Saharan dust event, 2003, Corsica and Sardinia. Source: NASA

Saharan dust deposited in Lake Bastani, Corsica: A continuous Holocene dust record off North Africa

Maxime Leblanc, 2nd year PhD

maxime.leblanc@univeriste-paris-saclay.fr

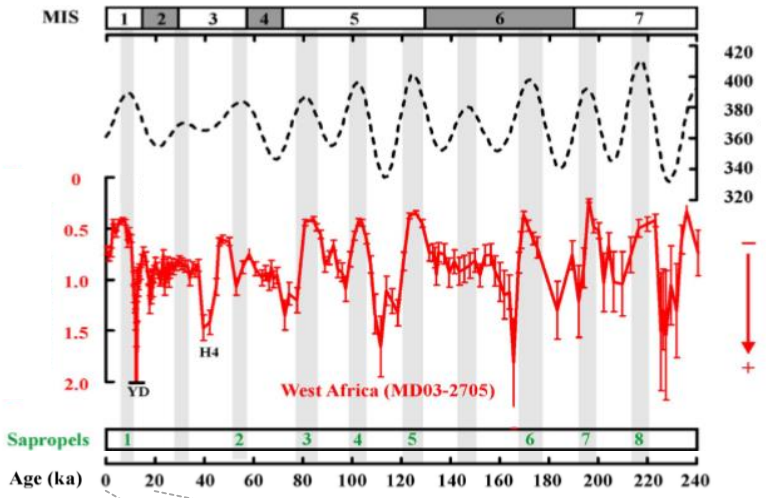
C. Skonieczny, P. Sabatier, C. Colin, S. Miska, A. Govin, V. Bout-Roumazeilles, A. Bory, M. Debret, I. Jouffroy-Bapicot, B. Vannière.

Phd topic: *Improve our understanding of the African Humid Periods (AHPs) recurrence during the last two climatic cycles from the Saharan dust deposited in Western Mediterranean and Northeastern Atlantic Tropical Ocean.*

Fundings: French INSU-LEFE projects AEROSED (2017-2018), AFROCLIM (2018-2020), Bourgogne Franche-Comté region and QMedFire project

