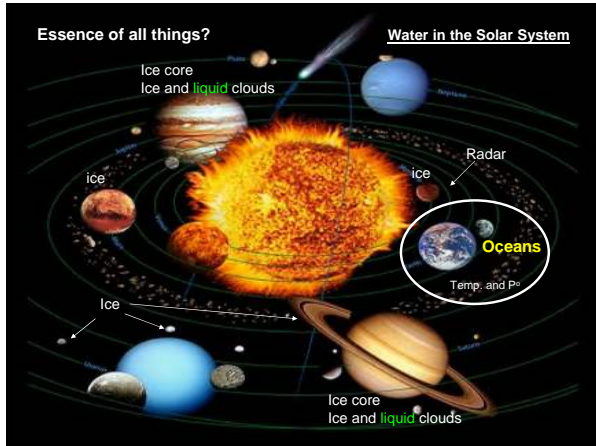


Students who did not attend lecture 1
See me after class for a syllabus and course basics













How much water is there?



400 billion billion gallons


326 million mi³
(one estimate)

Total Earth Water = 326 million mi³



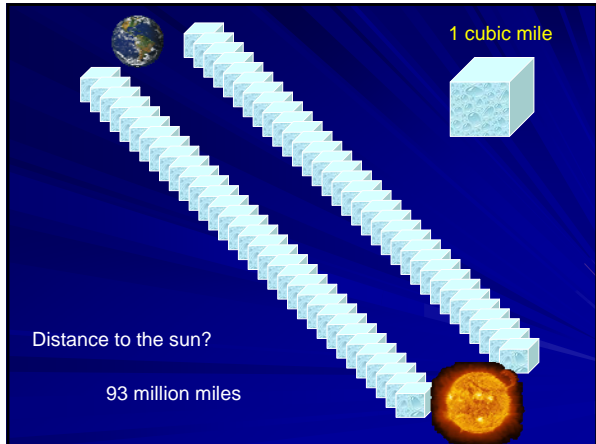
688 miles

Total Earth Water = 326 million mi³

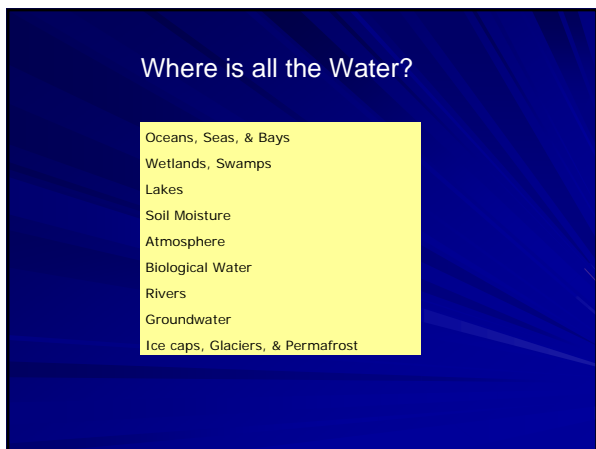


841 miles

3476 miles





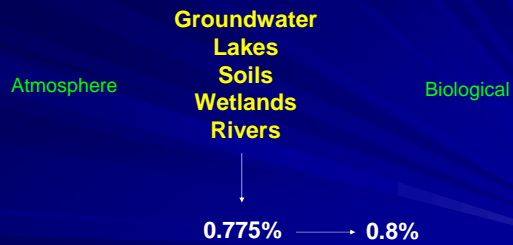


Where is all the Water?

Water source	Percent of fresh water	Percent of total water
Oceans, Seas, & Bays	--	96.5
Ice caps, Glaciers, & Permafrost	69.6	1.79
Groundwater	30.1	1.7
Lakes	0.26	0.013
Soil Moisture	0.05	0.001
Atmosphere	0.04	0.001
Wetlands, Swamps	0.03	0.0008
Rivers	0.006	0.0002
Biological Water	0.003	0.0001

Source: USGS

Freshwater



When did water appear and where did it come from?

