

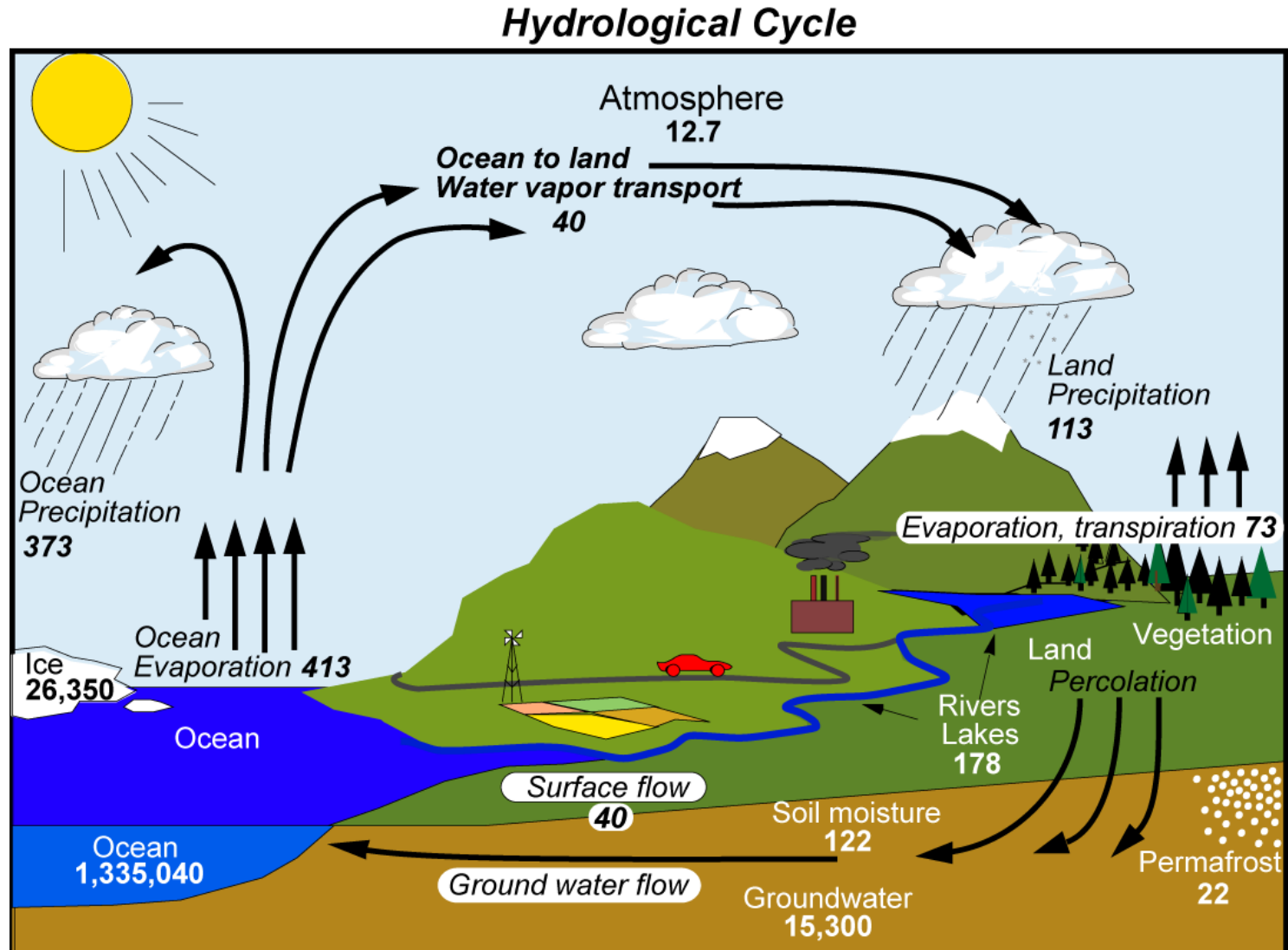


## Lecture 13a – Aquifers

# Learning Outcomes

- Be able to describe and explain the differences between aquitards, unconfined aquifers, confined aquifers, and advantages/disadvantages of wells dug into either
- Be able to explain how and why groundwater moves and draw flowlines on a cross-section of a drainage basin
- Be able to describe and explain what occurs when the water table intersects with the ground surface and what geologic arrangements might lead to springs occurring
- Be able to draw/describe/explain/carry out simple calculations related to the freshwater/saltwater interface near the ocean

