http://www.icdp-online.org/projects/world/africa/tanzania/

TANZANIA ONSHORE PALEOGENE INTEGRATED CORING (TOPIC)

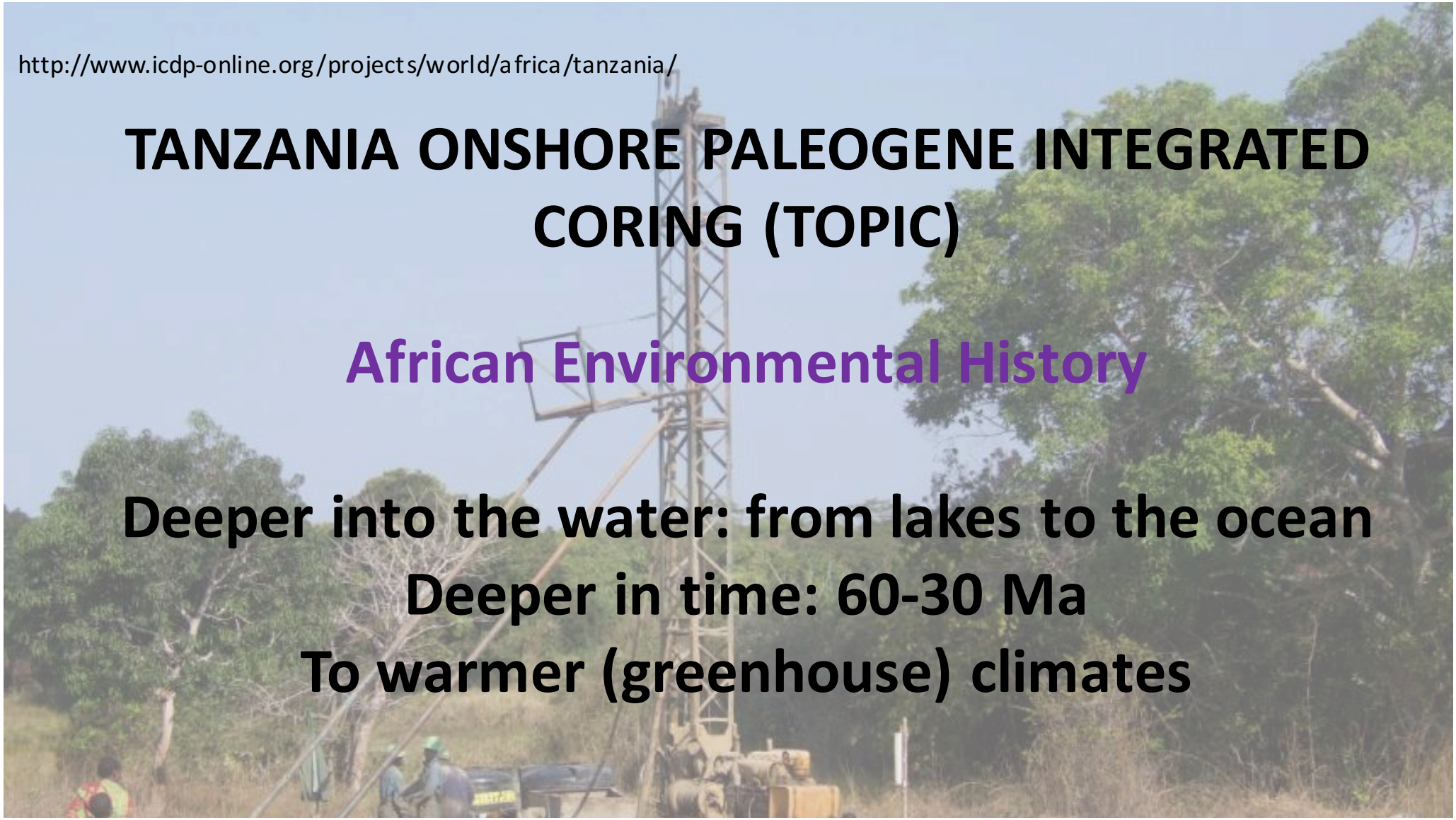
Paul Pearson (Cardiff University, UK)

Ellen Thomas (Wesleyan and Yale University, USA)

US participants:

Gabe Bowen (University of Utah), Melissa Berke (University of Notre Dame), Sarah Feakins (University of Southern California), Matt Huber (University of New Hampshire)

28 participants other countries



http://www.icdp-online.org/projects/world/africa/tanzania/

TANZANIA ONSHORE PALEOGENE INTEGRATED CORING (TOPIC)

African Environmental History

Deeper into the water: from lakes to the ocean
Deeper in time: 60-30 Ma
To warmer (greenhouse) climates

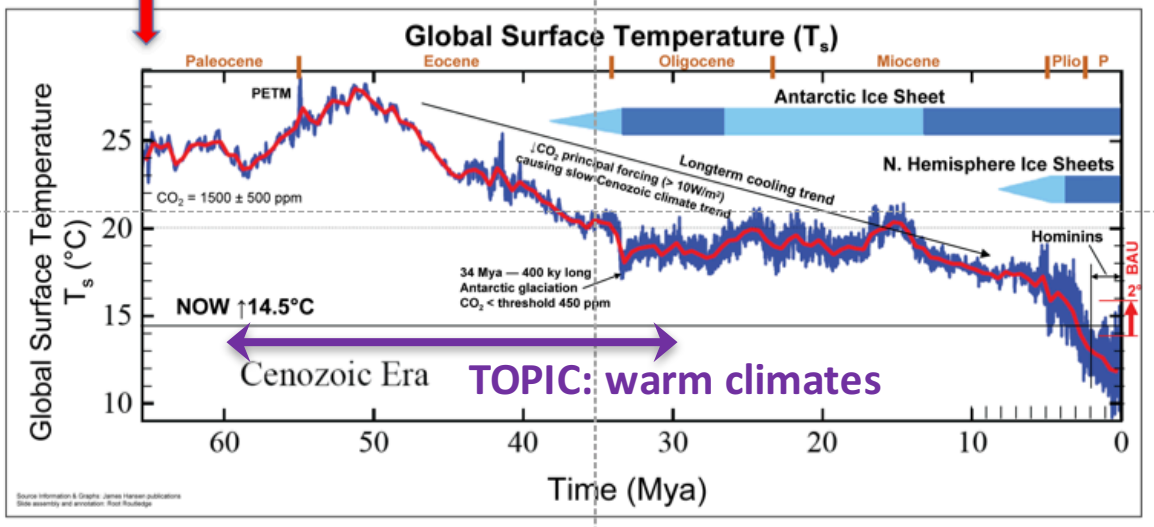
http://www.icdp-online.org/projects/world/africa/tanzania/

TANZANIA ONSHORE PALEOGENE INTEGRATED CORING (TOPIC)- goals?

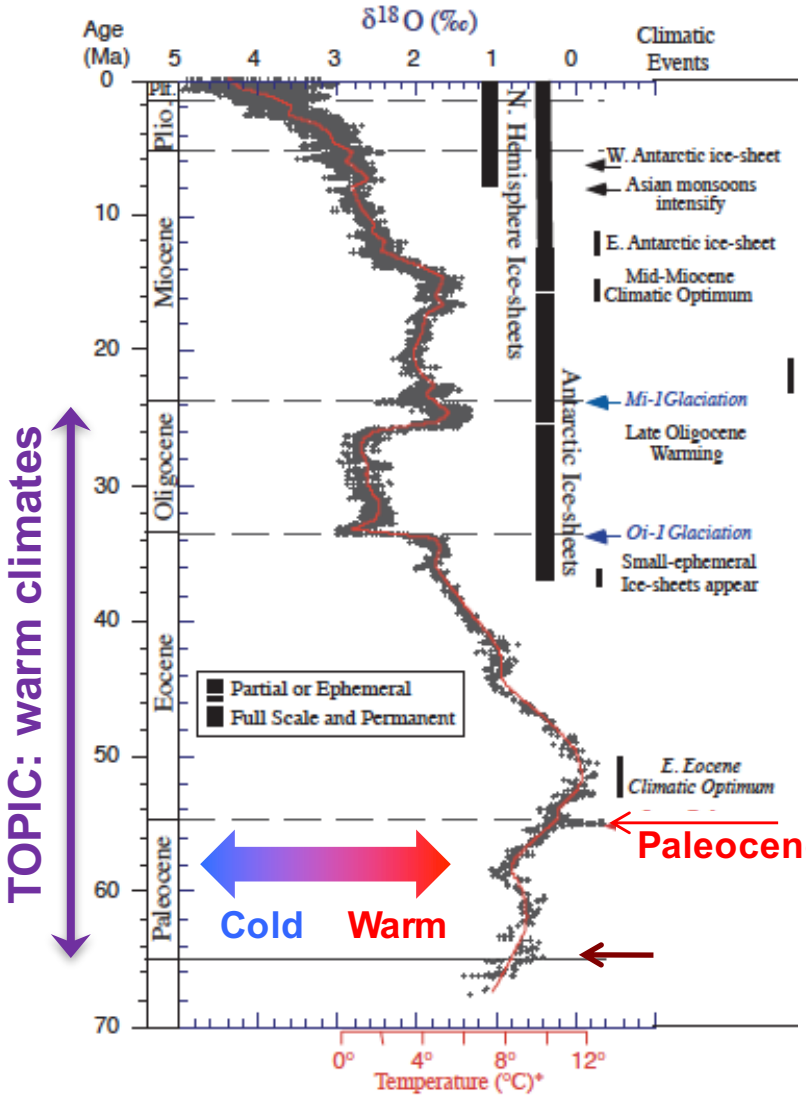
PAST CLIMATE OF THE EARTH- what do we know and how do we know it?

