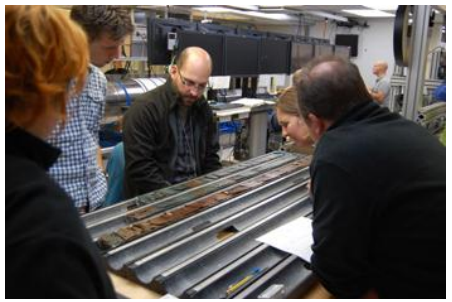
Drilling Back in the Future – Past Stability of the East Antarctic Ice Sheet

Tina van de Flierdt,
Imperial College London

C. Cook (Imperial College London); S. Hemming, T. William, E. Pierce (LDEO, Columbia University); Carlota Escutia (U Granada), H. Brinkhuis (NIOZ) & IODP Expedition 318 Science Party

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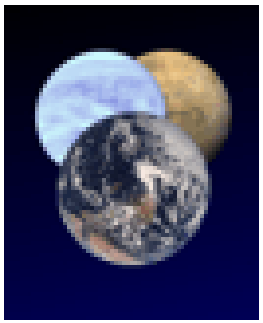
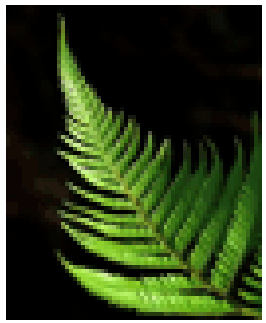




What we do:

Research Sections:

(1) Earth and Planetary Science

(2) Petroleum Geoscience and Engineering

(3) Energy, Environment, Modelling & Minerals (E^2M^2)

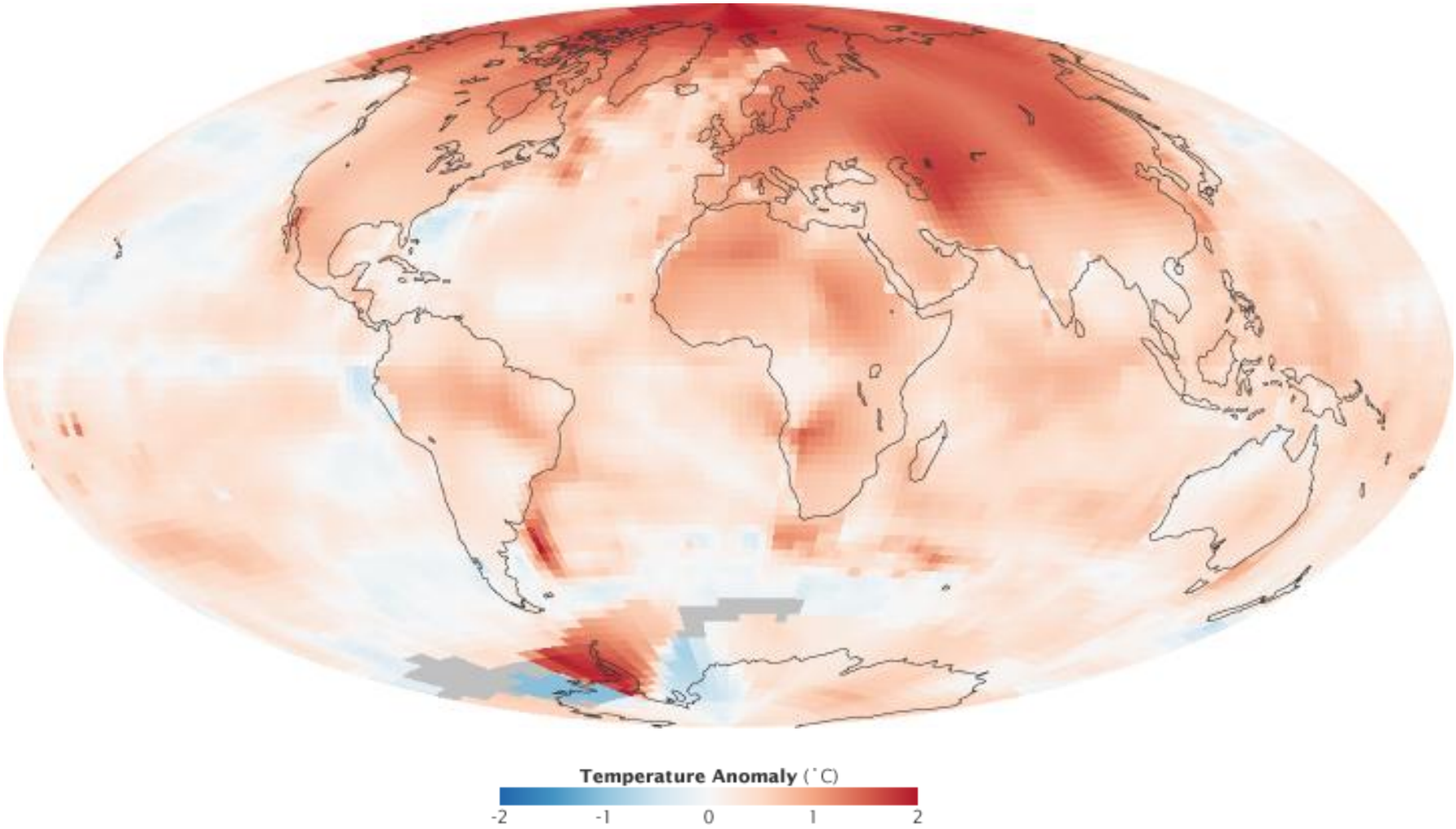
- Links with the *Grantham Institute for Climate Change*

Grantham Institute for climate change

⇨ **climate change research**

Imperial College London

Climate Change Observations: Temperature Anomaly, 2000 - 2009



http://earthobservatory.nasa.gov/Features/WorldOfChange/decadaltemp.php

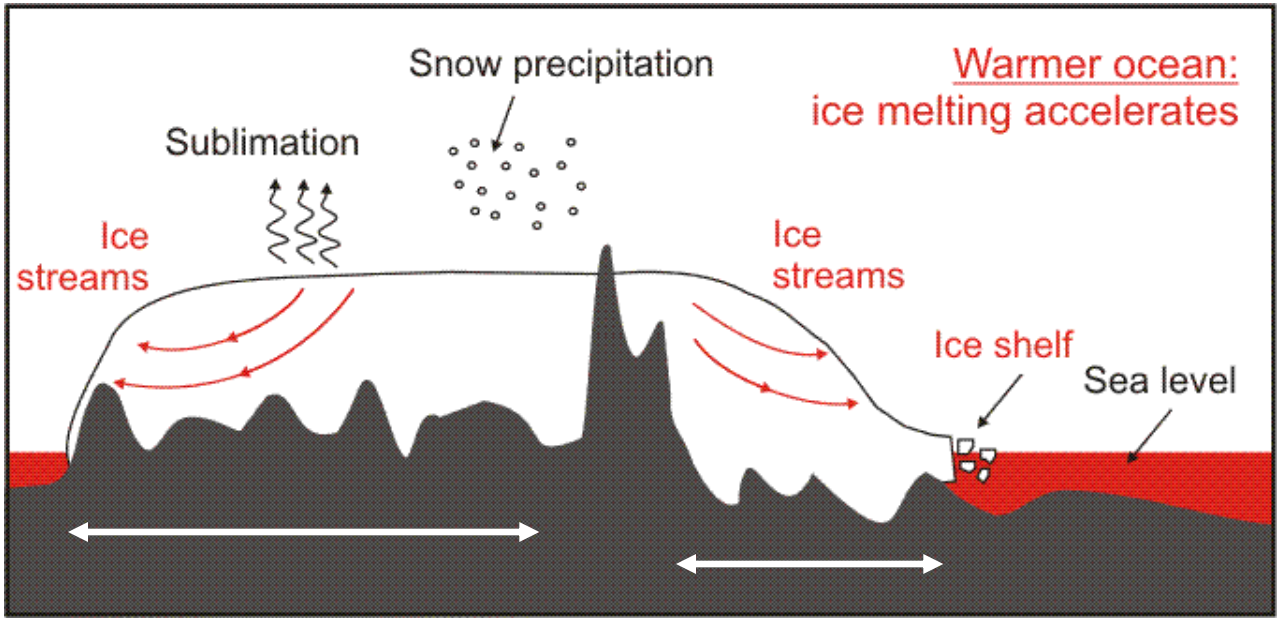
The Big Unknown in the Sea Level Equation – The Ice Sheets

