

Running Water and Groundwater

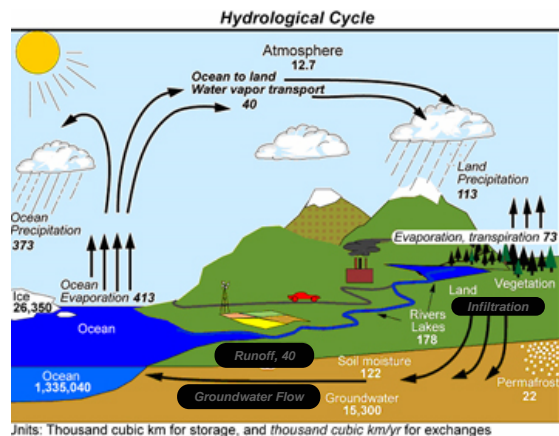
Chapter 3, *Earth Science* (Tarbuck and Lutgens, 7th Ed.)

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The Hydrologic Cycle

- **Hydrologic Cycle:** circulation of Earth's water supply among the oceans, the atmosphere and the continents
- Powered by Sun's energy
- Water is transported by:
 - **Evaporation** – liquid water converts to gas and rises into atmosphere from land or oceans
 - **Precipitation** – gaseous water in atmosphere condenses back into liquid and drops onto land or oceans
 - **Infiltration** – water from precipitation soaks into the ground
 - **Runoff** – water from precipitation flows over ground surface
 - **Transpiration** – water absorbed by plants is released into the atmosphere

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Source: <http://www.coloradocollege.edu/dept/ev/courses/EV211WWW/hydrological%20cycle.jpg>

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Running Water

- Importance:
 - Energy
 - Travel
 - Irrigation
 - Fertile floodplains
 - Shaping of landscape (via erosion)
- **Stream:** channel of flowing water of any size
 - River – larger streams
 - Tributaries or brooks – smaller streams

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Running Water, cont'd

- Streams flow because of gravity
- Streams are supplied by **runoff** and **infiltrating groundwater**.
 - Runoff and groundwater come from precipitation.
 - Drainage basin**: land area that contributes water to a stream.
 - Divide**: imaginary line separating drainage basins.

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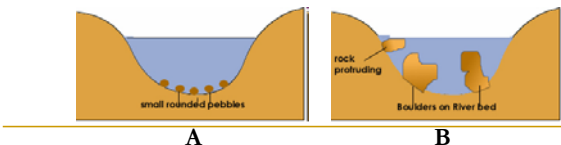
Stream Velocity

- Stream Velocity**: distance water travels in given time
- Measured at gauging stations
- Stream velocity determines erosional capability
- Three factors affect velocity:
 - Gradient** (slope) – expressed as the vertical drop of a stream over a fixed distance. High gradient = high velocity.
 - Channel characteristics** (shape, size and roughness) – more on this in next slide.
 - Discharge** (volume of water flowing per unit time) – High discharge = high velocity. Discharge also affects channel characteristics.

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Stream Channel Characteristics

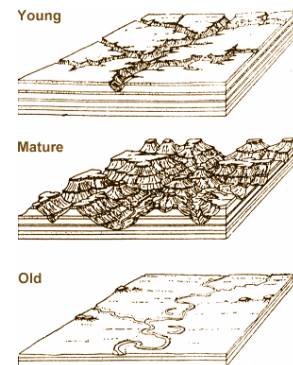
- Channel shape (cross-sectional) affects velocity.
 - Wide, shallow channel = slower (a lot of friction with streambed).
 - Semicircular channel = faster (least amount of friction).
- Channel size: larger = faster.
- Channel roughness: smoother = faster.
- Which stream below is faster?



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Stream Valleys

- Young streams demonstrate V-shaped valleys.
 - Shape results from downcutting.
 - Rapids and waterfalls are common.
- Older streams begin to erode to the side more than downward, and create a floodplain.
 - River is confined to channel except during flooding, when it deposits sediments.
 - Meanders (large curves in river) and oxbow lakes are common.



