Carbon cycle essay

System: Lithosphere: Carbon-rich minerals of the mantle, crust, sediments, fossil fuels. Biosphere: Cellular structure of plants and animals on land and in the oceans.

Hydrosphere: Dissolved and particulate carbon of the oceans. Atmosphere: Gases (primarily C02 and CH4) and aerosols (dust particles). Carbon Is exchanged (or transferred) between these various reservoirs by a variety of natural and anthropogenic (human) processes. Relative Size of Carbon Reservoirs – How does C in the deep Earth reach the surface of the planet to become part of the C-cycle that we experience everyday?

Most of the Earth's carbon is tied up in the solid Earth (rocks) but the relatively small amount of carbon In the biosphere allows life to exist, and carbon in the oceans and atmosphere control Important greenhouse gases that affect climate on the planet. Thompson and Turk text, Fig. 21.

9 Volcanism and subduction processes are both part of the Carbon Cycle that links the deep Earth (lithosphere and asthenosphere) to the atmosphere, hydrosphere and biosphere at timescales operating over millions of years. What happens to carbon found in the near-surface environment?

Thompson and Turk text, Fig. 21. 11 In any given year, tens of billions of tons of carbon move between the atmosphere, hydrosphere, biosphere and lithosphere.

Human actlvltles add about 5. 5 billion tons (Gt) per year of carbon dioxide to the atmosphere. The Illustration above shows total amounts of stored carbon In each reservoir In black, and annual carbon fluxes (transfers) in purple. httpwearthobservatory. nasa.

gov/ temporary storage place for carbon, which is constantly being cycled between the different reservoirs by processes that involve the full range of Earth Systems interactions.

The term “ carbon cycle” refers to the amount of carbon sequestered in ach of the reservoirs, and the rate at which carbon is exchanged (transferred) between these reservoirs. rhe carbon cycle is an active research area at the moment because of the role played by C02 (carbon dioxide) and CH4 (methane) as greenhouse gases and their link to climate change. In order to estimate future levels of these atmospheric greenhouse gases and their possible effects on climate we need to know where carbon is currently being stored, the mechanisms by which it moves between reservoirs, and the rates at which this transfer occurs.

Is human activity adding C02 to the atmosphere faster than other parts of the carbon ycle can cope with it (i. e.

remove it from the atmosphere)? It is difficult to obtain precise numbers for the rates at which carbon moves between reservoirs (i. e. the carbon cycle) but this is an important topic and we’ll return to this question in a later section of the course that deals specifically with global (climate) change and human Impact on global change. i) Reservoirs of Carbon: Atmospheric carbon is mostly C02 and lesser methane ICH4), both of which are important greenhouse gases affecting temperature (climate change).

Identify processes that produce these gases. Total carbon in all reservoirs is ” 800, 000 billion tonnes Thompson and Turk text, Fig. 21. 10 3. 09% of all carbon Numbers specify billions of tonnes of carbon in a reservoir (it) Reservoirs of Carbon: Carbon in the biosphere is a key component of organic material in plants and animals both living and dead (but not yet decayed).

How much carbon of the total? 500 + 1500 + 1000 = 3, 000 billion tons of C (” 0. 37% of all carbon). Total carbon in all the atmosphere and phytoplankton extract C02 from the oceans via photosynthetic activity. All plants and animals release C02 via respiration and CH4 via digestion. In these two Nays carbon is transferred back and forth between the atmosphere and biosphere. Carbon in the Biosphere Carbon is the fundamental building block of all organic tissue.

Plants and animals store carbon in their body parts and release carbon when they die and decay.

Some of this carbon directly enters the atmosphere as C02 (for example when forests burn) or it may be added to the soil and sediment where it decays and releases C02. In areas of high sedimentation, organic material from plants and animals may be buried quickly enough that decay is incomplete. Such carbon ends up stored as fossil fuels (coal, oil, gas). There is a big time lag to convert buried organic material to fossil Coal beds Abundant evidence for photosynthesis. (iii) Reservoirs of Carbon: Carbon in the hydrosphere is found in the oceans as dissolved C02, as C032- (carbonate ion) and HC03- (bicarbonate ion).

