Week #2: Effects of Earth Cycles on Nashville Now and in the Deep Time (~470 MY) in Past

- Earth News to investigate:
  - TVA names new Board Members – what next regarding fossil fuels?
  - Murfreesboro files suit charging landfill with contaminating river
    - https://www.newschannel5.com/news/newschannel-5-investigates/murfreesboro-notifies-middle-point-landfill-of-alleged-contamination-at-nearby-spring
  - Can Murfreesboro landfill problems be solved by “Wasteco”?
    - WPLN, Morning Edition, January 16

Nashville: Strongly Affected by Cycling of Materials Between Spheres

Carbon cycle – have both short term and long term cycling

1) Carbon cycle at work in Nashville – results in limestone dissolution
2) How the carbon cycle works at the surface of Earth, Nashville
3) How the carbon cycle works on whole Earth

Water (hydrologic) cycle

crucial component

Nashville: Strongly Affected by Cycling of Materials Between Spheres

Carbon cycle

Carbon cycle at work in Nashville – results in limestone dissolution
(one step in long cycle that takes tens of millions of years)

in atmosphere ……

Rain + carbon dioxide ➡ weak carbonic acid

Dissolves Nashville's rock = Limestone

Liquid flows to Cumberland River, Gulf of Mexico


© WorldAtlas.com
United States
Mississippi River
MISSISSIPPI
ALABAMA
GEORGIA
TEXAS
LOUISIANA
Atlantic Ocean
FLORIDA
GULF OF MEXICO
Nashville's limestone in dissolved form here
Rio Grande River
Risk Ranking:
Low
Moderate
High
Very High
Straits of Florida

What does it leave behind?

Not much; only ~1 – 20% of rock does not dissolve and remains to form soil..

Implications for Nashville, Middle Tennessee

-- Very little soil; no household garbage landfill in Davidson County
Why? Where does it (waste) go? Any landfill in Davidson County?

-- Very little soil; FLOODING EVENTS

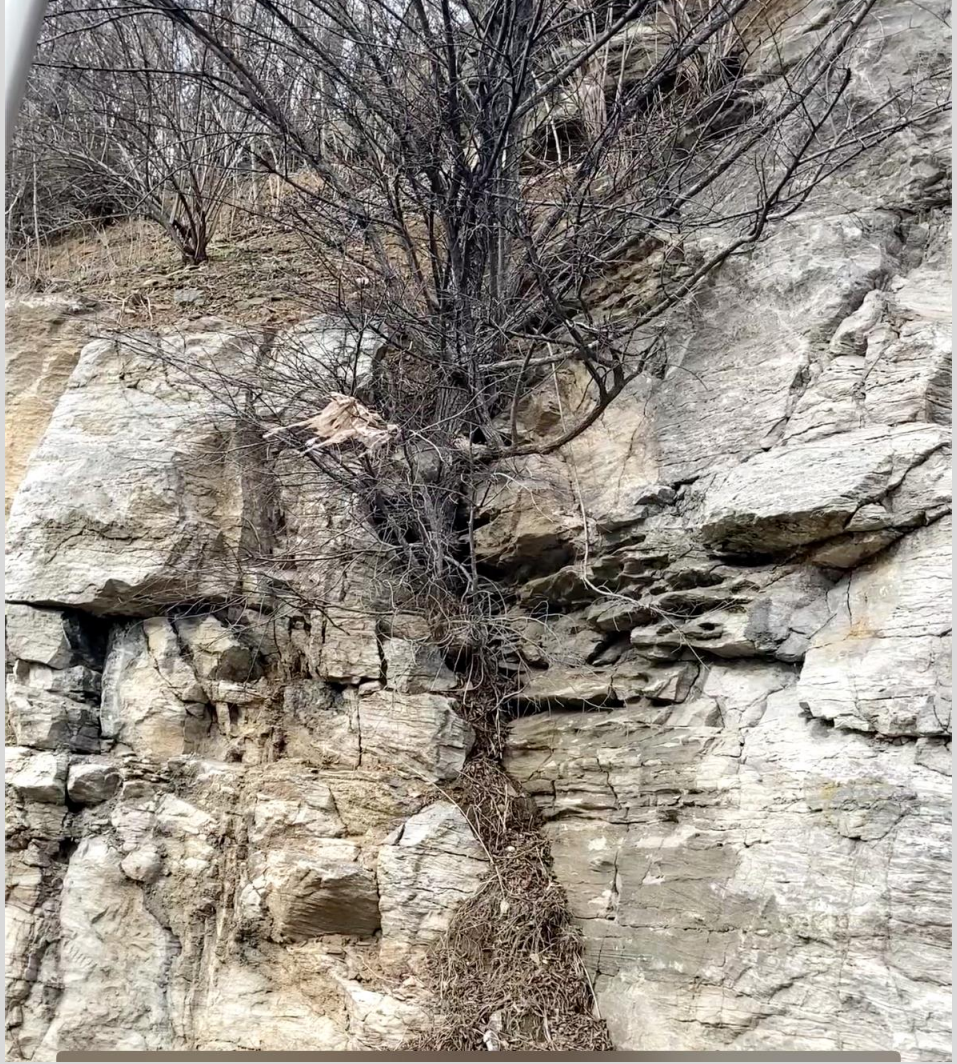
-- Very little soil; controlled growth, development patterns