Google, Bing, wikipedia, and so on…

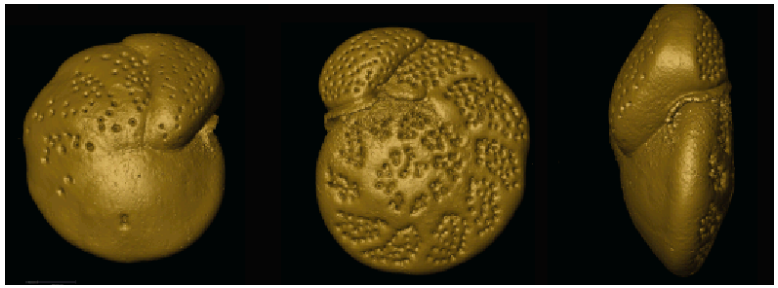
Extinction dinosaurs



http://www.alpineanalytics.com/Climate/DeepTime.html



- Source of many of these plots: Zachos et al., 2001, *Science*
  Updates: Zachos et al., 2008, Cramer et al., 2009



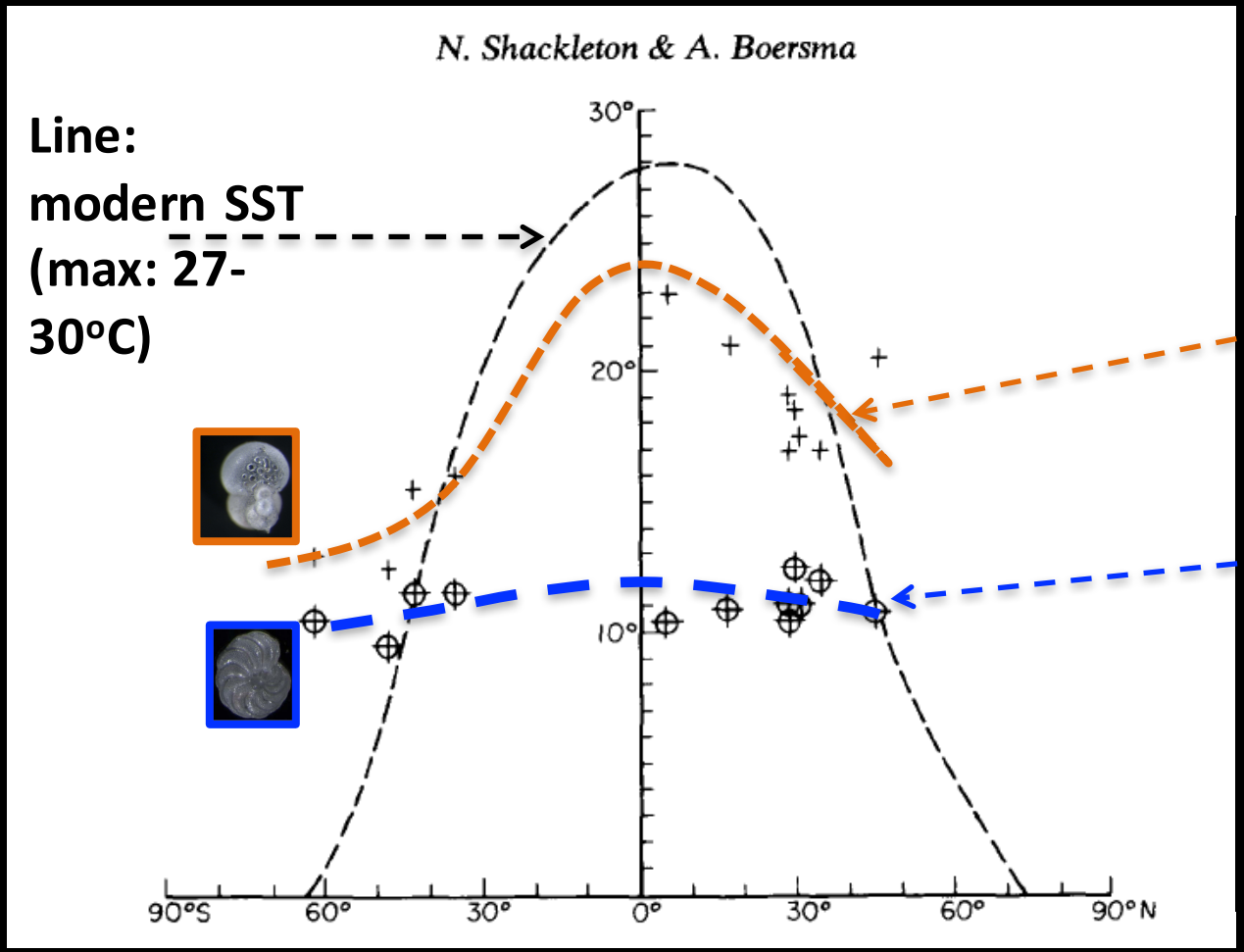
Stable isotope analyses ($^{18}O/^{16}O$) of $CaCO_3$ in benthic foraminiferal tests shells.

SHELLS MUST BE WELL PRESERVED

$\delta^{18}O$: lighter values (to the right) = warmer, and/or smaller ice caps

Paleocene-Eocene Thermal Maximum - PETM (~ 55-56 Ma ago)

End Cretaceous (K/Pg): extinction Dinosaurs (~ 65-66 Ma ago)



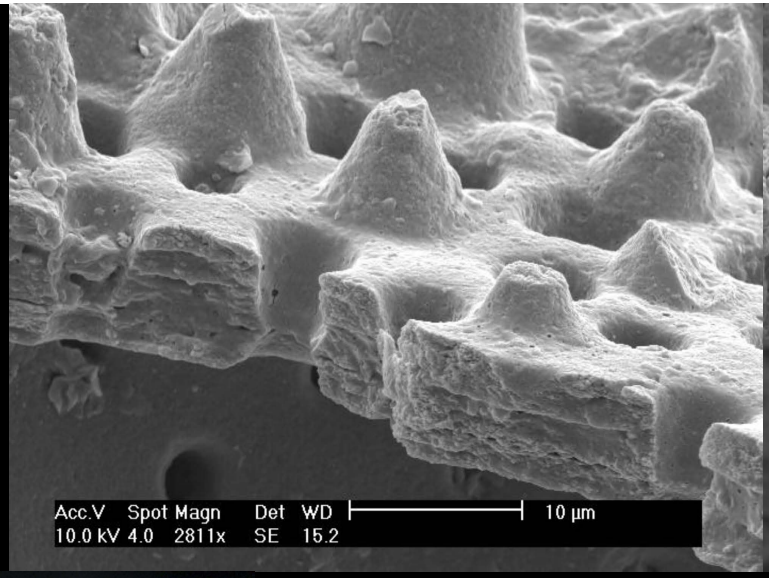
'Cool Tropics Paradox': tropical sea surface temperatures appeared cool while poles were very warm

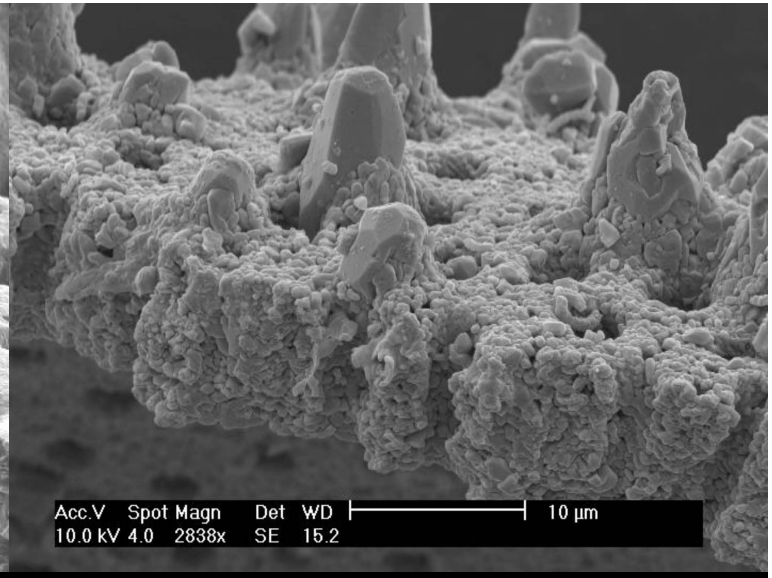
Crosses, orange line: early Eocene Sea Surface Temperature.