Greenland:
~ 5-7 m of SLE

West Antarctica:
~ 3-5 m SLE
East Antarctica:
~ 52 m SLE

SLE = sea level equivalent

Antarctic Ice Sheets and Ocean Warming

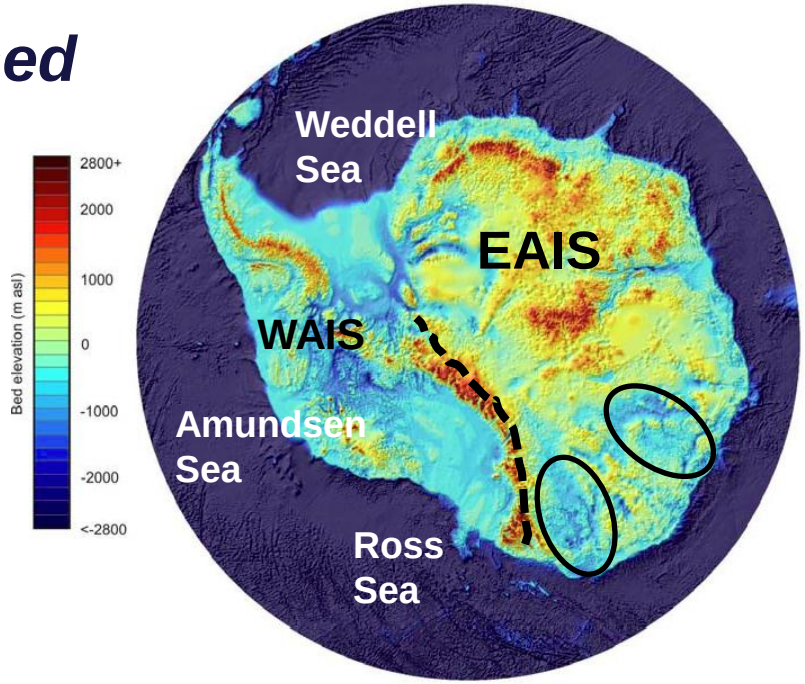


Continental-based ice sheet

(e.g. East Antarctic Ice Sheet = EAIS)

Marine-based ice sheet

(e.g. West Antarctic Ice Sheet)



... but not everywhere ....

Response of Ice Sheets to Warming

⇨ *last ten years*: dramatic increase in observational data and associated scientific understanding

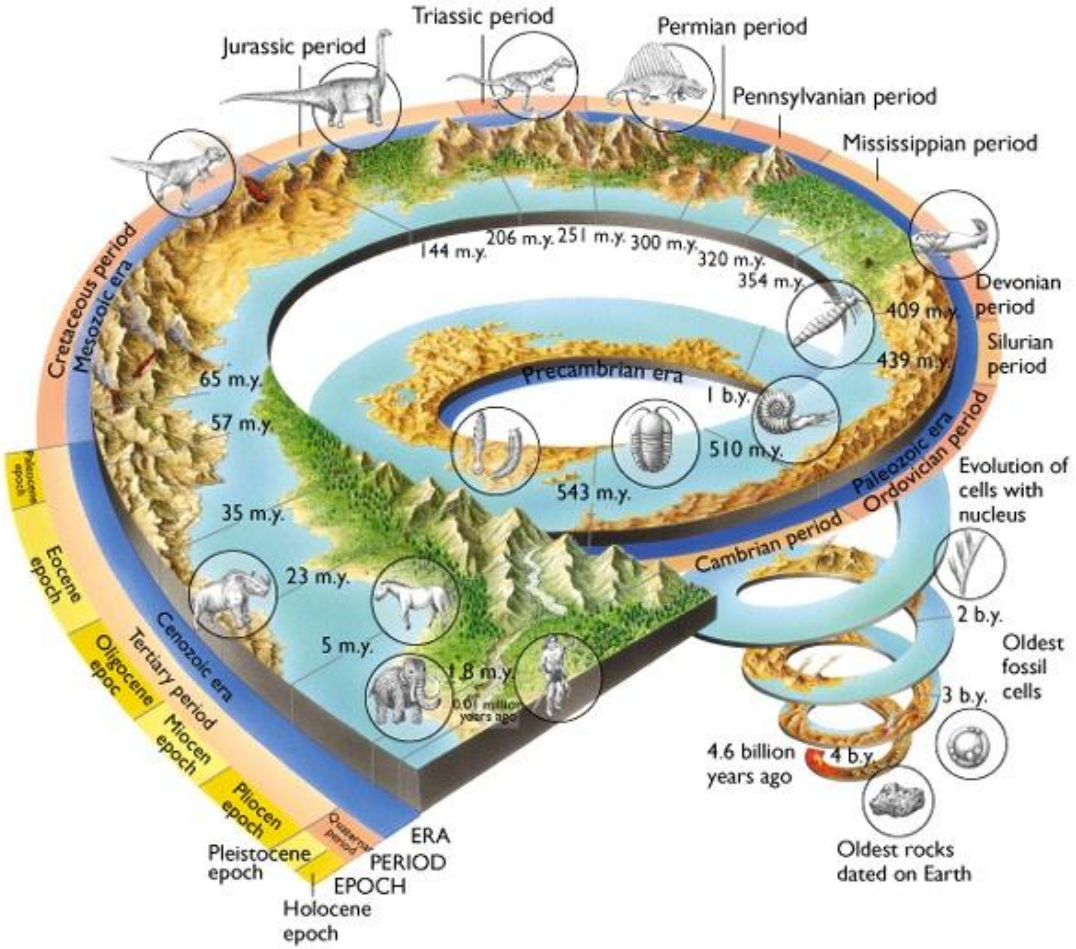
- 2001 IPCC report: '***loss of grounded ice*** leading to substantial sea level rise from West Antarctica is widely agreed to be ***very unlikely***' and 'the Antarctic ice sheet is likely to gain mass'
- 2007 IPCC report: 'new data show that ***losses from the ice sheets of Greenland and Antarctica*** have ***very likely*** contributed to sea level rise over 1993 to 2003'

…dynamics of the ice sheets were however still considered too complicated to include in predictions for sea level rise ...

