Karst Landforms

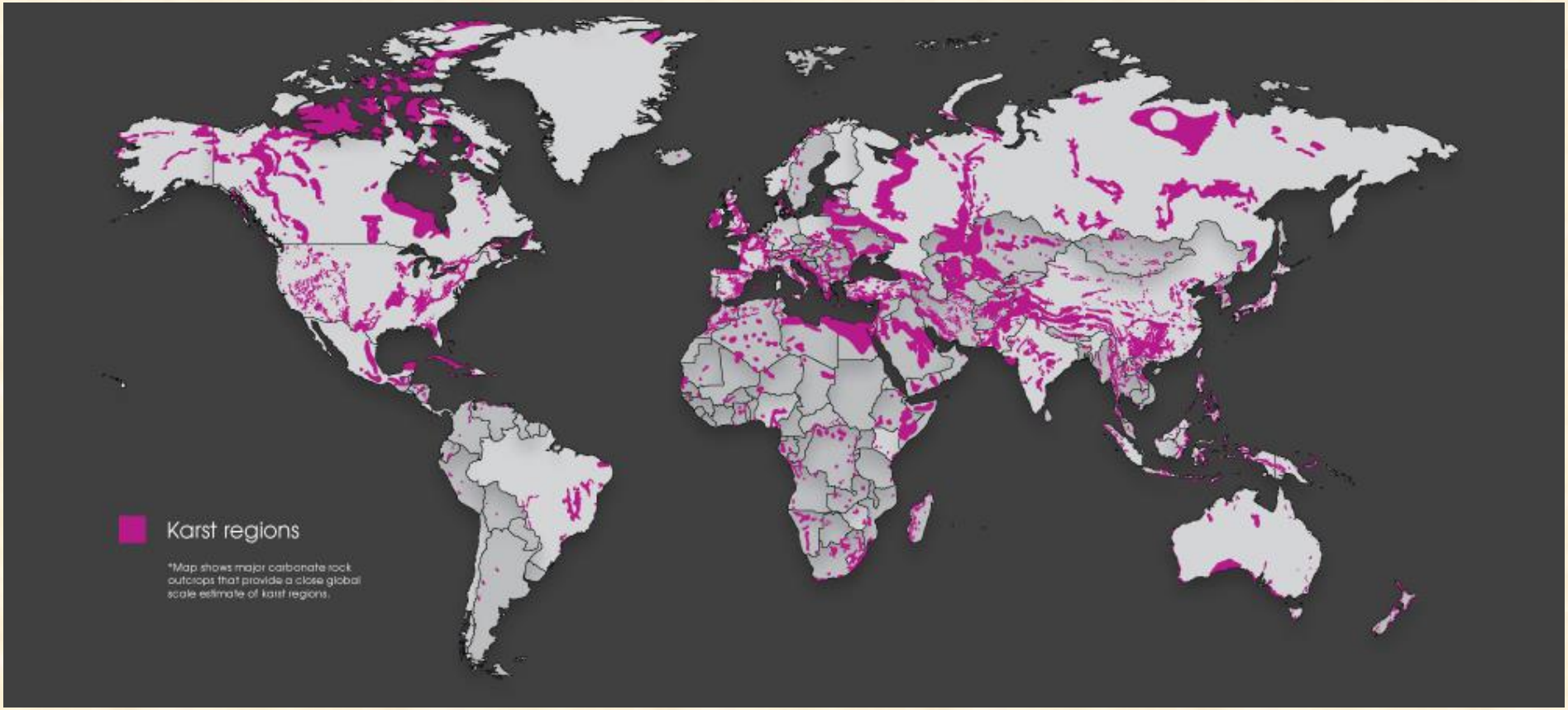
Karst is a term used to describe landscapes that are formed by chemical weathering process controlled by groundwater activity. Karst landscapes are predominantly composed of limestone rock that contains $\geq$ 70 percent calcium carbonate.

- Caverns
- Sinkholes
- Disappearing Streams
- Springs
- Towers

Onondaga Cave in Missouri is a karst landform formed by chemical solution in carbonate limestone rocks. Features within Onondaga Cave include stalagmites, stalactites, dripstones and active flowstone deposits. Missouri contains so many caves that it is nicknamed the "Cave State".

Karst Processes and Karst Landforms

- Word is German form of the Yugoslavian term *"Kras"* means "bare stony ground"
- Named after investigating a region near the Adriatic Sea in Yugoslavia
- In modern Geomorphology the term refers to any landscape formed by **dissolution** of the underlying bedrock
- Characterized by distinctive landforms which don't typically occur in any other circumstance



Factors affecting Karst Processes

Solubility of Bedrock

- percent calcite

Climate

- Temperature and Moisture

Structure of Limestone

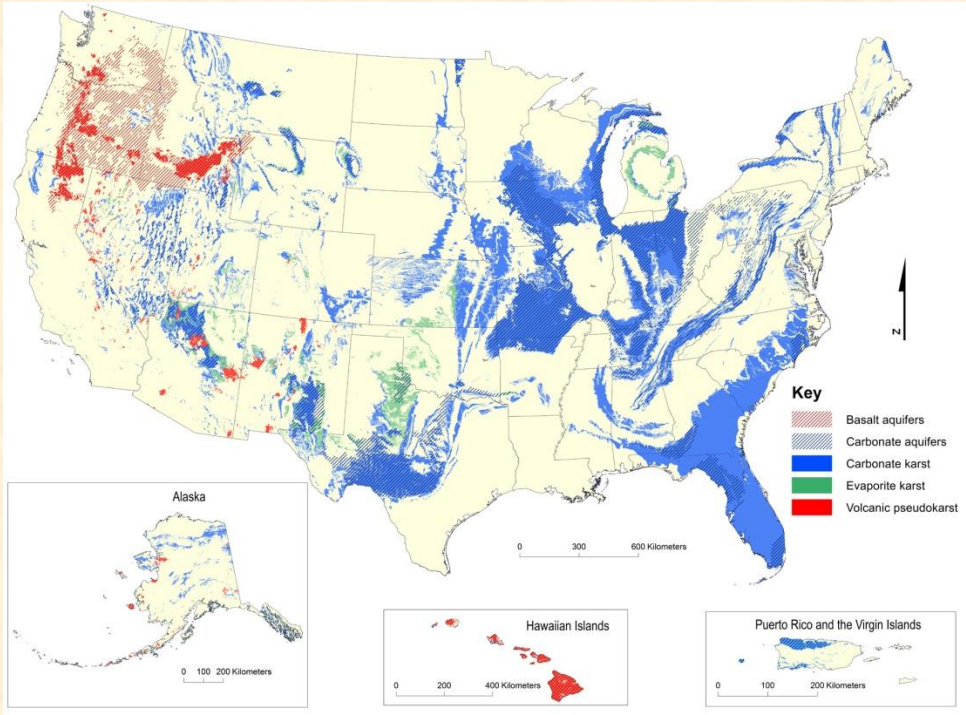
- joints, fractures, porosity,

Vegetation/Non-carbonate Geology

- acidity (pH) of groundwater

Atmospheric CO_2

- affects solubility of Carbonates



Other: hydrothermal/volcanic

Pseudokarst: iss the term for karst-like development in non-carbonate lithology that exhibits characteristics similar to karst landscapes, but which lack dissolution as a primary means of landscape formation.

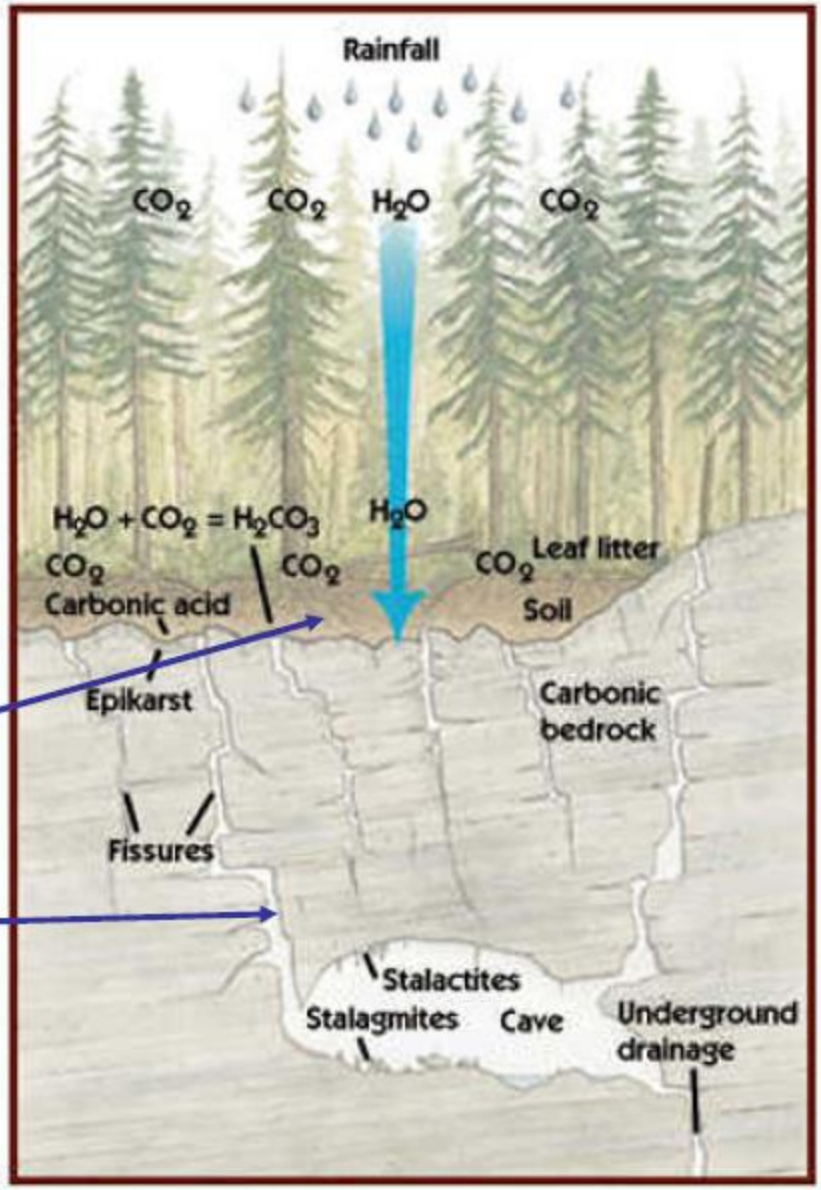
Porosity and Permeability

$P = (V_V / V) X 100$

where P is porosity,
V_v is volume of voids, and
V is total volume of material.

