1. Overview

Deeply-buried sediments below the sulfate-reducing zone play a major role in organic matter remineralization. However, the nature of the processes occurring in these deep sediments is still unclear. Here, we aim to learn more about these deep processes occurring in the central part of the Santa Barbara Basin (SBB; Fig. 1) by examining Δ^13C and δ^13C values of pore-water methane (CH₄), dissolved inorganic carbon (DIC), and dissolved organic carbon (DOC).

2. Specific questions

Q1: Is the CH₄ observed at this site (Fig. 1) biogenic or thermogenic?

Q2: Is the CH₄ produced by in situ methanogenesis, or transported from an external source (e.g., decomposing hydrates)?

Q3: What is the depth scale of remineralization at this site?

3. Pore-water and solid-phase profiles

- SO₄^2−, CH₄, DIC, and DOC (mmol kg⁻¹)
- DIC (mmol kg⁻¹)
- DOC (mmol kg⁻¹)
- δ^13C (per mil)
- δ^14C (per mil)

4. Evaluation of carbon sources using δ^13C and Δ^14C mixing plots

We use mixing curves to estimate the δ^13C and Δ^14C values of C added to a given depth interval.

5. CH₄ appears to be mostly from in situ methanogenesis, but input from external source cannot be ruled out (Q2)

<table>
<thead>
<tr>
<th>Table 2. Flux budget above the SMT</th>
</tr>
</thead>
<tbody>
<tr>
<td>solute</td>
</tr>
<tr>
<td>DIC</td>
</tr>
<tr>
<td>SO₄²⁻</td>
</tr>
<tr>
<td>Mg²⁺</td>
</tr>
</tbody>
</table>

6. Estimating the depth scale of remineralization from Δ^14C values

- POC remineralization should introduce 14C to the pore water to ~50 m depth (Fig. 5)
- Δ^14C-POC profile looks linear below 0.5 m (black circles)
- 14C decay curve using a sedimentation rate of 0.12 cm yr⁻¹ (solid line; ref 10.11) fits the data well
- this decay curve approaches -1000‰ at ~50 m depth

7. Summary

Q1: CH₄ observed at this site appears to be largely of biogenic origin

Q2: the source of the CH₄ appears to be in situ methanogenesis, possibly with some input from external source

Q3: Δ^14C values of DIC, DOC diffusing into the base of these cores suggest that remineralization occurs over a depth scale of at least 10s of meters

8. Next steps and more questions

- complete the dataset (including a similar dataset for neighboring Santa Monica Basin)
- conduct a more comprehensive data analysis through construction of a reaction-transport model
- does any of the ~2.4 m CH₄ appear to be from a local seep (a possible external source)?
- what is the composition of this CH₄ produced at depth?