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

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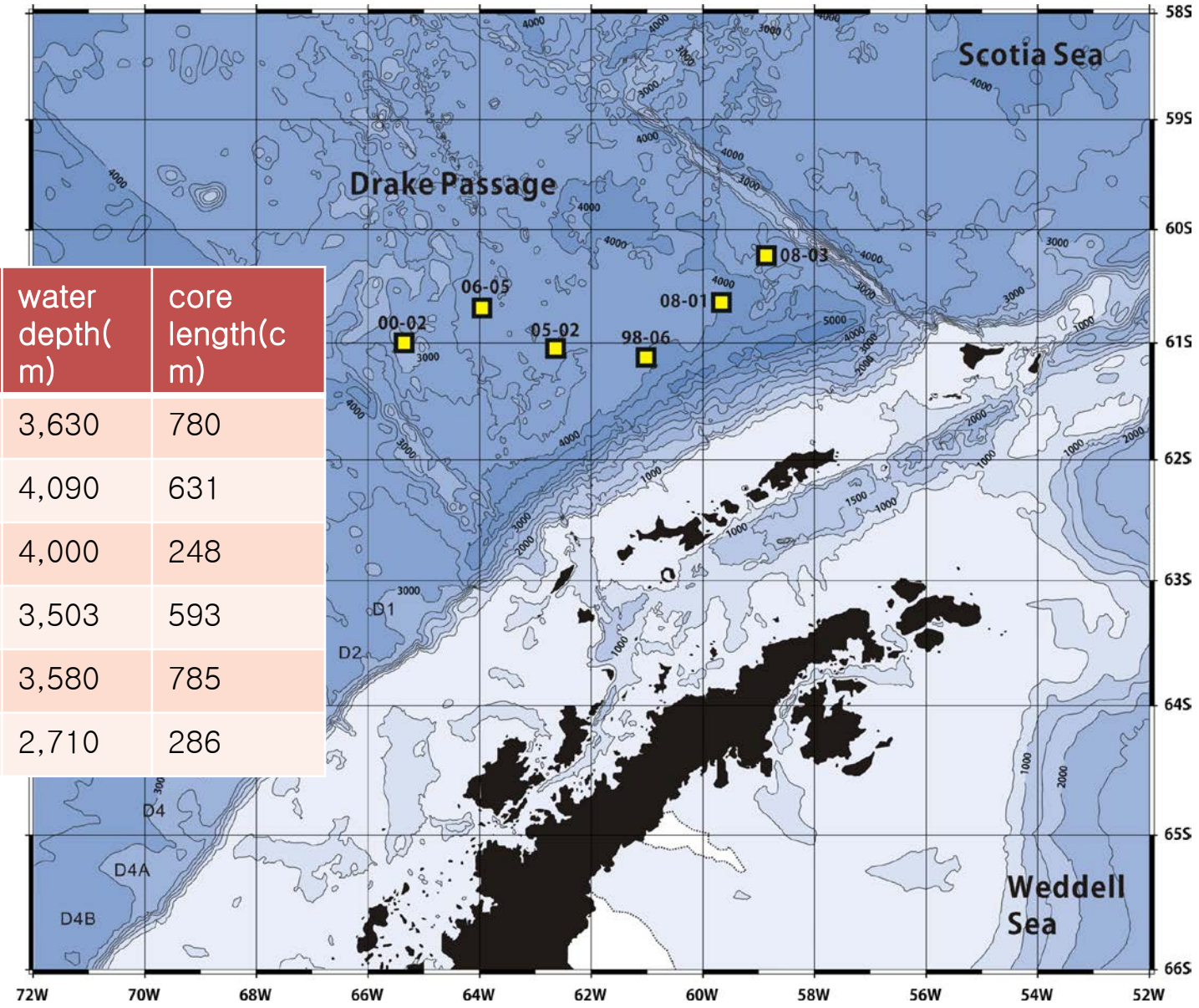
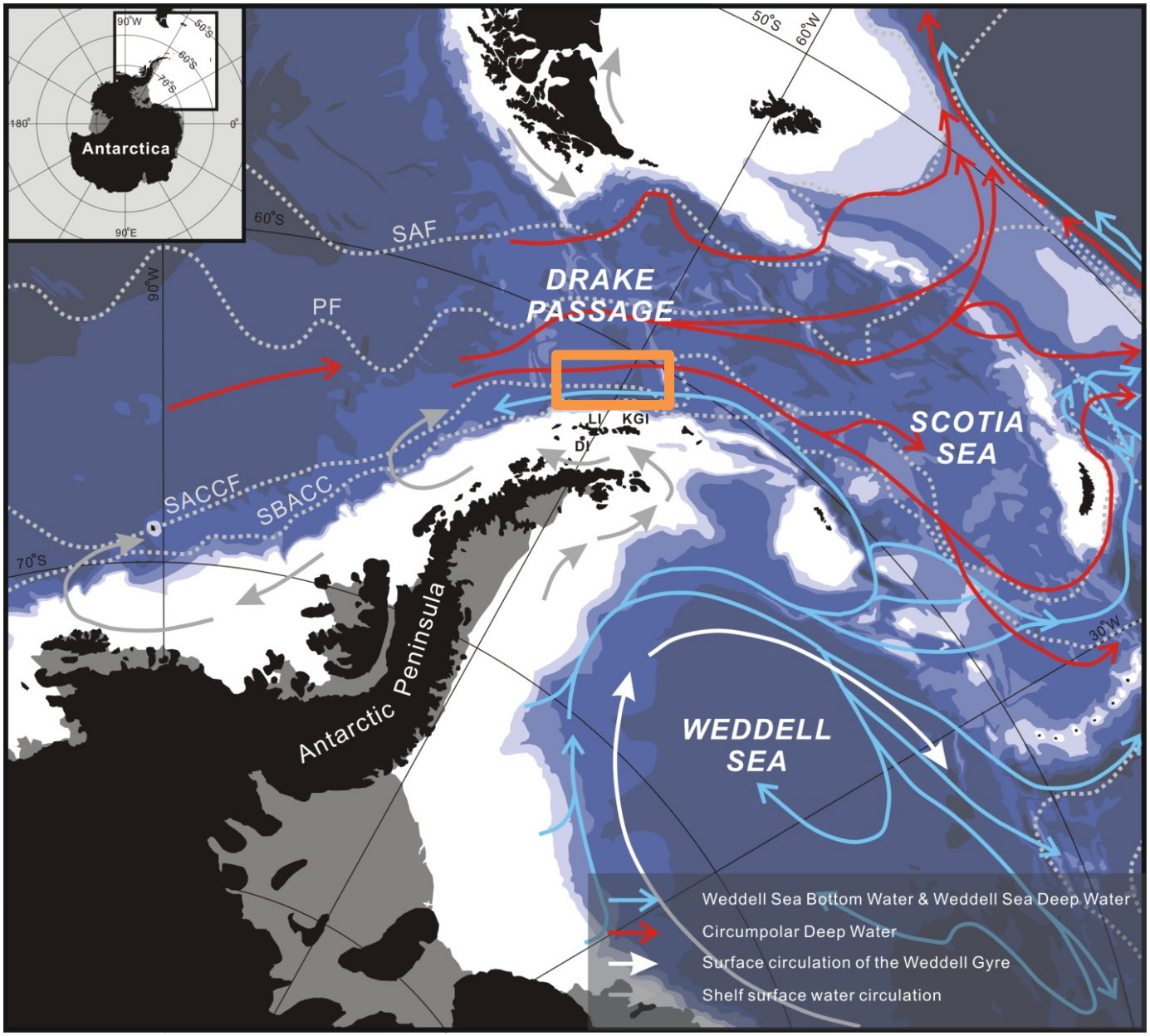
Study Area/Samples

