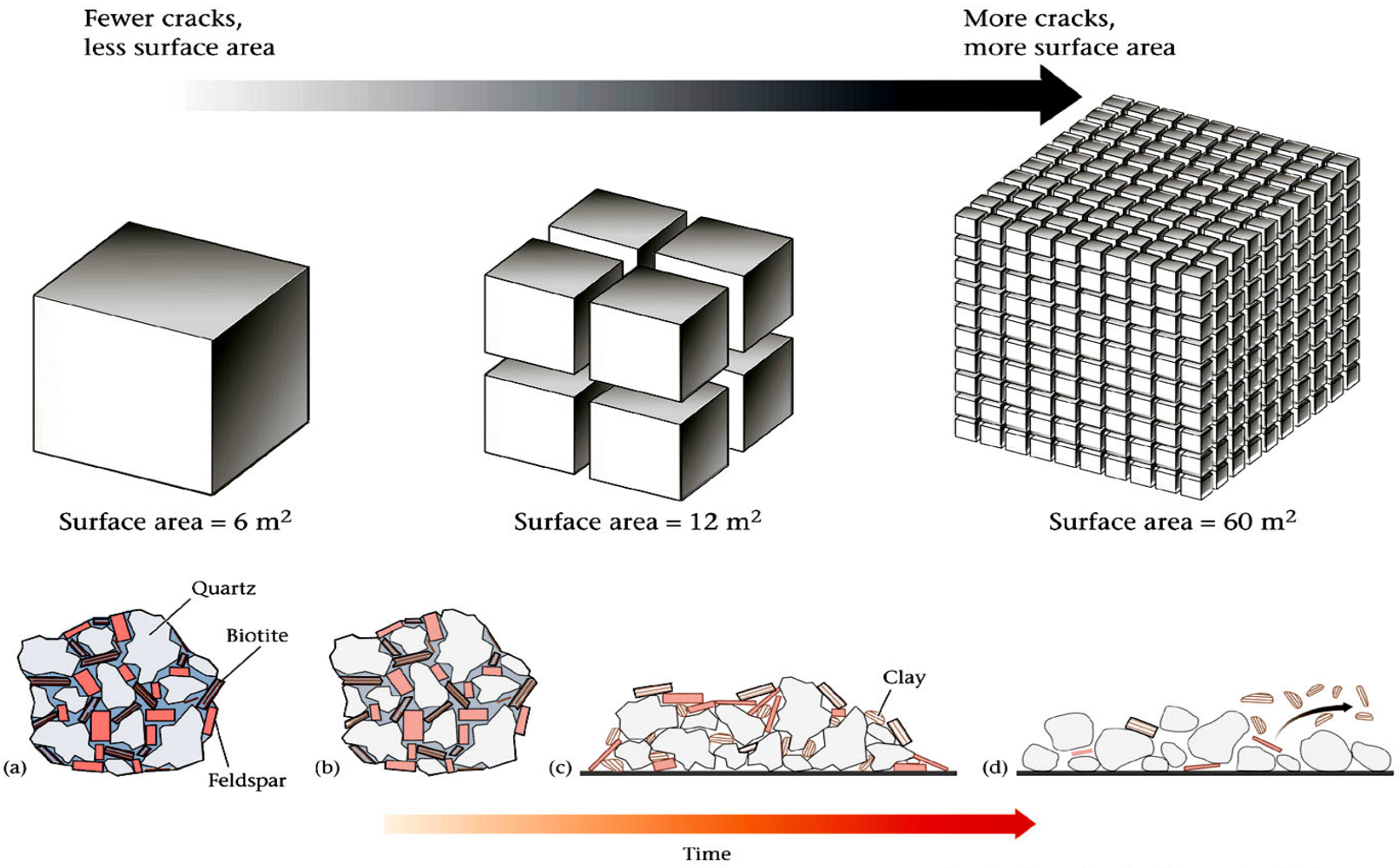
**Wearing away of rock by grit suspended in water or air**

*http://www.canadiangeographic.ca/Landforms/sea_cliffs.htm*

# Mechanical Weathering

## Abrasion

Mechanical weathering is an inefficient way to break down rocks. It does, however, increase the surface area on which chemical weathering can act.




FIGURES 7.8 and 7.9

*Earth: Portrait of a Planet*, 2nd Edition

# Chemical Weathering

Break down of rocks due to chemical reactions.

This is by far the most important of the three kinds of weathering.

