Global Chemical Cycles

Global Chemical Cycles - The Carbon Cycle

CO_2 flux into the atmosphere

CO_2 ***outgassing*** from midocean ridges, volcanic arcs, and hotspot volcanoes

some CO_2 left from formation of Earth

some CO_2 from metamorphism of subducted carbonates

respiration of organic matter by animals, fungi, bacteria, plants

mining/drilling and burning ***fossil fuels*** (coal, oil, natural gas)

CO_2 removal from the atmosphere

photosynthesis and burial of organic matter

(not all organic matter produced by photosynthesis is respired)

organic matter in sedimentary rocks: e.g., black shale, coal

weathering of silicate rocks via formation of carbonic acid

storage as carbonate rocks (limestone, etc.)

rate considerations

if the rates of these processes remain constant atmospheric CO_2 will be constant

if the rates of any of these processes change, then CO_2 and climate will change

negative feedbacks

negative feedbacks in the carbon cycle, especially weathering rates act to counter climate changes and have kept the Earth's climate largely within bounds that support life since life first evolved

(e.g., a warming climate would mean more weathering which would use more CO_2 which would tend to cool the climate, the net result being that climate wouldn't warm as much as it would otherwise; and the stronger the forcing toward warming, the stronger the negative feedback to resist the warming)

Global Chemical Cycles - Stable Isotopes as Indicators of Past Climate

carbon isotopes

plants preferentially use CO_2 containing ^{12}C over CO_2 containing heavier ^{13}C
high biological productivity → more ^{12}C stored in biomass and sedimentary rocks
marine carbonate rocks become enriched in heavier ^{13}C
biological productivity changes as recognized by carbon isotope variations
can be caused by climate change
can cause climate change

Summary: in marine carbonates

carbon isotope ratio shift	**can be caused by**
heavier (more positive)	increase in biological productivity and/or increased burial of organic carbon
lighter (more negative)	reduction in biological productivity

oxygen isotopes

H_2O containing ^{16}O evaporates easier than H_2O containing heaver ^{18}O
glacial ice is enriched in light ^{16}O
during glacial periods marine carbonates become enriched in ^{18}O
carbonate skeletal materials (shells & coral) also enriched in ^{18}O if water temp cools

Summary: in marine carbonates

oxygen isotope ratio shift	**can be caused by**
heavier (more positive)	increased global ice volume and/or ocean cooling
lighter (more negative)	decreased global ice volume and/or ocean warming