Mineral Sequestration of CO2 against climate change and ocean acidification

Rotterdam, November 28, 2012

Olaf Schuiling

Venus and Earth

Venus and Earth, two similar planets …. except

- Earth atmosphere, a few hundred ppm CO2, a surface temperature around 15^{o}
- Venus atmosphere, 85 bars CO2 pressure, a surface temperature of 460^{o}

Earth and Venus are permanently degassing

- The Earth emits annually an amount of around 0.5 billion tons of CO2, and Venus probably produces a similar amount.
- If this were not permanently and efficiently removed, we would soon (geologically speaking) have an atmosphere similar to Venus

What causes this difference between Earth and Venus?

- On Earth, there is liquid water, which makes weathering possible. Weathering turns CO2 into innocuous bicarbonate ions
- On Venus, there is no liquid water, so all the CO2 that is degassed remains in the atmosphere

Distribution of carbon on Earth. Modified after Dunsmore (1992)

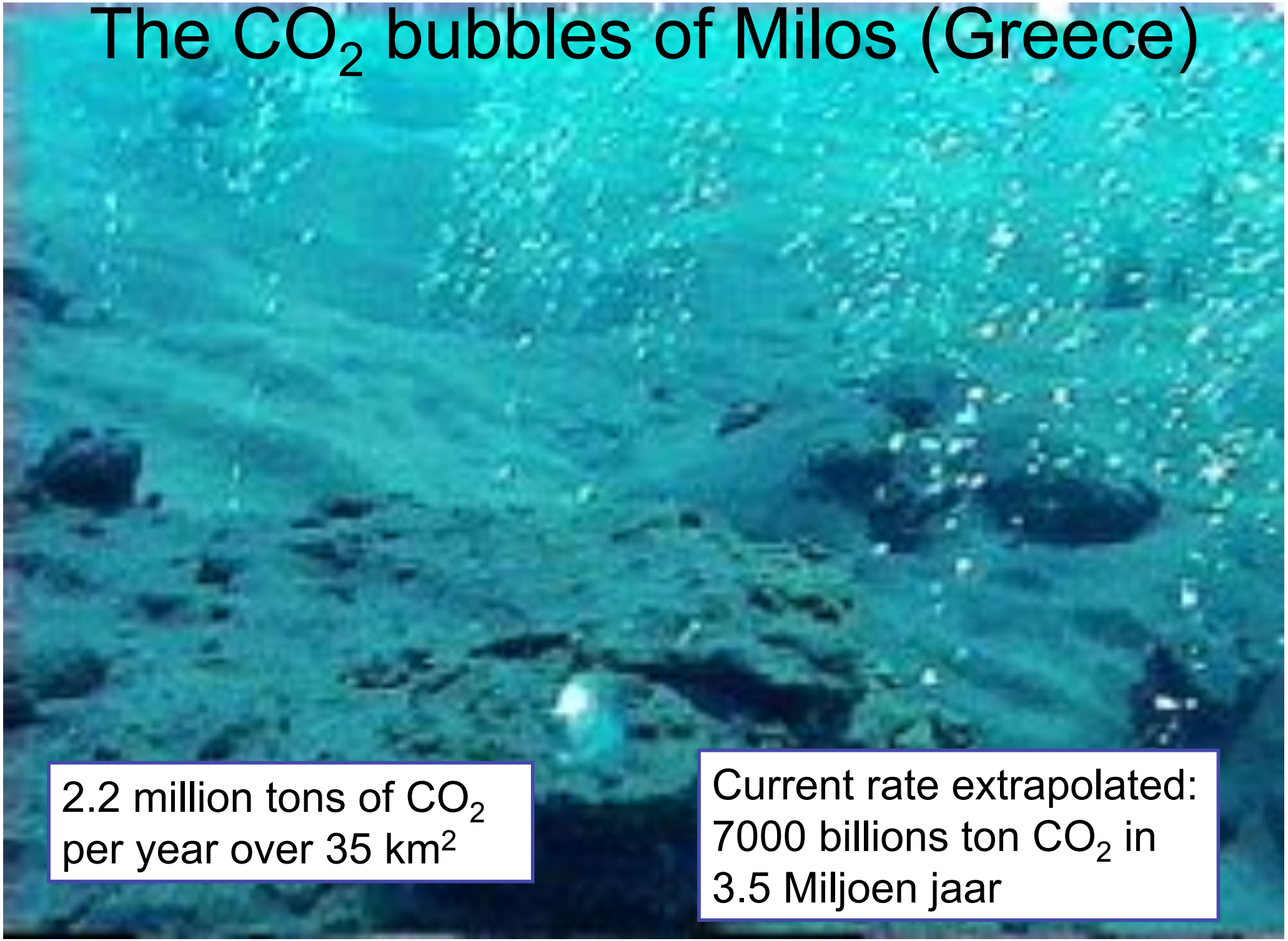
- Amount of carbon (x 10^{15} kg) Relative amount (%)

