GEOLOGY 10   Extended Notes #4

THE HYDROSPHERE

Earth's water (its *hydrosphere*) includes >97% saltwater in the oceans, and <3% fresh water (mostly in glaciers and groundwater) (LT Fig. 3.4).

The **water cycle** (Fig. 3.5) -- powered by the Sun -- includes evaporation, runoff, precipitation, groundwater, etc.

<u>Streams</u> (LT p. 66-69)
Streams (rivers, rivulets, creeks, etc.) channel water that flows downhill on Earth's surface.

A stream flows downhill from its **head** (or heads) to its **mouth (LT Fig. 3.8)**. The stream gradient (slope) is higher, and its water flows faster nearer its head.

Base level is the elevation at the mouth of a stream (e.g., a lake or the ocean).
If base level, slope, and climate stay constant, streams attain an equilibrium in which erosion balances deposition. If humans intervene—say, by building a dam—the balance is disturbed (LT Fig. 3.9).

A stream's *discharge* is the volume of water that passes a certain point in a certain time. If rainy weather causes discharge to exceed the carrying capacity of the stream channel, a **flood** results.

<u>The Work of Streams</u> (LT p. 69-75)

Erosion: Streams cut into bedrock to form stream valleys.

A stream that is downcutting towards base level typically produces a narrow, steep-walled valley with a V-shaped profile. The channel may be straight (LT Fig. 3.15) or meandering (LT 3.10B for an area that was gradually raised by tectonic forces).

Where downcutting is less rapid, the stream channel usually forms a series of smooth bends of similar shape, called **meanders** (meandering stream) (Fig. 3.10); such streamsmay produce an **oxbow lake** (LT Fig. 3.18).

Transportation & Deposition: streams move **sediment**, including solid particles suspended in water or pushed along the stream bed, and dissolved minerals in solution.

Where does sediment end up? Common destinations:

Most f**loodplains** (LT Fig. 3.11, 3.14) form due to side-to-side downcutting by the stream; floods deposit fine-grained sediment within the floodplain (great for agriculture).

A *delta* is a sediment pile built where stream empties into calm standing water (LT Fig. 3.12, 3.13)

An *alluvial fan* is similar to a delta, but forms in arid regions (LT Fig. 4.24).

The *ocean floor* is the ultimate resting place.

Groundwater (LT p78-87)

Imagine a water well drilled into soil or bedrock: what does it find? (LT Fig. 3.25)

First, it passes through moist soil (if any); water here is retained by plants.

Lower, it passes through soil or rock where spaces or fractures are filled w/air.

Finally it reaches soil or rock whose spaces are filled with water (the **saturated zone**).

The top of the saturated zone is called the **water table**.

Porosity: the volume of groundwater that could be stored in a material (given as a percentage).

Permeability: the "connectedness" of the porosity

An **aquifer** is a rock that holds and transmits enough water to be considered a useful, economical source (i.e., it has high porosity and permeability). Many of the best aquifers are sandstones, but other rocks work, too.

An *aquitard* is a rock that forms an impermeable barrier to groundwater flow, e.g., shale.

<u>Consequences/Effects of Groundwater "Mining"</u>

In arid areas, groundwater is the major source of water. The rate of withdrawal generally exceeds the recharge rate: **groundwater is not a renewable resource** on a human time scale.

Pumping lowers the water table: *cones of depression* may affect neighboring wells (Fig. 3.28).

Land subsidence (sinking): Groundwater pumping allows soil or sediment to settle or compact.
Central Valley of California (LT Fig. 3.31)

Mexico City: built on old lake bed; thousands of wells in early 1900s; up to 20′ of subsidence.

Saltwater contamination (not in LT): Along ocean coastlines, salty groundwater may contaminate wells if too much fresh water is pumped out (Ciudad Constitución).

<u>Groundwater contamination</u>

ANY chemical can enter groundwater, including:

Sewage: septic tanks (Fig. 3.32); landfills and dumps, streams and lakes

Toxic waste: leaky drums, barrels, etc.; Santa Clara County Superfund sites

Pesticides: runoff from agribusiness

<u>Geologic activity of groundwater</u>

Precipitates cement that glues together sedimentary rocks.