Antarctica was ice-free in the geological past, many million years ago…

Trees on Antarctica
~50 million years ago

(Pross et al., 2012, Nature)



Deep Sea Drilling Project (1968 – 1983)

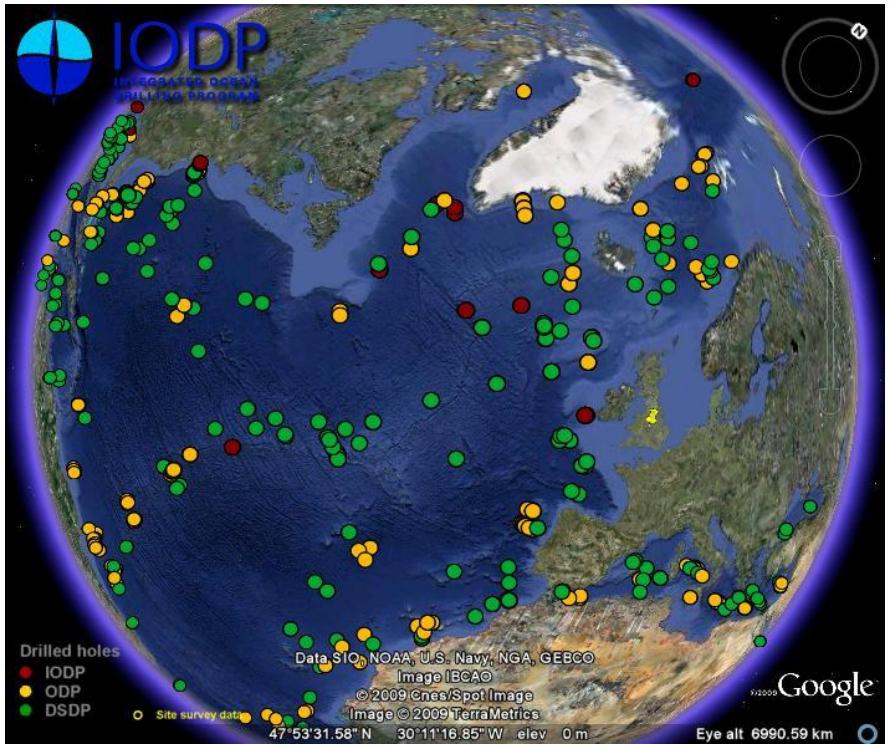
IODP INTEGRATED OCEAN DRILLING PROGRAM (since 2004)

OCEAN DRILLING PROGRAM (1985 – 2003)