I. Scientific context & objectives

- **Orbitally recurrence of AHPs throught the Quaternary**

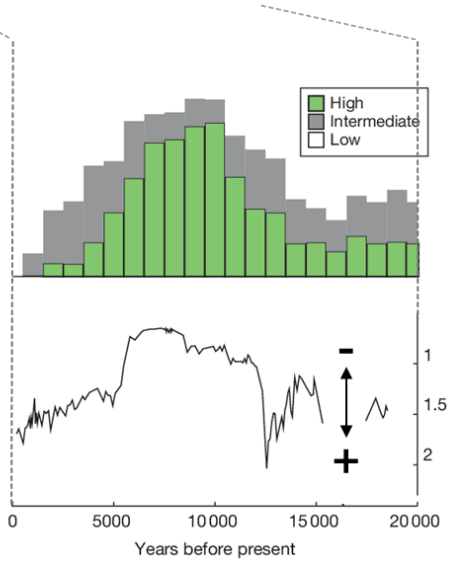


65°N Summer insolation
(W.m^{-2})
Laskar et al., 2004

MD03-2705

^{230}Th-normalized dut flux
(g cm^{-2} ka^{-1})
Skonieczny et al., 2019

- **Saharan dust : an indirect tracer of the Saharan hydrological cycle**



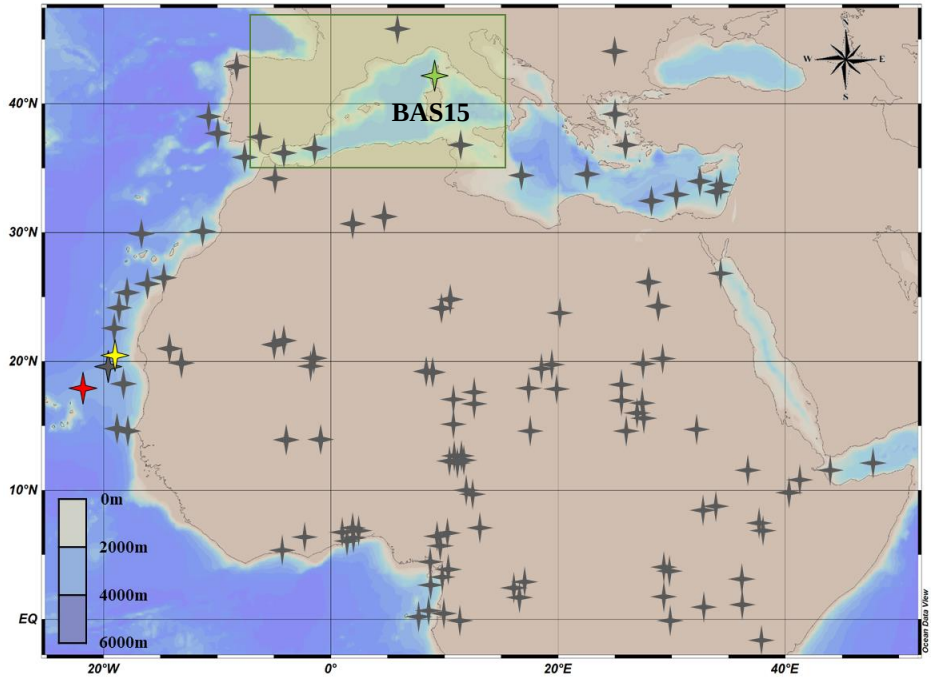
African lakes level
COHMAP Members, 1988
Street-Perrott et al., 1989

ODP 658C

^{230}Th-normalized dut flux
(g cm^{-2} ka^{-1})
Adkins et al., 2006

Modified from deMenocal, 2014

- **Deduction from a non-exhaustive synthesis of climatic archives recording the Holocene AHP termination in North Africa and Mediterranean: very few records from Western Mediterannean.**



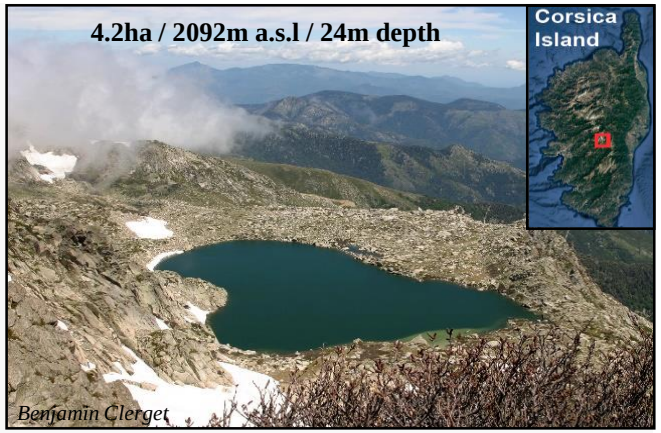
Modified from Shanahan et al., 2015 & Castañeda et al., 2016

Objectives of this work from BAS15 record (Corsica) :

1) Provide a continuous Saharan dust record covering the Holocene and located off North Africa in order to 2) better constrain the temporality of the latitudinal expression of the Holocene African Humid Period termination, as well as 3) improve our understanding of the dust proxy response to hydrological changes in North Africa through the time.