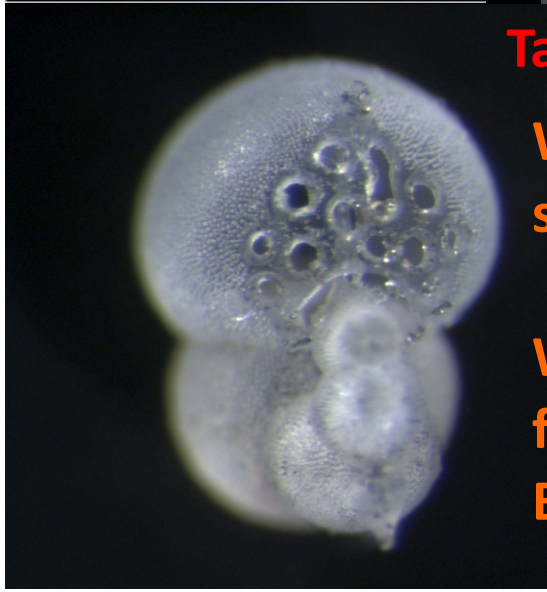
Circles with cross, blue line: bottom water temperature

Shackleton & Boersma, 1981

Planktonic foraminifera fall to sea floor – diagenesis/recrystallization in cold water







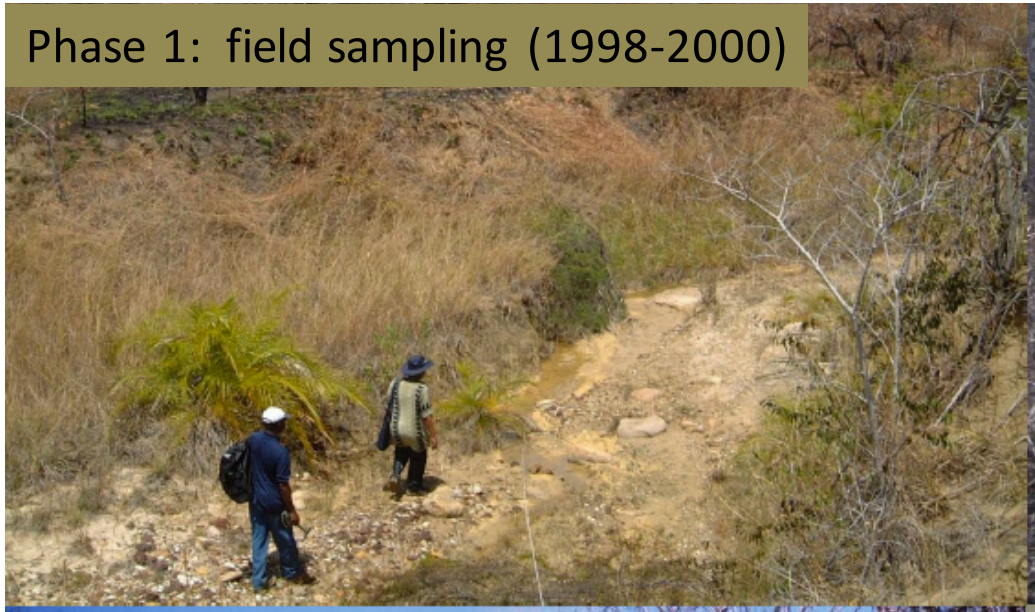
Tanzania (clay-rich sediment) **ODP Site 865 (calcareous ooze)**

WHY TANZANIA? Superb microfossil preservation in clay rich sediment ($CaCO_3$, organic material)

Walter Harry Blow (1924-1972): collection of planktonic foraminifera donated to Natural History Museum London by BP, 1998

Cribrohantkenina inflata
From Tanzania

Phase 1: field sampling (1998-2000)

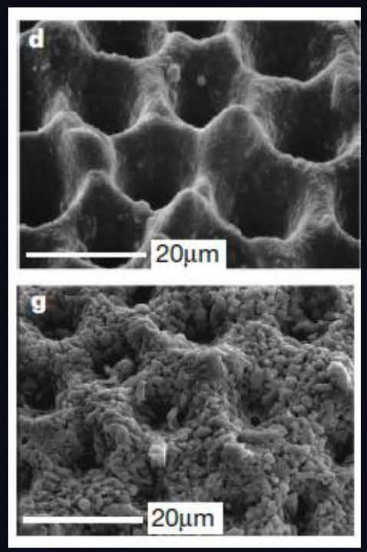


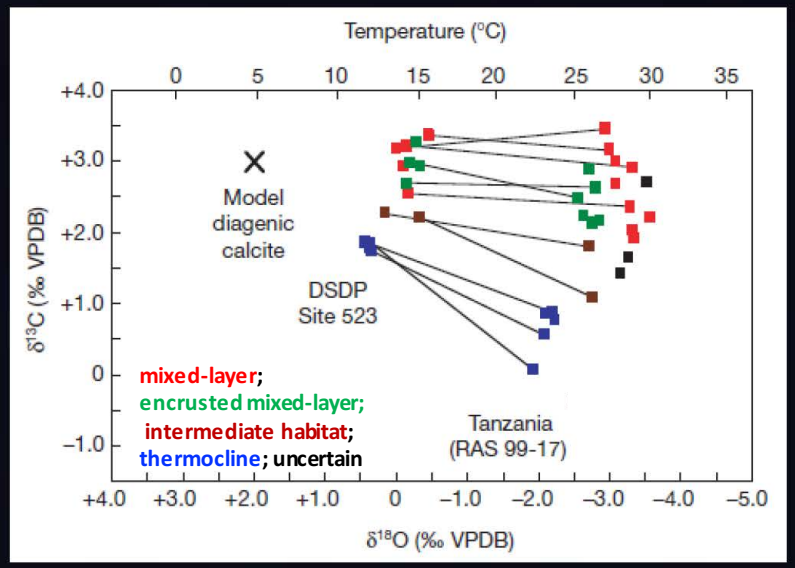
outcrop sampling: stable isotope proxies on foraminifera

Warm tropical sea surface temperatures in the Late Cretaceous and Eocene epochs

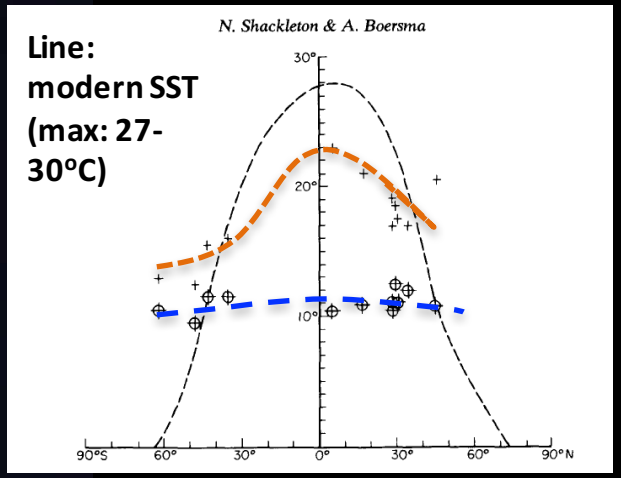
Paul N. Pearson*, Peter W. Ditchfield*, Joyce Singano†, Katherine G. Harcourt-Brown*, Christopher J. Nicholas‡, Richard K. Olsson§, Nicholas J. Shackleton‖ & Mike A. Hall‖

NATURE | VOL 413 | 4 OCTOBER 2001 | www.nature.com



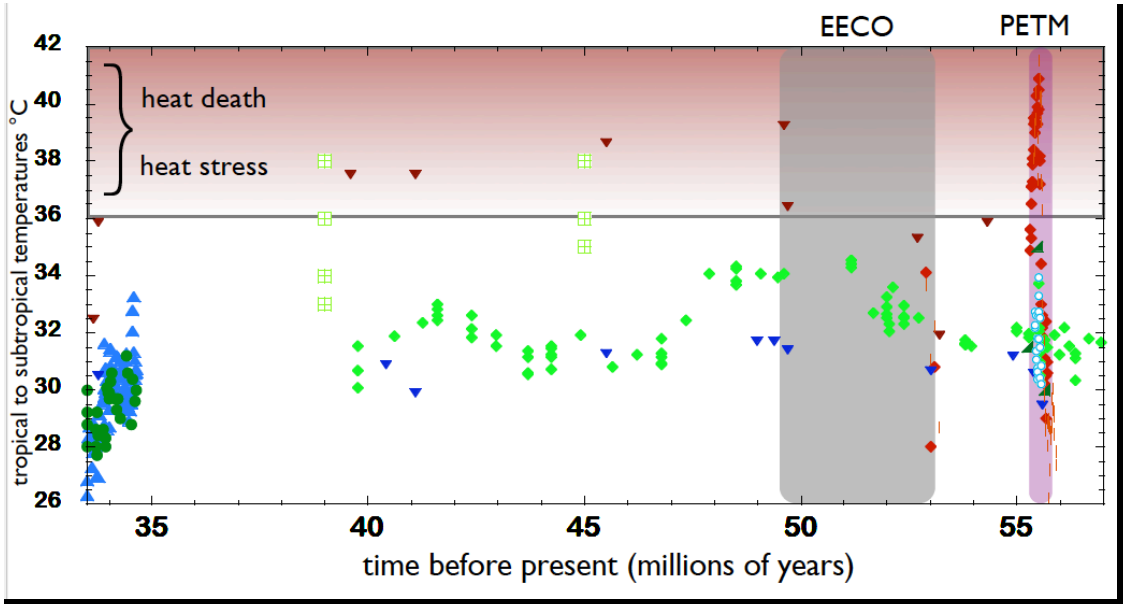


Tropical Sea Surface Temperatures at least 28-32°C (instead of 15-23°C)



Crosses, orange line: early Eocene Sea Surface Temperature. Circles with cross, blue line: bottom water temperature