Young sediment

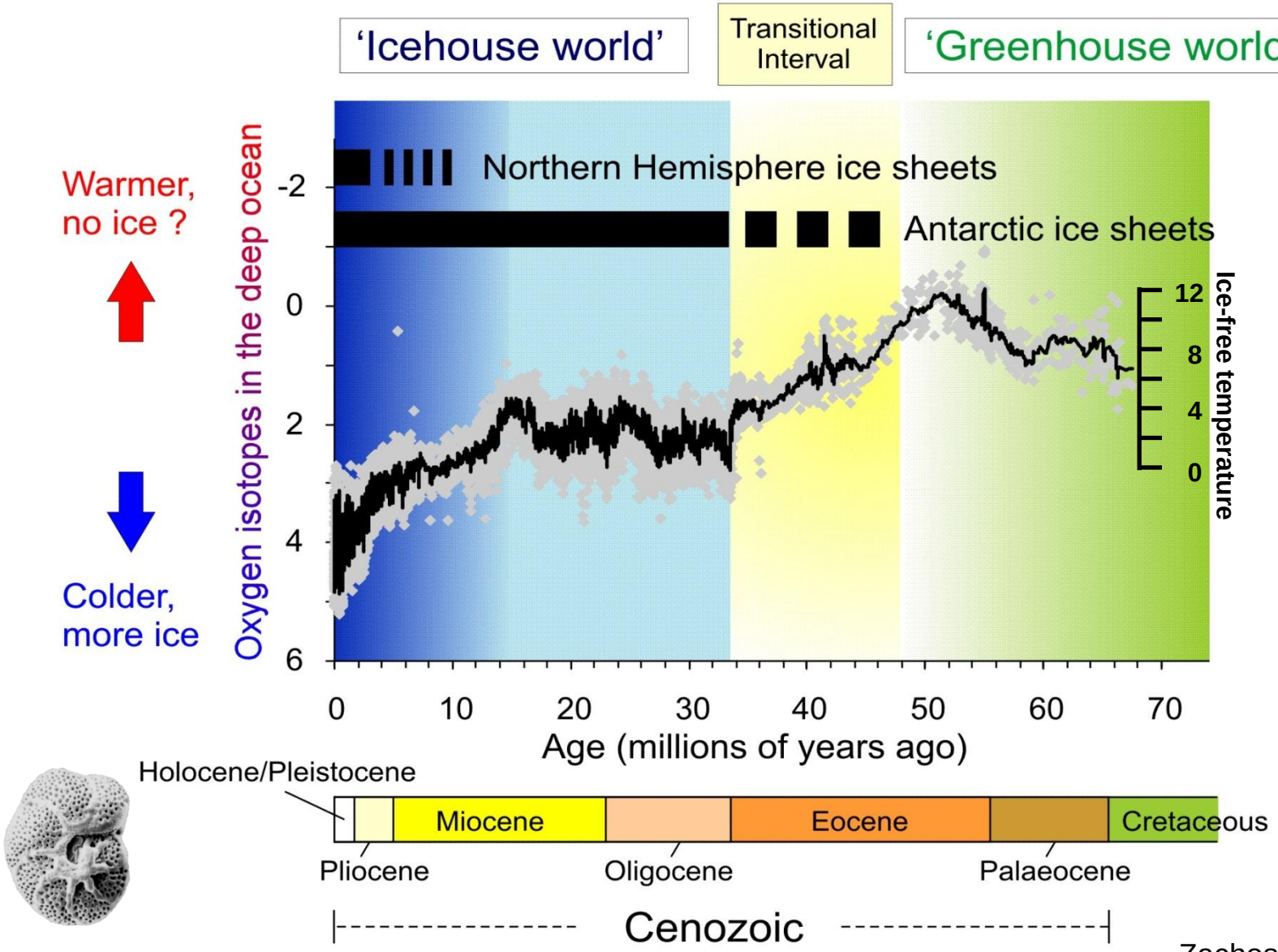
↓

Old sediment



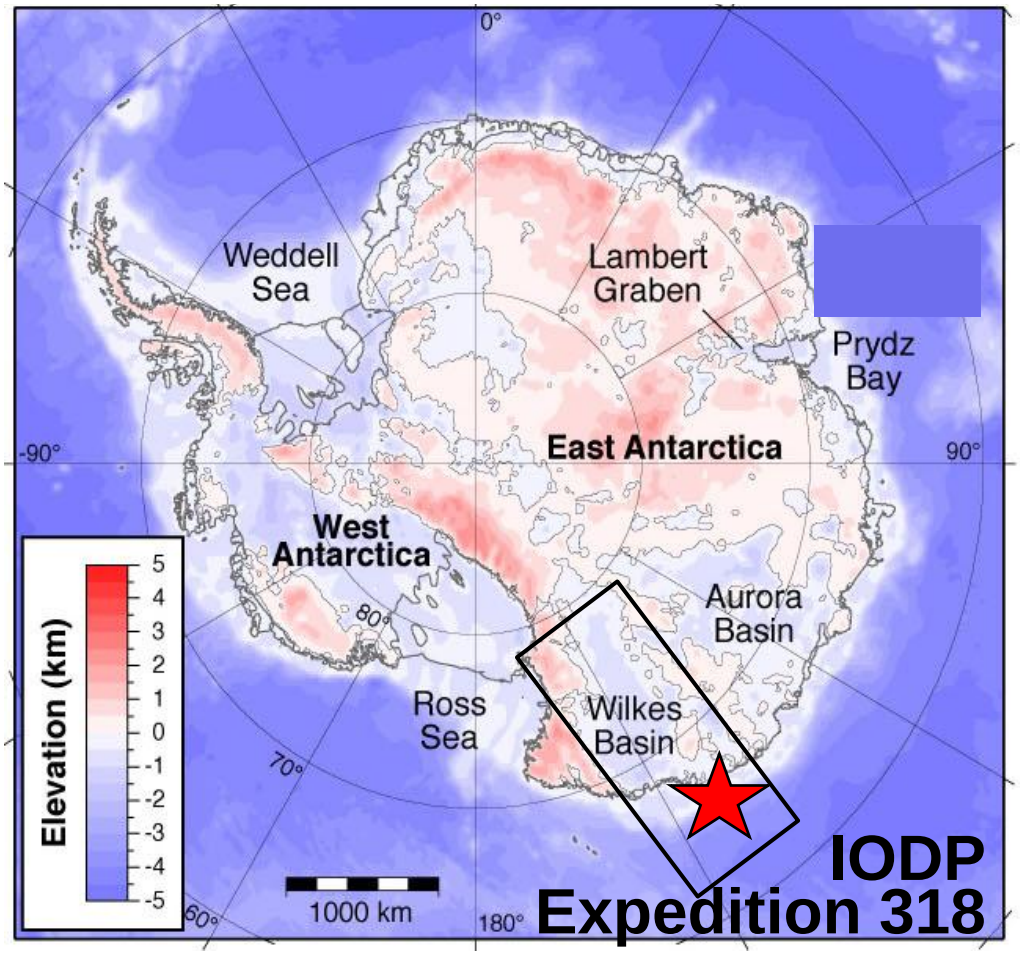
Starting 10/2013: International Ocean Discovery Program

Global Climate Over the Last 65 Myr

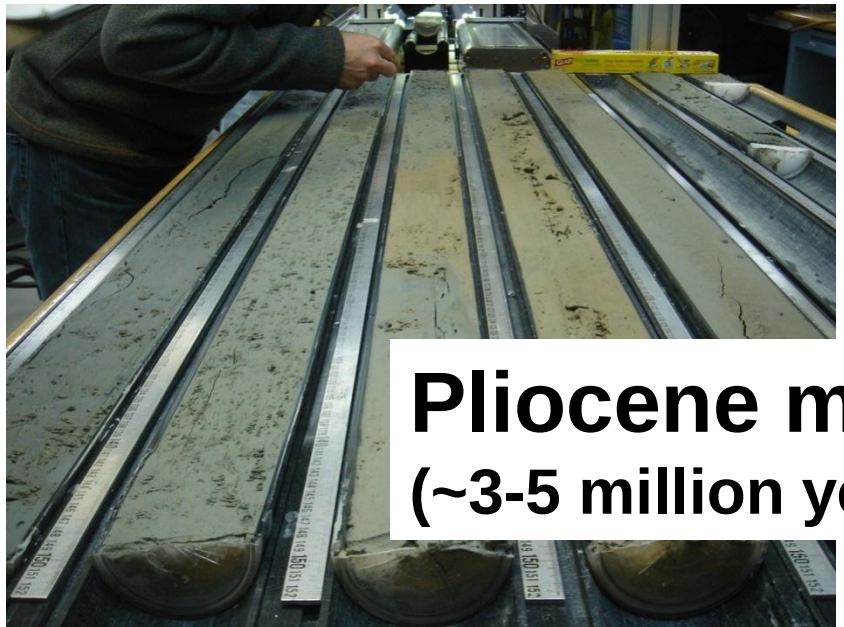


Zachos et al., 2008

IODP Exp. 318, Wilkes Land, Jan – March, 2010



Seasonally Laminated Holocene Record
(~10,000 yrs old)

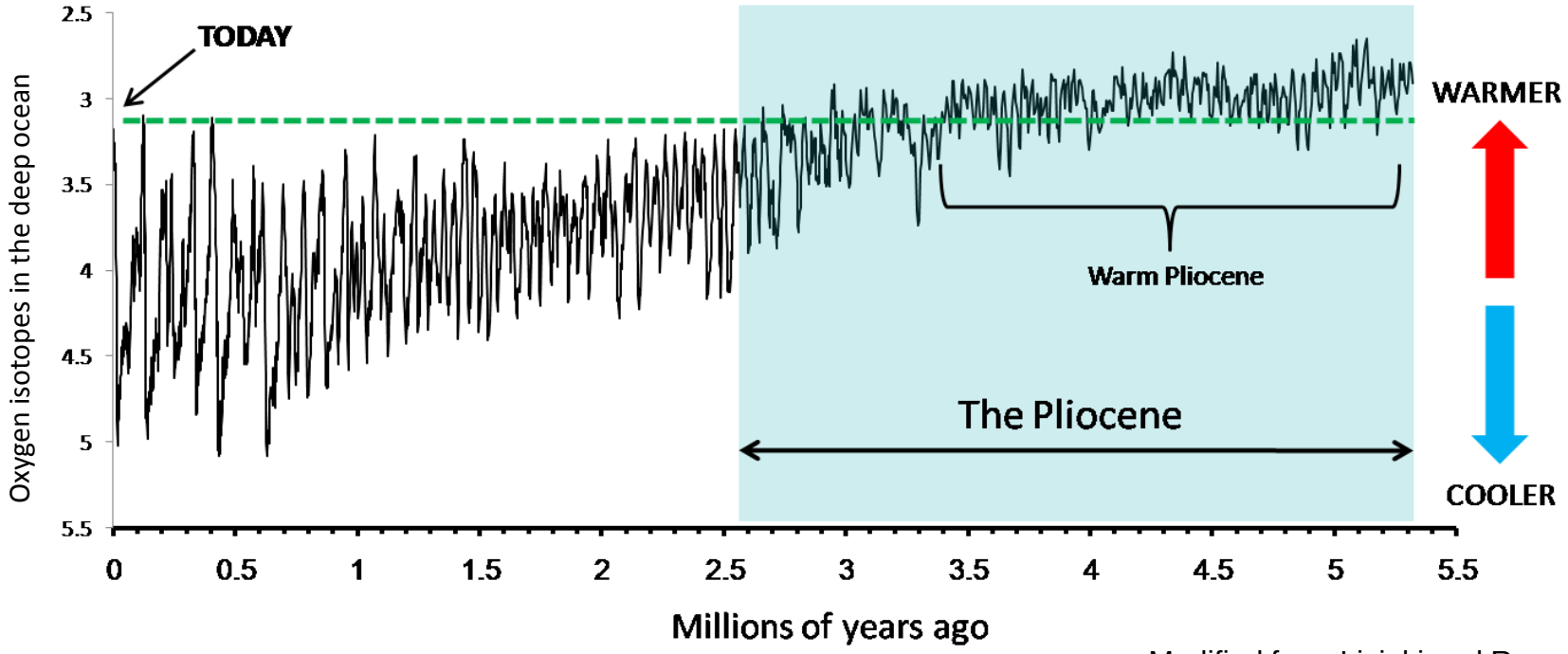


Pliocene mud
(~3-5 million years old)

⬆ Eocene Greenhouse Sediments
(~50 million years old)

