Radiocarbon Analysis of Microbial RNA to Determine Carbon Sources in Arsenic Contaminated Pleistocene Aquifers in Bangladesh

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Geogenic As and Iron Reduction

- Geogenic As
  - Naturally occurring
  - Prevalent in Southeast Asia

- Health effects:
  - Cardiovascular disease
  - Skin lesions
  - Cancers (skin, lungs, liver)

- As release through iron reduction
  - Fe $\text{III} \rightarrow$ Fe $\text{II}$
  - Where is the organic carbon coming from?

Oremland & Stolz, 2005; Ravenscroft et al., 2001
As Contamination of Shallow, Pleistocene Aquifer

- **Shallow wells:**
  - <40 m
  - Draws from Holocene aquifer
  - Cheap and easy to drill
  - As levels >10 µg/L

- **Intermediate wells:**
  - ~40 - 150m
  - Draws from Pleistocene aquifers
  - Cheap and easy to drill
  - Generally lower As (<10 µg/L)
  - *Some As contamination (>10 µg/L)*

- **Deep wells:**
  - >120m
  - Expensive to drill
  - Low As (<10 µg/L)
Young surface OC or ages similar to the Holocene aquifer (0-1,000 years old) (Mailloux et. al)

Old OC buried with the sediment (>10,000 years old) (McArthur et. al)

OC and organics diffusing out of clays (>10,000 years old) (Erban et. al)

Potential Carbon Sources

Bacterial Reduction of Sedimentary As

Extraction and Radiocarbon Dating

- RNA
- DNA
- PLFA
Pleistocene wells >30 meters
Possibilities for Carbon Movement at Site M:

Clay Sand Oxidized, low As sediment OC travel pathways
Arsenic Measurements at Site M:

- High As Holocene
- Generally Low As Pleistocene

Diagram showing depth and arsenic measurements at Site M, with pumping site indicated.
Extraction Methodology

• 33,860 liters pumped at Site M1.4A

• Filter cut in half to create duplicates

• Cell lysis, Tris-saturated Phenol
  Chloroform (1:1), LiCl precipitation

• Radiocarbon dated at LLNL

• Extensive E. Coli testing reproduced end member modern dates
RNA Radiocarbon Dates from Pleistocene Aquifer <1,000 years old

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<tr>
<th>Sample Name</th>
<th>$\Delta^{14}$C</th>
<th>$^{14}$C Age</th>
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<tr>
<td>RNA (1)</td>
<td>-111.4 ± 20.1</td>
<td>880 ± 190</td>
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<tr>
<td>RNA (2)</td>
<td>-121.8 ± 6.2</td>
<td>980 ± 60</td>
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Comparison of RNA, DOC, CH$_4$ Radiocarbon Ages

- Site M sediment (50.6 m) = >10,000 years old
- Site M DIC (54.5 m) = 1,050 years old
Young Dates Support Advection of Surface OC Around Clay to the Pleistocene Aquifer
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Conclusions:

• Duplicates worked

• RNA dates <1000 years
  • Younger than sediment and in situ carbon sources
  • Young OC transported around the clay

• Long term stability of Pleistocene aquifers may be compromised by the transport of young OC down to Pleistocene depths, possibly due to groundwater pumping
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- Van Geen Lab
- Bostick Lab
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Young Dates Support Advection of Surface OC Around Clay to the Pleistocene Aquifer