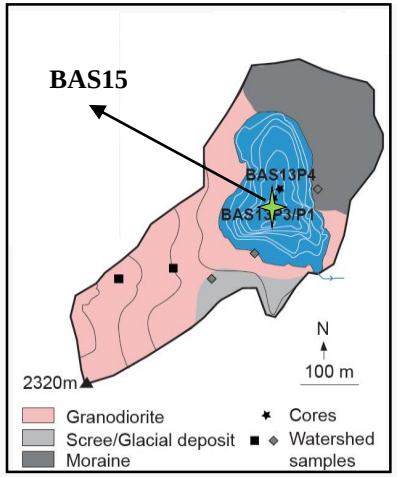
II. Material – High altitude lake Bastani: a natural saharan dust trap

Lake Bastani, Corsica



- Post LGM lake origin (Gauthier et al., 1983, 1984; Lestienne et al., 2020; Sabatier et al., 2020)
- Restricted watershed (17.3ha) mainly composed of granodiorite rocks (Lestienne et al., 2020; Sabatier et al., 2020)
- Limited local lithogenic input to the lake sediment (BRGM, 2009; Lestienne et al., 2020; Sabatier et al., 2020)
- Close to the mountain ridges: favor eolian particles accumulation (Robert et al., 1984)
- Low regional (Mte Renoso) erosion rate ~15mm/ka (Kuhlemann et al., 2005)

Lacustrine sediment core : BAS15



- Sediments composition: (Sabatier et al., 2020)

➢ Biogenic carbonates : -
➢ Organic Matter : +
➢ Biogenic silica : ++

- Reconstruction of the Saharan dust deposited in lake Bastani throught the last 3ka (Sabatier et al., 2020):

Clim. Past, 16, 283–298, 2020
https://doi.org/10.5194/cp-16-283-2020

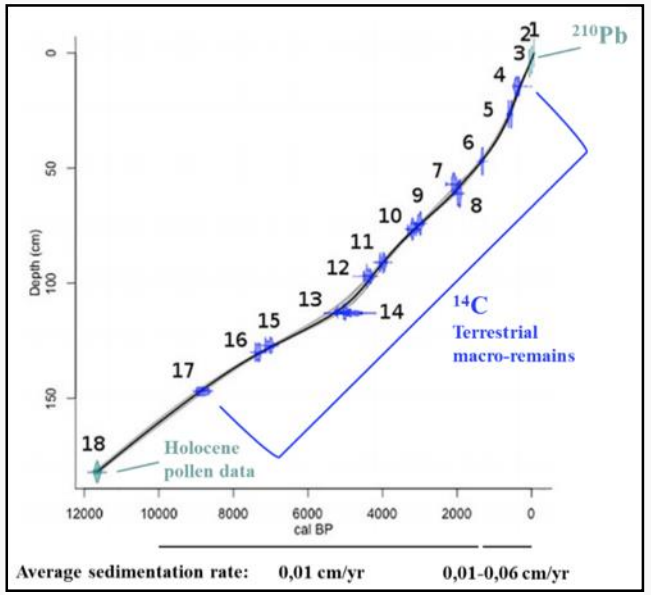
Climate of the Past

Past African dust inputs in the western Mediterranean area controlled by the complex interaction between the Intertropical Convergence Zone, the North Atlantic Oscillation, and total solar irradiance

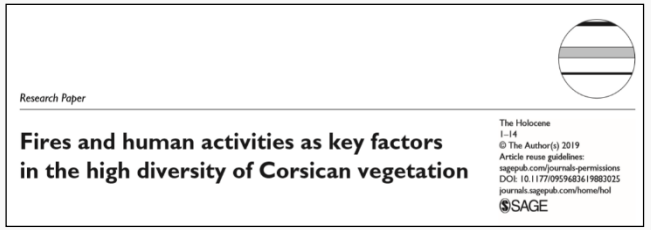
➢ **We will thus focus our paleoclimatic reconstructions on the 3-12ka time period, including the Holocene Climatic Optimum (corresponding to the AHP over Africa).**

BAS15 Age model

➢ 183cm recording the last ~12ka
➢ Low sedimentation rate : ~10cm/ka



(Modified from Lestienne et al., 2020)


Research Paper

Fires and human activities as key factors in the high diversity of Corsican vegetation