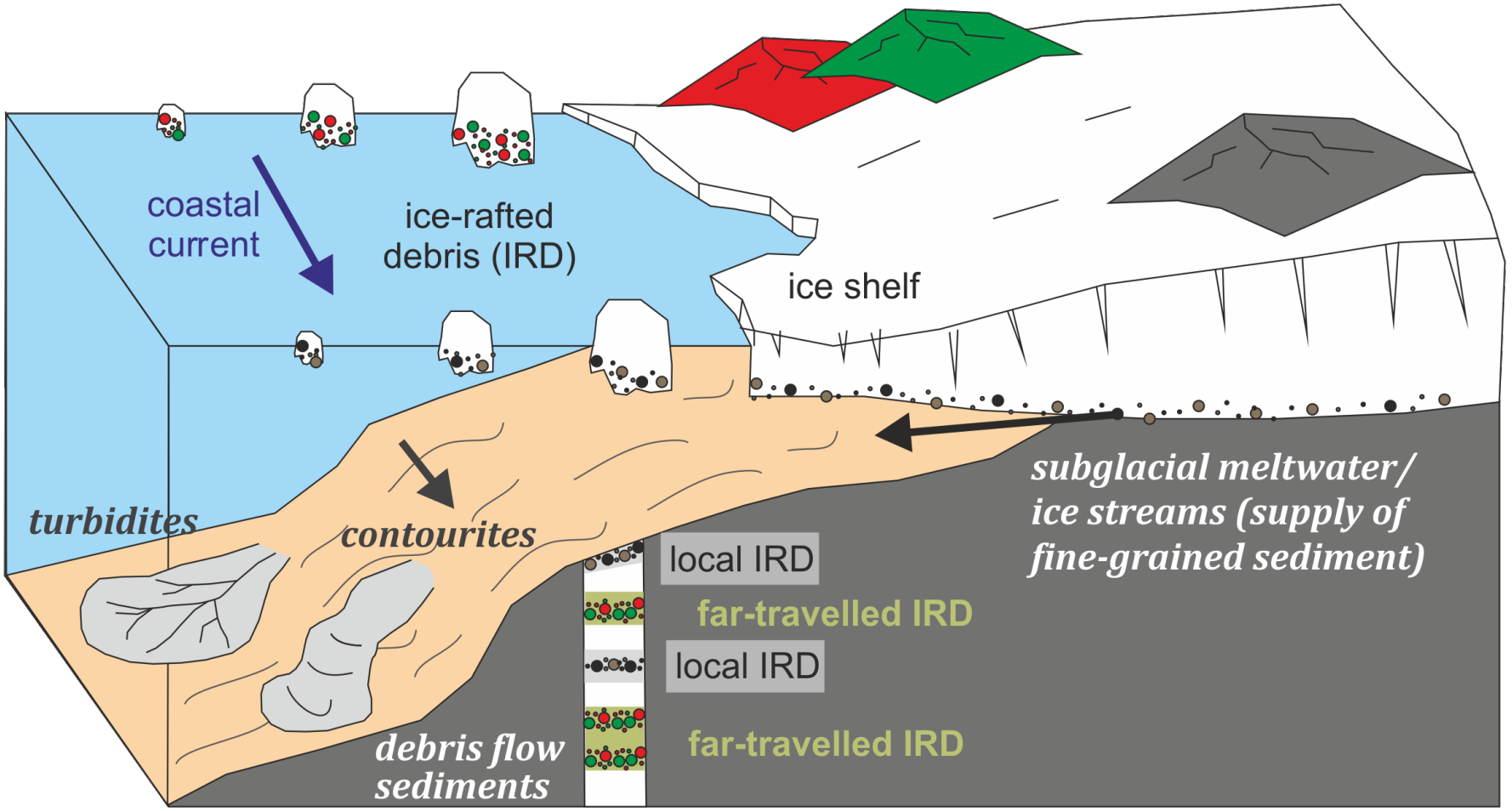
The Pliocene – A look into our Future?

- Pliocene temperatures were 2-3°C warmer, and atmospheric CO_2 levels were similar to today
- sea level has been estimated to be 12-30m higher than today (requires East Antarctic contributions)



Modified from Lisieki and Raymo, 2005

Sediments Hold a Chemical Record of Provenance and Can Tell us About Ice Stability Back in Time



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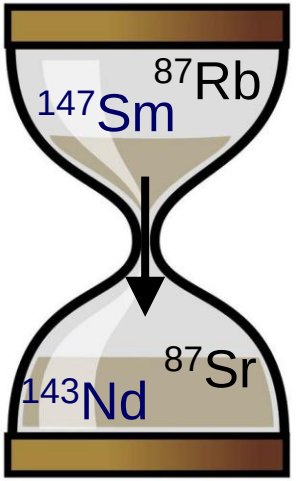
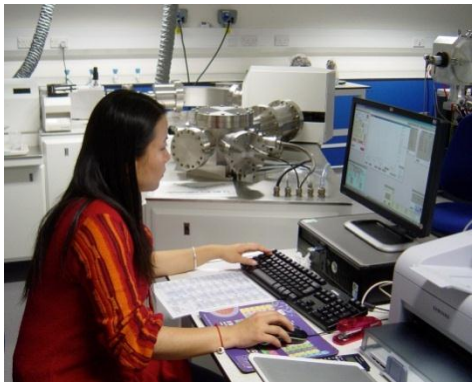
M A G I C

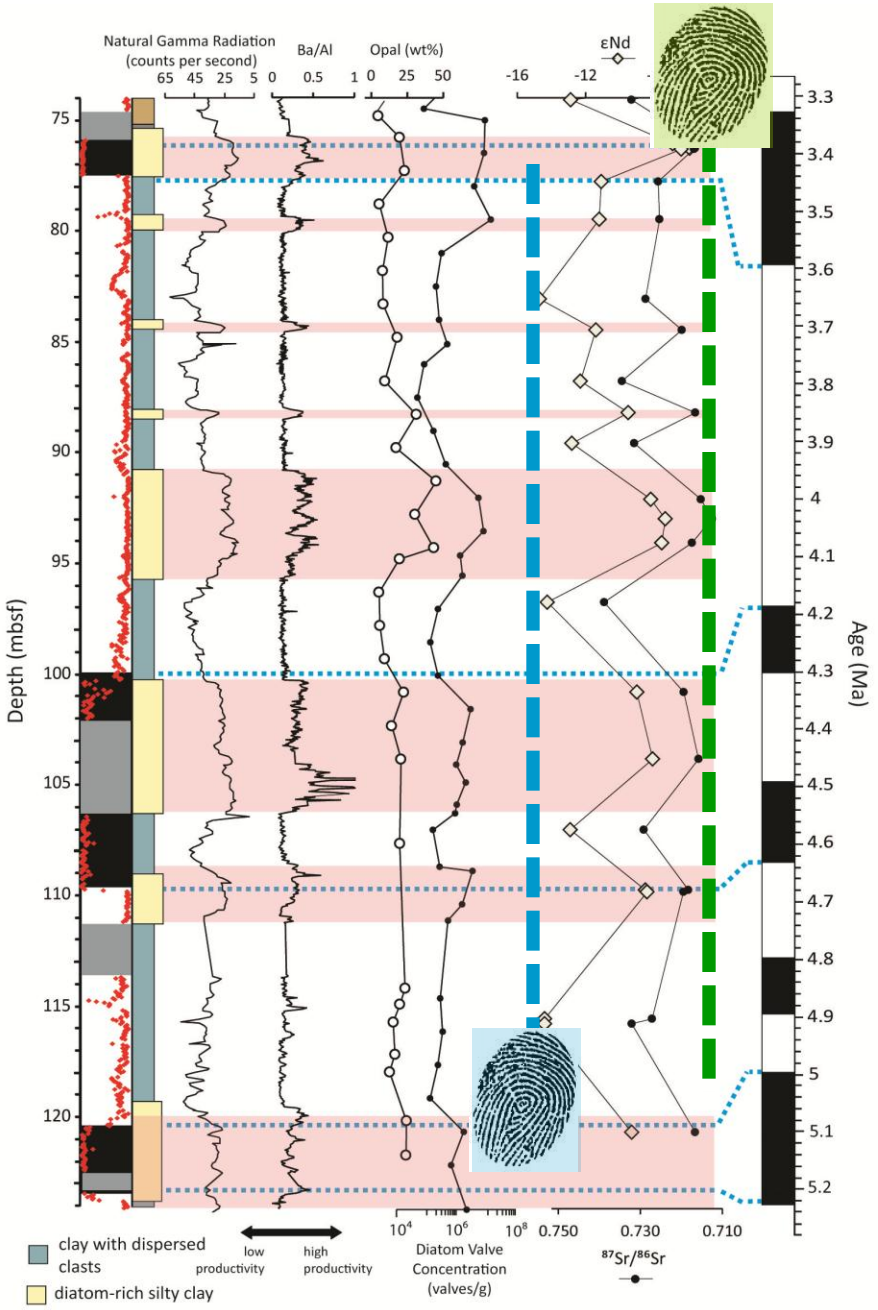
Mass Spectrometry and Isotope Geochemistry at Imperial College London





