



The Abdus Salam
International Centre
for Theoretical Physics



2453-4

**School on Modelling Tools and Capacity Building in Climate and
Public Health**

15 – 26 April 2013

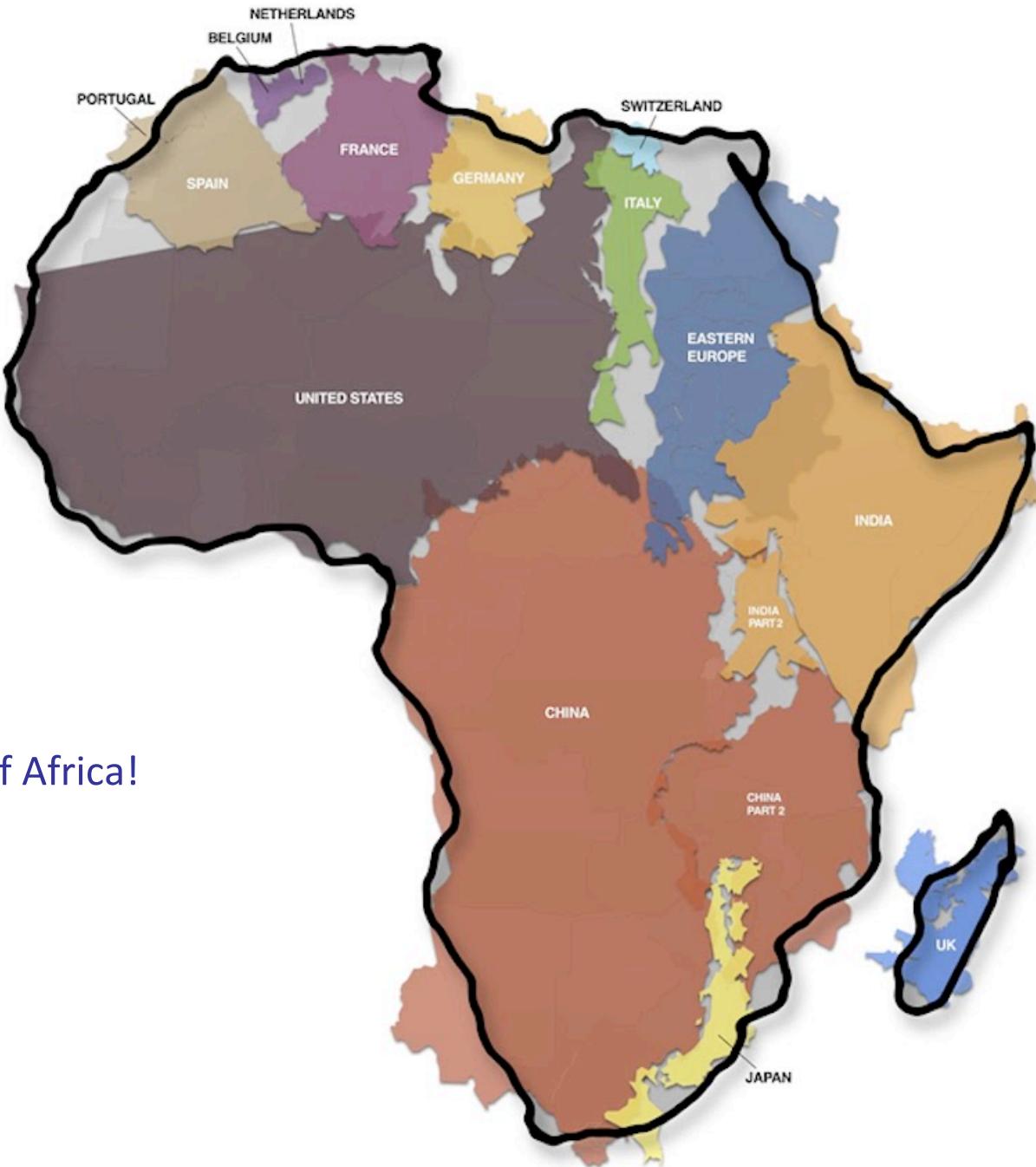
Environmental changes in Africa

TAYLOR David
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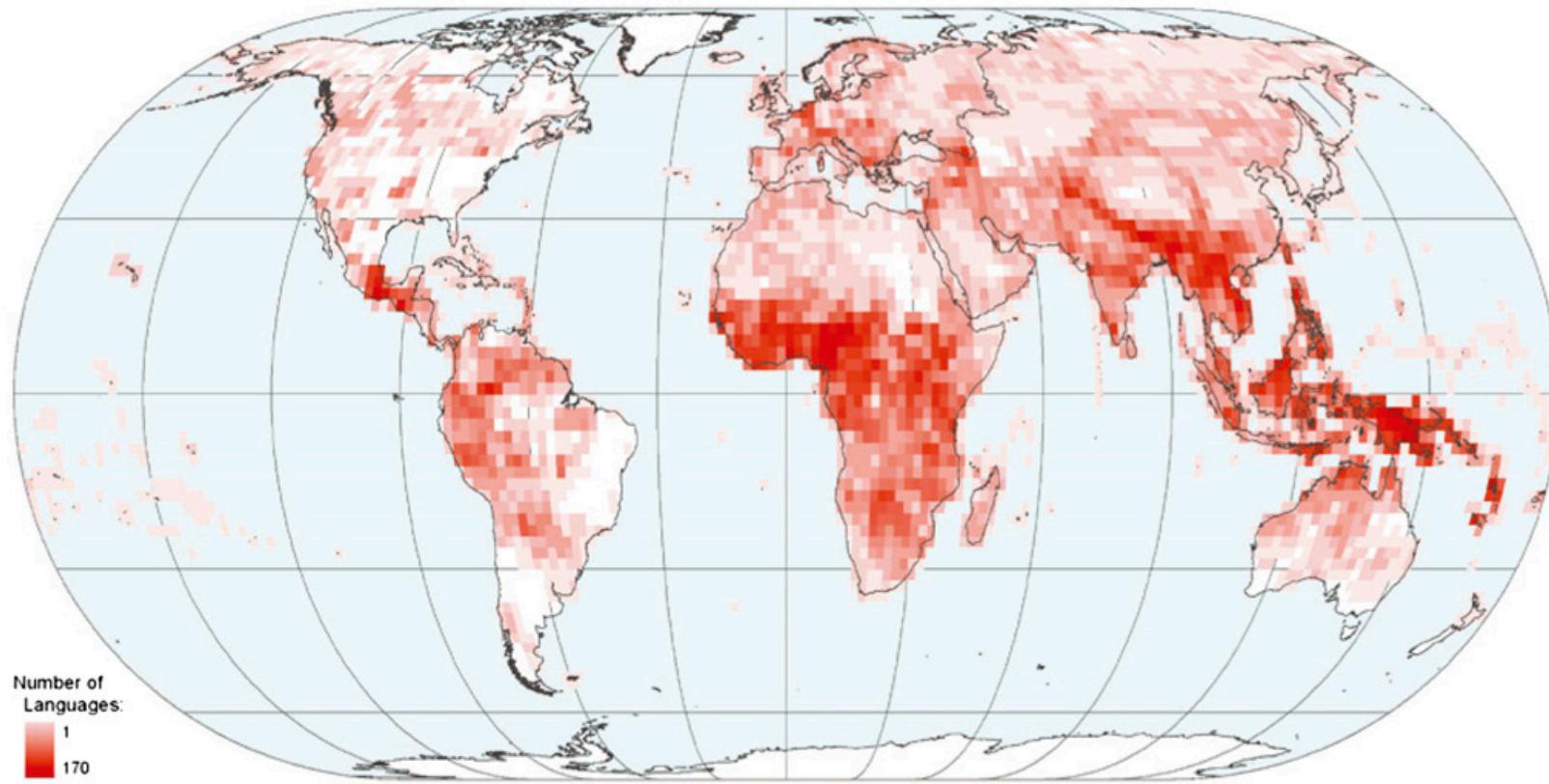


Environmental changes in Africa

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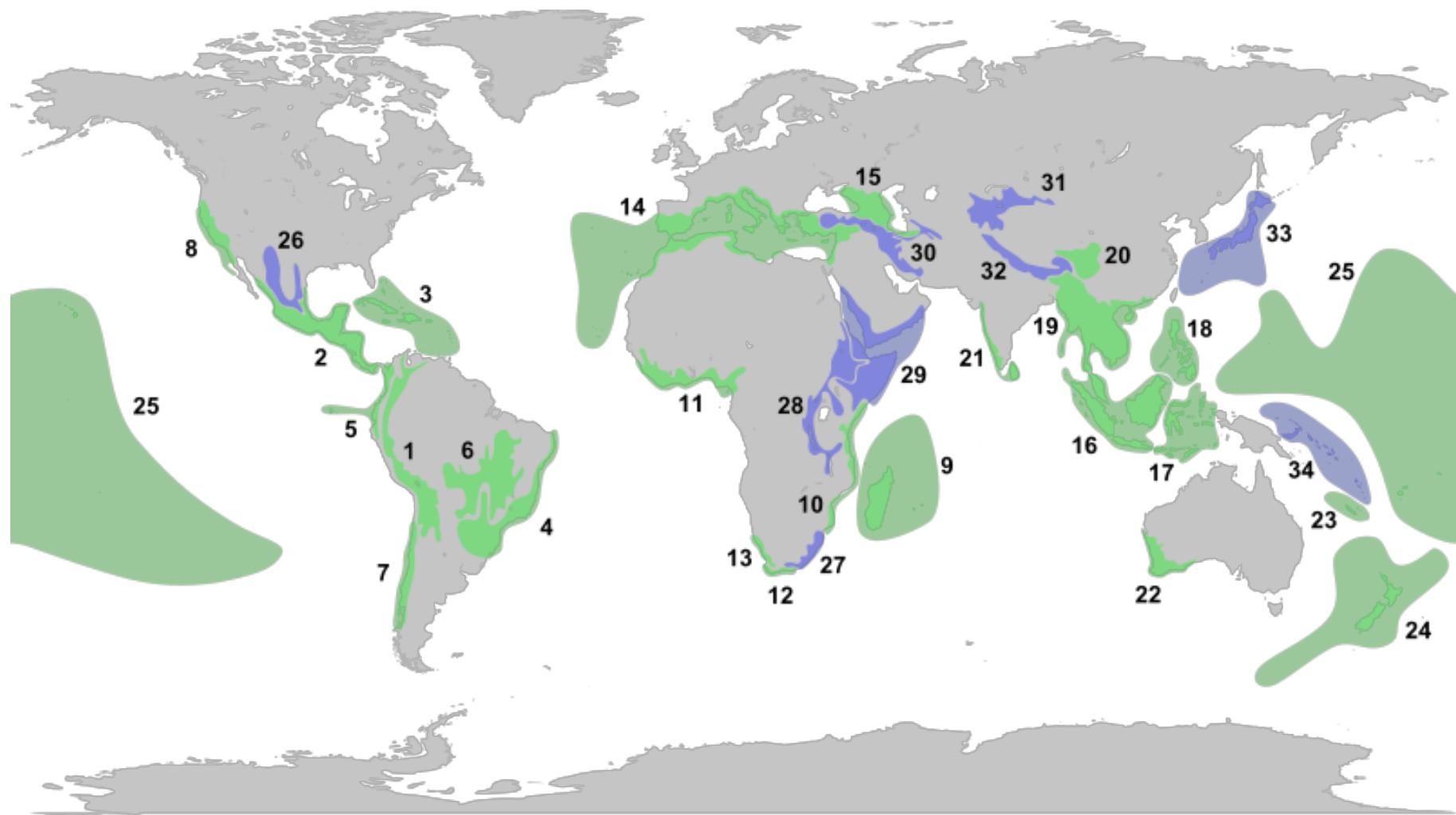


The true size of Africa!



Linguistic diversity globally (from Gorenflo *et al.* PNAS 2012)

Africa hosts all or part of 9 of total of 34 biodiversity hotspots



From Myers et al. (2000) & Lamoreux et al. (2006)



Urbanisation is proceeding faster on the continent than anywhere else on Earth – more than 50 cities population >1 million



Cape Town, SA

More than 50% population urban by 2030

Lion economies on the go

Go south, young man

World's ten fastest-growing economies*
Annual average GDP growth, %

2001 - 2010 †	
Angola	11.1
China	10.5
Myanmar	10.3
Nigeria	8.9
Ethiopia	8.4
Kazakhstan	8.2
Chad	7.9
Mozambique	7.9
Cambodia	7.7
Rwanda	7.6

2011 - 2015 †	
China	9.5
India	8.2
Ethiopia	8.1
Mozambique	7.7
Tanzania	7.2
Vietnam	7.2
Congo	7.0
Ghana	7.0
Zambia	6.9
Nigeria	6.8

* Excluding countries with less than 10m population and Iraq and Afghanistan

† 2010 estimate

† IMF forecast

Sources: *The Economist*, IMF

Rapid changes in landcover



Conversion of swamps to wetland agriculture (rice, Rwanda)

Africa's collective GDP expected to more or less double between 2008-2020

Asian countries (China, Japan, South Korea) are important drivers of this change

India too – annual trade between India and African countries increased from 3 billion US\$ in 2000 to 46 billion US\$ in 2010 (>15 x)



Many factors facilitating this change:

- Liberal economies (post IMF/WB restructuring of 1980s & 1990s), including labour laws
- Most land is state-owned
- Abundant resources
- Perception that resources are under-utilised (e.g. Africa has 60% of world's uncultivated land?)

