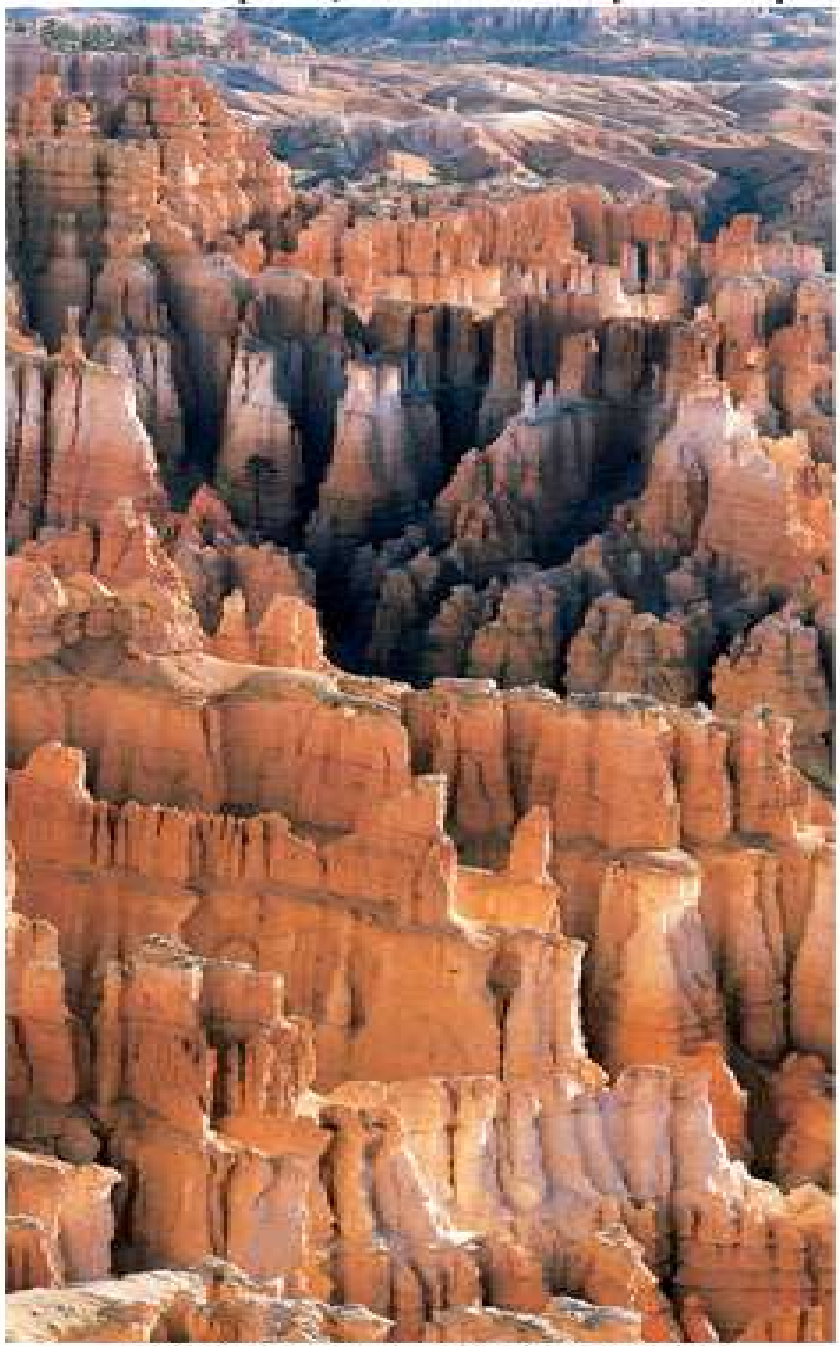
Weathering and Soil

Chapter 12



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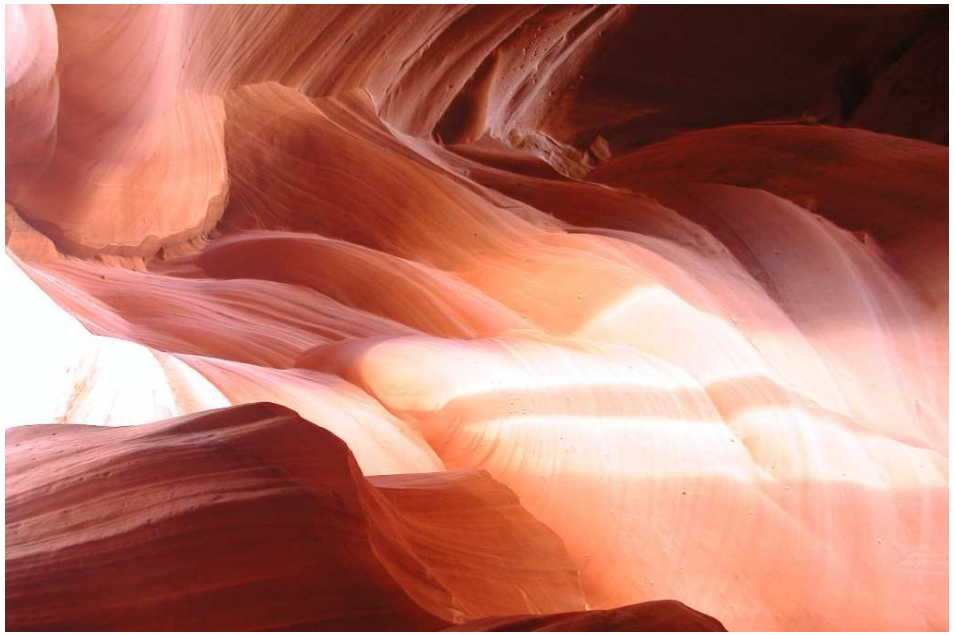
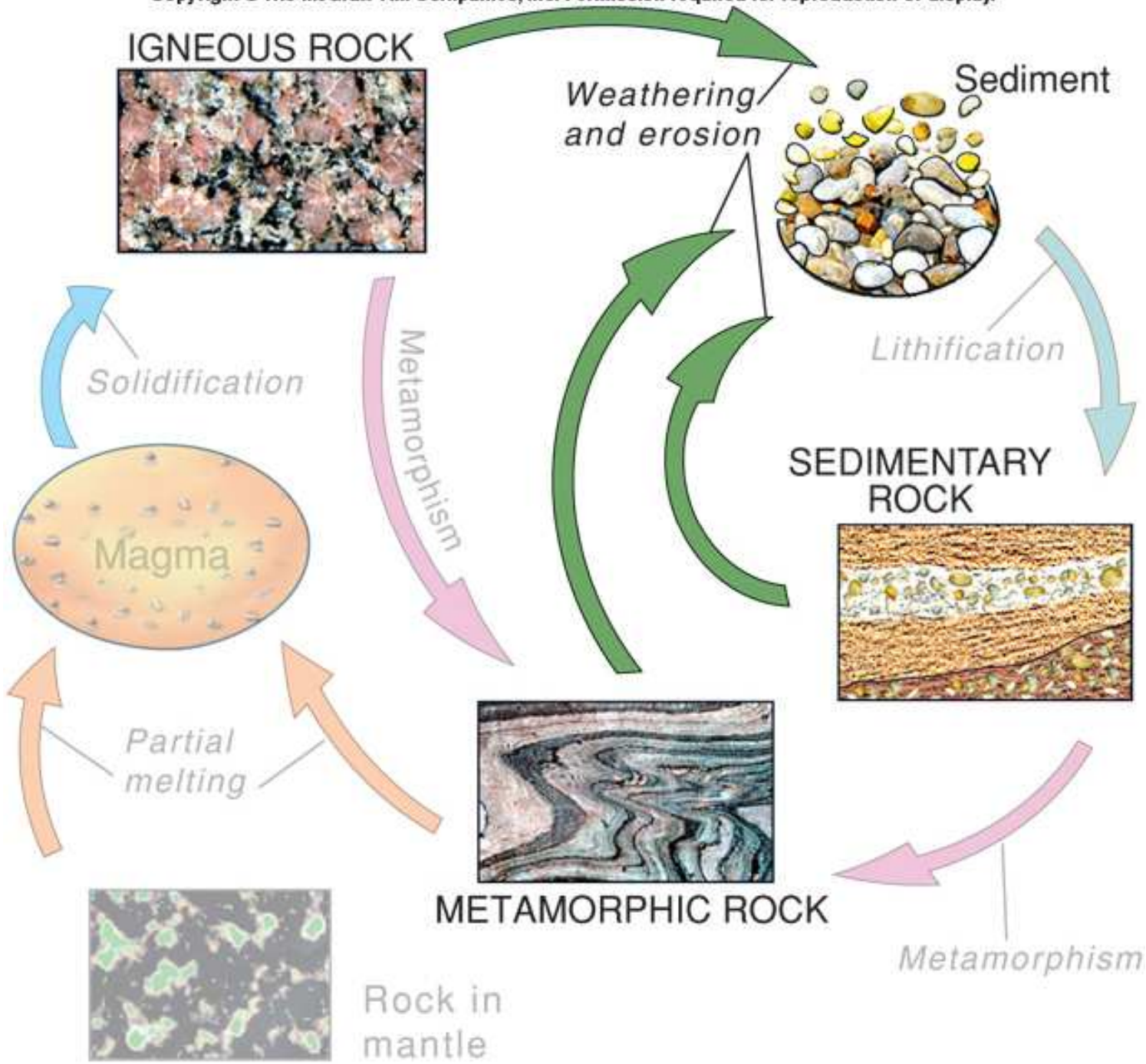
Weathering and Erosion: creating landscapes and sediment





Weathering and Erosion

- Rocks exposed at Earth's surface are *constantly changed* by water, air, temperature variations and other factors

- ***Weathering*** is the group of destructive processes that change the physical and chemical character of rocks at or near Earth's surface

- ***Erosion*** is the physical picking up of rock particles by water, ice, or wind

Types of Weathering

- *Mechanical weathering*
  - Physical disintegration
  - Frost action, pressure-release fracturing, plant growth, burrowing animals, salt wedging, thermal cycling

- *Chemical weathering*
  - Decomposition of rock from exposure to atmospheric gases (oxygen, water vapor and carbon dioxide)
  - New chemical compounds (minerals) form
  - Rate increased by increased rock surface area

Spheroidal weathering

What processes alter the landscape?

