# KARST LANDFORMS

- produced by weathering & erosion in regions of carbonate rocks and evaporites
- processes called karstification
- mainly below ground surface
- predominantly underground drainage – poorly-developed surface network of streams
- occurs everywhere, but most common in temperate & tropical climates; in US, occurs in PA, MD, central Florida, east-central Missouri, belt from south-central Indiana to east-central Kentucky, Edwards Plateau in Texas, NM

(karst terms listed in text)

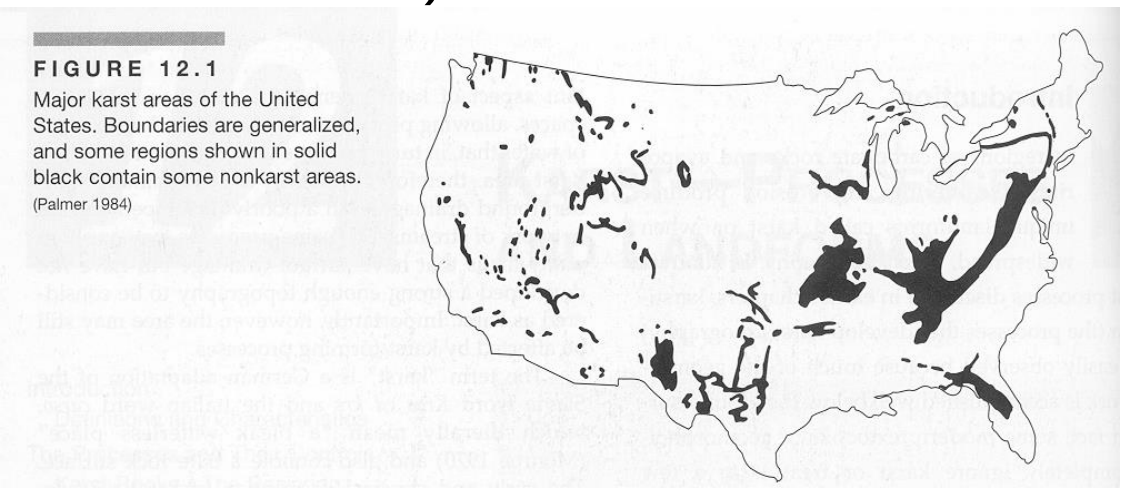


FIGURE 12.1
Major karst areas of the United States. Boundaries are generalized, and some regions shown in solid black contain some nonkarst areas.
(Palmer 1984)

Karst found mostly in limestone (rock with at least 50% carbonate minerals), depends on

1) permeability & porosity

increase permeability & porosity = increase solution = increase karst

2) secondary porosity along fractures, joints, faults, etc

3) bedding thickness: massive-bedded limestone is better for karst than thin-bedded limestone, where insoluble materials concentrate along bedding planes & restrict water flow

4) available relief: height above baselevel should be enough to permit free circulation of water in system

Warm, wet = ideal for karst because chemical reactions occur faster at higher temperatures, & lush vegetation & microbe activity give tropical soil water a high partial pressure of $CO_2$ [$P_{CO2}$]

Solution process:

$CO_2$ dissolved in water reacts to form weak carbonic acid ($H_2CO_3$):

