

## PLANKTONIC AND BENTHIC EUKARYOTIC COMMUNITY RESPONSES TO GLACIAL-INTERGLACIAL CLIMATE VARIABILITY IN THE ARABIAN SEA.

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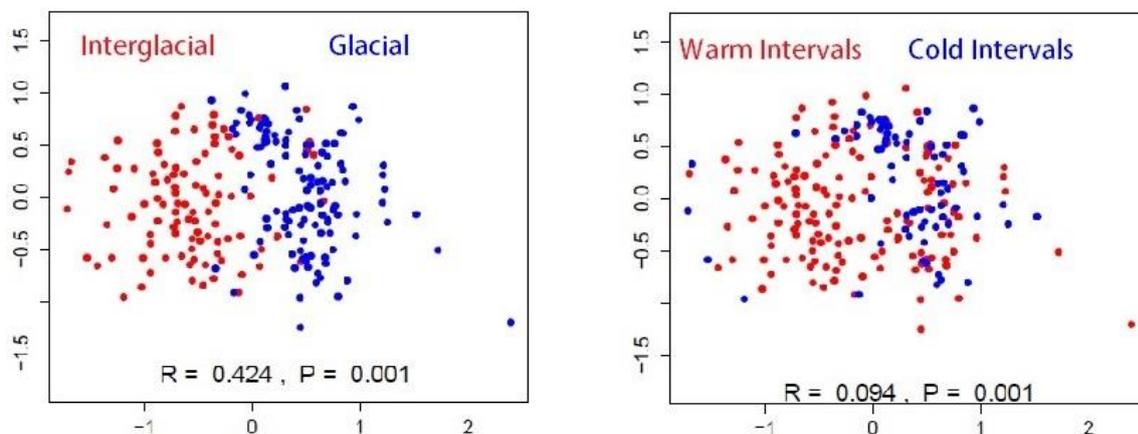
In aquatic systems, when respiratory oxygen demand during degradation of organic matter exceeds oxygen supply, results into the formation of Oxygen minimum zones (OMZ). An OMZ expands with the rise in the sea surface temperature and it is predicted to continue due to global warming (Keeling et al., 2010, Helm et al., 2011). The most extensive OMZ is observed in the northern Arabian Sea where Monsoon-influenced surface-water productivity remains the most influential factor (Reichart et al., 1998). In the Monsoon-impacted NE Arabian Sea, organic matter-rich and bioturbated sediments record fluctuations in OMZ intensity that match with North Atlantic climate oscillations over the last glacial-interglacial cycle (Schulz et al., 1998).

Information on how these climatic shifts affect marine planktonic and benthic communities in the OMZ-impacted Arabian Sea is mainly based on recent observations and modelling experiments (Schulte et al., 1999, Blackford and Burkill, 2002, Von Rad et al., 2006), and knowledge about how paleoenvironmental climate variability affected the past planktonic communities is restricted to a few fossilised species, notably foraminifera (Ganssen et al., 2011). As the majority of planktonic taxa lack diagnostic features preserved upon fossilisation, we here apply palaeontological-independent methods (i.e., lipid biomarkers combined with ancient DNA stratigraphy; e.g. Coolen et al., 2013) to reconstruct ecosystem-climate interactions. For this analysis a 13 m-long sediment core from the classical OMZ coring location off the Indus Canyon spanning key climate intervals of the last 52,000 years was collected. Here we present 18S rRNA gene sequence data paired with a sterol and alkenone record showing significant climate-induced changes in eukaryotic planktonic communities.

Non Metric Multidimensional Scaling (NMDS) (Fig. 1) and Analysis of Similarity (ANOSIM) revealed significant differences in the overall community structure during the glacial vs. interglacial, before and after last glacial maximum (LGM) and also during short-term warm interstadial with strong OMZ conditions vs. cold stadial climate stages with weak OMZ conditions over the last 52 Ka. In agreement with the fossil DNA data, a major population shift before and after the LGM was also observed in the lipid biomarker composition with an increase in plant and/or algal-derived sterols and a decline in haptophyte-derived alkenones after the LGM. Interestingly, DNA sequences of alkenone-producing haptophyte algae comprised only a small fraction of the DNA pool. However, the fossil DNA approach revealed an overall higher diversity than the use of lipid biomarkers alone. For example, dinoflagellates could be identified at the family to genus level to distinguish between phototrophic and heterotrophic taxa. Along with uncultured marine avelolata group I and prasinophytes, dinoflagellates were among the most significant indicator taxa for the interglacial as well as warm climate intervals (e.g. Dansgaard/Oeschger events). Chlorophytes (i.e. *Chlorella*) were among the most significant indicator taxa for the glacial and cold climate stages such as Heinrich events and the Younger Dryas.

Our results show that ancient DNA stratigraphy can provide a detailed overview of past plankton community changes in response to climate variability at centennial to millennial

scale resolution, covering at least the last glacial interglacial cycle. A paired lipid biomarker analysis was required to validate the fossil DNA results and for a more reliable overview of absolute quantitative changes in major plankton groups such as dinoflagellates vs. haptophytes.



**Figure 1** NMDS analysis of the total eukaryotic 18S rRNA gene profiles in 214 Indus core intervals spanning 52 kyrs of deposition. The groupings were significant (ANOSIM;  $P < 0.05$ ), albeit that plankton communities differed more before and after the LGM ( $R = 0.424$ ) than between short-term shifts in cold vs. warm periods ( $R = 0.094$ ).

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