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



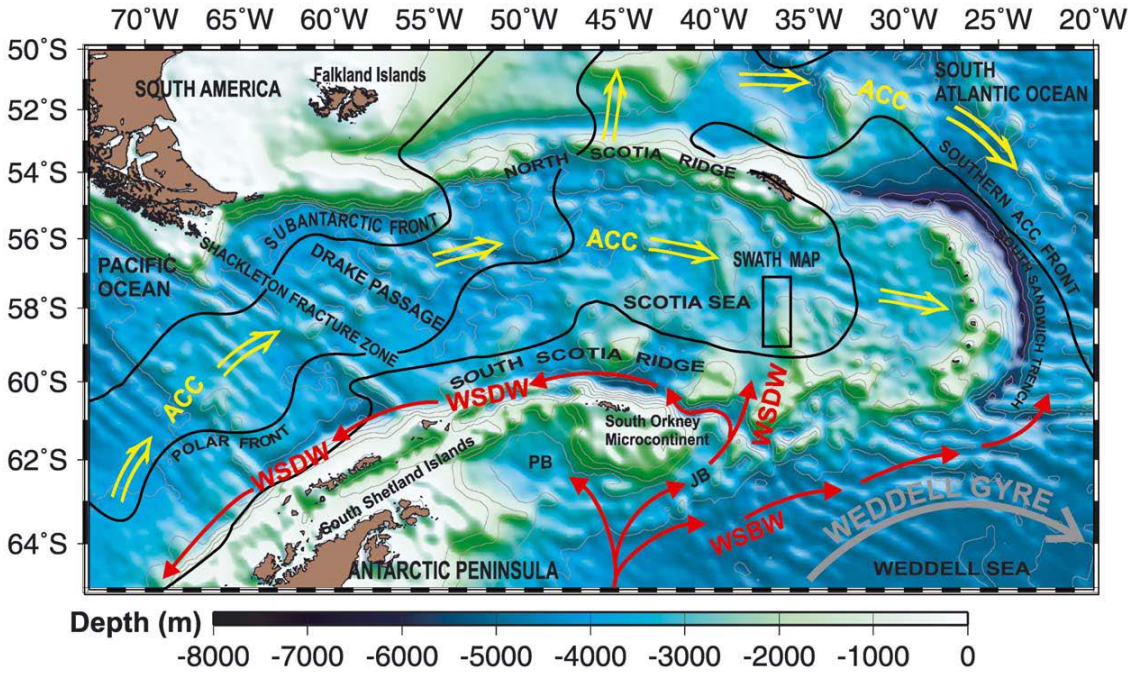
Study Area/Samples



modified from
Lee et al., 2012, QR

Study Area/Samples

- 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

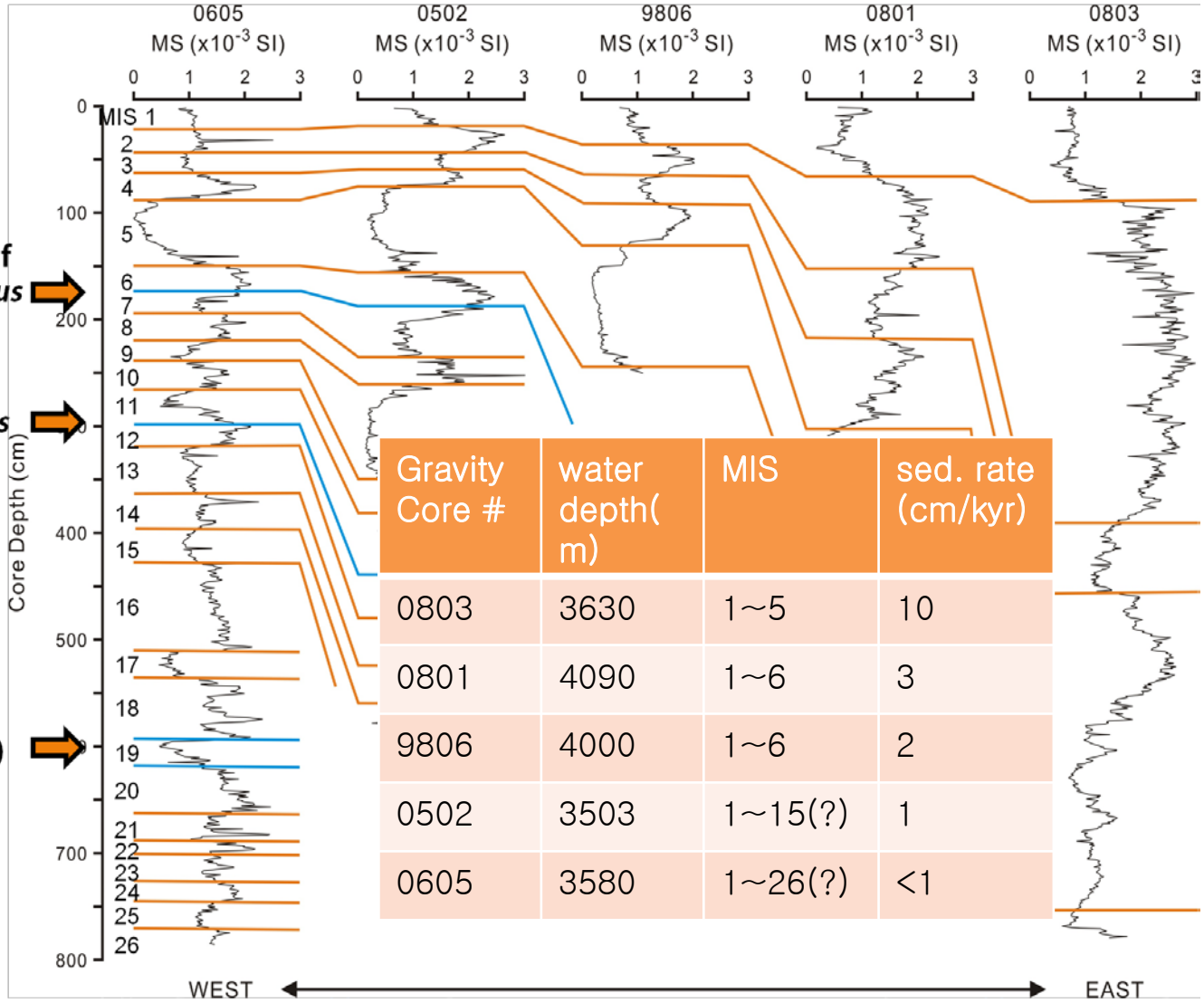


Maldonado et al., 2003, PPP

- 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



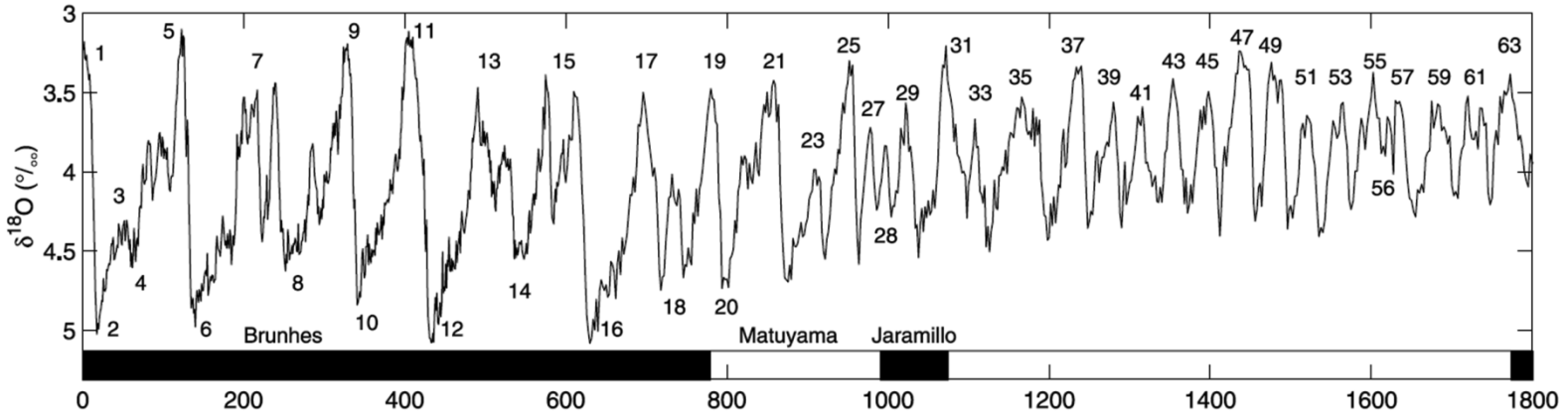
last occurrence of diatom *Hamidiscus karstenii* (0502)

last occurrence of radiolarian *Stylatractus universus* Hays (0502)

Brunhes/Matuyama magnetic reversal (0605)