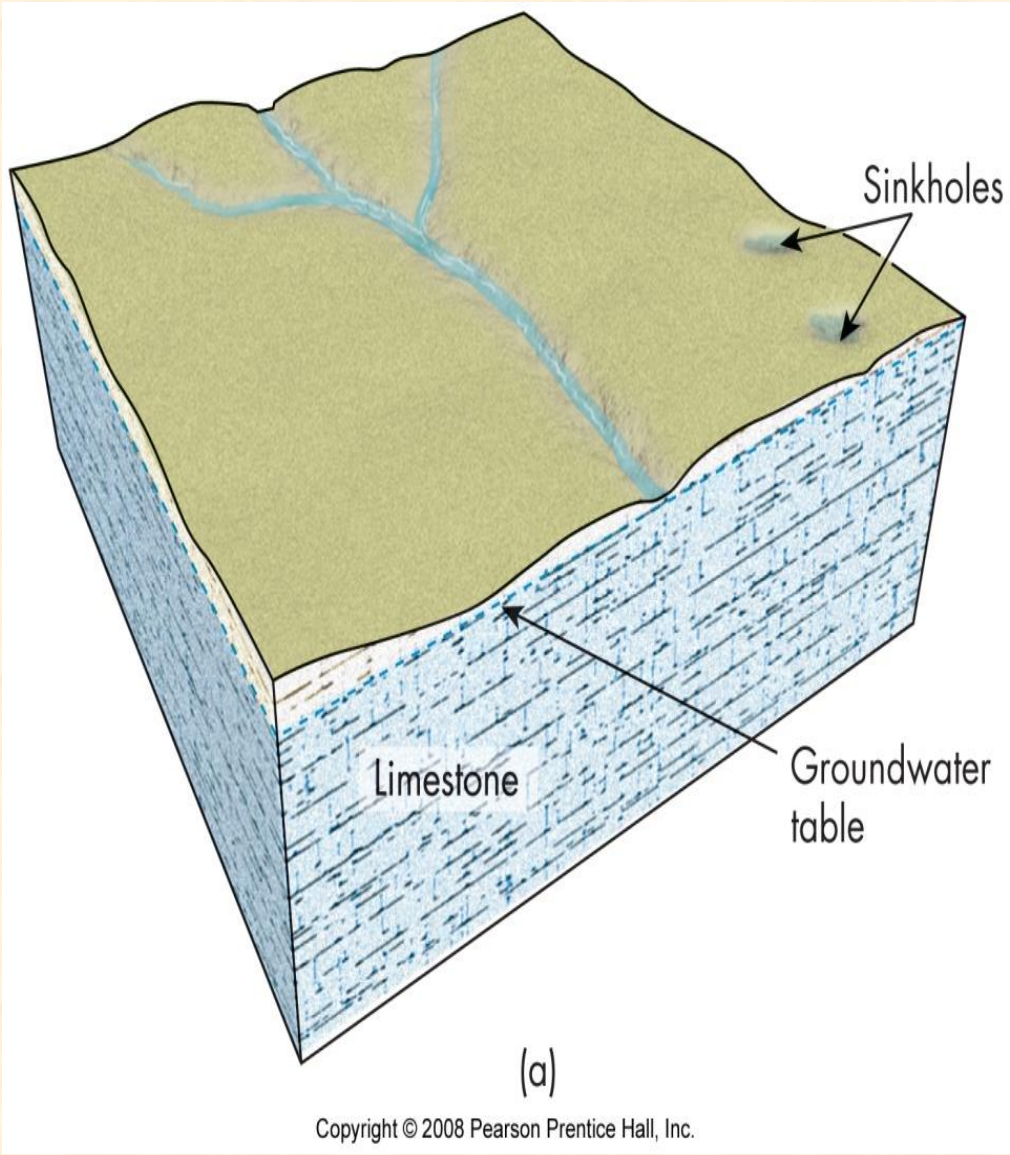
Two types of porosity:

- ***Primary porosity***
- ***Secondary porosity***



Additional Consideration: Water Table

- Rocks are dissolved by water: surface water or groundwater.
  - Carbonates, limestone ($CaCO_3$), and dolostone ($CaMg(CO_3)_2$)are dissolved by acidic water.
  - Evaporites, rock salt, and gypsum ($CaSO_4 \cdot 2H_2O$) are dissolved by water.

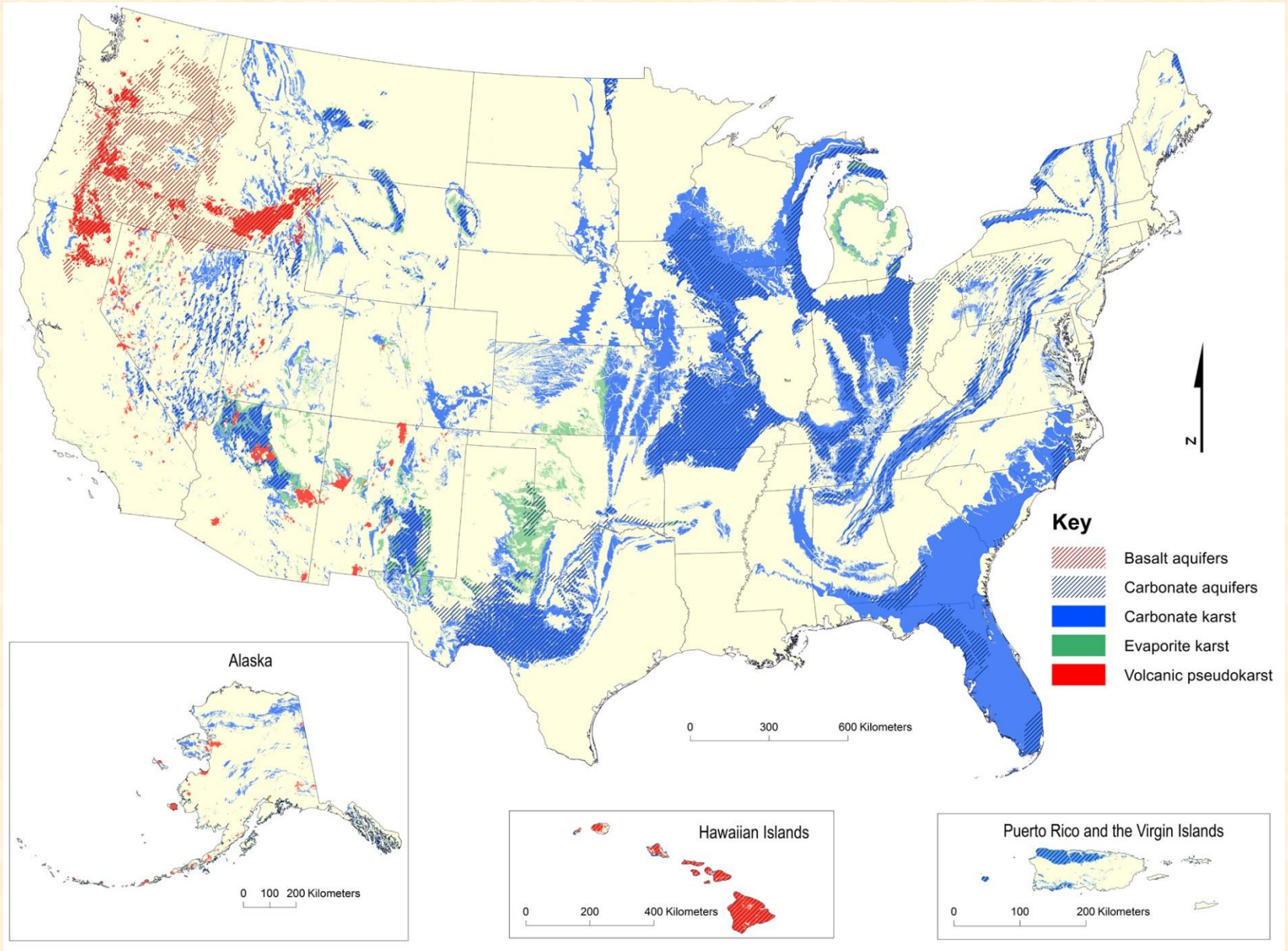


Karst Processes

Lithology - Limestones show great variability due to their definition.

- A limestone is a rock containing at least 50% carbonate mineral,
- The two most common carbonate minerals in limestone are a low magnesium (1-4%) calcite and dolomite.
- The purer the limestone is with respect to calcite, the greater tendency to form karst.
- Dolomites and evaporites such as gypsum and halite are also prone to karstification.