Caves Sinkholes

Roots are conduits for water – dissolve limrstone, form caves, sinkholes

Well exposed sinkholes, fractures along I-440

(N side, between I-65 and Hillsboro Rd)



Dissolution continues

Dissiution very extensiivef

Voids filled with nice stonework

Drain is circled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United States
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Clams, corals, etc., combine Ca^{++} & carbonate ions in ocean water to form shells of mineral calcite or aragonite

Both are $CaCO_3$

Young limestone

Nashville limestone

Nashville: Strongly Affected by Cycling of Materials Between Spheres

Carbon cycle

1) Carbon cycle at work in Nashville – limestone dissolves

2) How the carbon cycle works at the surface (short term cycling)

Water (hydrologic) cycle

(rain is crucial)

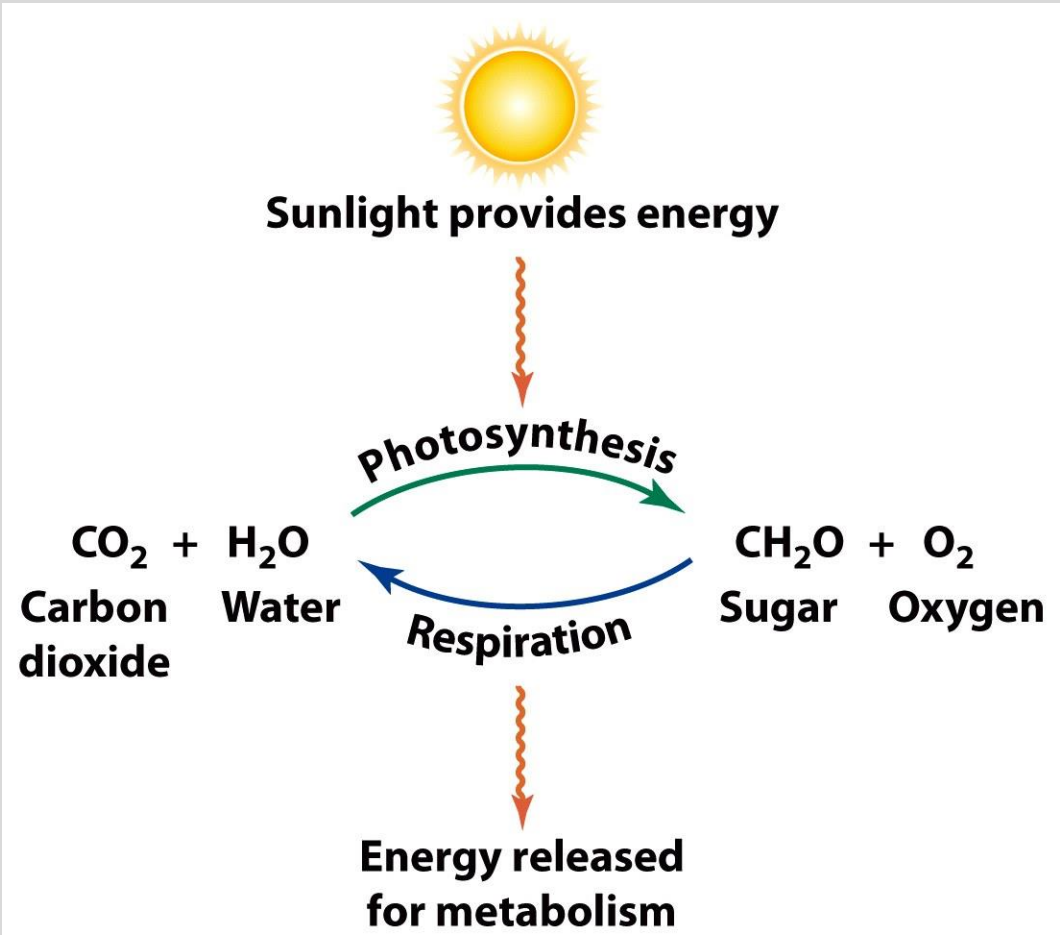


Figure 10-2
***Earth System History,* Third Edition**

Turkey vulture consuming organic matter from armadillo

Both involve short-term cycling

Fungi recovering organic matter from tree

(along Red Trail, Percy Warner Park)

