Oceanic temperature and pCO_2 reconstruction during the Pliocene in the Caribbean Sea (ODP site 999) using the coccolith geochemistry

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The Pliocene (5.33-2.58 Ma) is one of the key periods cited by the IPCC as a geological analogue of the Anthropogenic climate change. The global climate during this period is indeed comparable with modeling predictions for the near future: Sea Surface Temperatures (SSTs) were 3°C warmer than today and atmospheric pCO_2 was 1 to 1.5 times higher than preindustrial values.

These two major climate parameters (SST and pCO_2) are usually assessed using proxies involving measurements made on both organic matter produced by coccolithophores (alkenones) and calcite of foraminiferal tests. Our approach is to use a unique archive – the coccoliths – for the determination of both SST and pCO_2. Coccoliths are a very promising substrate to analyse for paleoclimate studies because they calcify in the uppermost water column and because their isotopic ratios are sensitive to both photosynthesis and calcification (Hermoso et al., 2016). Therefore, these isotopic ratios give us physiological and metabolic information about coccolithophores of the past.

After microseparation of coccoliths into various size fractions (Minoletti et al., 2009), we use oxygen isotopic ratios for SST calculations. We also derive pCO_2 from the $\delta^{13}C$ difference between small and large coccoliths fractions following a recently calibrated CO_2 proxy (Godbillot et al. 2022).

The results obtained on samples spanning the whole Pliocene interval (ODP 999A, Kogi Rise in the Caribbean Sea, 13°N and DSDP 516, Rio Grande Rise in South Atlantic, 30°S) show an increase of SSTs between 5 and 4 Ma in the Caribbean Sea from 26 to 31°C, in contrast with results from the Southeast Atlantic where surface waters freshened during the period. From 4 to 2.5 Ma, both temperature trends are reversed with a notable decrease in SSTs in the Caribbean Sea from 31 to 27°C. This is consistent with published results (Karas et al., 2017). Our pCO_2 values are in agreement with published datasets (Rae et al., 2021) and show small variations throughout the Pliocene (between 310 and 375 ppmv in the whole interval). These results confirm that the biogeochemistry of coccolithes has a great potential for paleoclimate reconstruction in the deep time.

References:

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