Palaeoenvironment of the earliest hominins in western Europe: the Guadix-Baza Basin

THE LEAKEY FOUNDATION

Junta de Andalucía

https://sun9-58.userapi.com/c850432/v850432965/1883a6/y2pf8wSeHhI.jpg

Hervé Bocherens, Hugues-Alexandre Blain, Mikael Fortelius, Juha Saarinen, Christian Sanchez Bandera, José Antonio García-Solano, Deborah Barsky, Carmen Luzón, Juan Manuel Jiménez Arenas

1

Scientific question

- The **Guadix-Baza Basin** (Granada Province, Southern Spain) is the richest area in Western Europe for the study of early hominin dispersal and evolution, having yielded the **earliest localities with evidence of hominin occupation** (a deciduous human molar, lithic industries and cutmarks) together with a rich large and small vertebrate assemblage dated to around **1.4 Ma**.

- Key question: **Were environmental changes involved in the arrival of hominins in this region at this time**?

➔ Investigations using various approaches, including **carbon and oxygen isotopes in tooth enamel, tooth wear analysis, ecometrics and microvertebrates** (amphibians, reptiles, mammals) as **proxies for palaeoclimate**.

➔ Possible environmental differences between one older site lacking evidence for hominin occurrence (**Venta Micena** VM, ~1.6 Ma) and younger sites with undisputable evidence (**Barranco León** BL and **Fuente Nueva-3** FN3, ~1.2-1.5 Ma)

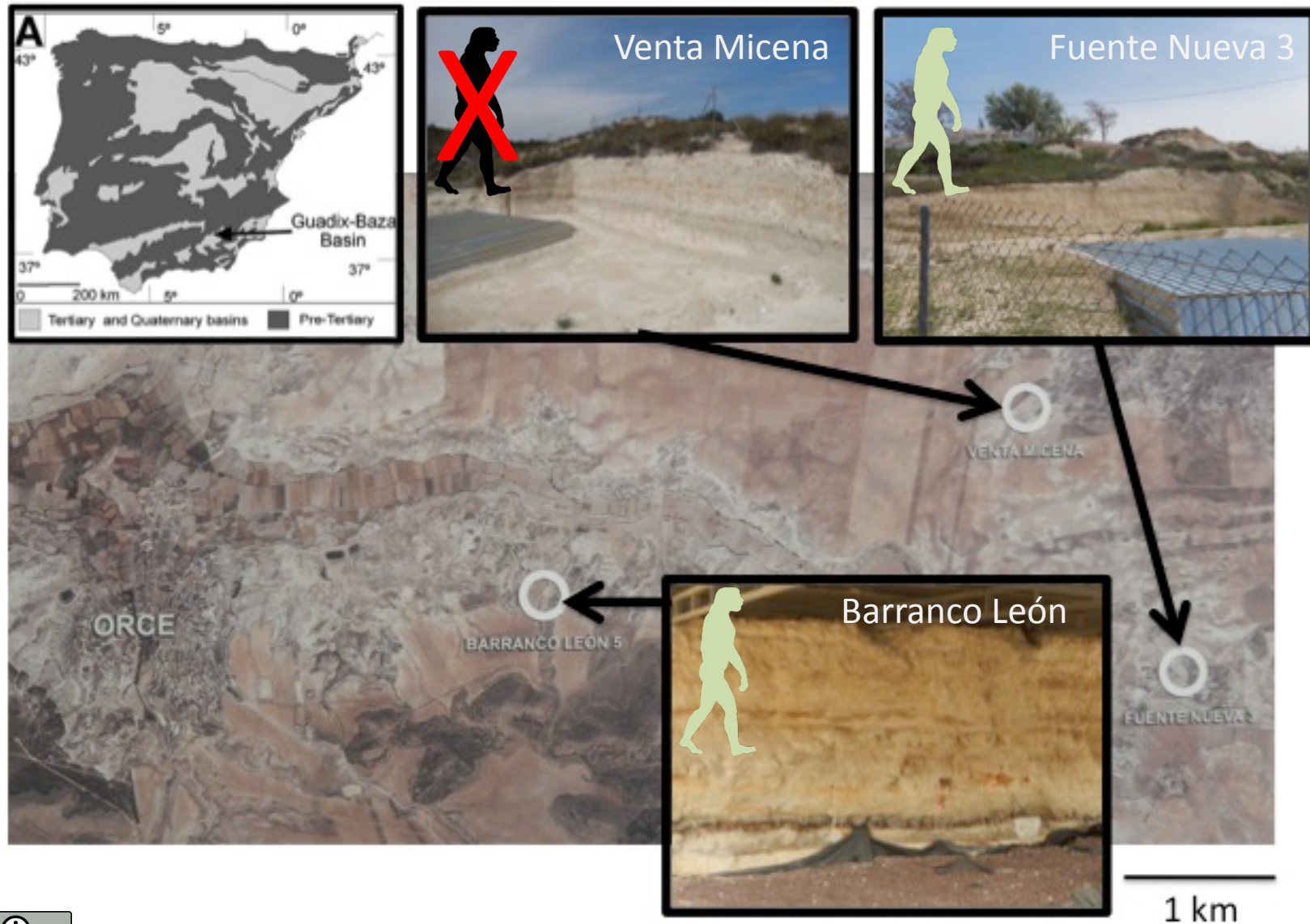# Expansion out-of-the-comfort-zone: "Out-of-Africa"