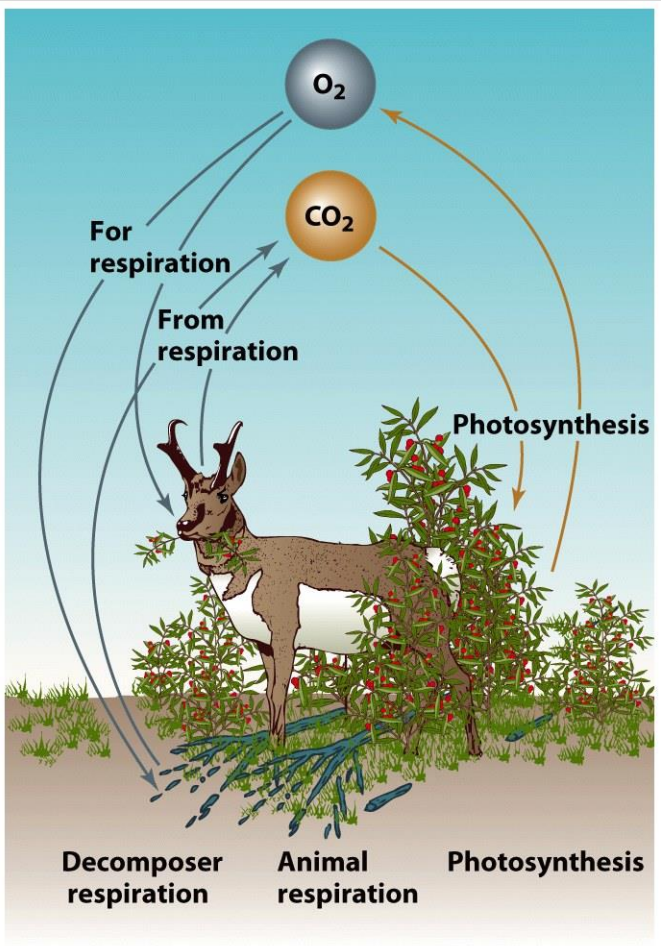


Figure 10-4
***Earth System History,* Third Edition**

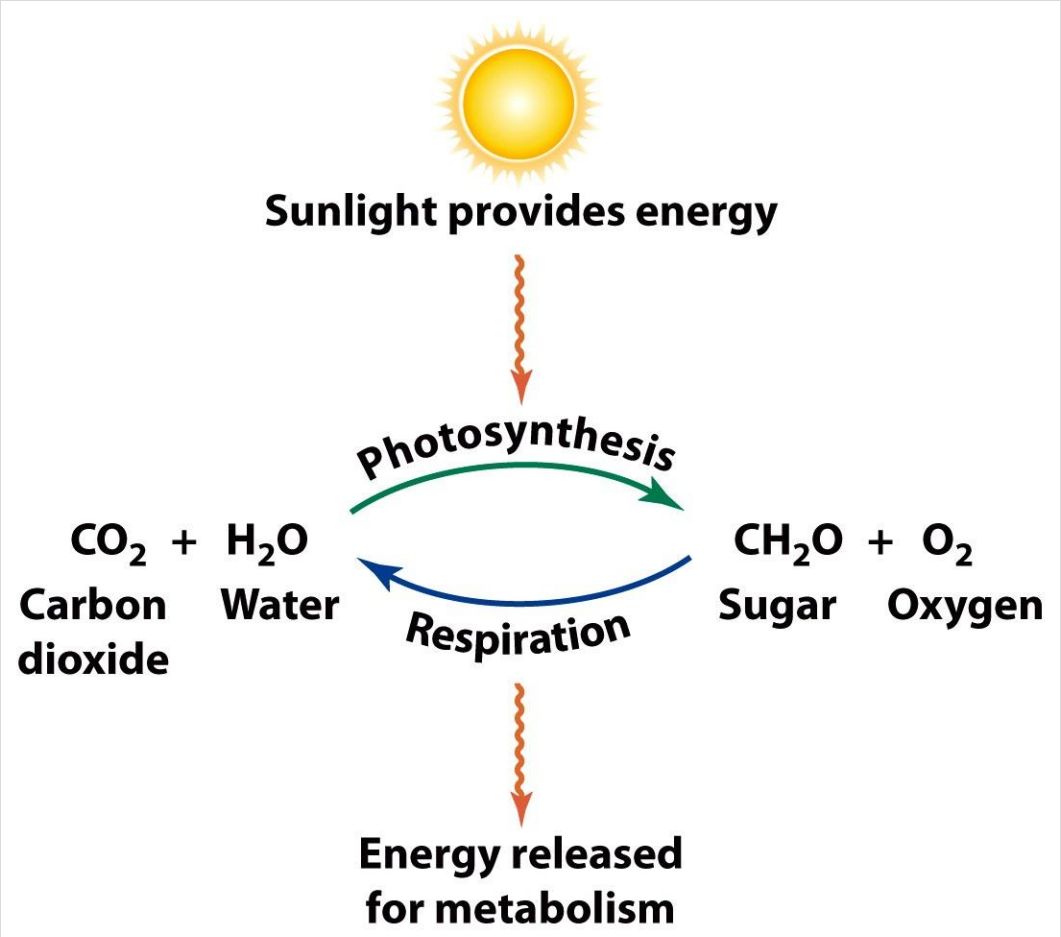


Figure 10-2
Earth System History, Third Edition

How to increase photosynthesis?

(add nutrients, fertilizer to stimulate algal growth)

How to decrease respiration, oxidation?

