Novel highly branched isoprenoid biomarkers as indicators of sea-ice diatoms: implications for historical sea-ice records and future predictions

Guillaume Massé 1, Simon Belt 1, Steve Rowland 1, Michel Poulin 2, Bernard LeBlanc 3 and Christine Michel 3

1. Petroleum and Environmental Geochemistry Group, University of Plymouth, Drake Circus, Plymouth PL4 8AA, U.K.
2. Research Division, Canadian Museum of Nature, PO Box 3443, Station D, Ottawa, Ontario K1P 6P4, Canada
3. Freshwater Institute, Fisheries and Oceans Canada, Winnipeg, Manitoba, R3T 2N6, Canada

Introduction

Polar oceans are important contributors to the Earth’s climate systems. In particular, sea-ice cover influences the exchanges of heat and moisture between polar oceans and the atmosphere, since it reflects much of incoming solar radiation. It is, therefore, essential to improve our knowledge of historical sea-ice fluctuations and the associated climate changes in order to better refine models of climate change. Although satellite imaging methods are now used routinely for sea-ice coverage determinations, we need to rely on so-called ‘proxy’ measures to interrogate the geological record. A good proxy should be Selective, Sensitive and Stable. We propose the use of Highly Branched Isoprenoid (HBI) alkenes as a novel proxy for Arctic sea-ice.

Selectivity

• Highly Branched Isoprenoids (HBIs) are common to Haslea spp. but found in very few other diatoms
• HBIs occur with 1-5 double bonds (see below)

HBI monoene

• A new HBI monoene (one double bond) is found in Arctic sea-ice and sediments

This monoene is absent from all other diatoms and sediments

• This biomarker is specific to Haslea vitrea, H. crucigeroides and H. Kjelmanii found in Arctic sea-ice

Sensitivity

• The HBI monoene biomarker is abundant in sea-ice

HBI monoene

• The HBI monoene biomarker is abundant in Arctic sediments: Concentration of the biomarker ranges from 0.1 to 3 µg g⁻¹

Stability

• HBI biomarker found in sea-ice samples from across the Arctic
• HBI biomarker found in all of the sea-ice covered Arctic sediments
• HBI biomarker found in surface and down-core sediments up to 6.5m (see below)

Conclusions and Future work

A novel biomarker has been identified which is a Selective, Sensitive and Stable proxy measure of Arctic sea-ice. This chemical marker, which is biosynthesised by a restricted number of sea-ice associated diatoms, has also been synthesised and structurally characterised in our laboratory. Despite the widespread occurrence of related highly branched isoprenoid biomarkers in other global environments, the new monoene described here is only present in Arctic sea-ice and sediments. The chemical structure of this novel biomarker makes it relatively resistant to degradation ensuring its use over extended geological timescales. In the future, we will quantify the new biomarker in Canadian Arctic sediments in order to determine the extent of seasonal ice cover (or otherwise) during the Holocene and Last Glacial Maximum events for both East-West and North-South transects. This new biomarker will be validated against other proxy measures of Arctic sea-ice.

Acknowledgements

We are grateful to the University of Plymouth, the NERC (UK), the Seal-Haye Educational Trust, the Canadian Museum of Nature and Fisheries and Oceans Canada, for financial support and to ArcticNet, the Churchill Northern Studies Center, the Polar Continental Shelf Project and the crew of the CCGS Amundsen for logistical support. We would also like to thank André Rochon, Tricia Schell, Éric Potvin and Robbie Bennett for their help with the coring during the 2005 ArcticNet cruise.