US: Karst Landforms, ~15%



Chemical Weathering: Carbonation

- Carbonation is a process by which carbon dioxide and water chemically react to produce carbonic acid, a weak acid, that reacts with carbonate minerals in the rock.

- This process simultaneously weakens the rock and removes the chemically weathered materials.

Influenced by:
Temperature
Pressure
Partial pressure of CO_2
pH
Ion concentration

$$\underset{\text{air}}{CO_2} + \underset{\text{water}}{H_2O} \longrightarrow \underset{\text{carbonic acid}}{H_2CO_3}$$

$$\underset{\text{calcium carbonate}}{CaCO_3} + \underset{\text{carbonic acid}}{H_2CO_3} \rightleftharpoons \underset{\text{calcium ion}}{Ca^{++}} + \underset{\text{bicarbonate ion}}{2HCO^-_3}$$

Chemical Weathering: Carbonation

CO_2 in air dissolved in cloud droplets

Falls as precipitation (say, rainwater)

$H_2O + CO_2 \Leftrightarrow H_2CO_3 \Leftrightarrow H^+ + HCO_3^-$

- Weak acid, very slow dissolution

- Calcite, rainwater, and Humic Acid; pH ~ 4 - 7
  - Precip. soaks though O and A horizons, adds plant acids
  - $CaCO_3\,(s) + 2H^+\,(aq) \Leftrightarrow Ca^{++}\,(aq) +$ **$CO_2\,(g) + H_2O(l)$**

Temp: Cold water contains more CO_2
Pressure: deeper H_2O , more CO_2 absorbed, more acidic

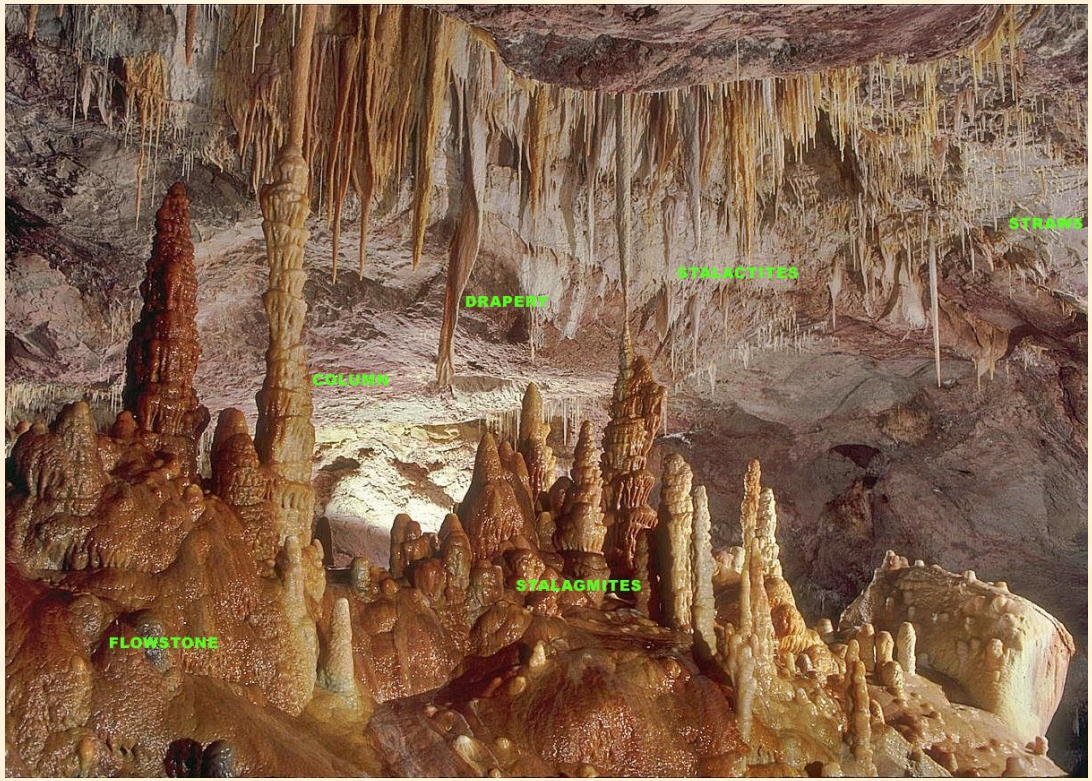
Chemical Weathering: Carbonation

- Carbonation primarily occurs in wet, moist climates and effects rocks both on and beneath the surface.

- Carbonation occurs with limestone or dolomite rocks and usually produces very fine, clayey particles.

Limestone weathered by carbonation processes

Photo source: Wikipedia GNU Free Documentation License



Chemical Weathering: Carbonation

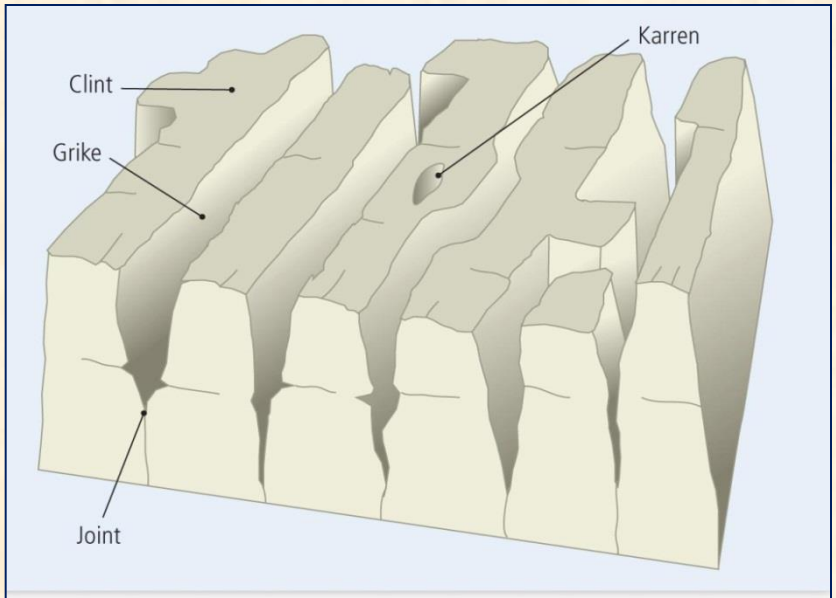
- Limestone (bedrock) is permeable
- Rain takes in carbon dioxide as it passes through the atmosphere
- Carbon dioxide (CO_2) dissolves in rainwater (H_2O)
- Forms weak carbonic acid (H_2CO_3)
- The carbonic acid reacts with the carbonate in the limestone (bedrock)
- This forms calcium (Mg etc..) bicarbonate, which is soluble in water
- This solution percolates through rock
- It removes the calcium carbonate
- Fissures in rock become enlarged
- Underground drainage system develops

Surface Landforms: Limestone Pavement

Exposed areas of limestone

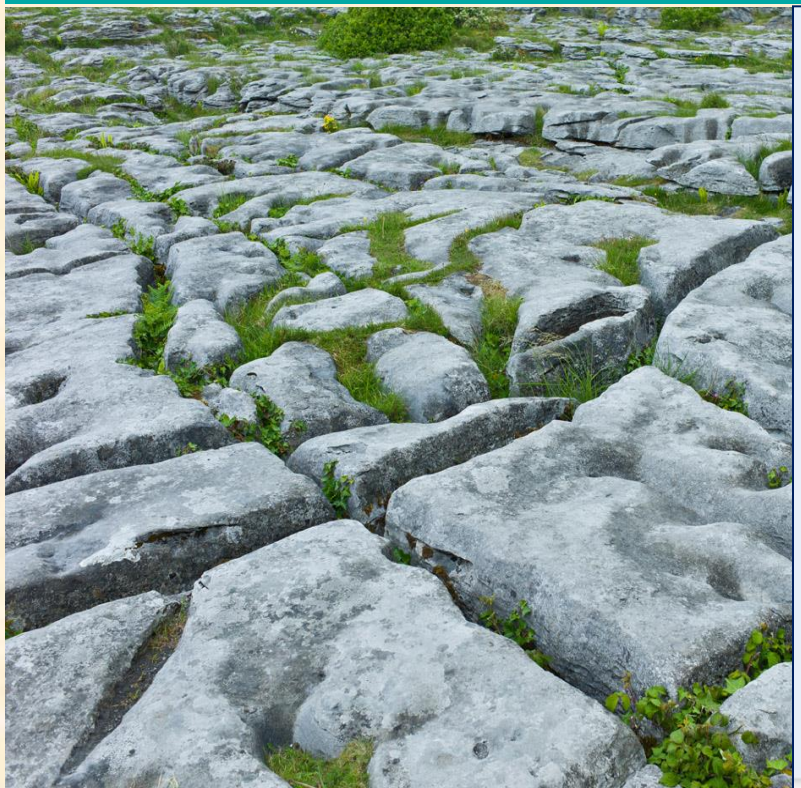
Rugged and bare landscape with flat areas of rock surface

