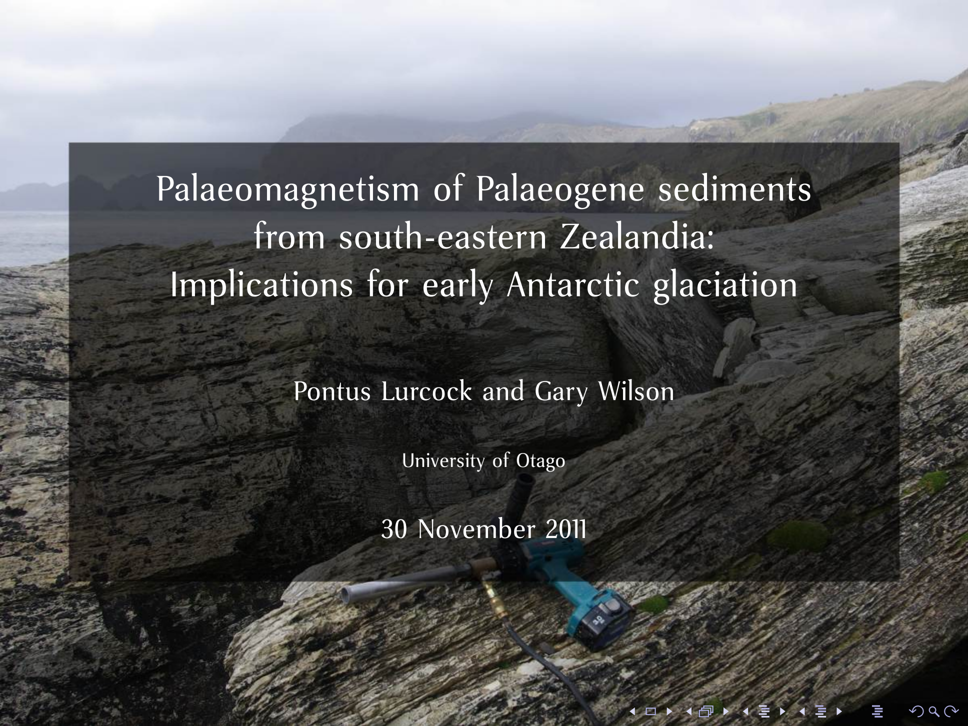

Palaeomagnetism of Palaeogene sediments from south-eastern Zealandia: Implications for early Antarctic glaciation

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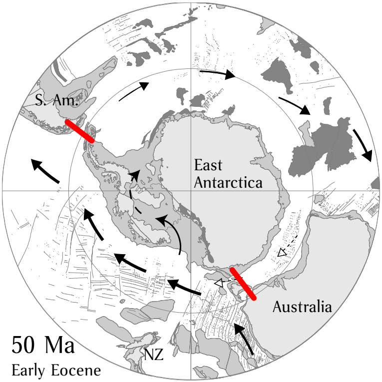
Overview

- The challenges:
  - Palaeomagnetism on rocks that are almost non-magnetic.
  - Does glaucony hold magnetism? If so, how?
  - Relationship between glaucony, magnetism, and palaeoenvironment
- The motivation:
  - Maybe Antarctic glaciation happened earlier than we thought.
  - We need accurate dating to find out.
- The outcomes:
  - A toolkit for palaeomagnetism on weak, glauconitic sediments
  - Magnetostratigraphies of N. Z. Palaeocene sections
  - Implications for early Antarctic glaciation

What initiated Antarctic glaciation?

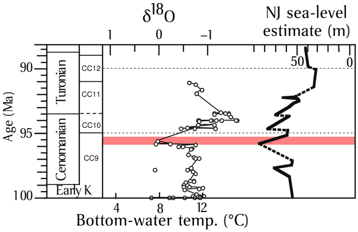


The usual answer:

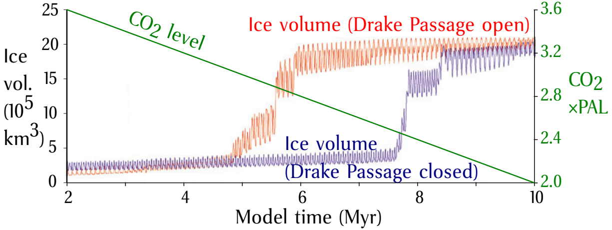
opening ocean gateways ⇒ circumpolar current ⇒ thermal isolation, producing a first major glaciation in the Oligocene.

(Reconstructions: Lawver & Gahagan, 2003)

The CO_2 hypothesis: glaciation without gateways



Miller *et al.* (2005) sea-level and $\delta^{18}O$ curves: where did the water go?