Gravity Core #	water depth(m)	MIS	sed. rate (cm/kyr)
0803	3630	1~5	10
0801	4090	1~6	3
9806	4000	1~6	2
0502	3503	1~15(?)	1
0605	3580	1~26(?)	<1

The Mid-Pleistocene Transition (MPT)



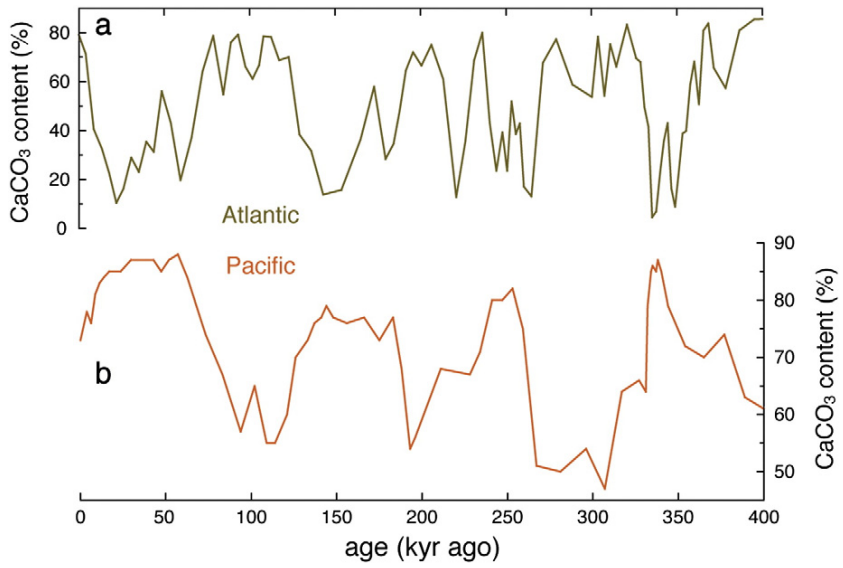
Lisiecki and Raymo, 2005, PO

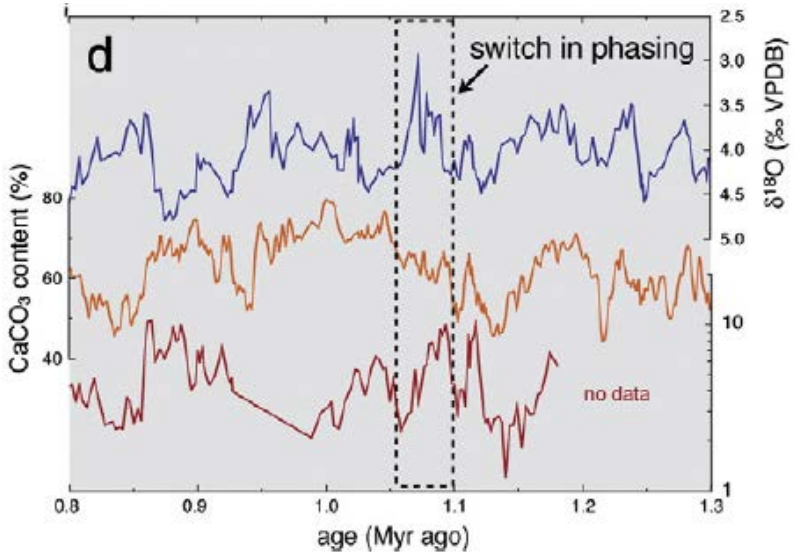
- 41-ka obliquity cycles → ~100-ka cycles
- Increased-amplitude of climatic oscillations: low → high

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

- Cause?
  - Astronomical?
  - 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.