$$CO_2 + H_2O \rightleftharpoons H_2CO_3$$

amount of $CO_2$ dissolved in water is function of $P_{CO2}$ & water temperature

$CO_2$ increases as $P_{CO2}$ increases & $T_{water}$ decreases

$$CaCO_3 + H_2O + CO_2 \rightleftharpoons Ca^{2+} + 2HCO_3^-$$

Karst is related to groundwater

# GROUNDWATER PROFILE

zone of aeration: pore spaces occupied by air & water

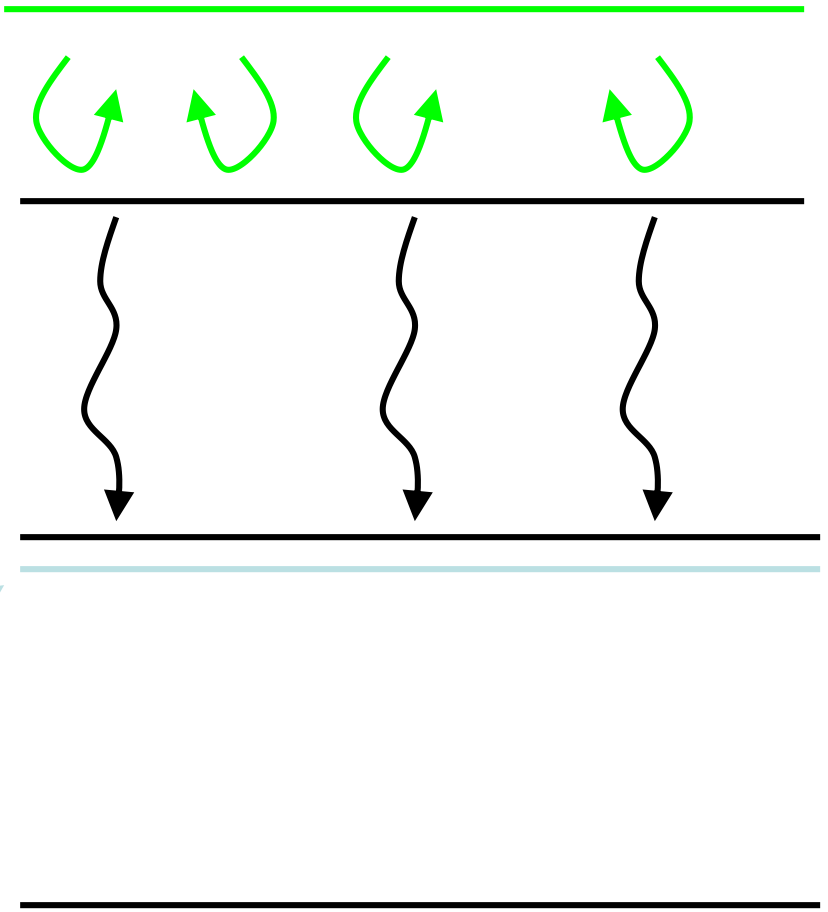
capillary fringe: all pore spaces are occupied by water held in tension, so the water won't drain freely

phreatic zone: water drains freely because hydrostatic pressure exceeds atmospheric pressure

water table: hydrostatic pressure = atmospheric pressure

The movement of groundwater is controlled by the amount of potential energy, which is a function of pressure & elevation above datum, and porosity (% of rock's volume taken up by void spaces – measure of rock's ability to hold water) / permeability (measure of capability of rocks to transmit fluid – size and connectedness of voids)

# Groundwater profile



zone of soil moisture

zone of aeration
(vadose water)

capillary fringe

water
table

phreatic zone

Groundwater flows from higher to lower potential zones, & perpendicular to equipotential surfaces

v, Q are proportional to loss of potential occurring as water moves from one point to another

aquifers: lithologic bodies that store & transmit water
- unconfined: open to atmosphere, & hydrostatic level (level at which water stands in an open hole) is within the water-bearing unit itself
- confined: water rises above aquifer when aquifer is penetrated; rises to piezometric surface determined by difference in potential at point where precipitation enters aquifer (recharge zone) & position of hole

artesian flow: where piezometric level is above ground

aquitard: impermeable layer

As a well is pumped, a cone of depression develops as the hydrostatic level around the well is lowered

With respect to karst, carbonate aquifers are

a) diffuse flow: cavities limited in size & number, caves rare, well-defined water table present

b) free flow: water moves through integrated conduits under influence of gravity; flow can transport sediment; discharge through springs