# Chemical Weathering

## Acid/Base Reactions

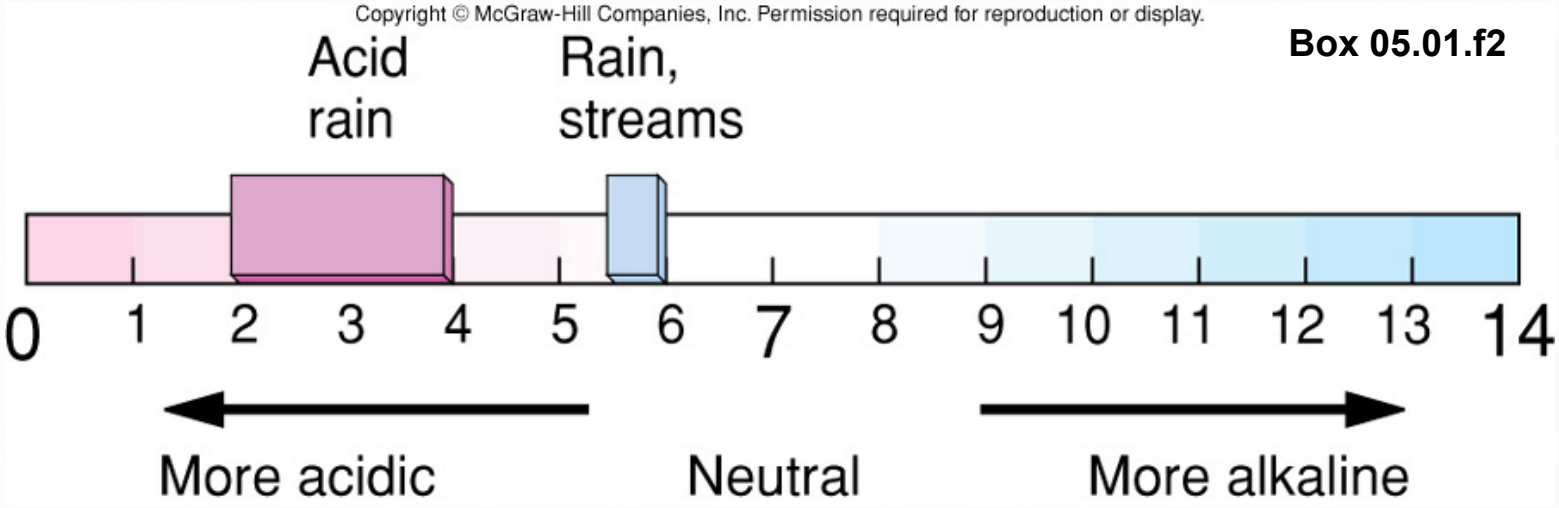
Changes in acid or basic conditions cause break down, e.g. limestone dissolved in acid rainwater

