The Intraterrestrials: Life inside the Earth

Jennifer Biddle
School of Marine Science and Policy
University of Delaware
The extent of what we know is small

“What we know is a drop, what we don’t know is an ocean” – Isaac Newton
Microbes in the ocean

~10^5-10^6 cells/mL

Inner space

Jed Fuhrman 1999
The sedimentary deep biosphere

From Jorgensen and Boetius, 2007
How globally important is it?

1/3rd to 1/10th of prokaryotic biomass on Earth

from Whitman et al. 1998

<table>
<thead>
<tr>
<th>Environment</th>
<th>No. of prokaryotic cells, $\times 10^{28}$</th>
<th>Pg of C in prokaryotes*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquatic habitats</td>
<td>12</td>
<td>2.2</td>
</tr>
<tr>
<td>Oceanic subsurface</td>
<td>355</td>
<td>303</td>
</tr>
<tr>
<td>Soil</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Terrestrial subsurface</td>
<td>25–250</td>
<td>22–215</td>
</tr>
<tr>
<td>Total</td>
<td>415–640</td>
<td>353–546</td>
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</tbody>
</table>

from Parkes et al. 2000
Accessing the deep subseafloor environment

- Scientific ocean drilling
  - NSF and international sponsored
- Ocean Drilling Program (DSDP, ODP, IODP)

Investigation of the deep biosphere is 1/3rd of IODP’s current mission
Night sampling of sediments offshore Peru: Poisonous H$_2$S gas, produced by microbial degradation of organic matter without oxygen
What do deep sediments look like?

Fine layers of methane hydrate
The sediment sequence of Site 1231, near the Galapagos

A young sediment pond in the mid-Atlantic
Sampling sediments for microbiology: Attempting to keep things clean
How do we know microbes are present in the deep subsurface?

• We can see their influence on chemistry
• We can see them
• We can harvest their genetic material
We rely on DNA and RNA, which we can extract and analyze from the environment.

- Every living thing has DNA and RNA.
- The sequences of these molecules can be compared.
The deep subsurface biosphere: a forest of novel, uncultured archaeal phyla emerging from the deep roots of this domain of life.
Clone libraries recover 16S rRNA phylotypes of the majority phyla; V6-tag sequencing uncovers also the highly diverse fringe groups of Archaea of four uncultured lineages (MCG, MBG-B, MBG-D, SAGMEG-1) dominate the sediment column of Peru Margin Sites 1227 and 1229 in 16S rRNA clone libraries and in V6-tag sequencing surveys.

These phyla were not found in rRNA clone libraries

Biddle et al. 2006
Sørensen and Teske 2006

Biddle, unpublished
Subsurface metagenomes

- Peru Margin
- Soudan Mine
- Gulf of Mexico
- Human Gut

PC1 (70.5%)
PC2 (12.8%)
Future advances from the sedimentary biosphere

- New, deeply branching microbial life
- Unusual genes
- New life strategies
- New metabolic processes
- Increase ability to detect life as we know it
- Better understanding of global processes
- Better understanding of element cycling
- And...?
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All chiefs and co-chiefs of ODP/IODP drilling cruises