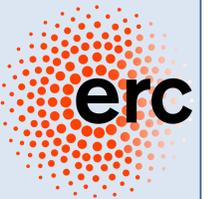




Highly Branched Isoprenoids as proxies for variable sea ice conditions in the Southern Ocean



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Introduction

Reconstruction of the historical and palaeo-environmental occurrence of sea ice is key to understanding climate change. Numerous sediment proxies of historical and palaeo-sea ice occurrence have been proposed. Amongst these is a hydrocarbon designated IP₂₅ (I, Figure 1) synthesised by sympagic sea-ice diatoms. IP₂₅ has a widespread occurrence in Arctic sea ice but it has never been reported in the Antarctic. However, a number of related chemicals (HBIs) have been reported in Antarctic sea ice diatom samples and sediments.

In the present study, we report the presence of a di-unsaturated HBI (II) in Antarctic sea ice and other poly-unsaturated HBIs (e.g. III-VI) in Antarctic phytoplankton. Using differences in structures and isotopic compositions, we assign the origins of HBI isomers present in recent sediments collected from the Adélie Land area in the Eastern Antarctic Continental Shelf area.

Study sites

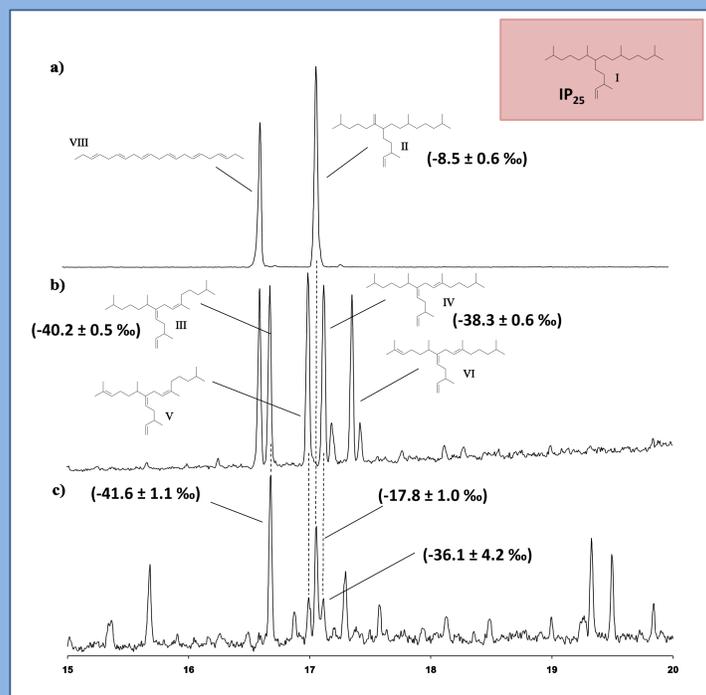
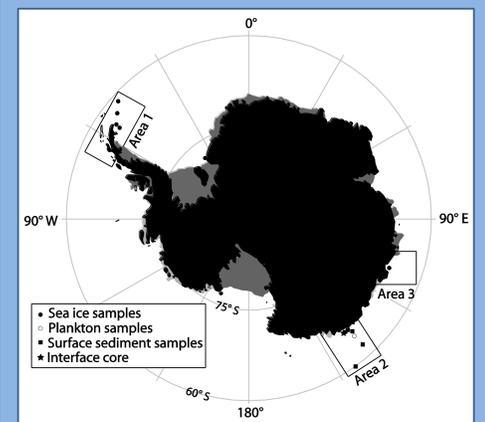


Figure 1: Gas chromatography-mass spectrometry total ion current chromatograms and isotopic data for HBIs in hydrocarbon extracts of samples from the Antarctic. a. Sea ice b. Mixed phytoplankton. c. sediment. I, IP₂₅; II, di-unsaturated HBI; III-IV, tri-unsaturated HBIs; V-VI, Tetra-unsaturated HBIs; VII, penta-unsaturated HBI; VIII, n-C_{21:6} (hencicosahexaene).

- A di-unsaturated HBI (II) is present in Antarctic sea ice samples (n>30).

- A suite of poly-unsaturated HBIs (tri- to penta-unsaturated isomers) is observed in Antarctic phytoplankton samples. (II) is absent from all the samples investigated.

- Antarctic sediments were found to contain (II) co-occurring with the HBIs III-VI which were observed in the phytoplankton samples.

- Consistent with a sea ice origin, II is highly enriched in ¹³C. HBIs III – IV are depleted in ¹³C, consistent with a phytoplanktonic origin. These isotopic signatures are preserved in the sediments.