Mechanical **vs.** **Chemical**

Weathering and Earth Systems

- ***Solar system***
  - Earth-style weathering (water, ice, wind) is nearly unique to our planet, at present. Small amounts of weathering (primarily by wind) still occur on Mars, and water erosion appears to have been important there in the distant past.
- ***Atmosphere***
  - Oxygen and carbon dioxide critical to ***chemical weathering***
  - Water cycled through atmosphere is critical to chemical and ***mechanical weathering*** processes
  - Chemical weathering also removes carbon dioxide from the atmosphere, helping keep global temperatures from soaring

Weathering and Earth Systems

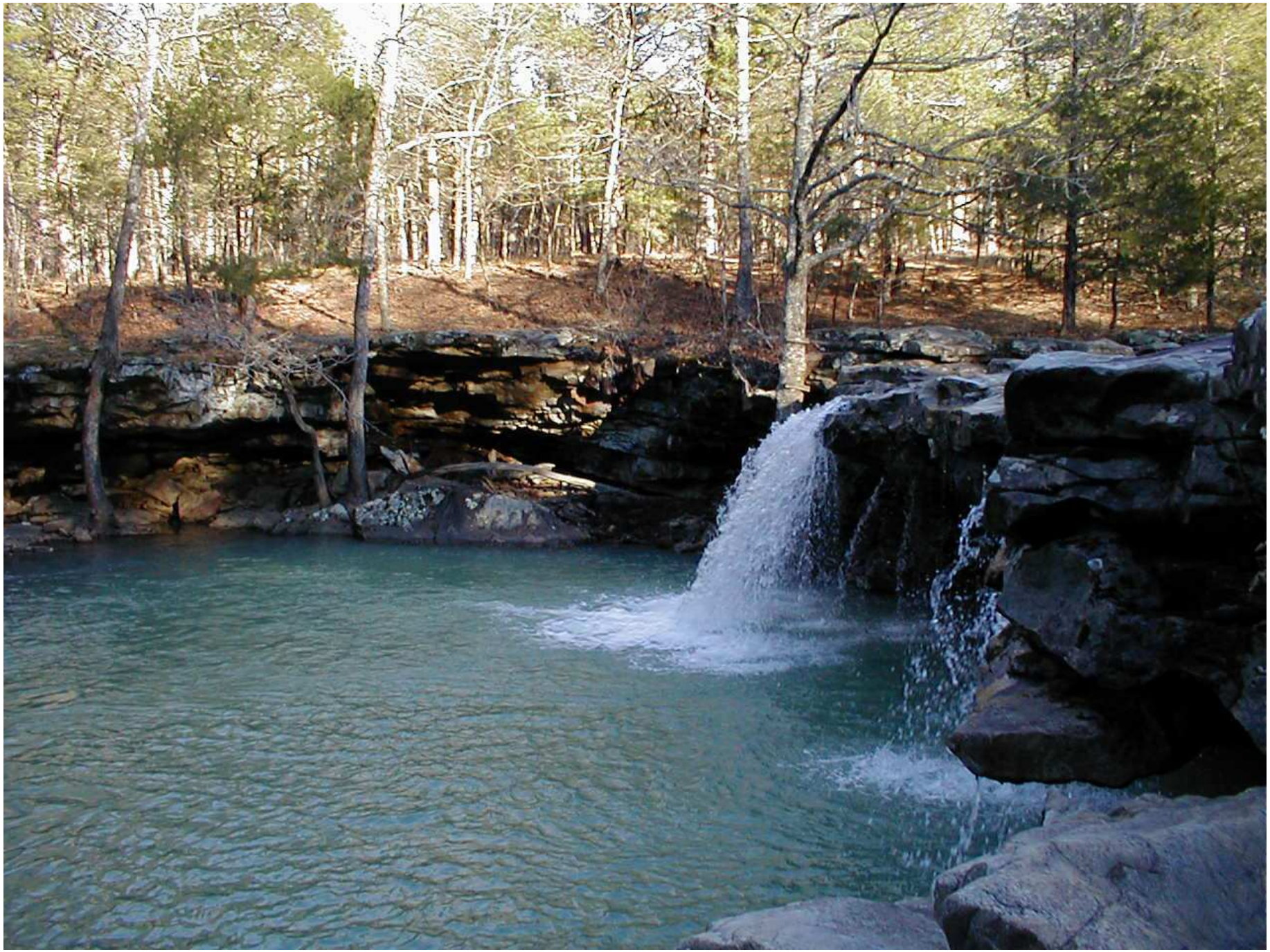
- ***Hydrosphere***
  - Water is necessary for *chemical weathering*
  - Oxygen dissolved in water *oxidizes iron* in rocks
  - Carbon dioxide dissolved in water creates *carbonic acid*
    - Primary cause of chemical weathering
  - Running water loosens and grinds particles
  - Glacial ice removes and grinds particles
  - Freeze/thaw cycling mechanically weathers

- ***Biosphere***
  - Plant root growth widen cracks in rocks
  - Animal movement and human activity mechanically weather
  - Decaying organic matter in soils produces acidic soil moisture

Mechanical Weathering

Agents

- ***Wind***
- ***Water***
- ***Ice (Glacier)***
- ***Heat***
- ***Human activity***



Spheroidal weathering

Differential weathering

D

Bret Bennington

Differential weathering

David McGeary

Mechanical Weathering

- *Frost action*
- *Pressure release*
- *Plant growth*
- *Burrowing animals*
- *Human activity*
- *Thermal cycling*