c) confined flow: water moves in response to pressure

Springs in karst areas are

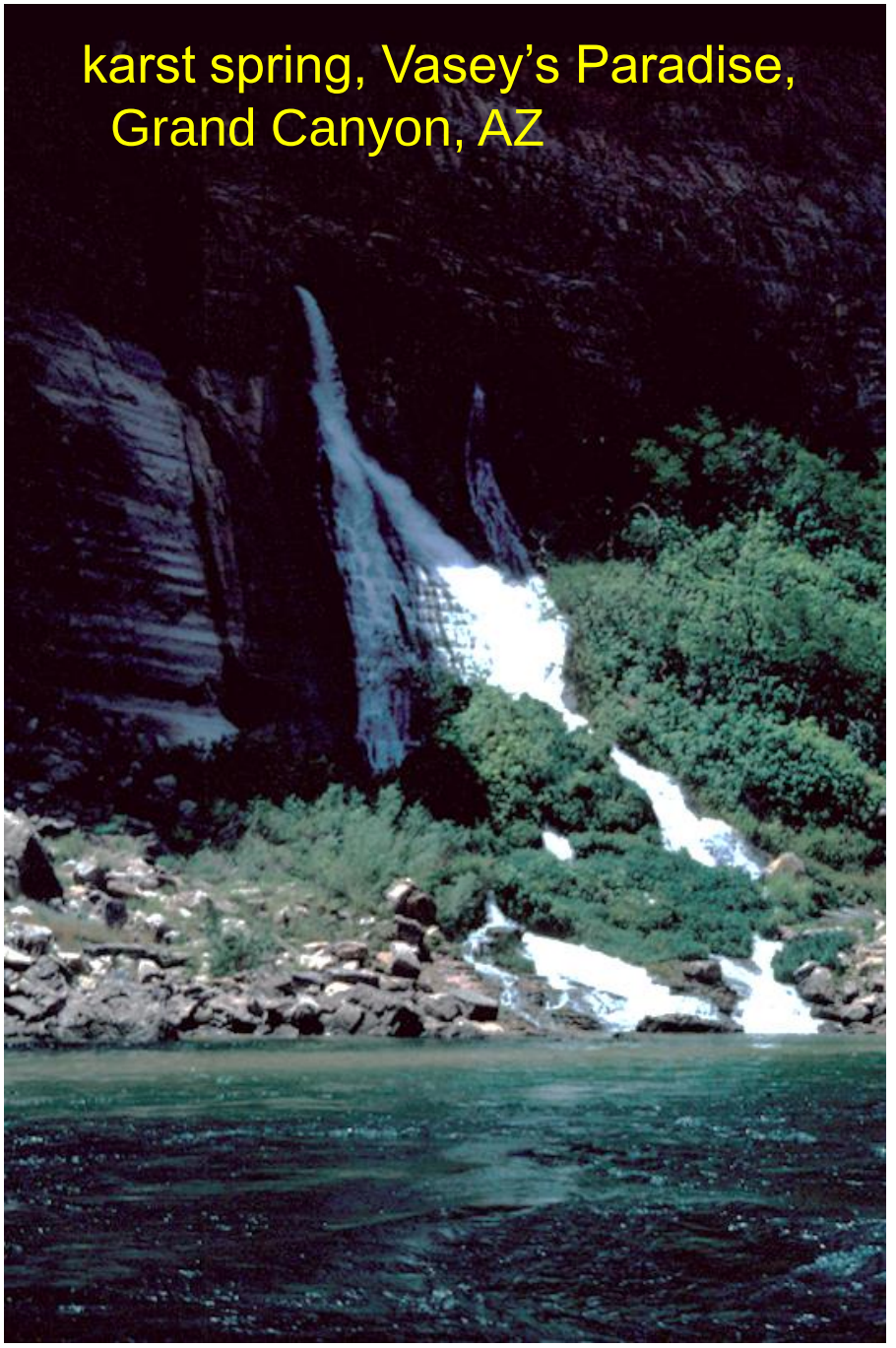
1) exsurgences: from flow in diffuse aquifers; fed by seepage

2) resurgences: fed by groundwater moving through distinct conduits

Springs are generally controlled by large structural or stratigraphic features, & in turn control surface topography (eg. n vs s Grand Canyon)


Grand Canyon Village
regional dip of bedrock
Google Earth
Image Landsat / Copernicus
N
20 km