Analysis of interface sediments collected at the ultra-high resolution site IODP U1357 reveals varying concentrations of HBIs in phase with environmental conditions:

- Triene (III) concentrations are at their maximum during the early summer when the phytoplankton bloom is occurring.
- Diene (II) abundances are at a maximum in early spring sediments when sea ice melts and the sympagic flora reaches the seabed.
- The ratio of the concentrations of Diene (II) vs Triene (III) also reflects the relative contributions of sea ice organic matter and phytoplankton-derived organic matter to Antarctic sediments. The highest (II)/(III) values are observed in spring when sea ice contribution is at a maximum. During the summer, (II)/(III) ratio is minimal, reflecting the large contribution of the phytoplankton bloom to the sediments.

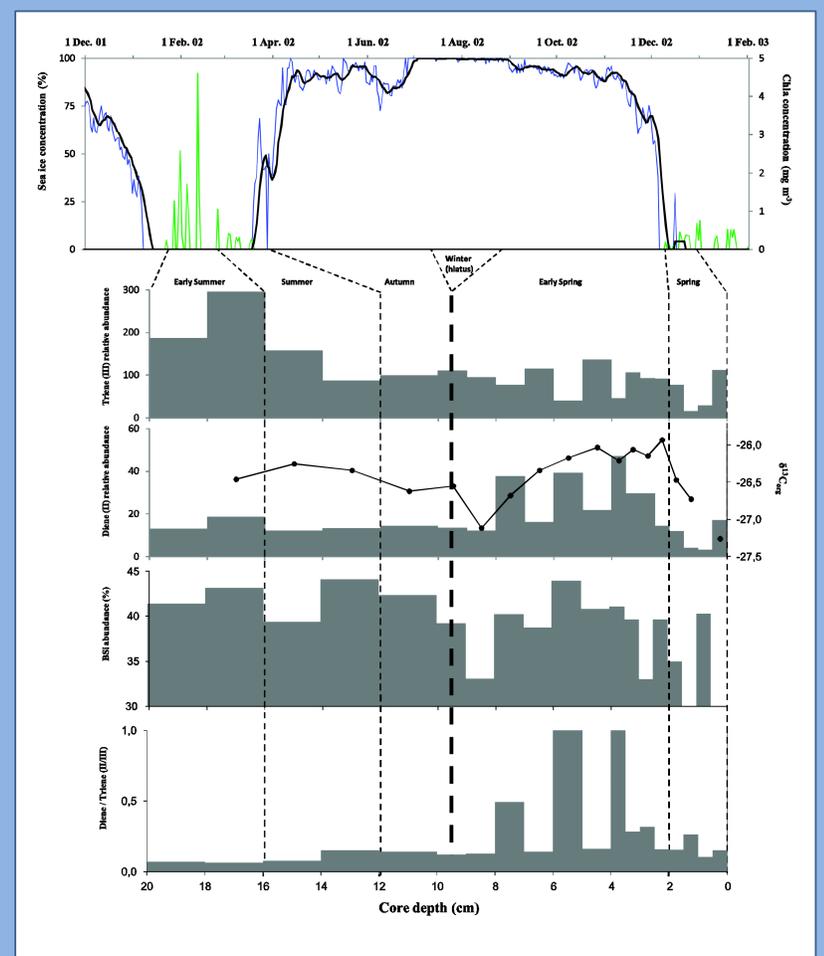


Figure 2: 2001-2003 Satellite-derived sea ice (SSM/I, 25km resolution) and Chlorophyll_a (SEAWIFS, 9km) concentrations at CADO 2 coring site. HBI, δ¹³C and relative concentrations of Diene (II) versus Triene (III) along core MD130-MC02.

Conclusions

We have extended previous reports of HBI alkenes in sediment samples from the Antarctic and report an HBI diene (II) in sea ice and other HBIs in phytoplankton. We determined the δ¹³C composition of individual HBIs in both sea ice and sediments and used the differences in the structures and isotopic compositions to assign HBI isomers present in sediments from the Eastern Antarctic Continental Shelf to specific origins. The presence of isotopically ¹³C-enriched HBI diene (II) might be a useful proxy for contributions of organic matter derived from sea ice diatoms to recent Antarctic sediments. A ratio of the concentrations of II/III reflects the relative contributions of sea ice organic matter and phytoplankton-derived organic matter to Antarctic sediments (possibly depending also on diagenetic effects). This study demonstrates that, when used in conjunction with other well established sea ice proxies (e.g. diatoms), HBI-based reconstructions have the potential to enhance our knowledge of past sea-ice dynamics around Antarctica.

Acknowledgments

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For more information please consult:

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