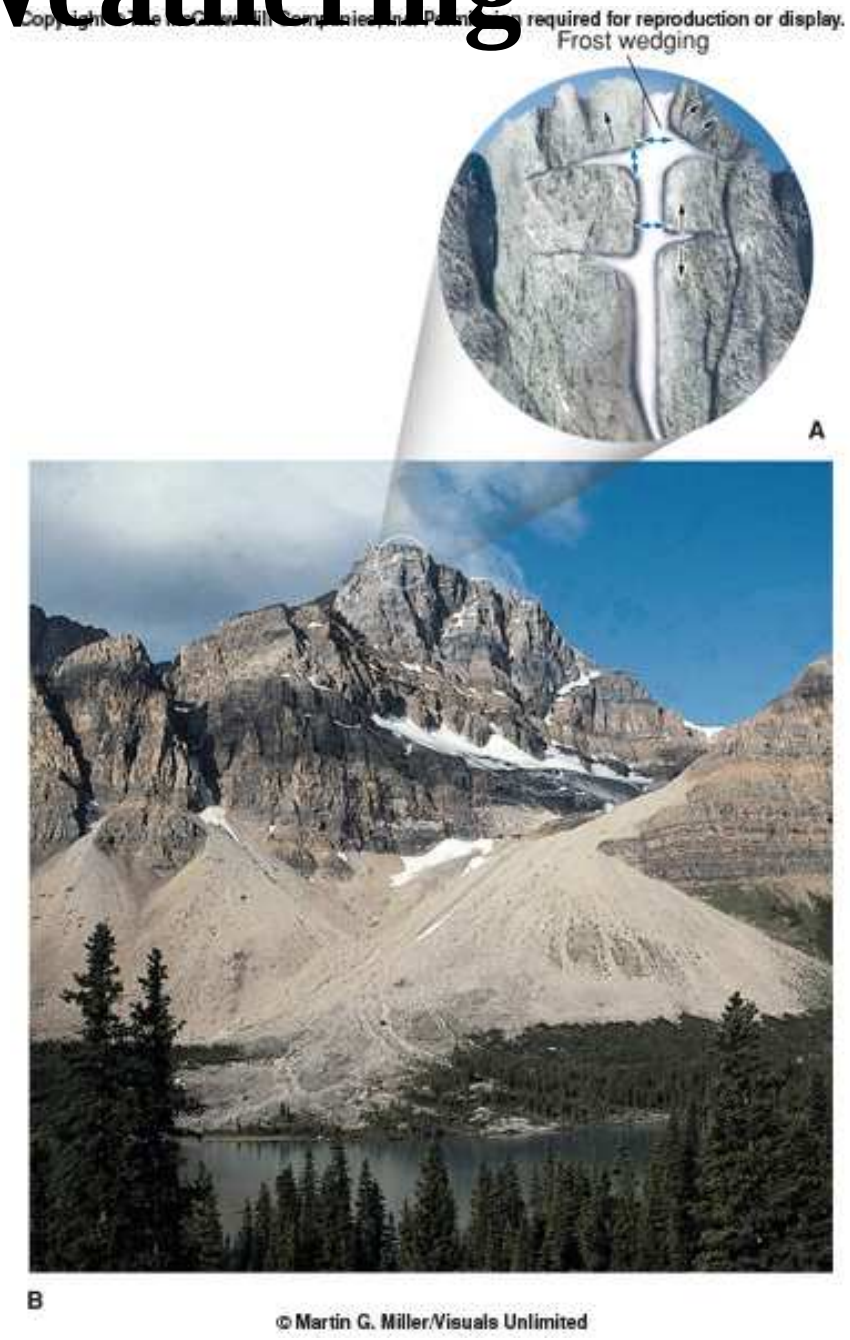
Mechanical Weathering

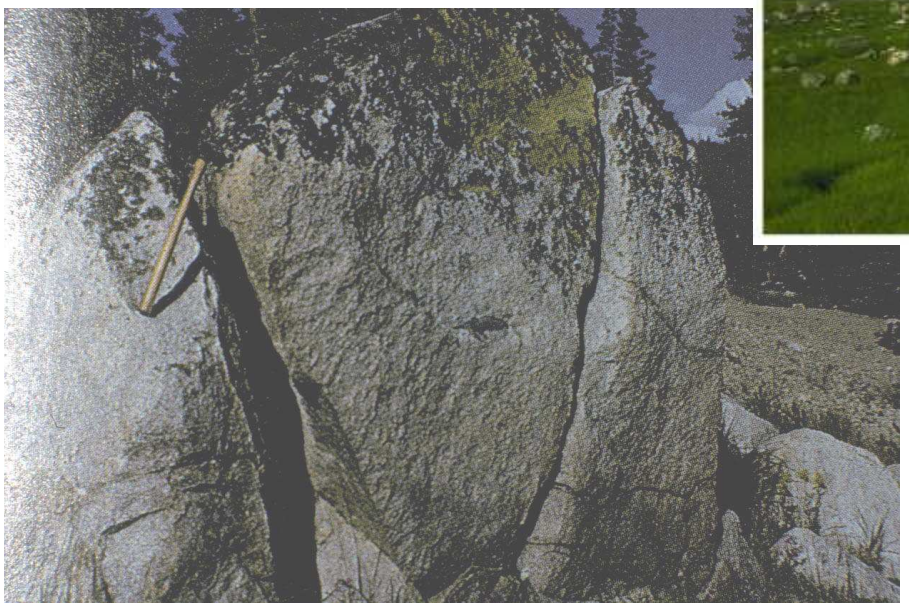
Frost Action

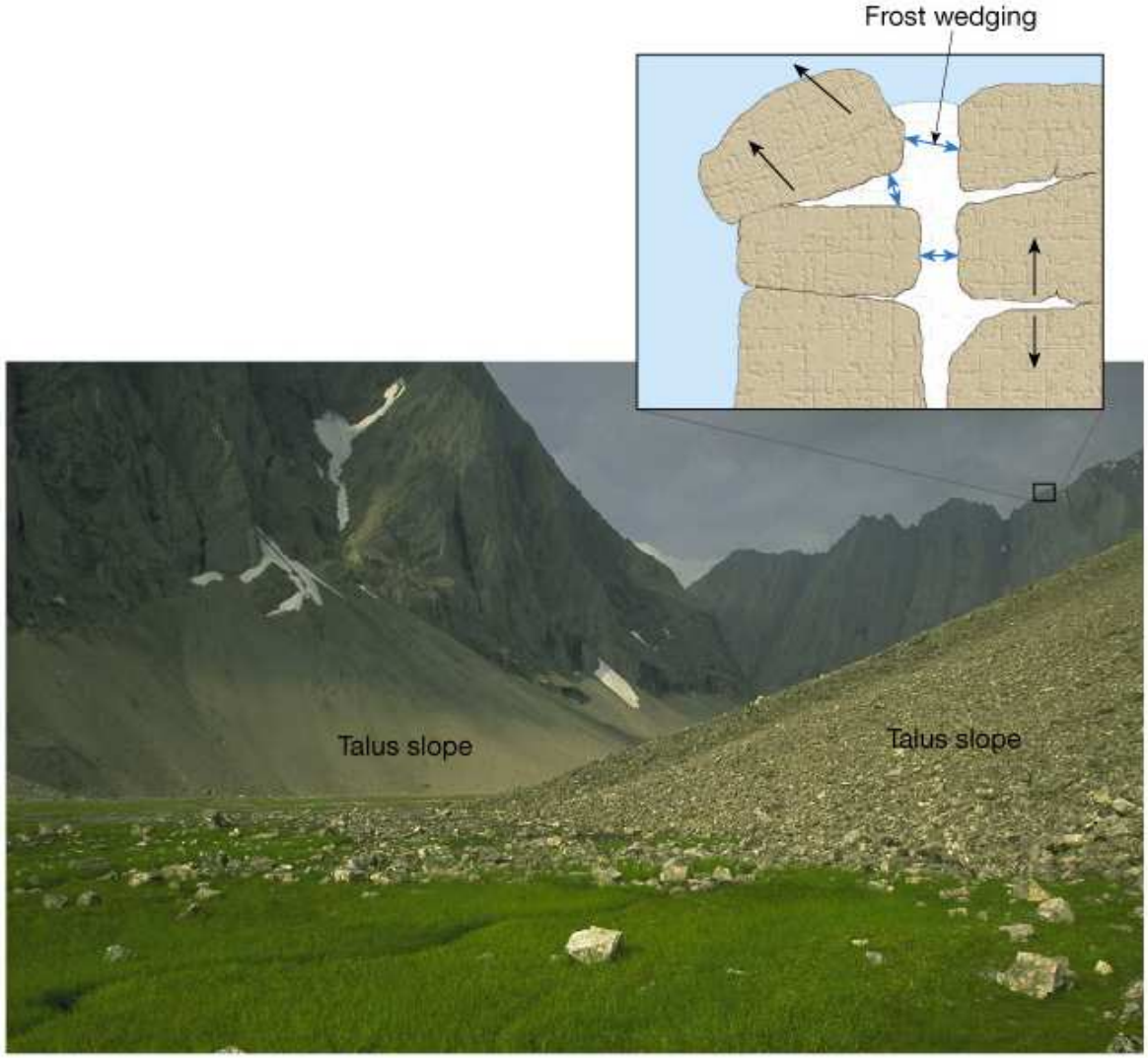
Frost Wedging

– Mechanic effect of freezing (and expanding) water on rocks

The broken rocks form cone shaped piles of debris at the base of the mountain called as : **Talus**





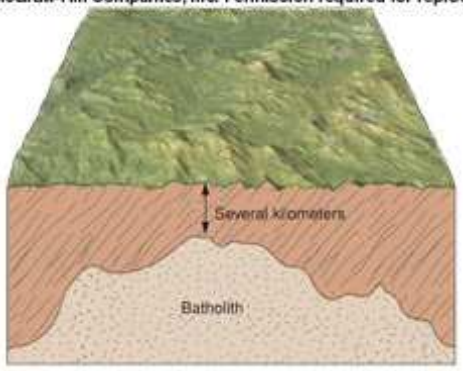

Frost wedging
Talus slope
Talus slope

Mechanical Weathering

Frost Heaving

Mechanical Weathering

- *Pressure release*
  - Removal of overlying rock allows expansion and fracturing – **Sheet Joints**



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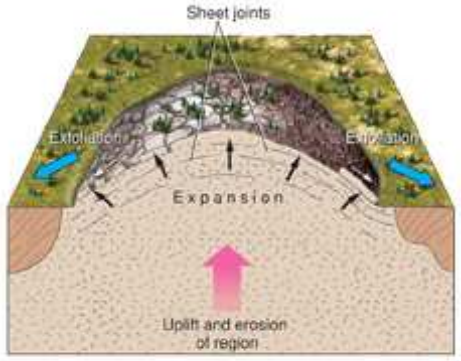

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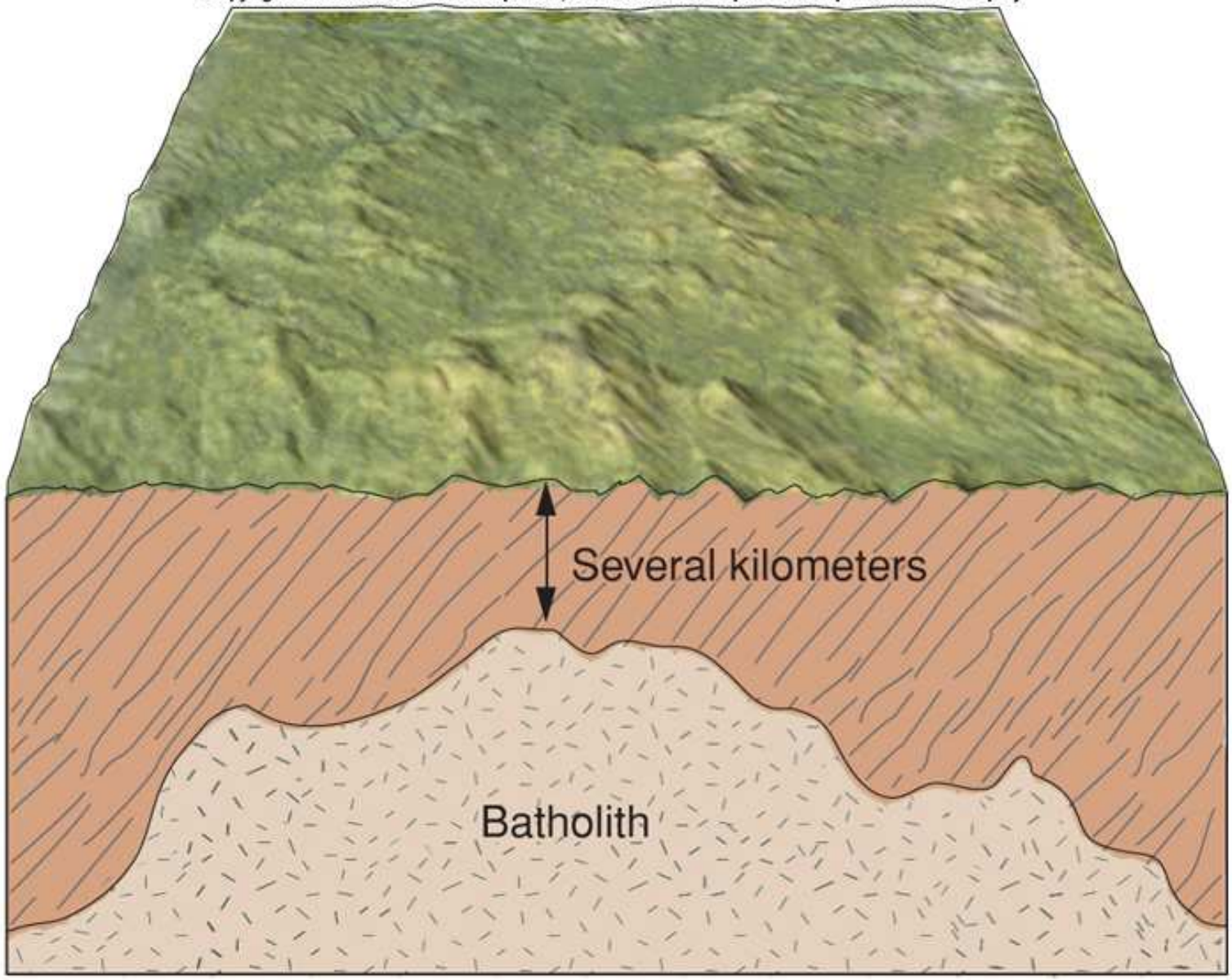