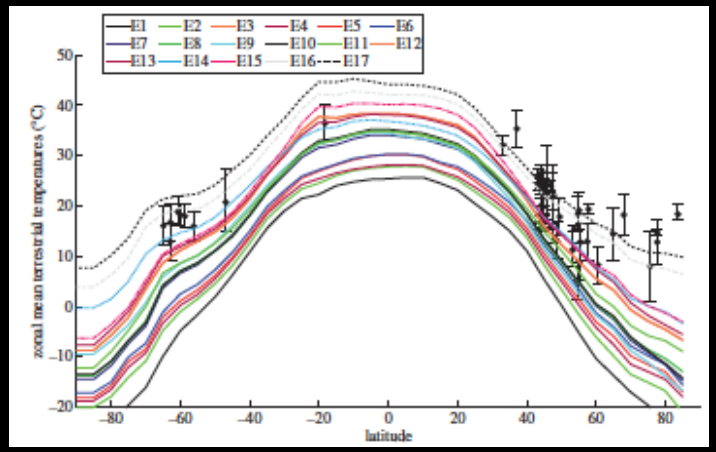
Shackleton & Boersma, 1981



Did low latitudes get too hot for many life forms during PETM, other hyperthermals?
Huber, 2008, Nature

Data from Tanzania (Aze et al., 2014, Geology) and Nigeria (Frieling et al., 2017) suggest they may have been.

Low latitudes data poor (Sagoo et al., 2013, Phil Trans. Roy. Soc.)



$\delta^{18}O$ temperature correction factors	Kim and O'Neil (1997)		
	Pre-PETM	PETM	Lowest $\delta^{18}O$
	$\delta^{18}O$ –3.38‰	$\delta^{18}O$ –4.04‰	$\delta^{18}O$ –5.14‰
No latitude or pH correction	26.3	29.6	35.4
Latitude correction, no pH correction	30.5	34.0	39.9
Latitude correction, pH correction –0.25	N/A	35.9	41.9
Latitude correction, pH correction –0.45	N/A	37.4	43.4

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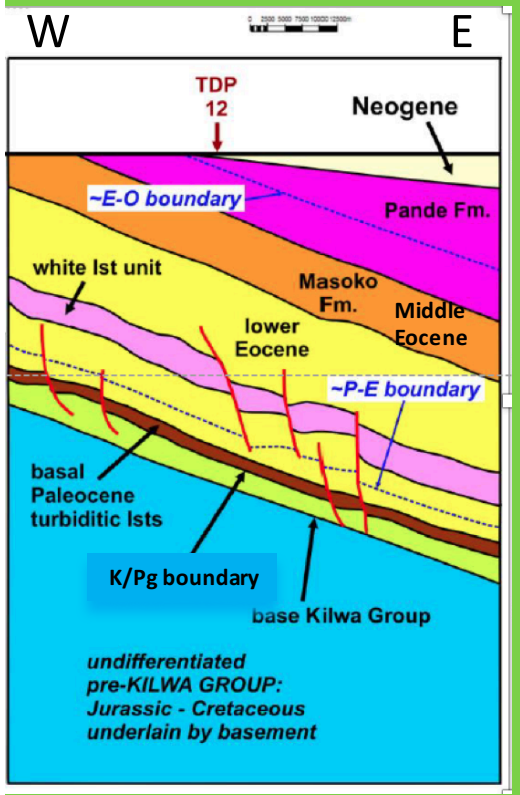
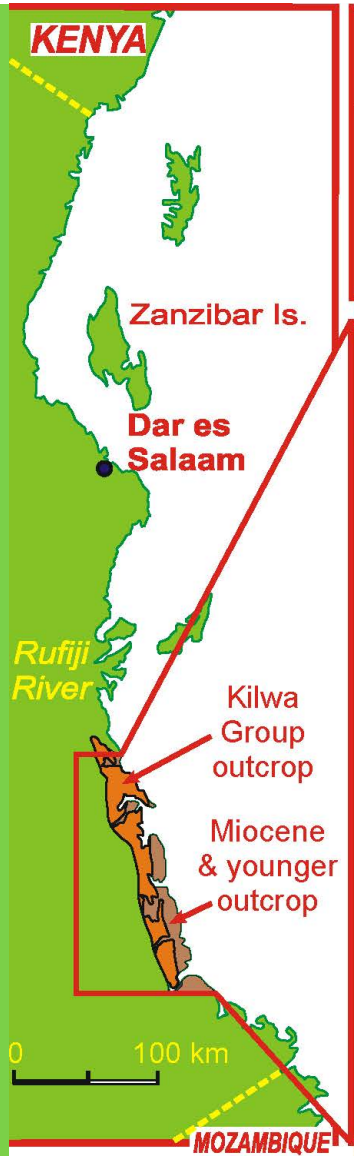
- **Tanzania Drilling Project (TDP):**
  2002-2009: Paleogene - Cretaceous

Funding:
NERC (1998, 2002, 2004)
Paul Pearson, Paleogene
NSF (2007)
Brian Huber, Cretaceous