# Hydrologic cycle



Units: Thousand cubic km for storage, and *thousand cubic km/yr* for exchanges

# Where is the water on Earth?

## of all water on surface:

3% as freshwater

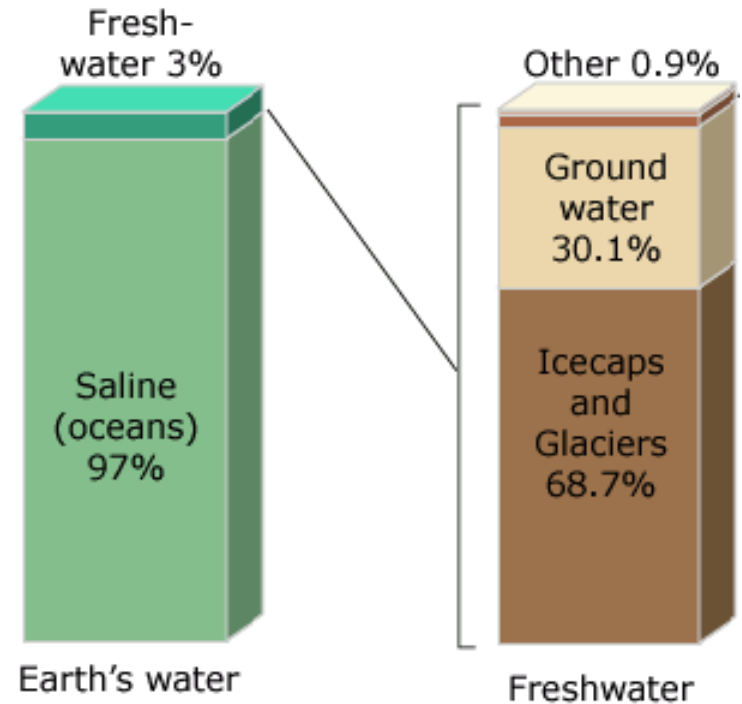
97% in oceans

## Fresh water on surface:

<1% lakes, rivers, etc...

