Changes in carbonate preservation in southern Drake Passage during the mid-Pleistocene transition

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Gravity Core # | water depth (m) | core length (cm)
--- | --- | ---
0803 | 3,630 | 780
0801 | 4,090 | 631
9806 | 4,000 | 248
0502 | 3,503 | 593
0605 | 3,580 | 785
0002 | 2,710 | 286
- Deep Sea drift sediments around the peninsula western Weddell Sea → northern Weddell Sea → 1) central Scotia Sea → 2) drifts near the Shackleton Fracture Zone → DP (?) → drifts on continental rise of the western AP

- Previous provenance study (0502 core; Lee et al., 2012)
  - Glacial: from SSI and AP
  - Interglacial: additional supply from Weddell Sea region

- Drift sediment affected by WSDW
Correlation and Age Control

<table>
<thead>
<tr>
<th>Core #</th>
<th>Water Depth (m)</th>
<th>MIS</th>
<th>Sed. Rate (cm/kyr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0803</td>
<td>3630</td>
<td>1~5</td>
<td>10</td>
</tr>
<tr>
<td>0801</td>
<td>4090</td>
<td>1~6</td>
<td>3</td>
</tr>
<tr>
<td>9806</td>
<td>4000</td>
<td>1~6</td>
<td>2</td>
</tr>
<tr>
<td>0502</td>
<td>3503</td>
<td>1~15(?)</td>
<td>1</td>
</tr>
<tr>
<td>0605</td>
<td>3580</td>
<td>1~26(?)</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>
The Mid-Pleistocene Transition (MPT)

- 41-ka obliquity cycles $\rightarrow$ ~100-ka cycles
- Increased-amplitude of climatic oscillations: low $\rightarrow$ high

- 1.2 Ma $\sim$ 500 ka (Head and Gibbard, 2005)
  - cf. Matuyama-Brunhes boundary $\sim$780 ka (MIS19)

- Cause?
  - Astronomical?
  - $\text{CO}_2$ levels / global T decline / Non-linear climate response to Milankovitch forcing / SST cooling and increased sea ice / Changes in THC vigor / Ice sheet stability, etc.
G/IG carbonate variability:
- high IG carbonate (‘Atlantic’ type)
- high G carbonate (‘Indo-Pacific’ or ‘Pacific’ type)

onset of ‘Pacific-style’ carbonate cycle at the MPT (Sexton and Barker, 2012, EPSL)
Carbonate content variability

- Carbonate content of deep-sea sediments = function of
  - productivity in overlying surface waters
  - dilution by non-carbonate phases
  - dissolution in the water column, at the sea floor, and in sediment pore waters
    - surface water chemistry
    - vertical shifts of the lysocline
    - postdepositional dissolution
  - distribution of deep-water masses

- Carbonate variations → Implications for changes in
  - the ocean’s carbonate system
  - deep-water circulation
  - atmospheric pCO2
Carbonate content variability of southern DP cores

0502 (3,503m) 0002 (2,710m)

(Bae et al., 2003, GML)

Carbonate dissolution in deeper part during interglacials

interglacials without carbonate interglacials with carbonate
Carbonate content variability of southern DP cores

0502 (3503m) vs. 0605 (3580m)

Onset of carbonate-free IG: MIS 19
Interpretation of the 0605 carbonate variability

(A) no dissolution, carbonate preserved: carbonate content of IG > G (productivity and dilution factors)

(B) carbonate dissolved in IG times: carbonate content of IG < G

(C) condition change from (A) to (B)
Summary: changes in carbonate variability

- **pre-MPT carbonate variability (core 0605)**
  - carbonate preserved
  - higher carbonate in interglacial sediments than in glacial sediments (‘Atlantic’ type)
  - higher productivity during interglacials
  - not affected by corrosive deep water

- **post-MPT (since MIS 19) carbonate variability**
  - carbonate (partially) preserved only in some glacial sediments (‘Pacific’ type)
  - no carbonate in interglacial sediments
  - carbonate preserved in 0002 site (water depth 2710m) (Bae et al., 2003, GML)
  - affected by corrosive deep water, esp. during interglacials
Corrosive deep water from the Weddell Sea during Interglacials

- sedimentary provenance data (Lee et al., 2012, QR), suggesting an increased sediment from Weddell Sea during interglacials.
- contourites around the Antarctic Peninsula
- → Influence of WSDW during interglacials

post-MPT Glacials vs. Interglacials

- Interglacial: Dense shelf water → (brine rejection and ocean/ice-shelf interaction) → AABW and deep waters (at present: the Weddell Sea, the Ross Sea and off the Adelie Coast)
- Glacial: Ice sheet to the edge of the continental shelf. G deep water ≠ IG deep water
Implication: ‘Atlantic’ vs ‘Indo-Pacific’ type

- Geographic distribution of ‘Atlantic’ vs ‘Indo-Pacific’ types
- ‘Pacific’ type in regions other than Pacific/Indian Ocean
  - deep South Atlantic Cape Basin (site 1089; Hodell et al., 2001, EPSL)
  - southern Drake Passage (this study)
- Working hypothesis: corrosive deep water from Antarctica dissolved carbonate in the Pacific and Indian oceans during post-MPT interglacials.

- the role of AA-sourced deep water:
  Deep waters from AA vs. North Atlantic $\rightarrow$ ‘Indo-Pacific’ vs. ‘Atlantic’ type

- Timing of the development of the ice shelves during interglacials

*Simmon, NASA Earth Observatory / wikipedia*
Implication: MPT climate change

low carbonate IG-high carbonate G in many oceans

more C in deep ocean during glacials
less C in deep ocean during interglacials

Increased amplitude of climatic oscillations
Thank You