The Holocene
1–14

DOI: 10.1177/0959683619883025
journals.sagepub.com/home/hol
SAGE

III. Extraction of the detritic signal from the bulk lacustrine sediments

Preliminary work: study the bulk sediments

- **Microscopy : (SEM observations)**

→ Numerous diatoms frustules with very variable sizes (<2 to ~200µm)

- **Geochemistry : Major elements (XRF core scanner)**

→ High Br intensity (OM content indicator; Cartapanis et al., 2011; 2012)

Adapted strategy to extract the detritic signal from the bulk:

→ Chose to work on the clay-size fraction (<2-4µm)
→ Leach the organic matter
→ No protocols conclusive to leach the silica biogenic fraction without alterate clays

➢ **Have to find ways to quantify the silica biogenic:**

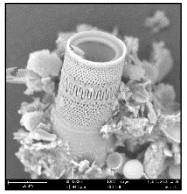
(1) From clay mineralogy calculations (Leinen, 1977)
(2) Using the Si/K ratio (Cartapanis et al., 2012)
(3) Using the XRD opal bulge intensity (Eisma et Van der Gaast, 1971)

➢ **To estimate the clay percentage (4)** (Leinen, 1977)

Conclusion: given the good correlations existing between (1), (2) and (3) as well as between (4) and the Quartz intensity, we are confident in our estimations of biogenic silica and detritic content.

SEM diatoms observation

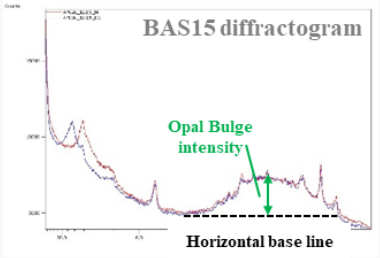
***Aulacoseira* diatom frustule**



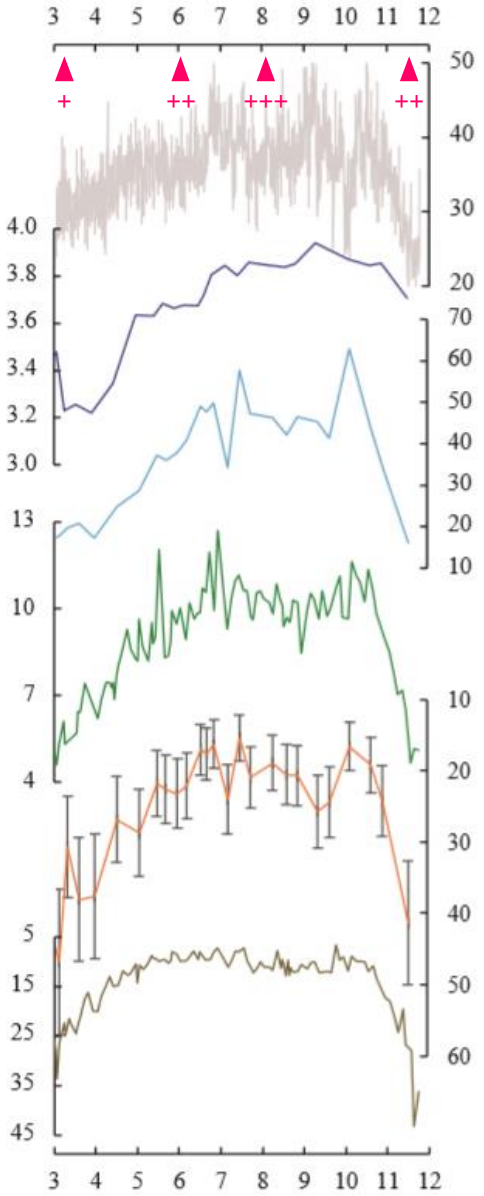
(1) Biogenic silica indicator
$[4*(\%_{smectite}) + 2.5*(\%_{illite}) + 2*(\%_{kaolinite}) + 4*(\%_{chlorite})] * (1/100)$

(3) Opal bulge determination (XRD)
Intensity ($x10^3$ counts)