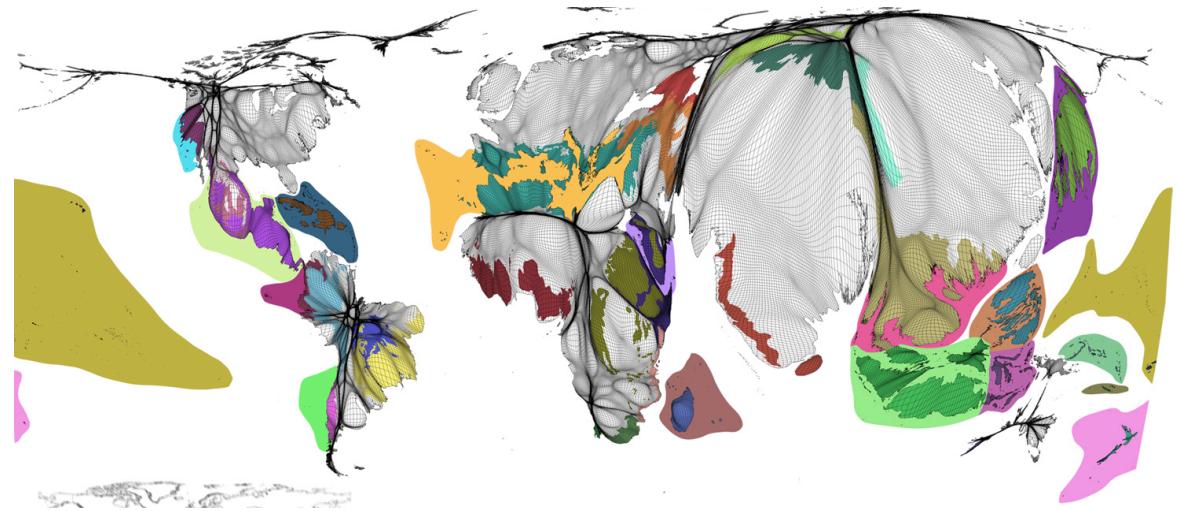


But *uncultivated* and *marginal* are not the same as *unneeded* and *unused* – and even may be untrue

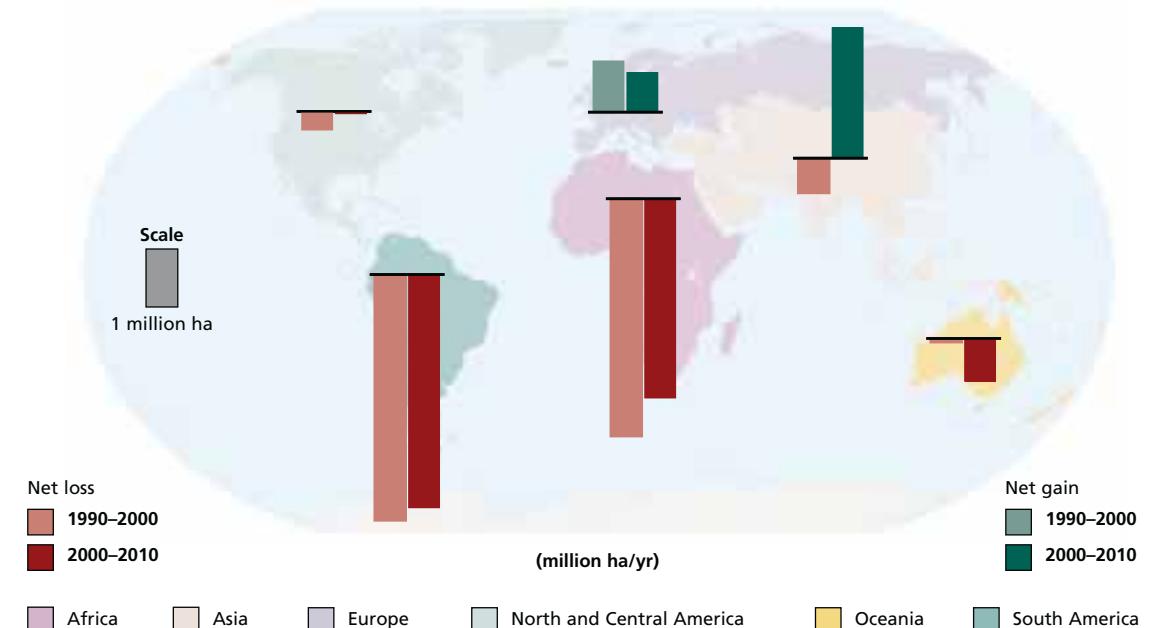
A new scramble for Africa: real lions on the move?



Lioness, Kidepo National Park,
northern Uganda



Population & biodiversity - from Hennig (2011)



Global forest loss 1990-2010 (FAO 2010)

How do current and projected changes compare with past environmental changes in Africa?

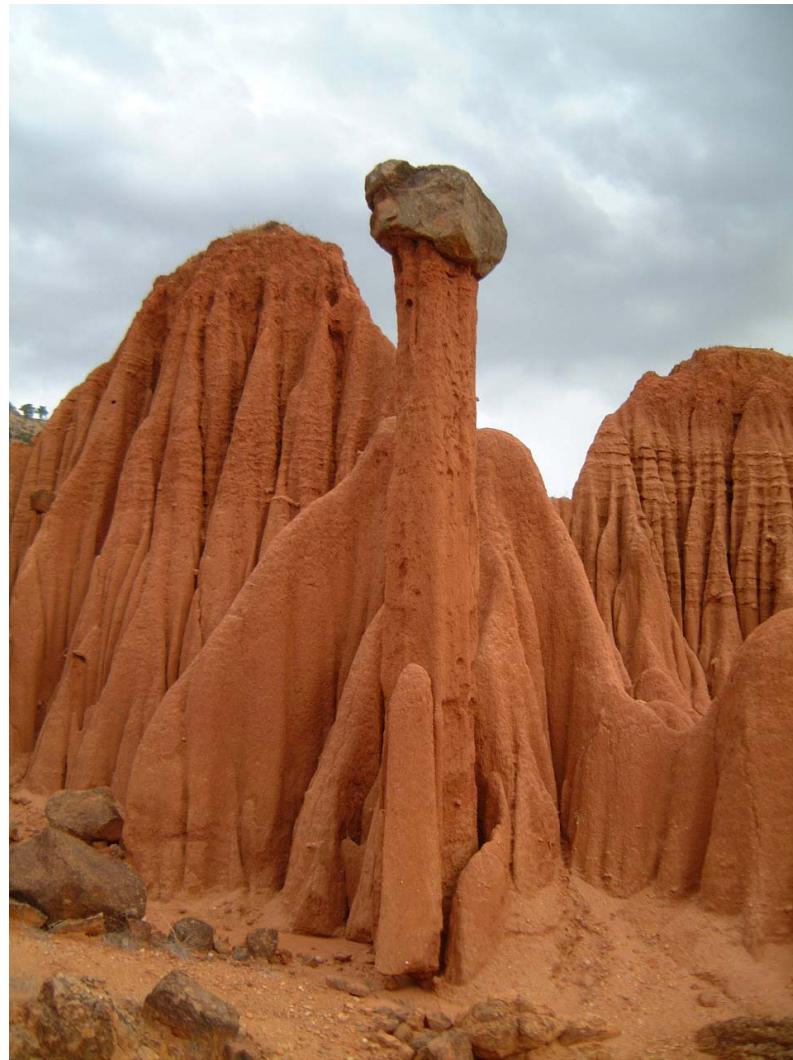
Several sources of information, basically:

- Direct – e.g. instrumental records, archived reports, photographs etc, landscape features etc
 - but often incomplete, geographically restricted etc
- Indirect – i.e. proxies of environmental changes
 - often difficult to interpret



*Weather station, Mozal Aluminum Smelter.
Maputo, Mozambique: installed in 1998*

Environments throughout Africa are rapidly changing...



Problems come in interpreting and dating these forms of evidence – what component of environment changed, when and at what rate to have these effects?

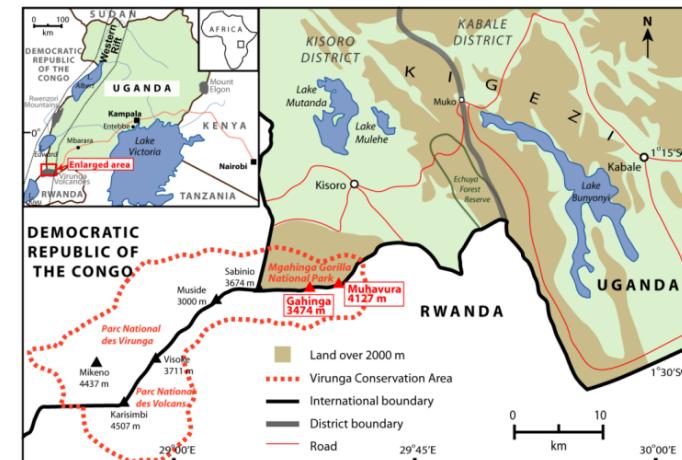


Difficulty of interpreting cause from effect
(many different causes have the same or similar effect). Also some effects may not agree with established narratives



Lake Bunyonyi, Kigezi, August 1984
(own PhD fieldwork)

Lake Bunyonyi, Kigezi, August 2008
(with thanks to Gail McGlynn)



e.g., Lolldaiga, Laikipia Plateau, Kenya



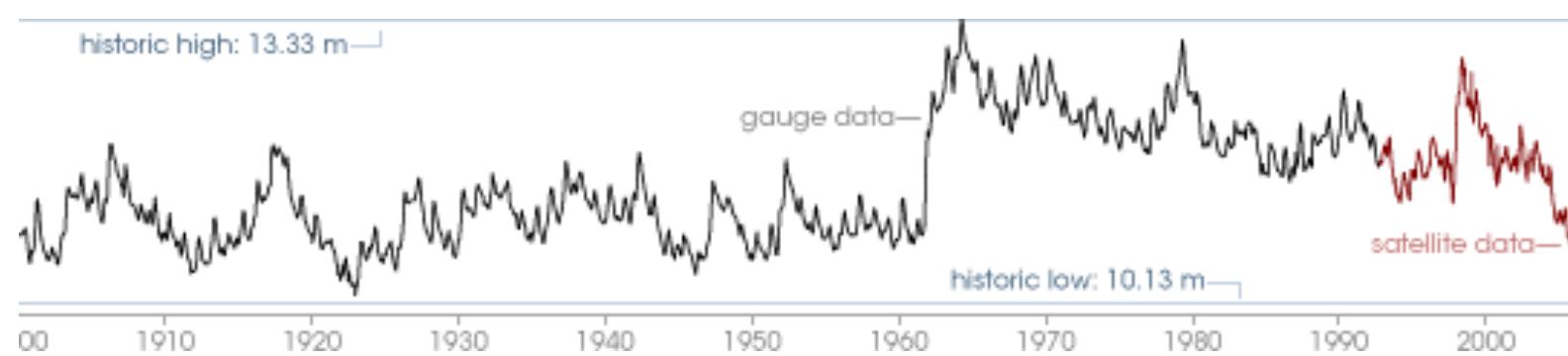
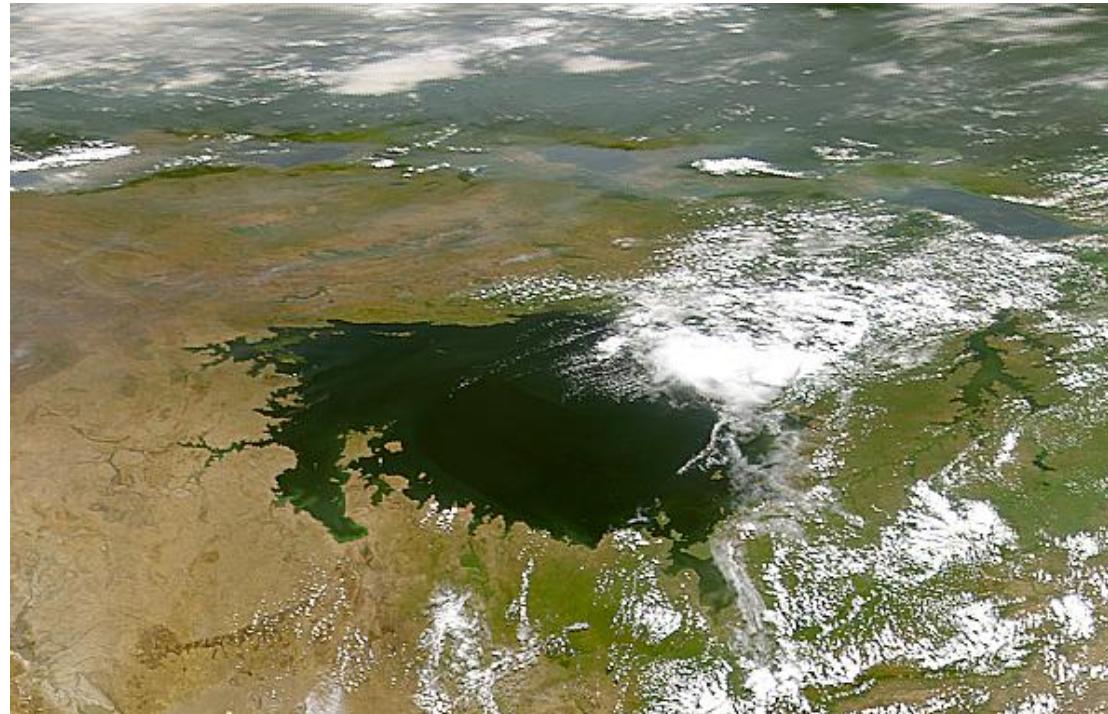
Fire prevention has led to changes in % tree cover in some savanna/woodland habitats



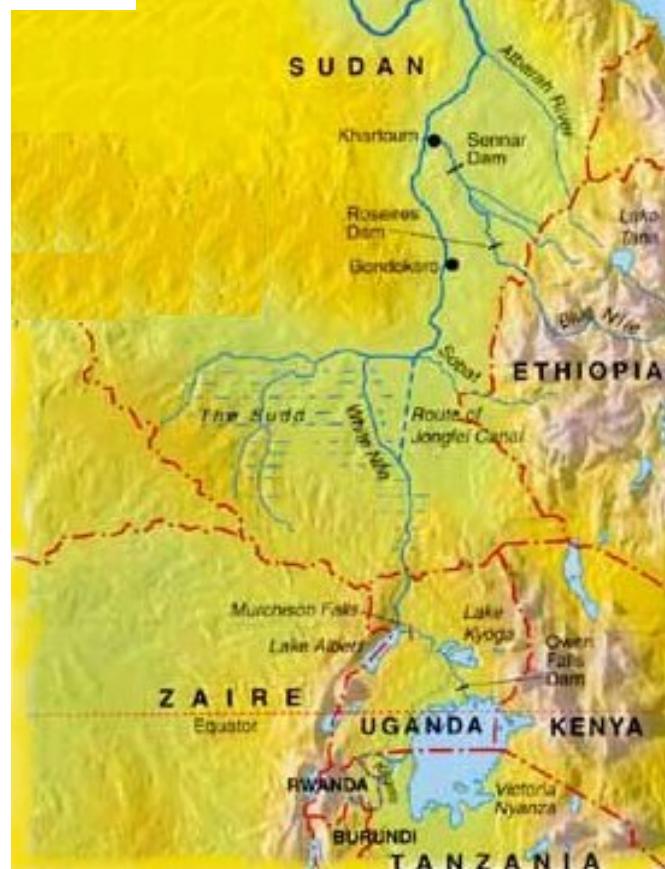
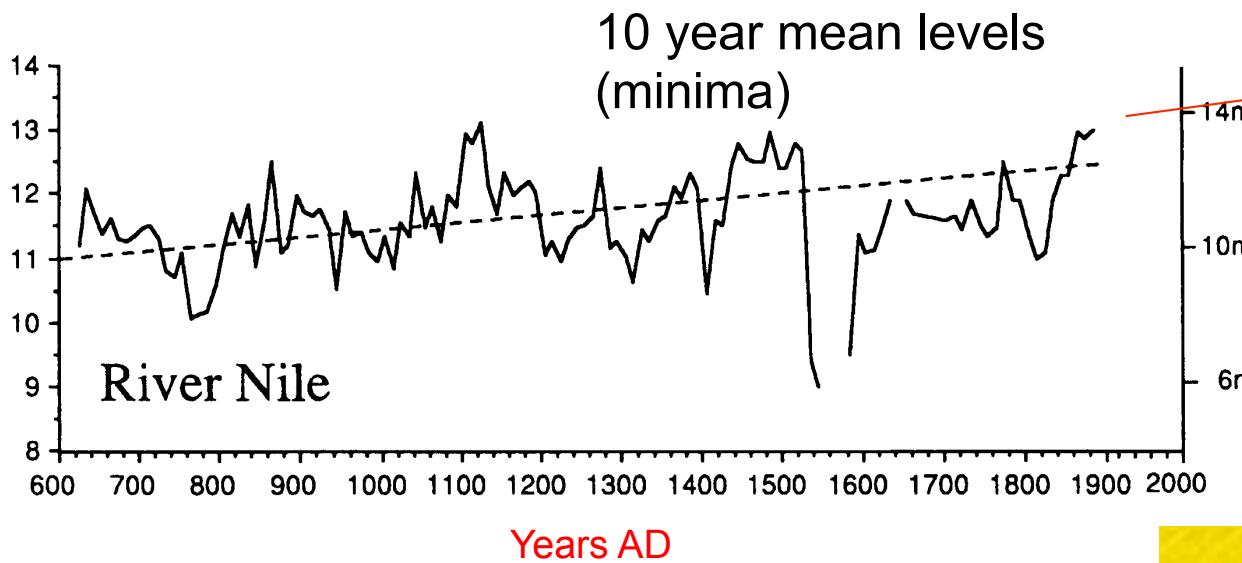
Photographs c/o Laragh Larsen