Guadix-Baza Basin (Leakey Foundation project)
➔ Environment of earliest Hominins in W Europe (niche partitioning, seasonal variations)?
➔ CO SI, ecometrics, tooth wear, small vertebrates
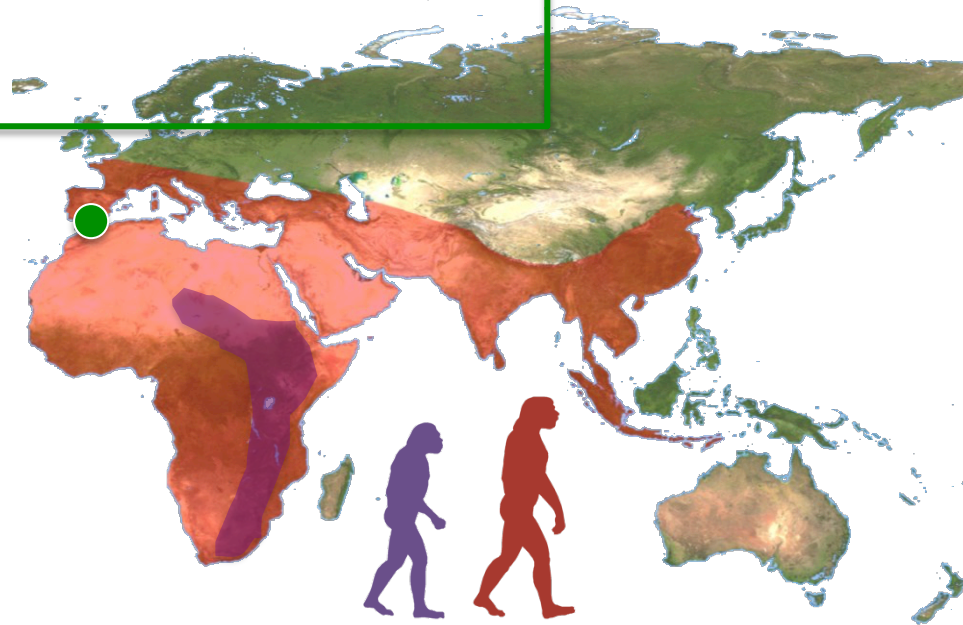
3 sites in Guadix-Baza Basin

4

Venta Micena

- Discovery: 1976
- 1st excavation: 1981
- Age: 1.6 Ma
- Abundant and diverse large mammal assemblage
- No evidence for hominin occupation

Barranco León

- Discovery: 1983
- 1st excavation: 1994
- Age: 1.4 Ma
- Abundant and diverse large mammal assemblage
- Hominin evidence: deciduous tooth, Oldowan lithic industry

Fuente Nueva 3

- Discovery: 1991
- 1st excavation: 1992
- Age: 1.2 – 1.3 Ma
- Abundant and diverse large mammal assemblage
- Hominin evidence: Oldowan lithic industry

Methods

- The results of 4 methods for reconstruction of paleoenvironments have been combined to evaluate the ecological conditions in the 3 sites:
  - Tooth wear analysis (mesowear) of large herbivorous mammals
  - Ecometrics and mammal body size
  - Mutual Ecogeographic Range applied to amphibians and reptiles
  - Carbon and oxygen stable isotopes in tooth enamel (COSI) of large herbivorous mammals

Methods: Tooth wear analysis - Mesowear

- Mesowear analysis examines a wear signal of worn occlusal surfaces and cusp shapes of ungulate teeth → sharpness and relief
- → Distinction between **browsers** (eat leaves, bark and green stems of dicotyledonous plants) and **grazers** (feed on grass and clip vegetation at or near ground level)
- All ungulates (except *Equus altidens* = grazer) are browsers or browse-dominated mix-feeders in all 3 sites
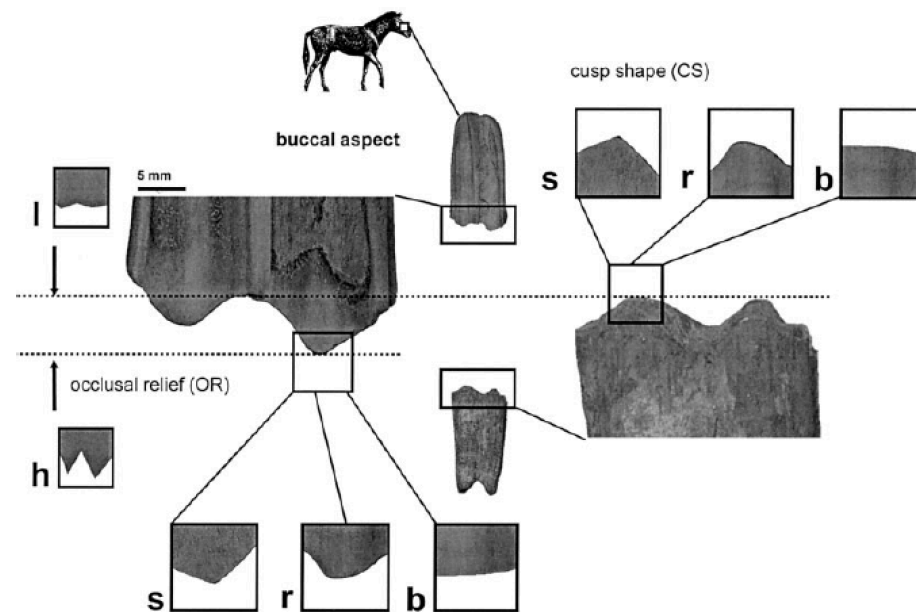

Fig. 3. The mesowear scoring convention for hypsodont ungulate cheek teeth as defined by Fortelius and Solounias (2000) for upper second molars. The convention is extended on lower cheek teeth. The occlusal relief (OR) may be scored "high" (h) or "low" (l), the cusp shape (CS) is classified as "sharp" (s), "round" (r), and "blunt" (b). In upper and lower teeth the buccal enamel band is scored. Reconstruction of *Hippotherium primigenium* (above) after O. Garreaux (in: Bernor et al., 1997).

9

# Methods: Dental ecometrics and body size of large herbivorous mammals

The mammalian dental **ecometric traits** used in the analysis are correlated with various aspects of their **environment** (Fortelius et al. 2016; Zliobaite et al. 2018; Oksanen et al. 2019), including aspects of **climate** (temperature and precipitation) and **vegetation** (primary productivity, vegetation type).