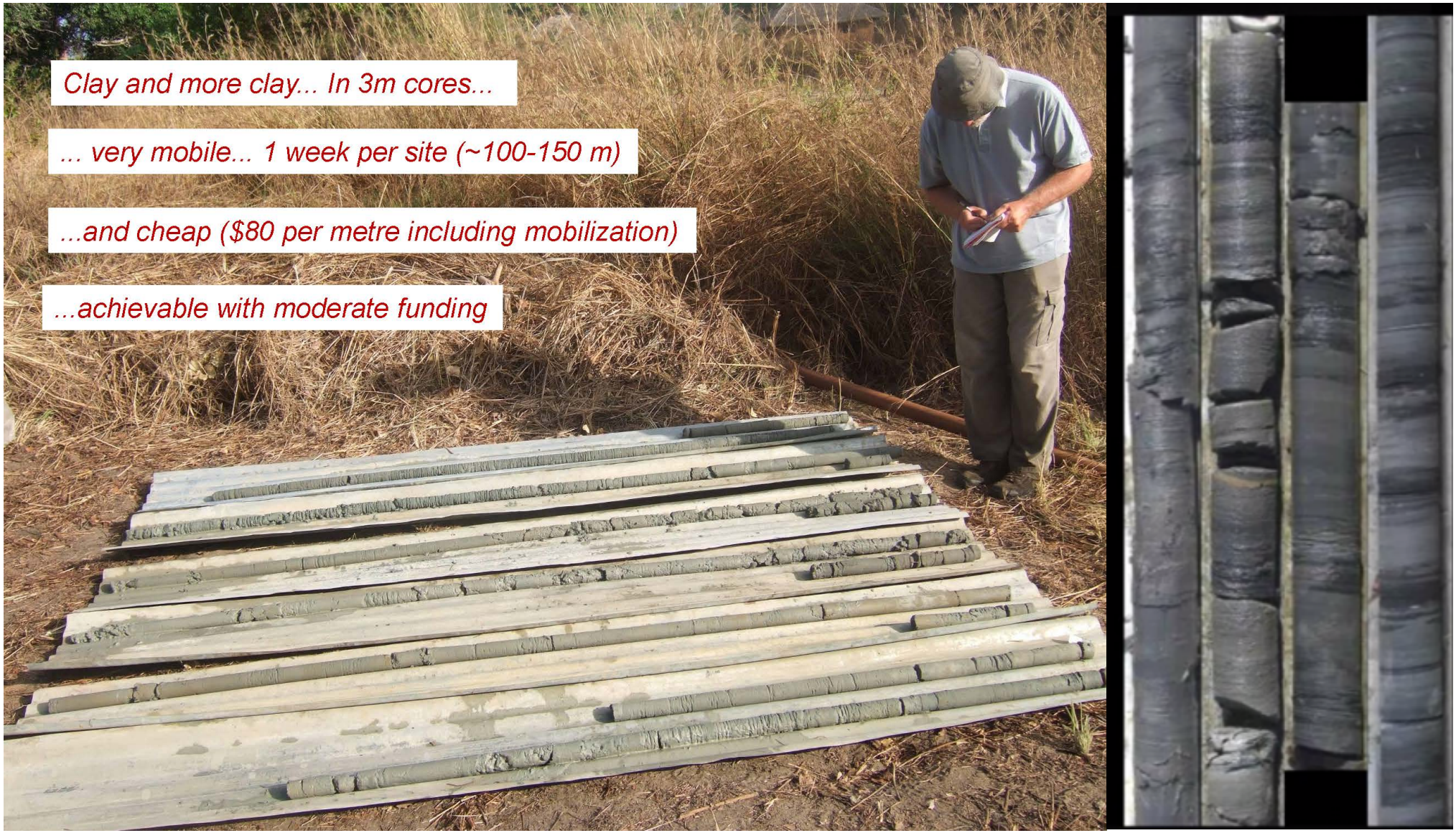


Tanzania Drilling Project: 2002-2009

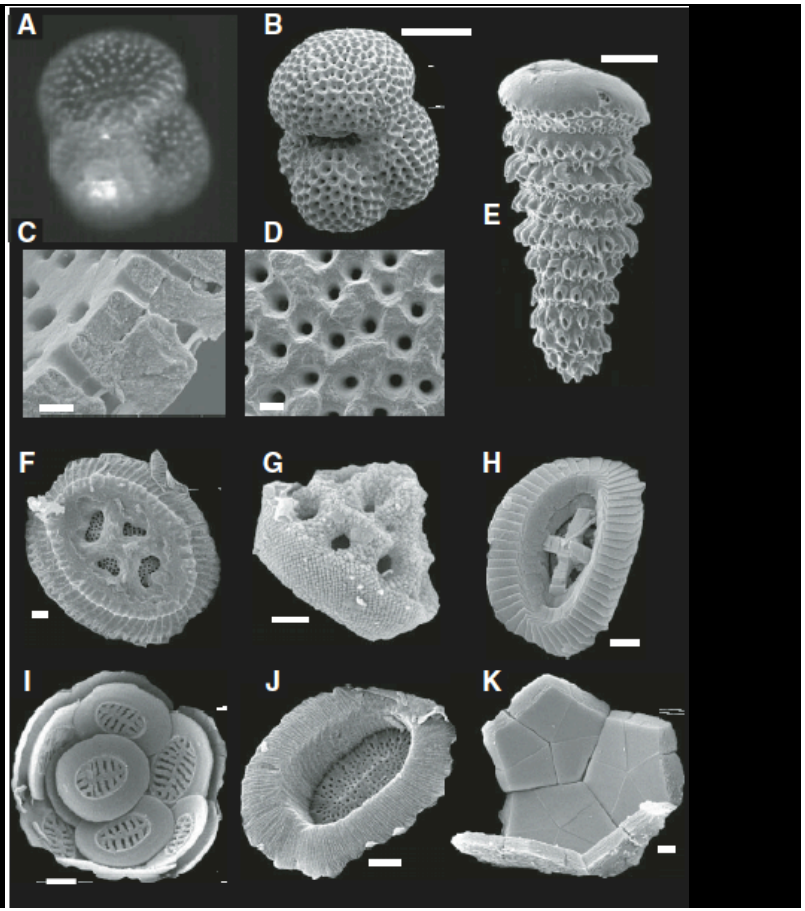
40 sites. Remote locations...

Tanzania Drilling Project

Ya Kale Hadi Yajayo


Clay and more clay... In 3m cores...
... very mobile... 1 week per site (~100-150 m)
...and cheap ($80 per metre including mobilization)
...achievable with moderate funding

A Paleogene calcareous microfossil Konservat-Lagerstätte from the Kilwa Group of coastal Tanzania

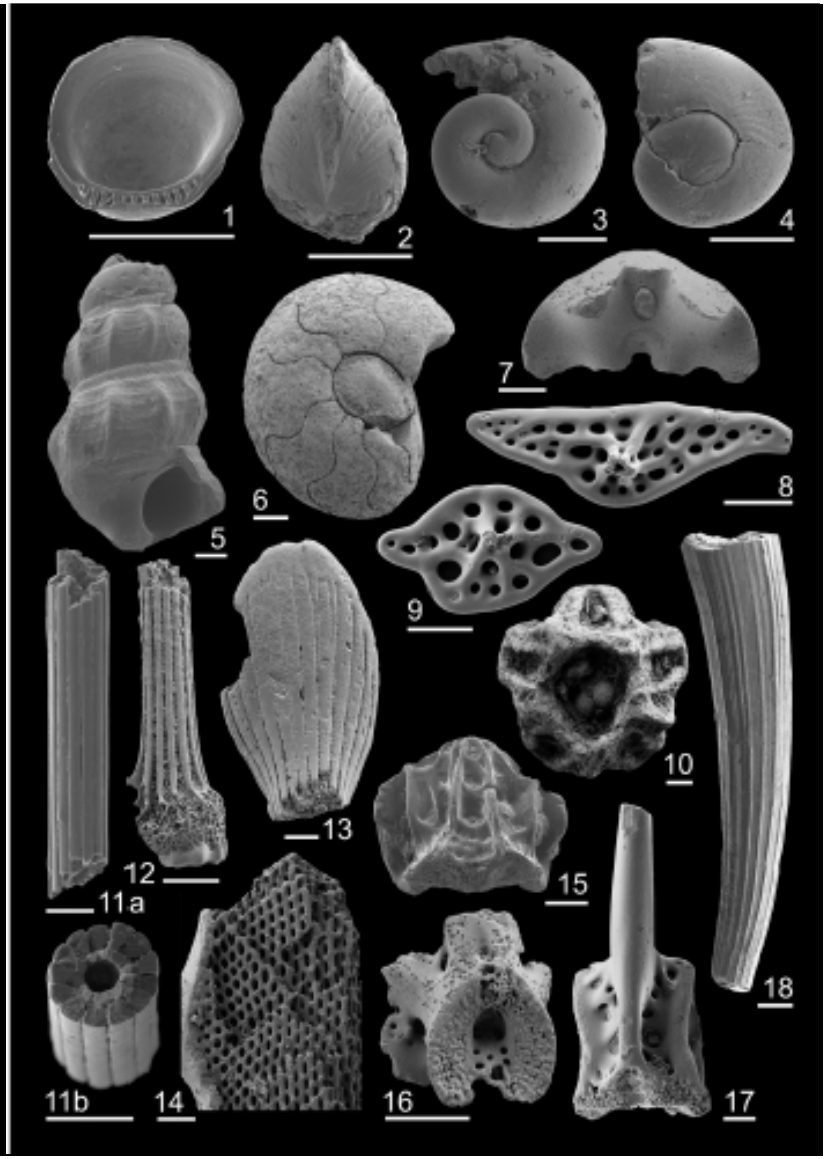


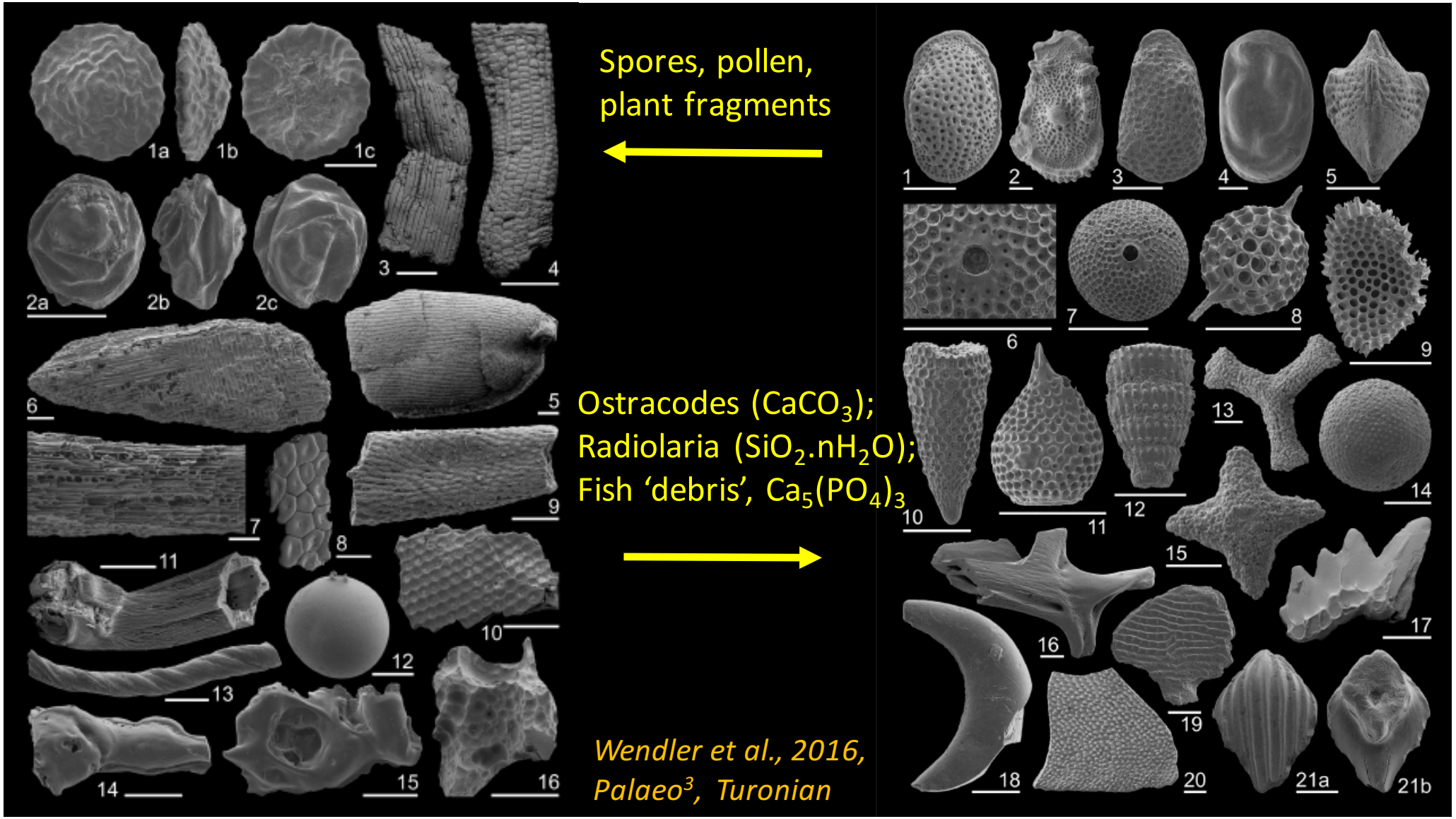
Planktic and benthic foraminifera, Eocene