*http://www.edutel.org/gravenet/grave_weathering.html*

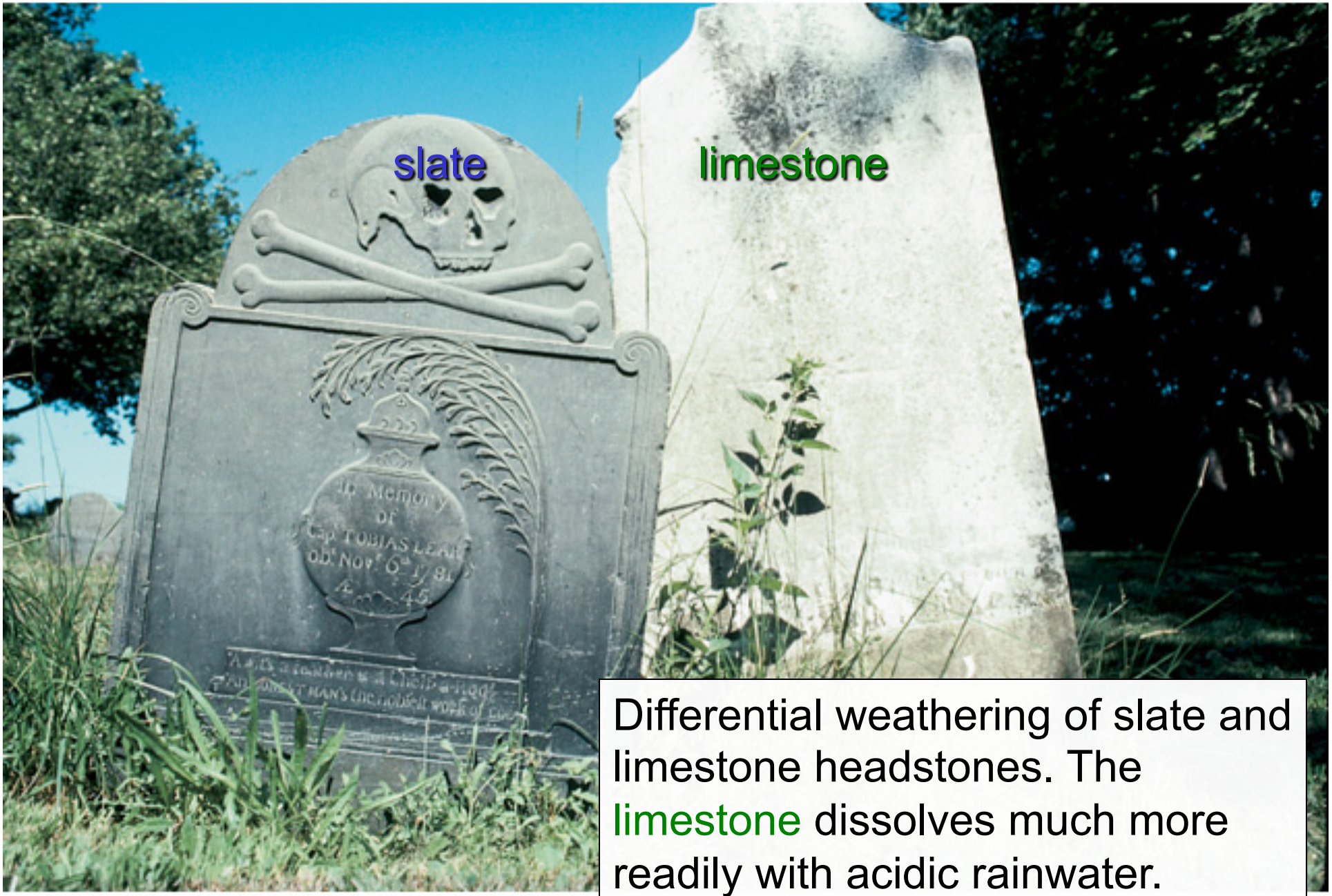
# Chemical Weathering

## Acid/Base Reactions






pH of natural and polluted rainwater




Differential weathering of slate and limestone headstones. The limestone dissolves much more readily with acidic rainwater.