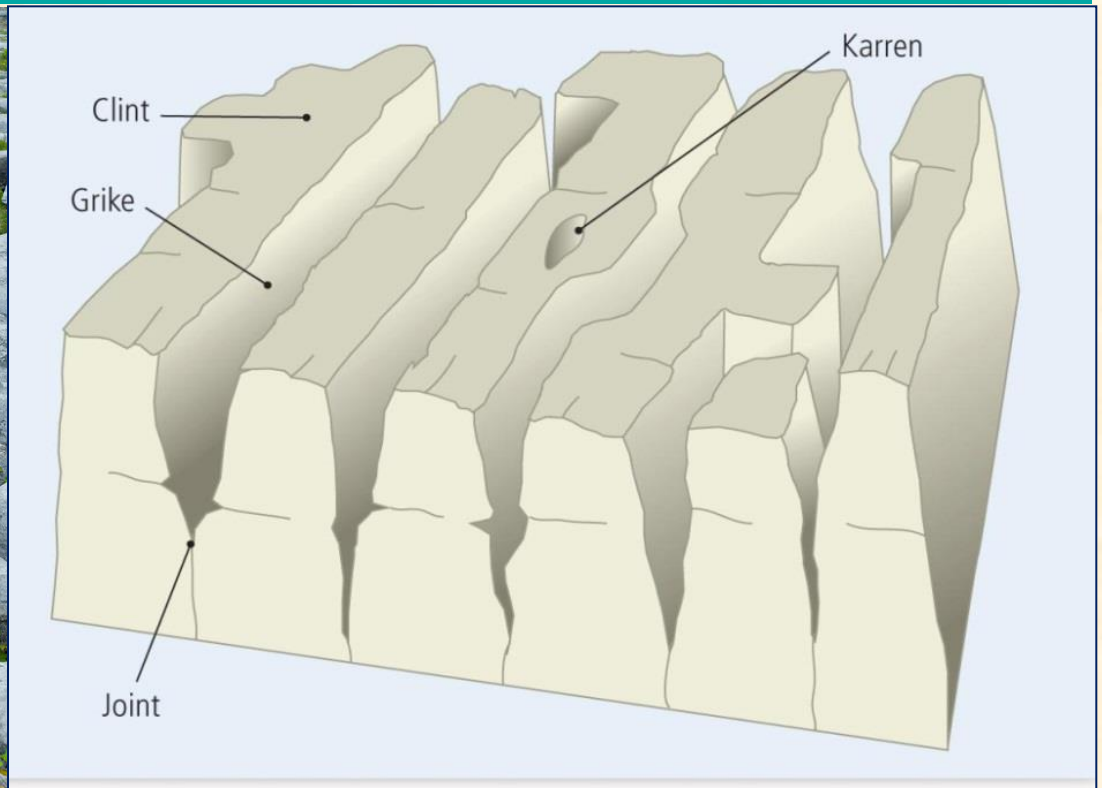
Gradual widening of joints and fractures (bedding)



Features of limestone pavements

- **Clint:** section of a limestone pavement separated from adjacent sections by grikes
- **Grike:** vertical crack that develops along a joint in limestone
- **Karren:** small hollow that forms on the surface of a limestone clint





Surface Landforms: Sinkholes

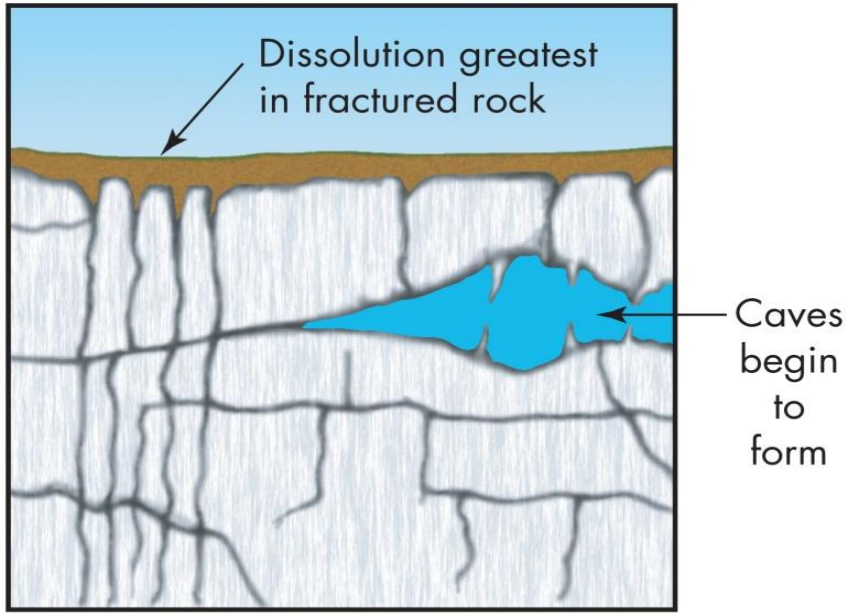
- Collapsed/depressed limestone features that develop in karst landscapes.

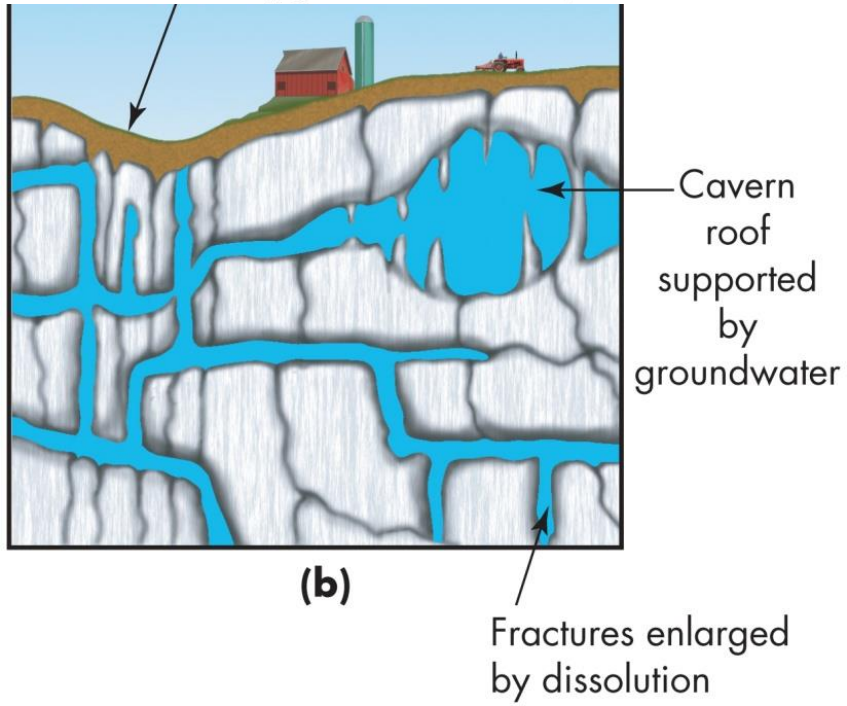
- The ground water slowly dissolves the limestone rock below the surface until it eventually becomes unstable and collapses creating local depressional features.

Photo: USGS

Sinkholes

- Groundwater dissolves soluble rock, creating fractures and caves.
- Dissolving continues to form larger caves and fractures.



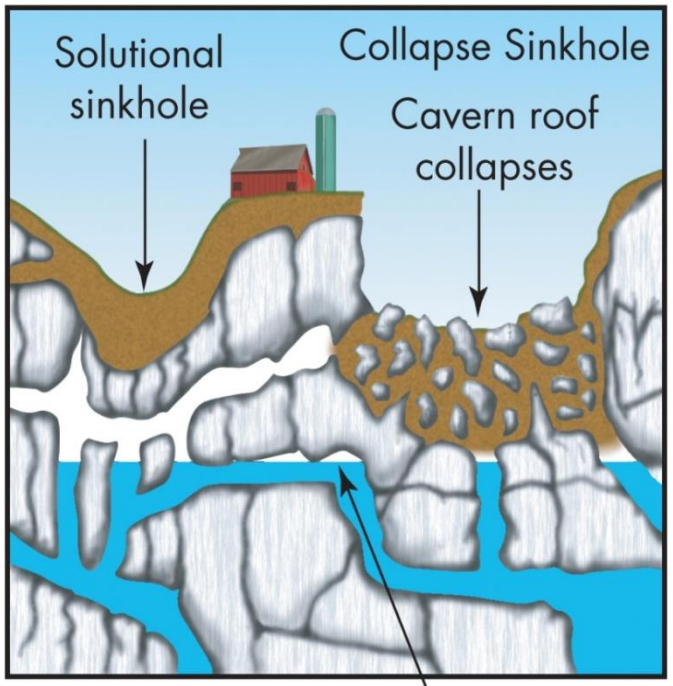


Dolines (Sinkholes, Cenotes)

- Collapse sinkholes form when water level drops

- Solution sinkholes due dissolution at surface

Large sinkhole and M.F. Peck at Hasan Temple, Albany, Ga. - 8/4/94 by L.E. Jones



Surface Landforms: Sinkholes

- Occur in a range of sizes, and can be temporarily, seasonally, or permanently filled with water.
- Sinkholes pose a threat to developed areas.
- Increased pressure on water resources and depleted ground water tables can trigger sinkholes to collapse under the pressure of gravity or the void formed by the depleted ground water.

Photo: USGS

www.sfwmd.state.fl.us

The left is an aerial view of the Tres Pueblos sinkhole in Puerto Rico. Solution of the underlying rock caused bedrock, soil, and vegetation to collapse into the sinkhole feature. The images above are from urban areas in Florida where sinkholes damaged several homes and businesses.

Sinkholes

- **Solution Sinkhole**
  - Little or no sediment is present over limestone
  - Easily dissolved by water
- **Cover-Subsidence Sinkhole**
  - Thick sediments overlay limestone
  - Underlying limestone is dissolved, sediments dump into the void
- **Cover-Collapse Sinkhole**
  - Triggered by heavy rainfall, drought, overloading
  - Cause **sudden** collapse into void

Winter Park sinkhole (1981)

- 100 m across
- One day
- Due to water table lowering
- Now an urban lake.