MPT and carbonate variability





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)

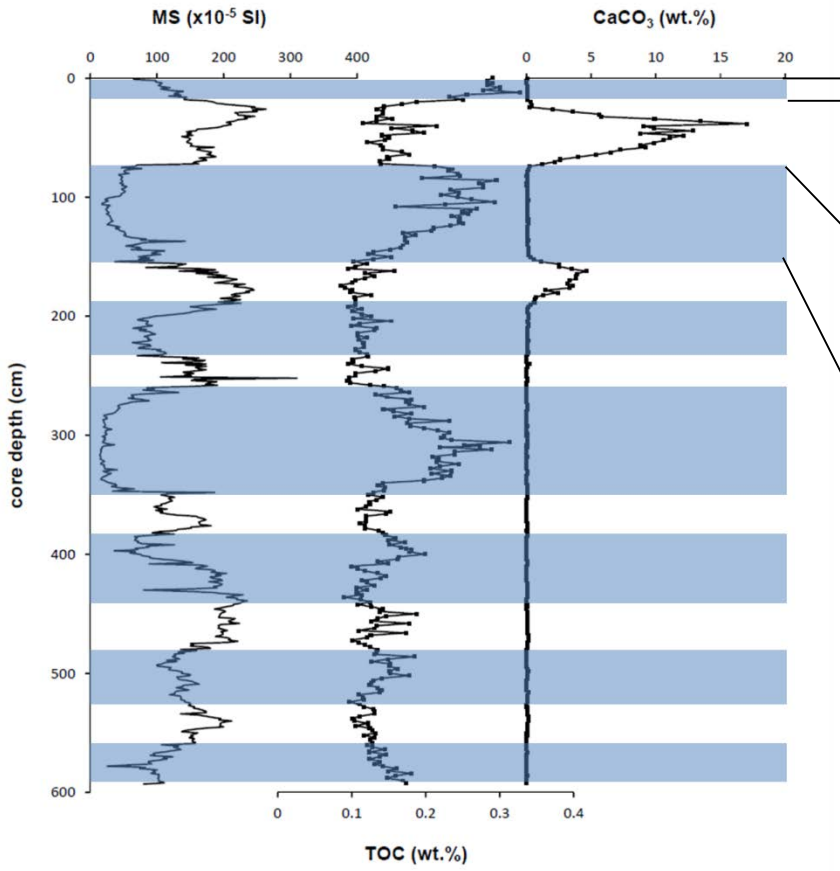
Carbonate content variability

- 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

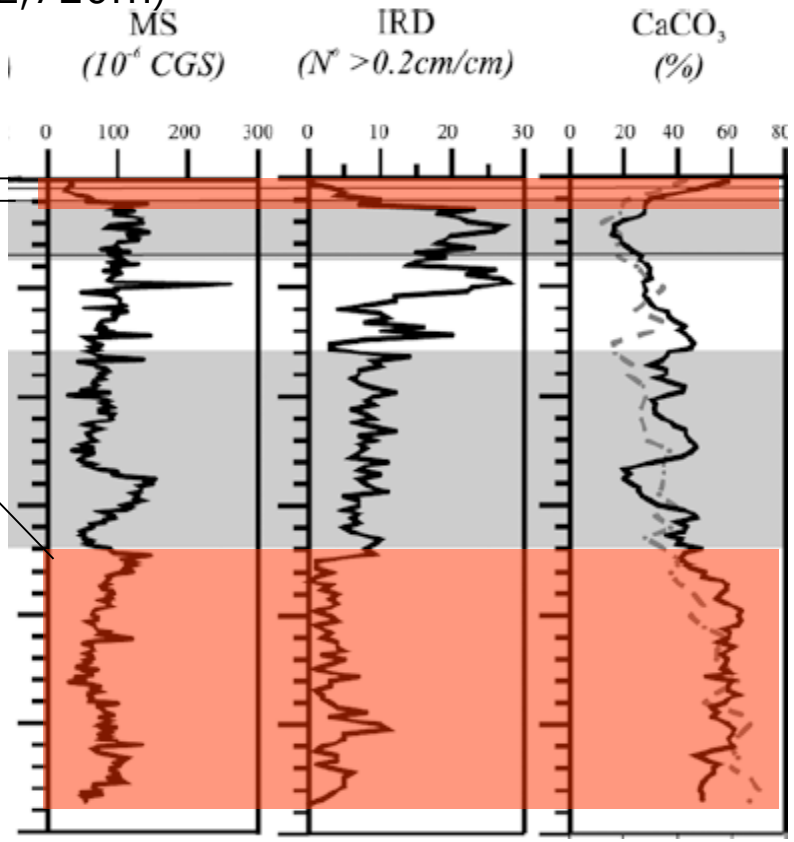
- Carbonate variations → Implications for changes in
  - the ocean's carbonate system
  - deep-water circulation
  - atmospheric pCO2

Carbonate content variability of southern DP cores

0502 (3,503m)