A

Fig. 05.01a

Photo by C. C. Plummer

# Chemical Weathering
## Oxidation/Reduction Reactions

Pyrite (Iron [$Fe^{2+}$] Sulfide) to left
Iron [$Fe^{3+}$] Oxides to right



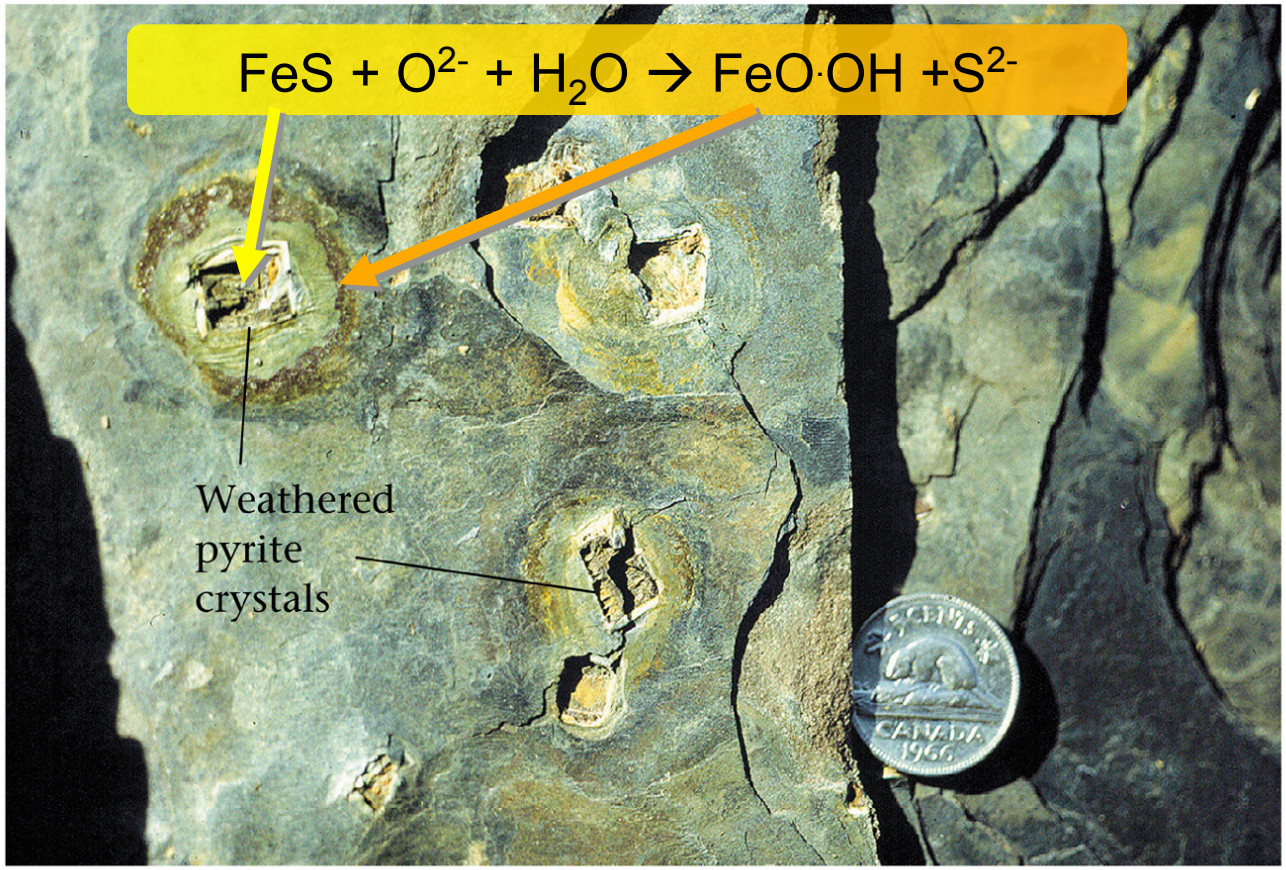



Loss or gain of an electron from an element (e.g., C, Fe or Mn).

Oxidation usually results in the formation of an oxide, e.g., “rusting” of iron-bearing minerals by oxidation of iron.

*http://www.gly.uga.edu/railsback/GeologicalDiagrams1.html*

# Chemical Weathering
## Oxidation/Reduction Reactions




(d)

FIGURE 7.7

# Chemical Weathering
## Oxidation/Reduction Reactions

**Acid Mine Drainage -**
Oxidation of pyrite forms red iron oxides and releases sulfur, which reacts with water to form sulfuric acids.

*http://www.ydeaglescry.com/Sulfide.htm*