Other sources of evidence, including documentary and instrumental records

e.g. Lake Victoria: variations in lake level during the historic period



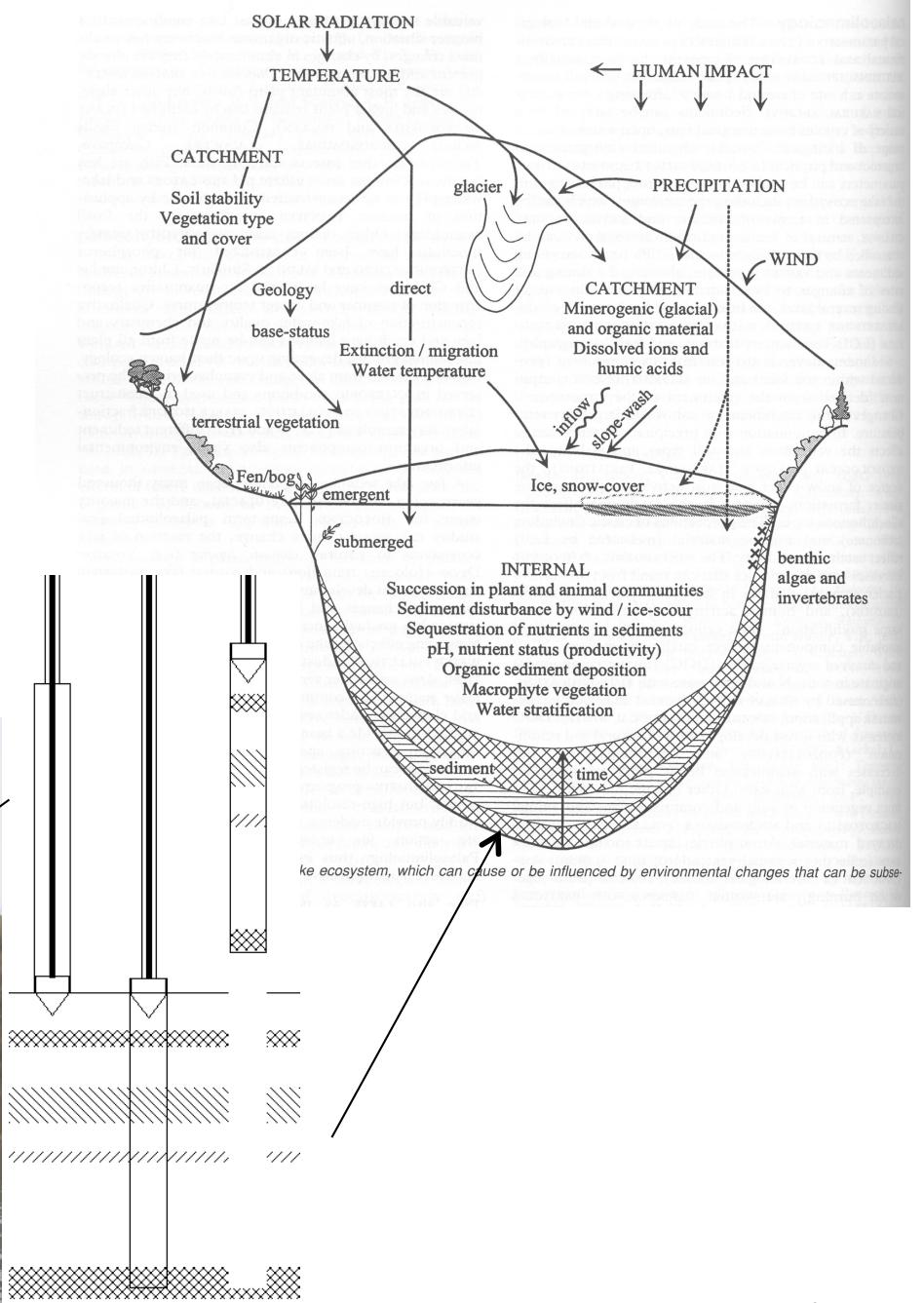
Source:
USDA
Foreign
Agricultural
Service

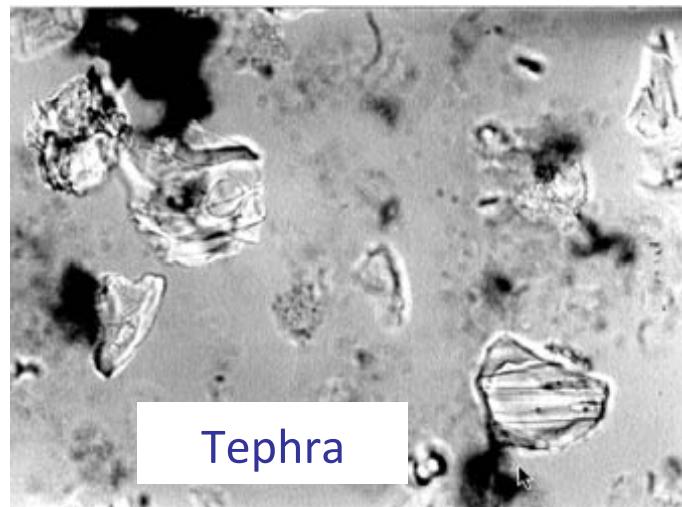
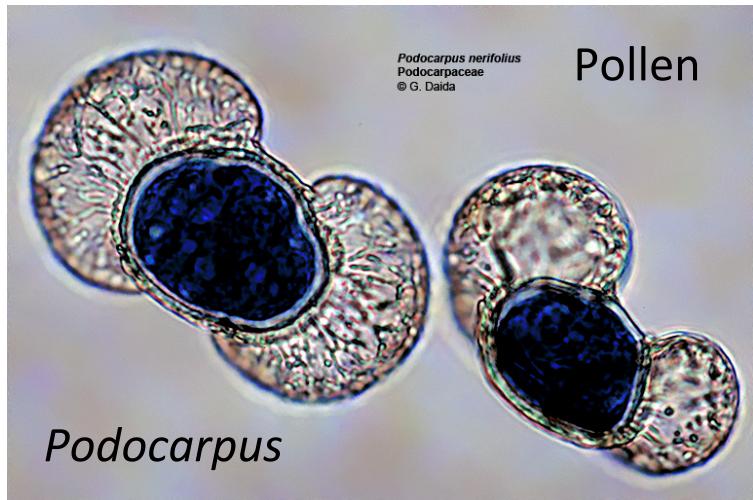


One of the longest instrumental records anywhere in the world and certainly in Africa is the nilometer, at the mouth of the Nile (actually several locations over its c. 3500 years history)

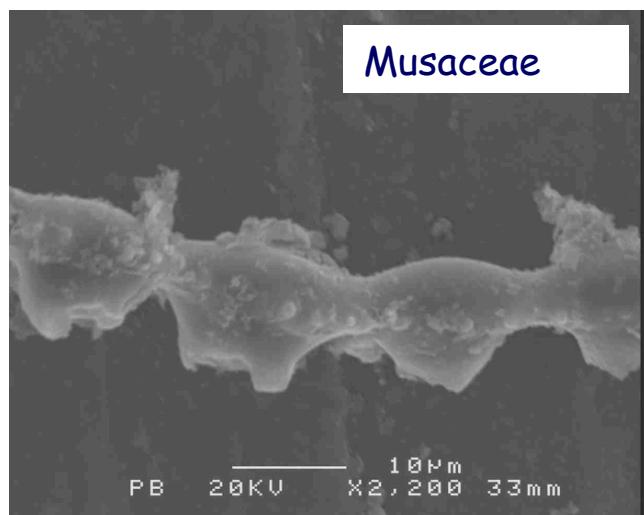
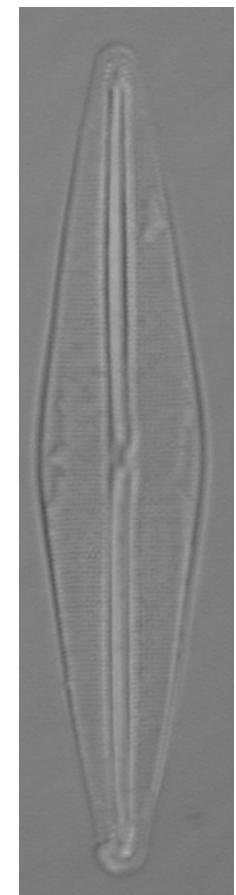


Sedimentary environments (lakes, swamps, floodplains) can potentially yield long, continuous records on environmental change drivers and effects





diatoms



Phytoliths

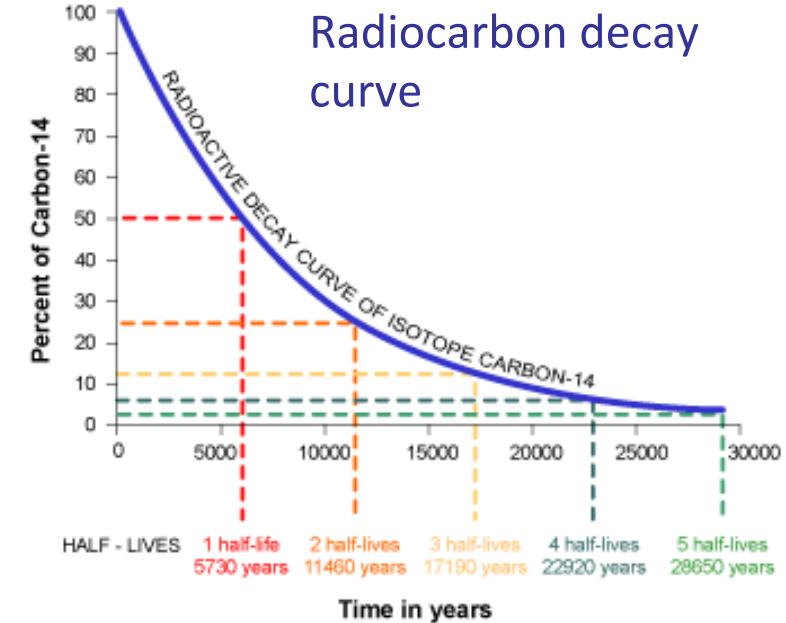
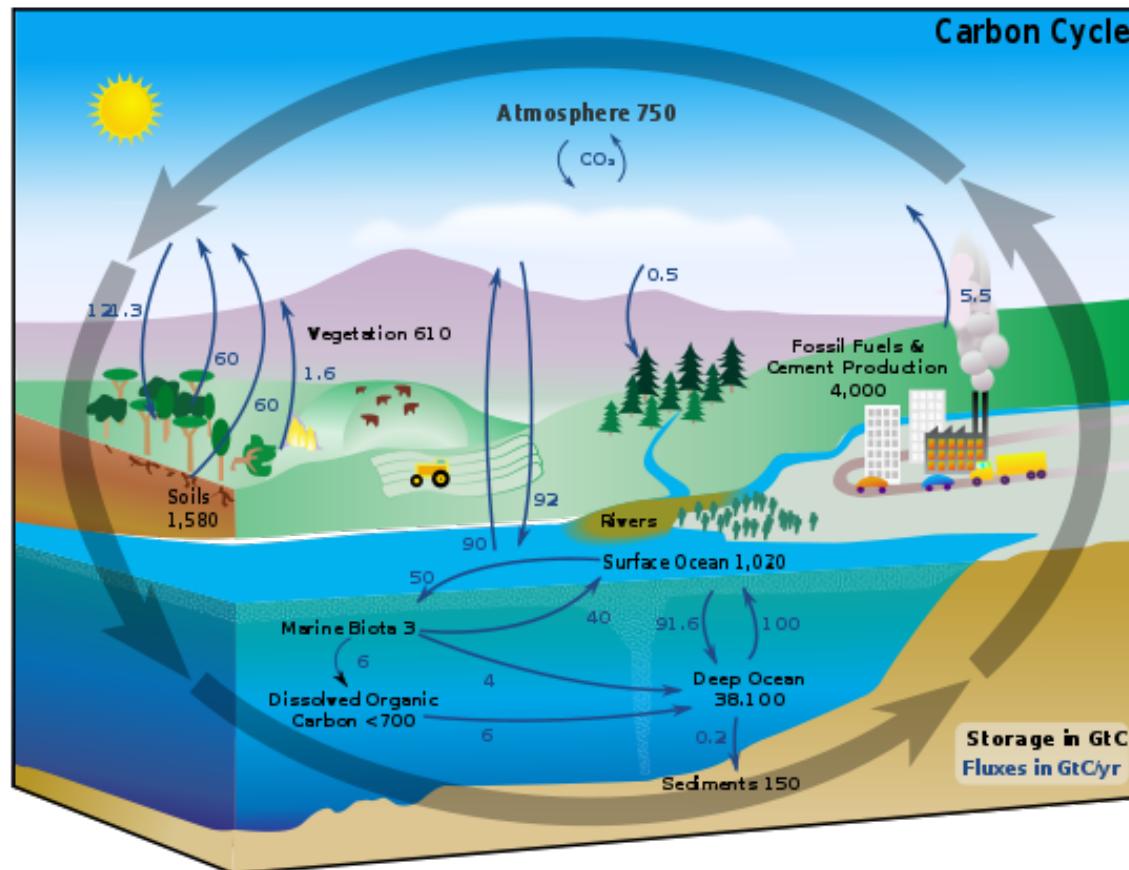