Model prediction ➔ Orce human sites Barranco León and Fuente Nueva 3 have a higher habitat suitability score for early humans than Venta Micena where evidence of human presence is lacking. This is largely due to BL and FN3 having a smaller relative amount of mammals with dental traits that would indicate adaptation to harsh environmental conditions than in VM.
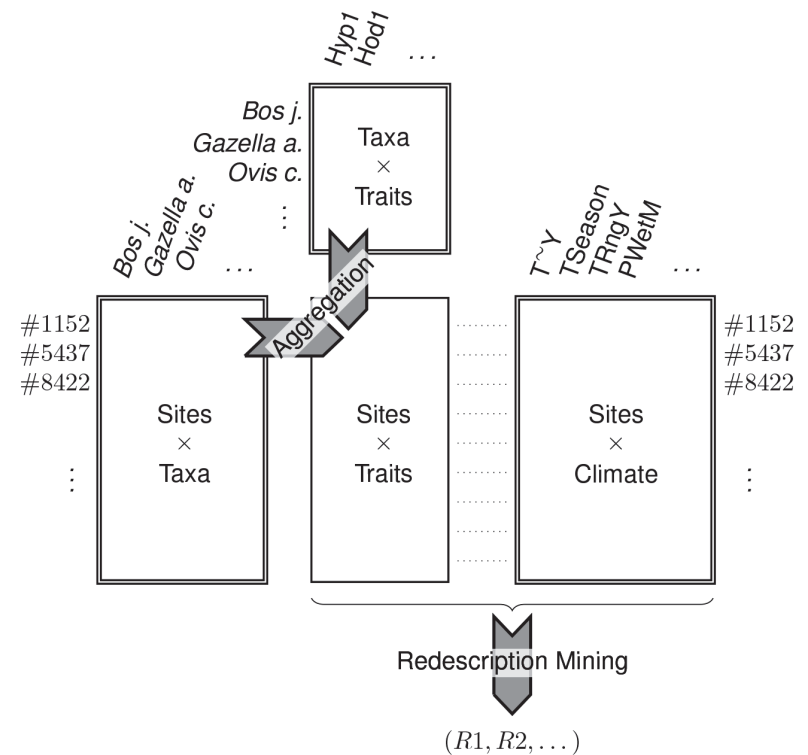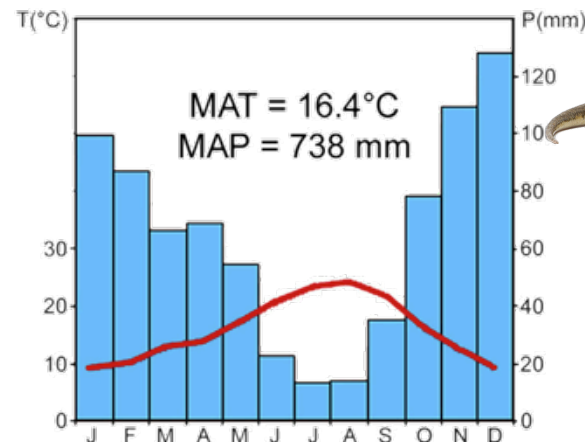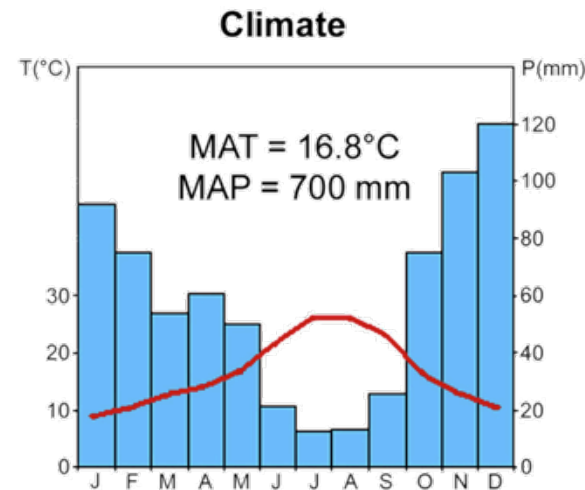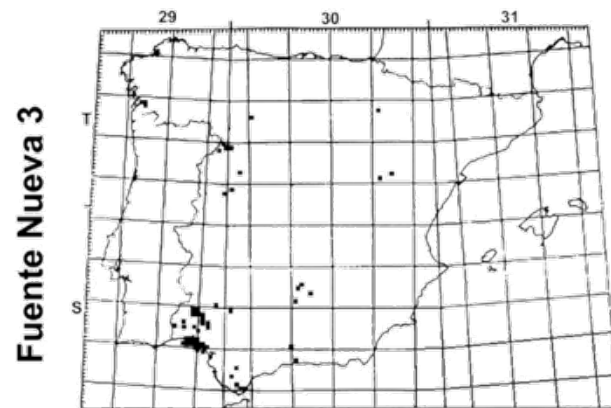