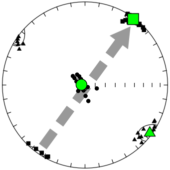
DeConto & Pollard (2003) simulation: CO_2 decline vs. Drake Passage

Leckie *et al.* (1995): dropstones in Palaeocene Whangai Formation.

How would we recognize Palaeocene glaciation?

Ice-rafted debris

Unconformities (from eustasy and current)

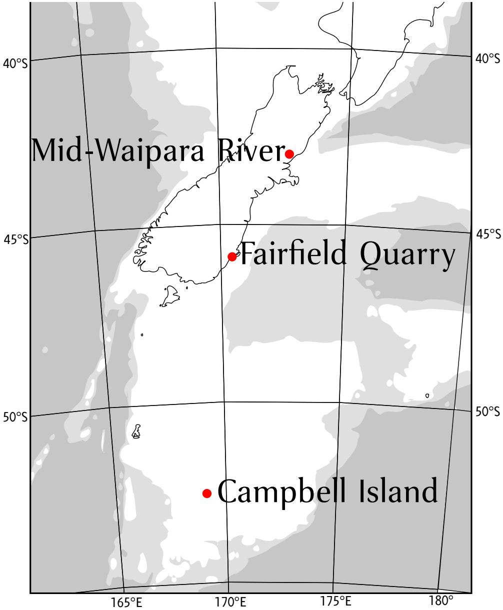


Sedimentary fabric (from palaeocurrent)

Glaucony (from reduced deposition)

- Other indicators: isotopes, biota.
- The Marshall Paraconformity provides a template.
- We need high-resolution temporal correlation across a wide area – **magnetostratigraphy** can provide this.

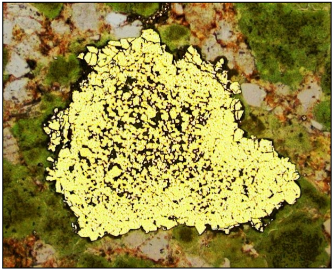
Field areas

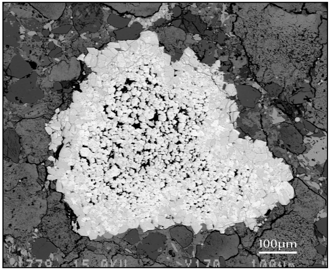


- Well placed for a proto-DWBC.
- Palaeocene to Eocene age.
- Mainly mud/silt.
- Broad geographical area.
- Range of palaeoenvironments.

Magnetic mineralogy

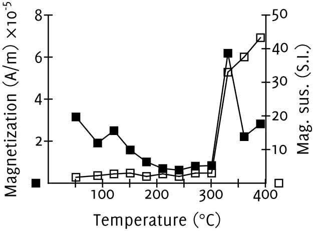
What's carrying the magnetization, and how did it get there?

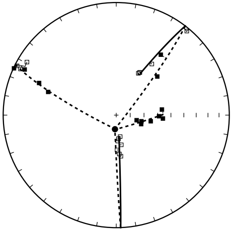




- Lots of (non-magnetic) pyrite and glaucony.
- Magnetism carried by non-glauconitic fraction.
- High-susceptibility glaucony complicates analysis.
- Rock magnetism indicates <1ppm sub-micron magnetite.
- Strangely, no greigite or pyrrhotite.
- How did any magnetite escape pyritization?
- Probably physically protected by encapsulation or overgrowth.

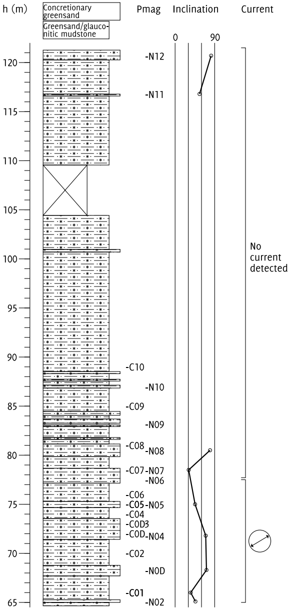
Palaeomagnetic behaviour





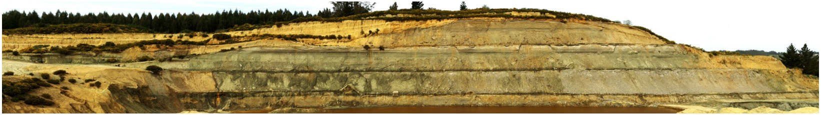
- Very weakly magnetized – little work on similar sediments.
- Stepwise heating: low alteration temperature (usually ~300°C).
- Mostly simple behaviour, but with hidden primary component.
- Great-circle remagnetization analysis required.
- Special software (PuffinPlot) written for analysis.