charcoal

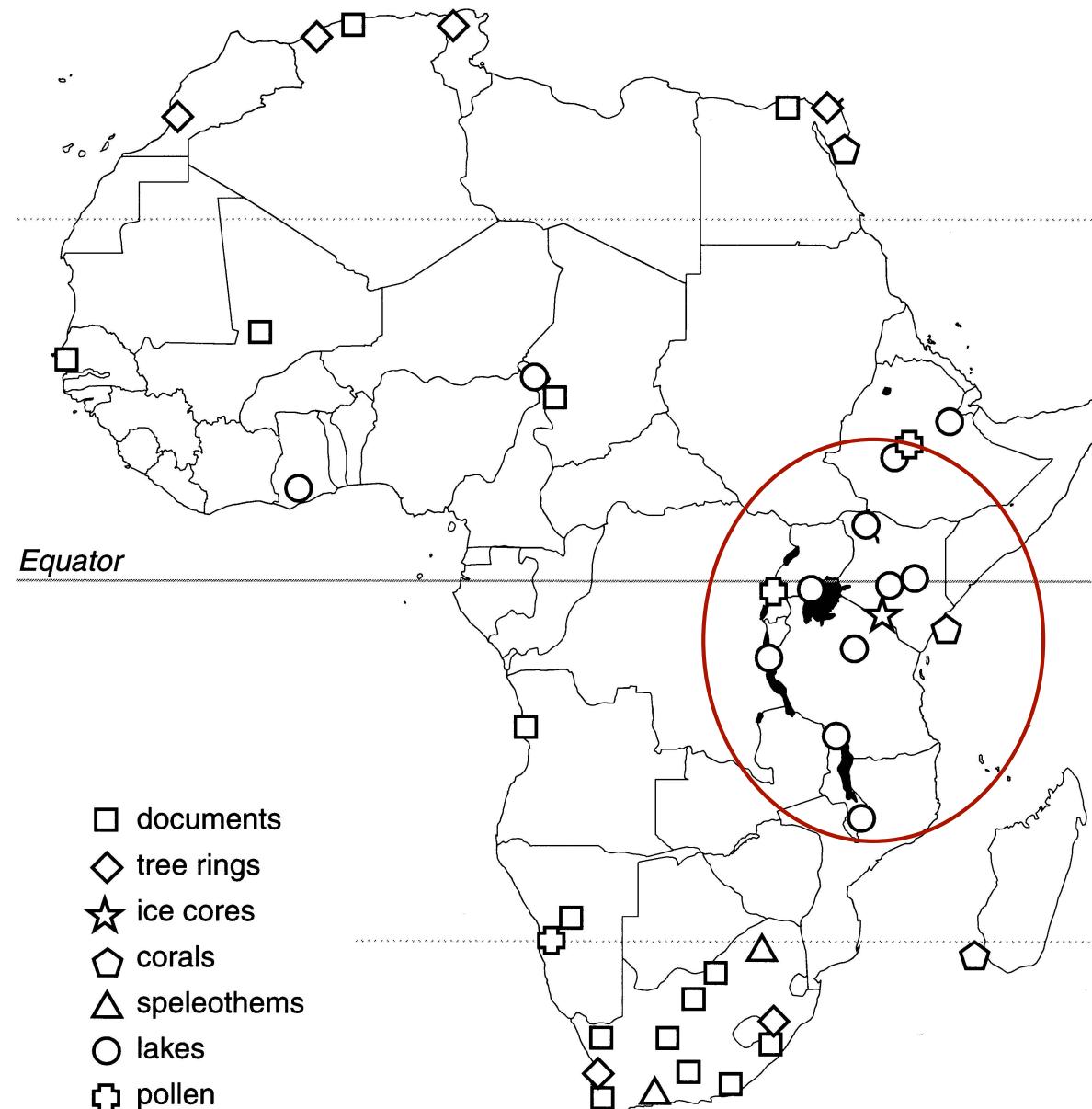
Frustulia

Sediment-based information also includes isotopic evidence (both stable and radioactive), remains of DNA etc that can be used in the reconstruction of past environments.

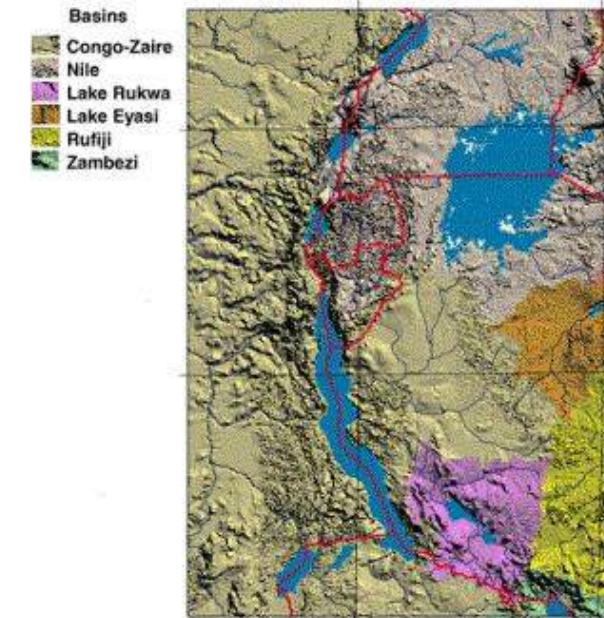
For example, radiocarbon (^{14}C) can be used to establish the age of sediment-based evidence, and past rates of environmental changes



Carbon cycle



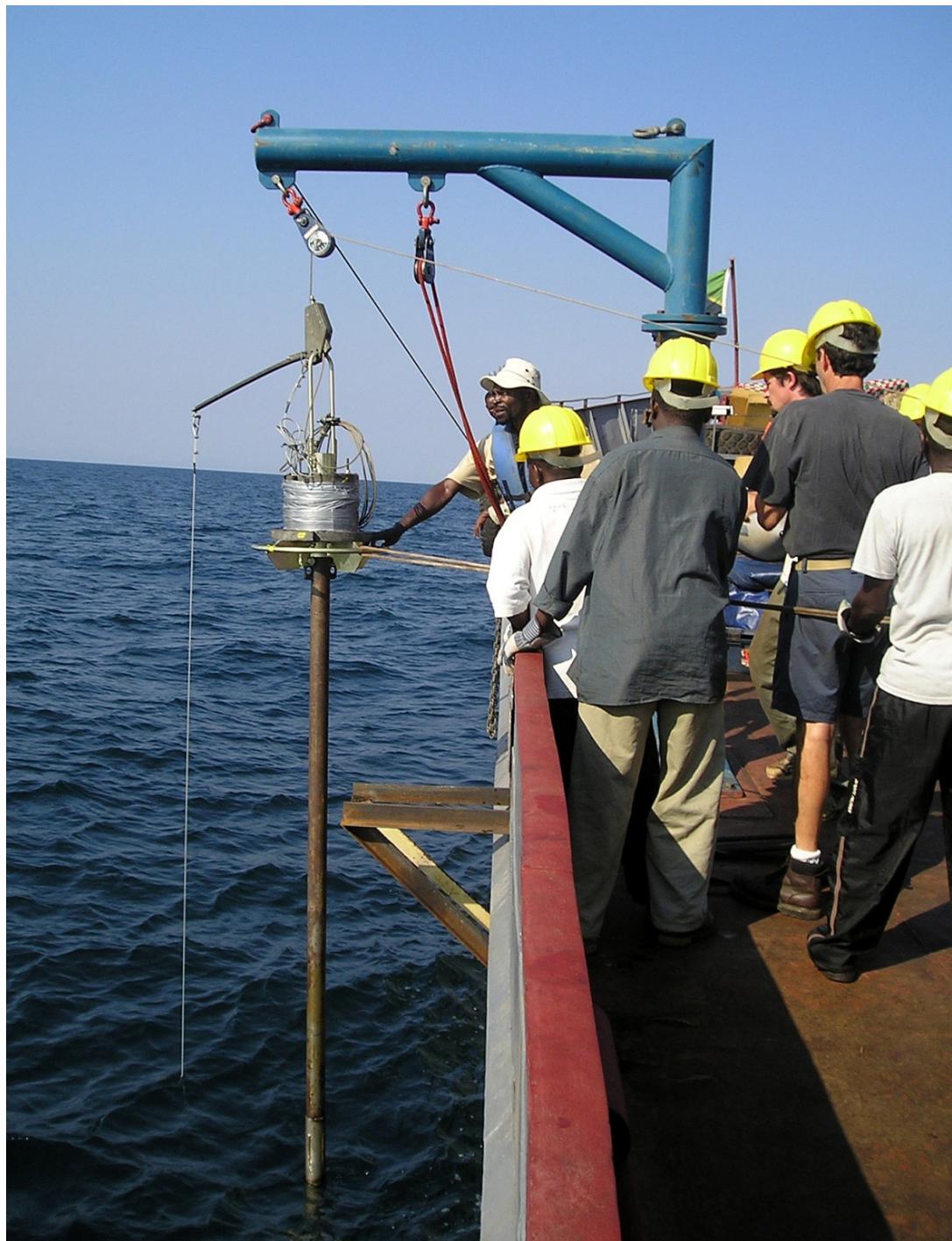
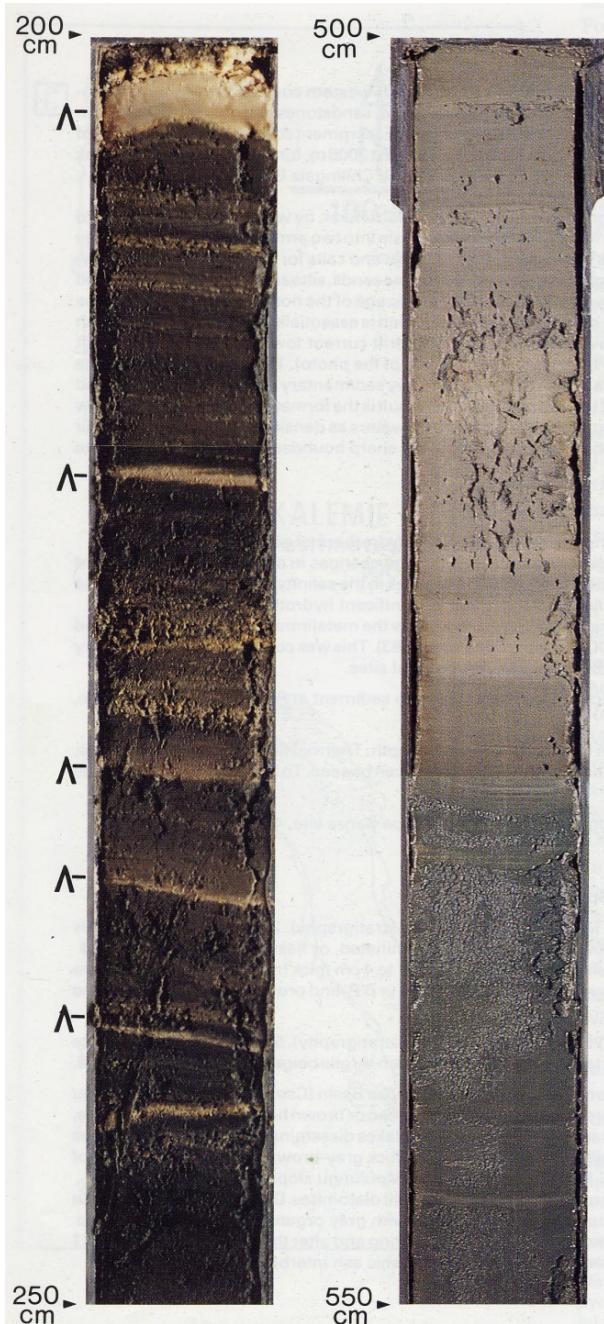
Locations of high resolution climate proxy records in Africa extending beyond c 1880 AD
 (from Verschuren, 2004)



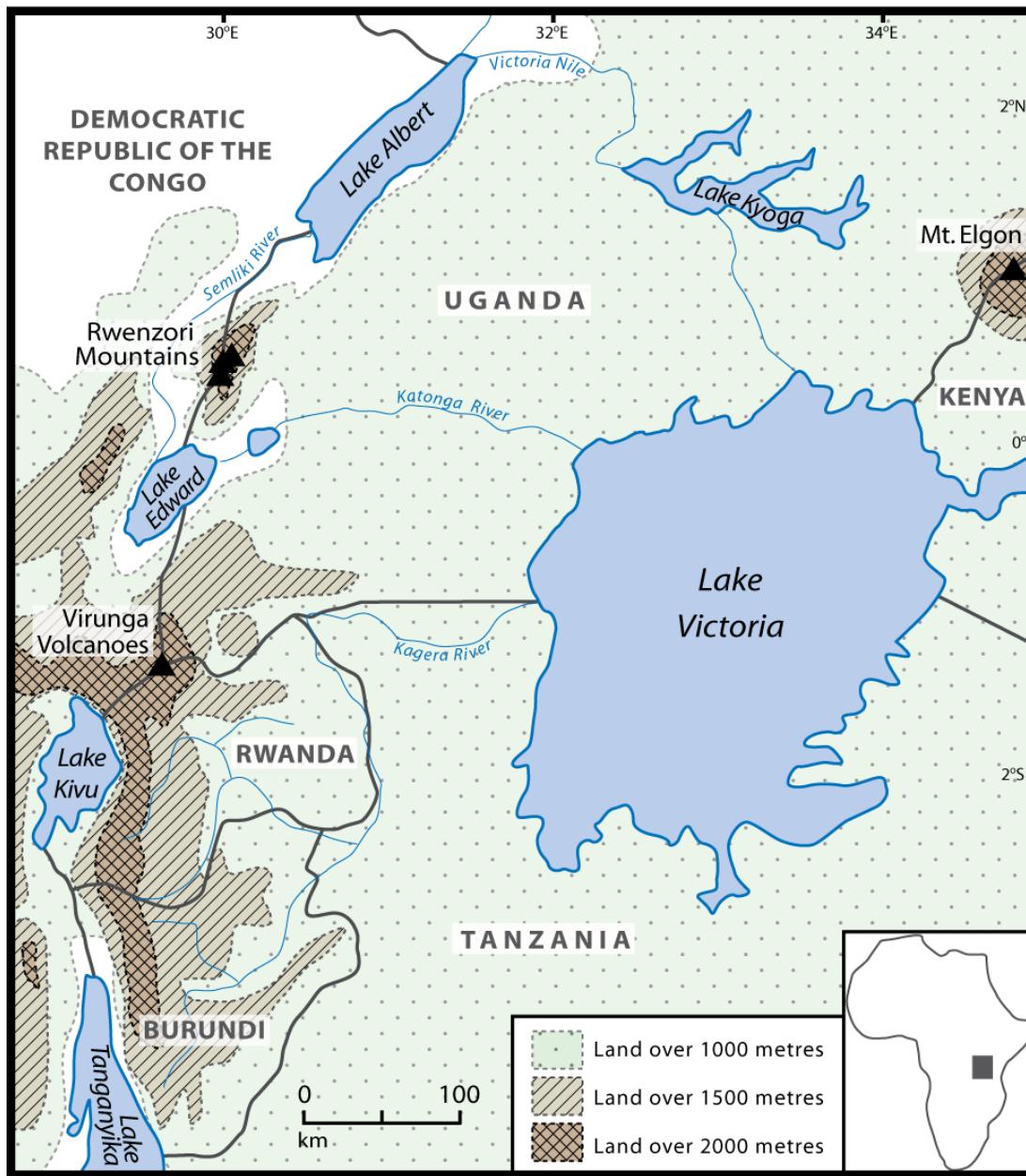
Tanganyika:

