Gamma spectrometry for chronology of recent sediments:

*Tracing human induced climate change in NW Africa*

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Outline

- Gamma emitters in sediments
- Radiotracers $^{210}\text{Pb}$ and $^{137}\text{Cs}$

Sediment chronology in paleoclimate research: Sahel zone dust record in the late Holocene
Gamma emitters in marine and lacustrine sediments

- U/Th decay series: $^{210}\text{Pb}$, $^{226}\text{Ra}$ ($^{214}\text{Pb}$, $^{214}\text{Bi}$), $^{234}\text{Th}$, $^{234}\text{mPa}$, $^{228}\text{Th}$ ($^{212}\text{Pb}$, $^{212}\text{Bi}$, $^{208}\text{Tl}$), $^{228}\text{Ra}$ ($^{228}\text{Ac}$)
- Primordial: $^{40}\text{K}$
- Cosmogenic: $^{7}\text{Be}$
- Artificial: $^{137}\text{Cs}$, $^{241}\text{Am}$

They can be used for dating sediment sequences or tracing changes in recent parts of sediment cores (up to 150 years old)
Pathways of $^{210}\text{Pb}$ ($T_{1/2}=22$ yr) into sediments

- **Supported $^{210}\text{Pb}_{sup}$**: in situ from $^{226}\text{Ra}$ decay in sediment
- **Unsupported (excess) $^{210}\text{Pb}_{xs}$**:
  - dry or wet deposition of $^{210}\text{Pb}$ generated by $^{222}\text{Rn}$ decay in the air
Radiotracer: $^{137}$Cs

- Artificial radionuclide introduced to the atmosphere by nuclear bomb-tests, nuclear accidents – Chernobyl - and other discharges from nuclear installations
- Half-life 30 years
- Often used as a independent chronometer for the last 60 years
- Onset in 1950’s, maximum 1963, 1986 Chernobyl peak in Europe

Figure VII. Caesium-137 deposition density in the northern and southern hemispheres calculated from fission production amounts with the atmospheric model.

UNSCEAR Annex C (2000)
The Senegal Mudbelt: Archive of Sahel Precipitation during the Holocene

Terigenous sediments sources:
- Senegal river suspension
- Atmospheric dust

GeoB9501-4, 43 cm (330 m)
GeoB9501-5, 5.3 m (323 m)
Age control

- **$^{210}\text{Pb} $ chronology**
  - the age of the core has been estimated using CRS (constant rate of supply) model
  - assuming a constant rate of supply of unsupported $^{210}\text{Pb} $ to the sediment per unit time and a variable sedimentation rate
  - absolute ages: top of the core 2005

- **$^{137}\text{Cs}$: additional calibration of the age**
  - present in the sediments due to the global fallout after nuclear bomb testing
  - onset in 1950’s, peaked in 1963 in the N hemisphere
  - any signs of fallout from 4 French atmospheric tests in Algeria (1960-61)?

- **$^{14}\text{C}$ chronology**
  - AMS $^{14}\text{C}$ of planctonic foraminifera
  - age span 3200 years
  - $^{210}\text{Pb} $ age of the bottom of the MUC provided local reservoir age for $^{14}\text{C}$
Multicore & gravity core matching

Multicore

Gravity core

www.icefloe.net,
www.marum.de
Combined chronology
Sources of terigenous material at site GeoB9501

- Bulk geochemistry: Si, Al, Ti, K, Ca, Fe
- Grain size analysis

- Senegal river contribution: Al+Fe rich, fine (95% < 10 μm)
- Aeolian contribution: Si rich, particles up to 200 μm

- Relative proportions of riverine, aeolian and marine contributions: end-member analysis:
  - dust and fluvial end-members constructed using the normalized relative abundances of Si, Al, Ti, K and Ca from modern aeolian and riverborne materials
  - a theoretical marine end-member (98% Ca, 2% Si)

- Compared to instrumental measurements of airborne African dust concentrations: Barbados from mid-1960s, and Senegal runoff and to literature data on δ18O authigenic carbonate from the lake Bosumtwi
Dust deposition at Site Geo9501

Mulitza et al. (2010), Bosumtwi: Shanahan et al. (2009), Barbados Dust: Prospero and Lamb (2003)
Human induced dust emissions started to contribute significantly to the overall dust budget about 200 years ago during the onset of commercial agriculture and have continued ever since.

Mulitza et al. (2010)
Bosumtwi: Shanahan et al. (2009)
Summary

• Gamma spectroscopy based $^{210}\text{Pb}_\text{xs}$ and $^{137}\text{Cs}$ profiles were used for:
  – Matching and aligning the MUC and GC and estimation of the amount of material missing on the top of the GC
  – Chronology of the youngest 140 year section of the sediment profile (upper 63 cm)
  – Estimation of the local radiocarbon reservoir age

Thank you for your attention

and

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