Fluid-Rock Interactions and the Origin of Hot Spring Fluids

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Sources of Heat, Water and Chemicals in Hot Spring Fluids:

- The local source of **heat** is usually magmatic.
  - Consequently, hot springs are usually in volcanically active regions (plate margins and mantle plume regions)
  - The ultimate sources of the heat are: subsurface radioactivity, crystallization of Earth's core, and gravitational separation of heavy and light elements deep within the Earth.
- The source of the **water** is usually groundwater (recycled precipitation), or, in the ocean, seawater.
- The source of the dissolved **chemicals** is water-rock exchange in the hydrothermal system.

Model of hydrothermal circulation

General model

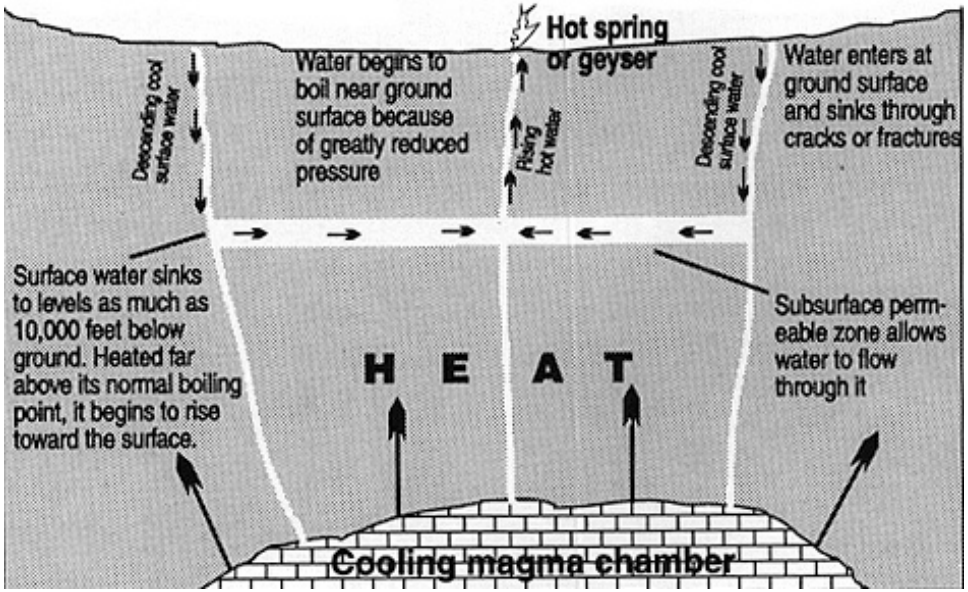


Figure from T.D. Brock (www 7/05).

Note that faults (fractures) often serve as conduits for the hydrothermal flow.

Mid ocean ridge model

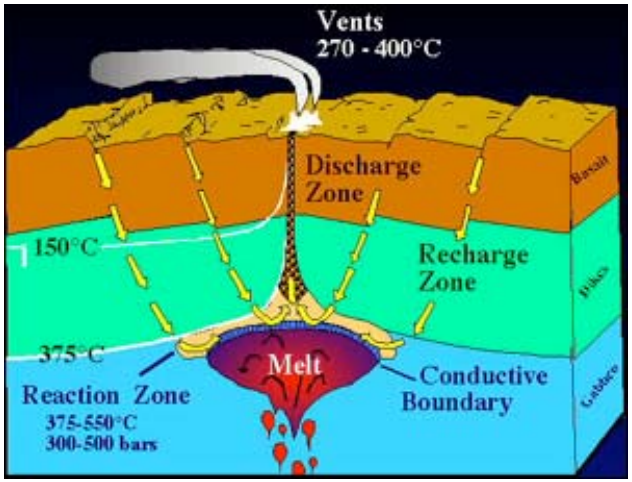


Figure from D.S. Kelley (www 7/05).