# Chemical Weathering
## Hydration/Dehydration

Addition and subtraction of $H_2O$ into the mineral to form a different mineral, e.g., anhydrite ($CaSO_4$) + $H_2O$ → gypsum ($CaSO_4*2H_2O$)

http://www.crscientific.com/minerals.html

+ $H_2O$ ➡

http://www.a-m.de/englisch/lexikon/mineral/sulfate/gips-bild2.htm

# Chemical Weathering

## Hydrolysis

Reactions between $H^+$ and $OH^-$ and silicate minerals yielding soluble positively charged ions and silica in solution.

Hydrolysis is the main decay pathway for silicate minerals (remember, the most abundant minerals in the Earth's crust are silicates!).

Further reactions result in the formation of clay minerals.

# Chemical Weathering

## Hydrolysis

Feldspars chemically break down when exposed to surface conditions, and form **clay minerals** through the process of ***hydrolysis***

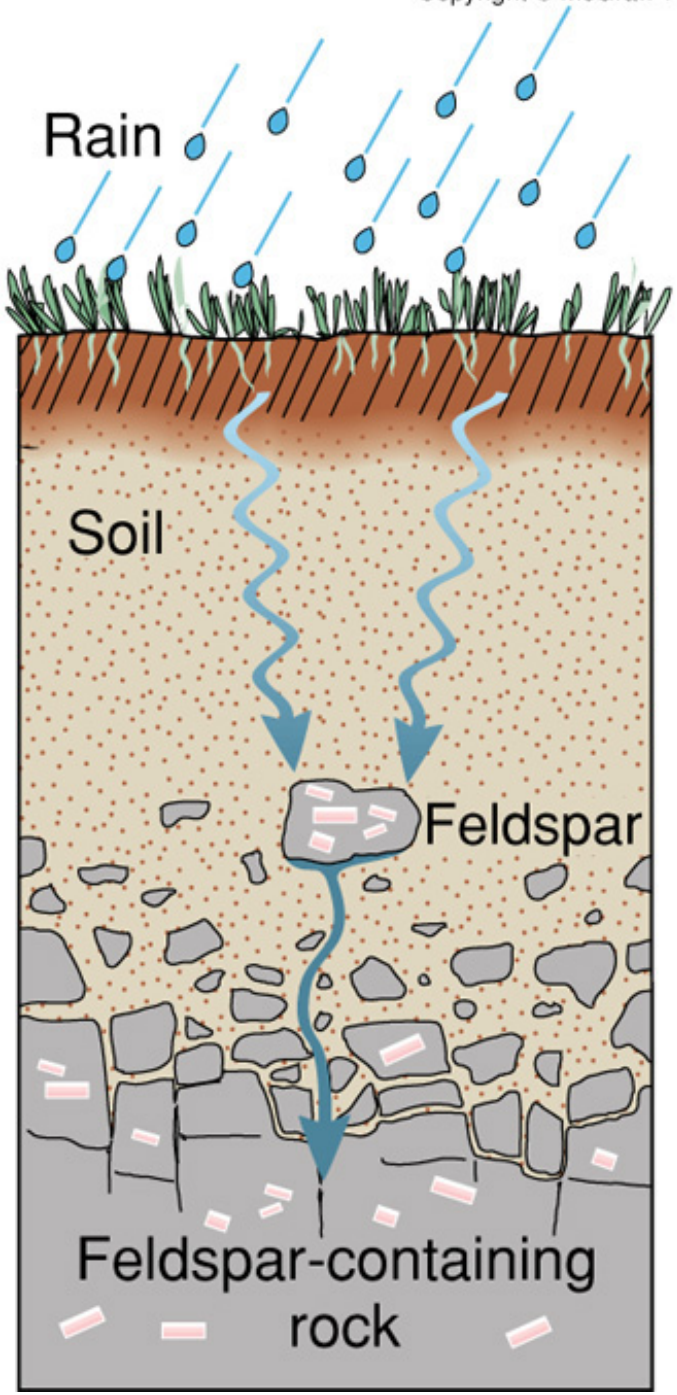
$$KAlSi_3O_8 + H^+ + H_2O \rightarrow H_4SiO_4 + KAl_3SiO_{10}(OH)_2$$