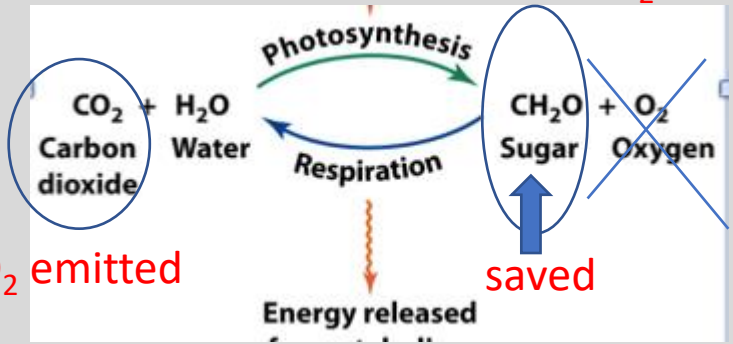
(use up oxygen as algae decay; organic matter preserved)

Radnor Lake – has algal blooms – sinks to bottom

Algal growth stimulated by fertilizer in runoff water

Nashville's demonstration of long term cycling perturbation

O_2 used up



Less CO_2 emitted

saved

Bottom of Radnor Lake –

Oxygen used up, not replenished by mixing

Decay (bacterial respiration) is stopped

Organic matter (sugar) is buried and thus preserved

j

What is mud like at bottom of Radnor Lake?

- slimy (algal slime)
- smells (rotten eggs). H_2S
- preserved organic matter
- (Radnor Lake will not last long enough
- for it to become oil)

Nashville: Strongly Affected by Cycling of Materials Between Spheres

Carbon cycle

1) Carbon cycle at work in Nashville – results in limestone
2) How the carbon cycle works at the surface
3) How the carbon cycle works on whole Earth – plate tectonic cycle

Water (hydrologic) cycle

(crucial)

Whole Earth Long-Term Carbon Cycle
Where is carbon in the Earth?

Form of carbon	Amount (10^{16} grams)	Amount relative to life
Calcium carbonate in sedimentary rocks	35,000	62,500
Ca – Mg in sedimentary rocks (mostly)	25,000	44,600
Sedimentary organic matter (kerogen)	15,000	26,800
Oceanic dissolved carbonate, bi-carbon	42	75
Recoverable fossil fuels (coal, oil)	4.0	7.1
Dead surficial material (e.g. humus)	3.0	5.4
Atmospheric carbon dioxide	0.72	1.3
All life – plants and animals	0.56	1

Most carbon is not visible at surface; moves slowly over millions (100's of millions of years) - Plate tectonic cycle

From Berner and Lasaga, 1989, Modeling the geochemical carbon cycle: Scientific American, March, 1989.

New Discoveries, Many New Unknowns and Ideas – last 10 years

-- Carbon links with many elements under different conditions (difficult to simulate).

-- Carbon may have been abundant in mantle (or is still)????

-- Carbon pivotal in development of early life.. How, where??

Read all about it: ***Hazen, Robert M., 2019, Symphony in C: Carbon and the Evolution of (Almost) Everything: William Collins, 282p.***

Plate Tectonic Cycle – What it is, development of concept, how it works

What it is: concept that distribution of continents, earthquakes, volcanoes is controlled by movement of a rigid lithosphere moving horizontally on underlying plastic asthenosphere

Development: Early 1900's knew that Earth had crust, mantle, core with densest in middle (https://www.iris.edu/hq/inclass/animation/layers_of_the_earth)

1912 – Alfred Wegener used distribution of fossil plants, animals, similar rock sequences as empirical evidence that continents moved– very strong evidence

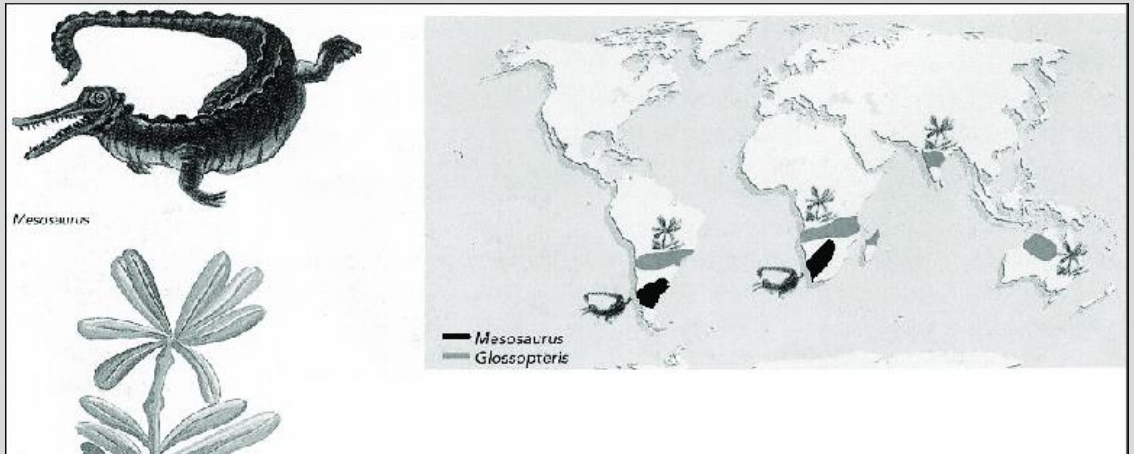
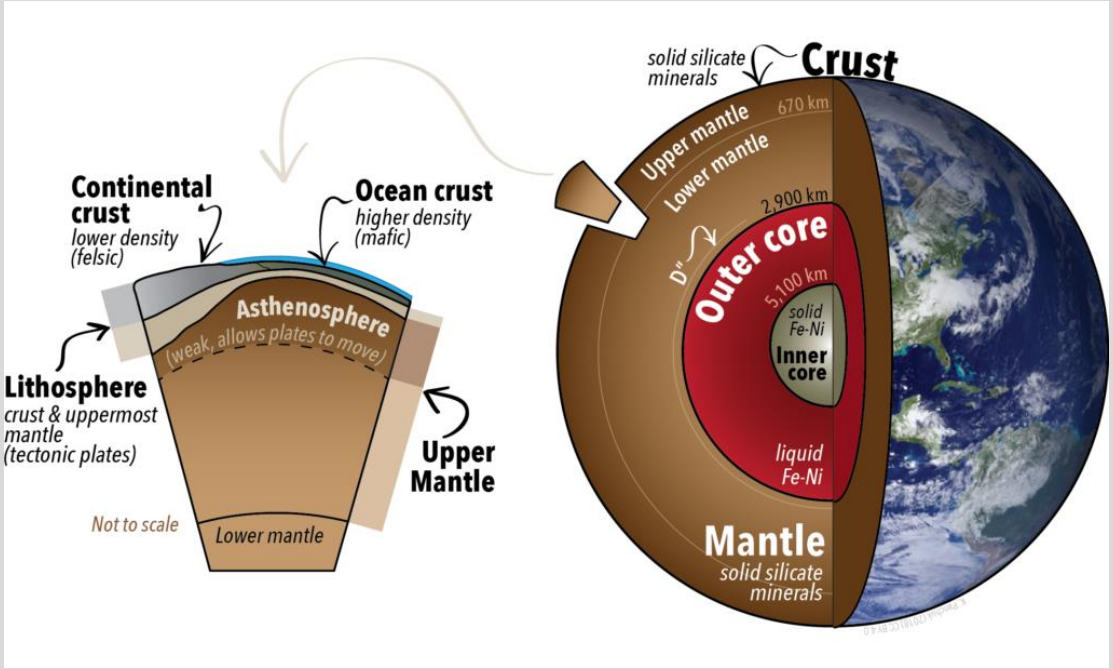