<http://www.geocities.com/geomwl/davis2.gif>

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Geologic Work of Streams – Transportation of Sediment

- Running water is the single most important factor in shaping the Earth's land surface.
- Water carries sediments in 3 ways:
 - In solution (**dissolved load**) – mostly transported by groundwater
 - In suspension (**suspended load**) – most materials carried by streams are suspended loads
 - Along bottom of channel (**bed load**) – moves only intermittently

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Geologic Work of Streams – Deposition of Sediment

- Streams deposit suspended sediment when they slow down.
- Recall from unit on rocks: fast streams can carry larger particles, while slow streams can only carry smaller particles.
- **Sorting**: particles of similar size are deposited together
- **Alluvium**: material deposited by a stream
 - **Delta**: deposits near the mouth of a river into a lake or ocean
 - **Alluvial fan**: similar to deltas, but on land – stream deposits sediment where it empties into a plain

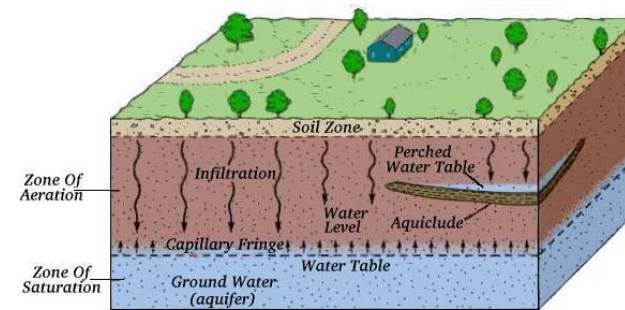
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Groundwater

- **Groundwater**: water that occupies pore spaces in sediment and rock in a zone beneath the Earth's surface
 - Largest reservoir of fresh water available
 - Produces caves and sinkholes
- **Zone of Saturation**: region where all the open spaces in sediment and rock are completely filled with water
- **Water Table**: upper limit of the zone of saturation
- **Zone of Aeration**: region above the water table where spaces are not completely filled

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Groundwater (cont'd)



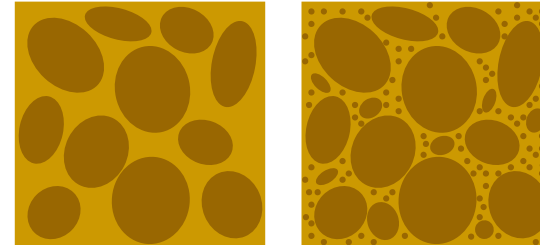
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Groundwater Storage

- Amount of water that can be stored depends on the **porosity** (the volume of open spaces) of a material.
 - Well sorted alluvial deposits have high porosity.
 - Poorly sorted alluvial deposits have low porosity – the small particles take up the spaces between the large.

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Porosity



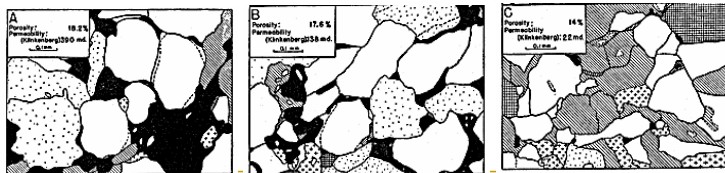
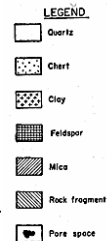
Well-sorted =
high porosity

Poorly-sorted =
low porosity

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Groundwater Movement

- Movement of groundwater depends on the **permeability** (ability to transmit fluid through interconnected pores).
 - **Fine texture** = low permeability, slow movement
 - **Coarse texture** = high permeability, fast movermer



<http://www.dmtcalaska.org/exploration/ISU/unit5/u5lesson1.html>

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Groundwater Movement

- **Aquitards**: regions of materials with very small pore spaces (like clay) that hinder groundwater movement
- **Aquifers**: regions of materials with large pore spaces (like sand) that are highly permeable

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Springs

- **Springs** occur when the ground surface is below the water table – groundwater then flows on the surface.
- Springs often occur where an aquiclude blocks the downward movement of groundwater.
- Example: Thousand Springs in Idaho

