# Lipids of the diatom genus *Proboscia* as tools for climate reconstruction

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**The presence and abundance of specific algae is strongly related to environmental conditions and, as a result, changes in environmental conditions cause changes in algal communities. As a consequence, remnants of algae can be useful tools for reconstruction of climate conditions in the past. Our work has shown that specific algae, belonging to the diatom genus *Proboscia*, produce series of specific lipids called long-chain 1,14-diols and 12-hydroxy methyl alkanoates. Because of their common presence in high-nutrient areas, it is suggested that these *Proboscia* lipids may be used as markers for high productivity. Analysis of a sediment core from the Arabian Sea off Somalia has shown that, in this area, a ratio of long-chain diols can be used to reconstruct upwelling intensity in the past. Furthermore, culture experiments and sediment studies have shown that the chain-length of the long-chain 1,14-diols may be related to growth temperature, suggesting that these lipids can also be used for temperature reconstruction.**

Diatoms are one of the most abundant divisions of phytoplankton, responsible for ca. one-fifth of the world's primary productivity. As a consequence, these algae are one of the most important sources of organic matter in marine environments, especially in areas with high nutrient availability like upwelling areas. The presence of remnants of diatoms may therefore be interpreted as an indication of high primary productivity.

Picture of *Proboscia* sp. CCAP 1064/2 (Scale bar : 50µm).

Several climate reconstruction studies are based on the silicified valves of diatoms; however, these cell-walls are prone to dissolution. Well preserved specific lipids, like long-chain 1,14-diols (Fig. 1) and 12-hydroxy methyl alkanoates, which we recently discovered in *Proboscia* diatoms, have shown to be a useful alternative.

## Upwelling reconstruction in the Arabian Sea.

Analyses of sediment traps from various locations in the Arabian Sea (Fig. 2) show that, in this area, the specific *Proboscia* lipids are only formed at times of upwelling during the Southwest monsoon, and predominantly in areas with strong upwelling intensity. Also present were long-chain 1,15-diols, probably produced by other algae, which have molecular structures very similar to the long-chain 1,14-diols produced by *Proboscia* diatoms. Abundances of long-chain 1,15-diols in upwelling and non-upwelling areas are nearly similar and their time of production is not limited to the Southwest monsoon. Based on the sediment trap results we developed an index of long-chain 1,14- and 1,15-diols that can be used as an indicator for upwelling intensity in the Arabian Sea. Analyses of this ratio in a piston core from the Somali Basin (Fig. 2) covering the last 90 kyr showed remarkable changes in the long-chain diol distribution with time, i.e. *Proboscia* diols were relatively high during the Holocene and low during the last Glacial, although elevated values were found between 60 and ~45 ka and at approximately 80 ka (Fig. 3). Our diol index record shows a strong inverse relation to global ice volume records; however, there are some remarkable differences with other productivity records from the same piston core. This suggests that productivity in the Arabian Sea is not only related to upwelling; in

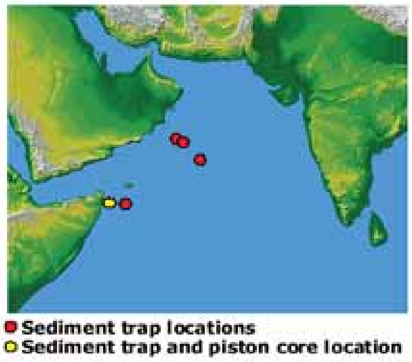


Fig. 2. Map of the Arabian Sea showing sediment trap and piston core locations.

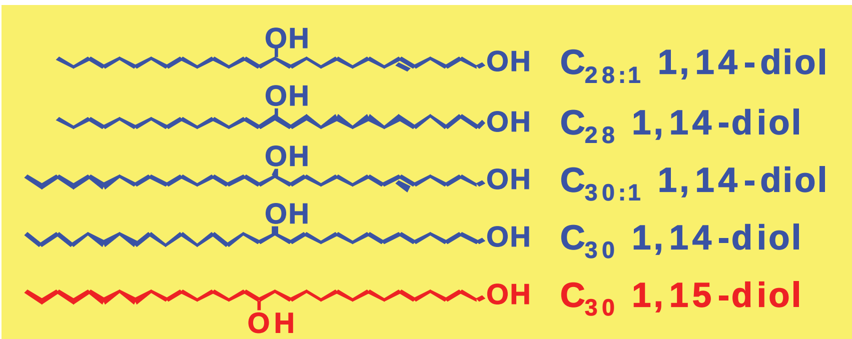


Fig. 1. Structure of *Proboscia* diols and $C_{30}$ 1,15-diols.

