The Cretaceous and Cenozoic stratigraphy and palaeoclimate of southern coastal Tanzania: results from a decade of fieldwork and scientific drilling

Paul N. Pearson (Cardiff University)

Why Tanzania?
History of project
Oxygen isotope palaeotemperatures
Carbon isotopes and the metabolic hypothesis
Future plans – ICDP / IODP
Onshore Kilwa Group: unique greenhouse tropical climate archive (mainly Cretaceous and Paleogene)

Bathyal marine ~ 350-1500 m water. Now emplaced on land
Superb microfossil preservation

*Turborotalia cerroazulensis*

*Fontbotia mkazamboensis*
Nannofossils - rock surface SEM

image width ~ 1/30 mm
Palaeoclimate proxies

- **Oxygen isotope**
  - palaeotemperatures

- **Boron isotope**
  - palaeo pH / pCO₂

- **Bacterial lipid biomarkers:**
  - Ocean temperature
  - Soil temperature

- **N-alkane biomarkers:**
  - Vegetation chemistry
  - D/H – evaporation/precipitation
Hemipelagic clays ~ 3000 m thick
but poorly exposed
Accessory beds: limestones
Cretaceous turbidites with agrichnia
Spiroraphe
Tanzania Drilling Project: 2002-2009

Kenya

Zanzibar Is.

Dar es Salaam

Rufiji River

Kilwa Group outcrop

Miocene & younger outcrop

Tanzania Drilling Project

Ya Kale Hadi Yajayo
40 sites. Remote locations...
Narrow diameter cores
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
Summary stratigraphy:

- exceptionally well-preserved carbonate and organic carbon throughout
- Key intervals: Paleocene / Eocene, Eocene / Oligocene, Cenomanian / Turonian
38 peer-reviewed papers, and counting
Planktonic depth habitats
(Birch et al., 2013)
Importance of preservation

*Cribrohantkenina inflata*

From Tanzania
Tanzania – TDP 14

Deep sea – ODP 865
Early Eocene *Morozovella* - Tanzania
Tanzania planktonic oxygen isotope stack (in prep.)

Late Cretaceous

PETM

approx. seawater range, to ice-free world
The “metabolic hypothesis”

Missing organic carbon in Eocene marine sediments: Is metabolism the biological feedback that maintains end-member climates?

Annette Olivarez Lyle and Mitchell W. Lyle

Diagram

- Cooling Event
- Eocene: Warm Oceans
- Modern: Cold Oceans

<table>
<thead>
<tr>
<th>Site 1218</th>
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<tr>
<td>38 - 43 Ma</td>
<td>41.1 - 41.4 Ma CAE-3</td>
<td>36 - 49 Ma</td>
<td>41.2 - 41.5 Ma CAE-3</td>
<td>Modern</td>
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Carbon isotopes and the “biological pump”
Reconstructing warm climate carbon isotope profiles
Modern (measured) and Eocene (modelled) water column temperature profiles for offshore Tanzania
Warm ocean processes and carbon cycling in the Eocene

Eleanor H. John, Paul N. Pearson, Helen K. Coxall, Heather Birch, Bridget S. Wade, and Gavin L. Foster

School of Earth and Ocean Sciences, Cardiff University,
Limitations...

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

ENORMOUS REMAINING POTENTIAL
Kilwa Group dips gently offshore, under clay-rich Neogene
Through the unique capacities of scientific drilling to provide exact, fundamental and globally significant knowledge of the composition, structure and processes of the Earth’s crust.
ICDP Workshop proposal (Academia + Industry):  
Tanzania Onshore Paleogene Integrated Coring (TOPIC)  
Recover Paleocene – Oligocene in a single 1 km site  
Wide diameter cores, logging, magnetostratigraphy
Phase I: Workshop funded ($60K)
Towards IODP

2009: Seismic survey cruise RV Pelagia

Locate potential IODP drill sites
Box and piston coring,
Dating outcropping reflectors
on sea floor
Plankton sampling
IODP Proposal 778
Tanzania Offshore Paleoclimate (TOP)
TOP-1
Paleogene in clay rich facies (v. deep hole)

TOP-2
Near-shore v. expanded Plio-Pleistocene
Objectives

- Temperature: multiple proxies ($\delta^{18}$O, Mg/Ca, TEX86, UK37).
- $p$CO$_2$: inorganic and organic proxies
- Evolution: terrestrial and marine biotic evolution and the biotic response to climate perturbations
- Terrestrial Africa: connect marine records with terrestrial vegetation, continental air temperatures, and hydrology to hominin evolution.
- Chronology: carbonate microfossils, dinoflagellates and paleomagnetics, cycles.

... ranked ‘excellent’ by IODP Proposal Evaluation Panel
Formal IODP – ICDP linkage...

- Deep targets difficult and time consuming from ship
- Combined and complementary objectives
- Linked planning
- Coordinated scientific teams and meetings
- Combined synthesis and publication