Tectonic settings of hydrothermal systems: plate margins

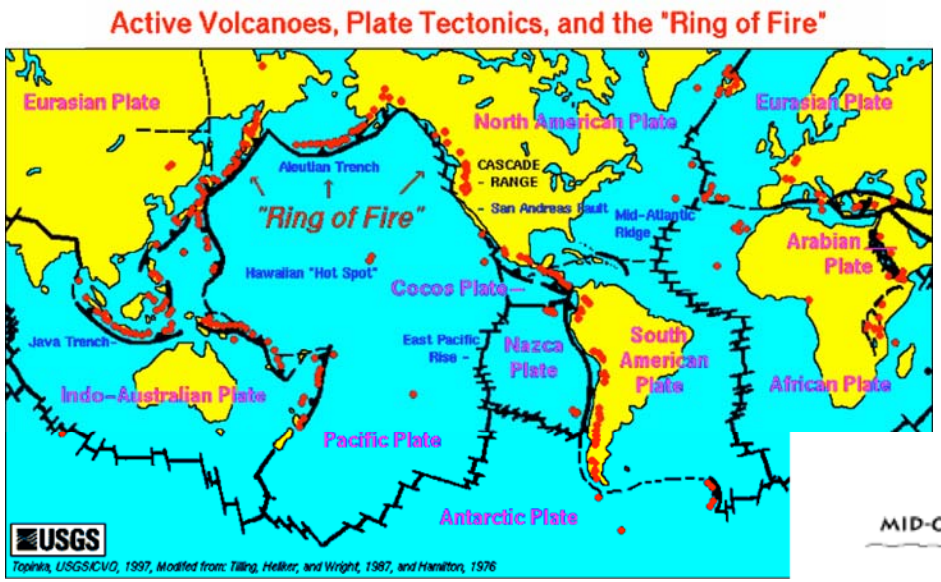
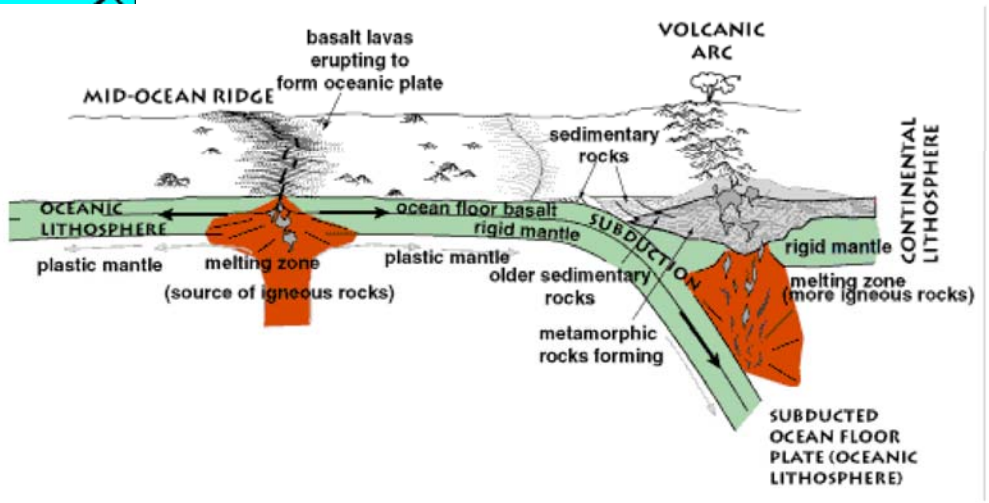


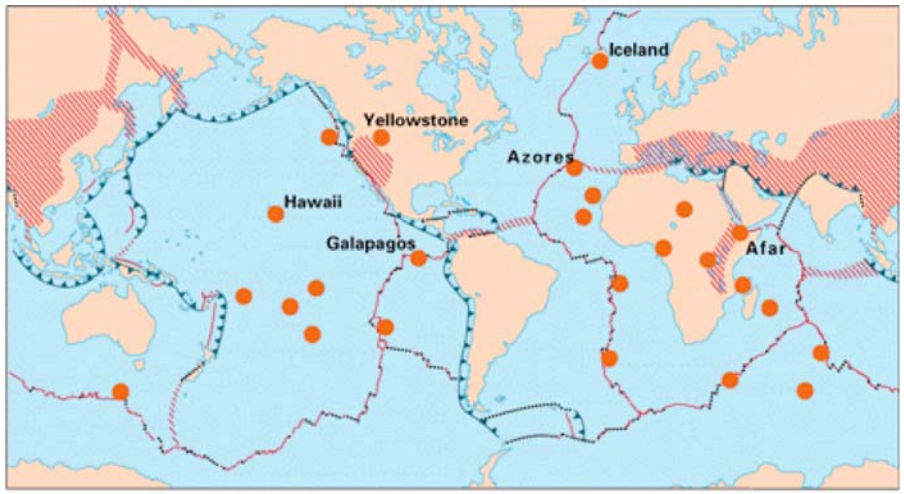
Plate tectonic margins (spreading ridges and subduction zones)

