Abstract:
The response of primary production and calcification of the coccolithophorid Emiliania huxleyi to different partial pressures of CO₂ (pCO₂) were investigated during a mesocosm bloom experiment in a Norwegian fjord. Glacial, present and next century atmospheric pCO₂ conditions (respectively 180, 370 and 700 ppmv) were simulated above the surface of large sea-water enclosures. If production of organic matter remains constant under elevated pCO₂, the production of inorganic carbon appears to be affected in two ways. First, the onset of calcification is delayed. Second, the production rate of inorganic carbon appears to be lowered by 40% in the next century conditions, decreasing subsequently the calcification/photosynthesis ratio from 1 to 0.8. During the experiment a strong viral growth was observed, which seriously depressed calcification. We propose the threshold value of 5.10⁻⁵ part.ml⁻¹ of virus specific to E. huxleyi abundance above which the calcification of the E. huxleyi population are severely affected.

Objectives:
In the context of atmospheric CO₂ increase, the biogeochemical significance of elevated pCO₂ on the future global carbon cycle with regards to calcifying organisms and community remains uncertain. In this context, previous studies of batch cultures in laboratory of coccolithophorid Emiliania huxleyi showed a marked depression of calcification under elevated pCO₂. The aim of our experiment was to extend these pioneer works closer to natural conditions by following the development of blooms of the coccolithophorid E. huxleyi in large seawater enclosures submitted to in situ conditions (light, temperature...) and placed under various atmospheric CO₂.

Method:
The experiment with trim mesocosms was carried out during 2001, at the Institute Biological Station of the University of Bergen, Norway. In the 9 mesocosms, the pCO₂ in the tests above surface water was achieved at 3 different levels with 3 replicates each: namely 180, 370 and 700 ppmv corresponding to glacial, present and future year 2100, assuming PCCY business as usual scenario and S80 atmospheric CO₂ level.

Results:

• Molar Respiration Ratio

Thanks to the mesocosm setup, it was possible to assess Net Community Production (NCP) in term of Carbon assimilation from the DIC and TAlk changes. When compared to the NCP calculated in term of Oxygen production from Oxygen incubations, it appeared that the two methods were consistent and it was possible to compute the Molar Respiration Ratio of the E. huxleyi community. We obtained a value around 1.43 (fig. 3). Hence, the amount of oxygen needed to respire the average planktonic composition (C/N/H₂O/N₂) was around 152 moles during the experiments in close agreement with the worldwide average value of 154 recently proposed by Hedges et al. [2002].

• Viral Lysis

The collapse of blooms of E. huxleyi have already been commonly observed in similar experiments, owing to viral lysis due to virus identified as ENV which belongs to the new genus Cocclithovirus. It has been suggested that there is a threshold for the host population of E. huxleyi above which virus production is induced. In return, virus production appears to drastically reduce calcification (Fig. 4). We propose a threshold of 5.10⁻⁵ part. ml⁻¹ for ENV abundance above which calcification of E. huxleyi is rapidly depressed. Thereafter, in comparing calcification and organic production with regards to the pCO₂ conditions, attention have been paid to consider only the time periods prior to viral lysis were considered.

• Organic and Inorganic Carbon Production

From the integration of the (NCP) and Net Community Calcification (Galli) over time, we computed the changes of standing stocks of Total Organic Carbon (TOC) and Particulate Inorganic Carbon (PIC) associated to the bloom of E. huxleyi. During the bloom of E. huxleyi, TOC increased steadily for all the mesocosm (i.e. for the three pCO₂ conditions) at a similar rate, ranging from 17.5 to 20.5 µmol C kg⁻¹ d⁻¹. In contrast, the mean rate of PIC increase was significantly lower in the next century/high pCO₂ conditions (Mean: 10.5 µmol kg⁻¹ d⁻¹) than in the present (Mean: 20.0 µmol kg⁻¹ d⁻¹) and in the past pCO₂ conditions (Mean: 18.5 µmol kg⁻¹ d⁻¹). Thereafter the calcification/photosynthesis ratio (C/P ratio) of E. huxleyi converges towards 0.98 and 0.90 in the glacial/flow and present pCO₂ conditions respectively, while in the next century/high pCO₂ conditions C/P converges towards 0.60. Thus, the increase of organic production of E. huxleyi under elevated pCO₂ was not detected during the experiments. However, the calcification rate of E. huxleyi appeared to be affected by the increase of pCO₂ of seawater, concomitantly preserving previous observations of in laboratory cultures.