Dusting the Ocean with Olivine: An Effective Method for Climate Engineering?

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Olivine is a green mineral found in rocks containing magnesium, iron and silicate. Weathering of powdered olivine in acidic soils releases these cations which sequester carbon dioxide (CO_2) from the atmosphere. Recently, it has been proposed that dumping olivine in the ocean can counter „ocean acidification“ due to the released magnesium which can increase the alkalinity of seawater. In addition, the silicates released may also enhance primary production by diatoms.

Theoretical considerations:

According to calculations, dissolution of 1 mol olivine sequesters 4 mols CO_2.

$$Mg_2SiO_4 + 4CO_2 + 4H_2O \Rightarrow 2Mg^{2+} + 4HCO_3^- + H_4SiO_4$$

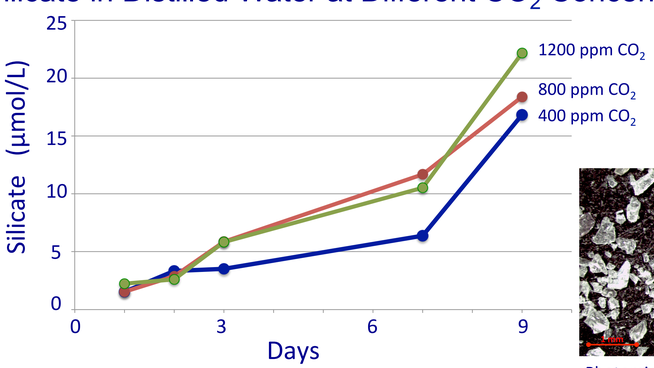
In the ocean the Mg^{2+} and H_4SiO_4 further precipitate to

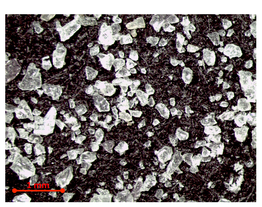
$$2Mg^{2+} + 4HCO_3^- + H_4SiO_4 \Rightarrow 2MgCO_3\downarrow + SiO_2\downarrow + 2CO_2\uparrow + 4H_20$$

Where $MgCO_3$ may increase Total Alkalinity and SiO_2 may be utilised as a nutrient by phytoplankton.

In preliminary experiments using distilled water with added olivine, the concentration of silicate increased with time and CO_2 concentration. The influence of CO_2, however, was not significant.

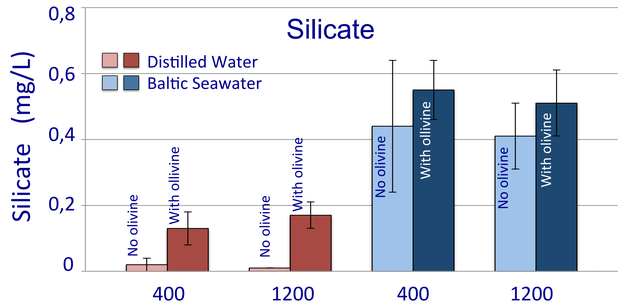
Silicate in Distilled Water at Different CO_2 Concentrations

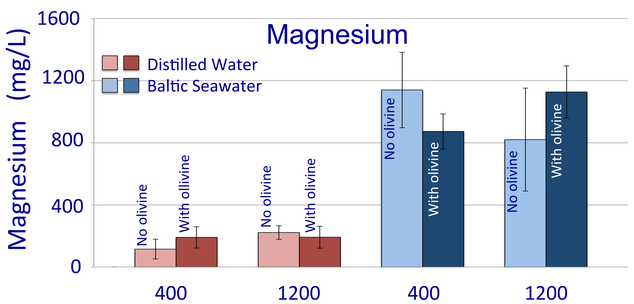


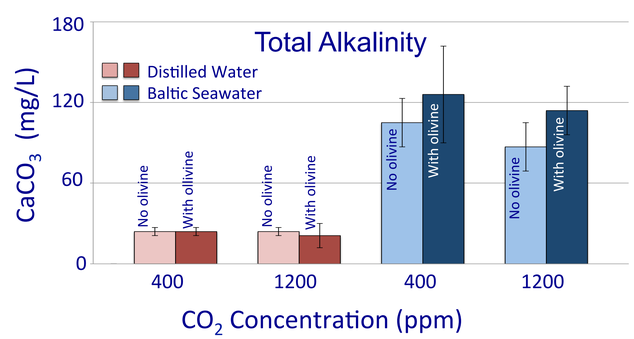


Photomicrograph of olivine used

One gram powdered olivine (grain size < 200 µm) was added to 1 Liter distilled water or Baltic seawater (salinity 15) and bubbled with 400 and 1200 ppm CO_2. Samples were taken after 10 days and analysed for silicate and magnesium concentrations and total alkalinity.

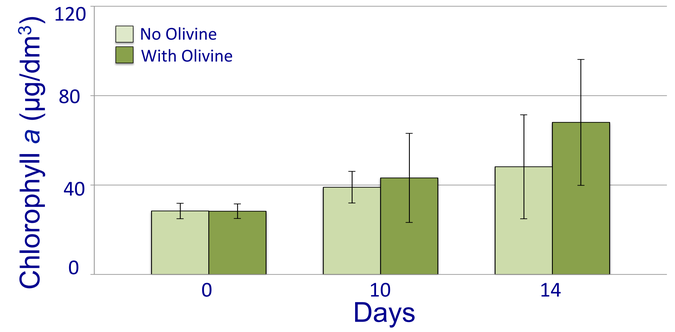






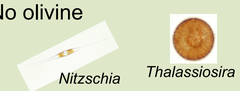
Phytoplankton collected from the field was cultured in the Baltic seawater used from the previous experiment to test if the silicate released from the dissolution of olivine can be utilised for primary production.

Growth of Phytoplankton in the Presence of Olivine

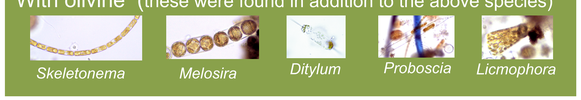


More species of diatoms were found in the microalgae cultures containing olivine.

No olivine



With olivine (these were found in addition to the above species)



- **Observed increases in silicate, magnesium and total alkalinity in Baltic seawater samples with added olivine were not significant.**
- **Siginificant increase in silicate was observed only in distilled water samples at both CO_2 concentrations.**
- **Olivine promoted diatom growth but this was also not significant.**
- **The grain size of the olivine used in this study (< 200 µm) must have been to big for faster dissolution under the experimental conditions. However, production of finer olivine powder is energetically costly, outbalancing its probable potential for climate engineering measures in the marine environment.**
- **Dusting the ocean with olivine is not very effective in increasing the capacity of the ocean to sequester carbon dioxide.**

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