Feldspar (microcline) — Illite (clay mineral)

$$NaAlSi_3O_8 + H_2CO_3 + H_2O \rightarrow Na + H_4SiO_4 + Al_4Si_4O_{10}(OH)_8$$

Feldspar (albite) — Kaolinite (clay mineral)

***Other common clay minerals:*** *schmectite, gibbsite, montmorillonite, etc.*




Rain picks up $CO_2$ from the atmosphere and becomes acidic

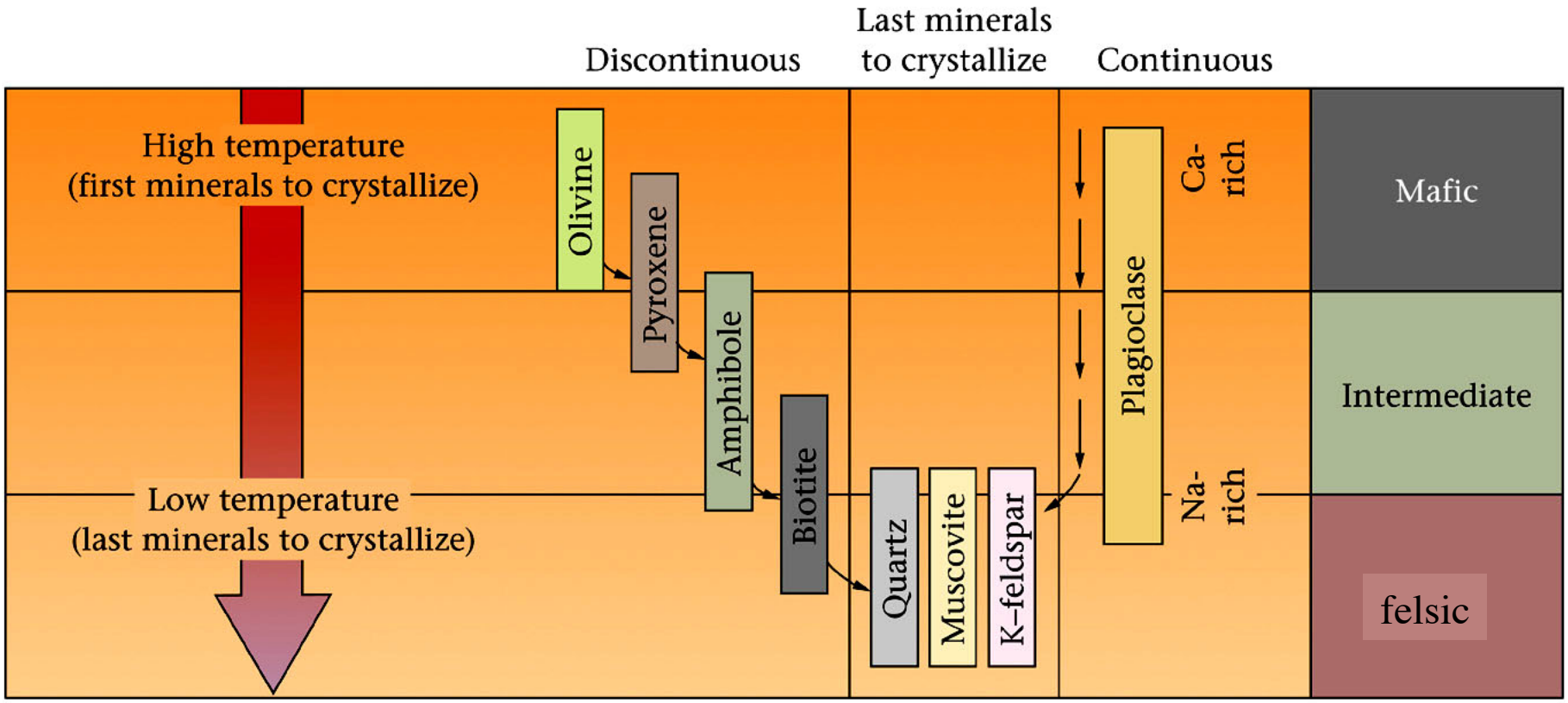
Water percolating through the ground picks up more $CO_2$ from the upper part of the soil, becoming more acidic