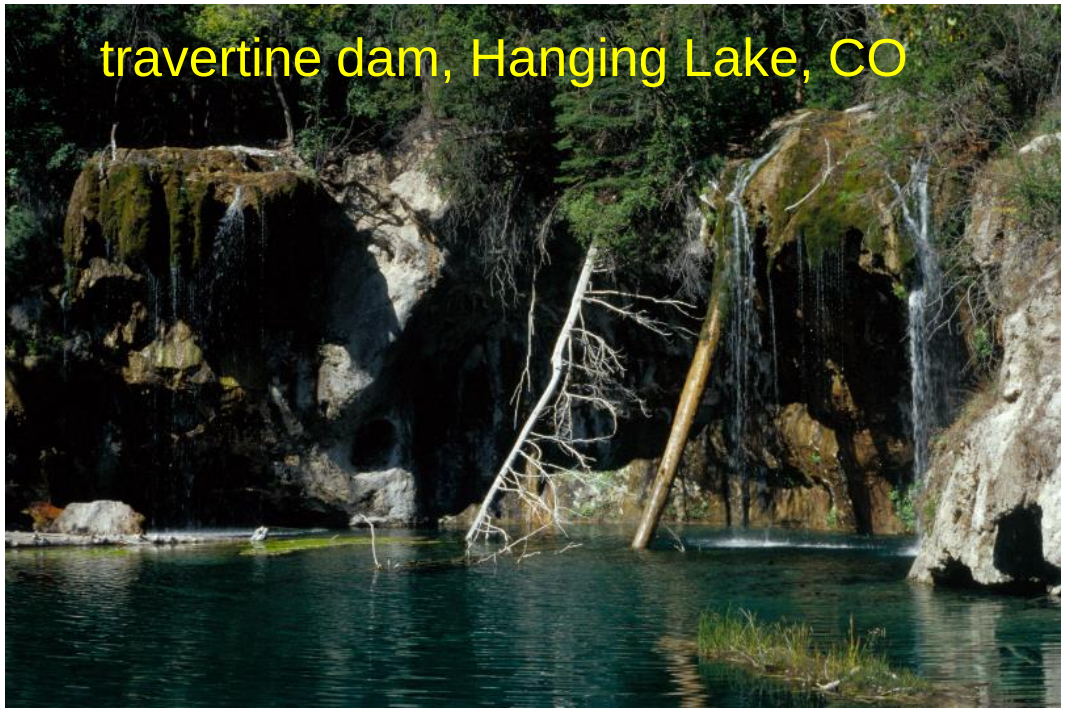

karst spring,
Glenwood Canyon,
CO


karst spring, Vasey's Paradise,
Grand Canyon, AZ


hot springs travertine,
Jemez Creek

close-up of travertine along
Ribbon Falls, Grand Canyon, AZ


tufa formations, Mono Lake, CA


travertine dam, Hanging Lake, CO

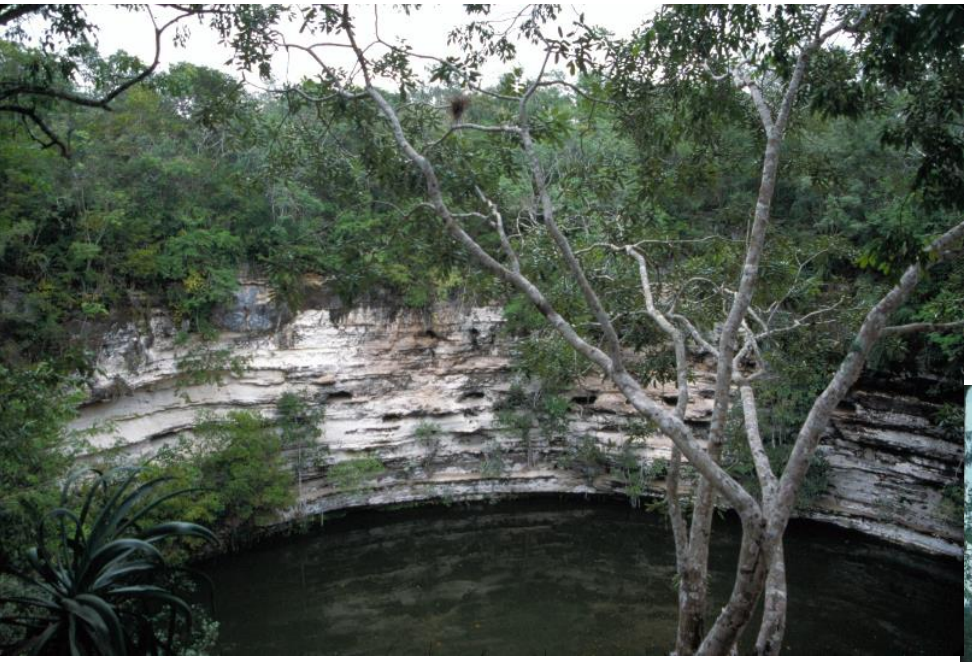

travertine terraces,
Havasu Creek, AZ

travertine formation & hot springs, Yellowstone

travertine formation & geysers, Yellowstone

## Surficial Landforms

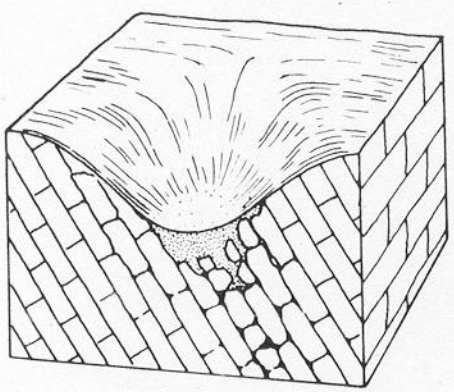
1) Closed depressions
   dolines/sinks/sinkholes: closed hollow of small or moderate size, wider (10-100 m) than deep (2-100 m), circular or elliptical, usually in groups
   solutional: water infiltrating into joints & fissures enlarges cracks by solution; function of slope (low is best), lithology & structure (dense, well-jointed limestone is best), & vegetation & soil cover (increase solution)
   collapse: depressions initiated by solution occurring beneath surface
   uvalas & poljes: larger than dolines; as dolines enlarge, they coalesce into hollows with undulating floors
2) Karst valleys
   allogenic valleys: head in impermeable rocks adjacent to karstic area
   blind valley: valley terminates at cliff face due to sink