(Pearson)

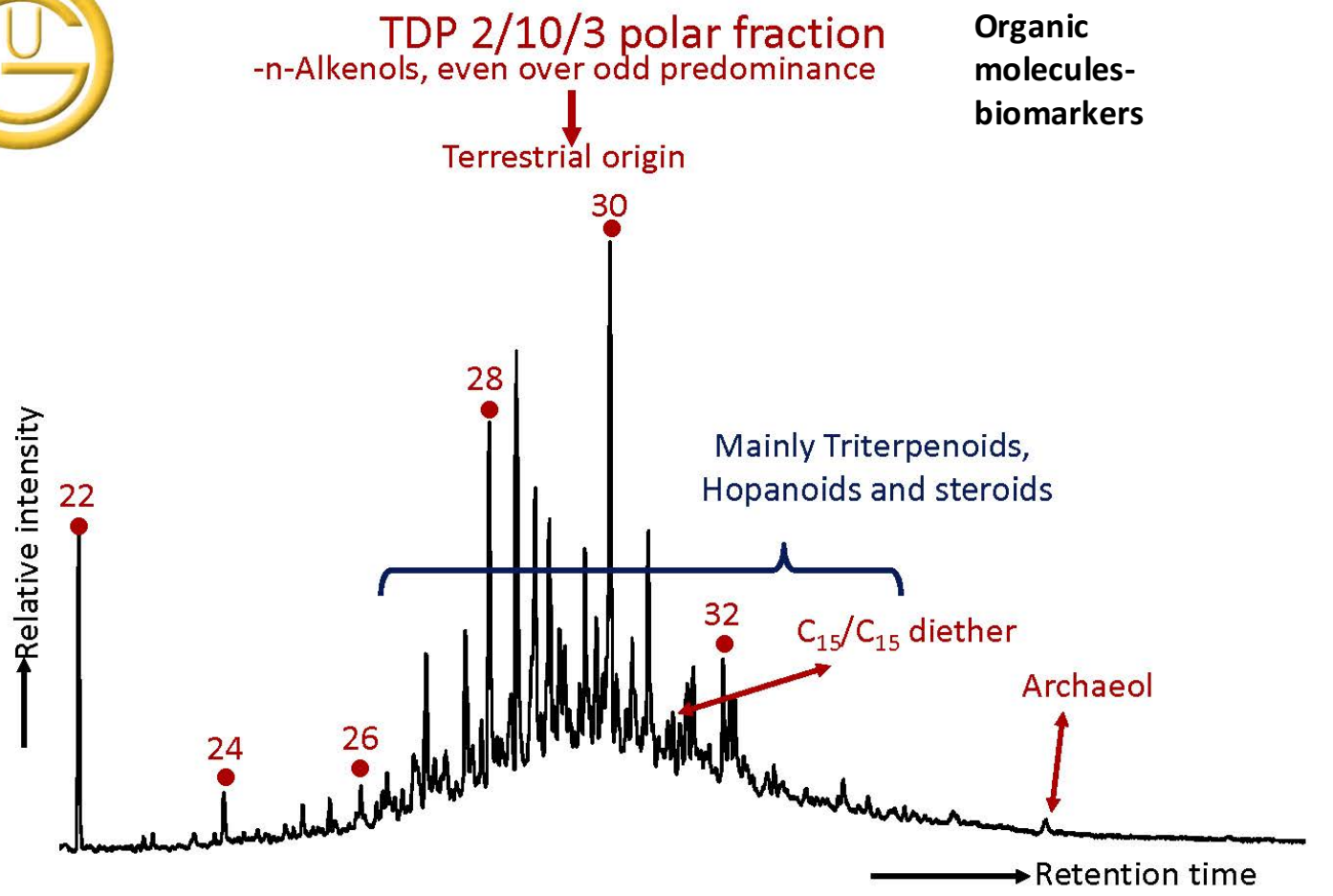
Juvenile molluscs; holothurian ossicles; crinoid fragments; echinoid spines; scaphopod.

Wendler et al., 2016, Palaeo³, Turonian




Spores, pollen,
plant fragments
Ostracodes ($CaCO_3$);
Radiolaria ($SiO_2.nH_2O$);
Fish 'debris', $Ca_5(PO_4)_3$
Wendler et al., 2016,
Palaeo³, Turonian

Organic molecules- biomarkers



University of BRISTOL

IODP open ocean sites, Pacific Ocean (carbonate ooze)

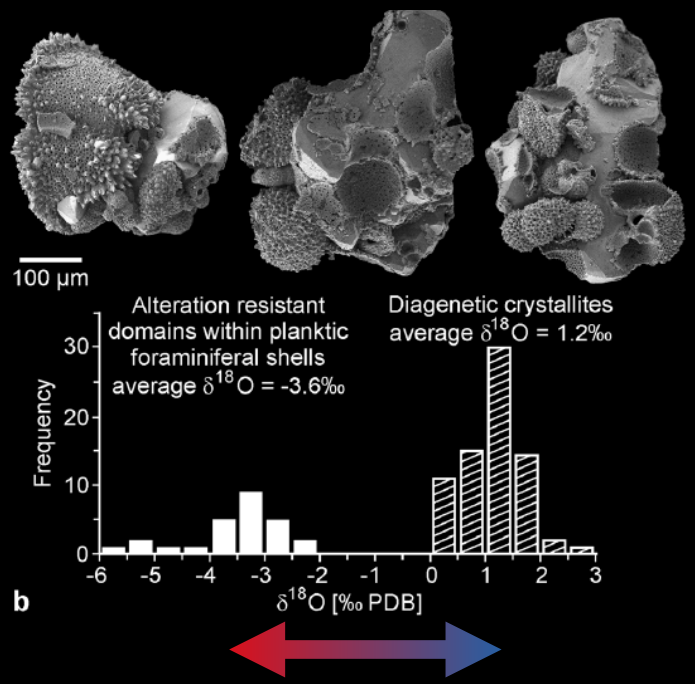
Site 865 Site 1209

Open: benthos; closed: plankton

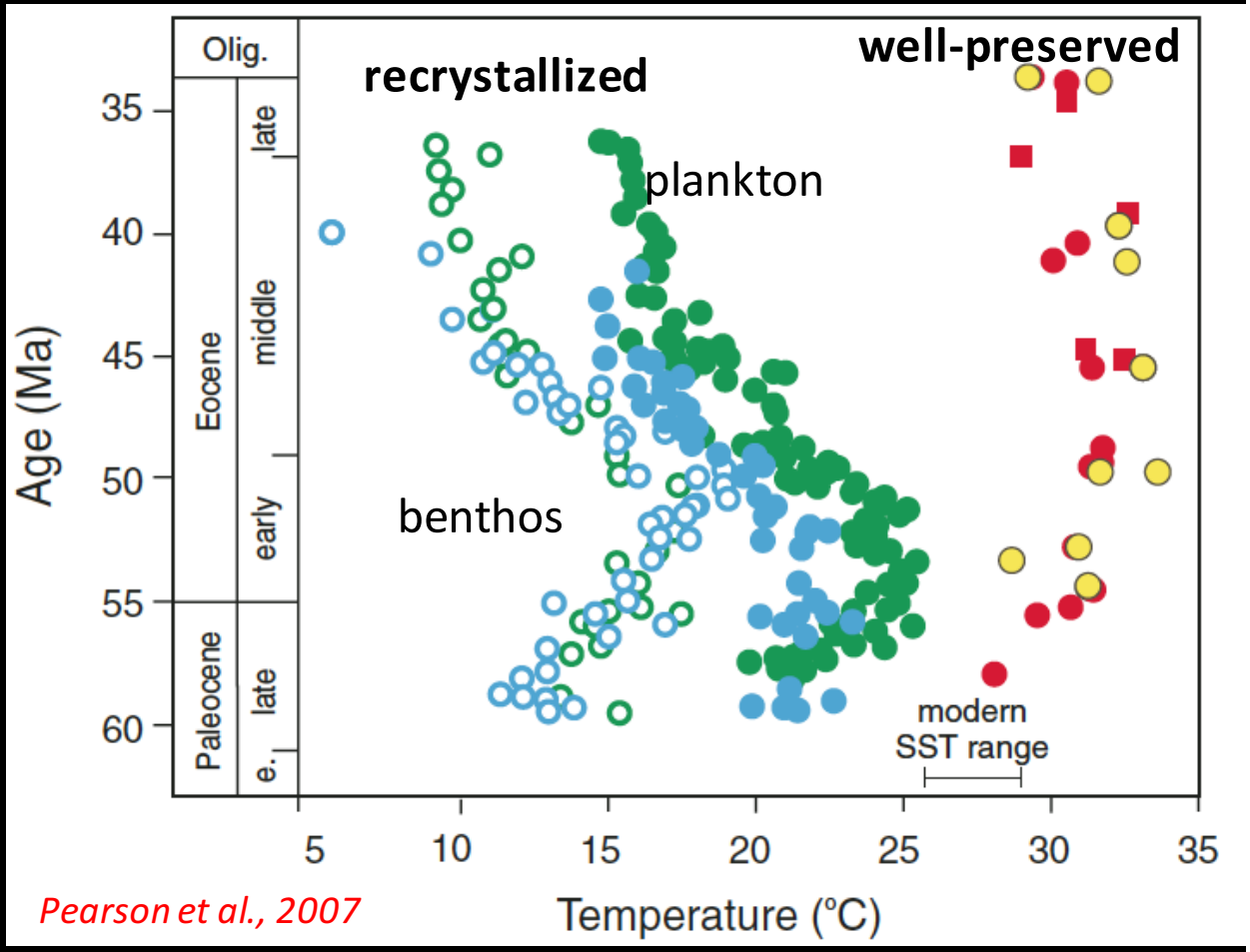
Tanzania Mg/Ca forams

Tanzania Tex_{86} (organic proxy)