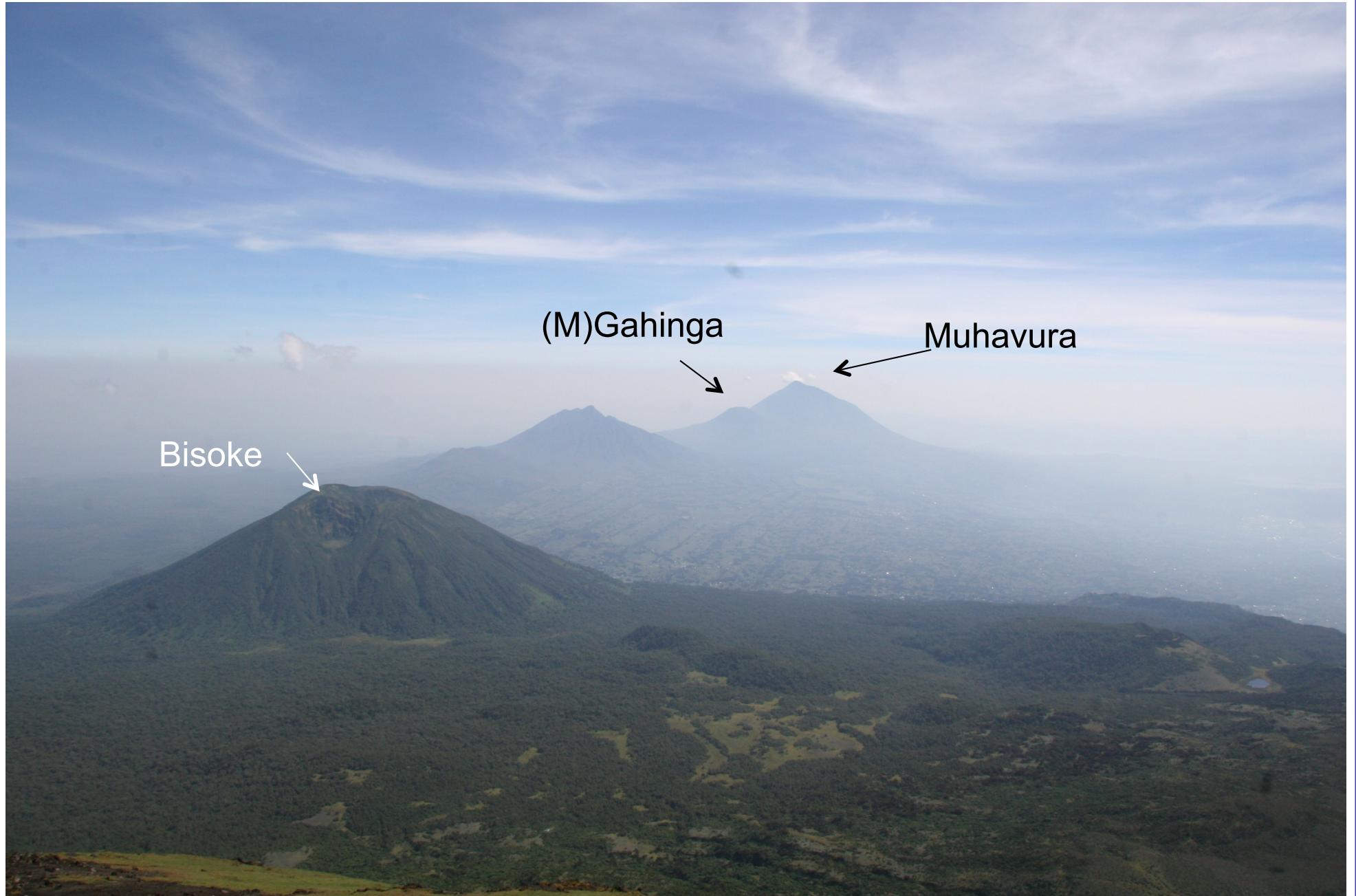
the largest of the rift valley lakes
of eastern Africa

- 32,000 km² surface area;
- > 700 km long
- 1470 m maximum depth
- > 5° latitude
- 230,000 km² catchment area,
incorporating 2000 m of altitude



Virunga volcanoes – part of the Albertine (Western) Rift





Three very basic research questions:

- 1) How have environmental conditions changed on hundreds to thousands of years timescales, as recorded in sediments accumulating in the Virunga volcanoes?
- 2) What are the likely drivers of any changes?
- 3) What, if any, are the implications for development and conservation?



Three sites studied *in detail* to date:

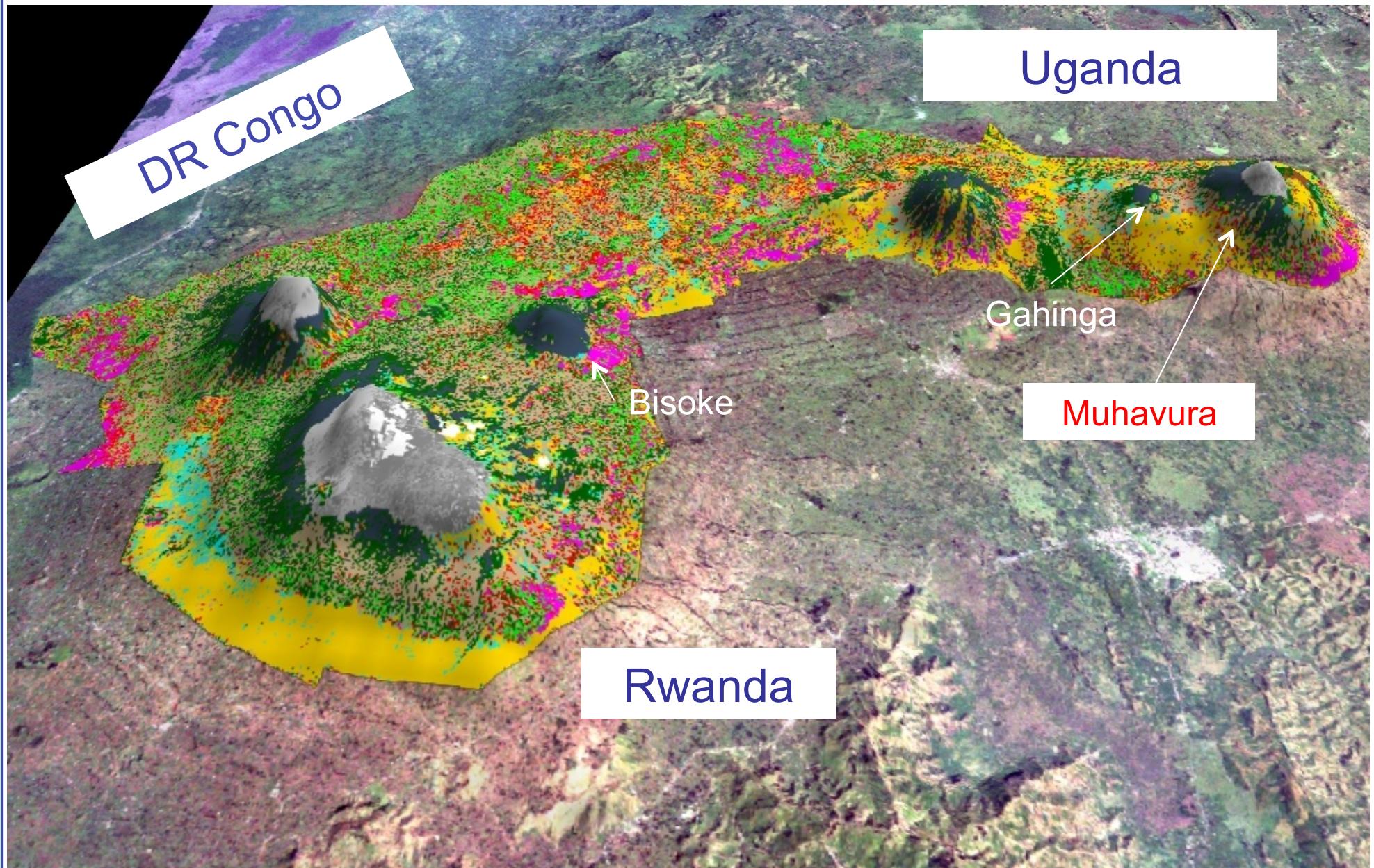
Crater lake on Muhavura (ca. 4127 m above sea level)

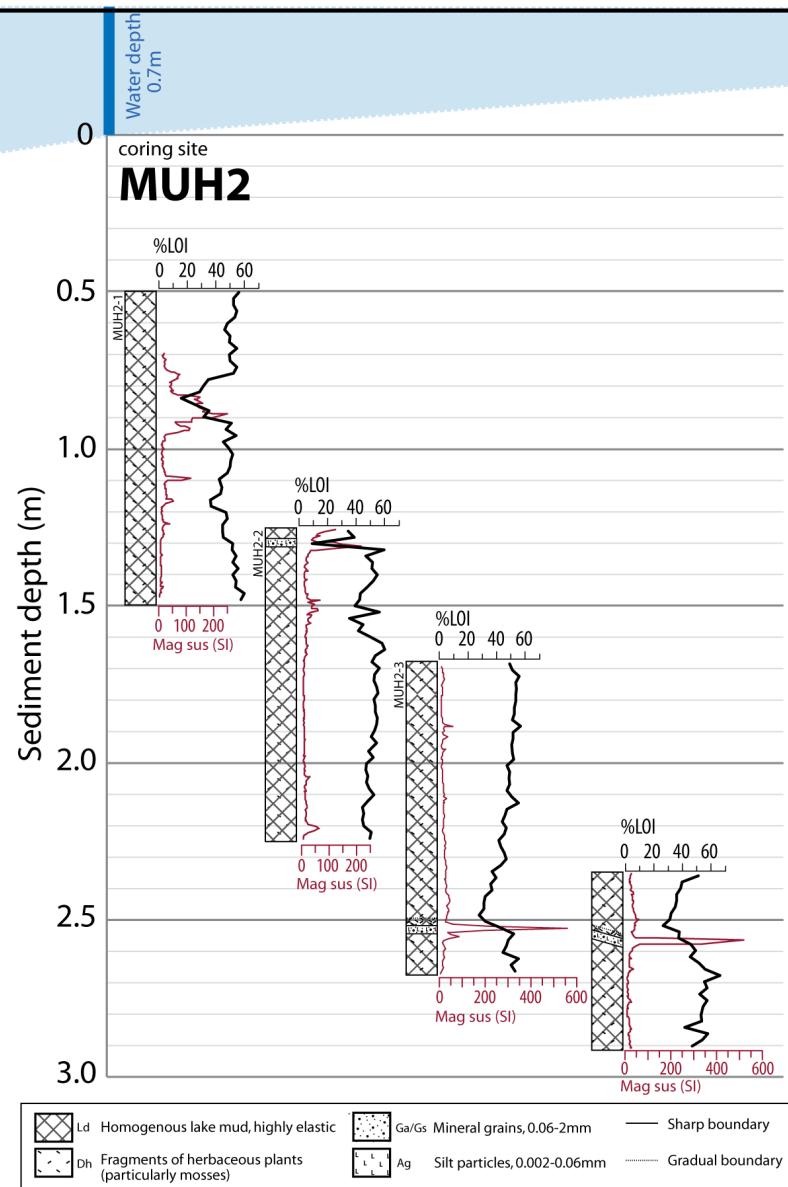
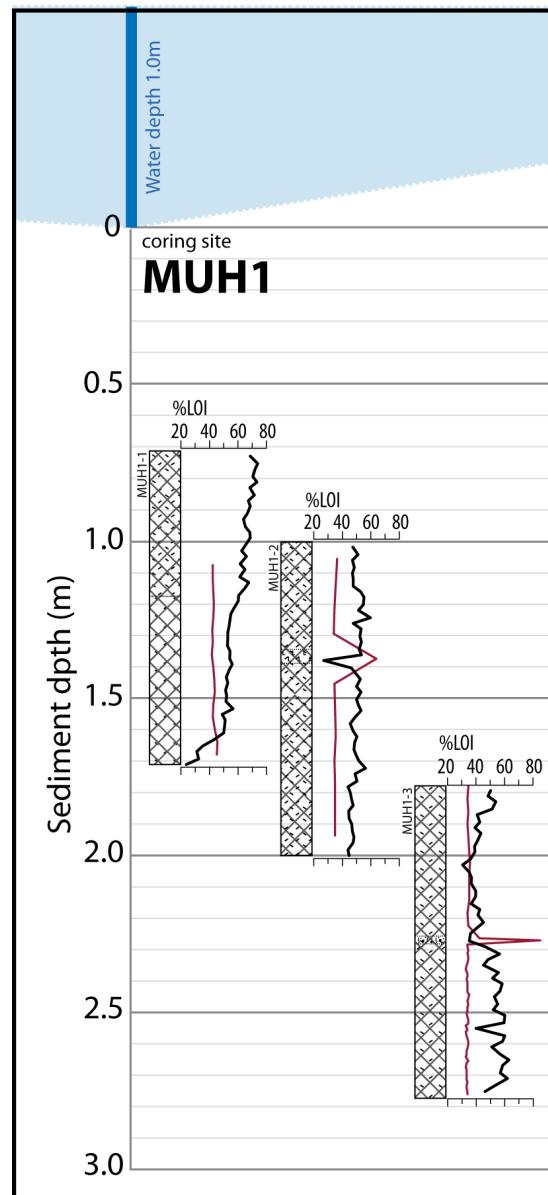