Opal 'bulge' height = base line intensity – maximum height intensity



Quartz 3.34Å (XRD)
Intensity ($x10^3$ counts)
Detritic indicator



Age (ka)

Br (XRF core scanner)
Intensity ($x10^2$ counts/sec)
Organic matter indicator

(2) Si/K ratio (XRF spectrometry)
Biogenic silica indicator
$Si_{(biogenic + terrigenous)} / K_{(terrigenous)}$

(4) Clay-size fraction percentage (XRF spectrometry)

(1) * Al_2O_3 total measured

IV. Extraction of the dust signal from the bulk lacustrine sediments

~10.5 to 12ka → high detritic supplies

- Pics of Zr, Ti and Quartz => Filling of the Lake Bastani by the glacial physical erosion of the watershed.
- Consistent with the deglaciation / Younger Dryas colder conditions.
- Potential dust supplies (small pic of Kaolinite) but if present, the dust supplies are certainly highly diluted by the massive watershed supplies.

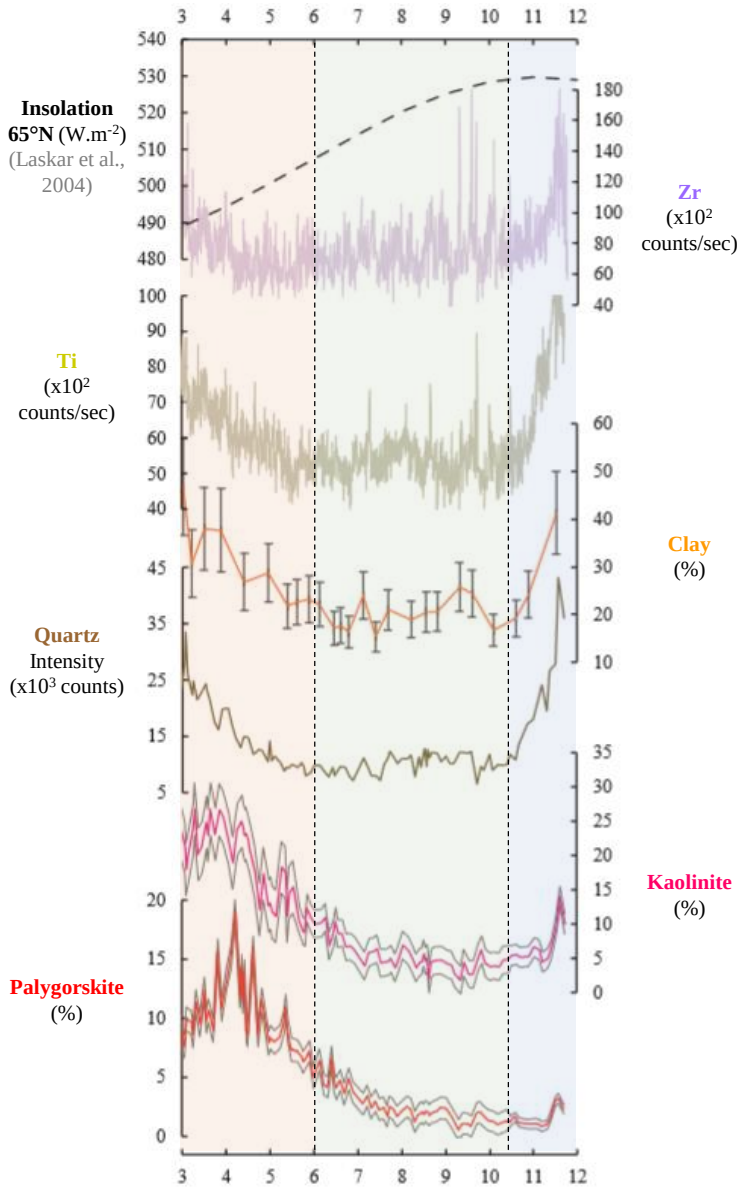
→ If Saharan dust deposits = undetectable

~6 to ~10.5ka → low detritic supplies

- Low Zr, Ti and Quartz intensities.
- Low clay, Kaolinite and Palygorskite percentages.

