Geophysical Research Abstracts
Vol. 15, EGU2013-9645, 2013
EGU General Assembly 2013

Application of the TEX86-L temperature proxy in the Southern Ocean

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The TEX86 (TetraEther indeX of tetraethers consisting of 86 carbon atoms, Schouten et al., 2002) paleothermometer was proposed based on the relative distribution of thaumarchaeotal lipids, i.e. isoprenoid glycerol dibiphytanyl glycerol tetraethers (GDGTs), and has been increasingly used to reconstruct past sea surface temperatures (SSTs). However, it appears that the TEX86 proxy might not be directly applicable for the polar oceans (Kim et al., 2008) and the use of a modified version of TEX86 with a logarithmic function which does not include the crenarchaeol regio-isomer (i.e. TEX86-L) seems to be a better option to reconstruct paleotemperatures in the Polar Oceans (Kim et al., 2010). More recently, a new calibration of TEX86-L with depth-integrated annual mean temperatures from 0 to 200 m water depth was also introduced with the calibration error of $\pm$2.8ºC (Kim et al., 2012), since Thaumarchaeota are in low abundance in the Antarctic summer surface water (the $\sim$0–45 m layer of low salinity water mass) but more abundant in winter in a $\sim$45–105 m interval of cold, salty water (i.e. the summer remnant of the previous winter, surface-mixed layer) (Kalanetra et al., 2009).

We applied the TEX86-L proxy and its 0-200 m calibration model on piston core MD03-2601 (66°03.07S; 138°33.43E; 746 m water depth) recovered from the eastern Antarctic continental margin and jumbo piston core 10 (JPC-10, 64°53'S, 64°12'W, 905 m water depth) obtained from the western Antarctic Peninsula. We also analyzed 19 sediment samples of ODP 1098 (64°51'S, 64°12'W, 1010 m water depth) drilled at the JPC-10 site for comparison with the record of Shevenell et al. (2011). The application of the TEX86-L on most recent sediments at core sites MD03-2601 and JPC-10 resulted in +4.0°C and +1.2°C temperature estimates, respectively, within the range reasonable of the present annual mean 0-200 m temperature at core sites considering the calibration error. TEX86-L-derived temperatures varied between +0°C and +4°C for the Holocene. The most striking features of the TEX86-L record were 1) a prominent increase in temperature centred at 6 kyr BP and 2) substantial temperature variability during the Late Holocene. The TEX86-L record from JPC-10 showed its maximum (>+3°C) at $\sim$9,000 years BP. Following this peak, temperatures decreased to $\sim$+1.5°C, until $\sim$7,000 years BP. From $\sim$7,000 to 4,200 years BP, temperatures slightly declined from +1.6 to +0.7°C, before reaching lowest values at $\sim$3,000 years BP. The late Holocene was characterized by variable temperatures with a mean of +0.3°C. At around $\sim$1,000 years BP, the temperature record exhibited a peak, with values approaching +2.5°C. Our new TEX86-L records from JPC-10 and ODP 1098 showed a consistent picture of temperature variation in Palmer Deep Basin. However, our results gave different temperature estimates in terms of amplitude and variations in comparison to the TEX86-SST values published by Shevenell et al. (2011). Our study also showed that TEX86-L derived temperatures at our core sites reflect a subsurface rather than a surface signal. Nevertheless, care has to be taken in interpreting the absolute values of TEX86-L derived reconstructions and relative changes in TEX86-L derived temperature can be viewed with more confidence.

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