Galbrun et al. 2018

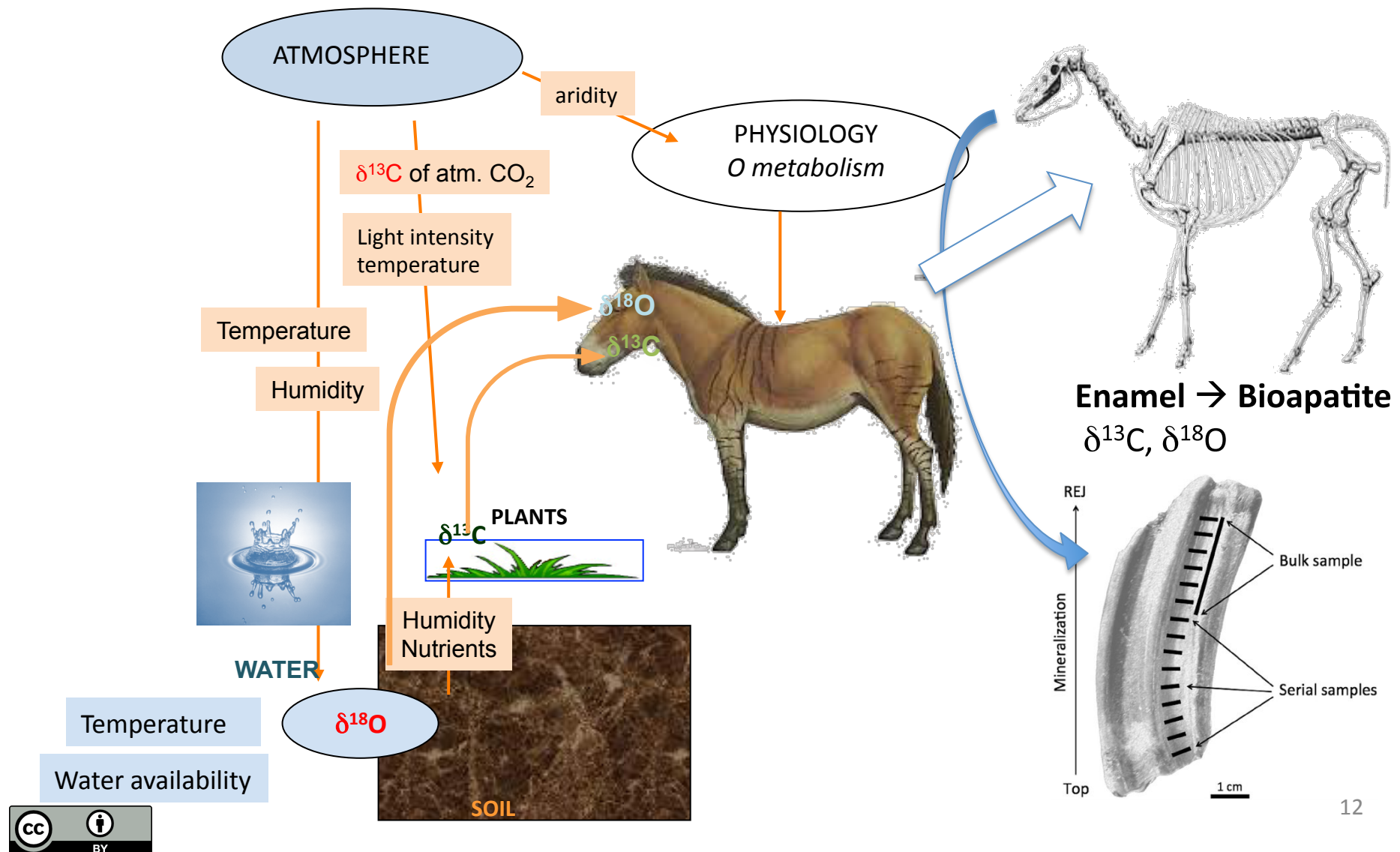# Methods: Mutual Ecogeographic Range (MER) of microvertebrates → climate
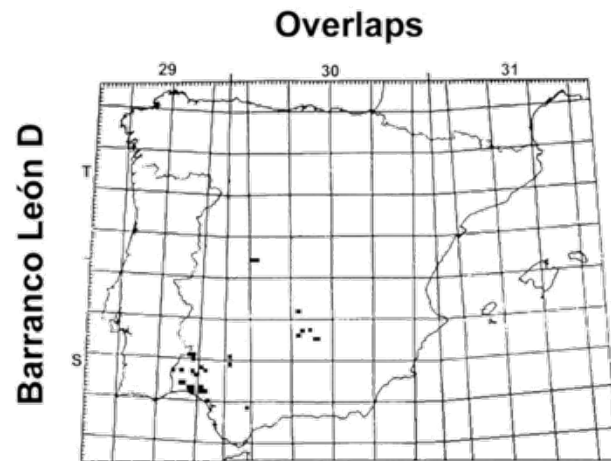
Blain et al. 2016

➢Barranco Leon: 19 amphibian and reptile taxa
➢Fuente Nueva 3: 13 amphibian and reptile taxa
Assumption: methodological uniformitarianism and niche conservatism
(Blain et al. 2016)

"you are what you eat (and drink)"

ATMOSPHERE

aridity

PHYSIOLOGY
O metabolism

$\delta^{13}C$ of atm. CO_2

Light intensity
temperature

Temperature

Humidity

$\delta^{18}O$
$\delta^{13}C$

$\delta^{13}C$ **PLANTS**

WATER

Humidity
Nutrients

Temperature

Water availability

$\delta^{18}O$

SOIL

Enamel → Bioapatite
$\delta^{13}C$, $\delta^{18}O$

REJ

Mineralization

Bulk sample

Serial samples

Top

1 cm

12

Sampling strategies for tooth enamel

- Bulk sampling
  - 1 sample per tooth
  - Sampling along growth direction
  - Sampling > 1 year growth
  - Results to compare with other specimens

