# Improvements and applications of the $TEX_{86}$ paleothermometer.

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**The determination of past sea surface temperatures (SSTs) in oceans and coastal seas is of great importance for the reconstruction of historical changes in climate and oceans currents. For this purpose, organic compounds from micro-organisms in the sediment are often used. A new paleo-thermometer to reconstruct ancient SSTs was recently developed at MBT. This $TEX_{86}$ index is based on temperature-induced changes in the molecular structure of the lipids from the cell wall of Crenarchaeota. In this project we made further analytical improvements and applied the method to several settings from recent geological time periods. Furthermore it was discovered that tetraether-lipids reach the seafloor in faecal pellets of zooplankton and that growth season and ocean currents appear to influence the $TEX_{86}$.**

Real thermometers have been available only since the 17th century and for periods before this, researchers depend on climatic archives. Sediment cores from open oceans and coastal areas provide such archives as they contain a variety of geochemical signatures from the past. The $TEX_{86}$ has recently been developed at the MBT department and is based on temperature-dependent changes in the lipid composition of the cell walls of Crenarchaeota, a branch of the Archaea. Together with the bacteria and the eukaryotes, Archaea form the three domains of the tree of life. Their cell membranes are composed of tetraether lipids (Fig. 1) of which the number of carbon rings in the molecule increases with increasing temperature of the surrounding seawater. Determination of the (past) composition of these cell membrane lipids can therefore be used to reconstruct the temperatures at which these Archaea were living. We have studied several aspects of this paleothermometer in greater detail and made significant improvements to their determination.

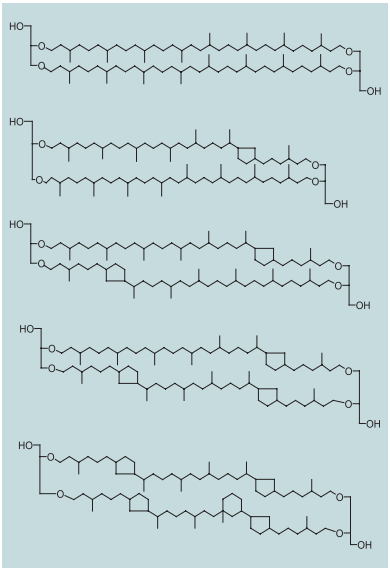

Fig.1. Structures of tetraether membrane lipids of Crenarchaeota.

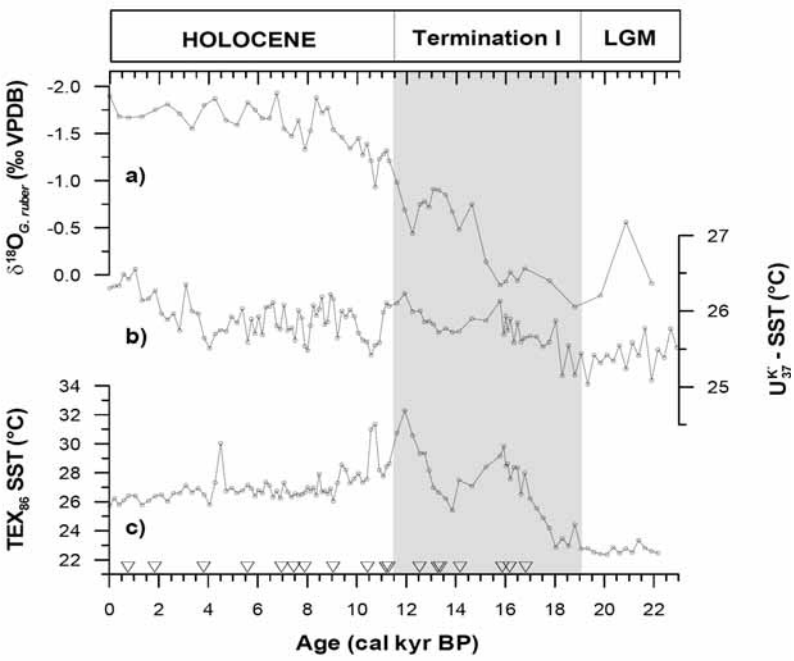


Fig. 2. Temperature evolution in the Arabian Sea by a) $\delta^{18}O$ of foraminifera, b) $U^{k}_{37'}$ of alkenones and c) $TEX_{86}$.

## $TEX_{86}$ improvements and applications.

We first improved the analytical method of the $TEX_{86}$ paleothermometer. This led to an improvement of the analytical reproducibility of ±0.3 °C and the deviation in absolute concentration measurements was reduced to 5% of the measured average. The $TEX_{86}$ values for organic material out of the water column and from the uppermost layer of the seafloor sediment best match the temperatures of the uppermost 100 m of seawater. However, the small cells of Crenarchaeota cannot sink to the seafloor by themselves as organic matter is less dense than water. We found that the cells of Crenarchaeota are eaten by crus-

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taceous zooplankton. The time spent in the gastrointestinal tract of the crustaceans was found not to affect the $TEX_{86}$ value. Analysis of a sediment core from an anoxic branch of the Oslofjord, showed that the measured $TEX_{86}$ record paralleled the average spring-autumn air temperature record in Oslo. Temperature estimations of the transition from the last ice age to the present interglacial period were made using two cores drilled from the Arabian Sea. The $TEX_{86}$ temperatures were compared with values from another paleothermometer, the $U^{K}_{37}{}'$ (Fig. 2). Both proxies reflected different temperatures with different trends. This could be explained by differences in the growing season of the Archaea and the algae which produce the components upon which the $U^{K}_{37}{}'$ index is based.

The results show that the $TEX_{86}$ paleothermometer can now be measured with reproducibilities similar to that of other paleothermometers and yield reasonable temperature estimates from a variety of settings and time periods.