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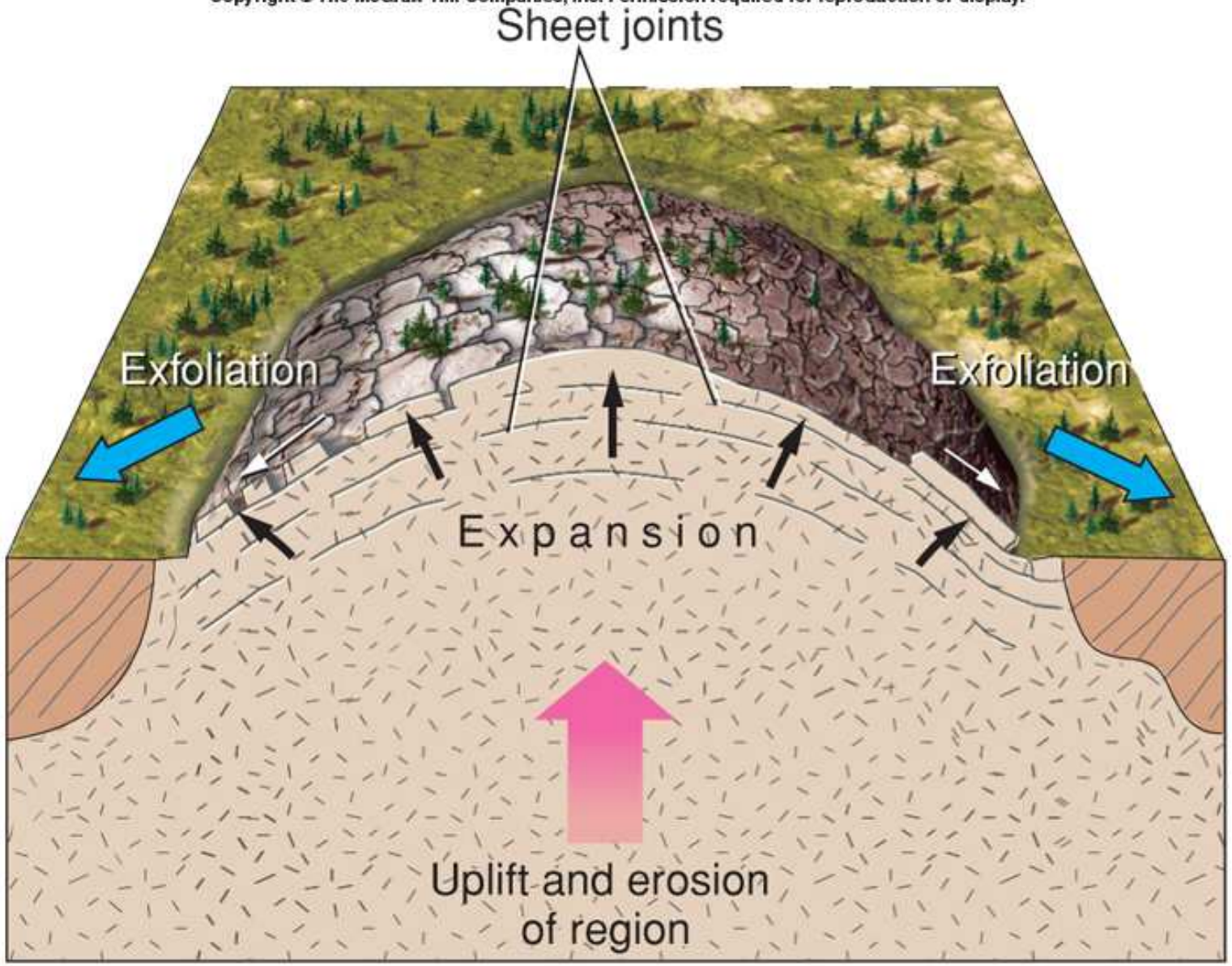

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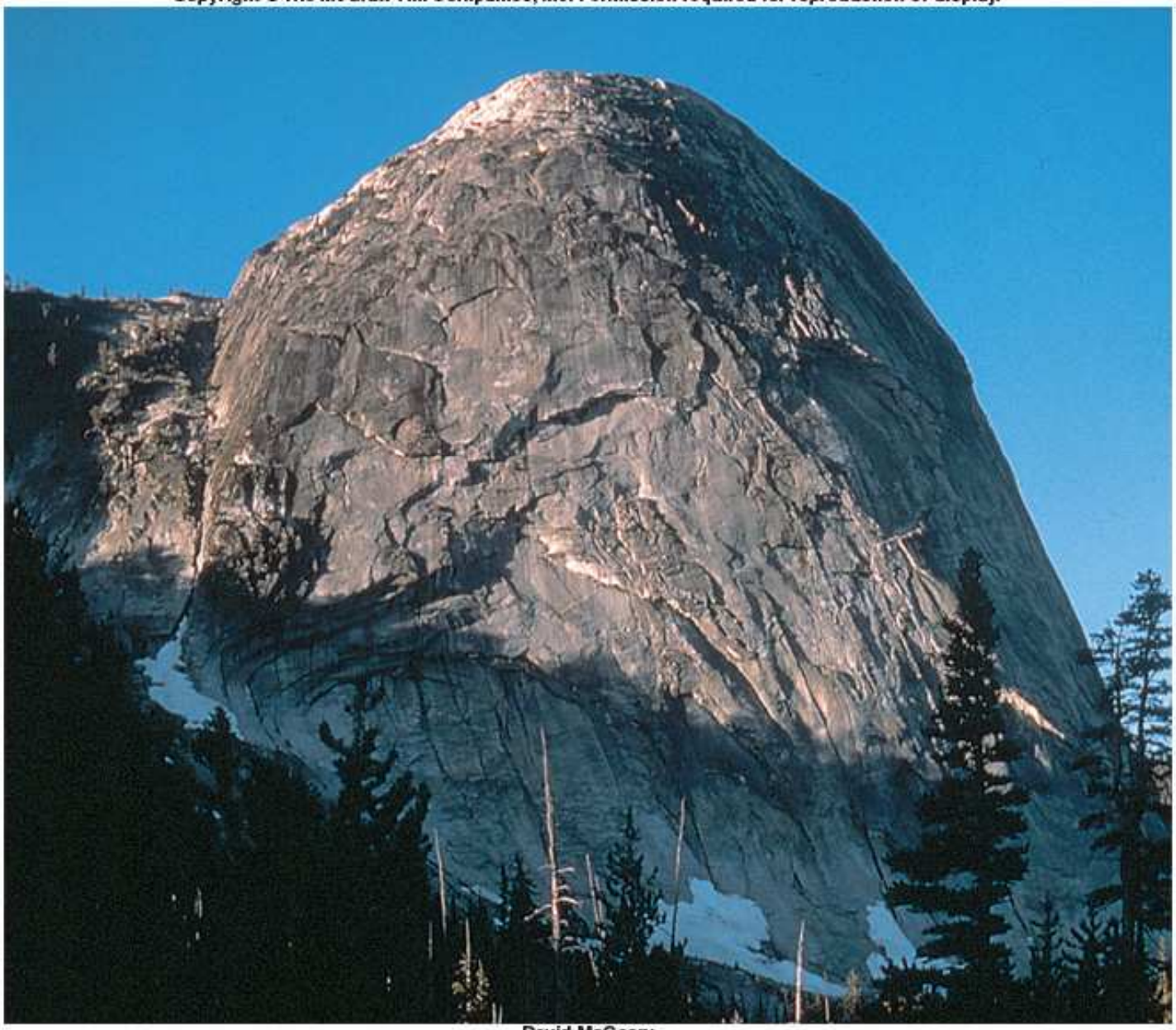
Exfoliation Domes