- Serial sampling
  - Several samples per tooth
  - Sampling perpendicular to growth direction
  - Sampling every ~5mm
  - Variation curves for $\delta^{13}C$ and $\delta^{18}O$
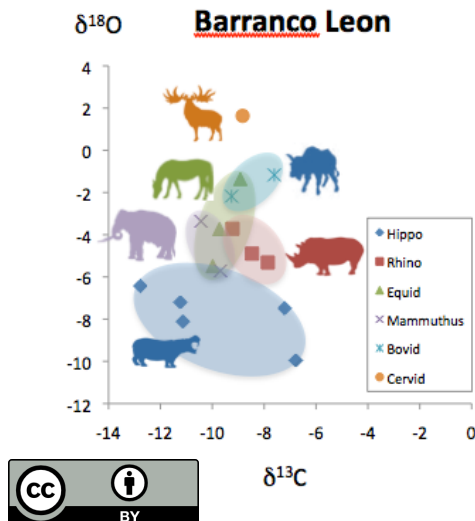
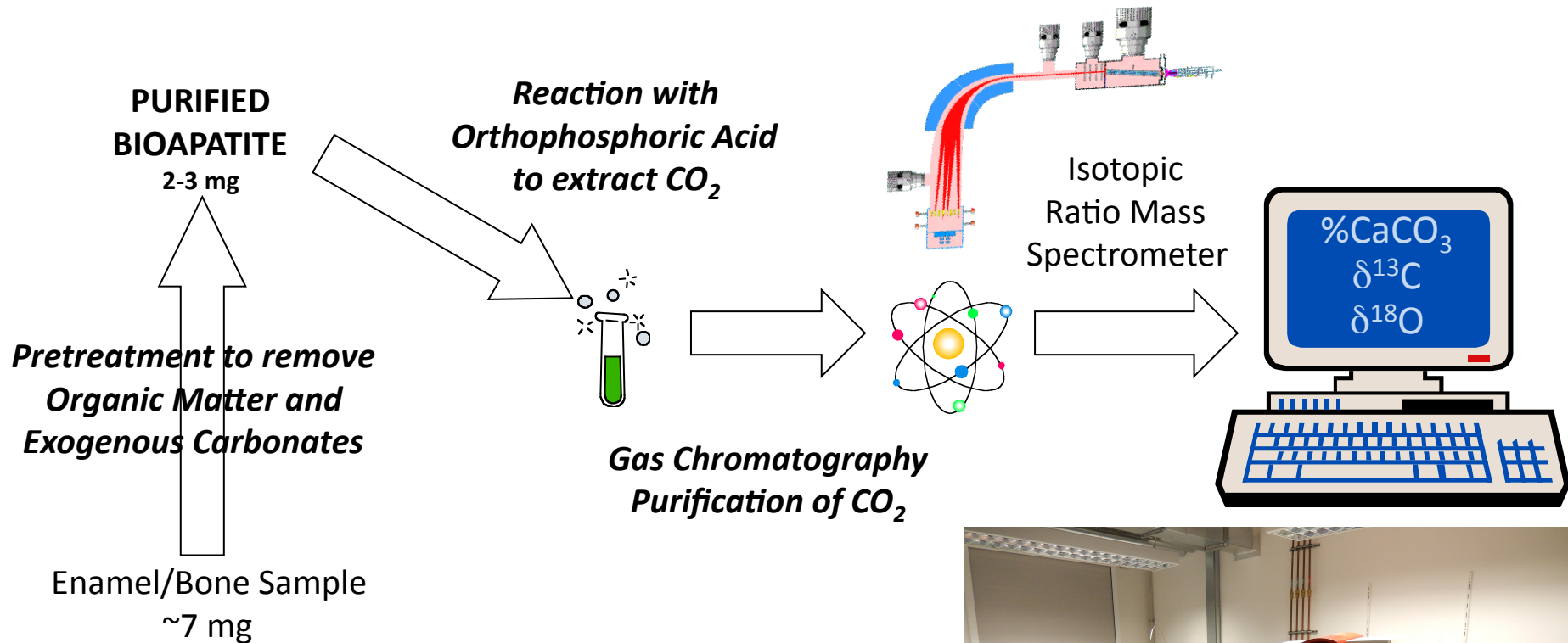Horse tooth from BL
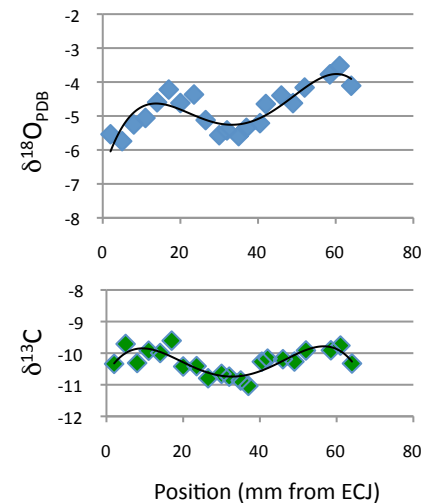
Horse tooth from VM

Enamel pretreatment and isotopic analysis of the carbonate fraction of bioapatite

PURIFIED BIOAPATITE
2-3 mg

Reaction with Orthophosphoric Acid to extract CO$_2$

Isotopic Ratio Mass Spectrometer

%CaCO$_3$
δ^{13}C
δ^{18}O

Pretreatment to remove Organic Matter and Exogenous Carbonates

Gas Chromatography Purification of CO$_2$

Enamel/Bone Sample
~7 mg

Isotopic analysis using an Elementar Multiflow Geo connected to an IRMS Isoprime 100 at the University of Tübingen (Working group Biogeology)
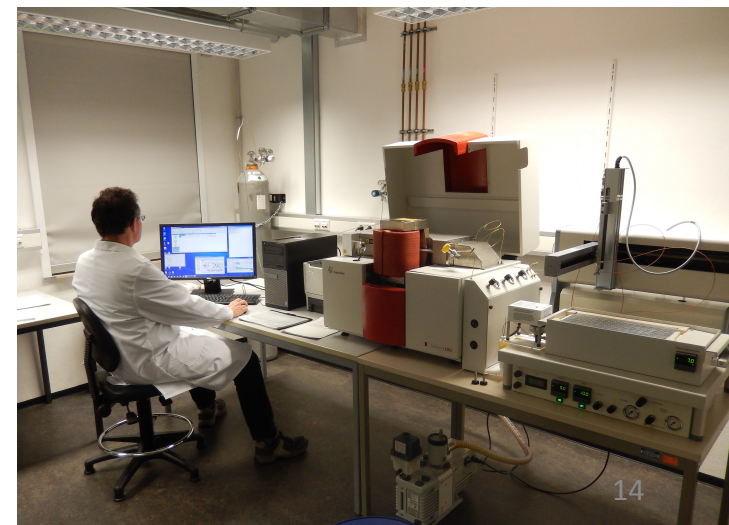
Isotopic measurements made so far

- 65 teeth analyzed for C & O isotopes on enamel ➜ diet, habitat and niche partitioning
  - From VM, BL, FN3
  - Various large herbivore species
- 368 serial C & O isotopic analyses on 30 teeth ➜ intra and inter-annual variability of diet and climate
  - From VM, BL, FN3
  - Various species
    - Molars from mammoths, rhinos, horses, bovids, cervids
    - Canines and cheek teeth from hippos