Model of spreading ridge and subduction zone

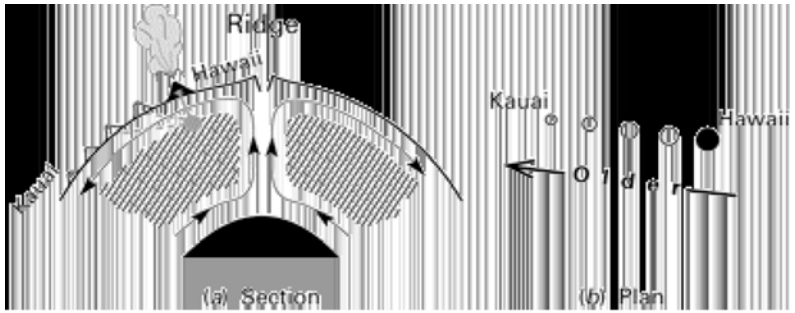


Figures from USGS (www 7/05).

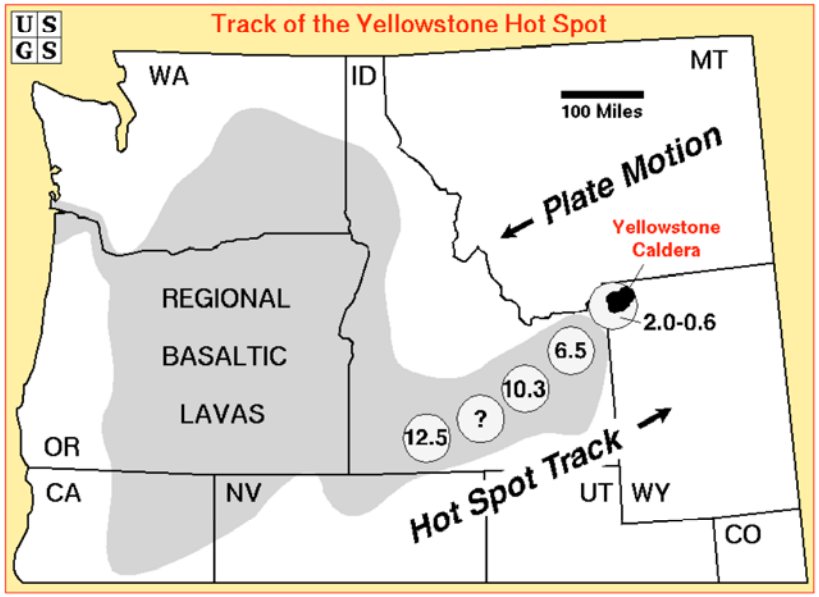
Tectonic settings of hydrothermal systems: hot spots (mantle plumes?)



Locations of hot spots = dots (above)



General model of hot spot motion.



Track of the Yellowstone hot spot [numbers = age (myrs)].

Figures from USGS (www 7/05).

Water-rock interactions in hydrothermal systems:

- Leaching of soluble elements from rock [e.g., Ca^{2+}, H_2S, Fe(II)]
- Precipitation of low-solubility phases (e.g., Mg-silicates, $CaCO_3$, SiO_2)
- Examples—
  - "Exchange" of rock Ca^{2+} for ocean Mg^{2+} in submarine basalts [and subsequent precipitation of calcite ($CaCO_3$)]
  - Production of dissolved H_2 by rock alteration,
    - e.g., during serpentinization of basalt,

$$3Fe(OH)_2 \rightarrow Fe_3O_4 + H_2 + 2H_20.$$