30% ground water

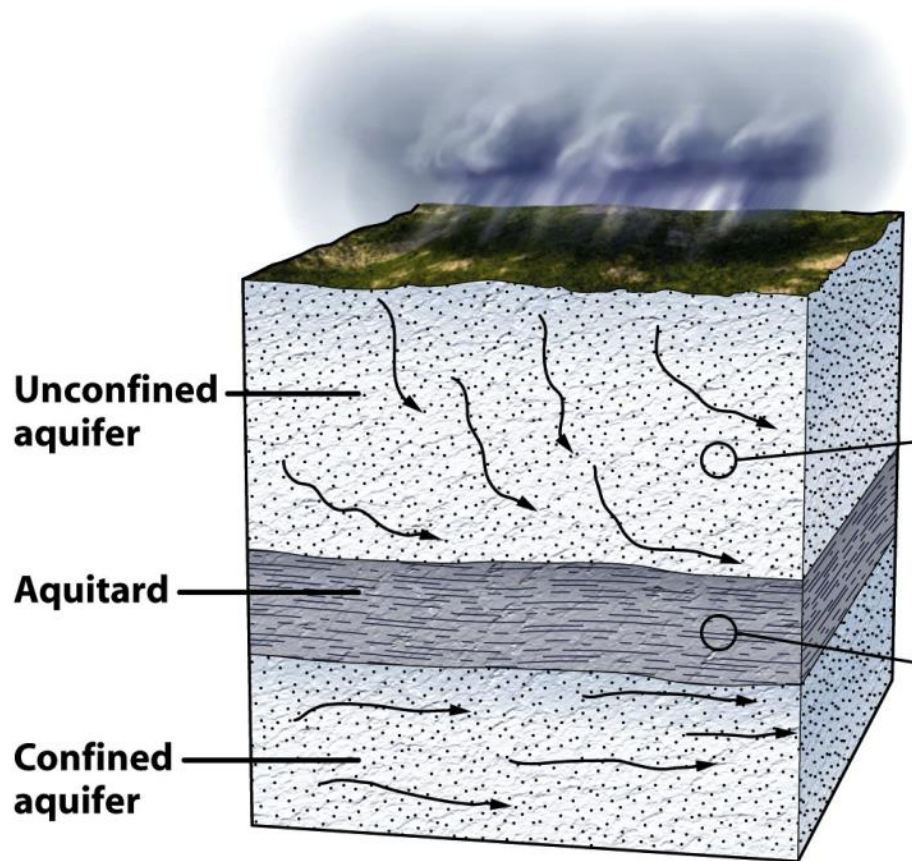
69% in cryosphere





# Storage and movement of groundwater

- Aquifers: *porous* and *permeable* rocks or sediment that store significant amounts of water and can transmit water rapidly
- Aquitards: impermeable layers that hinder or prevent water movement



# What creates aquifers and aquitards

Rock types exhibit a wide range of porosities ( $\phi$ ) and permeabilities

- Primary porosity – originally formed with the rock
  - Primary porosity may decrease with burial compaction and with cementation
  - Crystalline rocks have very little primary porosity
- Secondary porosity - develops later
  - Fracturing
  - Faulting
  - Dissolution

Note:

$$\phi = V_w / (V_w + V_s)$$

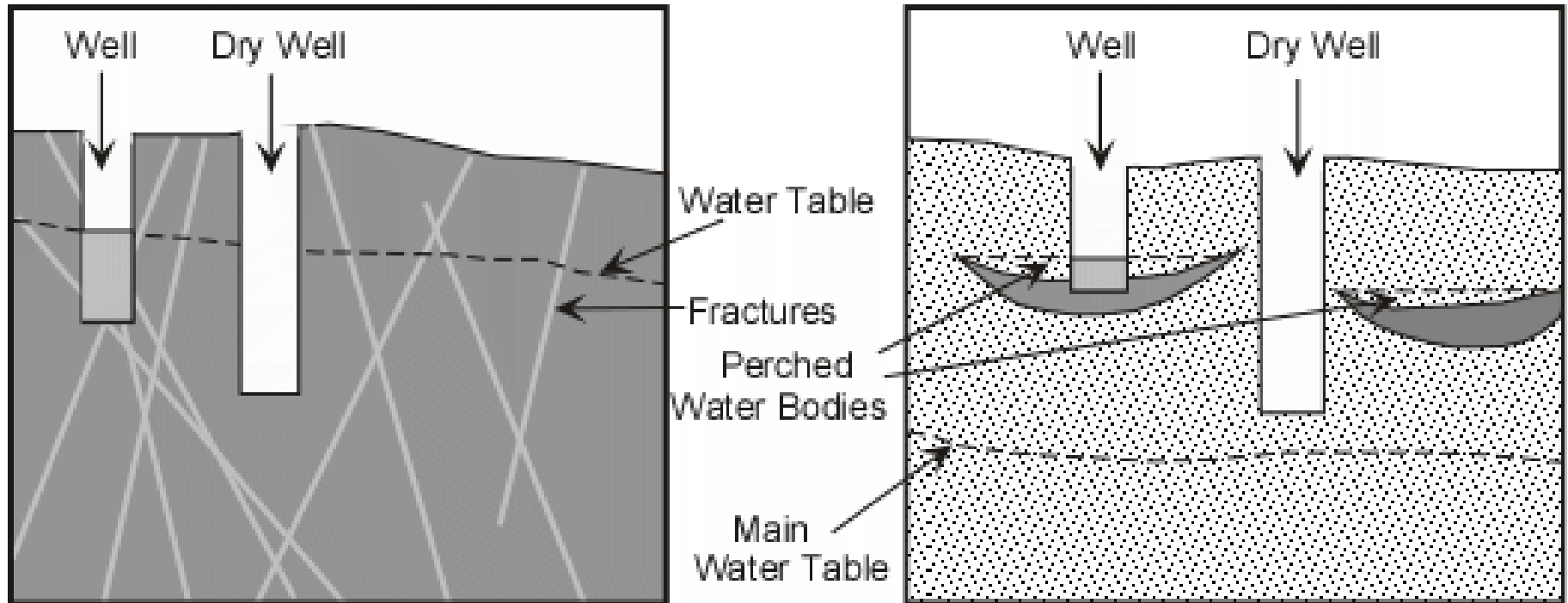


# Quick question

Which of these rocks would make the best aquifer?

