Compound-specific hydrogen isotope ratios: a new paleoclimate proxy

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Overview

- The isotopic signature in the water cycle
- n-alkanes as biomarkers
- Do n-alkane $\delta^D$ values reflect modern climate variability?
- Do n-alkanes preserve the $\delta^D$ values over geological timescales?
The water cycle and climate

The isotopic signature of water describes processes in the water cycle

Interpolated δD of Precipitation (‰, V-SMOW)

Bowen et al. (2003)
n-alkanes as molecular fossils

\[ C_{17}H_{36} \text{ (Heptadecane)} \quad \text{n-C}_{17} - \text{n-C}_{23}: \text{aquatic origin (algae, water plants)} \]

\[ C_{29}H_{60} \text{ (n-Nonacosane)} \quad \text{n-C}_{25} - \text{n-C}_{31}: \text{terrestrial origin (leaf waxes of higher plants)} \]

advantages of n-alkanes:
- different organisms produce different n-alkanes (biomarker significance)
- stable over geological timescales
- no exchangable hydrogen (H directly bound to C)
Is modern climate variability recorded in n-alkane $\delta^D$ values?
Sachse et al.: Compound-specific hydrogen isotope ratios - a new proxy to reconstruct the palaeoclimate
Sachse et al.: Compound-specific hydrogen isotope ratios - a new proxy to reconstruct the palaeoclimate

**n-alkane δD values in recent lake sediments**

![Graph showing n-alkane δD values in recent lake sediments.](image)

- **ε = -130 ‰**
- **ε = -157 ‰**

Legend:
- **Meteoric water**
- **n-C_{17} (aquatic)**
- **n-C_{29} (terrestrial)**

Sachse et al. (2004) GCA 68(23)
The difference between terrestrial and aquatic biomarker δD values.
Lake Nam Tso, Central Tibet - a highly evaporative environment
The difference between terrestrial and aquatic biomarker δD values

-30 %
55 %

Humid
Arid

Mügler et al. (in prep)
Is modern climate variability recorded in n-alkane $\delta D$ values?

- n-alkanes from recent lake sediments record the water $\delta D$ value and hence can be used for reconstruction.

- the fractionation during biosynthesis is not dependant on environmental parameters.

- the isotopic difference between aquatic and terrestrial n-alkanes is an indicator of hydrological conditions at a site.
How stable is the n-alkane $\delta^D$ signal over geological timescales?

Sachse et al.: Compound-specific hydrogen isotope ratios - a new proxy to reconstruct the palaeoclimate
Thermal maturity of Permian (Kupferschiefer) black shales

Sachse et al.: Compound-specific hydrogen isotope ratios - a new proxy to reconstruct the palaeoclimate
Influence of thermal maturity on the δD values of biomarkers

C\textsubscript{16} to C\textsubscript{19} alkane

\[ y = 56x - 160 \]

\[ r^2 = 0.581 \]

isoprenoids

\[ y = 179x - 341 \]

\[ r^2 = 0.729 \]
How stable is the n-alkane δD signal over geological timescales?

- Biomarker δD values are altered by thermal maturation
- C-H bonds are more resistant to exchange processes
- The relationship is linear and therefore a correction might be possible, if the maturation history is known
What’s next?

- reconstruction of the paleohydrology of lakes
  - work on high-resolution lake sediments to reconstruct changes in atmospheric circulation patterns (Asian Monsoon, ENSO, NAO) in the recent geological past
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