A rock particle containing a feldspar crystal, loosened from the rock below, slowly alters to a clay mineral as it reacts with the acidic water

The water carries away soluble ions and $SiO_2$ to the ground-water supply or to a stream

**Fig. 05.15**

# Bowen's Reaction Series and Weathering




Felsic minerals are most resistant to chemical weathering.
Mafic minerals are least resistant to chemical weathering.

FIGURE 6.6

# Biological Weathering

Weathering due to the activities of living things (plants, animals, fungi, bacteria, protists, etc.)

All organisms alter their local environments, causing both physical and chemical weathering. Plants are the most obvious destroyers of rocks, but bacteria are by far the most important biological weather-ers.

# Biological Weathering


Some bacteria can digest minerals for energy. They form complex colonies that alter the local chemical conditions, causing both weathering and deposition of minerals

blue=bacteria

sphalerite = green and orange

*http://www.sciencemag.org/content/vol290/issue5497/index.shtml*

# Biological Weathering

Lichen breaking down rock. Primarily (bio)chemical

# Biological Weathering

## Burrowers

Lemming burrowing in sediment. Mostly physical.

*http://www.earthsciences.ca/arctic/arrowsmith_river/default.htm*

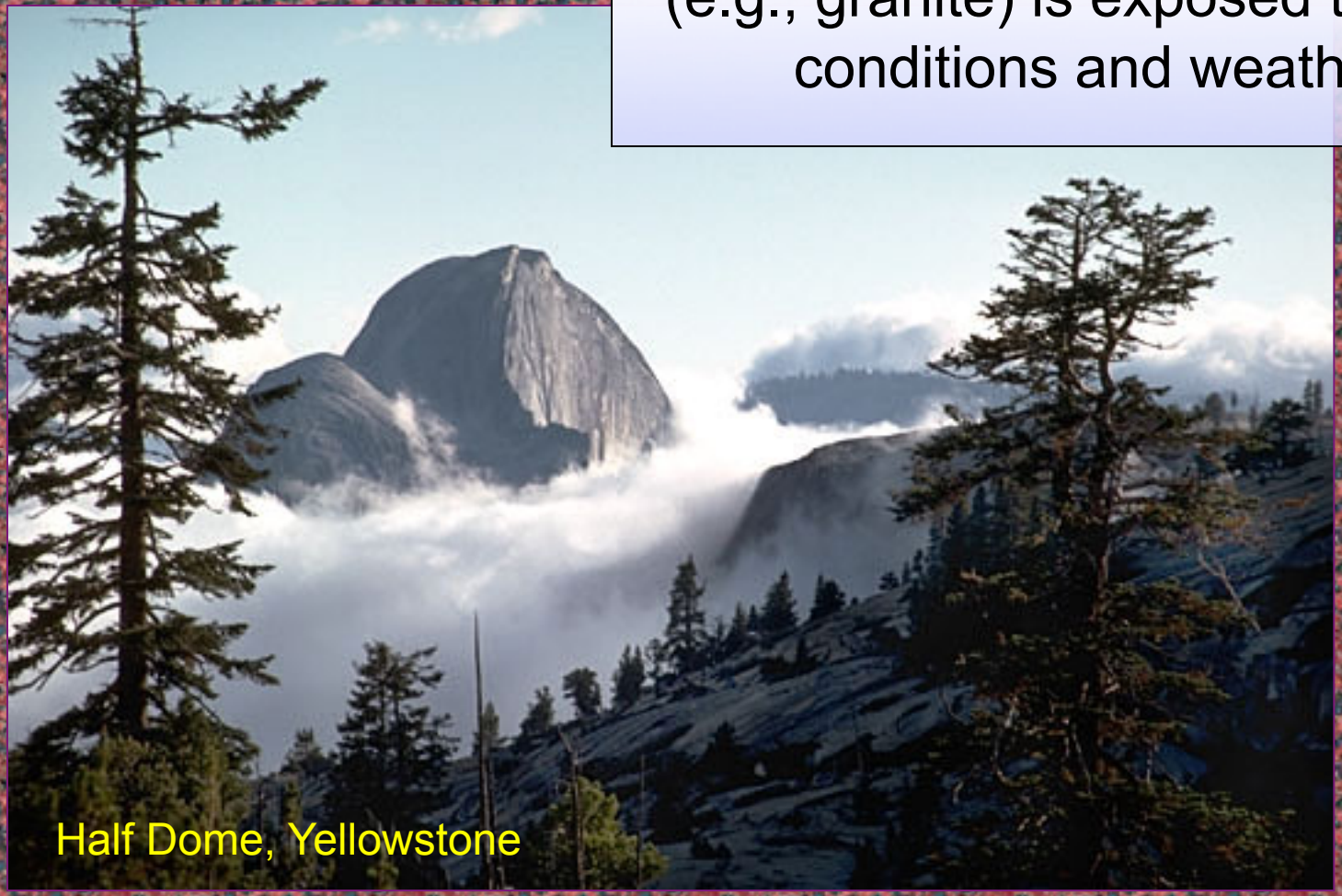
# Biological Weathering

## Root Wedging

Tree roots breaking down rock. Both physical and chemical weathering

*http://www.gpc.peachnet.edu/~pgore/geology/geo101/weather.htm*

What happens when a typical rock (e.g., granite) is exposed to surface conditions and weathers?



Half Dome, Yellowstone

*http://geoimages.berkeley.edu/*

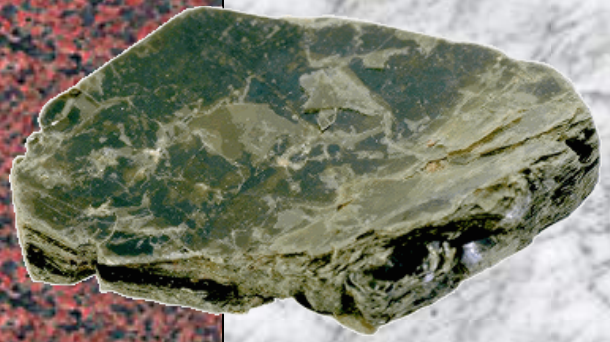
**Granite**
(Rock)

**Quartz**
(Mineral)

**Hornblende**
(Mineral)

**Feldspar**
(Mineral)

Photos by
Edward J. Tarbuck



P

resistant

susceptible

resistant

susceptible

resistant

susceptible

## *Physical Weathering*

### Quartz

**Hardness** = 7

no cleavage, brittle

**Tenacity** - strong

### Feldspar

**Hardness** = 6

2 directions of cleavage, brittle

**Tenacity** - intermediate

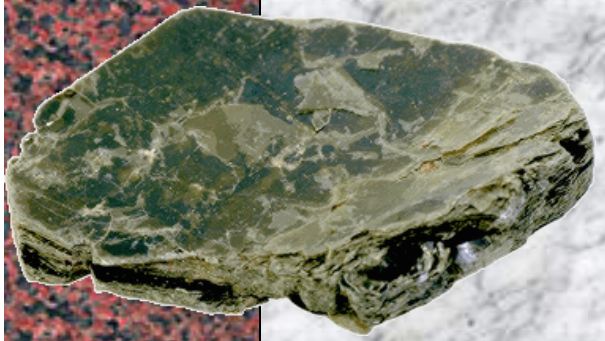
### Mica

**Hardness** = 2.5

1 perfect cleavage, elastic

**Tenacity** - weak

## Chemical Weathering






### Quartz

Chemically resistant to most surface processes

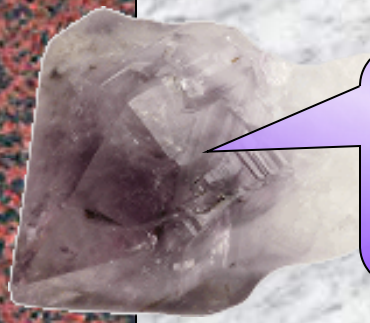
### Feldspar

Breaks down quickly to form clay minerals

### Mica

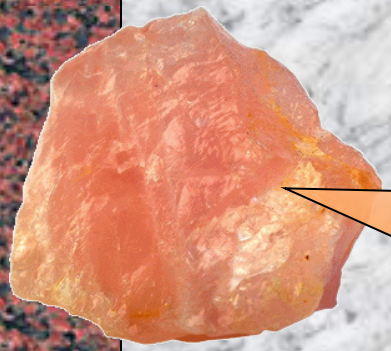
Breaks down slowly to form clay minerals