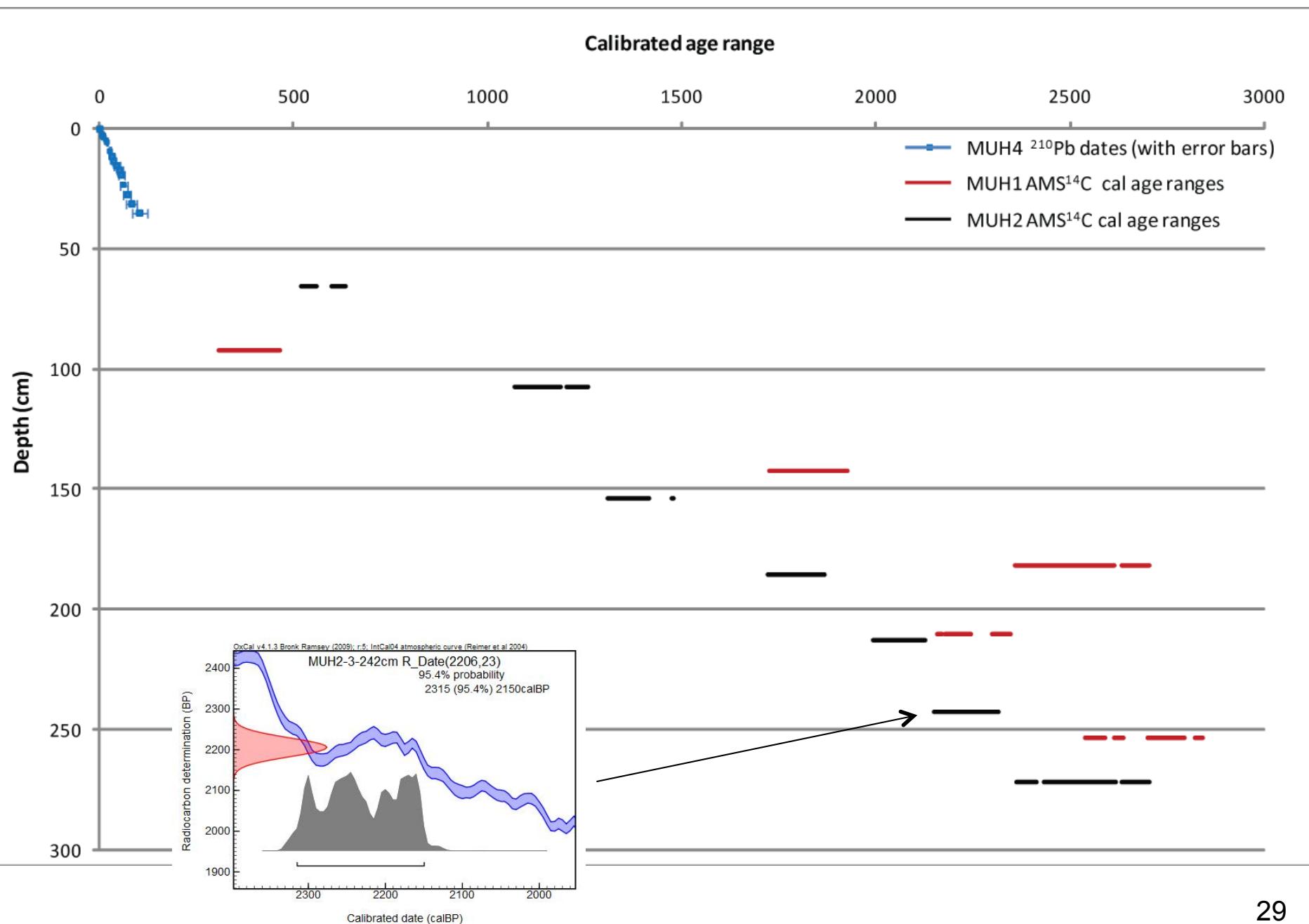
Camp site, Muhavura

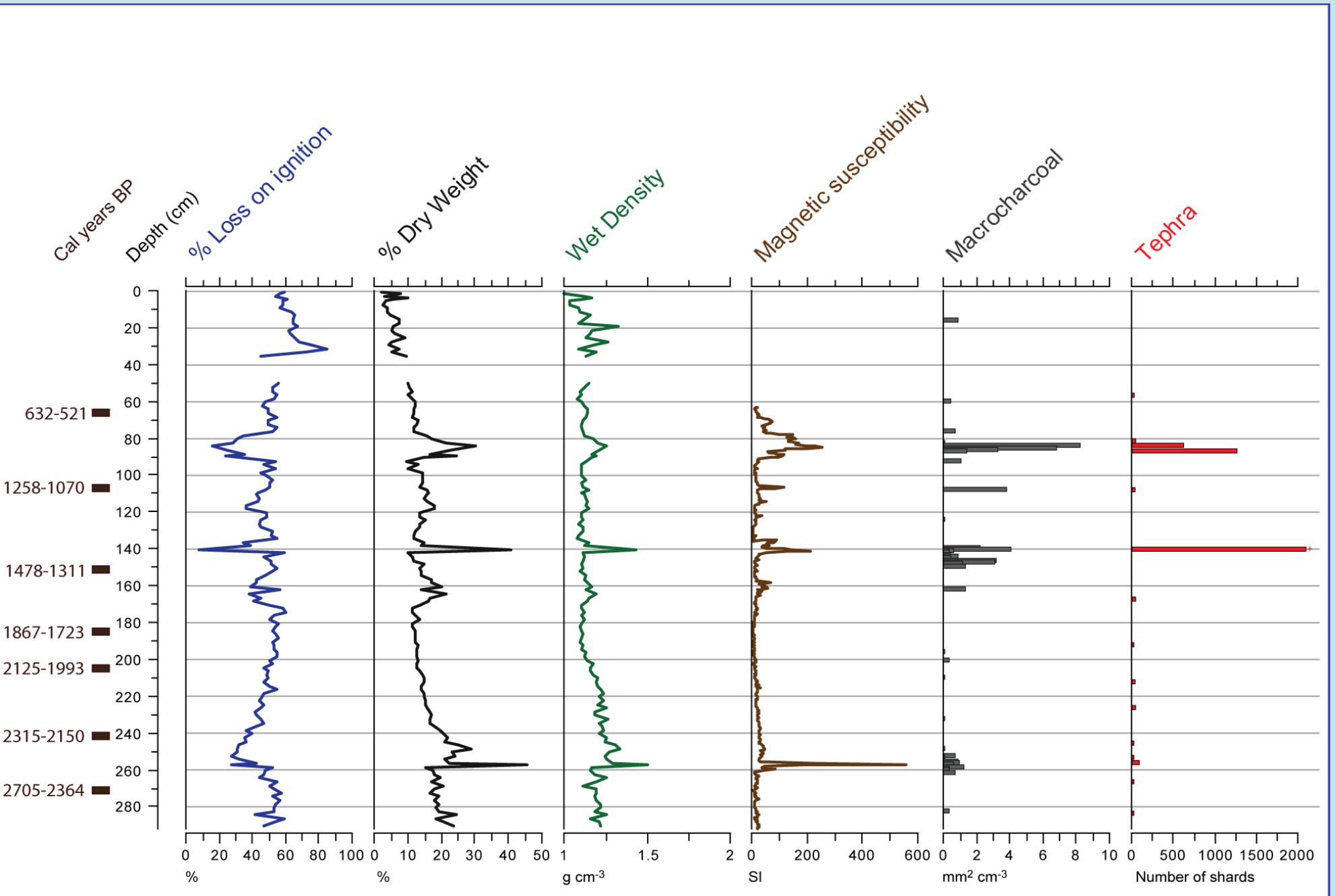
Crater swamp on Gahinga (ca. 3474 m above sea level)

