Natural CO$_2$ from Submarine Hydrothermal Systems

John Lupton, Presenter

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Outside Collaborators

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- Gary Massoth (IGNS and Mass-Ex3 Consulting)
- Mark Schmitt (Univ. Kiel, Germany)
Typical subduction zone
Mariana Arc
Champagne Vent, NW Eifuku, 2004
Champagne Vent, NW Eifuku, 2004
CO$_2$ Phase Diagram
modified from Jessup and Leitner, 1999
liquid CO$_2$ droplets $\sim$3°C
deposit + H$_2$O
CO$_2$ hydrate
liquid CO$_2$
103°C vent fluid
Sampling devices used for gas collections
Champagne Vent, Droplet Catcher, 2005
Comparison with mid-ocean ridge systems
Mussel beds on NW Eifuku: Does low pH environment change calcification? Tunnicliffe et al. 2007
# Shell Samples (from live mussels)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Site</th>
<th>Depth (m)</th>
<th># shells</th>
<th>pH</th>
<th>alk</th>
<th>Max T °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>Eifuku</td>
<td>1576</td>
<td>41</td>
<td>5.88</td>
<td></td>
<td>2.3</td>
</tr>
<tr>
<td>E2</td>
<td>Eifuku</td>
<td>1596</td>
<td>11</td>
<td>5.94</td>
<td>2.49</td>
<td>2.5</td>
</tr>
<tr>
<td>E3</td>
<td>Eifuku</td>
<td>1610</td>
<td>5</td>
<td>6.51</td>
<td>2.46</td>
<td>2.4</td>
</tr>
<tr>
<td>E4</td>
<td>Eifuku</td>
<td>1638</td>
<td>12</td>
<td>5.36</td>
<td>2.62</td>
<td>2.7</td>
</tr>
<tr>
<td>T1</td>
<td>Tonga</td>
<td>1103</td>
<td>10</td>
<td>7.85</td>
<td>2.46</td>
<td>-</td>
</tr>
<tr>
<td>L1</td>
<td>Lau</td>
<td>1830</td>
<td>10</td>
<td>8.42</td>
<td>2.34</td>
<td>2.0</td>
</tr>
<tr>
<td>L2</td>
<td>Lau</td>
<td>1820</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L3</td>
<td>Lau</td>
<td>1900</td>
<td>12</td>
<td></td>
<td></td>
<td>Water collection using a low pumping sampling or with evacuated bottles with controlled intake flows.</td>
</tr>
<tr>
<td>L4</td>
<td>Lau</td>
<td>2622</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L5</td>
<td>Lau</td>
<td>2714</td>
<td>12</td>
<td></td>
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</tr>
</tbody>
</table>
Dry weight of shells:
much lighter shells in high CO$_2$ setting
Thickenss of shells on cut slices

Shells from low CO₂ habitat are 2.5 times the thickness of those on Eifuku Volcano

Tunnicliffe et al., 2007
Of 22 volcanoes studied on the Mariana and Tonga-Kermadec Arcs, 6 are venting a separate CO2-rich gas phase.
Volcano-1
160 m depth, 30 - 152° C
Volcano-1, Tonga-Kermadec Arc
Summary

- Of 22 active submarine volcanoes investigated, 6 had a free CO₂-rich gas phase
- Excess CO₂ is derived mainly from subducted marine carbonates incorporated into the volcanic melt.
- Tunnicliffe et al. study indicates that the mussel shells on NW Eifuku compromised by low pH environment.
- CO₂ flux at NW Eifuku equals 0.1% of the global mid-ocean ridge carbon flux

Future Directions

- Estimate the carbon flux at CO₂-rich hydrothermal sites
- Assess effect of submarine CO₂ venting on the global oceanic carbon budget
- Evaluate the effects of high CO₂ concentrations on marine ecosystems via biological studies at natural sites such as NW Eifuku – relevance to Ocean Acidification