Plate Tectonic Cycle – What it is, development of idea, how it works

Response to Wegner – until late 1960's: geophysicists: "NO WAY!!" Earth is too solid to move

Discoveries of 1950's and 1960:



New divisions of Earth
Lithosphere = crust +
Upper mantle:it is RIGID

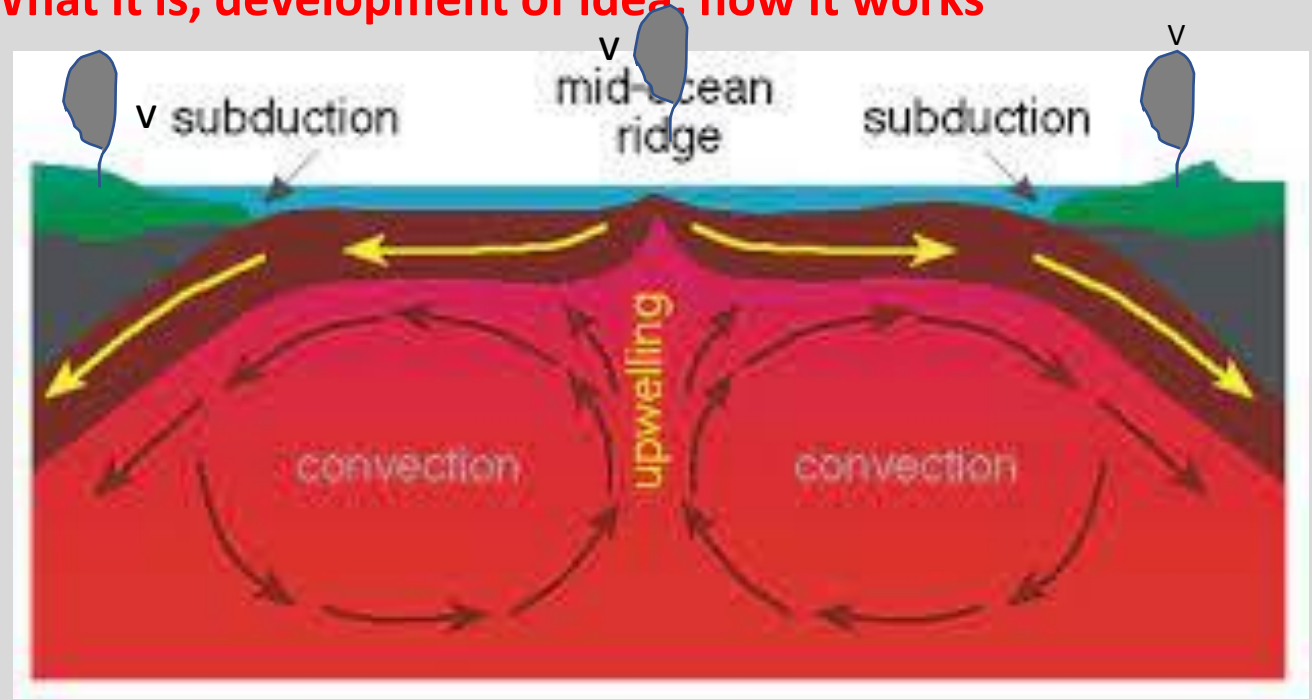
Asthenosphere = plastic, flows when stress applied slowly