0002 (2,710m)

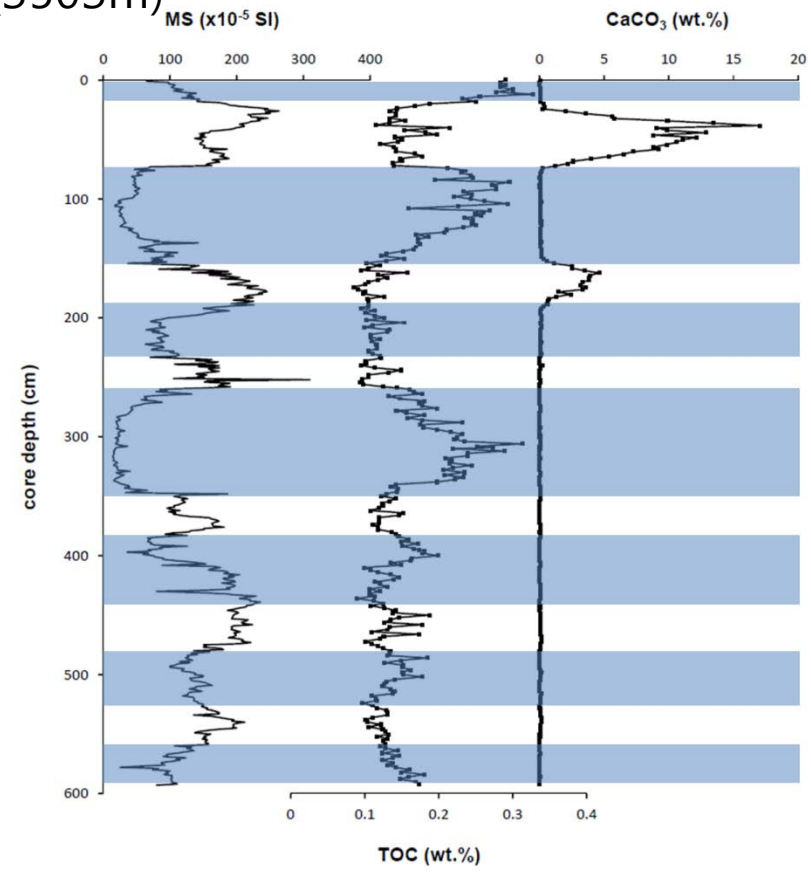


(Bae et al., 2003, GML)

→ Carbonate dissolution in deeper part during interglacials

Carbonate content variability of southern DP cores

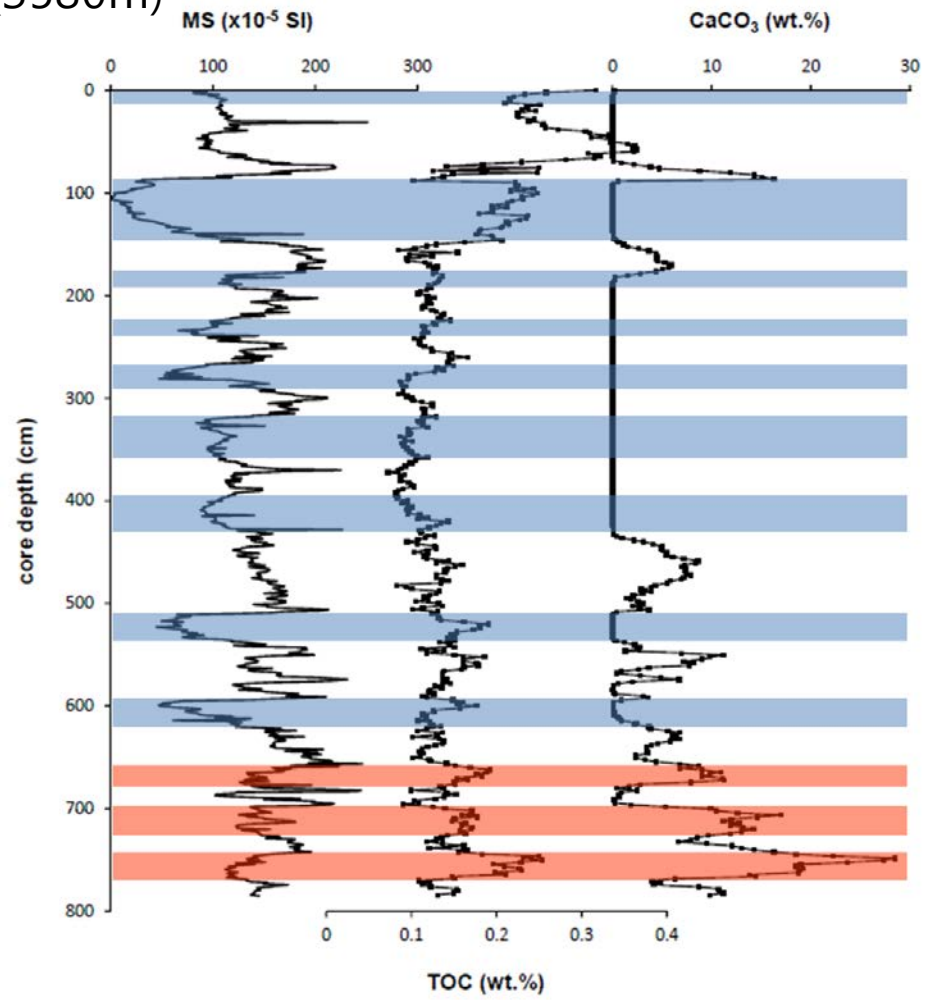
0502
(3503m)