Sinkholes

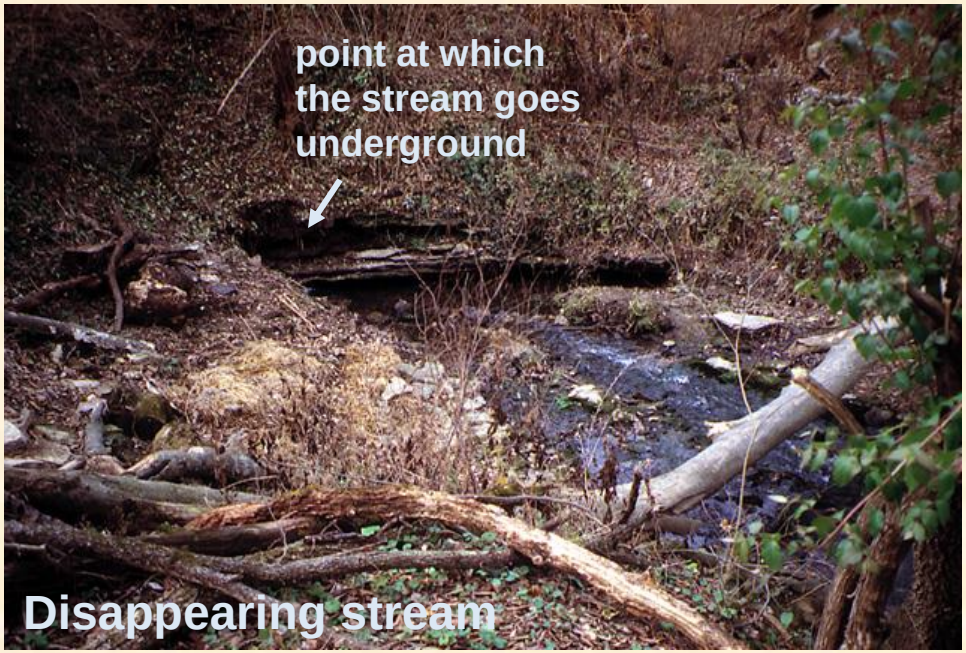
Often occur along the same subterranean drainage system

Uvala: series of smaller sinkholes coalesce into a compound sinkhole

Surface Water Features

- Karst regions are noted for their **lack of well-established surface drainage**.
  - Surface drainage is actually replaced by extensive underground drainage.

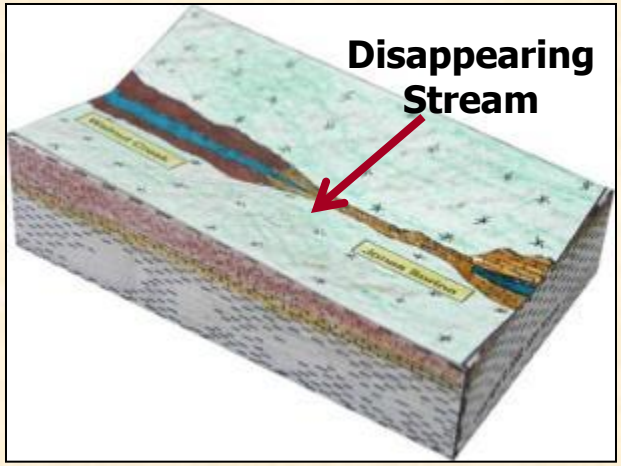
- Where surface streams **do** develop, they do not flow very far – they "disappear" **(disappearing streams)** and "reappear" **(springs)**.



Disappearing Streams

- Streams that flow on the surface and then seemingly "disappear" below ground.
- Disappearing streams disappear into a sinkhole or other karst solution features (caves)
- They may also disappear into factures or faults in the bedrock near the stream.
- Disappearing streams are also referred to as **losing streams, sinks, or sieves**.

www.northeastiowarcd.org



The stream in this image on the left disappears into the limestone and continues to flow underground before resurfacing downstream.

Resurface
6340

Sink
6555

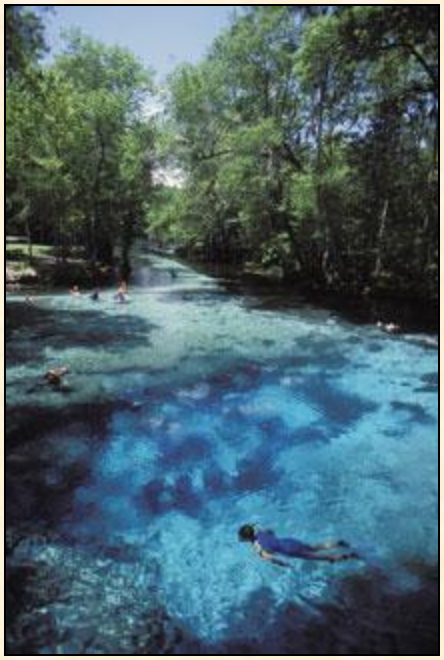
Disappearing streams will often continue flowing underground and may resurface at another location downstream from where they disappeared.

Popo Agie River, Wyoming

Sinking stream in karst area of Kentucky

Springs

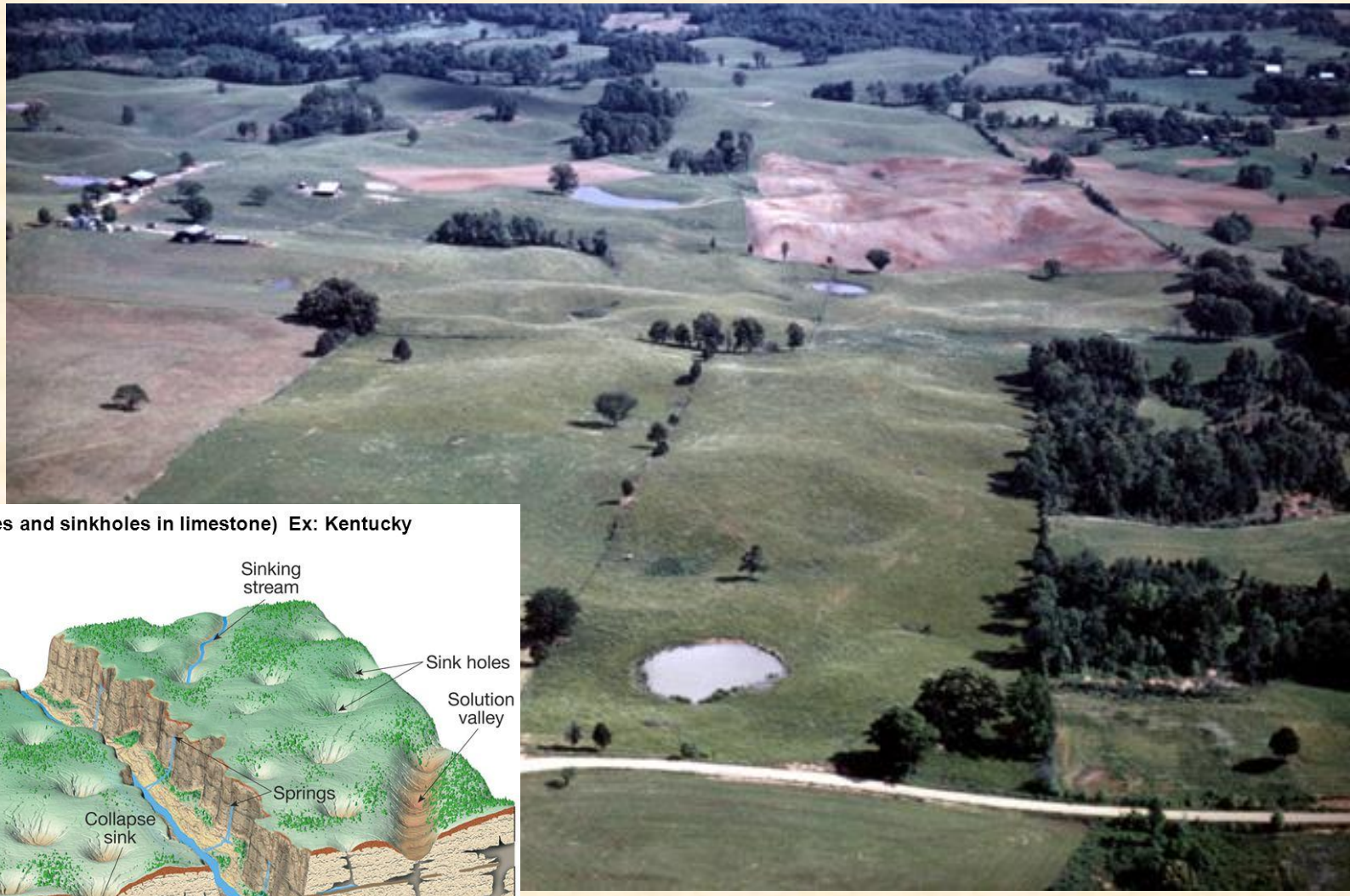
- Karst springs are locations where groundwater emerges from the limestone and flows across the surface forming a stream or contained pool.
- The flow of Karst springs is generally dependant on the weather and climate.
- Ephemeral springs only flow following rainfall or snowmelt events.
- More permanent springs are connected to aquifers and flow year-round