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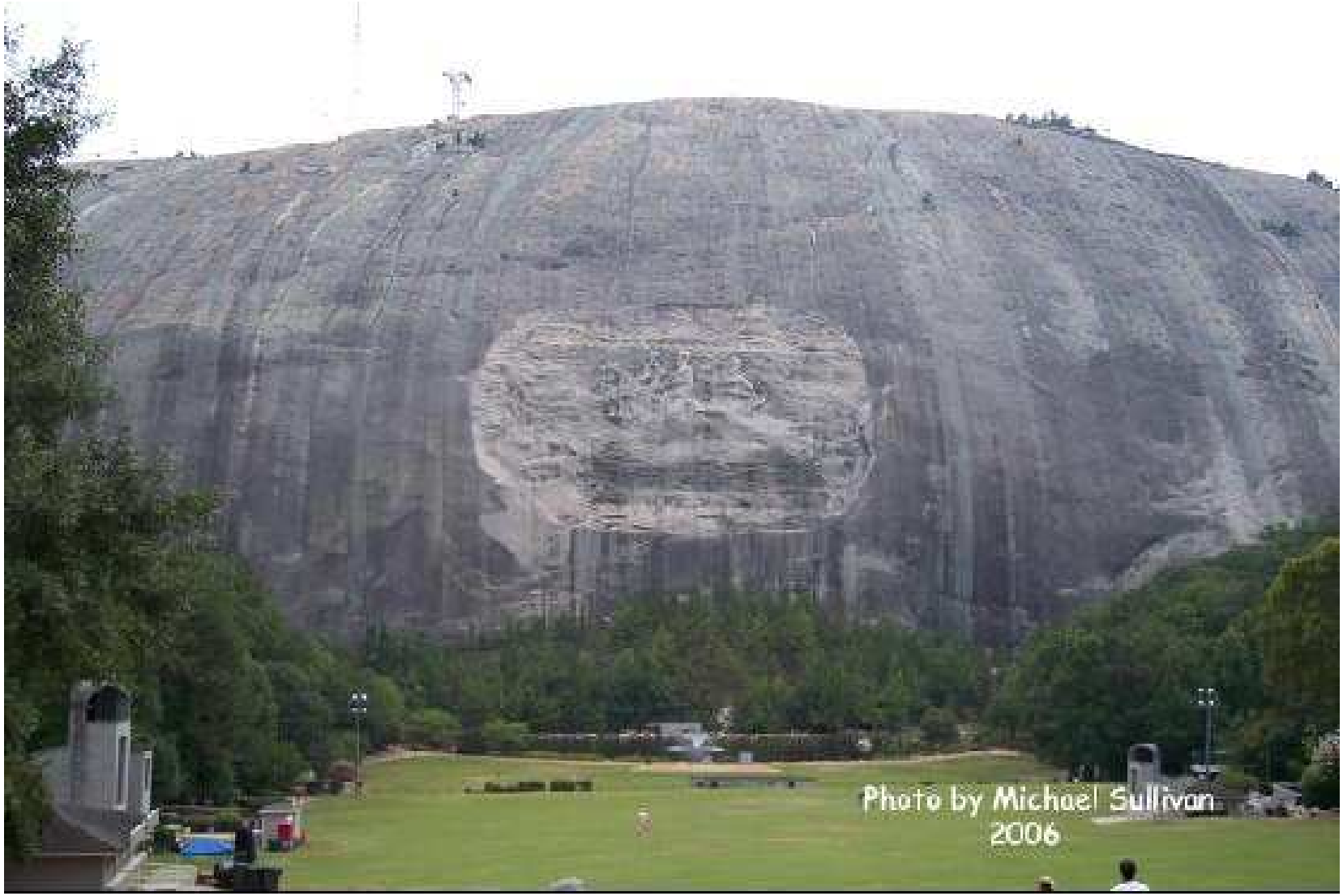
Exfoliation Domes

Famous Example **– Stone Mountain, GA**



Mechanical Weathering

- *Plant growth*
  - Growing roots widen fractures

- *Burrowing animals*

- Speed up chemical weathering

by enlarging passage ways for water and air

Photo by Diane Carlson

Mechanical Weathering

- *Thermal cycling*

  – Large temperature changes fracture rocks by repeated expansion and contraction

  – Forest fire expand rocks

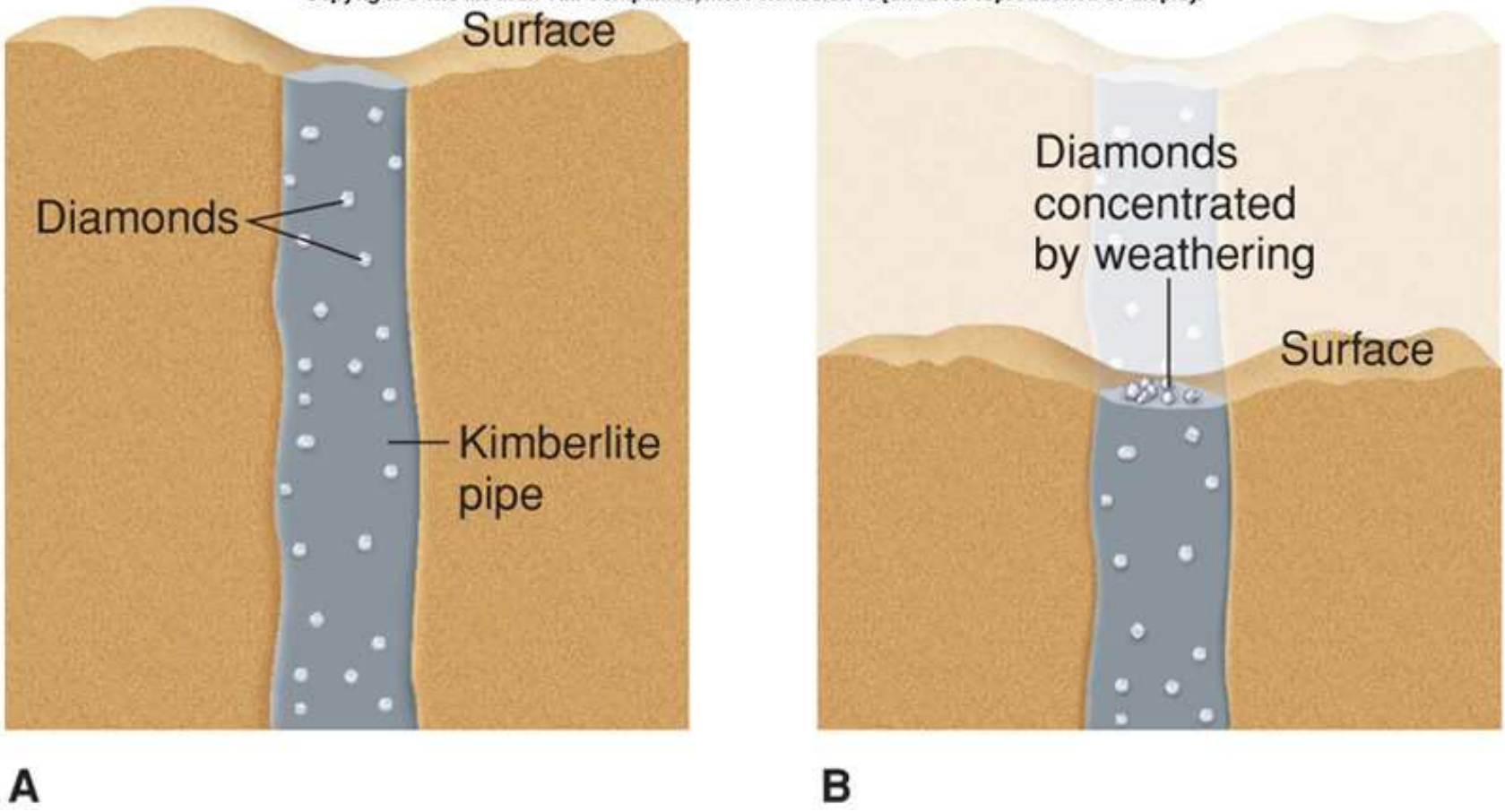
  – Long summer- disintegrate desert rocks

  – The pressure of salt crystals as water evaporates due to heat inside small space in rocks