interglacials without carbonate

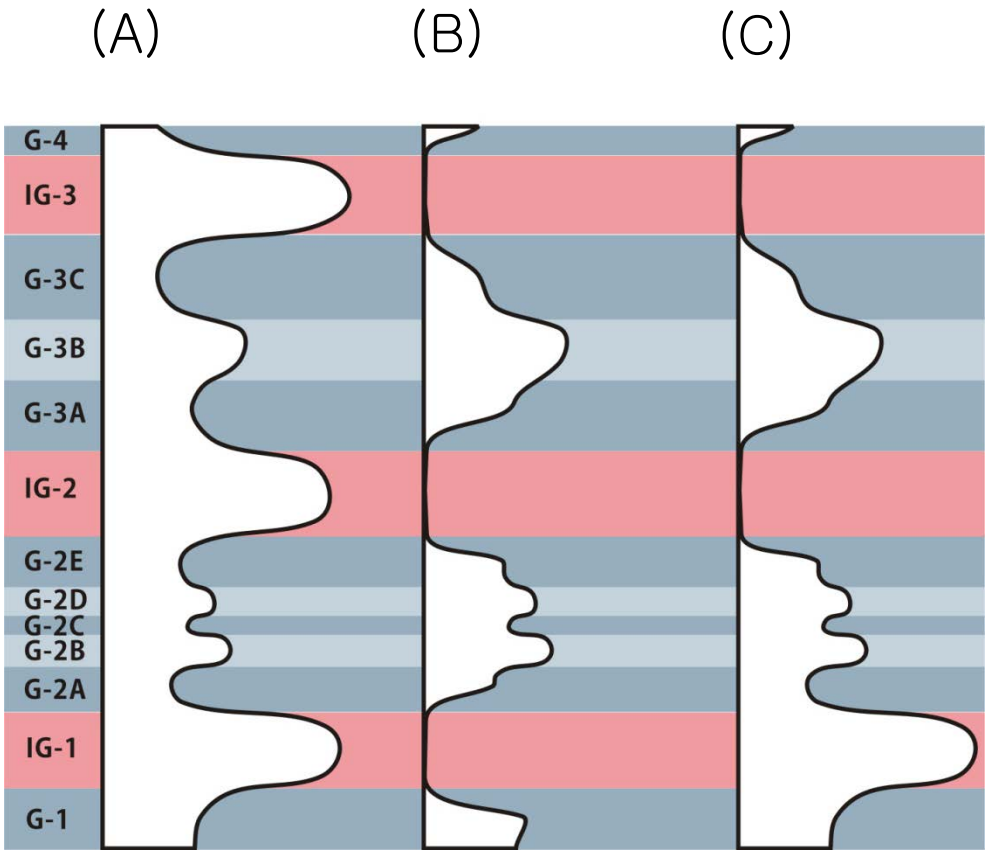
interglacials with carbonate

0605
(3580m)



Onset of carbanate-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

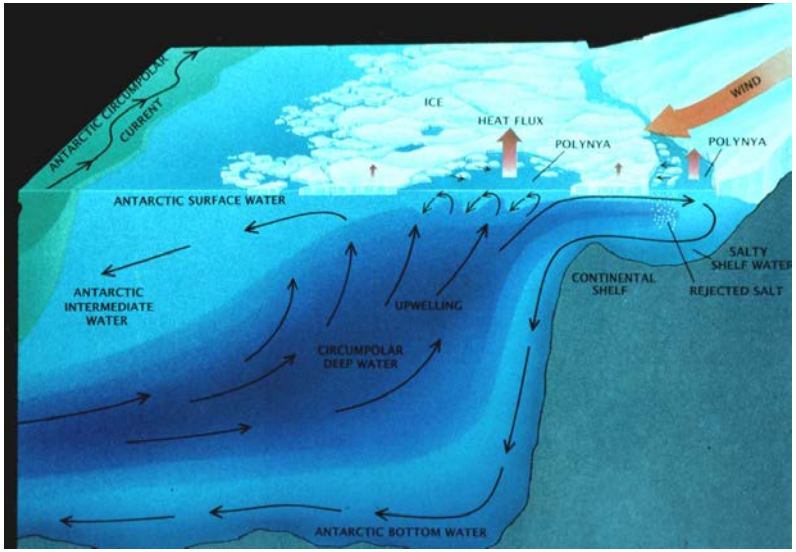
- pre-MPT carbonate variability (core 0605)
  - carbonate preserved
  - higher carbonate in interglacial sediments than in glacial sediments ('Atlantic' type)
  - ← higher productivity during interglacials
  - ← not affected by corrosive deep water