Limestone (CaCO3)	35.000	46.6 %
Dolomite	25.000	33.3 %
Sedimentary carbon	15.000	20 %
Recoverable fossil fuels	4	0.005 %
Oceanic CO2	42	0.056 %
Atmospheric CO2	3	0.004 %
Biomass	0.056	0.0007 %
Anthropogenic emission	30	Gt/year
Input from Earth's interior	0.5	Gt/year

What do these numbers mean?

- If you take all the CO2 that is sequestered on Earth in limestones, dolomites or inorganic carbon, and put that in the Earth's atmosphere, we would have an atmosphere of 100 bar CO2.
- (well, evidently, ***we*** wouldn't have that, because ***we*** would not be alive)

The CO_2 bubbles of Milos (Greece)



2.2 million tons of CO_2 per year over 35 km^2

Current rate extrapolated: 7000 billions ton CO_2 in 3.5 Miljoen jaar

But nowadays most of the CO2 comes this way

Where does this CO2 go?

- By the weathering of basic silicates the CO2 is first converted to bicarbonate solutions.
- These are transported by rivers to the oceans, where they are precipitated as solid carbonate sediments (limestones and dolomites)

This is how CO2 is stored

Or this way

The Olivine option
Follow Nature

- By burning in a few hundred years the fossil fuels that have taken several hundreds of million years to form we emit much more CO2 than the Earth emits normally.
- It is a logical choice to speed up the mechanism that has always taken care of the balance as well, to reach a new balance between input and output.

How are we going to do that?

A 3-step approach

1. Select materials that are abundantly available and weather fast
2. Mine them and mill them
3. Spread the powder over fields and beaches
4. (Then sit back and let nature do the hard work; don’t make it complicated and expensive by add-on technologies)

A major advantage

- This way we make use of the same weathering mechanism that has always kept the CO2 levels of the atmosphere within bounds.
- It is highly unlikely that a process that has worked well for 4.6 billion years would suddenly cause environmental problems.

The recipe is simple, but the size of the problem is enormous

- In order to compensate the anthropogenic emission of CO2 we will have to mine 7 km3 of olivine each year, a huge operation, but within the limits of present-day mining. The biggest mine on Earth has an excavated volume of 25 km3.
- Instead of mining one such hole every years, we must spread it over many olivine mines to save on transport costs

Such a hole, every 3 to 4 years

Many Governments harbor two misconceptions

- 1. We have to capture “our own” CO2
- 2. We have to capture the CO2 from industrial point sources
- Answer to both: **NONSENSE!**

S0, if you hear this, remember what Truman said

1. You can fool all people some of the time
2. You can fool some people all of the time BUT
3. You can’t fool all people all of the time!

Argument 1

- Why should we have to capture our “own” CO2? When it comes out of the chimneys of Dutch coal-fired power plants it depends on the wind direction if it is German or French CO2 the next day. For the climate it makes no difference where we capture the CO2, nor what its origin is.
- The atmosphere is a well-mixed reservoir, so for the climate it is irrelevant where we capture it

Argument 2

- We should only capture CO2 from point sources if that is the safest, most sustainable and **CHEAPEST** way.
- CCS is certainly not the safest, not the most sustainable and certainly not the cheapest way, so it is **harmful** for the climate. With the same amount of money we can capture 7 to 10 times more CO2!

The best advice to combat climate change

- Sequester as much CO2 as possible in safe, sustainable and cheap ways anywhere on Earth and independent of origin.

Emission reduction or emission compensation

- ZERO emission of CO_2 is not realistic
- The priority for China and India is to improve their economies, and by doing that raising the standard of living for their population
- This requires access to cheap and abundant energy
- They both have huge coal deposits

Draw your conclusions

They also have huge olivine deposits, and a large workforce

So the answer is:

- Emission reduction in the West **AND** emission compensation by olivine in the emerging economies, starting **NOW!**

This is our olivine technology!

And this is our reactor!

Climate Change and Ocean Acidification

Don’t take it lying down

Let’s fight it!