Analyzed species per site

- Analyzed tooth enamel samples (in brackets, teeth with serial sampling)

| Species	VM	BL	FN3
Hippopotamus antiquus	1 (1)	5	7 (3)
Stephanorhinus	5 (4)	3	6 (6)
Equus altidens	5 (2)	3	8 (4)
Equus sussenbornensis		2 (2)	
Mammuthus meridionalis		2	6 (4)
Large bovini	3 (3)	5 (2)	1 (1)
Praemegaceros	2	1	
Total	16 (10)	21 (4)	28 (18)

16
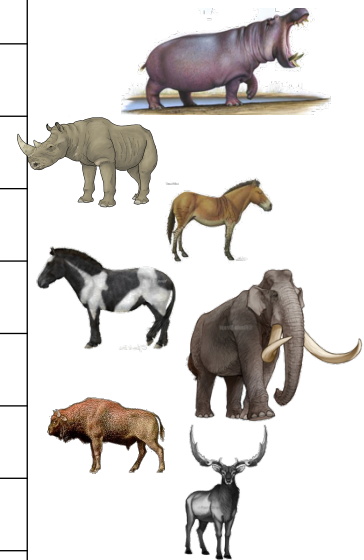
Preliminary results:
$\delta^{13}C$ and $\delta^{18}O$ per taxon per site

Data for tooth enamel from this study and from Cerling et al. (1997)
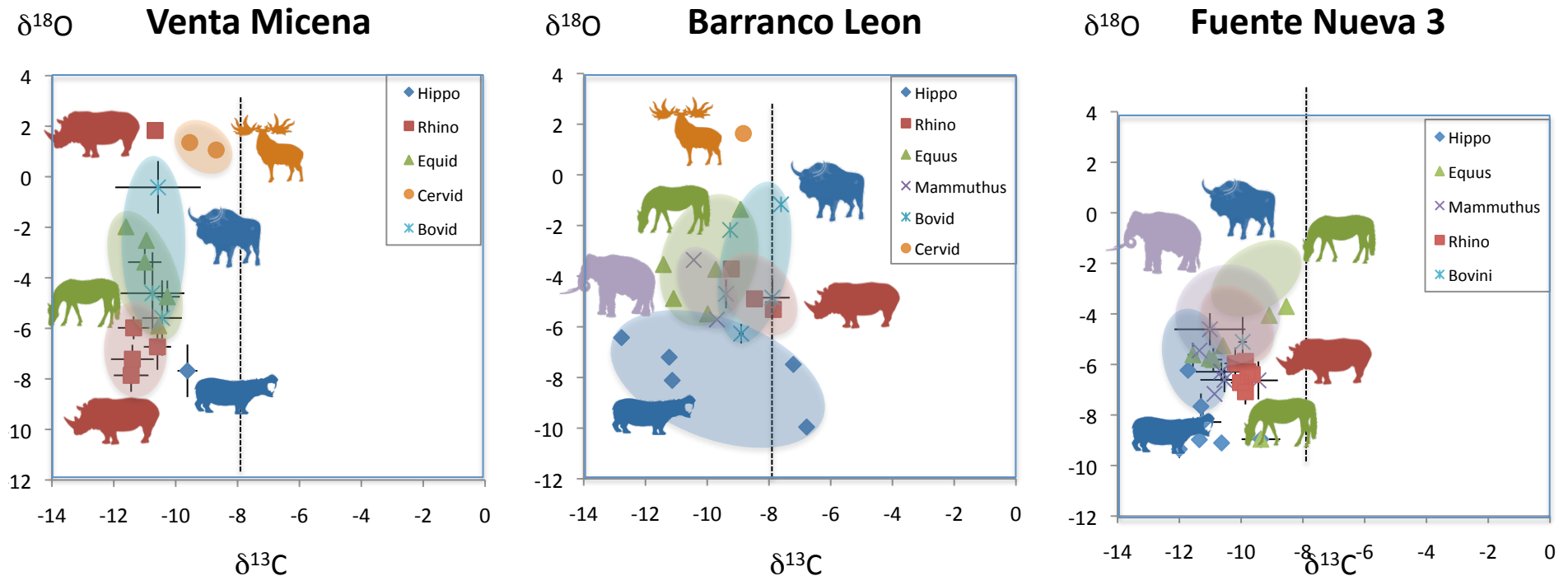
- Hippos always among the lowest $\delta^{18}O$ values ➜ semi-aquatic, good preservation
- Cervids among the highest $\delta^{18}O$ values ➜ browsing tree leaves
- No $\delta^{13}C$ < -13‰ ➜ no dense canopy forest
- $\delta^{13}C$ > -8‰ ➜ contribution of C4 plants only in Barranco Leon for hippo, rhino, bovini

17

Preliminary results:
$\Delta\delta^{13}C$ and $\Delta\delta^{18}O$ in teeth sampled serially