# Weathering

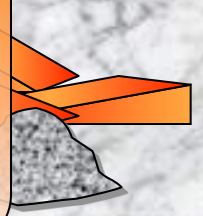


**Quartz:** physically breaks down to form smaller quartz grains

physical break down → *fracture*

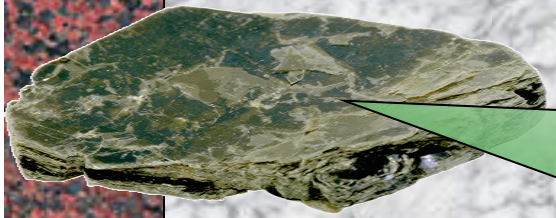


**Feldspar:** physically breaks down to form smaller feldspar grains, chemically breaks down to form clay minerals

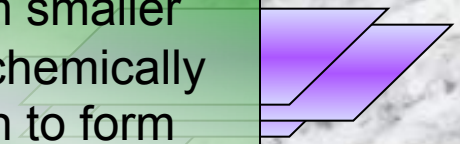


physical break down → cleavage

chemical break down → hydrolysis

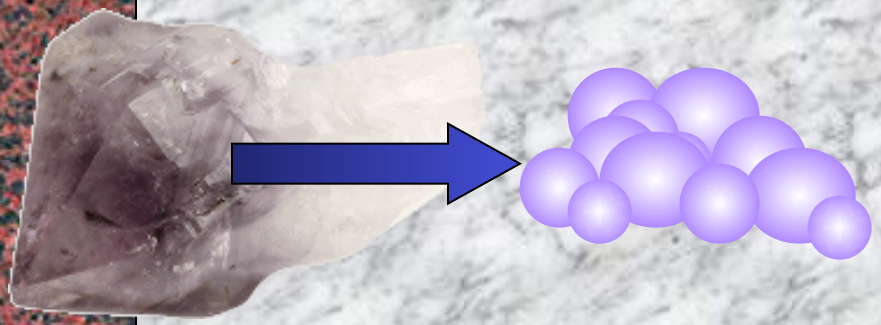


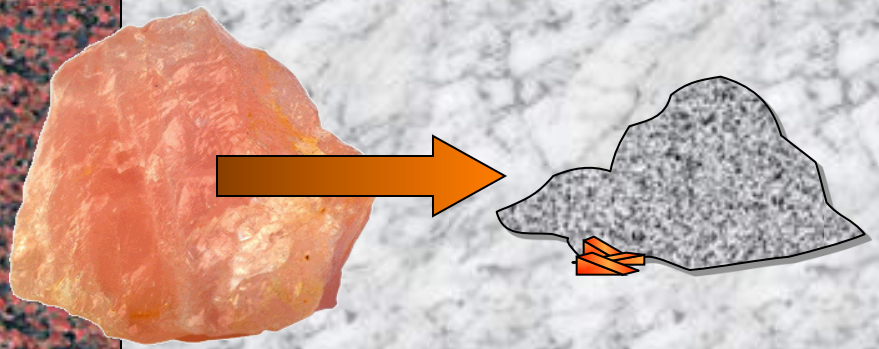
**Mica:** physically breaks down to form smaller mica grains, chemically breaks down to form clay minerals

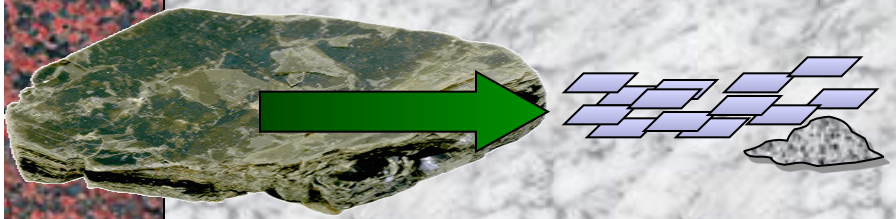


physical break down → cleavage

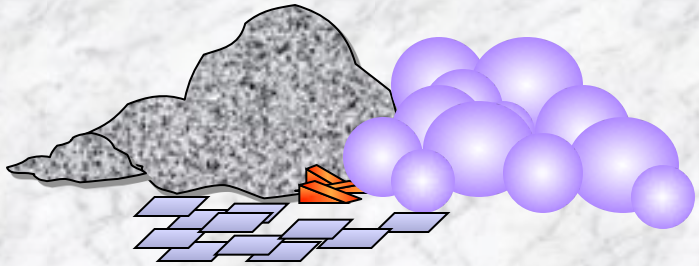
chemical break down → hydrolysis







## Sediment Produced from Granite



**Given enough time, all that will remain will be sand-sized quartz grains and mud-sized clay minerals**