- a) Granite (crystalline igneous rock)
- b) Shale (made of clays)
- c) Well sorted sandstone (grains of similar size)
- d) Poorly sorted glacial sediments (grains of different sizes)

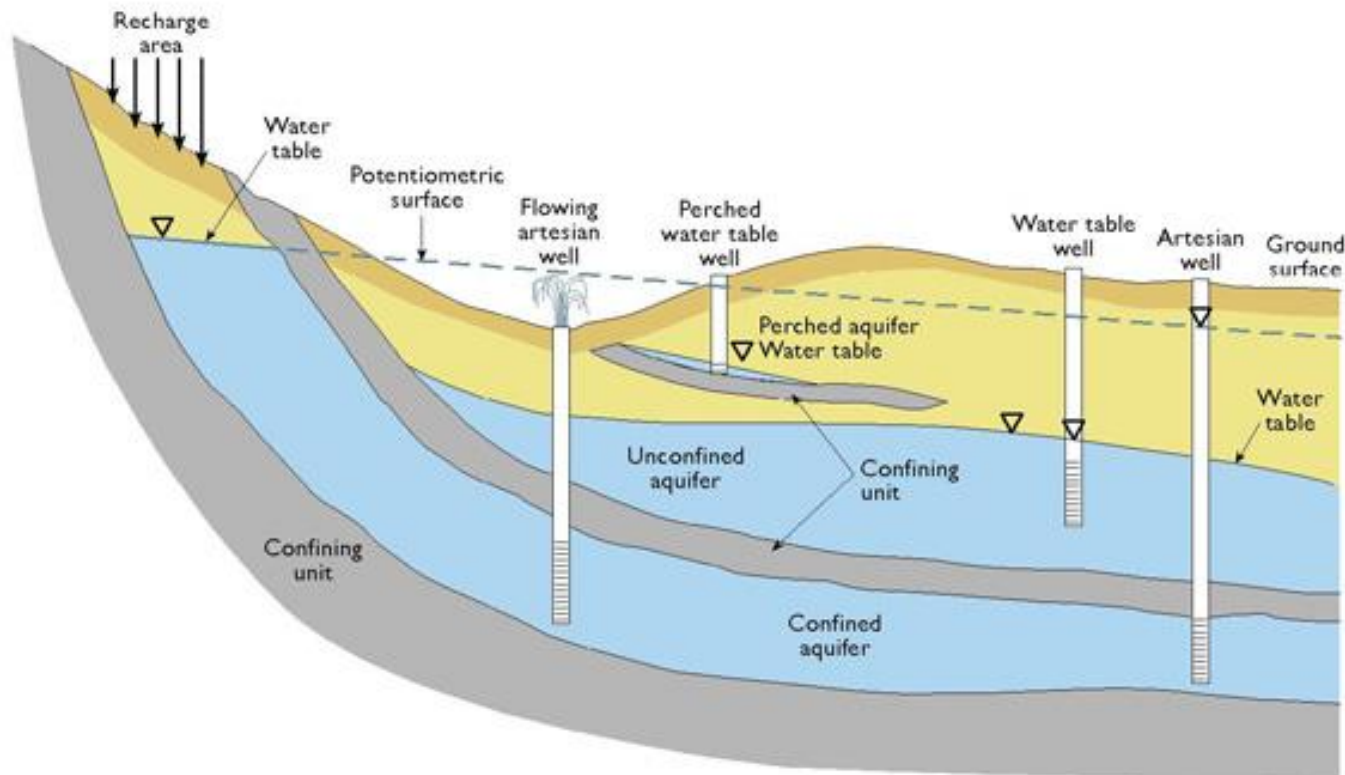
Why does the shorter well have more water in each of these cases?





# Storage and movement of groundwater

- **Unconfined aquifer**: upper boundary of groundwater is a water surface at atmospheric pressure. Recharge occurs from above and water table elevation can vary. Flow and storage are correlated.



# Storage and movement of groundwater

- **Confined aquifer**: bounded above and below by aquitards (confining layers) so pressure throughout is above atmospheric. If allowed, water will flow upwards to meet potentiometric surface – analogous to water table. Recharge occurs upstream. Flow and storage not correlated.