Site 865



SIMS analysis; Kozdon et al., 2013



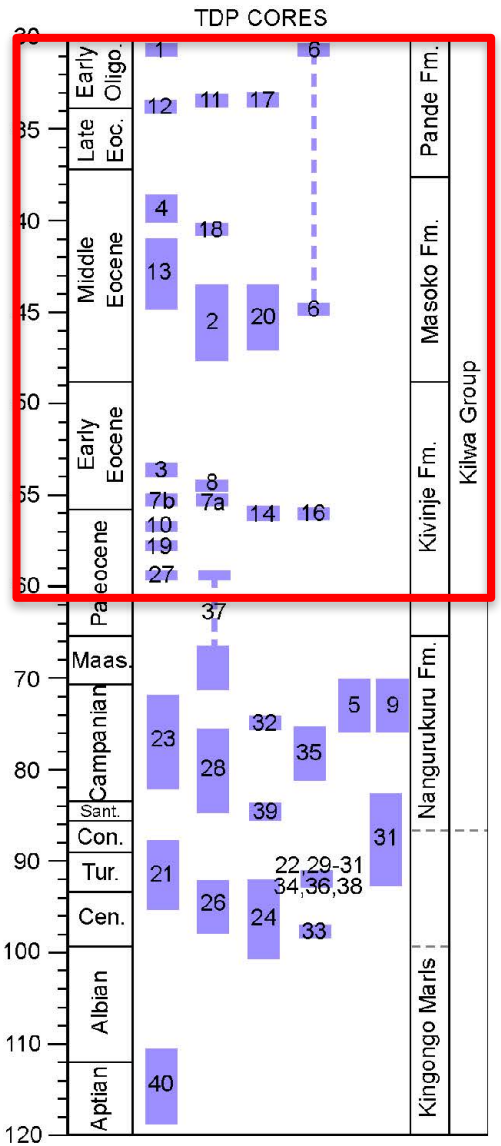
Pearson et al., 2007

Red Box:
TOPIC drilling

But...

- Many missing gaps (50%)
- Maximum penetration 150 m
- No wireline logs (no cycles)
- Variable recovery

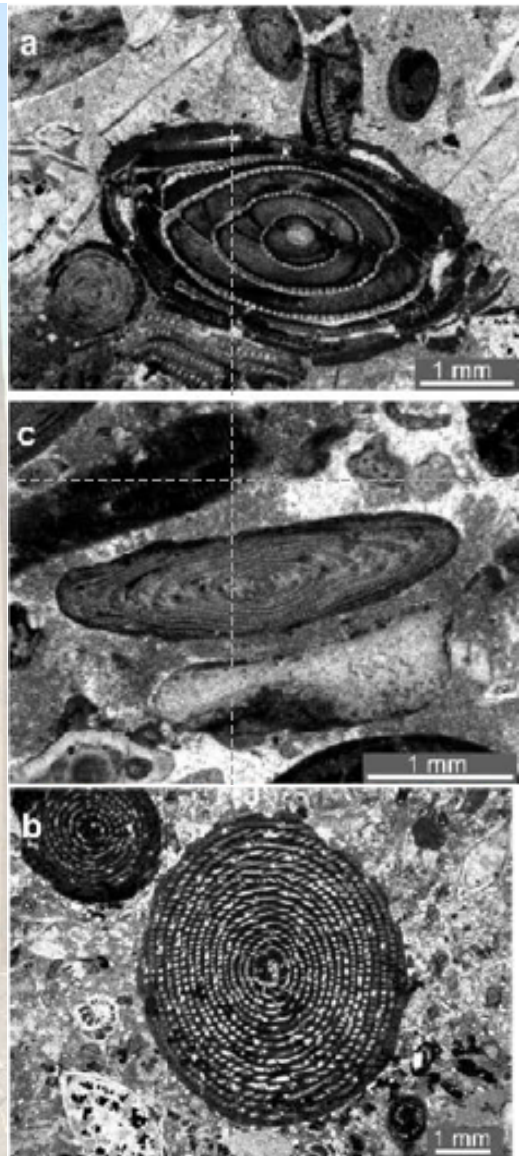
ENORMOUS REMAINING POTENTIAL



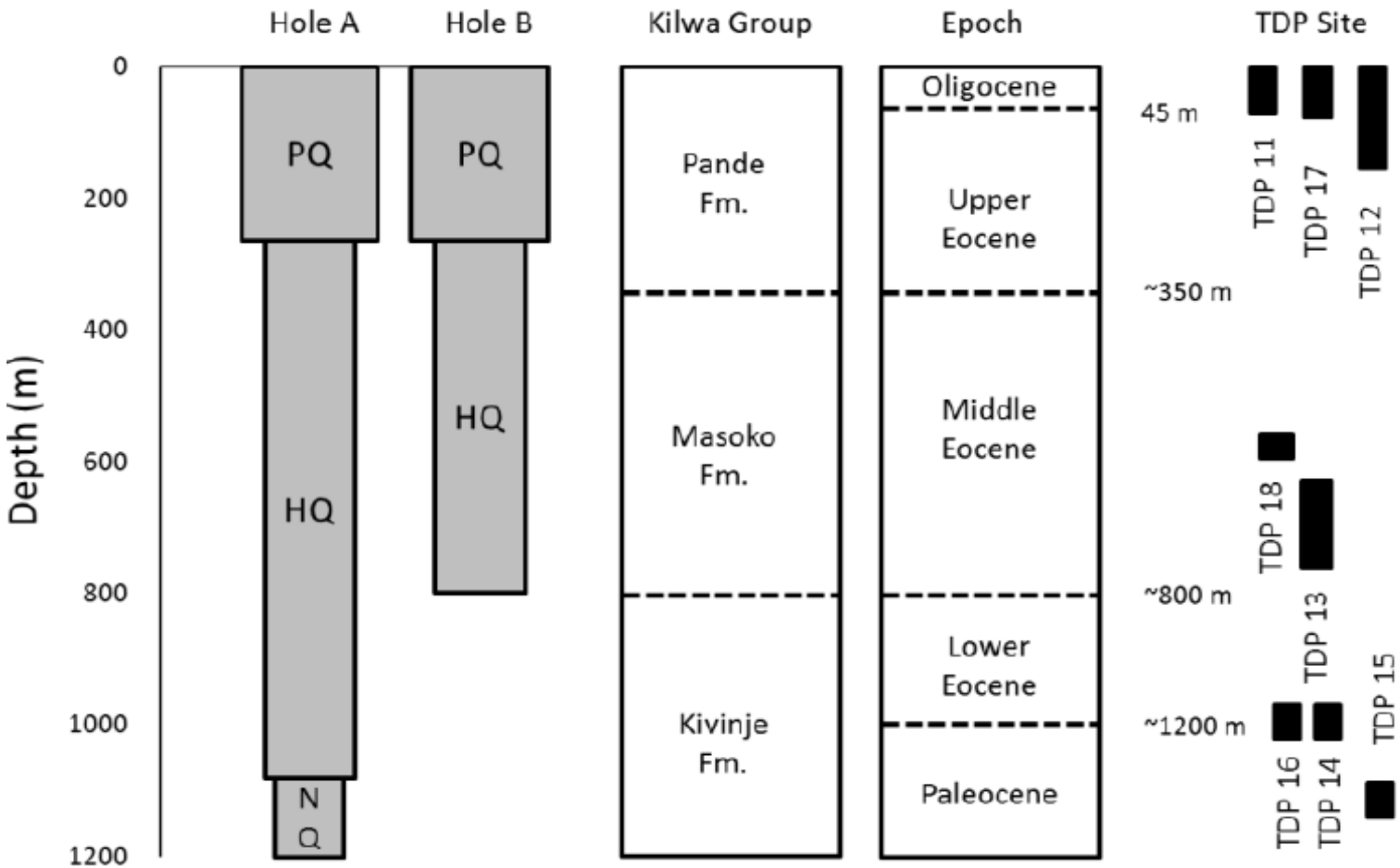
POTENTIAL:

- Deposits very thick (several km), homogeneous (claystone), Aptian through middle Miocene.
- Tropical – subtropical (8-10ºS, Eocene 17-19ºS): reconstruct conditions close to the warm end-member of the global climate state
- Hemipelagic deposits, deep water (200-500 m, possibly deeper), oceanic 'blue water' microfossil assemblage and bathyal benthos.
- Sufficiently close to the continent (50-70 km from the paleoshoreline) for terrestrial material such as soil bacterial biomarkers, pollen and woody matter and shallow water microfossils (larger foraminifera).

