Molecular fossils inferring Quaternary sea-level changes

INTRODUCTION

Sea-level changes have occurred many times, especially during the Quaternary (last 2.6 Ma), due to glacio/isostatic/glacial and/or crustal rebound. Determining the modes of sea-level changes is traditionally carried out by macro- and micro-fossil, lithological and geophysical analyses.

Sea-level changes are driven by both external (e.g., ice-volume changes due to the cyclic growth and decay of continental ice sheets) and internal (e.g., eustatic sea-level changes since the end of the last glacial) factors. Major transgressions and regressions occurred throughout the Quaternary, with transgression rates varying from thousands to millions of years. The most recent of these was the Last Glacial Maximum (LGM), which occurred around 21,000 years ago.

The study of marine microfossils, particularly the alkenones produced by phytoplankton, has proven to be a valuable tool for understanding past sea-level changes. Alkenones are a type of long-chain alkane that is produced by certain marine phytoplankton species. The ratio of the different carbon structures of these alkenones can be used to infer past sea-surface temperatures and sea-level changes.

Long chain alkenones represent marine very long chain alkenones (VLCAs) produced by certain phytoplankton species. The degree of similarity in molecular structure between these long chain alkenones and terrestrial plant waxes is used to infer the palaeo-environmental conditions.

Experimental: Molecular fossils are extracted from the sediment matrix by solvent extraction. Chromatographic separation, detection and quantification are carried out.

The transgression around 5939-5612 cal BP is a well-documented event in the Nar Valley, Norfolk, UK. This transgression is characterized by a brackish lake with increased salinity and deposition of terrestrial and freshwater molluscs and foraminifera.

RESULTS AND DISCUSSION

The results of the molecular fossil analysis show a clear shift in the palaeo-environmental conditions. The presence of marine microfossils indicates a sea-level rise, while the presence of terrestrial microfossils indicates a sea-level fall. The analysis of the alkenone distribution further supports these conclusions, with a higher proportion of marine alkenones indicating a more marine environment and a higher proportion of terrestrial alkenones indicating a more terrestrial environment.

Conclusions: The molecular fossil evidence complements the microfossil analyses of Barlow et al. (2017) and highlights palaeo-environmental features that were not previously evident. The high degree of similarity in the molecular fossil distribution between the four Nar Valley cores indicates that the sequences relate to similar palaeo-environmental conditions, though without conclusive dating, correlation of the cores to the same MIS remains uncertain.