- 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

post-MPT interglacial dissolution of carbonate

- Corrosive deep water from the Weddell Sea during Intergalcials
  - 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

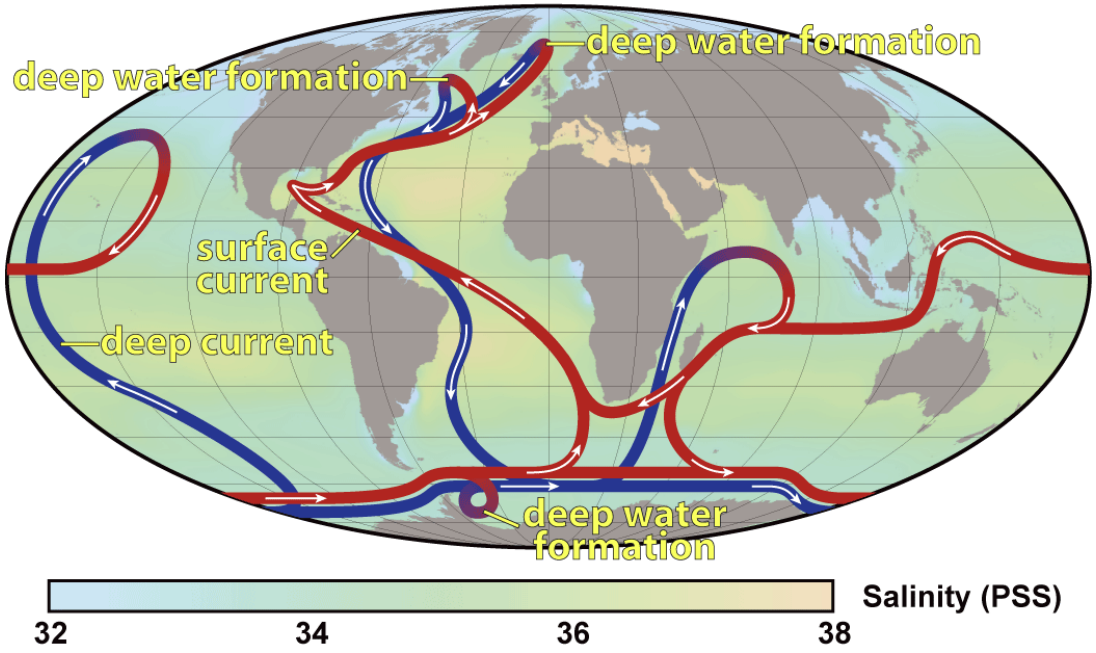


Implication: 'Atlantic' vs 'Indo-Pacific' type

- 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.

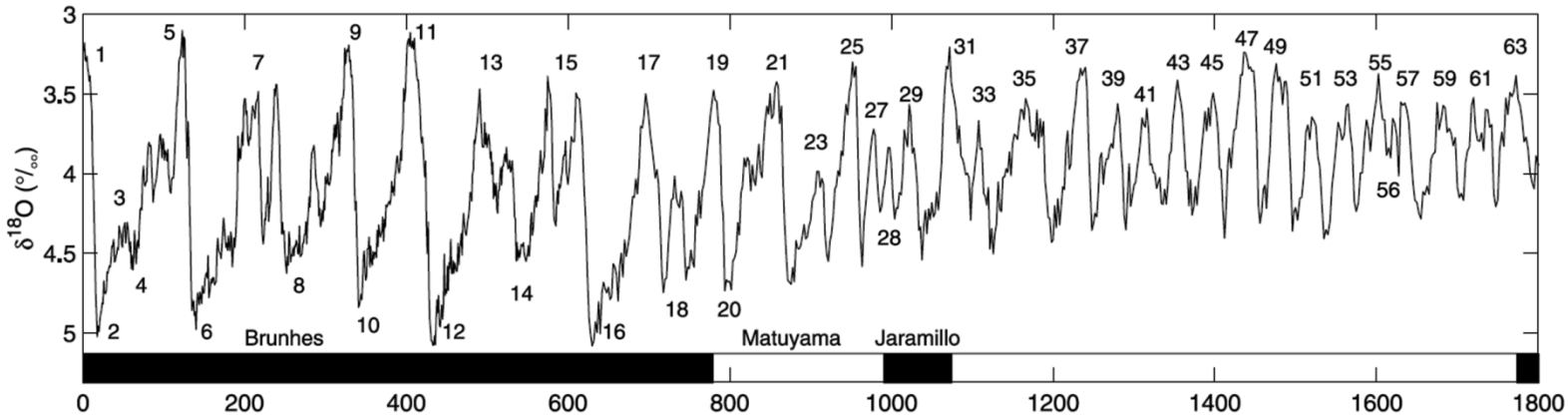
- the role of AA-sourced deep water:
  Deep waters from AA vs. North Atlantic → 'Indo-Pacific' vs. 'Atlantic' type

- 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

high carbonate IG-
low carbonate G

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

Increased amplitude of climatic oscillations

Thank You