→ Limited detritic supplies, nearly no dust supplies

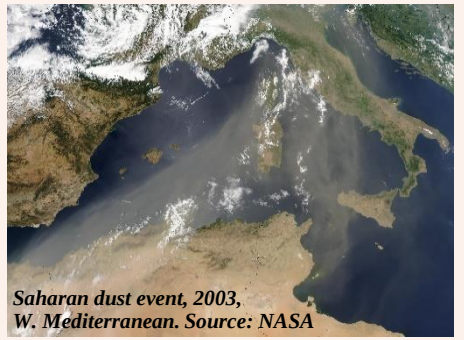
Consistent with humid conditions over both the studied and the dust sources areas (African Humid Period).

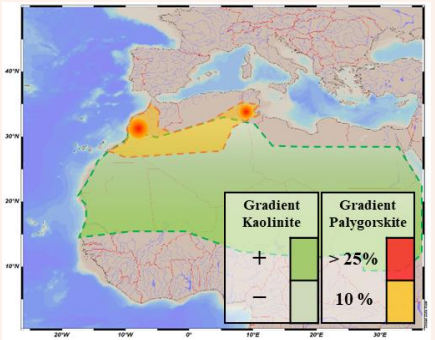


~ 3 to 6ka → high detritic supplies

- Increasing of Zr, Ti and Quartz intensities.
- Increasing of Palygorskite and Kaolinite percentages.

NB: palygorskite and kaolinite majority are clay minerals that cannot be originated from Lake Bastani watershed chemical weathering but that are particularly abundant in Saharan dust deposited in Corsica, Sicily and south Italy (Robert et al., 1984; Foucault et Mélières, 2000).





Modified from Bout-Roumazeilles et al., 2007
Interpretation from Pastouret et al., 1978; Paquet et al., 1984; Caquineau et al., 1998

- Limited local lithogenic input to the lake sediment (BRGM, 2009; Lestienne et al., 2020; Sabatier et al., 2020)
- Low regional erosion rate ~15mm/ka (Kuhlemann et al., 2005)

→ Clays deposited at lake Bastani corresponds to Saharan dust

Conclusion :
Clay fraction essentially corresponds to Saharan dust deposits at BAS15 core site from ~10.5ka

V. Discussion : response/record of the AHP

▪ Optimum climatic Holocene / AHP over Africa

➢ **Western Mediterranean climatic context**

- High Br intensity and XRD Opal bulge from ~10 to ~7ka.

=> Increasing of the biologic « activities » in lake Bastani.

Consistent with humid lower Holocene conditions over Mediterranean area, as indicated by high W. Mediterranean forest development (Fletcher et al., 2013) and regional enhanced rainfall between 8.9 and 7.3ka in Corchia cave - Italy (Zanchetta et al., 2007).

➢ **Saharan dust supplies off North Africa**

- Low palygorskite percentages from 10 to ~7ka.

=> Very limited saharan dust deposited at lake Bastani

Consistent with the palygorskite signal recorded in Sicilian-Tunisian strait (Bout-Roumazeilles et al., 2013) and the high african lakes level indicating strong humid conditions over potential saharan dust sources.