Virunga volcanoes

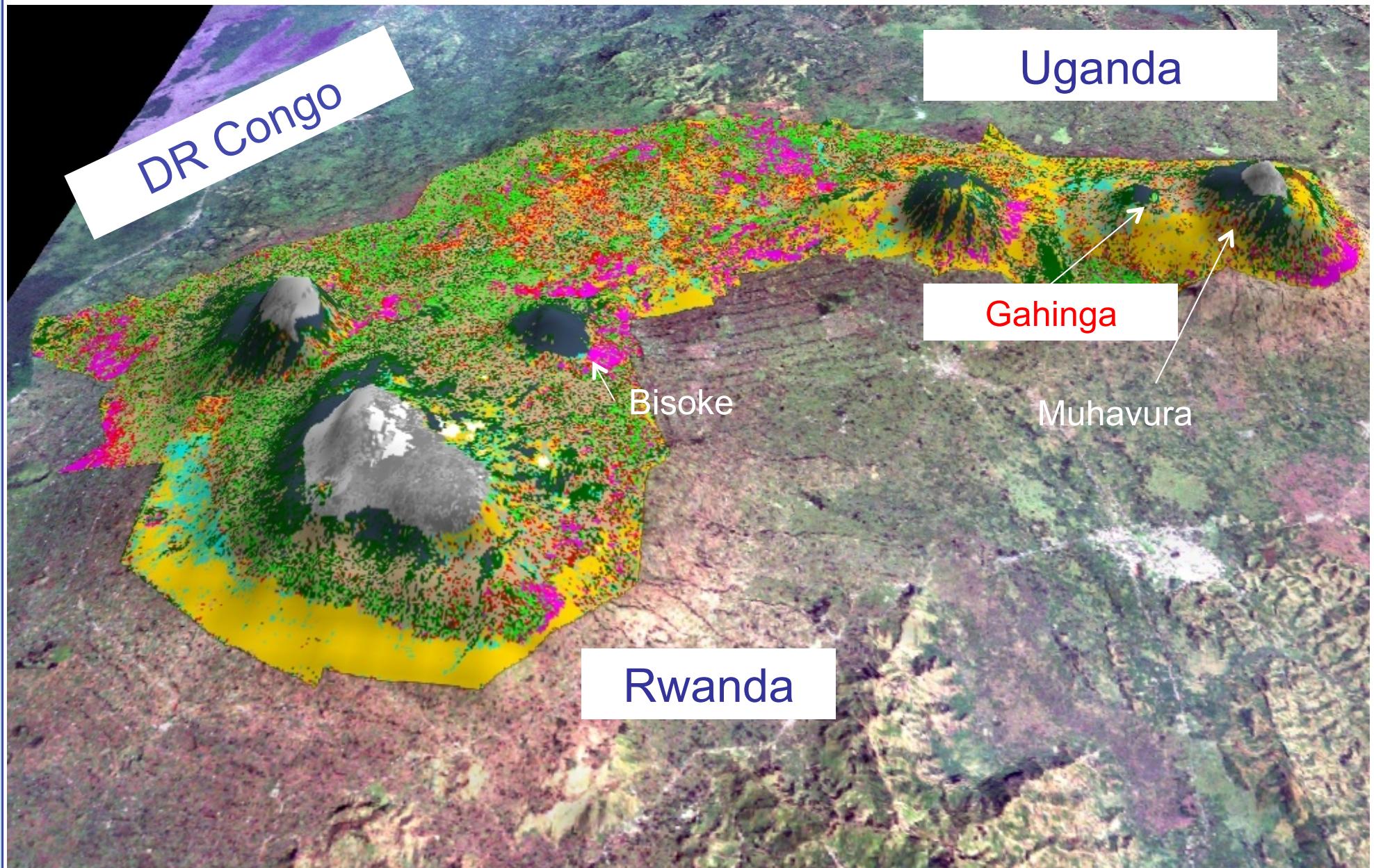


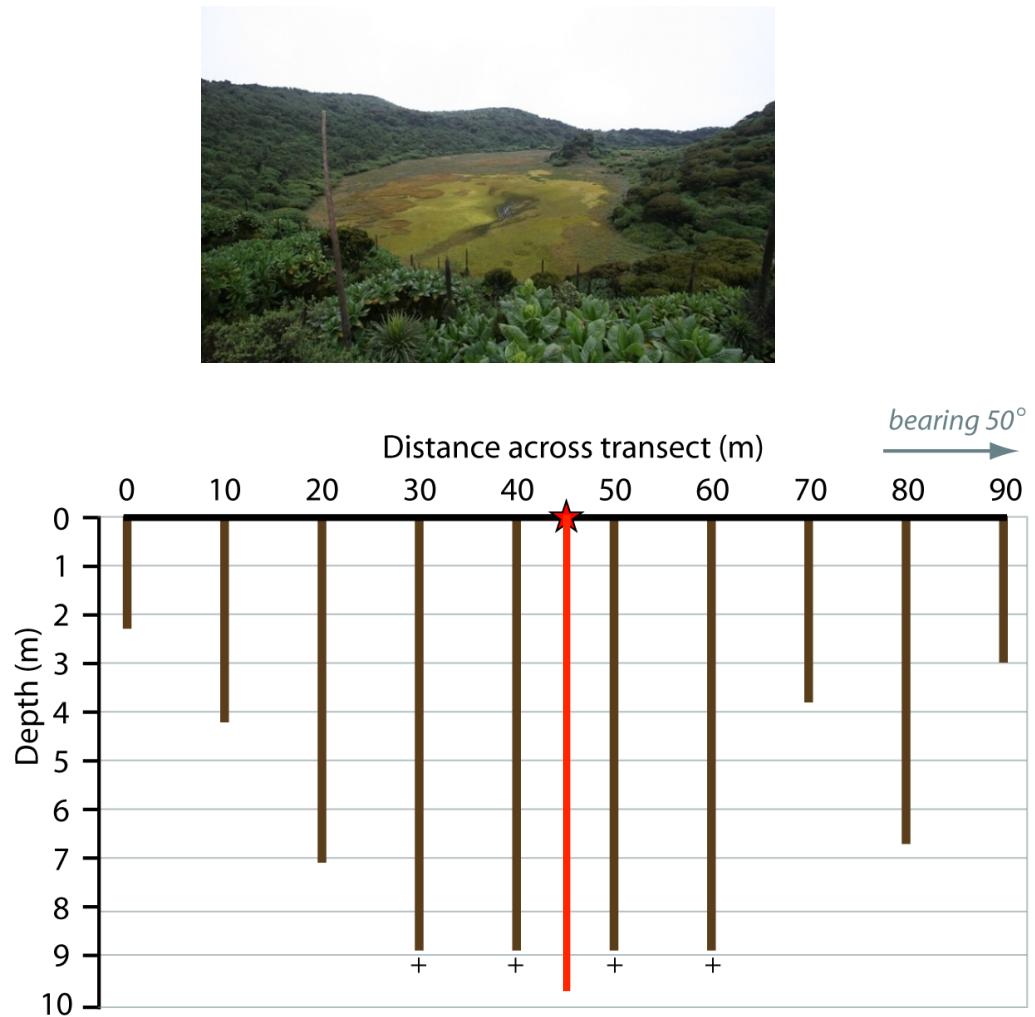






Virunga volcanoes





Gahinga record – from a *Sphagnum* (moss) swamp



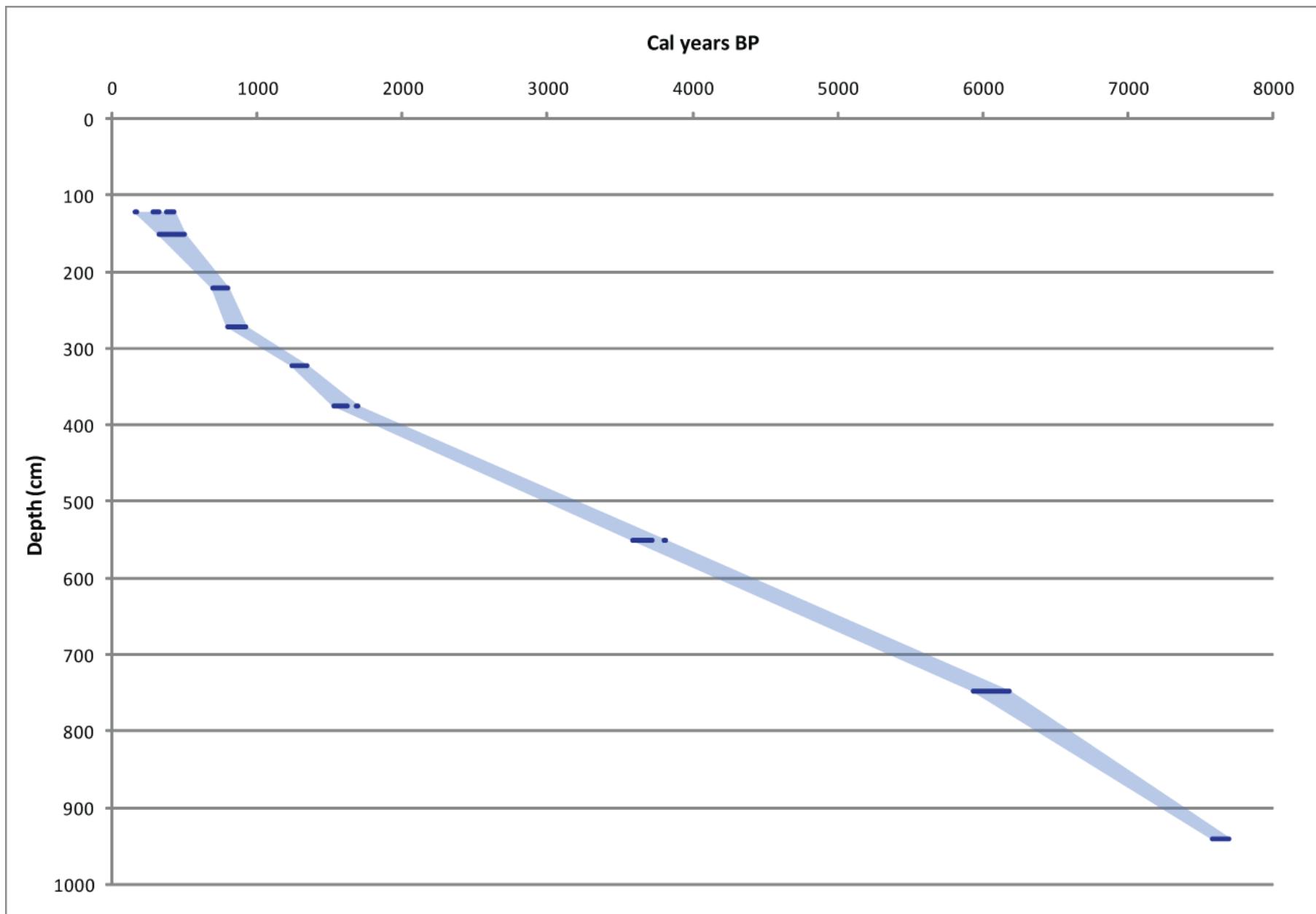
■ Sediment depth

+ continued beyond extent of measuring equipment

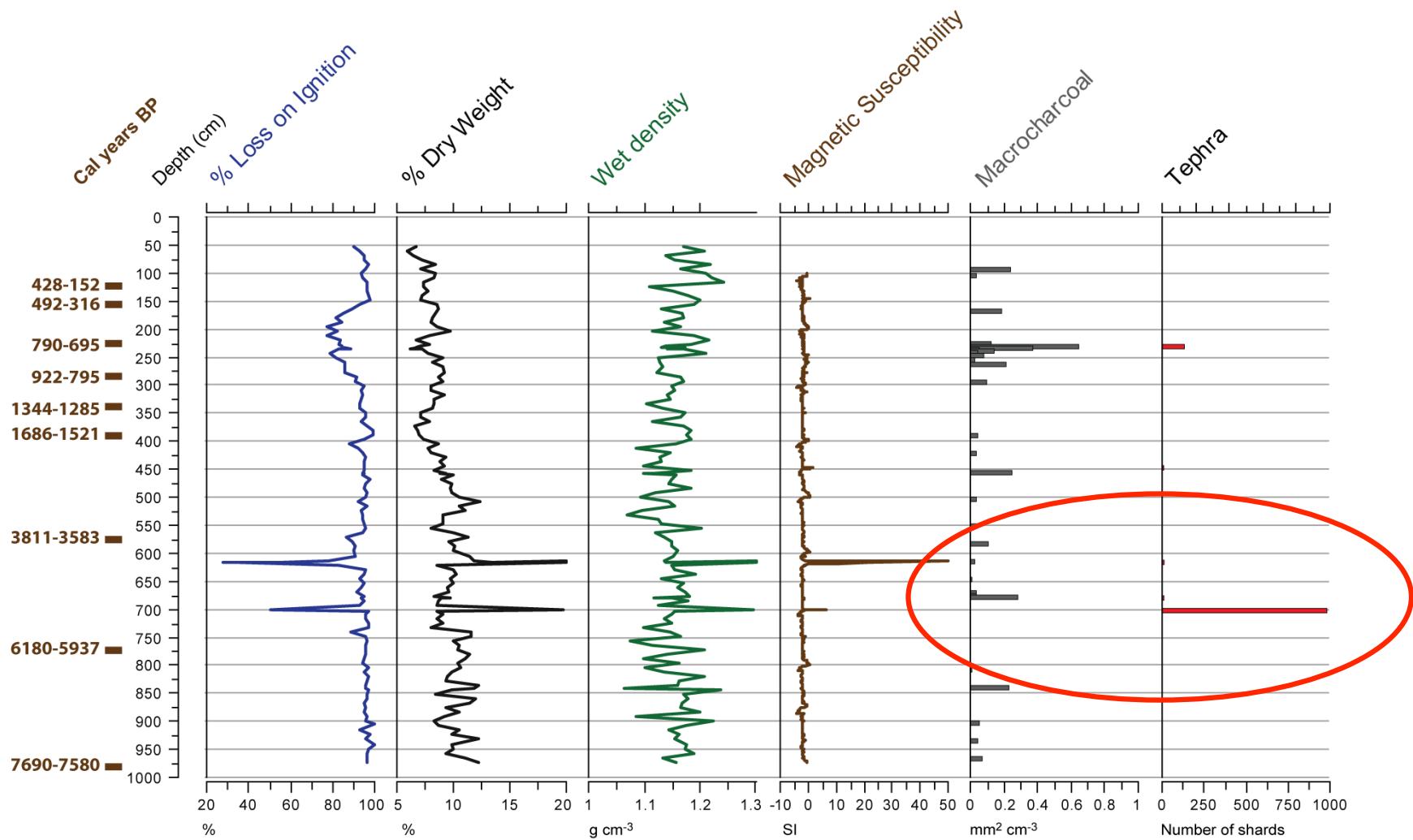
★ Sampling site for Livingstone coring

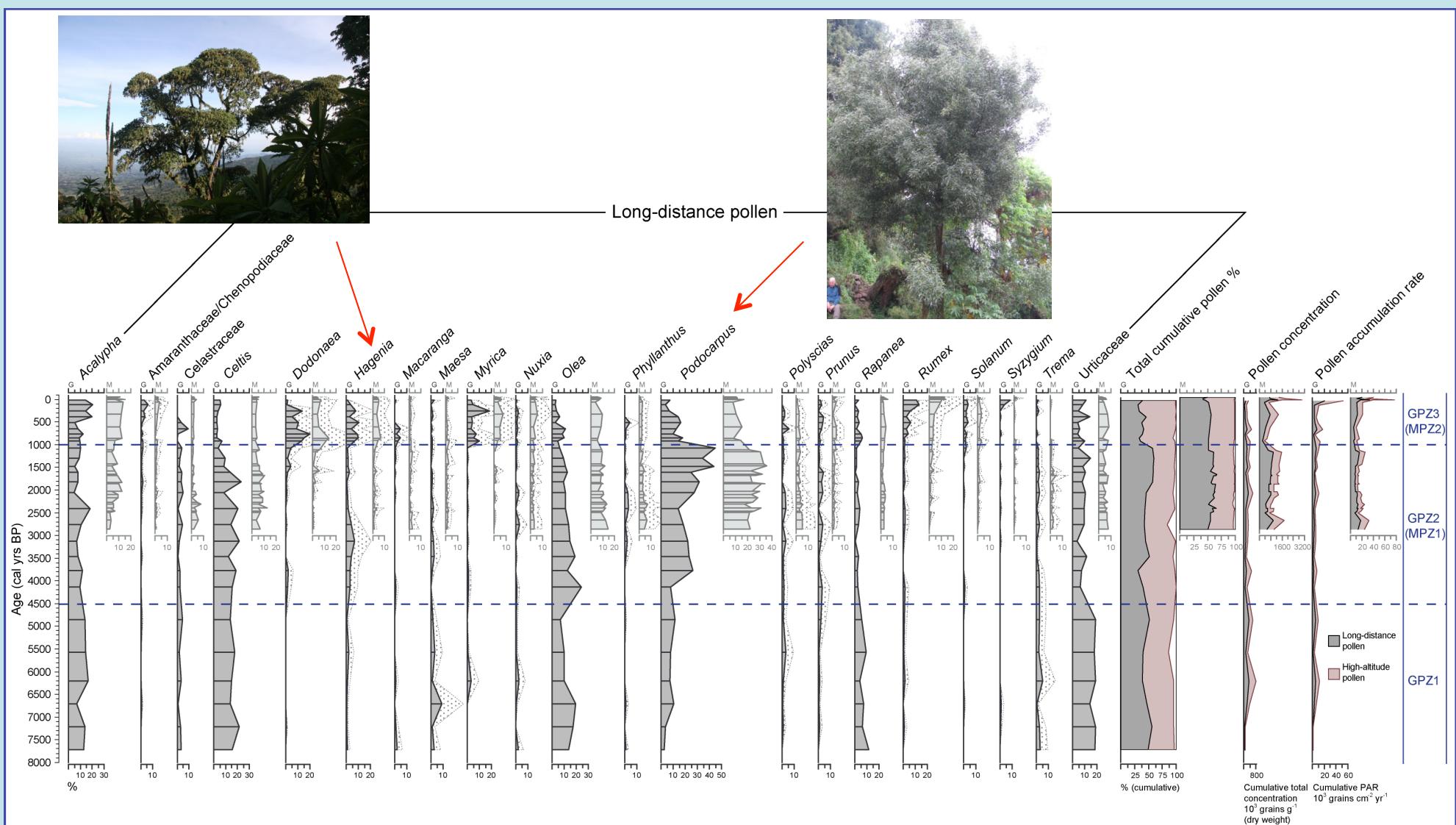


GAH crater swamp site AMS¹⁴C dates



Massive peak in magnetic susceptibility = incorporation of ash (tephra) from eruption of Muhavura ca. 5500 BP (but no link to increased burning apparent)?



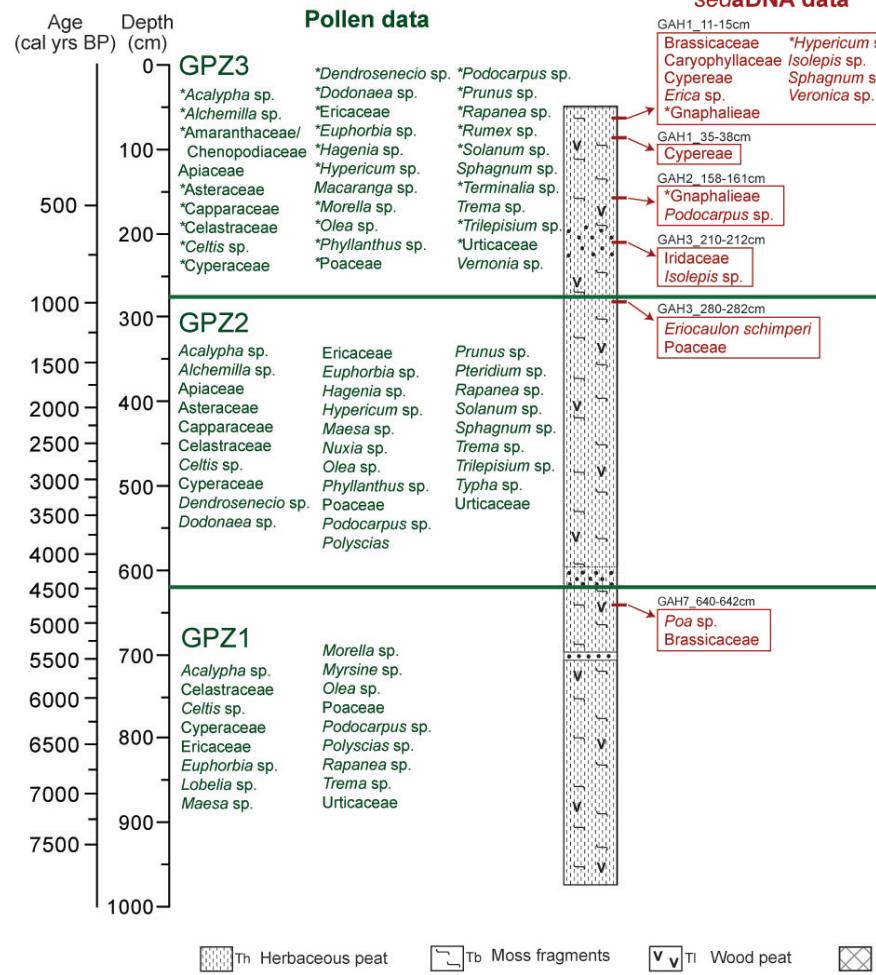


Pollen data from McGlynn, Mooney & Taylor (2013) Sediment-based evidence for Holocene environmental change from the Virunga volcanoes in the Albertine Rift, central Africa *Quaternary Science Reviews* 61: 32-46