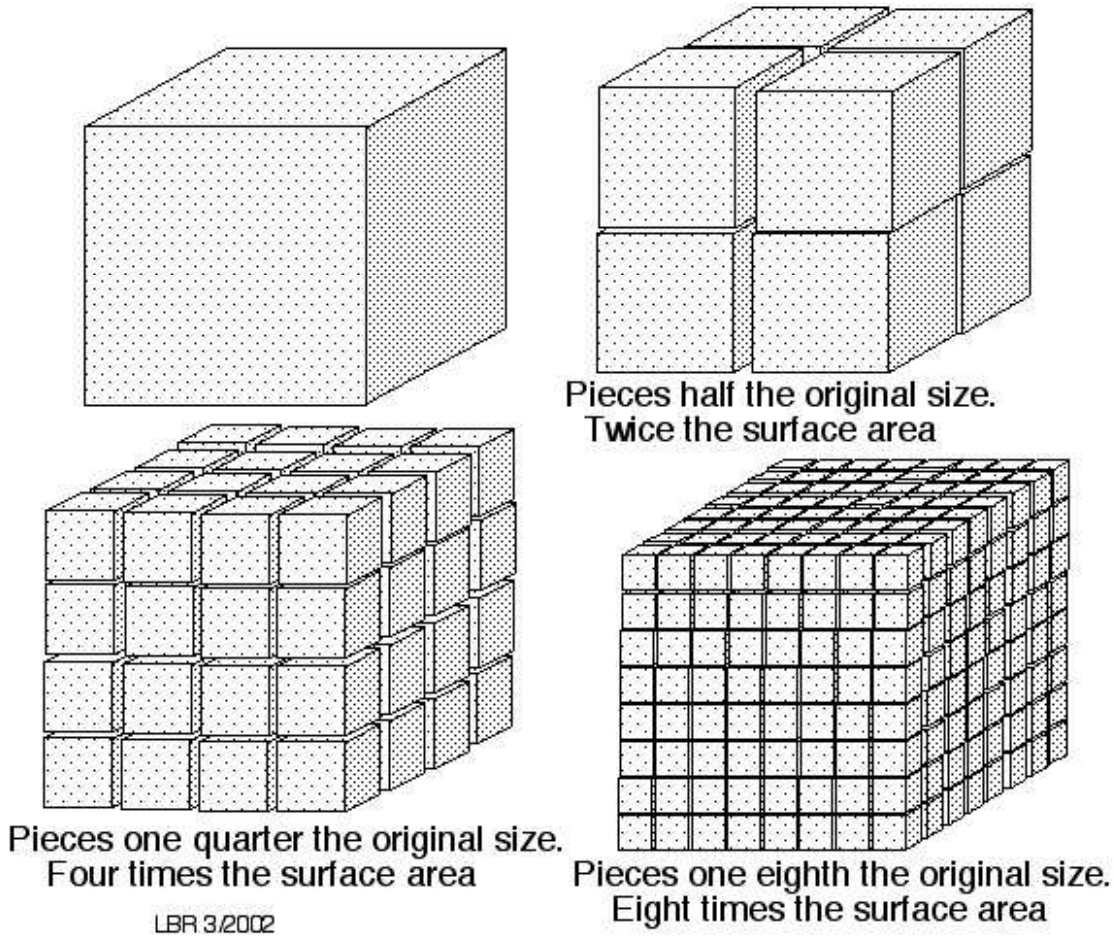
B

Crystal Hootman and Diane Carlson

Valuable Mechanical Weathering Product



Mechanical weathering can play an important part of the chemical weathering processes



Chemical Weathering

- *Decomposition*

  – The process of chemical weathering is called as “rock decomposition”.

  – Chemical weathering transform rocks and minerals exposed to water and air into new chemical products.

  – Minerals change gradually at the surface until they come into equilibrium with the surrounding conditions.

Chemical Weathering

Role of Oxygen

- *Oxidation*
  - Chemically active oxygen from atmosphere
  - Affect all mafic rocks (feromagnesian minerals)
  - Iron oxides are common result (Fe_2O_3): Mineral name - **Hematite**
    - Soil and sedimentary rocks often stained with iron oxides

Felsic rocks –> Mechanical Weathering –> Seperatation of silica and feromagnesian minerals –> Enhancement of Oxidation

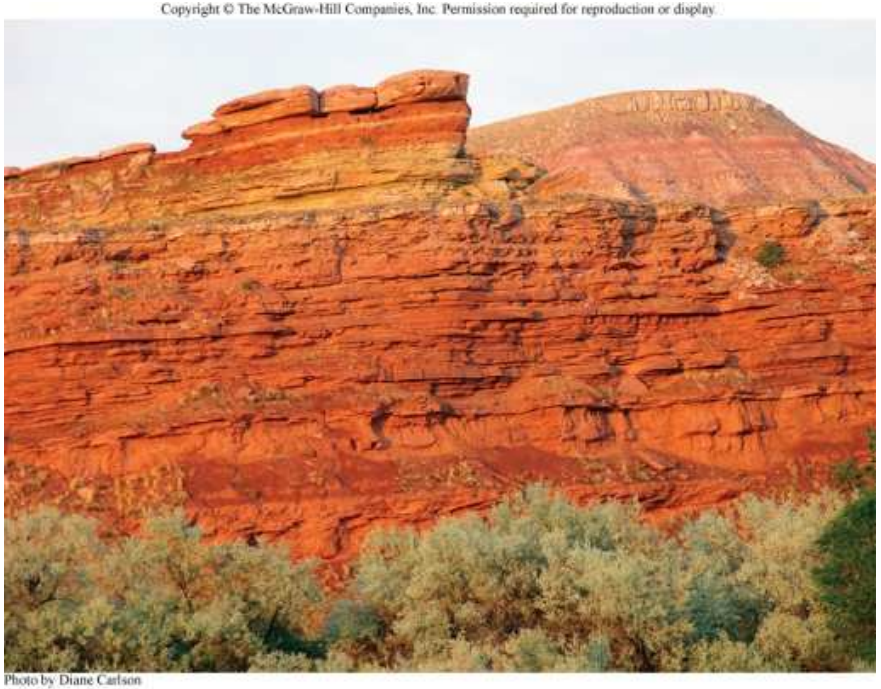


Photo by Diane Carlson

Charles Alpers, U.S. Geological Survey

Chemical Weathering

Role of Carbon Dioxide (CO_2)

- *Acid dissolution*
  - Carbonic acid (H_2CO_3) from atmospheric CO_2 dissolved in water
  - Some minerals, such as calcite, may be totally dissolved
  - Human activity, such as mining and burning of fossil fuels, produces acids

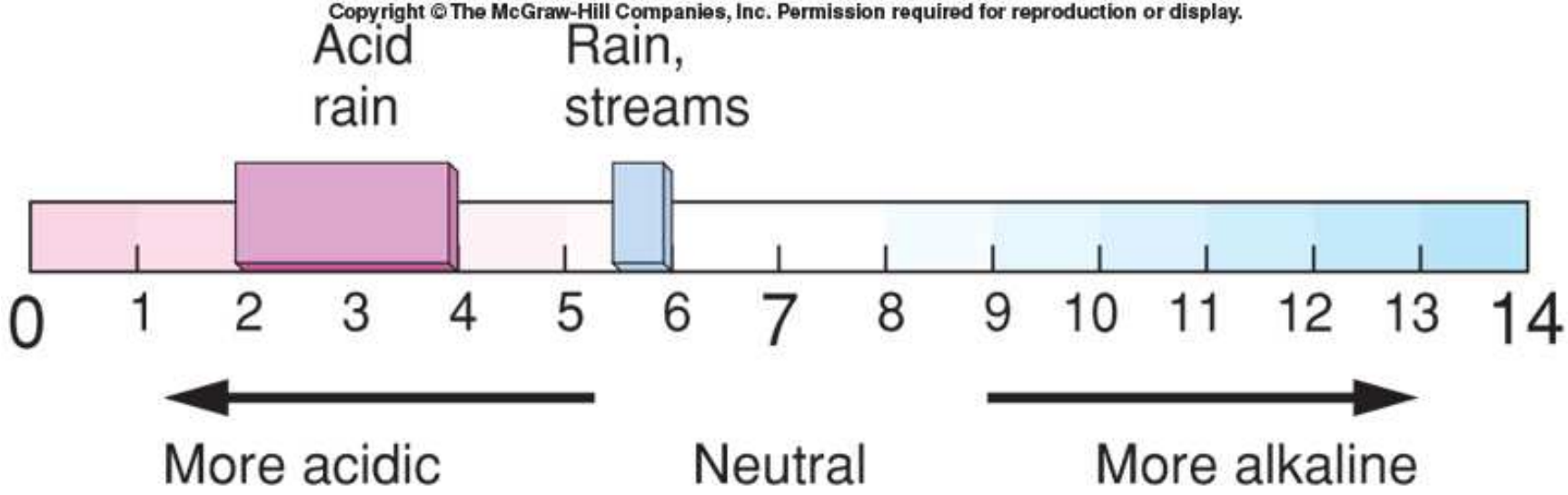
Chemical Weathering

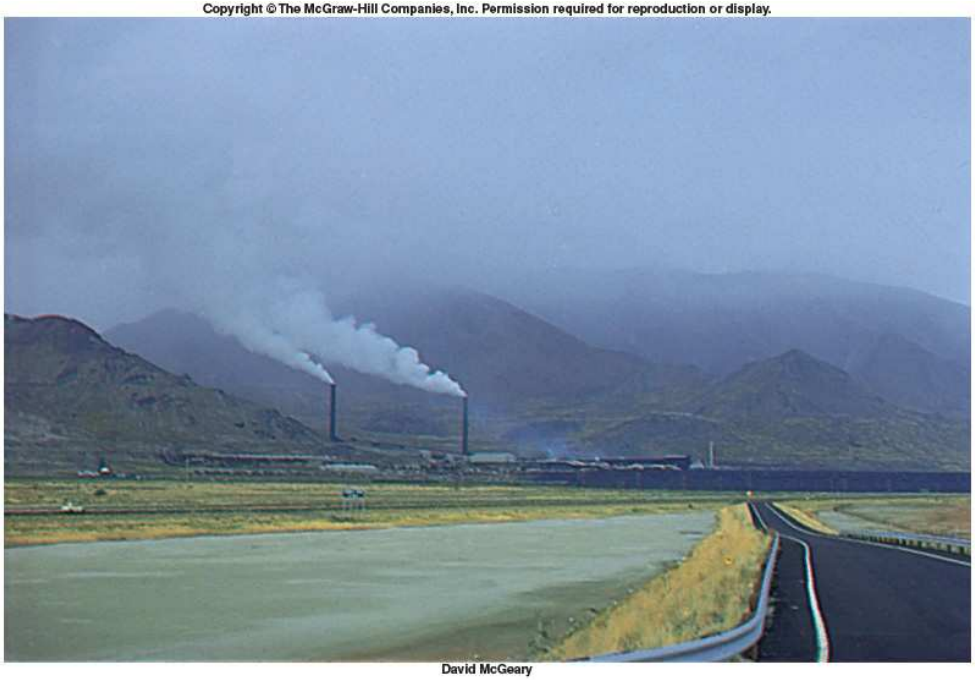
Role of Carbon Dioxide (CO_2)

- *Acid dissolution*
  - Atmospheric CO_2 (0.03%) dissolved in rain water – **Acid rain**
  - Acidic rain percolates through soil and weather minerals. Soil has more CO_2 (10%) than atmosphere because of respiration of soil organisms, decay of organic matter etc.