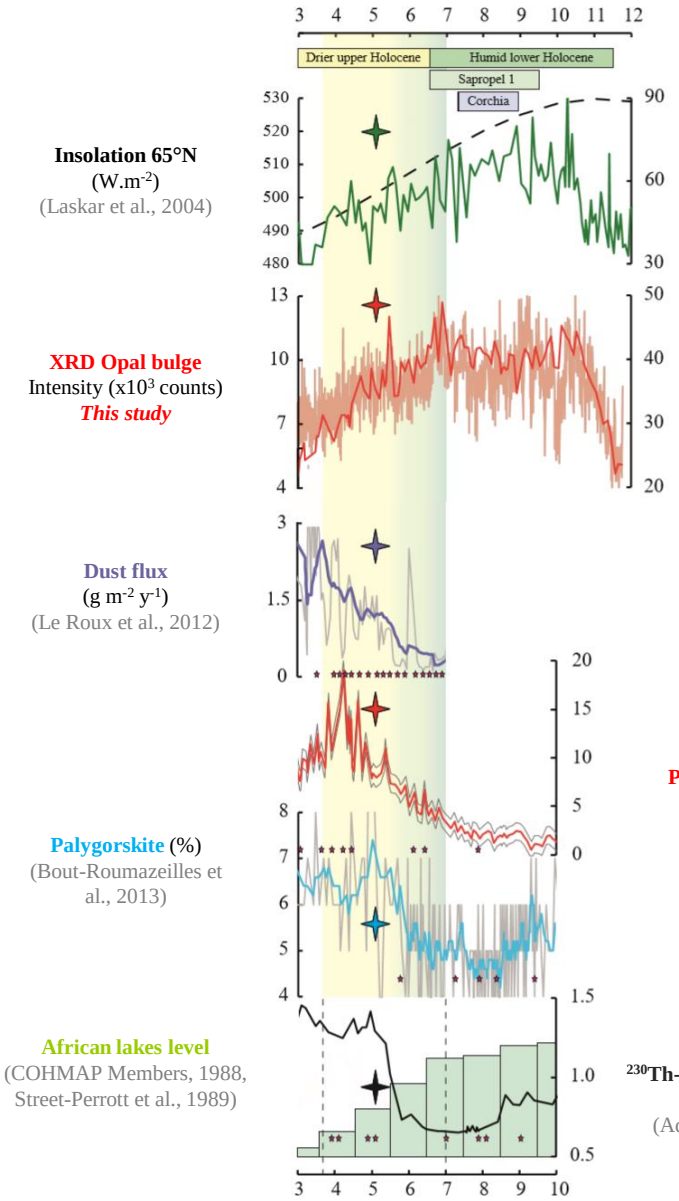
▪ Termination of the AHP from a regional comparison of the saharan dust deposits.

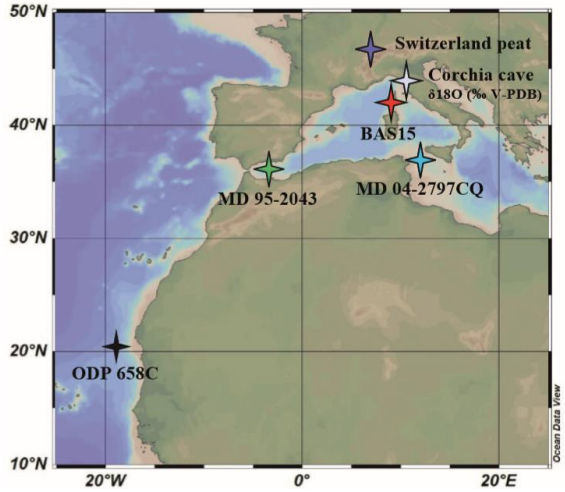
➢ **Saharan dust supplies off North Africa**

- Taking account age model constraints: progressive increasing of the dust supplies from ~6 to ~4ka at Lake Bastani indicated by palygorskite, kaolinite, clay percentages and quartz intensity.
- This progressive trend seems to be consistent with the regional saharan dust signal recored in Sicilian-Tunisian strait and Switzerland.

➢ **Saharan dust supplies off West Africa**

- Abrupt reduction of dust emissions around 5ka.





Pollen grains (%) W. Mediterranean forest development (Fletcher et al., 2013)

Br (XRF core scanner) Intensity (x10² counts/sec) *This sudy*

Palygorskite (%) *This study*

^{230}Th-normalized dut flux (g cm^{-2} ka^{-1}) (Adkins et al., 2006)

A work in progress…

Leblanc et al., in prep.