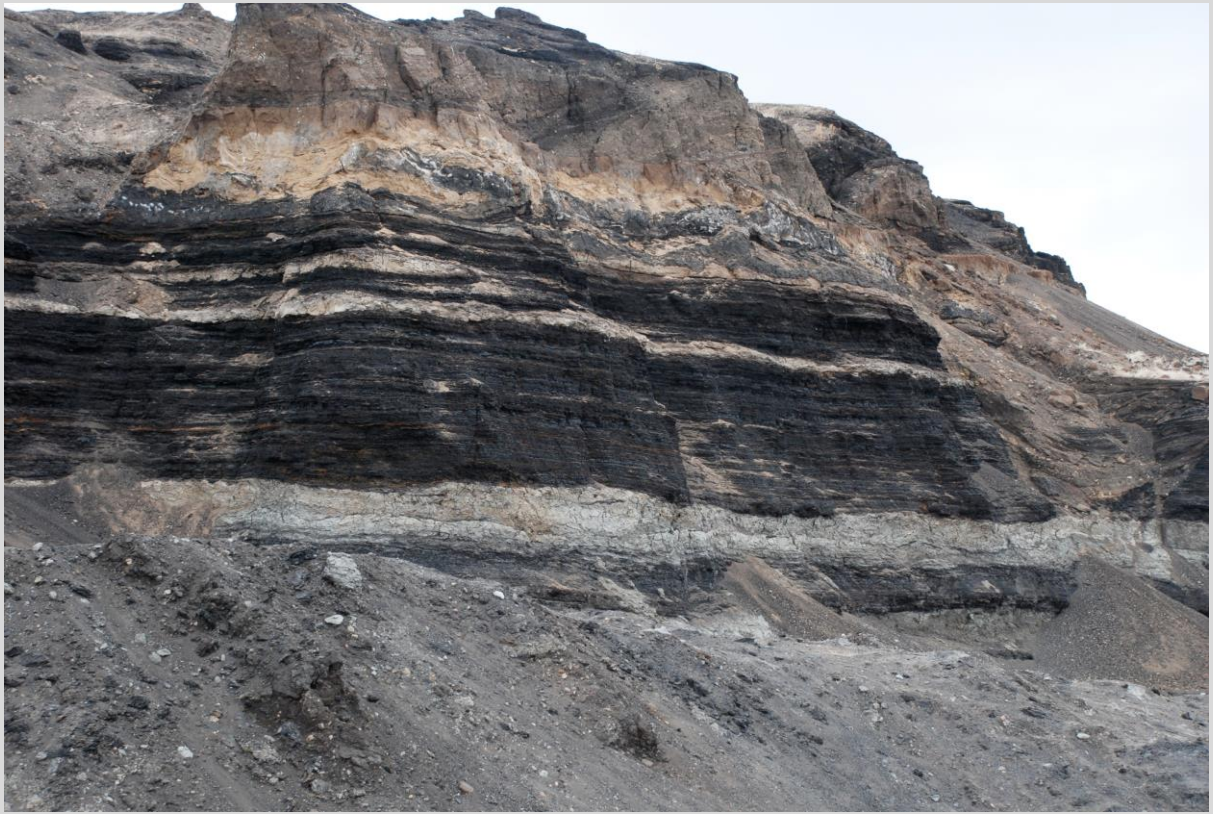
Provided mechanism for horizontal movement of lithosphere