How much 38, 000 + 1, 000 = 39, 000 billion tonnes of C (” 5% of all carbon) Total carbon in all Carbon is found in the oceans as dissolved C02, as C032(carbonate ion) and HC03- : bicarbonate ion) (38, 000 + 1 , OOO = 39, 000 billion tonnes ” 5% of all carbon) Carbon in the Hydrosphere C02 dissolves in seawater across the air-sea boundary. rhe amount of C02 dissolved in the oceans depends on temperature. Warmer emperatures promote the release of dissolved C02 into the atmosphere.

This is a positive feedback mechanism (high temperature releases C02 from the oceans which causes a further temperature increase in the atmosphere). We will say more about this in our discussion of global change. (iv) Reservoirs of Carbon: Carbon in the lithosphere is stored primarily as carbonate rocks (limestone and dolomite) plus lesser amount as fossil fuels.

How much carbon 750, 000 + 10, 000 = 760, 000 billion tonnes of C (” 95% of all carbon) Total carbon in all Carbon in the Lithosphere The vast majority of carbon (” 95%) resides in the crust nd upper mantle in sedimentary rocks.

Carbonate rich sediments (e. g. limestone) may be transported into the mantle at subduction zones. Most of this subducted carbon will be returned to the atmosphere by volcanic activity. Some marine organisms build shells from calcium carbonate, and these shells gradually accumulate to form limestone.

Any process that exposes the continental margin or other parts of the ocean floor will expose limestone to the atmosphere and allow it to undergo chemical weathering Nhich returns C to the hydrosphere. Weathering of Carbonate Rocks Chemical weathering of limestone or calcium silicate minerals (e. pyroxene) in igneous and metamorphic rocks at the Earth’s surface consumes atmospheric C02 via the following reactions to produce aqueous (soluble) bicarbonate anions (HC03-): cac03(s) +C02(g) *H20 cast03?) +2 C02(g) +3 H20 ca2+(aq) +2 HC03-(aq) ca2+(aq) +2 HC03-(aq) +H4Si04(aq) rhe calcium and bicarbonate ions are soluble in water, and so are carried to the ocean by river runoff. Chemical weathering of limestone transfers C02 from the atmosphere to the oceans, thereby cooling the atmosphere. This process reflects interaction among and atmosphere.

Carbon in Fossil Fuels Carbon stored in fossil fuels is released to the atmosphere Nhen these fuels are burned. Recoverable reserves of fossil fuels (i. e. what we can get our hands on today) are estimated to be five times the amount of carbon now present in the atmosphere. If the fossil fuels were all burned in a relatively short period of time, atmospheric C02 could rise dramatically, but this would depend on how quickly other natural processes could extract the C02 from the atmosphere and fix it in the oceans as dissolved HC03-, or in the biosphere as organic matter, or in the lithosphere as limestone (CaC03).

Ne know that atmospheric C02 concentration in the atmosphere has risen by ” 30% since the start f the industrial revolution (” 1850) – implying? Another reservoir of carbon: Methane in seafloor sediments. When organic material settles to the seafloor, bacterial degradation releases methane (CH4) gas. At water depths of 500 – 1000 metres, seawater temperatures are low enough and the pressure high enough to convert methane gas to a frozen methane ice called methane hydrate or methane clathrate (frozen H20 with CH4 trapped inside).

Many of the continental margins of the world contain vast quantities of methane hydrate, perhaps as much carbon as all other forms of fossil fuel combined.

Methane hydrate burns, so here have been some attempts to recover it as a possible energy source but no commercial operations have been successful to date. A particular concern is that global warming could, at some point, cause this methane hydrate to melt and release huge amounts of CH4 into the atmosphere. This additional CH4 would Initiate a very worrisome positive feedback process, possibly leading to runaway global Narming.

Atmospheric C02 and Plate Tectonic Activity Levels of atmospheric C02 are known to have varied considerably over the geological record correlating with levels of plate tectonic activity.

Times of rapid plate generation and subduction (e. . the Atlantic opening or the collisions that formed Pangaea) correlate with high levels of atmospheric C02 and globally warm intervals. Times of slower plate generation and is so from the cartoon to the right. Also, note that changes in sea level play an important part of this story.

… ee next slides for explanation. Thompson and Turk text, Fig. 21.

14 Less volcanism means less C02 outgassed Slow rates of subduction produces less volcanism (less C02) and slow rates of spreading produces narrow mid-ocean ridges which don’t displace as much water onto continental margins. Carbonates on the margins are thus exposed to the air and hemical weathering that consumes atmospheric C02. Hence, slow

subduction and spreading correlates with less atmospheric C02 and cool episodes in Earth's history.