Accepted Age of the Earth: 4.6 billion years



Accretion of materials
from formation of
the solar system

Molten Surface

8000° F

Geologic Time Line

Precambrian
(Earth formation)

Paleozoic
(Multicellular explosion)

Mesozoic
(Age of the reptiles)

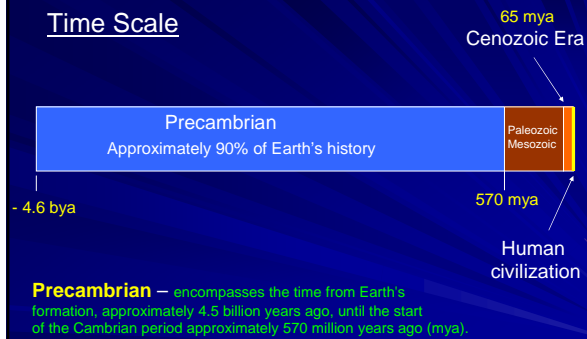
Cenozoic

Chicxulub Crater

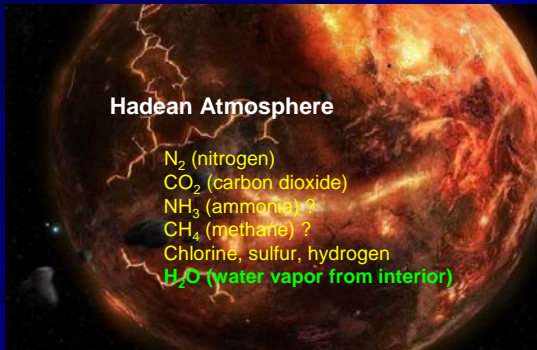
65 mya

570 mya

Time Scale



Early Precambrian



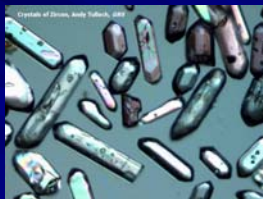
Cooling and condensation of water from the atmosphere



Rainfall and liquid water at the surface

Earliest Evidence of liquid Water on Earth ~ 4.3 bya

Western Australia, 2001



Zircon Crystals

Earth's oldest terrestrial materials

Water and the Rocks

Western Greenland

Minerals indicate
Interaction with water

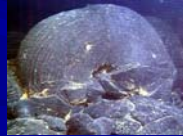
3.8 billion years old



Pillow Lavas

Basaltic Extrusive Rock

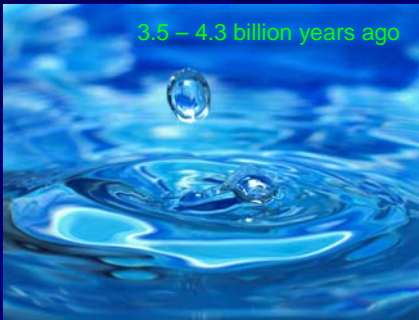
3.5 bya



<http://video.yahoo.com/watch/111691/635356>

Liquid Water

3.5 – 4.3 billion years ago

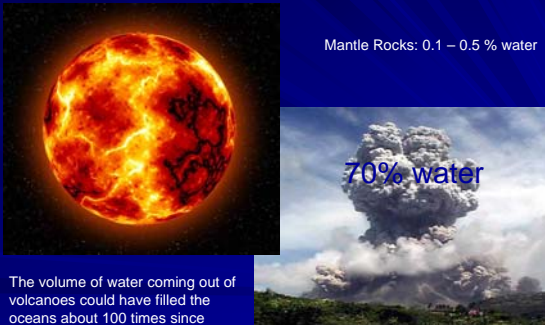


Present levels 326 million mi³

Origins of Earth's Water

- Sources of Earth's Water
- Earth's Mantle**
 - Asteroids**
 - Comets**

1. Volcanic Outgassing



Mantle Rocks: 0.1 - 0.5 % water

70% water

The volume of water coming out of volcanoes could have filled the oceans about 100 times since the earth cooled down

2. Asteroids

0.1 – 0.5 % water



chondritic meteorites (~5%)
up to 10-20% water

Ceres' layers

- Thin, dusty outer crust
- Water-ice layer
- Rocky inner core

Could contain more fresh water than earth

The largest known asteroid
25 percent of the asteroid belt's total mass

3. Comets

Small, but possibly numerous
Wrong kind of water?

Hydrogen in Water (H₂O)

Nucleus
Proton (+)
Neutron

Electron (-)

Deuterium has a neutron

The earth ratio of hydrogen to deuterium is about 6000:1
For many comets, the ratio is 12,000:1

Comet LINEAR (2000)

3.6 million tons (3.3 billion kilograms) of water

LINEAR was the first comet with a chemistry that indicated its water had the same ratio of hydrogen to deuterium as the water actually found on Earth.

Origins of Water

3.5 – 4.3 billion years

Setting the stage for the evolution of life



Water is an essential precursor to life.