Plate Tectonic Cycle – What it is, development of idea, how it works

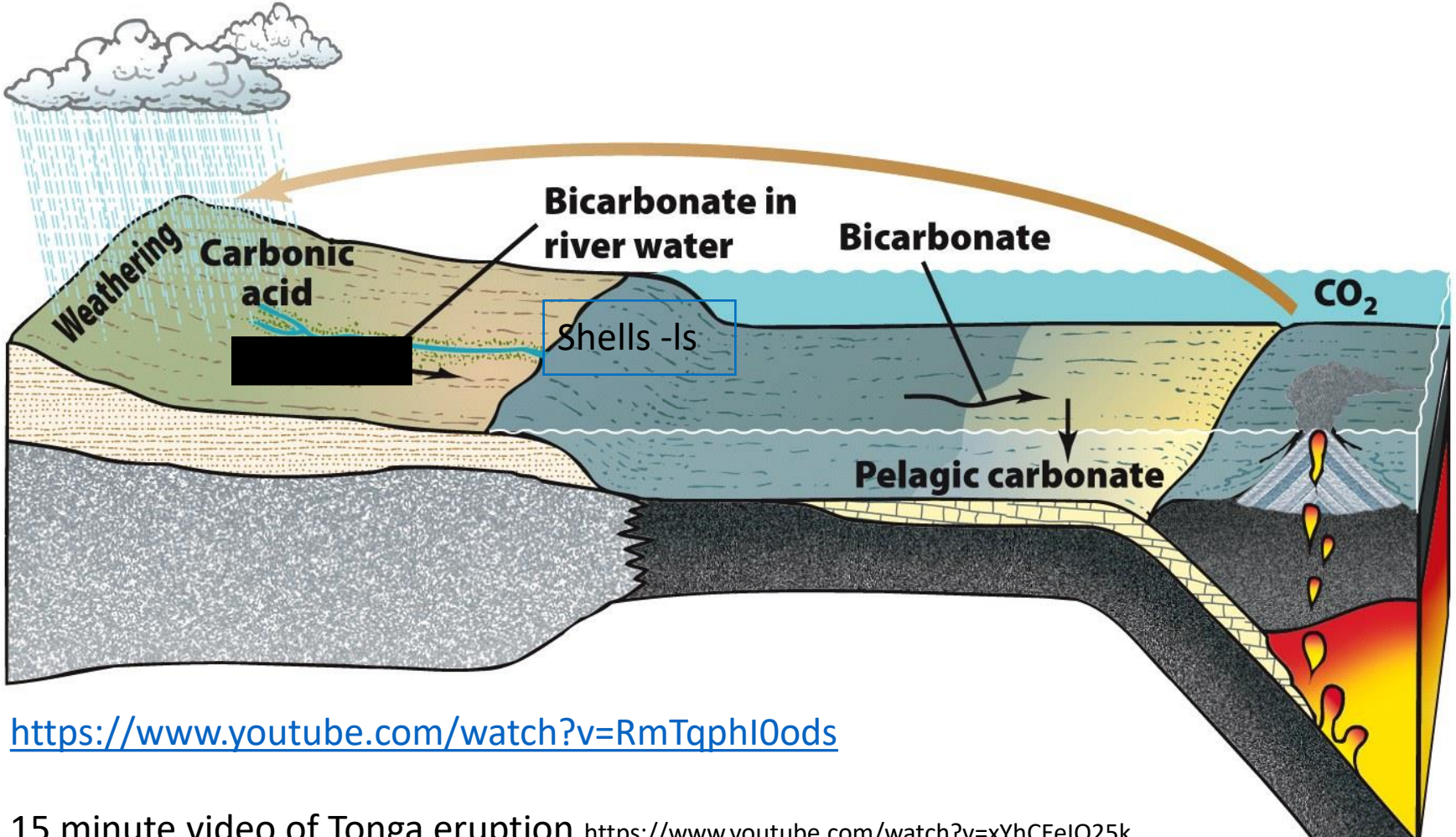
Convection current in asthenosphere pulls lithosphere down as it cools

Rock melts, volcanoes form, mountains, earthquakes



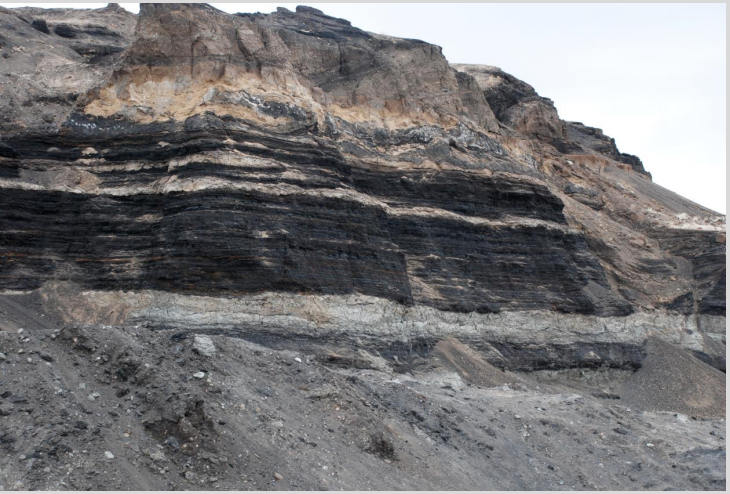


After millions of years, Radnor Lake bottom turns into a coal bed –
Eventually erosion would expose it at the surface –
It would be oxidized slowly -- gradually releasing energy and carbon dioxide



https://www.youtube.com/watch?v=RmTqphI0ods

15 minute video of Tonga eruption https://www.youtube.com/watch?v=xYhCFeIO25k



What humans do –

SPEED UP the oxidation burn coal, oil

Release carbon dioxide rapidly

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Carbon cycle

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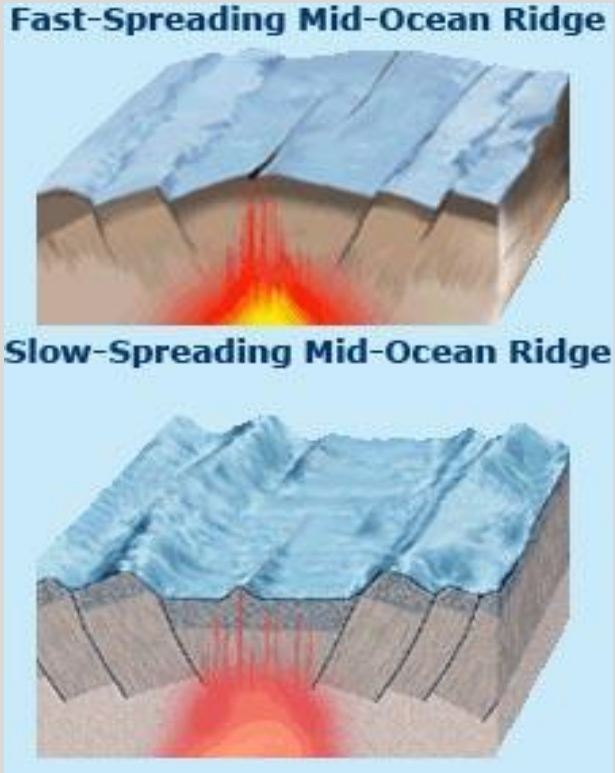
3) How the carbon cycle works on whole Earth – plate tectonic cycle
4) How plate tectonics cycle resulted in Nashville's limestone

