

9. Tectonic/Rock Cycles

I. creation and destruction of the lithosphere

first figure

- A. plate tectonics and continent building
- B. weathering that destroys this continental crust
 - 1. materials ultimately deposited in sediments
 - 2. some of this material and the oceanic crust are then subducted
 - 3. eventually brought back to sfc. completing the geologic cycle
 - 4. some added to the continents during plate collisions
- C. These processes are linked to the hydrologic cycle and some biological cycles
- D. these processes also affect ocean chemistry and elemental cycles **hydrothermal figure**
 - 1. seawater circulates through mid-ocean ridges
 - 2. undergoes chemical rxns. w/ fresh, hot basalt
 - 3. resulting hydrothermal fluids that exit have very different chemistry than seawater
 - a. loss of Mg^{2+} , sulfate
 - b. addition of silica, many trace metals
 - 4. plays a major role in the cycling of these elements in the oceans
 - 5. likely plays some role in balancing riverine sources of some of these elements
 - a. Mg^{2+} , bicarbonate
- E. hydrothermal soln's. are very acidic
 - 1. adds H^+ to oceans and helps remove riverine bicarbonate
 - 2. titates it back to CO_2
 - 3. returns it to the atmosphere
 - 4. more later

II. Weathering/Erosion Processes

weathering figure

- A. weathering of continental crust creates soils
 - 1. different types of weathering
 - a. mechanical vs. chemical
 - 2. different types of chemical weathering
 - a. cation-rich Al-silicates + H^+ $\rightarrow$ cation poor-clays + SiO_2 + diss. cations
 - b. different mineral show different stabilities
- B. weathering is a primary source of major ions to seawater
 - 1. plays a major role in controlling their oceanic composition
 - 2. source of protons is hydrated atm CO_2
 - 3. rivers also transport bicarbonate to the oceans **Fig. 8-17**
 - 4. this process is an atmos CO_2 sink
- C. role of organisms in weathering **show pictures**
 - 1. the presence of plants accelerates the weathering process
 - a. organisms produce and secrete organic acids that accelerate weathering
 - b. enhance the build-up of CO_2 in soils
 - 2. in the absence of life, pCO_2 would have to be much higher so that weathering rates (consumption of CO_2) balance CO_2 input (from vulcanism, metamorphism and diagenesis)
 - 3. is biological involvement part of a Gaian feedback system (?)
- D. also part of an ocean/atmos. CO_2 cycle **Fig. 8-17 (w/anim.)**
 - 1. weathering is an acid/base rxn

- a. consumes atmos. CO_2 and produces bicarbonate and dissol. silica
- 2. bicarbonate transported to the oceans
- 3. silica and carbonate ppt. out in oceans
- 4. weathering on land uses atmos CO_2 leads to biogenic carbonate and silica ppt in the oceans
- 5. to maintain steady state need to get CO_2 back to the atmos. **C-S figure**
 - a. see evidence for this in hydrothermal vent chemistry
 - (i) solutions are acidic and titrate oceanic bicarbonate back to CO_2
 - b. volcanic gasses are also ~10-40% CO_2 by volume
- E. on long time scales atmos. CO_2 removal by weathering must balance CO_2 inputs from all of these tectonic/geol. processes

III. Carbonate-silicate cycle related to climate

Fig. 8-18's w/anim.

- A. this cycle has a negative feedback loop associated with it that stabilizes climate from internal or external perturbations/forcing functions
- B. vulcanism/tectonic activity
 - 1. likely not strongly affected by atmos. CO_2 or global climate
 - a. independent forcing functions on atmos CO_2
 - 2. increase in CO_2 could occur if there were an increase in tectonic activity
 - a. negative feedback will then work to lower CO_2 and stabilize climate
- C. other external forcing functions
 - 1. can affect different components of this system
 - 2. increase in sfc temp due to increasing solar luminosity
 - a. will lead to a drop in CO_2 by increased weathering to stabilize temp.
 - 3. part of the long term trend in atmos CO_2
 - a. luminosity $\uparrow$, atmos CO_2 $\downarrow$