Surface features associated with groundwater

• Hot springs
  – Water 6-9°C warmer than the mean annual air temperature of the locality
  – Mostly associated with igneous activity

Sinter Hot Springs, Yellowstone Park

Geysers

• Boiling point at depth is higher because of increased pressure
• Expansion results in some outflow, reducing the pressure
• This reduces the pressure at depth, boiling occurs, and the water flashes into steam

Fig. 11.10, p. 310

Echinus Geyser, Yellowstone Park
New Zealand

Old Faithful geyser in Yellowstone National Park

Distribution of hot springs and geysers in the United States (Fig. 11.8, p. 309)

Geysers produce their own rocks

• Chemical sedimentary rock
  – Siliceous sinter (from dissolved silica)
  – Travertine (from dissolved calcium carbonate)

Travertine (limestone), Mammoth Hot Springs

Groundwater withdrawal

Wells

Drawdown and Cone of Depression

Problems associated with groundwater withdrawal

• Groundwater as a nonrenewable resource?
  – Recharge to aquifer is less than the amount withdrawn: groundwater mining

Problems associated with groundwater withdrawal

• Subsidence
Example: San Joaquin Valley of California

Fig. 11.C, p. 317

14 Area of subsidence,
Fig. 11.B, p. 317

15 \textit{Groundwater contamination}

\begin{itemize}
  \item Sinking a well can lead to groundwater pollution problems
\end{itemize}

16 Contaminated vs. clean water, Fig. 11.19, p. 318

17 Pumping may change the hydraulic gradient
Fig. 11.20, p. 318

18 \textit{Dissolution and Precipitation of calcite}
Calcite dissolved from soil or rocks

\[
\text{CaCO}_3 + \text{H}_2\text{O} + \text{CO}_2 \rightarrow \text{Ca}^{+2} + 2\text{HCO}_3^-
\]

(Dissolved in water)
Calcite deposited in formations

\[
\text{Ca}^{+2} + 2\text{HCO}_3^- \rightarrow \text{CaCO}_3 + \text{H}_2\text{O} + \text{CO}_2
\]

19 \textit{Geologic work of groundwater}

\begin{itemize}
  \item Caverns and speleothems
    \begin{itemize}
      \item stalactites (hang from the ceiling)
      \item stalagmites (form on the floor)
    \end{itemize}
\end{itemize}

20 Carlsbad Caverns National park

21 "Soda straws," Lehman Caves, Nevada

22 Cave Formations

23 \textit{Geologic work of groundwater}

\begin{itemize}
  \item Karst topography
    \begin{itemize}
      \item Landscapes shaped by the dissolving power of groundwater
        \begin{itemize}
          \item Irregular terrain
          \item Striking lack of streams
          \item Sinkholes (collapse structures)
        \end{itemize}
    \end{itemize}
\end{itemize}

24 Development of karst topography
Fig. 11.25, p. 322

25 Sinkhole, Florida

26 \textit{End of Chapter 11}