£2 million facility,
£1.5 million
extension underway

Tool: Radio-active clocks



WARM EARLY PLIOCENE INTERVALS

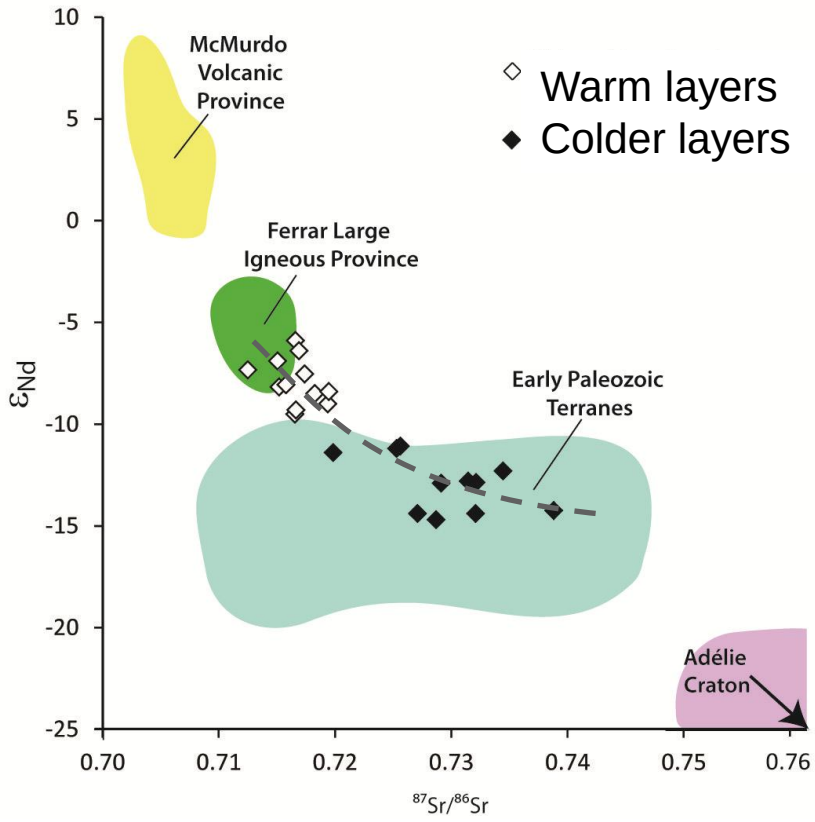
Characteristics:

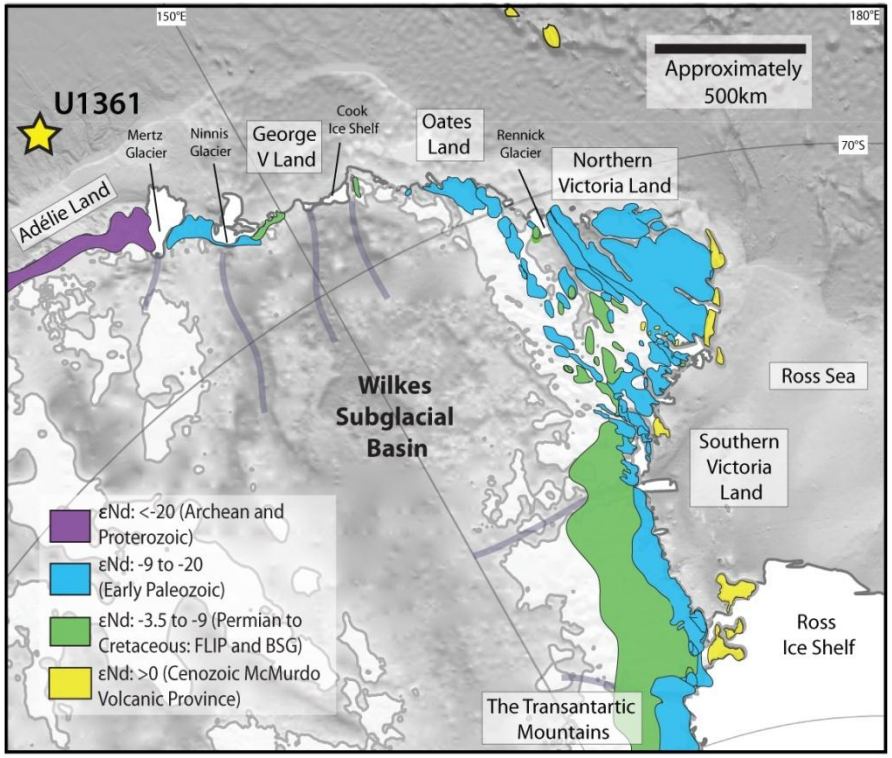
- diatom and opal-rich
- low in clays
- rich in clasts
- high productivity