Dissolves limestone to form caves, stalactites (ceiling), stalagmites, sinkholes, karst (Fig. 3.34).

OCEANS (LT Chapter 9-10)

Introductory Stuff

Locations on a map of Pacific, Atlantic, Indian, Arctic oceans, Mediterranean and Caribbean seas, Gulf of Mexico.

To earth scientists, “marine” = “oceanic.”

Ocean Coastlines

Waves can erode bedrock along coastlines, especially in winter storms (in California) (Figs. 10.14, 10.15).

Beach sand consists of this eroded material, plus sediment moved by rivers that feed the oceans.

When uninterrupted, this sand mixture moves along the beach face in a *longshore current* (Video*: Beach -- A River of Sand*; LT Fig. 10.18).

Humans many interrupt this process in order to “control” erosion, but usually only divert or postpone the “problem.” (Video*: Beach -- A River of Sand*; (Fig. 10.20, 10.21).

Tides are daily changes in the elevation of the ocean surface caused by the gravitational attraction exerted on Earth by the Moon and (less so)the Sun.

High tides on sides facing Moon (closest, strongest pull) and away from Moon (farthest, weakest; centifugal force effect -- backpack demonstration) (Fig. 10.25).

When the Sun is aligned with the Moon and Earth (full and new moon), the Sun and Moon pull parallel to one another, and Earth has its largest tidal range (*spring tides*). When Sun and Moon act at right angles, the tidal range is least (Fig. 10.26).

Seawater Composition and Structure

Seawater contains many kinds of dissolved salts (about 2/3 is NaCl) that are present in the same proportions around the world’s oceans — the oceans are well-mixed (Table 9.1, Fig. 9.3).

Salinity is affected by many factors (Fig. 9.4).

Salinity is decreased by precipitation, runoff, and melting icebergs and sea ices.

Salinity is increased by evaporation and the formation of sea ice (LT Fig. 10.5).

Many of these factors -- and, thus, ocean salinity -- are sensitive to climate change.

At latitudes lower than about 50°, water is saltier and warmer near the sea surface, leading to a three-part division as shown in Fig. 9.5. The average temperature of water in the "deep zone" is only 2-3°C (about 35°F).

An important point that the book neglects is that the cold, deep water is denser than the warm surface water. We'll return to this point later.

<u>Ocean Circulation</u>

Surface Currents (Fig. 10.2)

Winds drive *surface currents* (compare Fig. 10.2 and Fig. 13.15). We'll talk more about air currents later.

Equatorial currents flow westward in the Pacific and Atlantic oceans, and are deflected poleward at their western margins (due to the Coriolis effect, Fig. 13.6).

Roughly circular loops ("gyres") form in each ocean, separated by the equatorial current.

The California Current and the **Gulf Stream** are responsible for such different beach experiences in the western and eastern U.S.

Deep-Ocean (Thermohaline) Circulation
Water in the "deep zone" isn't affected by winds, but instead follows complicated paths that are controlled by differences in temperature (thermo) and density (haline = salt, which is denser than pure water).

Thermohaline circulation moves water between the surface zone and deep zone in a complex way that is very simplified in Fig. 10.6. This diagram depicts general trends, not all the details; for instance, water exists everywhere in the oceans, not just on the "conveyer belt!"

As noted on p. 5, the deep-zone waters are colder and denser than surface waters. In some places, winds and bathymetry force these deep-ocean "currents" to rise -- a process called upwelling (LT p. 258-259). Upwelling occurs along the coast of California, and elsewhere in the world.

Critters

Coral reefs — Made of and by both plants and animals, reefs are fundamental to the marine food chain, and need warm, clear, sunlit water. They're threatened by many human activities.

Marine sediments — When marine organisms die in the oceans, their shells are preserved in sedimentary rocks, and help us study changing climate in the past (LT p. 248-250).