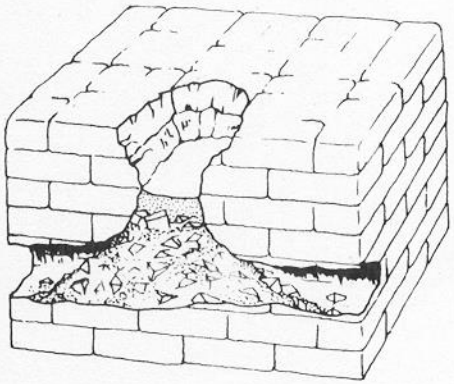
Chichen Itza, Yucatan
cenote (sinkhole)

uvala, West Virginia

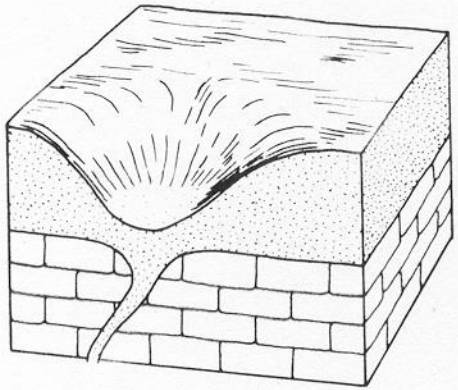
Florida sinkhole



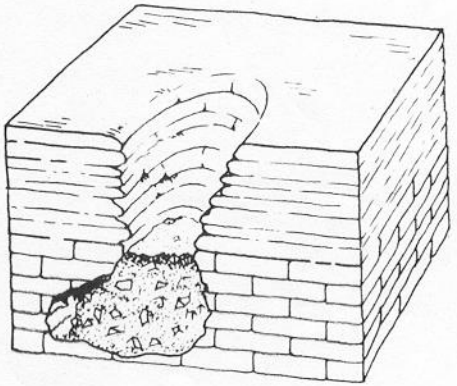
(a) Solution doline (funnel sink)



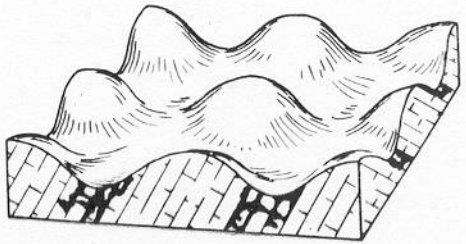
(b) Collapse doline



(c) Subsidence doline



(d) Subjacent karst collapse doline



(e) Cockpits (intersecting star-shaped dolines)

**Figure 7-10.** Five major classes of dolines. (From Jennings, 1971, Figs. 36, 9, and 58.)


karst collapse terrain, Yellowstone

2) Karst valleys (continued)

pocket valley: begins where groundwater resurges as springs

dry valleys: don't have well-defined water courses, or carry only ephemeral flow when flooding

3) Minor solution features (karren)

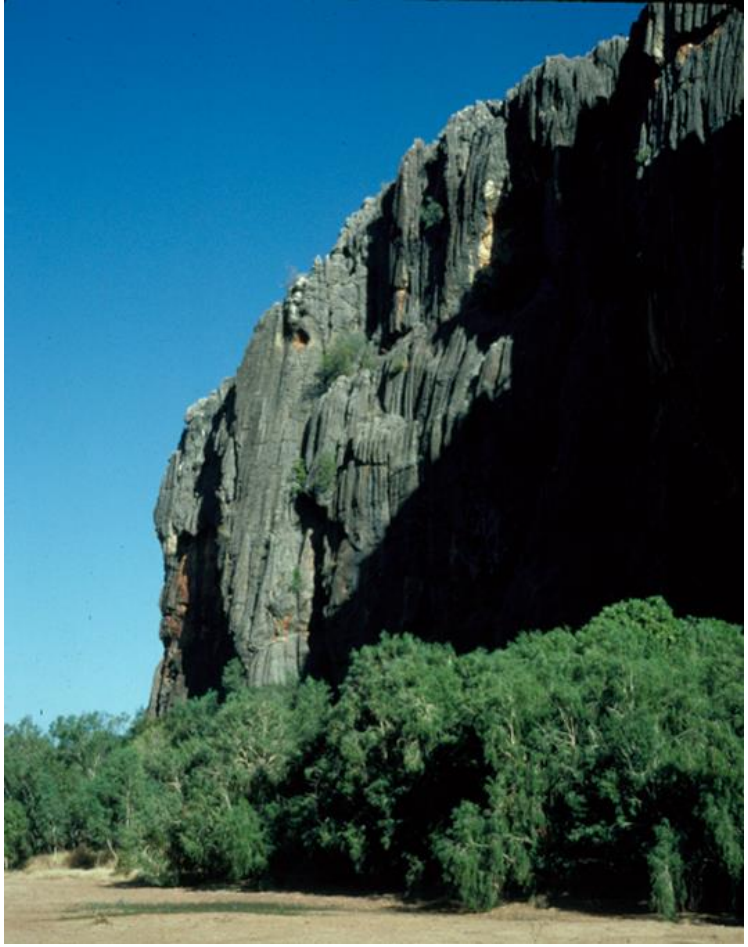
grooves, pits, flutes, pinnacles, etc of cm to a few m in size

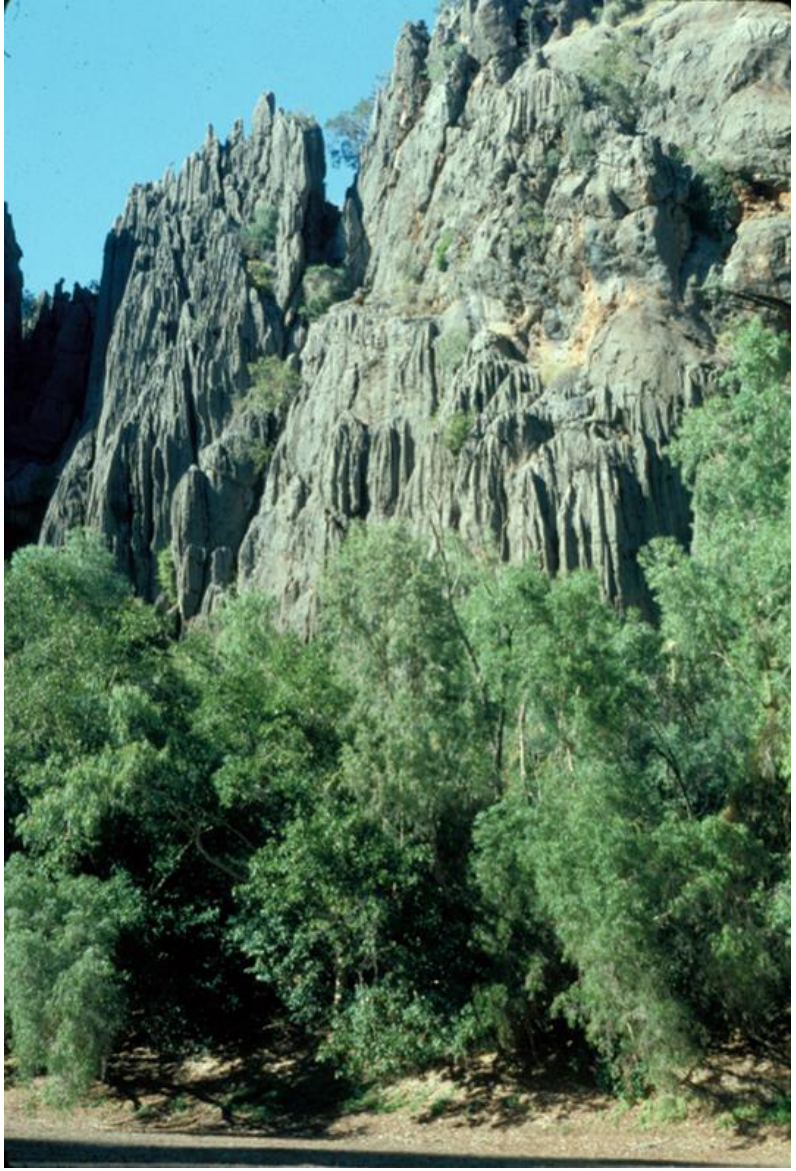
dry valley, West Virginia

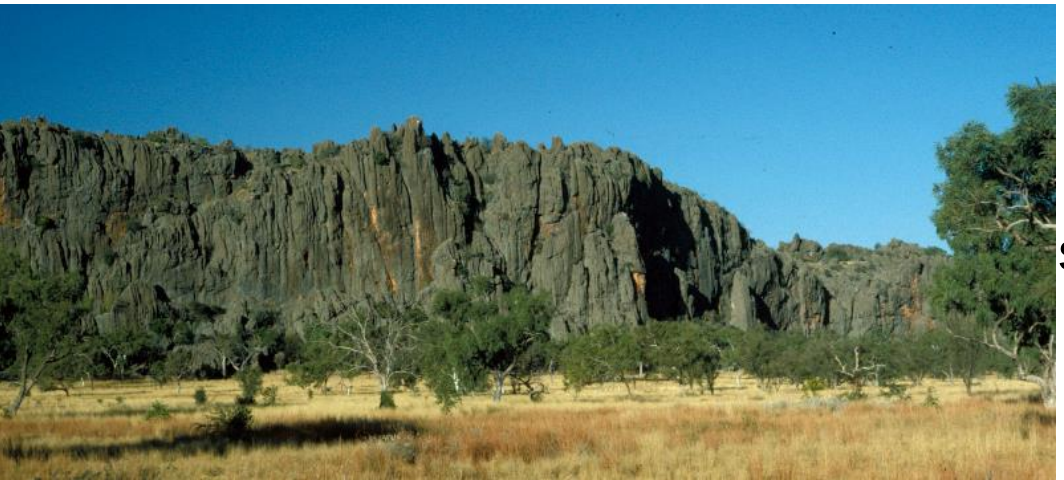
arid-region carbonate weathering patterns, southern AZ