$\Delta\delta^{18}O$
2.2 ‰

$\Delta\delta^{13}C$
1.4 ‰
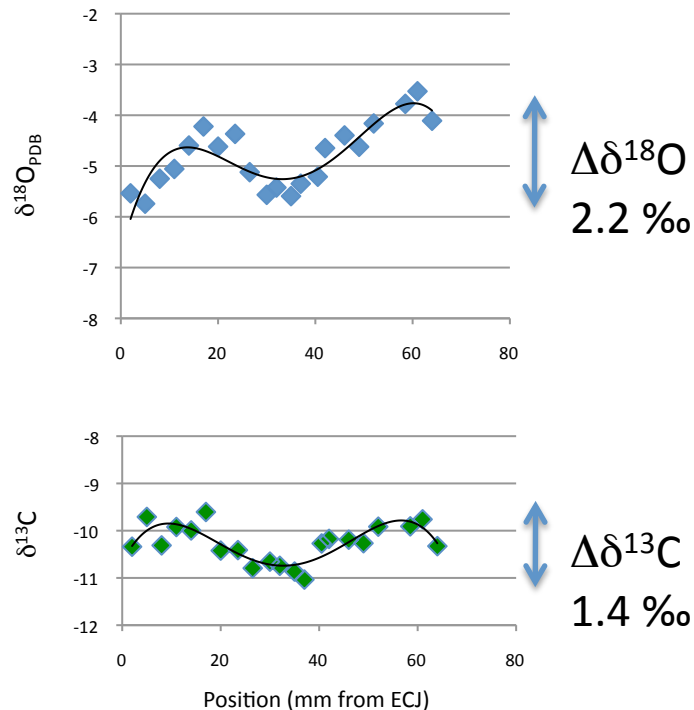
Horse tooth from VM
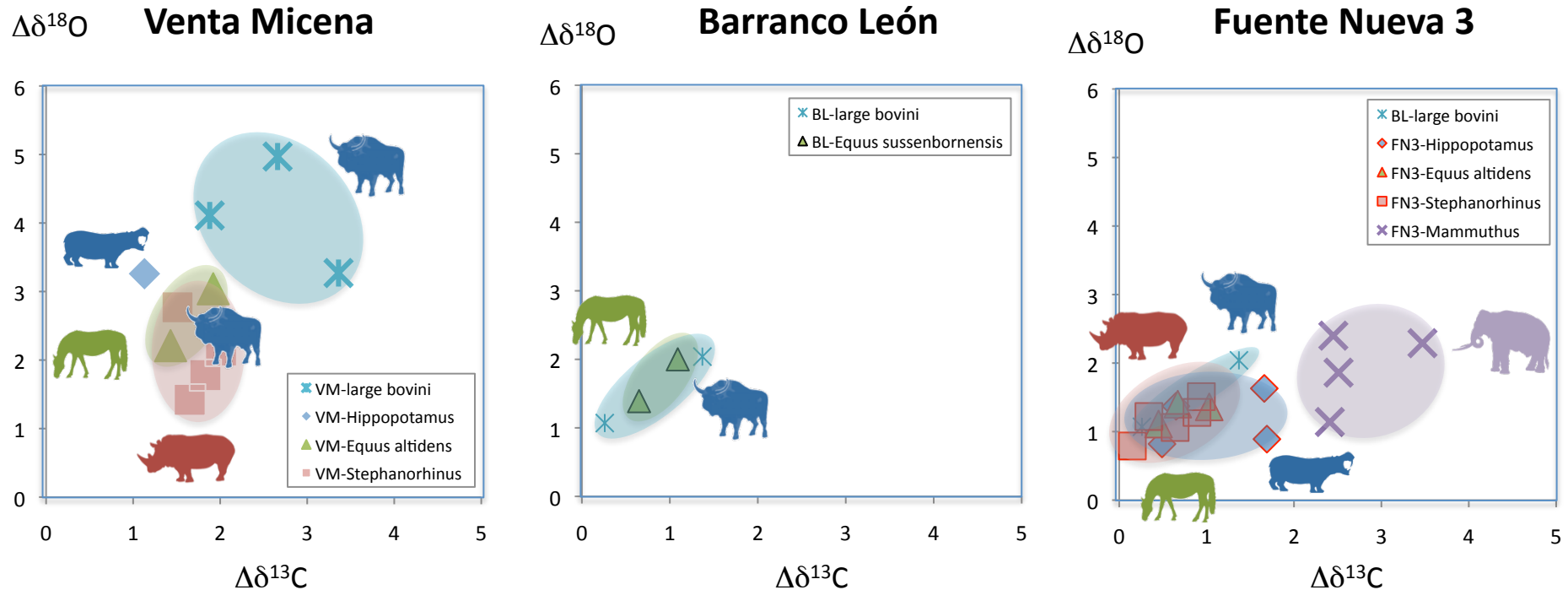
$\Delta\delta^{13}C$ and $\Delta\delta^{18}O$ = difference between the lowest and highest $\delta^{13}C$ and $\delta^{18}O$ values measured in one given tooth, respectively

$\Delta\delta^{13}C$ ➔ variability of food resource consumed through several months/years

$\Delta\delta^{18}O$ ➔ seasonal climatic variability during several months/year

Mobility can influence these values

18

Preliminary results:
$\Delta\delta^{13}C$ and $\Delta\delta^{18}O$ per taxon per site

Venta Micena — $\Delta\delta^{18}O$ vs $\Delta\delta^{13}C$
Legend: VM-large bovini, VM-Hippopotamus, VM-Equus altidens, VM-Stephanorhinus

Barranco León — $\Delta\delta^{18}O$ vs $\Delta\delta^{13}C$
Legend: BL-large bovini, BL-Equus sussenbornensis

Fuente Nueva 3 — $\Delta\delta^{18}O$ vs $\Delta\delta^{13}C$
Legend: BL-large bovini, FN3-Hippopotamus, FN3-Equus altidens, FN3-Stephanorhinus, FN3-Mammuthus

◆In Venta Micena, higher $\Delta\delta^{13}C$ and $\Delta\delta^{18}O$ values than in Barranco Leon and Fuente Nueva 3, for bovini. Horse, rhino and hippos ➔ more seasonal variation of temperature/ precipitation and food supply

◆ Mammoth in Fuente Nueva 3 have higher $\Delta\delta^{13}C$ values than other taxa but similar $\Delta\delta^{18}O$ values ➔ higher mobility?