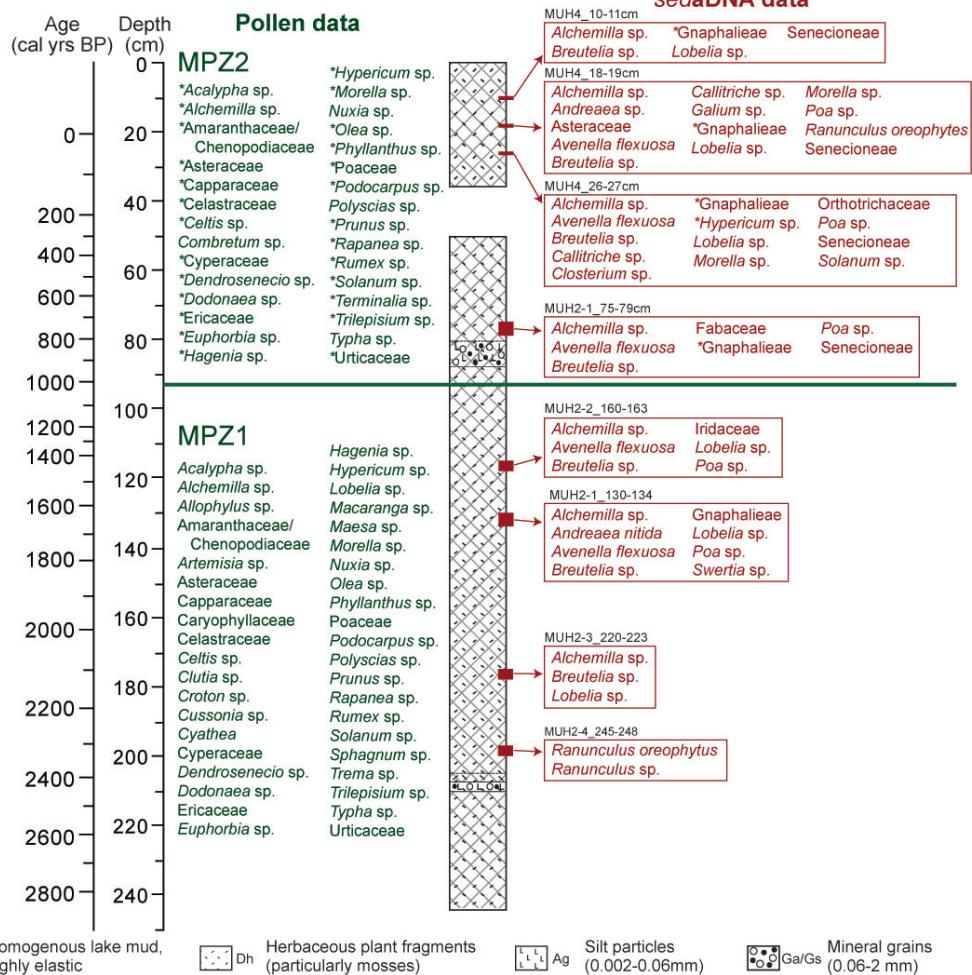
Sediments accumulating in the crater sites at Muhavura and Gahinga have also yielded ancient sedimentary plant DNA – up to 5000 years old – that can be identified to plant taxa ... the first time this has been done in the humid tropics!



(a)



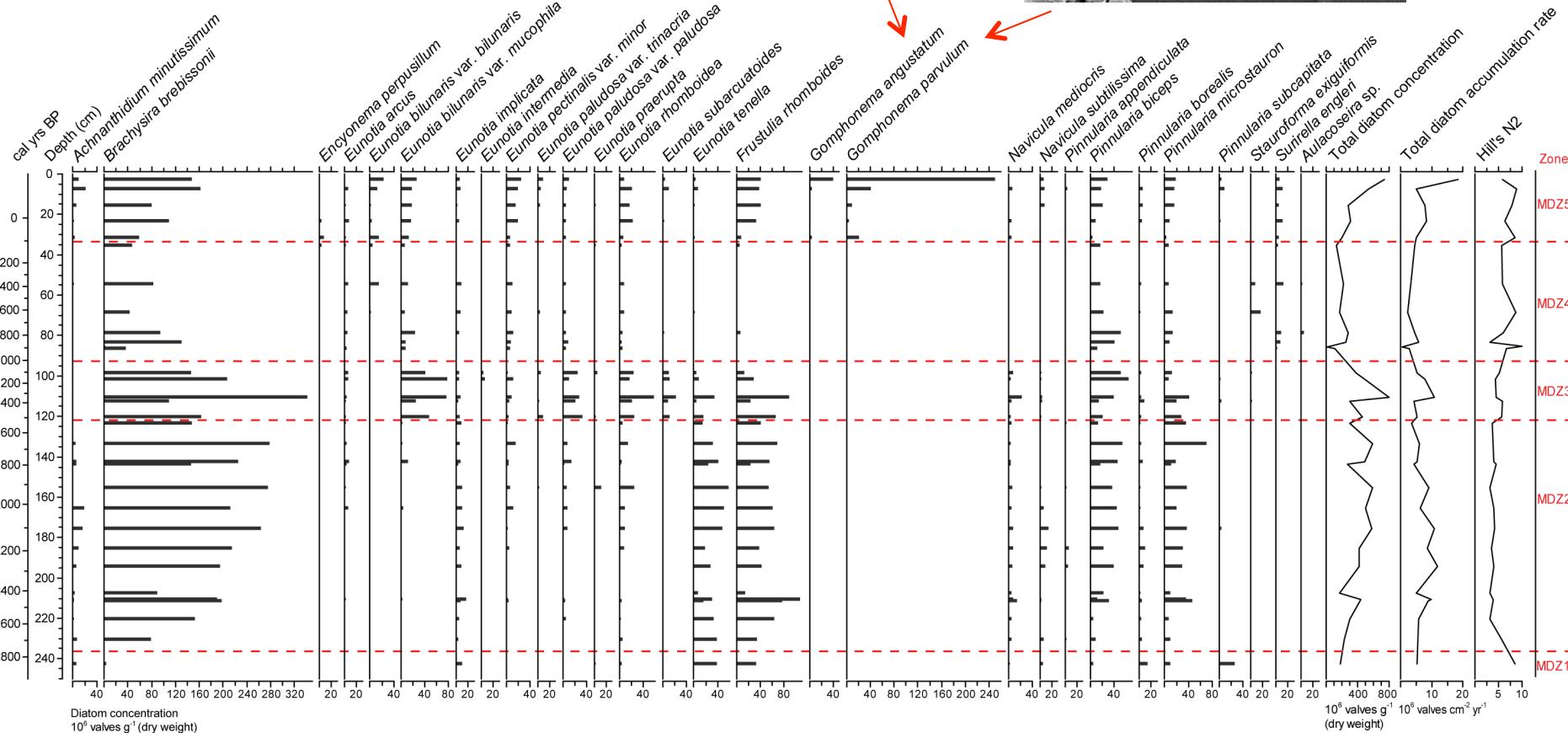
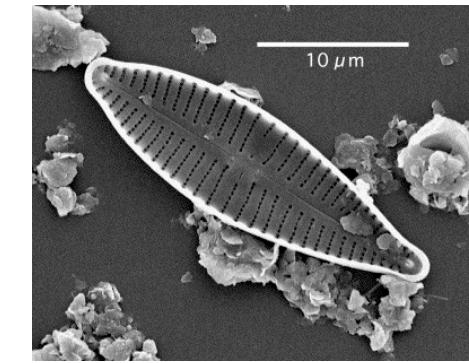
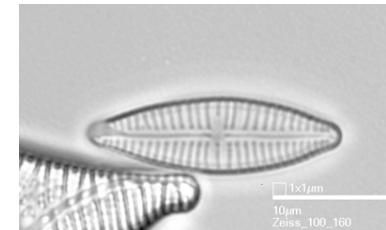
(b)



* = taxa that occur in the most recent pollen zone at both sites (GPZ3 and MPZ2)

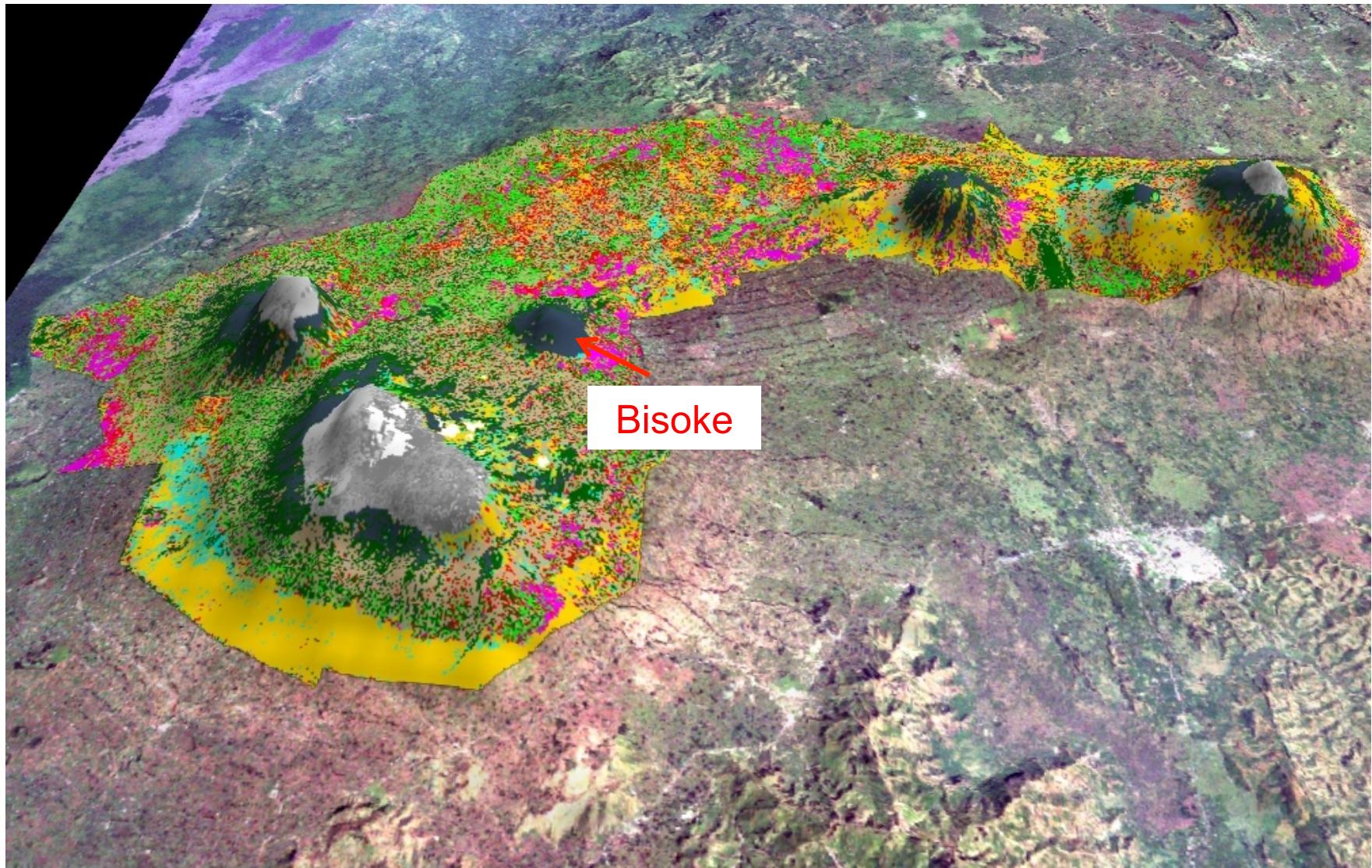
Comparison of seda-DNA and sub-fossil pollen in sediment samples from Virunga sites

(research in conjunction with Biosystematics Research Group, Natural History Museum, Oslo, Norway. Data from Boessenkool, McGlynn, Epp, Taylor, Pereira, Gizaw, Nemomissa, Brochmann and Popp (submitted) Ancient sedimentary DNA from a biodiversity hotspot in the humid tropics introduces a novel tool in conserving high altitude tropical biodiversity *Conservation Biology*)



Recent (atmospheric) fertilisation effect? Evidence of the ubiquity of recent (last 100-150 years) human impacts?

Research has been extended to a third site: **Bisoke**





Bisoke has two *relatively* easily accessible crater sites – only one has a lake, however – c. 3700 m amsl



Bisoke camp, August 2010

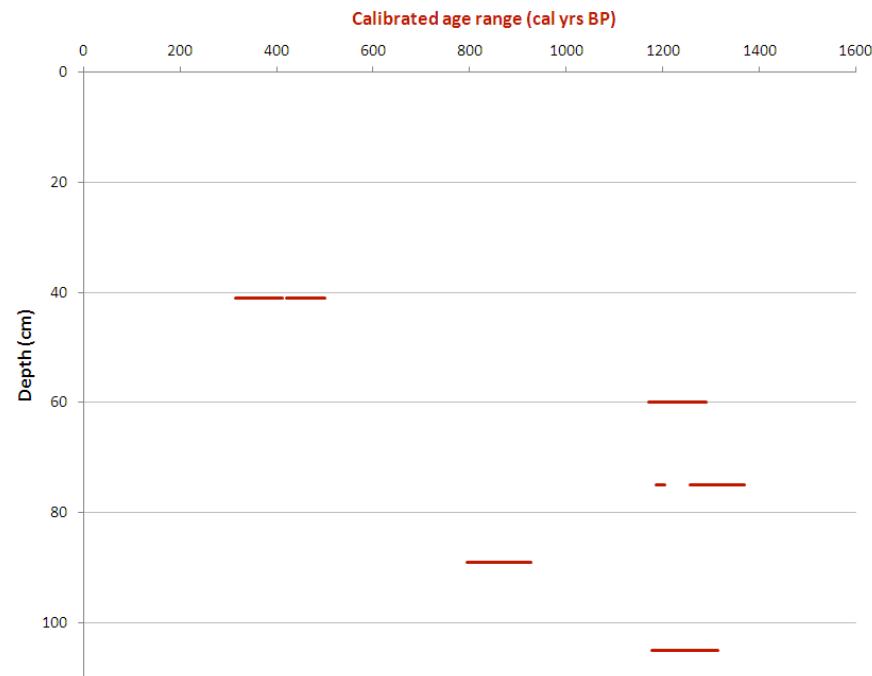




Bisoke summit camp most days



110 cm-long core of sediment recovered.
Now being analysed for diatoms and pollen
(charcoal already completed)



Chronological control (5 ^{14}C dates) is so far not so good as at other two sites – age anomalies around 60-80 cm.
Awaiting $^{210}\text{Pb}/^{137}\text{Cs}$ dates and additional ^{14}C date to check whether uppermost part of core is intact



Research in eastern Africa is ongoing, but is producing interesting information on long-term environmental changes:

- Environments have never been stable for long, if at all – driven by climate change, volcanic activity and human impact
- The past impacts of these drivers – and interactions between them – should become more clear as further data are obtained. But cause-effect relationships are complex **and not easily modelled**
- Current remnants of forest are not *pristine* (composition contains an imprint of past environmental change impacts) and rainfall levels may have varied hugely in past
- New sediment proxies (e.g. ancient DNA) have potential to open up new areas of research, including restoration of degraded habitats





Thank you!

Early morning view from the Nile-Congo divide, Rwanda