⇨ **Different fingerprints in colder and warmer intervals**

Cook et al. (2013), Nature Geoscience

Local Geology And its Chemical Fingerprint



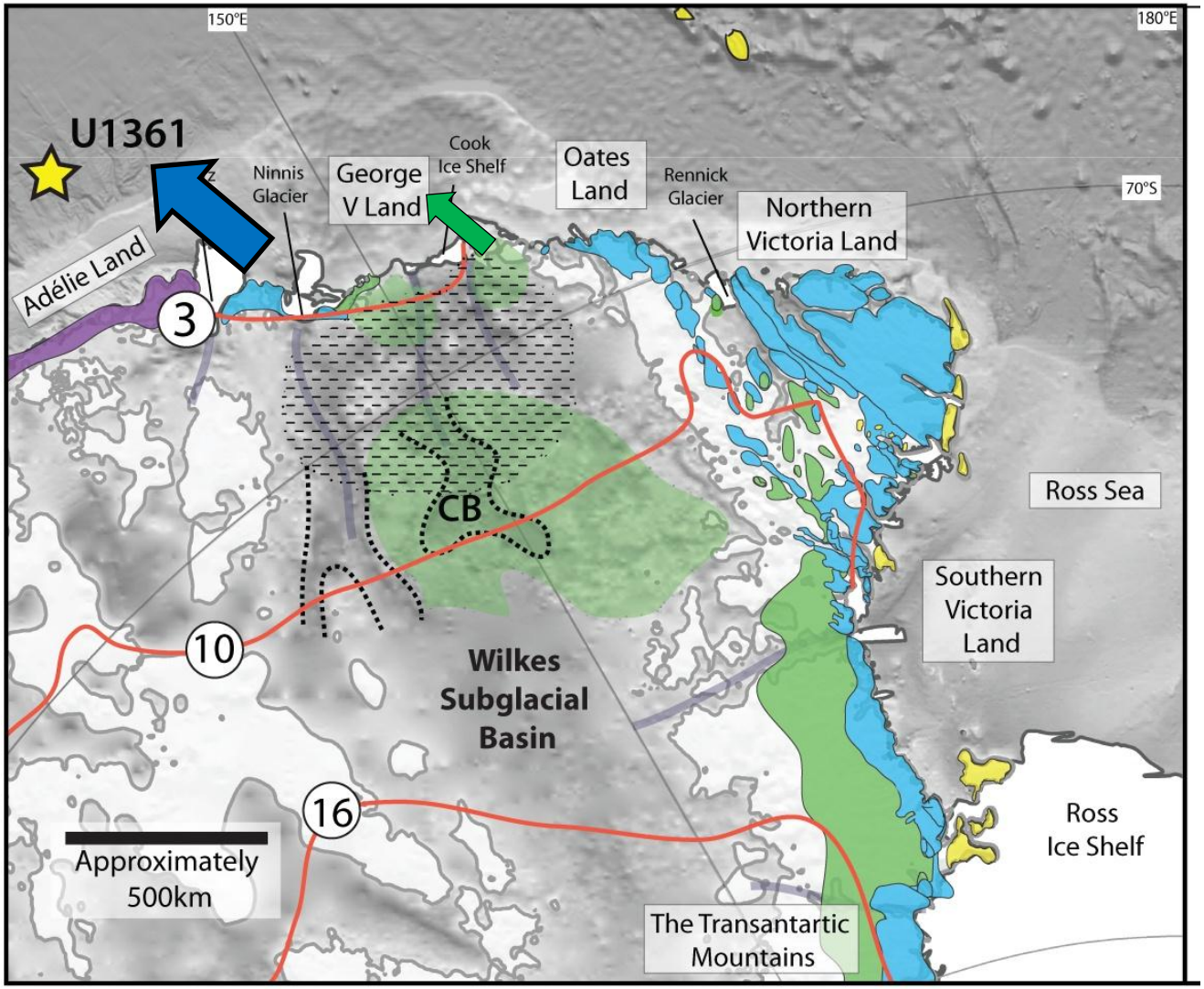


Four main geological terranes.

⇨ Pliocene samples fall between **Palaeozoic terranes** and **Ferrar Large Igneous Province**

Cook et al. (2013), Nature Geoscience

Local Erosion during Colder Times



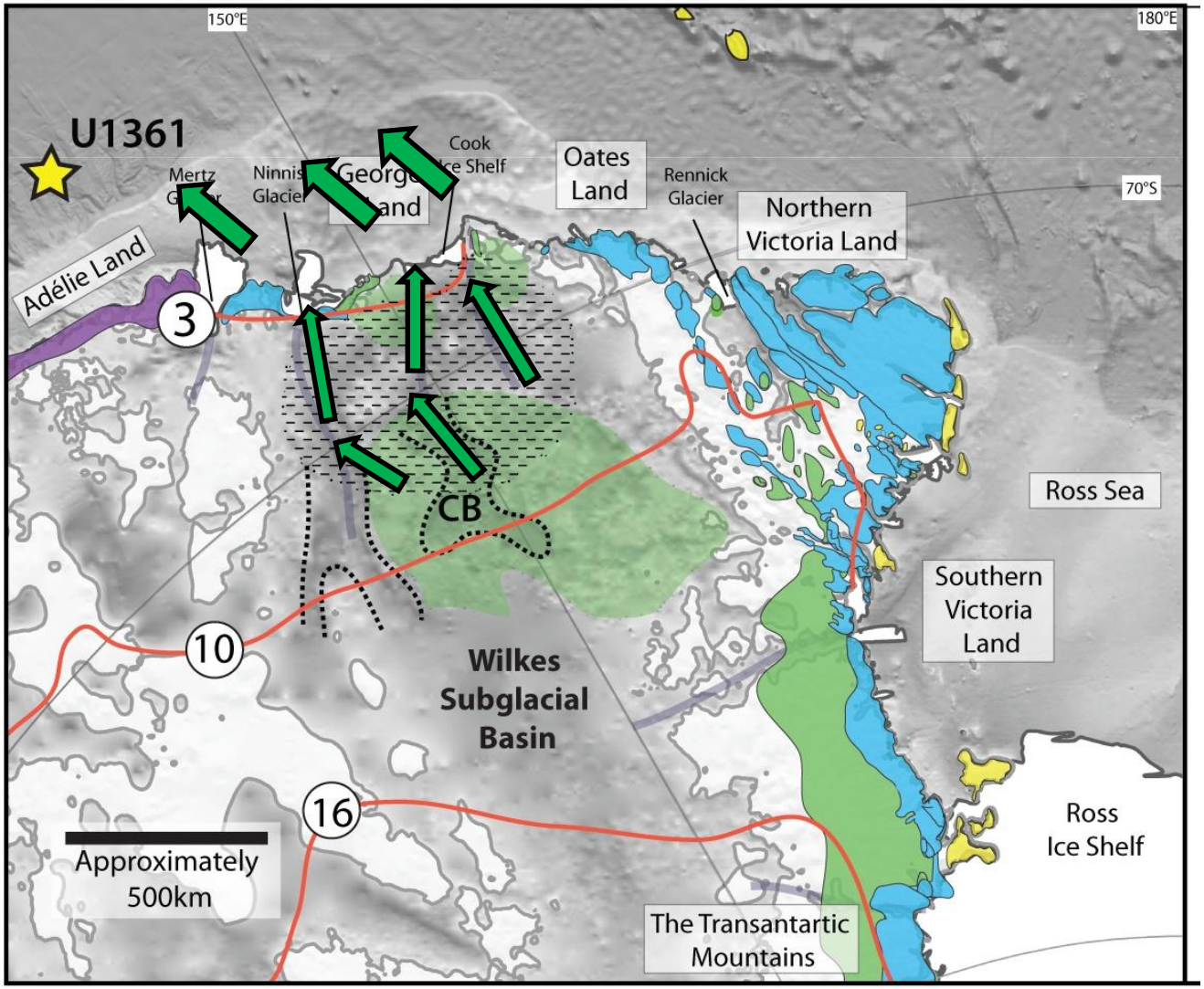
Hatched – area of maximum erosion.

Green shading – Ferrar basalts inferred from airborne geophysics.