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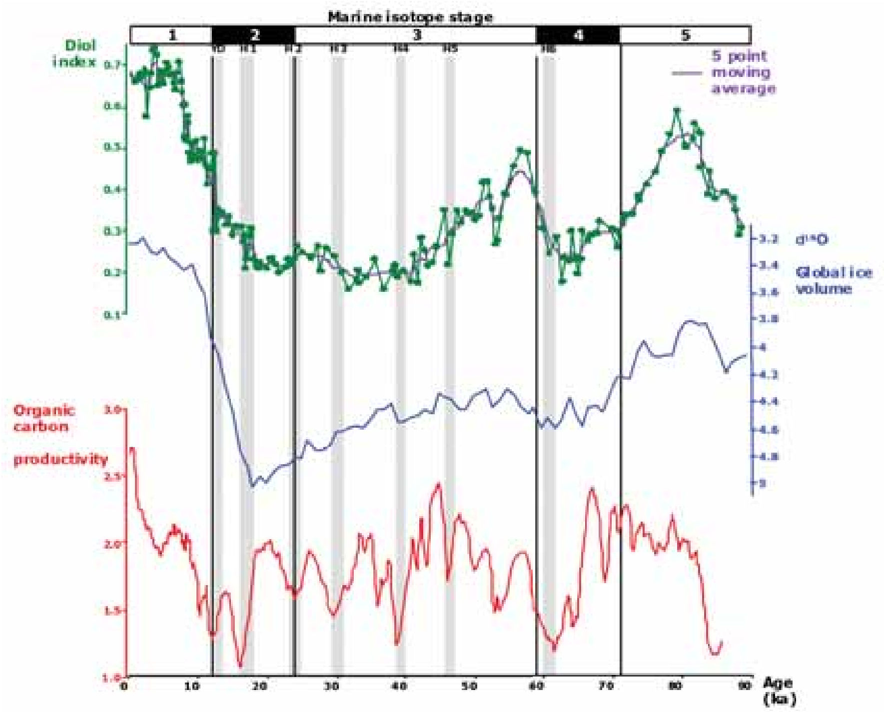


Fig. 3. The diol index record from the Somali Basin, combined benthic foraminiferal $^{18}O$ records as a proxy for global ice volume (Lisiecki and Raymo 2005, Paleoceanography 20) and an organic carbon record from the same Somali Basin core as a proxy for productivity (Ivanochko et al. 2005, Earth Planet. Sci. Lett. 235: 302-314).

periods of low upwelling intensity, enhanced productivity may be related to enhanced deep water mixing caused by strong Northeast monsoon winds.

## Long-chain diols as temperature indicators?

To determine the effect of temperature on the lipid content of *Proboscia* algae we analyzed and compared the lipid composition of four different species, grown at different temperatures (between 2° and 27°C). The results show increasing chain lengths and a decreasing degree of unsaturation for long-chain 1,14-diols with increasing temperature. The relationship between chain-length and growth temperature was confirmed by analyses of surface sediment samples from the eastern South Atlantic, suggesting that the chain length of long-chain 1,14-diols is determined by temperature (Fig. 4) and that suggests that an index based on chain-length of long-chain 1,14-diols may provide information on sea surface temperatures in the past.

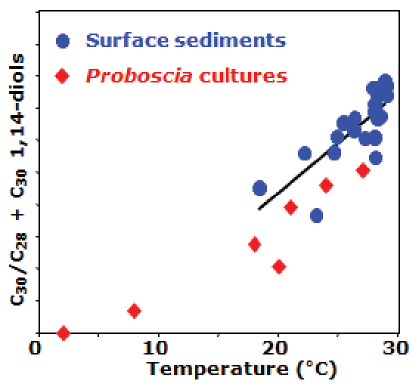


Fig. 4. Ratio of $C_{30}$ 1,14-diols / $C_{28}$ + $C_{30}$ 1,14-diols, measured in *Proboscia* cultures and surface sediments, plotted against temperature (Locarnini, R.A. et al., 2006. World Ocean Atlas 2005, Volume 1: Temperature. US Government Printing Office, Washington).