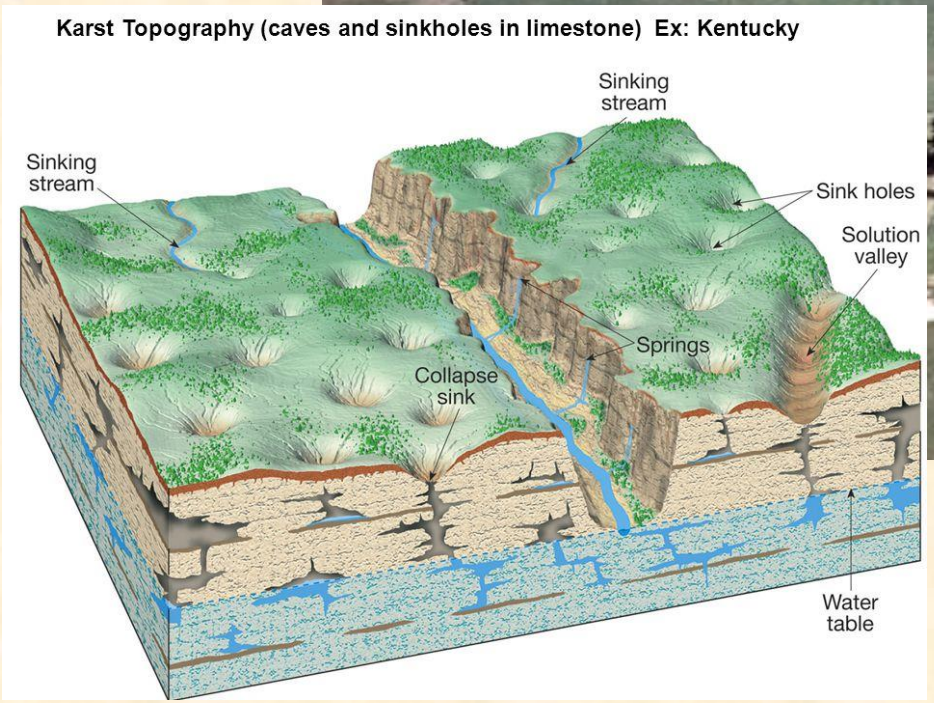


http://www.floridasprings.com/about.html

Figure 17-6
Understanding Earth, Fifth Edition

Sinkhole Plain in Kentucky

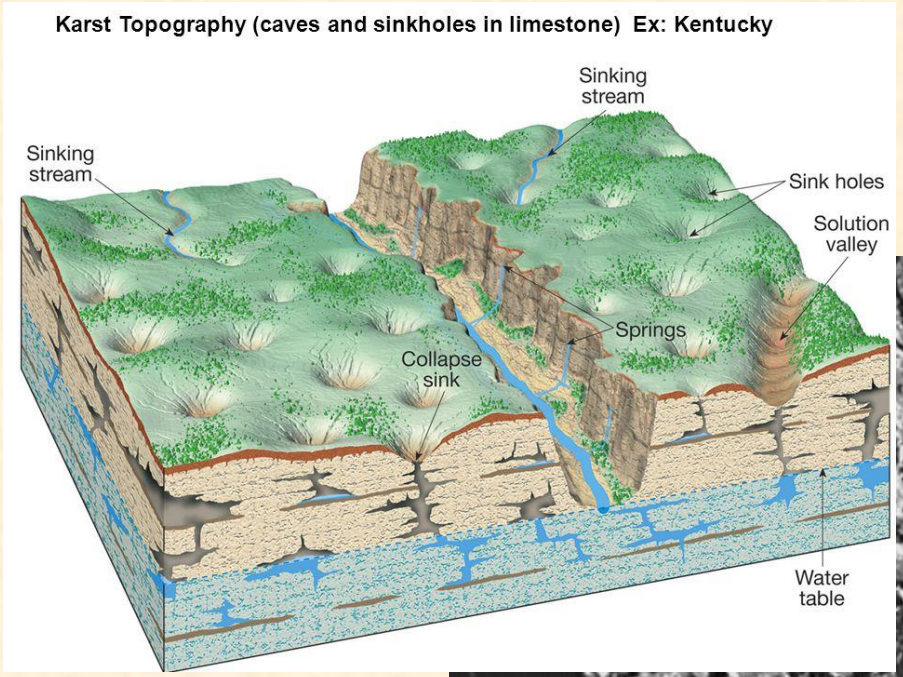


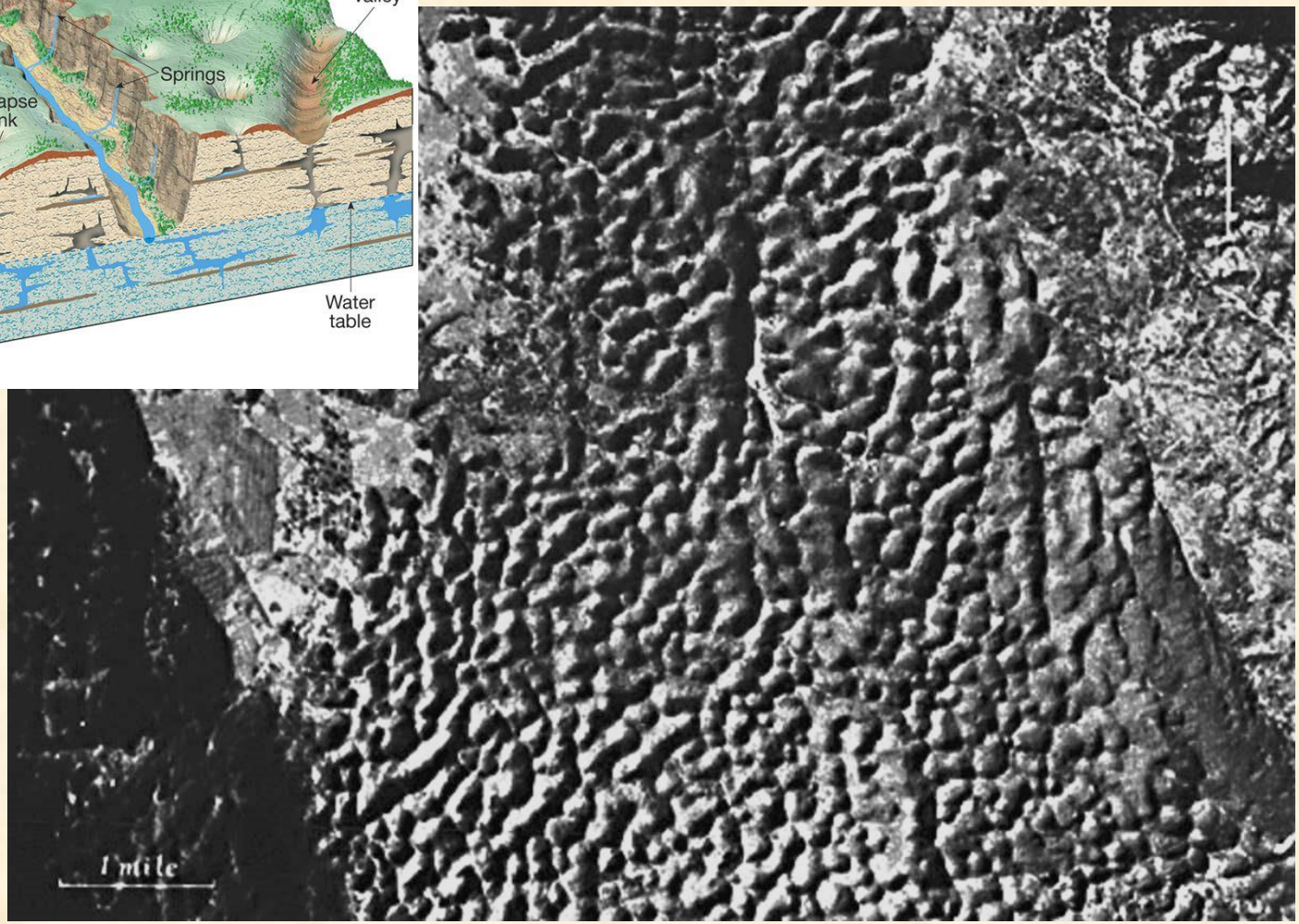


Cockpit Karst Cockpit karst is a form of karst in which the residual hills are chiefly hemispheroidal and surround closed, lobed, depressions known as dolines or "cockpits" each of which is drained to the aquifer by one or more sinkholes

Arecibo Radio Astronomy Observatory, Puerto Rico

Cockpit Karst region in Jamaica





Karst Towers

- Landscape is mottled with a maze of steep, isolated limestone hills
- Limestone beds are thick and highly jointed
- Puerto Rico, western Cuba, southern China, and northern Vietnam
- CO_2 production by vegetation in these climates facilitates weathering

Karst Towers: Stone Forest, China

Subsurface Karst Features: Caverns

- Limestone caverns and caves are large sub-surface voids where the rocks has been dissolved by carbonation.
- In sections where the ground water table has dropped, pressure release promotes precipitation of minerals creating a variety of **speleothems**

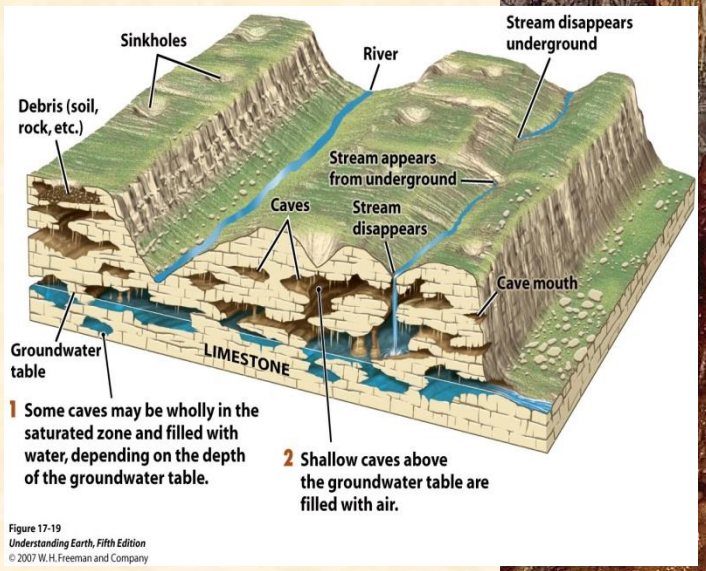
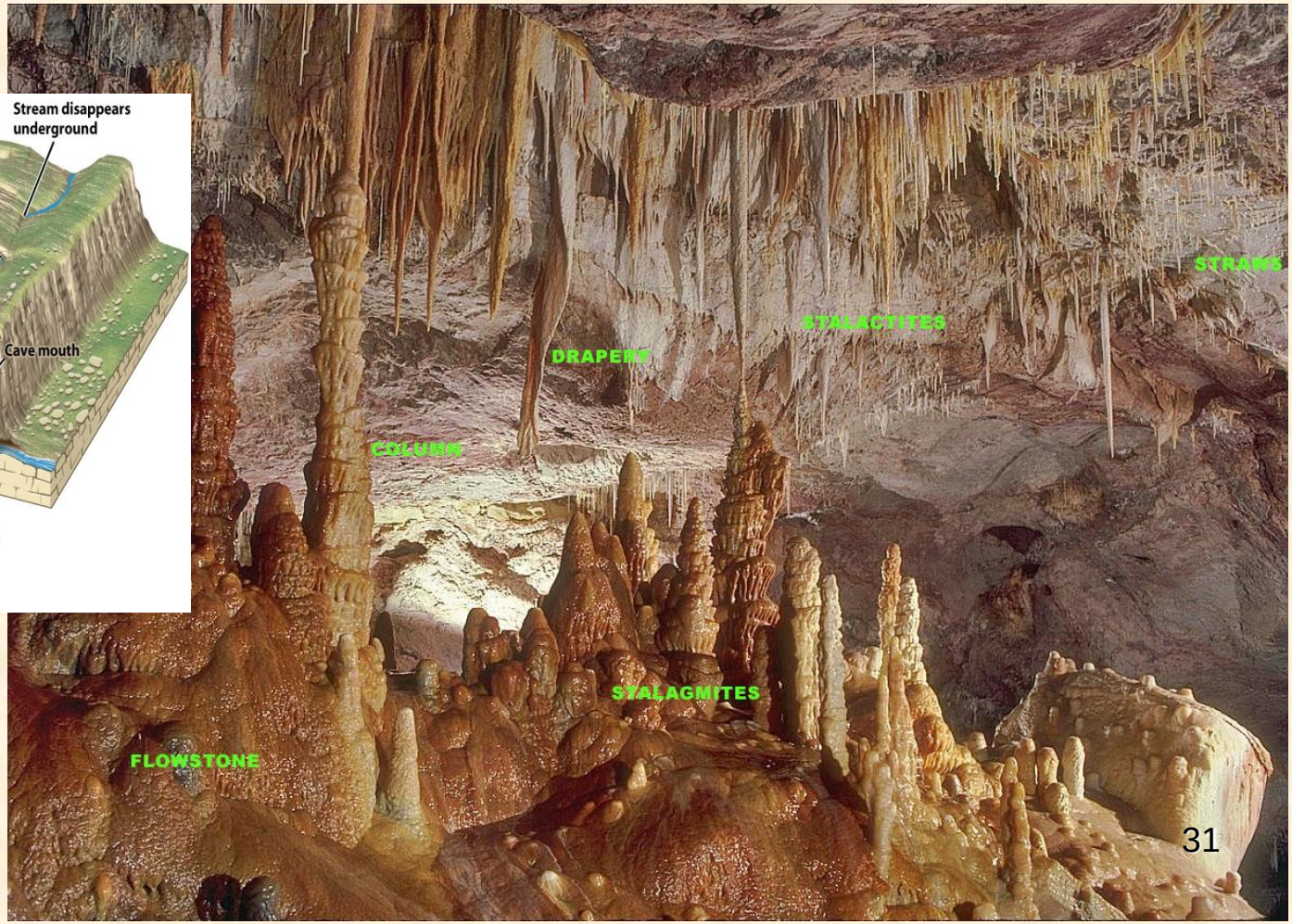


Figure 17-19
Understanding Earth, Fifth Edition

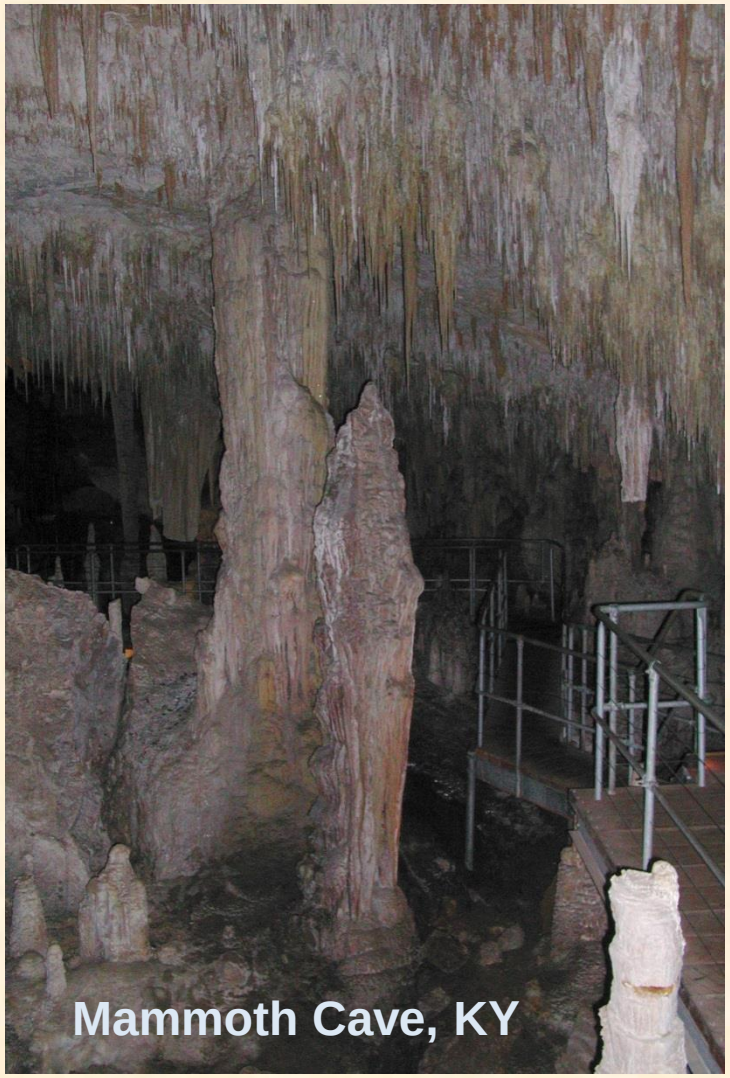


Subsurface Karst Features: Caverns

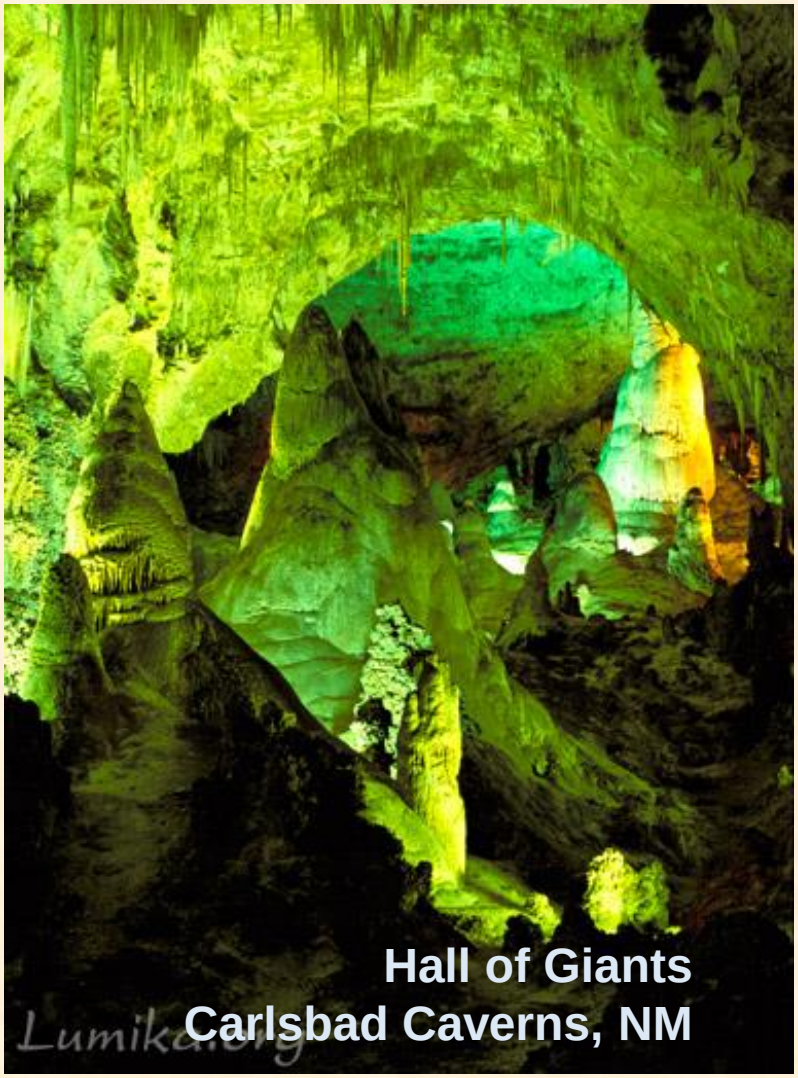
- Calcium carbonate precipitates out of the saturated carbonate solution and accumulates as deposits.
- **Stalactites** are deposits that grow from the ceiling downward
- **Stalagmites** are deposits that grow from the ground up.
- If the stalactite and stalagmites join they form a continuous **column**.
- Mammoth Cave in Kentucky and Carlsbad Caverns in New Mexico are two of the largest cave systems in North America .