Preliminary results:
$\Delta\delta^{13}C$ and $\Delta\delta^{18}O$ per site per taxon
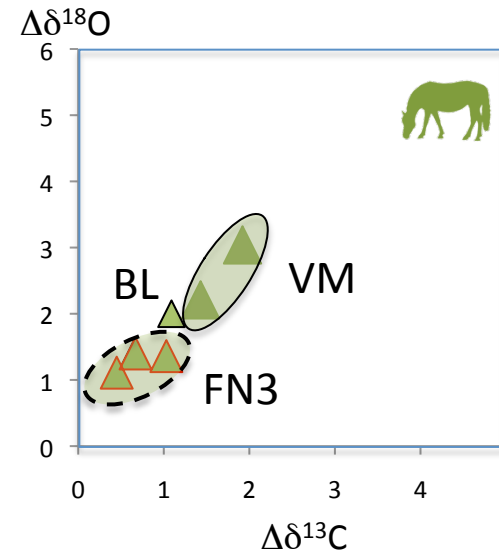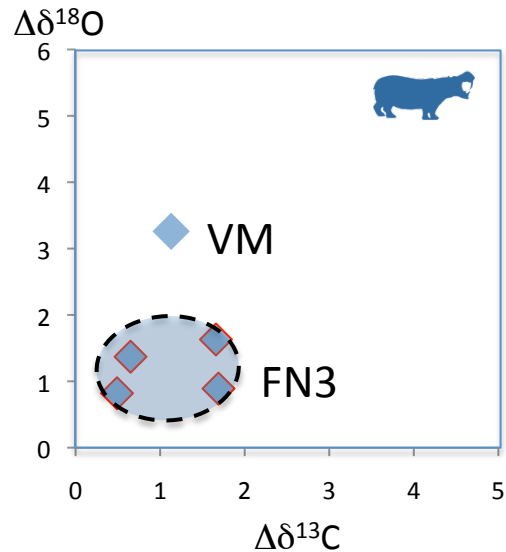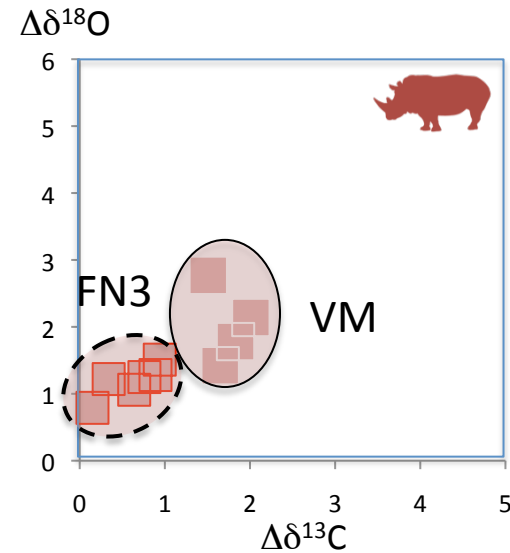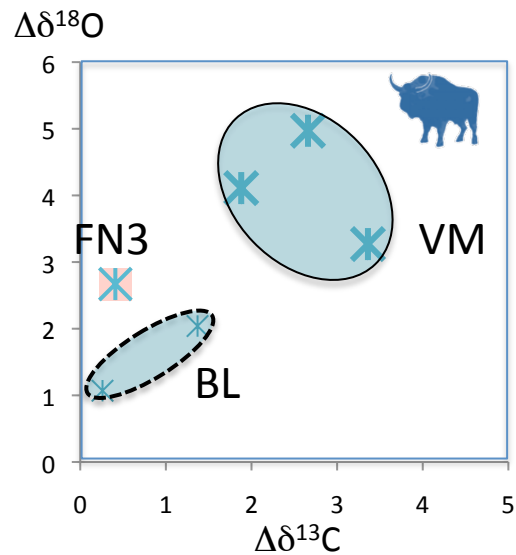
Conclusions

- In all 3 sites, browsing diet dominates, only few grazers (Dental Mesowear)
- Venta Micena → harsher climate conditions than Barranco León and Fuente Nueva 3 (Ecometrics, CO SI)
- Barranco León more humid and more diverse vegetation than both other sites (MER and CO SI)
- Sites with evidence of hominin occurrence had different environmental conditions than earlier site without hominins, both sites (BL and FN3) are also different from each other → early hominins in SW Europe had some ecological flexibility around 1.2-1.4 Ma.

Affiliations

- **Hervé Bocherens[1,2], Hugues-Alexandre Blain[3,4], Mikael Fortelius[5], Juha Saarinen[5], Christian Sanchez Bandera[3,4], José Antonio García-Solano[6], Deborah Barsky[3,4], Carmen Luzón[7], and Juan Manuel Jiménez Arenas[7,8,9]**

- 1 Universität Tübingen, Department of Geosciences, Biogeology, Tübingen, Germany (herve.bocherens@uni-tuebingen.de)
- 2 Senckenberg Centre for Human Evolution and Palaeoenvironment, Tübingen, Germany
- 3 IPHES, Institut Català de Paleoecologia i Evolució Social, Tarragona, Spain
- 4 Universitat Rovira i Virgili, Area de Prehistoria, Tarragona, Spain
- 5 University of Helsinki, Department of Geosciences and Geography, Helsinki, Finland
- 6 Universidad de Sevilla, Departamento de Prehistoria y Arqueología, Sevilla, Spain
- 7 Universidad de Granada, Departamento de Prehistoria y Arqueología, Granada, Spain
- 8 Universidad de Granada, Instituto Universitario de la Paz y los Conflictos, Granada, Spain
- 9 University of Zurich, Department of Anthropology, Zürich, Switzerland

Sources

- Blain et al. 2016. *Quat. Sci. Rev.* 144: 132-144.
- Cerling et al. 1997. *Nature* 389: 153-158.
- Fortelius et al. 2016. *Phil. Trans. R. Soc. B*. 371: 20150232.
- Galbrun et al. 2018. *Palaeontologia Electronica* 21.1.3A 1-31.
- Oksanen et al. 2019. *J. Biogeo.* 46: 1760-1776.
- Žliobaitė et al. 2018. *Evol. Ecol. Res*. 19: 127-147.

Thanks

- Thure Cerling for having shared the raw data of his 1997 article.

- The Leakey Foundation and the Regional Government of Andalucia for funding this research

- The EGU 2020 for the opportunity to present this research

- You for your attention

Looking forward to the chat!