The Remarkable Properties of Seawater

Chemical Properties of Seawater

Why is the Sea Salty?

Graphic: Deploying a Conductivity-Temperature-Depth (CTD) rosette, with water sampling bottles to measure the physical and chemical properties of seawater. Capt. R. A. Pawlowski, photographer. Image courtesy of NOAA.

How Warm Was it in the Geologic Past?

One estimate…

Note that climate was most different at the poles

Water and the Ocean

Reservoir	% of Total Volume
Ocean water and sea ice	~97

Glaciers

1.7

Groundwater

0.8

Rivers and lakes

0.007

Atmospheric water vapor **0.001**

Graphic: See Garrison Figs. 7.1, 1.1.

What is Water?

2 Hydrogen atoms + 1 Oxygen atom = H_2O

Water is a <u>compound</u> that is held together by <u>chemical bonds</u>

These "covalent" bonds arise because electrons are shared between hydrogen (H) and oxygen (O)

Graphic: Garrison, Fig. 6.1

Structure of the Water Molecule

Water is a <u>polar molecule</u>

Positively charged (+) protons are clustered on one side of the molecule

Negatively charged (-) electrons are clustered on the other

Graphic: Garrison, Fig. 6.1

Liquid Water

Because water is a polar molecule, water molecules attract other water molecules

Liquid water is a matrix of molecules loosely held together by hydrogen bonds

Water molecules attract other charged particles

Graphic: Garrison, Fig. 6.2

Salts in Seawater

Positive and negative ions in solid salts are held together by ionic bonds

When dissolved, the polarity of the water molecule breaks the "salt" into positive and negative ions

Graphics: See Garrison, Fig. 7.2

Summary: Chemical Bonds and Seawater

Covalent - very strong bond

- due to electron sharing between atoms

- holds the H's and O together in a water molecule

Ionic - weak bond

- due to attraction between + and – charged ions

- holds salts together in their solid state

Hydrogen - weaker bond

- aligns water molecules in liquid water

- aids in dissolving salts in sea water

The Remarkable Properties of Water

Only natural substance occurring as a solid, liquid and gas on Earth's surface

Greatest dissolving power of any common liquid

Unusually high melting, boiling points

Solid phase (ice) is less dense than liquid phase (water)

Graphic: Mangrove swamp, SE United States, R.F. Kresge, photographer, courtesy of NOAA.

Chemical Composition of Seawater

Seawater is ~96.5% pure water and ~3.5% dissolved solids ("salt")

Salinity = amount of dissolved solids in seawater

(3.5% dissolved solids = 35 parts per thousand)

Graphic: Garrison, Fig. 7.3.

The Salt Shaker - Adding Salt to the Sea...

- Weathering of

continental rocks

- Hydrothermal vents

- Chemical reactions at

mid-ocean ridges

- Volcanic eruptions

Graphics: (left) North Cascades National Park, courtesy of National Park Service, (center) Black smoker at a mid-ocean ridge hydrothermal vent, P.Rona photographer, courtesy of OAR/NURP and NOAA, (right) Kanga Volcano, Alaska, E.Klett (USFWS) photographer, courtesy of USGS.

Salt Balance – “Steady State”

The change in ocean salinity depends on the

- **rate at which salt enters the sea**
- **rate at which salt leaves the sea**

More salt in than out --- salinity increases

More salt out than in --- salinity decreases

Average ocean salinity will not change if the supply of salt equals the rate of removal ("salt balance")

salt in **salt out**

salinity doesn't

change

How to Remove Salt from the Sea

- Formation of shells or hard body parts

- Uplift or subduction of marine sediments

- Chemical reactions at mid-ocean ridges

- Formation of salt deposits by

evaporation of seawater

Graphics: (left) Foramiferia shells (courtesy of NOAA), (center) uplift of marine rocks in the Andes, South America, George Ericksen, photographer. Courtesy of USGS.

Rivers, Sea Salt and Deep Time

The ocean is hundreds of times saltier than typical river water

If all of the salt in the sea had to be replaced by salts coming in from rivers, it would take over 1 million years to reach today's salinity

Ocean vs. River Chemistry

Ocean chemistry differs from river chemistry because:

- Chemicals are added to the ocean from sources other

than rivers

- Some chemicals are selectively removed from the

ocean

What's on the menu Friday night?

Pizza – yum! Cupcakes – yum!

Veggie platter – it'll do…

Parsnips????

What's left in the morning?

Empty pizza boxes, one lone cupcake, and a fridge full of broccoli, carrots and parsnips…

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Substances More Common (by Percent) in River Water than Seawater

Bicarbonate, Calcium

Used by marine organisms to form hard parts (shells, bones)

Magnesium

Chemically reacts with new basalt at mid-ocean ridges

Graphics: (top) Foramifera, Garrison, Fig. 5.13a, (bottom) Black smoker at a mid-ocean ridge hydrothermal vent. P.Rona photographer, courtesy of NOAA NURP.

Substances More Common (by Percent) in Seawater than River Water

Sodium and Chloride

Not significantly used by marine organisms or in chemical reactions in the ocean

A small amount is removed when salt deposits are formed by evaporation

Graphic: (top) Jordanian salt evaporation ponds, as (bottom) salt ponds in San Francisco Bay, photographed from the space shuttle. Courtesy of NASA.

Why is the Sea Salty?

Sources of sea salt:

Erosion, weathering

of continental rocks

Outgassing of material

from Earth's interior

Salt is removed by:

- forming into sediments

- returning to the mantle in subduction zones

Graphic: Garrison, Fig. 7.4.

Seawater As Earth Tea

Every element that occurs naturally on Earth is found in the sea…

Major constituents are present in large concentrations

Minor constituents are present in smaller concentrations

Graphics: (top) Kelp forest, Channel Islands National Marine Sanctuary Collection, courtesy of NOAA (bottom) Kelp community, courtesy of NOAA Restoration Center, M.Golden, photographer.

Minor Constituents – Ingredients for Life

Many minor constituents are necessary for important life processes

Nitrogen and phosphorous are needed to build nucleic acids

Iron is needed to produce proteins and for photosynthesis

Graphics: (top) Cowrie, Dr. J.P. McVey, NOAA Sea Grant, (bottom) anemones, courtesy of NOAA National Marine Sanctuaries.

The Iron Hypothesis – More Food, Less Climate Change?

Because plant growth uses carbon dioxide, seeding the ocean with iron to encourage plant growth was suggested as a way to reduce potential climate change and produce more food from the sea

- Graphics: (top) Courtesy of US JGOFS, data from K.Johnson and K.Coal, (bottom left) seeding the ocean with iron during the 1993 IRONEX experiment, courtesy of NASA, (bottom right) increase in plant production observed following iron seeding, (Image courtesy Jim Acker, Goddard Distributed Active Archive Center, the SeaWiFS Project, NASA/Goddard Space Flight Center, and ORBIMAGE).

Next Lecture- Sea, Sky and Land: The Climate Connection

Oceans and Heat

Monsoons

Reading:

Ch 6: 6.3-6.5, 6.11-6.13;

Ch 8: 8.12-8.13;

Ch 9: 9.9

Graphic: Bergy bits, the size of houses, being released into the ocean in Southeastern Alaska, J.Bortnaik, photographer (NOAA Corps), courtesy of NOAA.