Photo by David McGeary

Acid Rain





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Carbon Cycle

- ***Follow the carbon!***

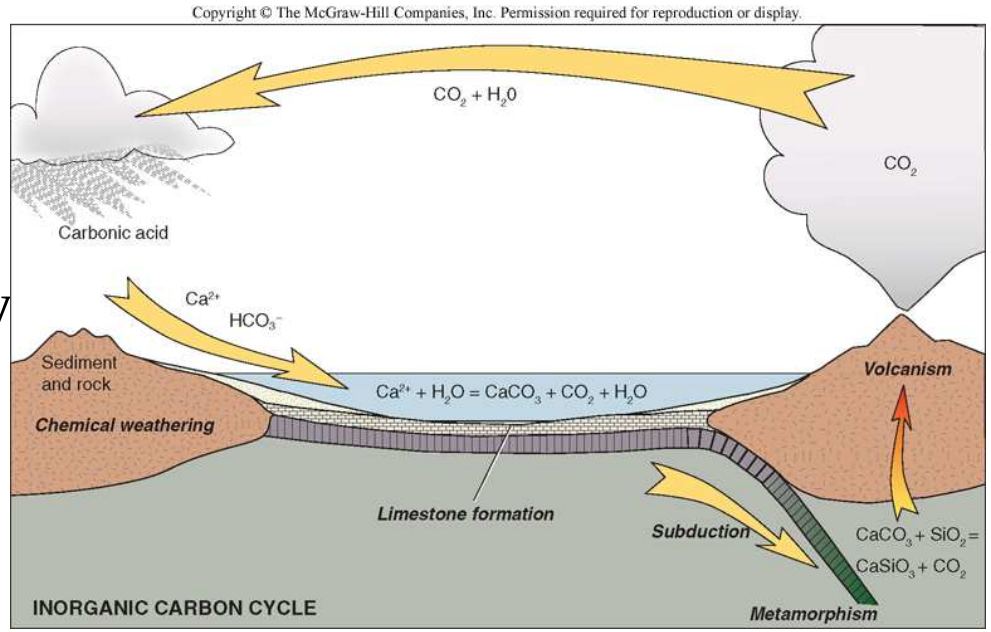
– Present as carbon dioxide in atmosphere

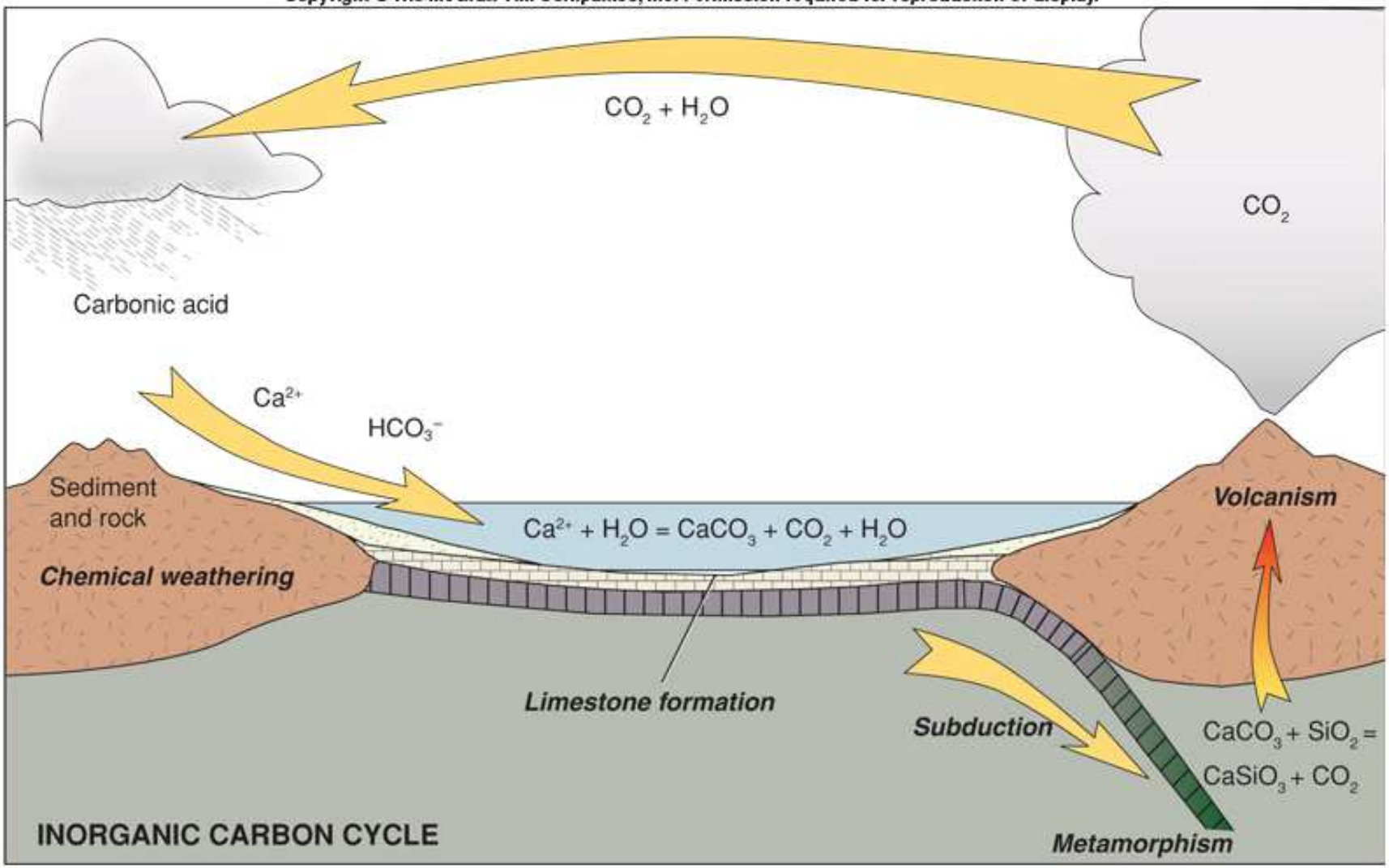
– Combines with water to form carbonic acid

– Weathers rocks and leads to limestone formation in bodies of water

– Returned to mantle by tectonic plate movement

– Released back to atmosphere by volcanic eruptions

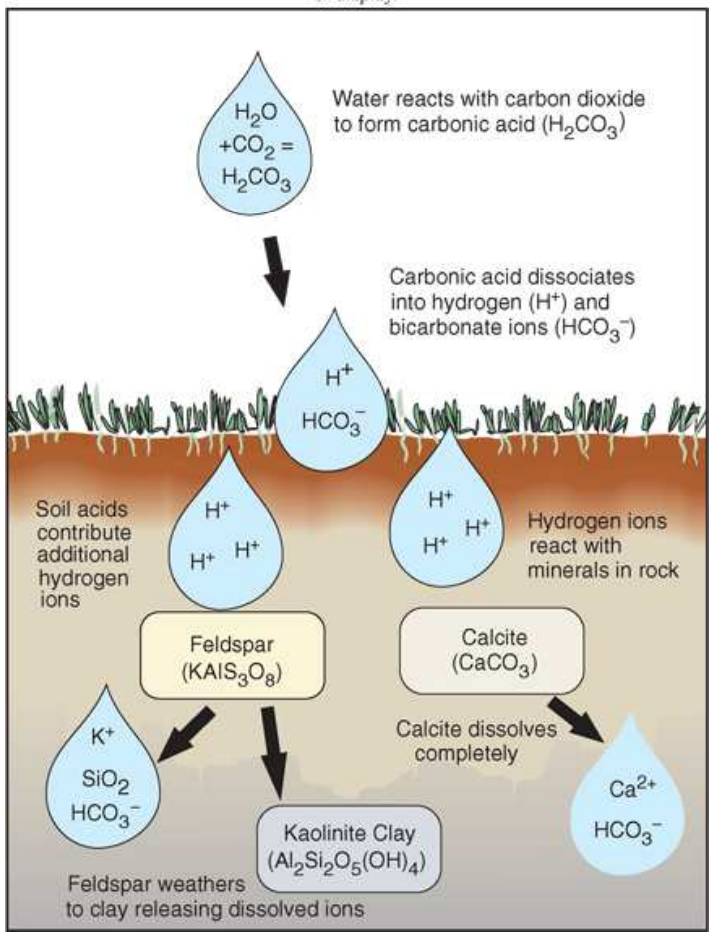




Chemical Weathering

- *Feldspars*
  - One of the most common minerals in crust
  - Slightly acidic rain water attacks feldspar
  - *Clay minerals* are produced