On-site core sampling and description




Access Road (Pande Road) 2005



- **Single dry season drilling: mid July-late September**
- **Preferred Site: TDP 12 (alternates along strike)**
- **Two holes to depth ~ 1200m in hole, 800 m in second hole (?)**
- **Lower Oligocene – Upper Paleocene**
- **Wide diameter core (PQ-8.58 cm; HQ-6.35cm; NQ-5.08 cm).**

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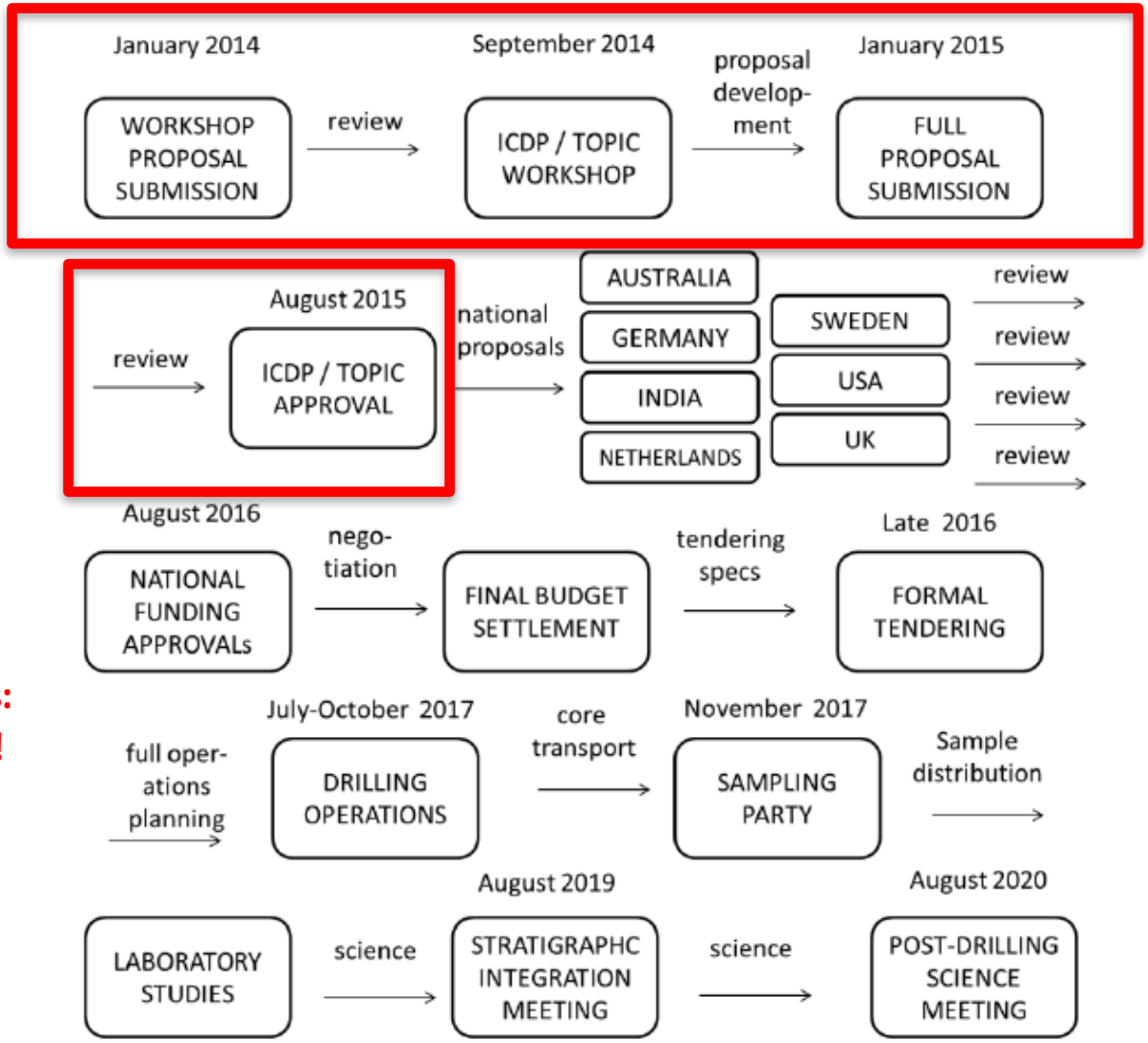
TANZANIA ONSHORE PALEOGENE INTEGRATED CORING (TOPIC)

- **How extreme did climatic conditions become in the tropics, in the oceans and on land?**
- **To what extent did atmospheric CO_2 and global temperature co-vary during intervals of global warmth?**
- **What was the response of the marine and terrestrial biota to extreme climate states and intervals of climate change?**
- **Is the paleoclimate forcing and response we infer from the sediment record consistent with the predictions of General Circulation Models (GCMs) and Earth System Models?**
- **'Deep biosphere' in mudstones with very little pore fluid migration – geologically quiescent sub-surface environment.**

Red boxes: done!



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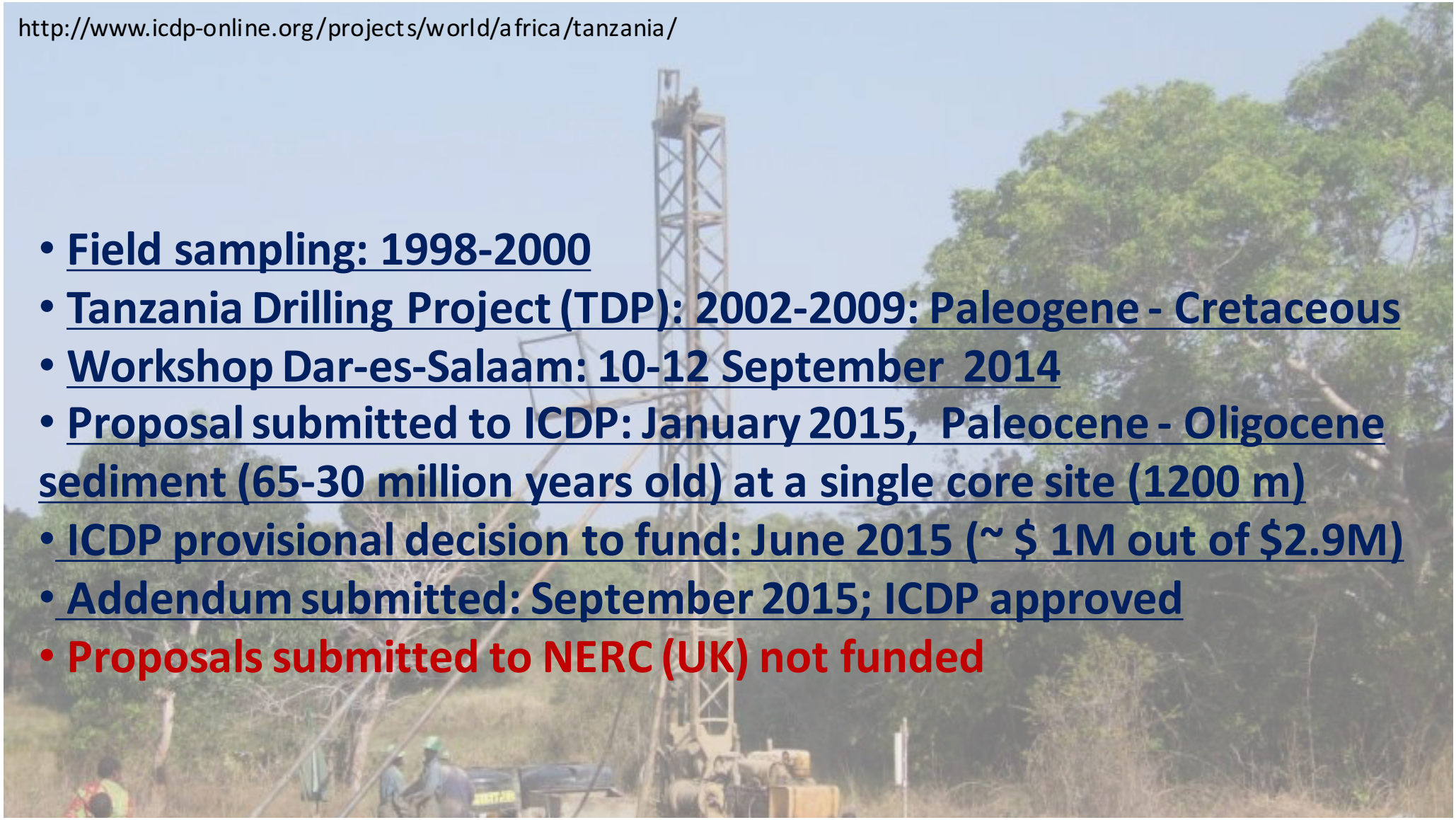

- Field sampling: 1998-2000
- Tanzania Drilling Project (TDP): 2002-2009: Paleogene - Cretaceous
- Workshop Dar-es-Salaam: 10-12 September 2014
- Proposal submitted to ICDP: January 2015, Paleocene - Oligocene sediment (65-30 million years old) at a single core site (1200 m)
- ICDP provisional decision to fund: June 2015 (~ $ 1M out of $2.9M)
- Addendum submitted: September 2015; ICDP approved
- Proposals submitted to NERC (UK) not funded


Thank you.
ICDP Workshop Dar es Salaam, Tanzania September 2014