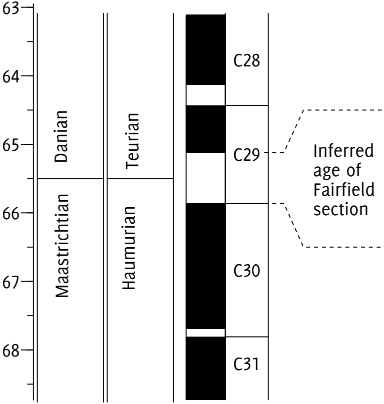
Mid-Waipara River



- 16 m thickness sampled, glauconitic throughout.
- Frequent glauconitic concretionary horizons.
- All within C26r chron (61.65–58.74 Ma).
- Falls between Leckie *et al.* IRD event and ~58–56 Ma PCIM event.
- Palaeocurrent weakens up-section.

Fairfield Quarry



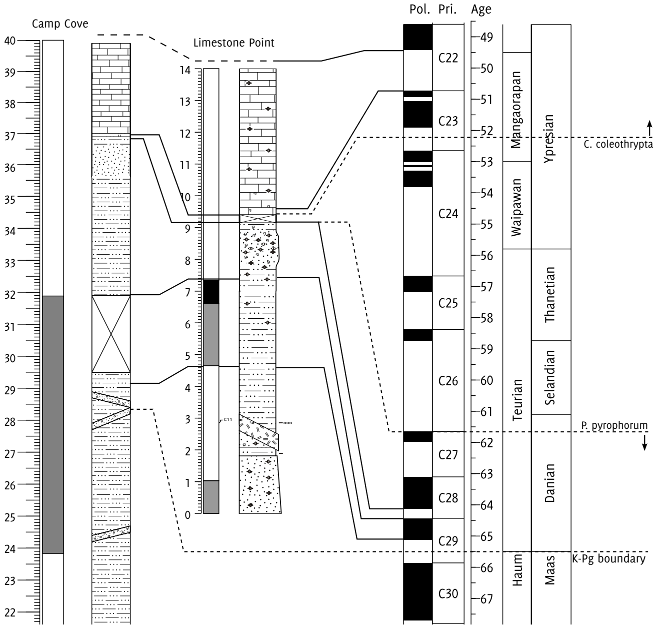


- Dinoflagellate age: latest Cretaceous to Early Palaeocene (McMillan, 1993).
- Magnetostratigraphy constrains sampled portion to C29r (65.86–65.12 Ma)
- Unconformities higher in section: sedimentation rate implies significant duration.

Campbell Island: introduction

- Garden Cove Fmn. (mudstone) / Tucker Cove Fmn. (limestone)
- Known Palaeocene/Eocene unconformity.
- Two sections sampled, analysed, and integrated.

Campbell Island: magnetostratigraphy



Campbell Island: conclusions

- Known duration of unconformity expanded.
- Unconformity old enough to contain Leckie *et al.* (1995) IRD episode (and already known to contain PCIM).
- Lonestones (possible IRD) found at unconformity.
- Palaeocurrent (TODO)

Conclusions

- Analysis of weakly magnetic glauconitic sediments:
  - High susceptibility / weak magnetization complicates rock magnetic work.
  - Glaucony doesn't complicate palaeomagnetism like e.g. greigite.
  - Main problems are thermal alteration and weak magnetization.
- General-purpose palaeomagnetic analysis software.
- Improved dates and sedimentation rates for studied sections.
- Results consistent with widespread Palaeocene unconformity.

Acknowledgements & References

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References

Robert M. DeConto and David Pollard. Rapid Cenozoic glaciation of Antarctica induced by declining atmospheric CO_2. *Nature*, 241:245–249, 2003.

Lawrence A. Lawver and Lisa M. Gahagan. Evolution of Cenozoic seaways in the circum-Antarctic region. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 198(1-2): 11–37, 2003.

Dale A. Leckie, Hugh Morgans, G. J. Wilson, and A. R. Edwards. Mid-Paleocene dropstones in the Whangai Formation, New Zealand – evidence of mid-Paleocene cold climate? *Sedimentary Geology*, 97(3-4):119–129, 1995.

S. G. McMillan. *The Abbotsford Formation*. PhD thesis, University of Otago, Dunedin, New Zealand, 1993.

Kenneth G. Miller, James D. Wright, and James V. Browning. Visions of ice sheets in a greenhouse world. *Marine Geology*, 217(3-4):215–231, 2005.