Solution Processes & Karst Topography

Come forth into the light of things,
Let Nature be your teacher.
—William Wordsworth
Solution Processes and Karst Topography

- The Impact of Solution Processes on the Landscape
- Solution and Precipitation
- Caverns and Related Features
- Karst Topography
- Hydrothermal Features
The Impact of Solution Processes on the Landscape

- Underground Water
  - Slightly Acid
  - Dissolves certain rock-forming chemicals, especially calcium and magnesium carbonates.
  - Elements stay in solution until air pressure or temperature of the environment changes.

- Solution Products on the Landscape
  - Karst topography
  - Hydrothermal surface features
• Solution and Precipitation
  • Dissolution – Process of going into solution
    – Solubility varies among different elements.
Carbonate Rocks

- Common rocks and highly soluble

**Dissolution (breakdown of minerals) → Solution (salts dissolved in water)**

\[
\begin{align*}
\text{CaCO}_3 & \quad + \quad \text{H}_2\text{O} & \quad + \quad \text{CO}_2 & \quad \rightarrow \quad \text{Ca(HCO}_3)_2 \\
\text{calcium} & \quad \text{water} & \quad \text{carbon} & \quad \text{bicarbonate} \\
\text{carbonate} & \quad & \text{dioxide} & \\

\text{CaMg(CO}_3)_2 & \quad + \quad 2\text{H}_2\text{O} & \quad + \quad 2\text{CO}_2 & \quad \rightarrow \quad \text{Ca(HCO}_3)_2 + \text{Mg(HCO}_3)_2 \\
\text{dolomite} & \quad \text{water} & \quad \text{carbon} & \quad \text{bicarbonate} \\
\text{dioxide} & \quad \text{bicarbonate} & \quad \text{bicarbonate} \\
\end{align*}
\]
• Role of Bedrock Structure
  – Joints become solution pathways.
  – Network of solution tubes widen to form small rooms and large caverns.
• Precipitation Processes
  – Elements recombine
  – Caves (air pressure lower in caves than in joints and bedding planes)
  – Geysers and hot springs (air pressure drops suddenly, rapid heat loss to air)
  – Precipitate deposits result
    • Travertine, tufa or sinter

Geyser with a nozzle in Yellowstone NP, WY
• Precipitation Processes
  – High pressure and temperature environment: Elements remain in solution with water
  – Precipitation occurrence
    • Caves (air pressure lower in caves than in joints and bedding planes)
    • Geysers and hot springs (air pressure drops suddenly, rapid heat loss to air)
Precipitate formations

- Speleothems
  - Small scale features
  - Precipitated mineral deposits (usually calcite)
  - On walls, roofs, floors of caves

  - E.g., flowstone on cavern ceiling (a) and wall (b), Lost River Caverns, Hellertown, PA
Caves and Related Features

• Location
  – Massive limestone bedrock usually, plentiful underground water

• Formation: Two-stage process
  – Initial excavation stage by solution action
  – “Decoration stage” by precipitation of minerals
    • Speleothems: e.g., stalagmites, stalactites and pillars
Speleothems such as stalactites hang from the ceiling of this room in New Mexico’s Carlsbad Caverns. Some of them have joined with stalagmites to form pillars.
Karst Topography

• ‘Karst’
  – Ancient Slavic word (Germanized)
  – Name of region of the former Yugoslavia with this kind of topography

• Topography
  – Rugged hilly area shaped by solution of limestone (sometimes dolomite, gypsum or halite)
Namesake karst region of former Yugoslavia.
– Extent – 10% of Earth’s land area has soluble carbonate rocks at or near surface.
• Surface features
  – Early development: Sinkholes (or dolines) and disappearing streams
- Advanced development: Sinkholes (or dolines), collapse dolines and uvala
Tower Karst (Late development): Haystack hills (mogotes) and exposure of non-soluble bedrock
Tower karst in Guilin, China.
• Sinkholes as Natural Hazards

This sinkhole swallowed a house in central Florida.
Hydrothermal Features

- Hot Springs
  - Eject hot water
  - Volcanic heat and pressure source
  - Calcium carbonate precipitates
    - Travertine (massive)
    - Tufa (porous)
– Carbonate terraces accrete around hot springs

Hot spring atop a carbonate terrace in Yellowstone National park. Algal growth highlights the spring.
– Travertine terraces (hot spring on top of terrace and out of view)

Mammoth Hot Springs, Yellowstone National Park, WY
• Geysers
  – Intermittent hot spring
  – Hot water ejects (erupts) sporadically or flows continuously.

Old Faithful geyser in Yellowstone National Park.
• Fumaroles
  – Very little water drains into the tube of a fumarole.
  – A hot spring that lacks water; it sends out only steam
• Yellowstone National Park, Wyoming
  – America’s showcase of hydrothermal features
Summary

- Underground water dissolves certain chemicals (especially calcium and magnesium carbonates).
- Dissolution produces a network of subsurface tubes and caverns.
- Surface expressions of underground dissolution includes karst topography and hydrothermal features.
• Karst topography is a landscape thoroughly dominated by solution-produced forms.
• The sinkhole is the most ubiquitous karst feature and the most hazardous.
• Hydrothermal activity occurs on the landscape wherever solution tubes allow volcanically heated water to reach the surface.
• Hydrothermal surface features include hot springs, geysers and fumaroles.
• Underground caverns and hydrothermal features exhibit interesting small-scale mineral deposits left by the precipitation of dissolved chemicals.