Establishment of plants in solutional weathering pits, Big Bend National Park, Texas

humid-region carbonate weathering patterns, Niagara Escarpment, Ontario







seasonal tropics carbonate weathering patterns (rillenkarren), northwestern Australia

## Tropical Karst

- all temperate landforms are present, but the landscape is dominated by residual hills rather than the closed depressions of temperate karst
- higher temperature, total precipitation, & precipitation intensity produce rapid & prolonged corrosion
- rapid plant growth & decay combine with extreme microbial activity to supercharge infiltrating water with CO2 and intensify the solution process
- examples are cone karst, cockpits (depressions around cones), towers, phytokarst (type of karren that develop into sponge-like pinnacles under biochemical action of blue-green algae)

cockpit & tower karst, Goundong Province, China


Jamaica
Google Earth
Image © 2018 DigitalGlobe
N
1 km

small towers, western Australia

Caves: natural underground cavities that include entrances, passages, & rooms

Caves form

1) above water table by corrosive action of vadose water

2) beneath water table by deep circulation of phreatic water

3) at water table or in shallow phreatic zone, associated with fluctuations of water table

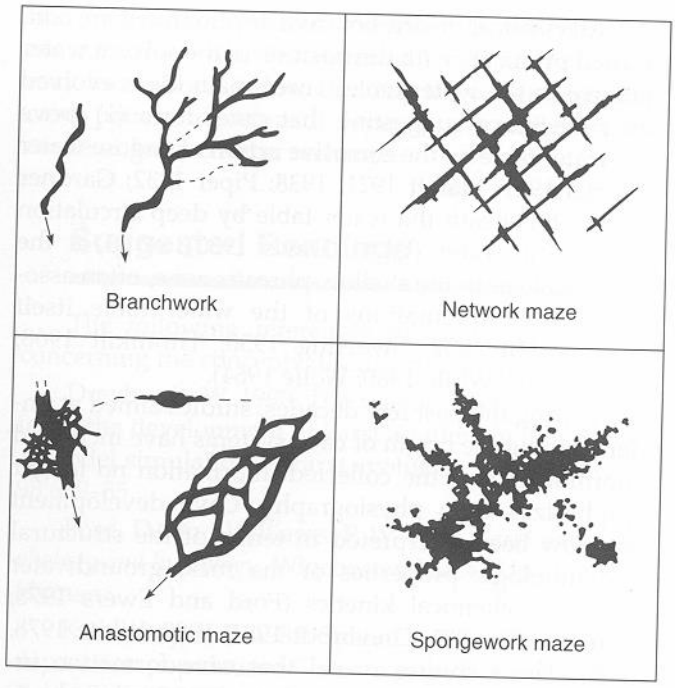
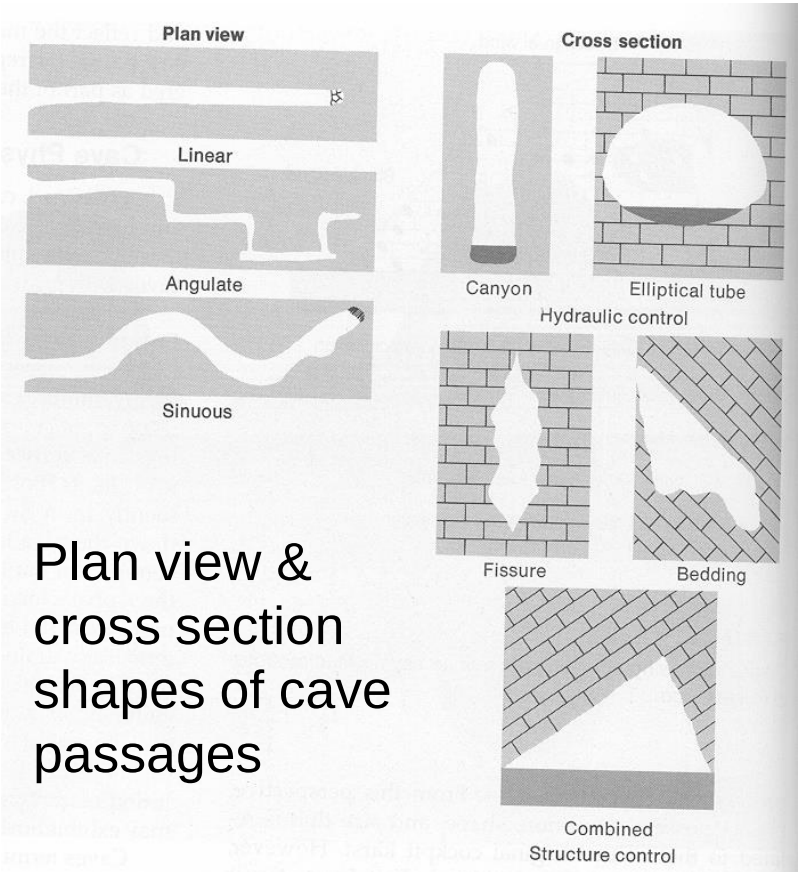
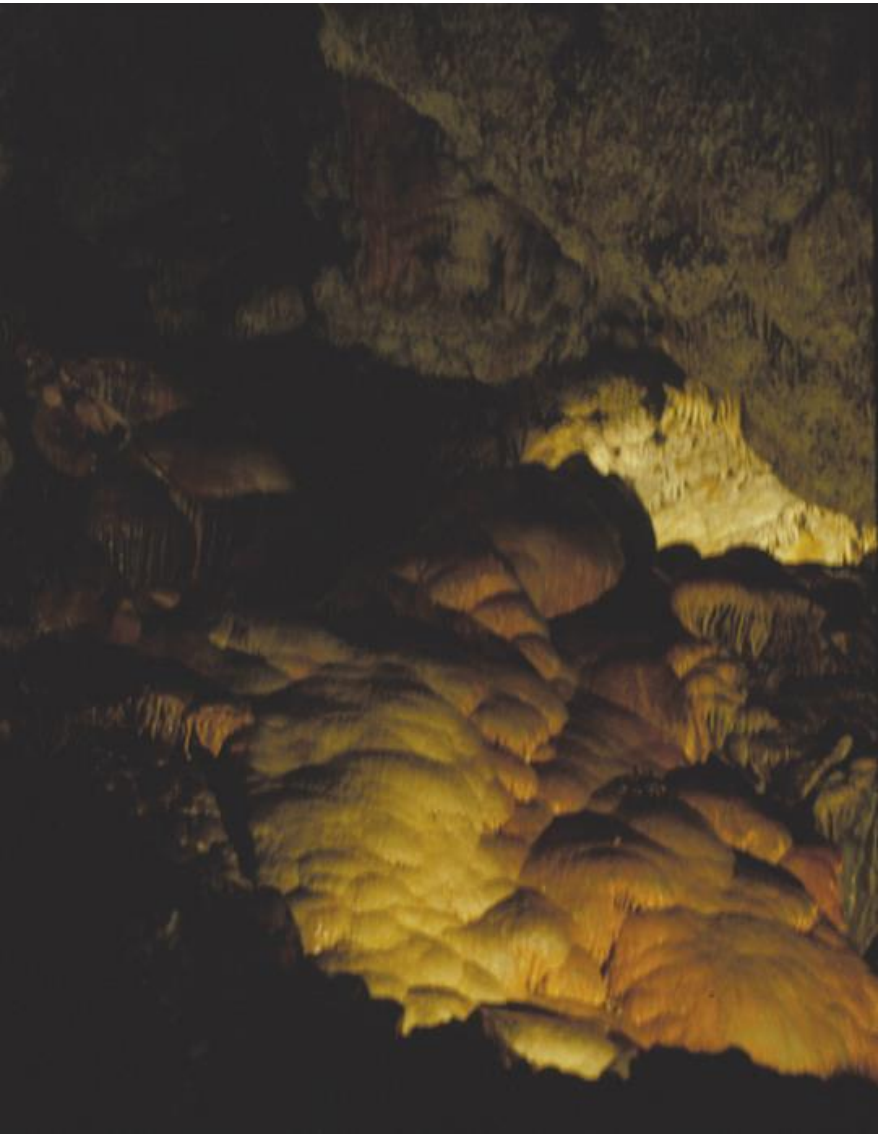



FIGURE 12.23
Branchwork and maze patterns of cave development.
(Palmer 1991)




Plan view & cross section shapes of cave passages



Wind Cave National Park,
South Dakota

cave, southern Australia

cave, southern Australia