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

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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.

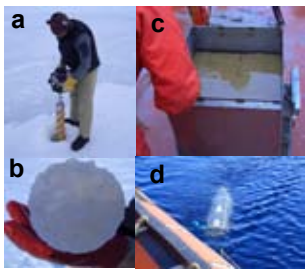
Methods

- The hydrocarbon content of Arctic sea-ice, sediments and phytoplankton were analysed using GC-MS

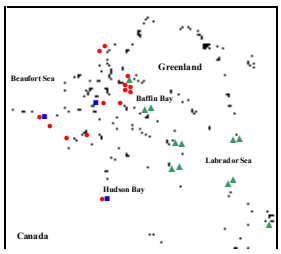
✓ Sea-ice was collected from Resolute Bay, Franklin Bay and Churchill in 2003, 2004 and 2005 respectively

✓ Sediments were collected during the ArcticNet 2005 cruise and obtained from various repositories.

✓ Phytoplankton samples were also collected during the ArcticNet 2005 cruise



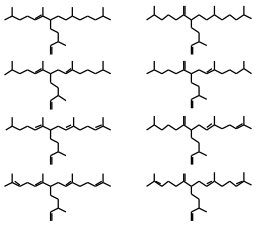
(a) Sea-ice coring (b) diatoms in Sea-ice (c) box core sediment (d) phytoplankton trawl



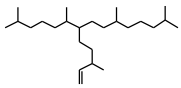
Sampling locations

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)



- 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

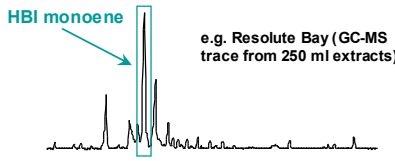
H. crucigeroides

H. vitrea

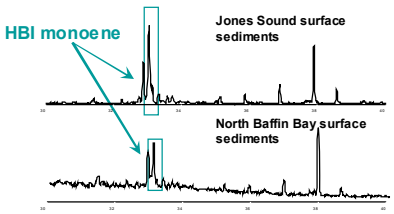
H. kjelmanii

Sensitivity

- The HBI monoene biomarker is abundant in sea-ice



- The HBI monoene biomarker is abundant in Arctic sediments: Concentration of the biomarker ranges from 0.1 to 3 µg g^{-1}

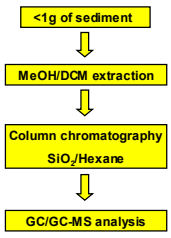


- Rapid and robust analysis

✓ Usually the most abundant hydrocarbon in the sediment

✓ Less than 1 gram of sediment needed for the analysis (high resolution achievable)

✓ Straightforward analytical procedure (typically more than 20 samples a day)

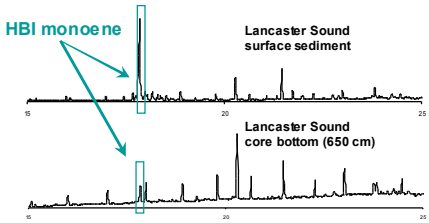


Stability

•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)



- HBI biomarker found in sediments up to (at least) 10,000 years old
- HBI monoene biomarkers are relatively resistant to biodegradation and diagenesis

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.

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