- *Warm, wet climatic conditions maximize weathering*



Soil Production

TABLE 12.2 Weathering Products of Common Rock-Forming Minerals

Original Mineral	Under Influence of CO_2 and H_2O	Main Solid Produc		Other Products (Mostly Soluble)
Feldspar	→	Clay mineral	+	Ions (Na^+, Ca^{++}, K^+), SiO_2
Ferromagnesian minerals (including biotite mica)	→	Clay mineral	+	Ions (Na^+, Ca^{++}, K^+, Mg^{++}), SiO_2, Fe oxides
Muscovite mica	→	Clay mineral	+	Ions (K^+), SiO_2
Quartz	→	Quartz grains (sand and silt)		
Calcite	→	–		Ions (Ca^{++}, HCO_3^-)

Soil

- *Soil* - a layer of weathered, unconsoli material on top of bedrock

  - Common soil constituents:
    - *Clay minerals*
    - *Quartz*
    - *Water*
    - *Organic matter*

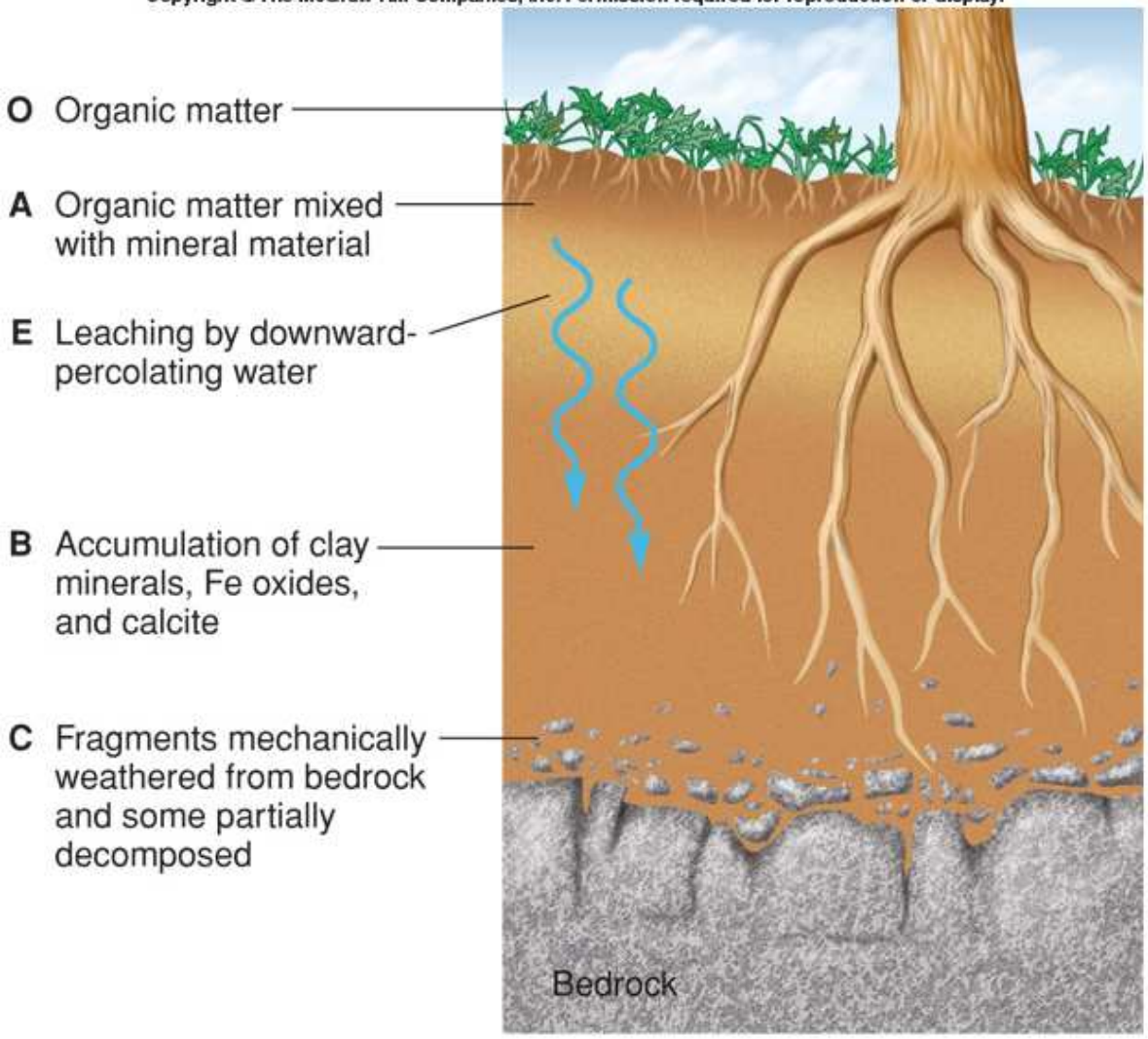
B

United States Department of Agriculture

Soil

Soil horizons

- *O horizon* - uppermost layer; organic material
- *A horizon* - dark layer rich in organic acids
- *E horizon* - zone of leaching; fine-grained components removed by percolating water
- *B horizon* - zone of accumulation; clays and iron oxides leached down from above
- *C horizon* - partially weathered bedrock



Soil Development Over Time

- *Residual soil* - weathering of underlying rock

- *Transported soil* - brought in from elsewhere
  - Floodplain deposits, etc.
  - Wind-transported soil

- *Soil composition*
  - Determined by parent rock composition
  - Evolves with time and chemical weathering

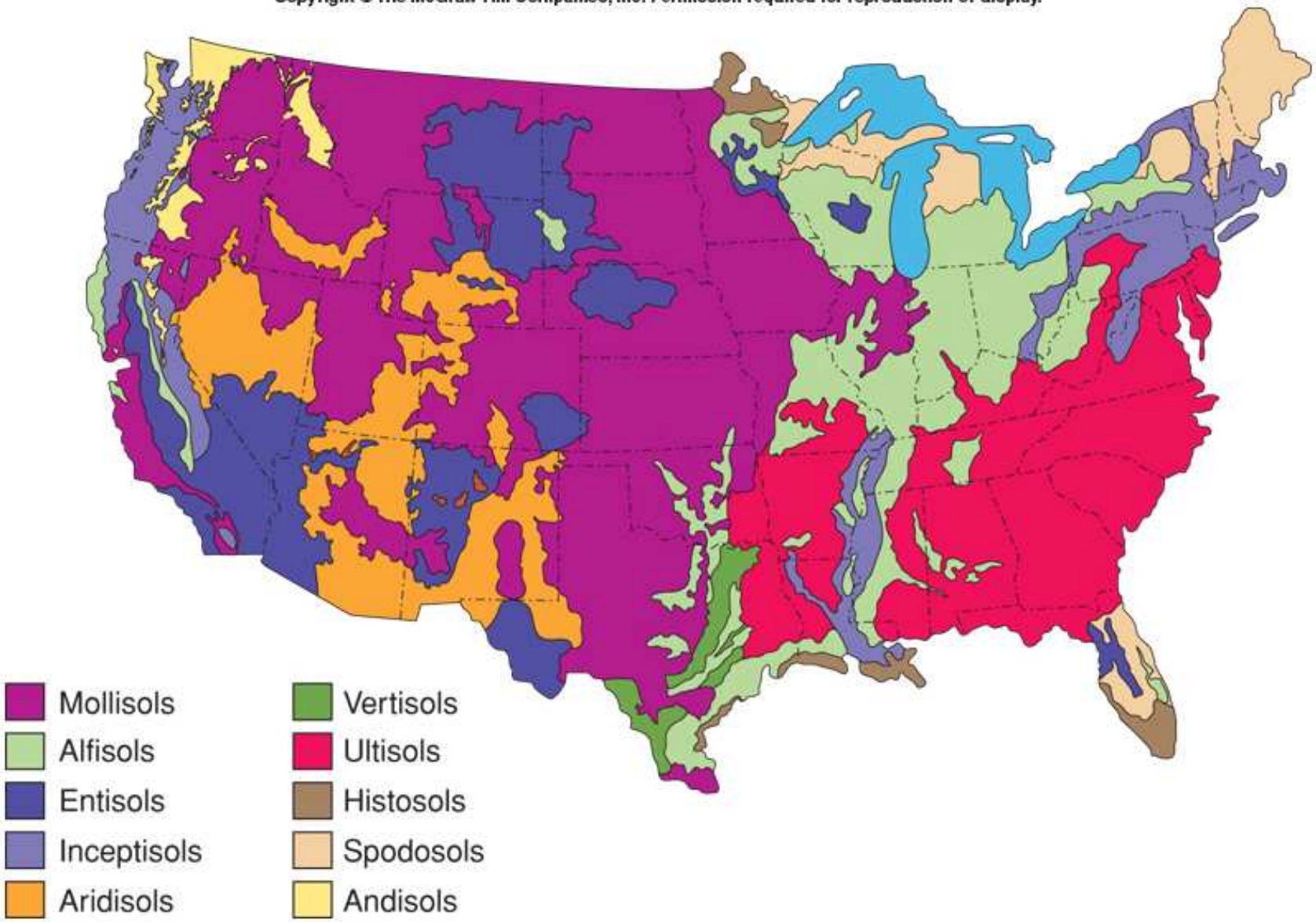
- *Soil thickness*
  - Increases with time
  - Greater in areas with low slopes

Soils and Climate

Soil thickness and composition are greatly affected by climate

- Wet climates:
  - More chemical weathering and thicker soil
  - Soils in moderately wet climates tend to have significant clay-rich layers, which may be solid enough to form a ***hardpan***
- Arid climates:
  - Less chemical weathering and thinner soils
  - Subsurface evaporation leads to build-up of salts
- Extremely wet climates (e.g., tropical rainforest)
  - Highly leached soils (***laterites***) – Red color soil (heavily Iron Oxide)

Soils Distribution in the USA



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