This image of the "Chinese Theatre" in Carlsbad Caverns National Park illustrates how stalactites and stalagmites can join to form columns. Notice the person in the lower left for scale!

Karst: Caves & Caverns



Mammoth Cave, KY



Hall of Giants
Carlsbad Caverns, NM

Cave Features

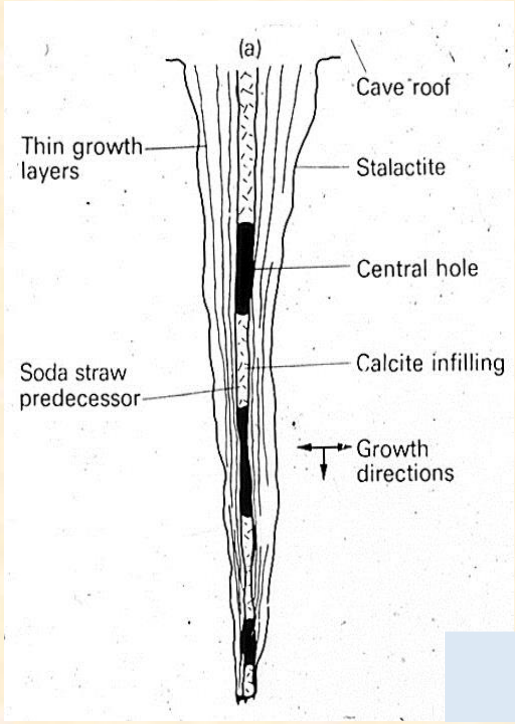

Soda Straws


Stalactite


Stalagmite

Soda straws to stalactites

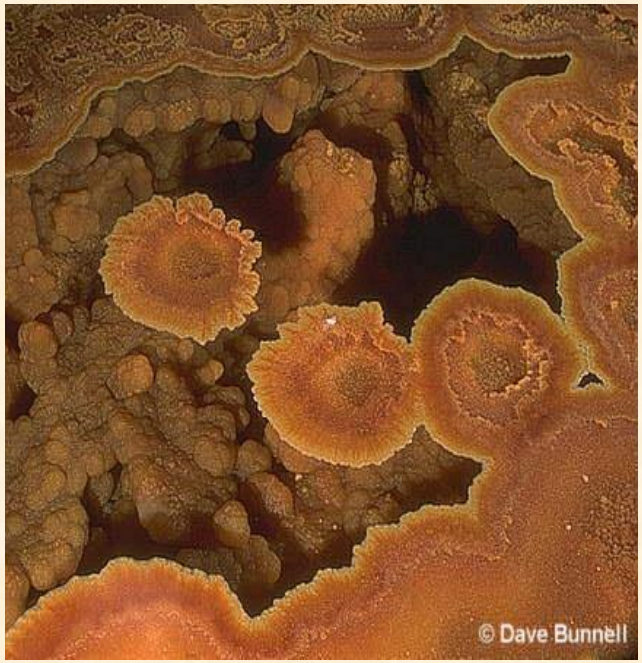
- Soda straws are initially **hollow**, allowing dissolved limestone to travel through the tube.
- Because a dissolved solid is traveling through the tube, it sometimes gets plugged up.
- This forces the dissolved limestone to "back up" and start flowing on the outside of the straw.
- Eventually, it thickens and becomes recognizable as a stalactite!



Cave Features

Pool Spar crystallization of dissolved limestone in water

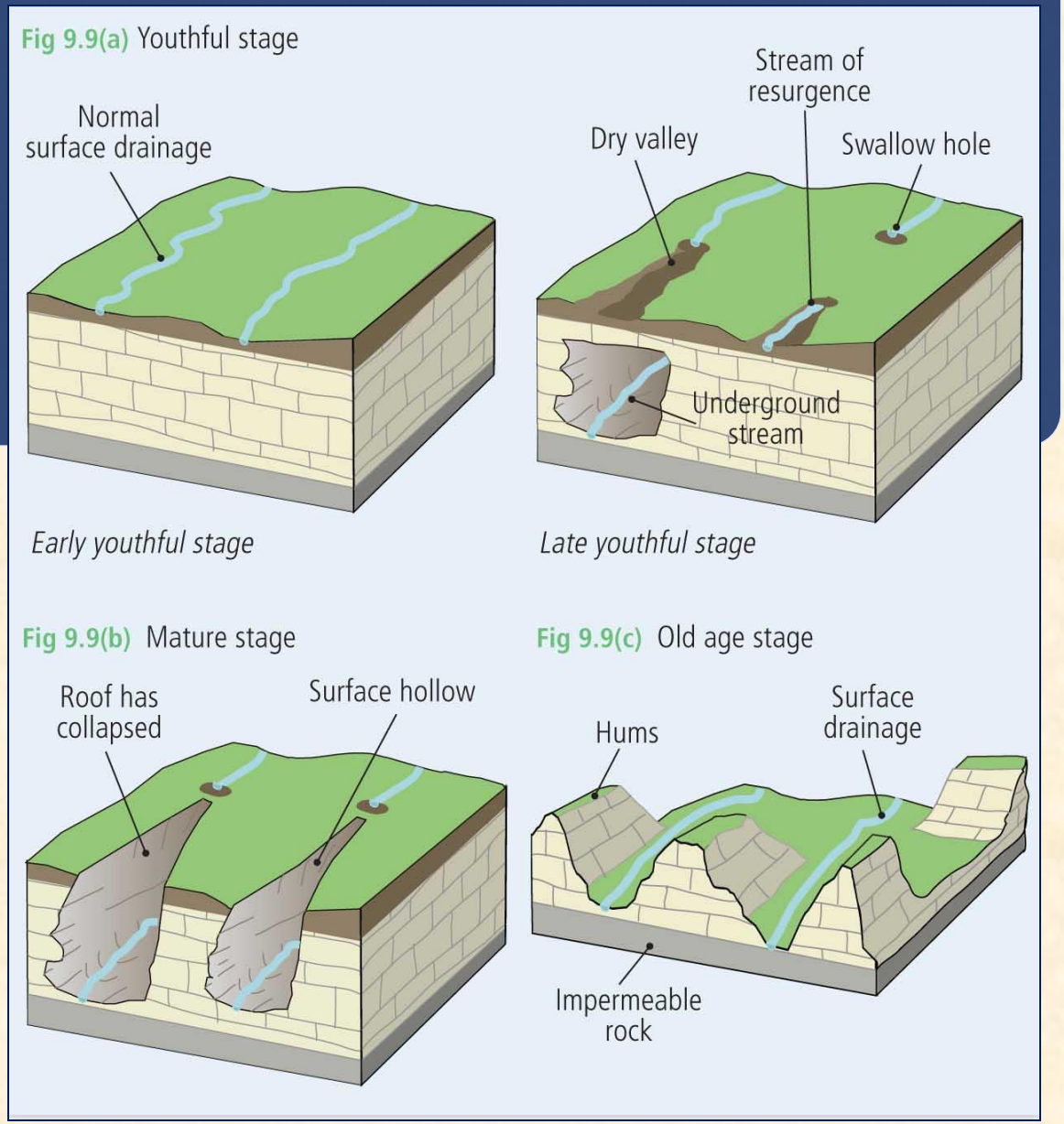
A shelfstone develops when spar attach to side of a cave pool



Columns form when stalactites & stalagmites grow together

Cycle of Erosion in a Karst Topography

- **Three stages:**
  - Youthful
  - Mature
  - Old age



Additional Fun Karst Features

Abîme, a vertical shaft in karst that may be very deep and usually opens into a network of subterranean passages
Cenote, a deep sinkhole, characteristic of Mexico, resulting from collapse of limestone bedrock that exposes groundwater underneath
Foibe, an inverted funnel-shaped sinkhole
Scowle, porous irregular karstic landscape in a region of England
Turlough (turlach), a type of disappearing lake characteristic of Irish karst
Uvala, a collection of multiple smaller individual sinkholes that coalesce into a compound sinkhole. Word derives from South Slavic languages.
Karren, bands of bare limestone forming a surface
Limestone pavement, a landform consisting of a flat, incised surface of exposed limestone that resembles an artificial pavement
Polje (karst polje, karst field), a large flat specifically karstic plain. The name "polje" derives from South Slavic languages.
Doline, also sink or sinkhole, is a closed depression draining underground in karst areas. The name "doline" comes from *dolina*, meaning "valley", and derives from South Slavic languages.
Karst spring, a spring emerging from karst, originating a flow of water on the surface
Ponor, also sink or sinkhole, where surface flow enters an underground system. Derived from South Slavic languages
Sinking river, or *ponornica* in South Slavic languages
Karst fenster ("karst window"), a feature where a spring emerges briefly, with the water discharge then abruptly disappearing into a nearby sinkhole