An update on geochemistry at MC 118

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Outline

• Spatial survey of biogeochemical cycles at MC 118
  – Tying microbial activity to deep seeded faults
  – Additional cores from HyFlux cruise
• Results of seafloor instruments
• Hydrate dissolution lab experiments
Microbial activity as a seafloor indicator of deep seeded fault

Relative Microbial Activity
- High
- Moderate
- Low
- CO3

* See Beth Huettel’s poster at Ocean Sciences, Feb 2010, highlighting this work
HYFLUX cruise objectives

- Pick up seafloor instruments
- Collect gravity cores
  - GC1 was targeted by Leo because of a deeper acoustic anomaly. This site also corresponded to mass spec anomaly found by Rich Camilli on a June 09 AUV cruise to MC 118.
  - GC2 was targeted to test one of the locations of the proposed borehole. This site is northeast of the mound, so we didn't expect to see either methane or sulfides.
  - GC3 and GC5 were targeted because they are along one of the surface reaching faults that Jim Knapp has identified in the industry data and there is a deeper acoustic anomaly.
  - GC4 was chosen because it was targeted as a potential place for a borehole due to a shallow bright spot identified in the industry seismic data. My understanding is that there is a fault that extends down to the hydrocarbon reservoir but not up to the seafloor.
Coring priorities

Hypotheses:

Microbial activity increases closer to faults
Increased microbial activity associated with deeper seismic anomaly
Deep bright spot anomaly is associated with higher microbial activity
No Core Recovery

C1=1μM
δ^{13}C-CH_4 = -50\%_o
δ^{13}C-DIC = -10\%_o

C1=15μM, linear
δ^{13}C-CH_4 = -60\%_o
δ^{13}C-DIC = -30\%_o

C1=4μM, concave
δ^{13}C-CH_4 = -80\%_o
δ^{13}C-DIC = -40\%_o

* Slight SO4 depletion in all cores, but nothing substantial
HYFLUX gravity cores

Methane (uM)

Depth (cmbsf)

GC1
GC2
GC4
Lithostratigraphy and Biostratigraphy by Charlotte Brunner, USM

Cores 1, 4 diagenetically altered

~4000 yrs sed missing

Figure 4. Biostratigraphy of the cores showing the absence of the Y1 Subzone in cores GC01 and GC04, which are near the “yellow” fault. The absence of the subzone suggests an unconformity. The fate of the missing sediment is in question.
Why are these outcrops there?
Hydrate dissolution experiments

Hyp: Near surface or outcropping hydrates are more stable than predicted and diffusion is not only factor controlling their dissolution (oil coatings, crystal lattice, microbial slimes, etc.)

Crystal Meth(ane) Laboratory

Seafloor
Seafloor instruments at MC 118
Lab set up

A) Set-up

CH₄ (g)

H₂O

B) Hydrate formation

hydrate

C) Experiment

hydrate

discreet CH₄ measurements
Experimental set-up: Pressure chamber

- Pre-expt:
  - Solution added to chamber
  - Pure CH4 introduced thru bubbling tube and brought to pressure and temperature
  - Over 2 days, hydrate formation was stimulated by vigorously bubbling, shaking and stirring.
  - On the night of the 3rd day, at 1am, hydrate formed on window within 2 minutes
Experimental set-up: Pressure chamber

A) Set-up
- CH₄ (g)
- H₂O

B) Hydrate formation
- hydrate

C) Experiment
- hydrate
- discreet CH₄ measurements
The experiment

- Once hydrate was formed, it was flooded with more water and headspace flushed of methane
- Chamber was left alone (no stirring)
- The picture shows assumption of how hydrate formed. No visual confirmation of this.
- Water and headspace gas were collected at ~daily intervals and measured for methane concentrations on a Shimadzu 2014 Gas Chromatograph
Hydrate dissolution results
Hydrate dissolution results

- Methane (mM) vs. Time (hrs)
- Expt 7, Expt 12, Expt 18, Expt 19, Expt 20
- Theory
- Sat'n at 7 days
Hydrate dissolution results

### Rate summary

<table>
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<tr>
<th>Study</th>
<th>Dissolution rate (x10^-7mmol/m^2/sec)</th>
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<tr>
<td>Rehder et al., 2004</td>
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<tr>
<td>Theory (1mm BL)</td>
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<td>Lapham et al., in review</td>
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<td>Gradient 2 = 9</td>
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<td>This study</td>
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We have begun to shed light

Future work:

Continue experiments with mixed gases

Add in oil and other natural ingredients

Duan et al., 2006
Conclusions

- The Crystal Meth(ane) lab allows us to determine factors, other than pressure and temperature, controlling hydrate stability.
- Preliminary experiments show that under unstirred conditions, pure methane hydrate dissolves more slowly than stirred experiments and close to theoretical predictions.
- Next step is to determine how mixed gases and other natural ingredients (oil, marine sediment, etc) may affect dissolution rates.
- Overall, this research adds to our deeper understanding of gas hydrate stability and allows additional parameters to be included in models.
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Thank-you for your attention!