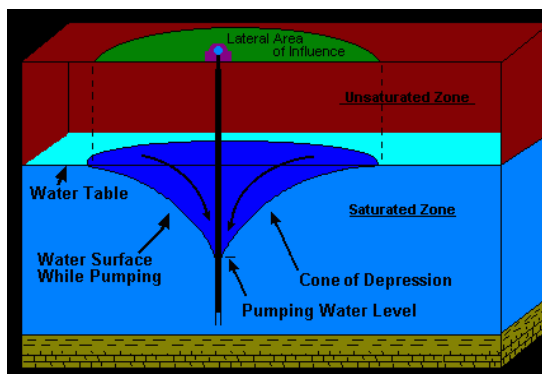
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Wells

- **Wells** are drilled openings into the zone of saturation.
- Important freshwater source – 65% of wellwater is used for irrigation.
- **Drawdown**: lowering of the water table as water is taken from a well.
- Drawdown creates a **cone of depression** around the well (a local depression of the water table).
 - Not noticeable around domestic wells.
 - Problematic around industrial or irrigation wells – nearby shallow wells can dry up.

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Well Drawdown and Cone of Depression



<http://www.epa.state.il.us/water/groundwater/wellhead-protection.html>

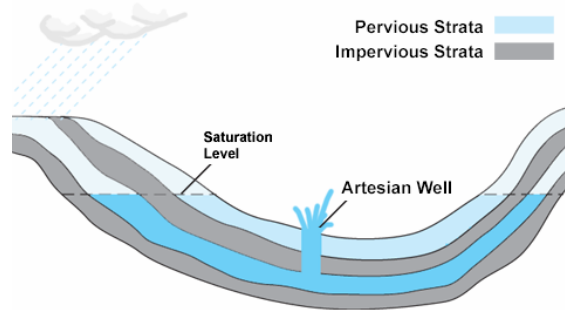
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Artesian Wells

- Artesian Well: water rises above the level where it was tapped.
- Can only occur when there is/are
 - An inclined aquifer where the higher side is exposed at the surface to receive water
 - Confining layers both above and below the aquifer keep it from moving anywhere except into the well.

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Artesian Wells (cont'd)



http://commons.wikimedia.org/wiki/File:Artesian_Well.png

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Environmental Problems with Groundwater

- Overuse can threaten supply.
- Land subsidence: Groundwater removal can cause ground to sink (example: San Joaquin Valley dropped almost 9 meters between 1925 and 1975).
- Groundwater contamination from:
 - Sewage
 - Other sources



http://www.aegweb.org/images/Geologic%20Hazards/subsidence_Poland.jpg

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Hot Springs and Geysers

- **Hot springs** result from water that circulates deep below the surface and gets warmer (6-9 °C or 10-15 °F) than the average local air temperature.
- Source of heat: cooling igneous rock
- Geysers are intermittent hot springs or fountains that eject columns of water periodically.
 - Occur where extensive underground chambers exist within hot igneous rock – allows pressure to build up.
 - Example: Old Faithful in Yellowstone (erupts about every hour)

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Geothermal Energy

- Produced by tapping naturally occurring steam and hot water below the surface.
- First commercial geothermal power plant in the U.S.: The Geysers, north of San Francisco
 - At peak, produced about 1800 MW (enough energy for San Francisco and Oakland)
 - Electricity production then started to decline as the source of hot water and steam were diminished.
- This is not necessarily a renewable resource, and can't provide a large percentage of the world's power needs.

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Geologic Work of Groundwater

- Groundwater primarily erodes by dissolving rock (especially limestone and other more soluble rocks).
- Produce **caverns** under the water table, and carry the dissolved load away to streams.
- Where water drips through the caverns, it leaves deposits of the dissolved loads called *dripstones*.
 - Stalactites (hang from ceiling)
 - Stalagmites (grow upward from floor)
- Groundwater can also cause areas that exhibit **karst topography** – areas of irregular terrain punctuated by many sinkholes where the limestone has dissolved away.