Water (hydrologic) cycle

(crucial)

Why sea level was so high – 470 million years ago

1. Sea level is controlled on a large scale by rate of plate tectonic motion

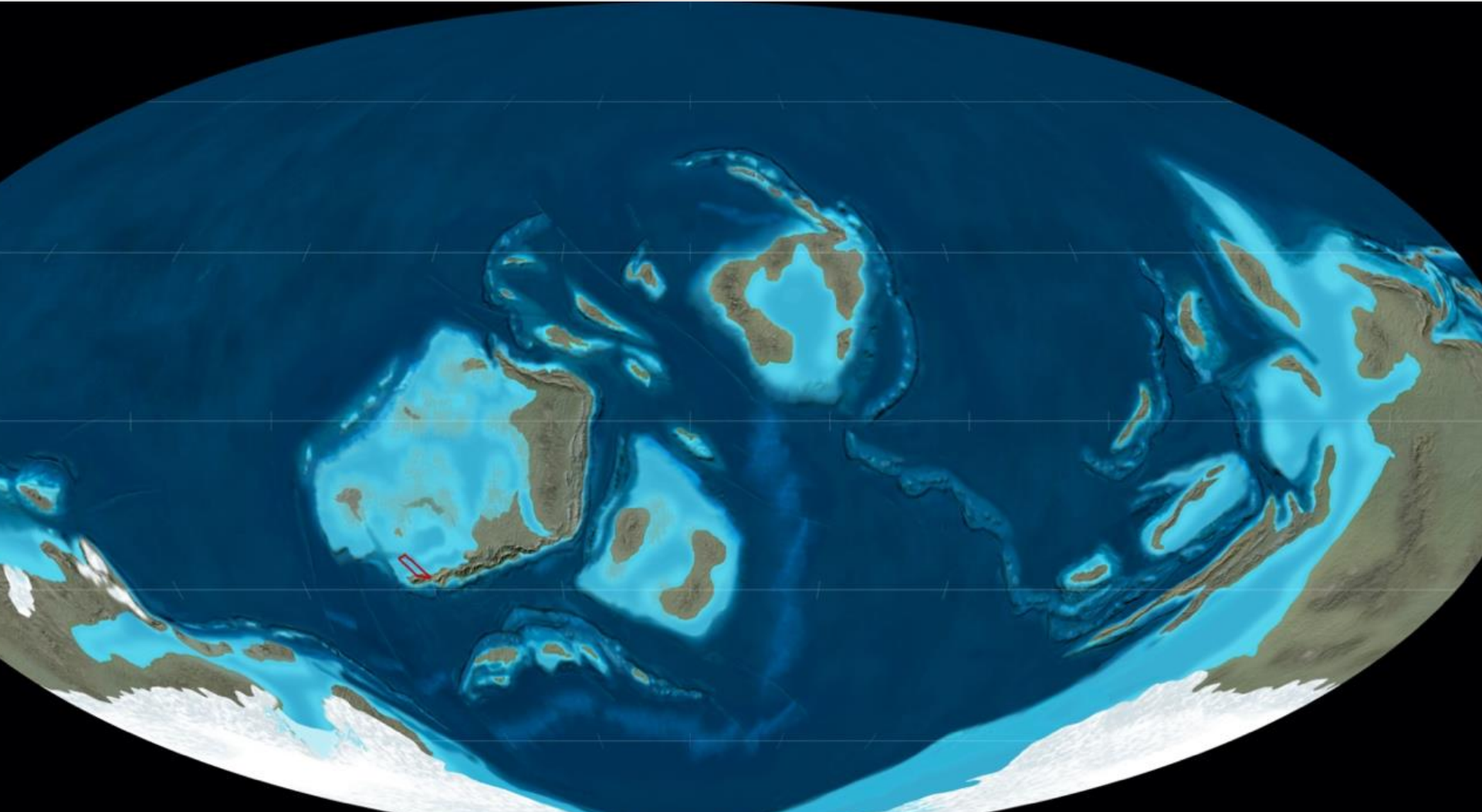


Compare the height and the volume of the Mid Ocean Ridge when spreading is fast vs slow.

Note that ridge is puffed up by heat when Spreading is fast. When slow, ridge has time to cool and sink…

Fast spreading: ridge puffed and high, ocean water sloshes onto continents (Nashville)

Slow spreading: ridge sinks, sea level low



Why limestone only – 460 million years ago??

Land was far away from Nashville **– too far to shed sediment as far as Tennessee**

Summary

Nasville's rocks and environmental reflect carbon carbon and plate tectonic cycles.

Carbon cycling – present-day limestones dissolve in acid – rain + carbon dioxide

Dissolution products (liquids) flow down to Gulf, leave no soil

Lack of soil is heart of many of Nashville's environmental issues: no soil, no landfills

Plate tectonic cycle – fast spreading caused continental flooding, high sea level

Plate tectonics caused land source of sediment to be too far from Tennessee

Only source of sediment was skeletons of organisms made of calcite – no eroded silt and clay-rich dirt from continents