Red lines – modelled ice retreat in metres

Cook et al. (2013), Nature Geoscience

Ice Retreat into the Wilkes Subglacial Basin during Pliocene Warmth



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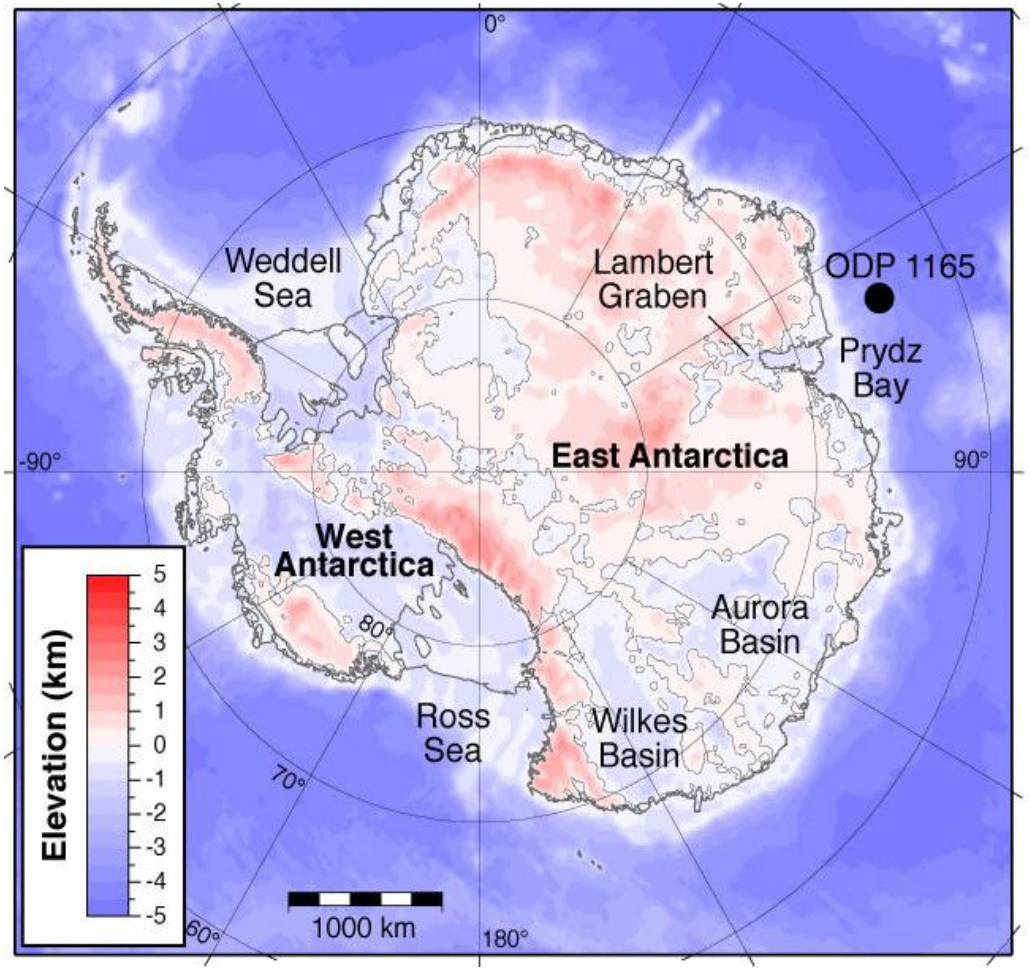
Red lines – modelled ice retreat in metres

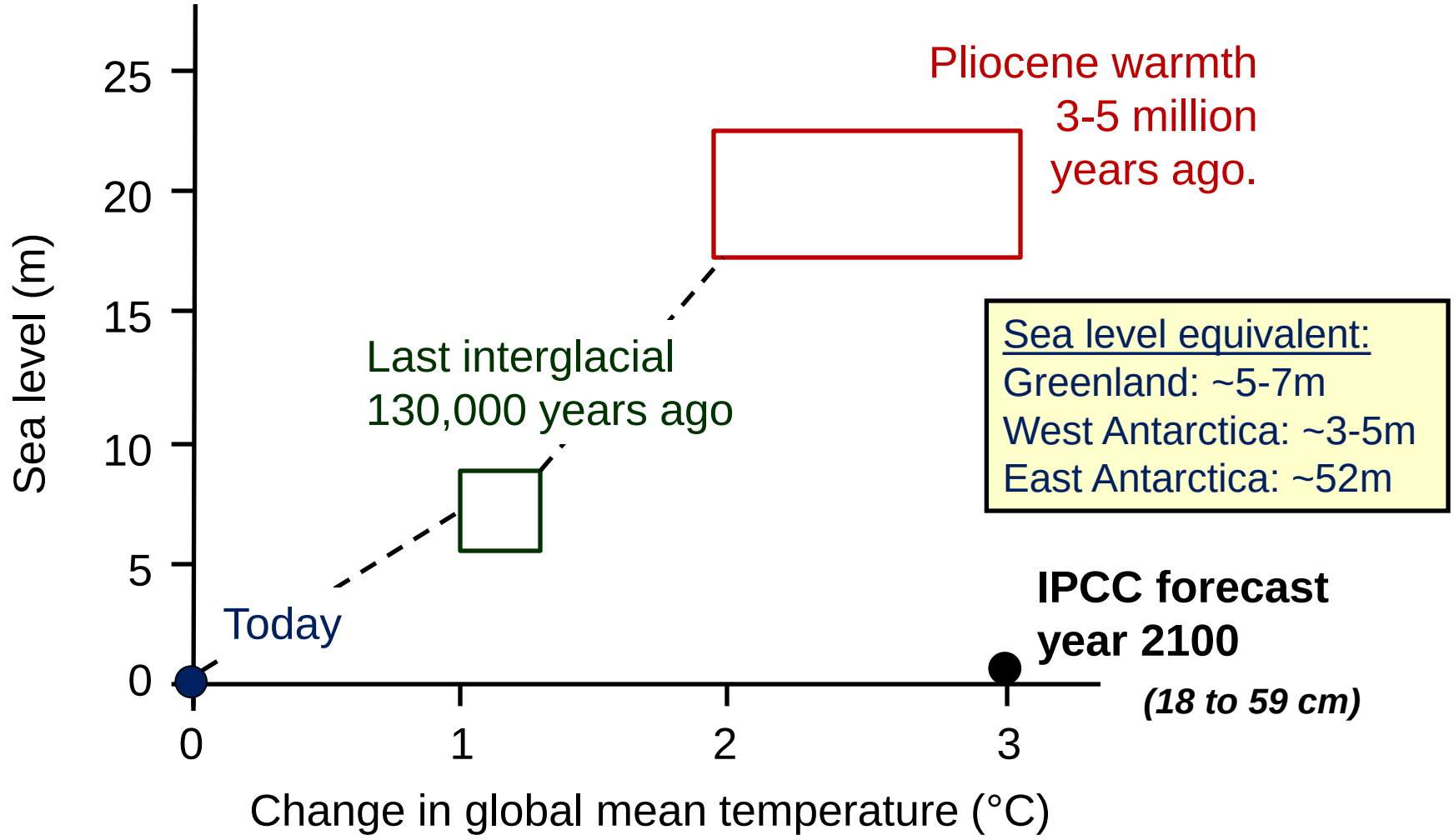
Cook et al. (2013), Nature Geoscience

Implications for Places of Ice Instability under Future Warmer Climate



Low lying subglacial areas (blue colours) seem vulnerable to melting / ice retreat under conditions similar to the ones predicted for 2100.

Palaeoclimate Data Urge us to Not Forget About the Ice Sheets in a Warmer World ...



modified from: Archer and Rahmstorf, 2010

Acknowledgements: