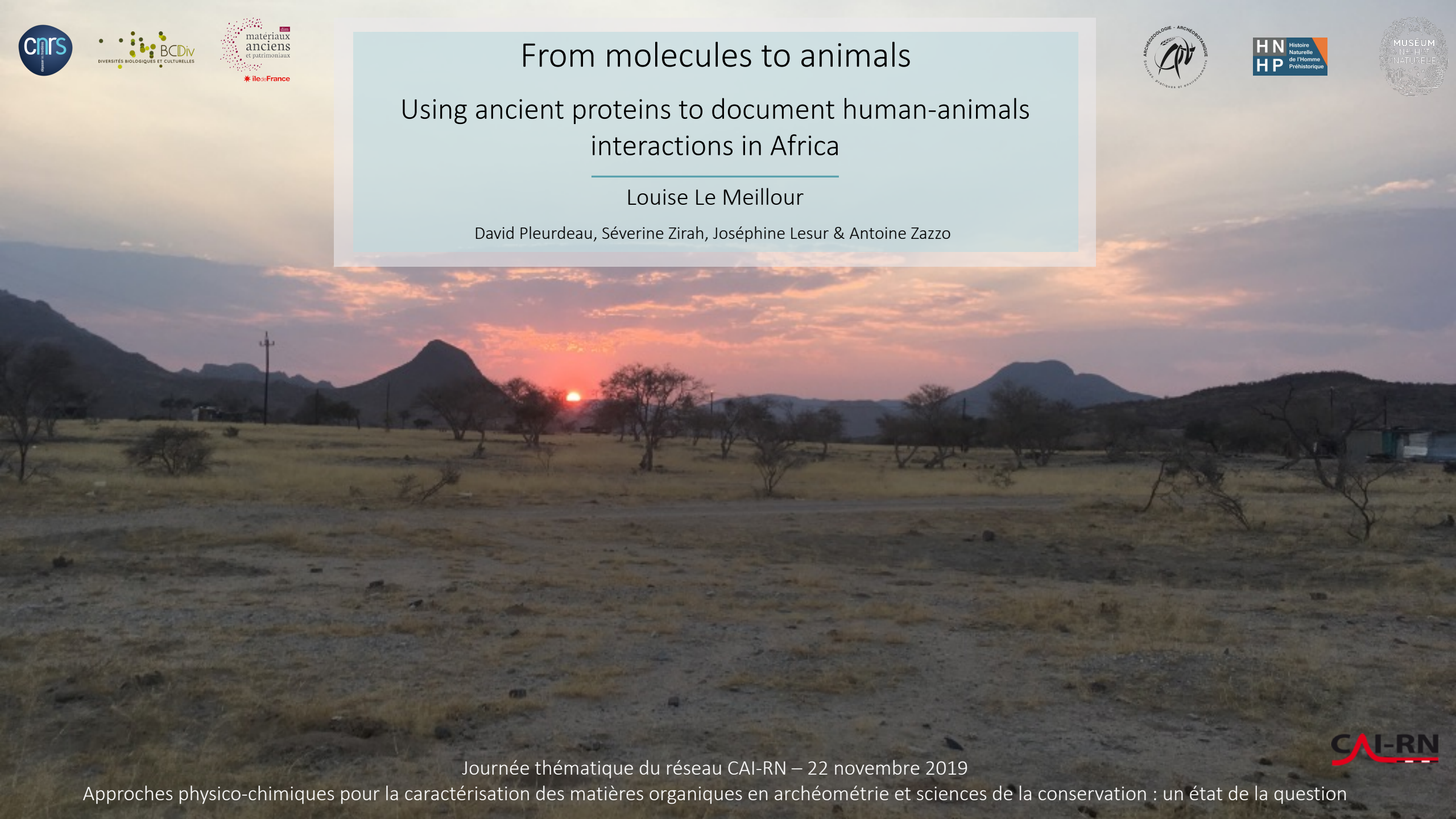


# From molecules to animals

## Using ancient proteins to document human-animals interactions in Africa

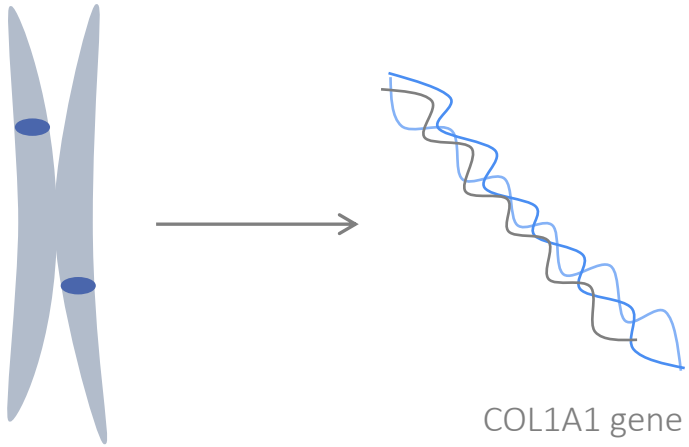
Louise Le Meillour

David Pleurdeau, Séverine Zirah, Joséphine Lesur & Antoine Zazzo



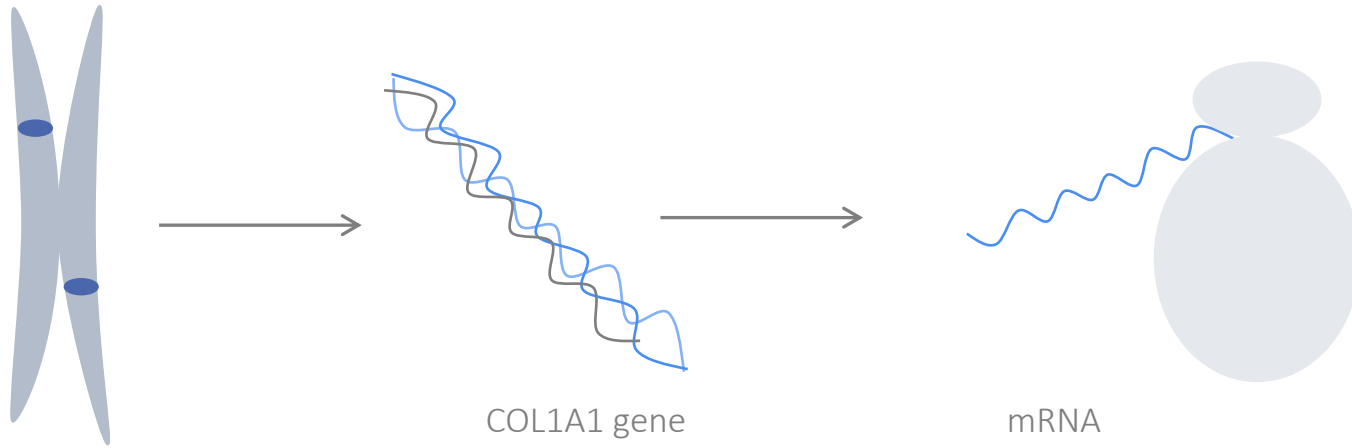
# What is palaeoproteomic?

From gene to protein



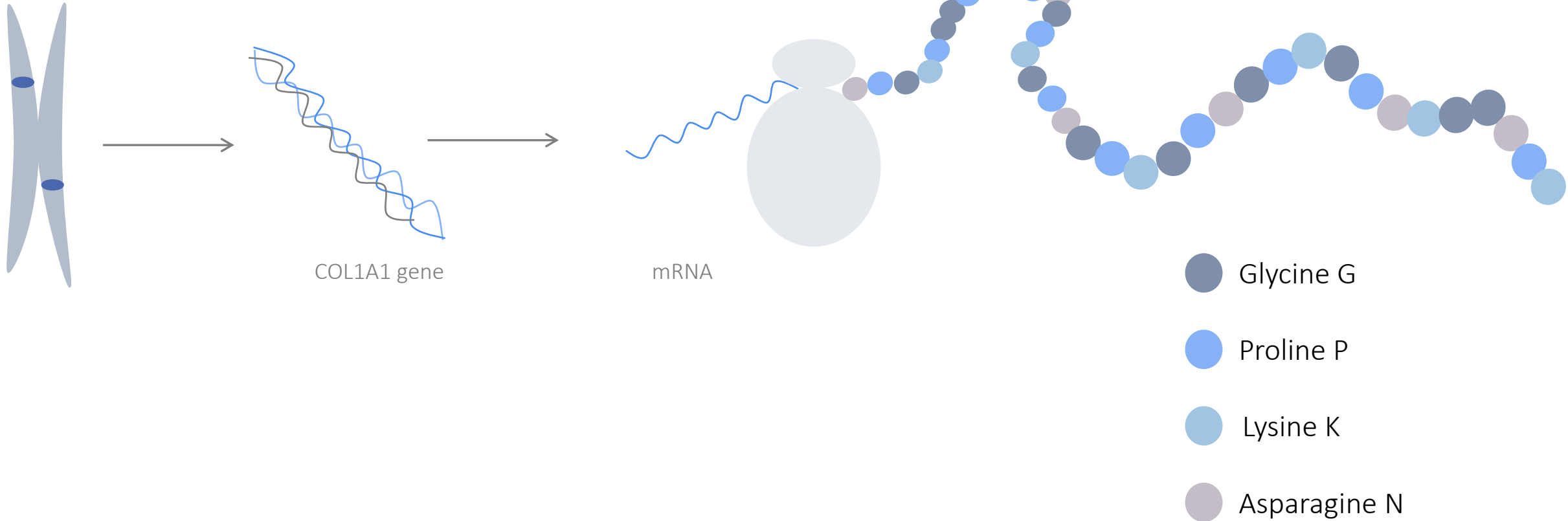
# What is palaeoproteomic?

From gene to protein



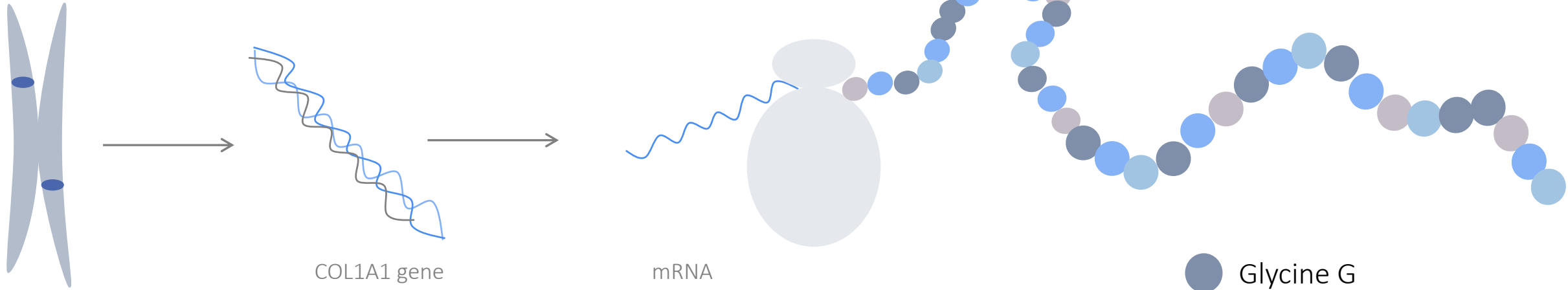
# What is palaeoproteomic?

From gene to protein



# What is palaeoproteomic?

From gene to protein

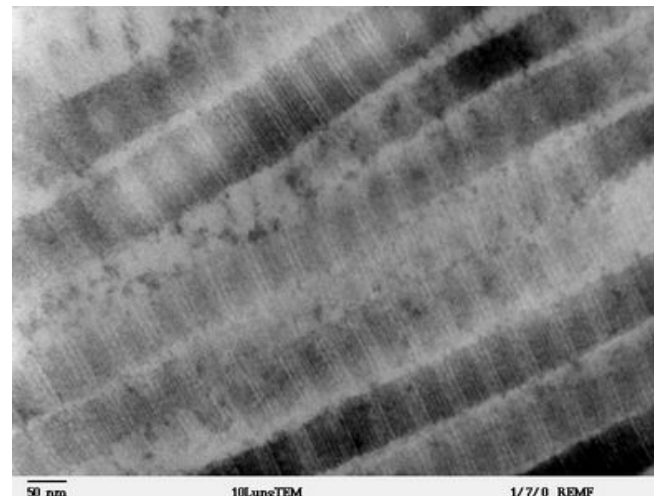
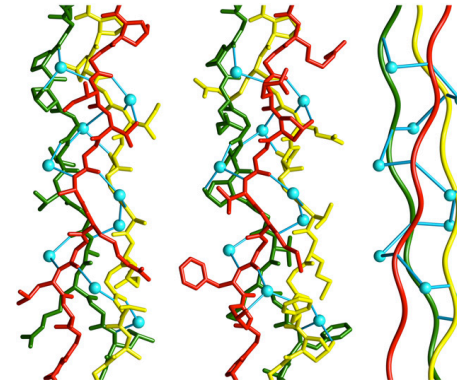
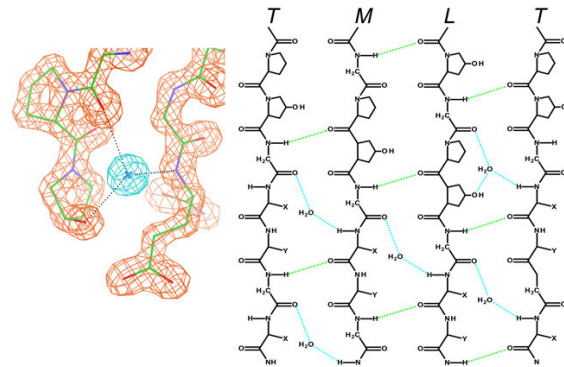
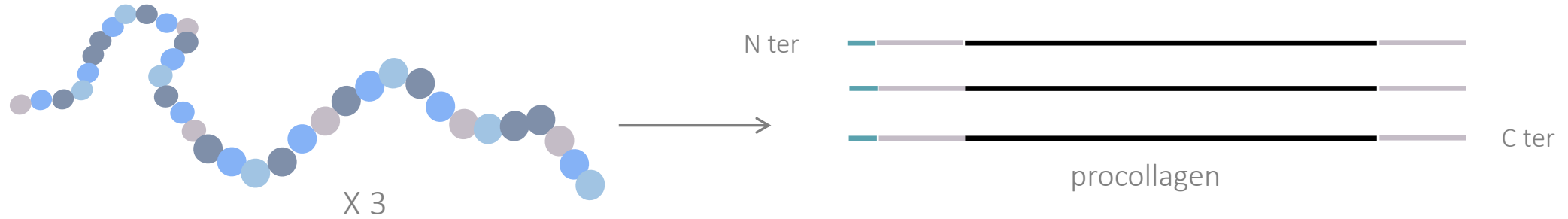


845 GPSGEPGTAGPPGTPGPQG**LLGA**PGFLGLPGSR 877



845 GPSGEPGTAGPPGTPGPQG**FLGP**PGFLGLPGSR 877

# Collagen: structure, function



Mature collagen assembled in fibrils (MET)

# Palaeoproteomics

## Protein characterization

Archaeological remains



Choice

Permits

Sampling

Organic phase preservation (ATR-FTIR)

# Palaeoproteomics

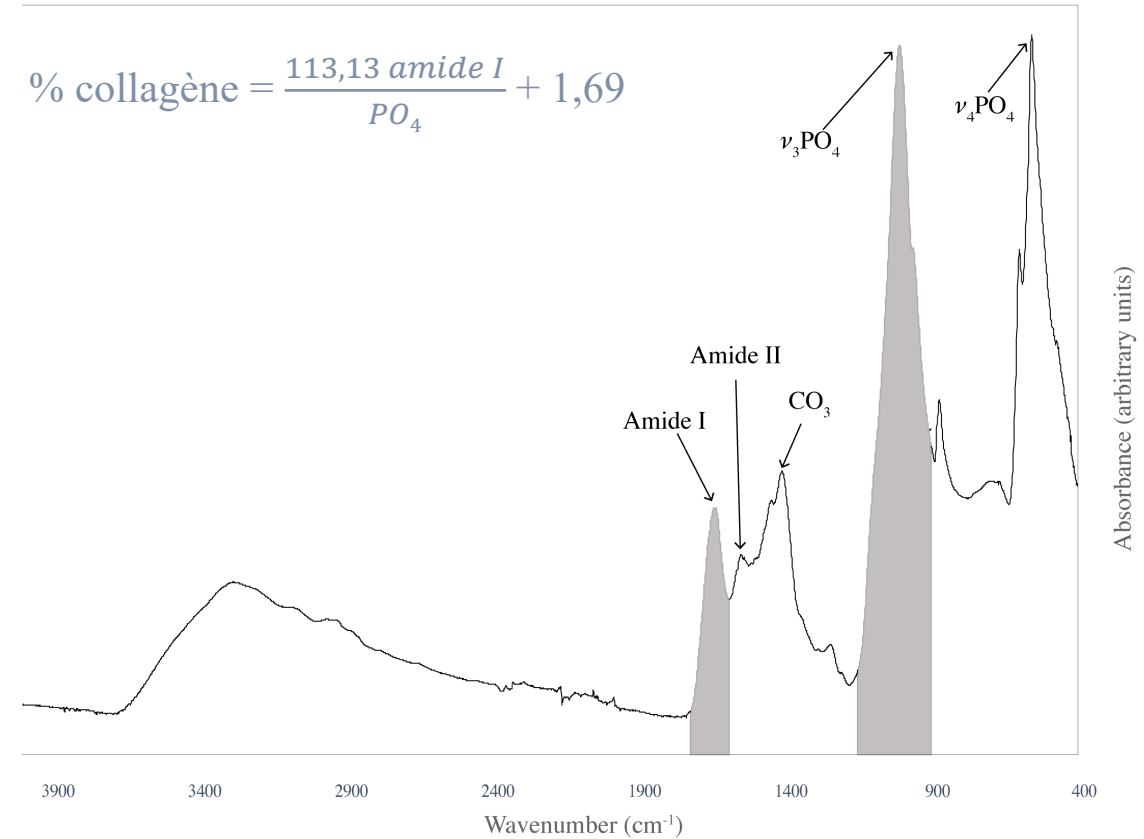
## Protein characterization

Archaeological remains



Choice  
Permits  
Sampling

Organic phase preservation (ATR-FTIR)



limit for analyses (<sup>14</sup>C & palaeoproteomics): ~ 4 ± 1.2%wt coll.



# Palaeoproteomics

## Protein characterization

Archaeological remains



Choice  
Permits  
Sampling

Organic phase preservation (ATR-FTIR)

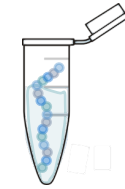


Chemical extraction

Decalcification  
Solubilization  
Enzymatic hydrolysis  
Solid phase extraction



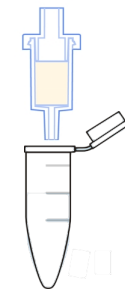
Tris-EDTA



ammonium bicarbonate  
 $\text{NH}_4\text{HCO}_3$



Trypsine, Lys-C, Asp-N, etc.



C18 cartridges

# Palaeoproteomics

## Protein characterization

Archaeological remains



Choice  
Permits  
Sampling

Organic phase preservation (ATR-FTIR)



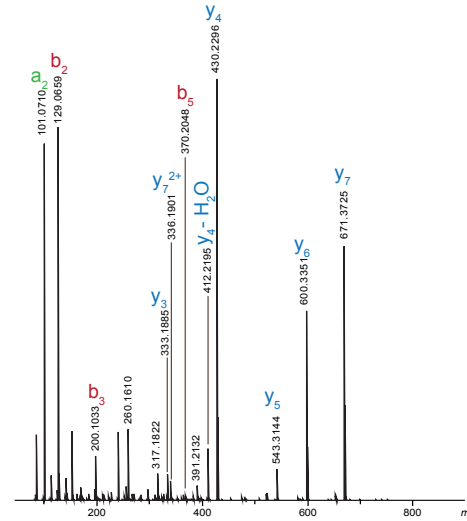
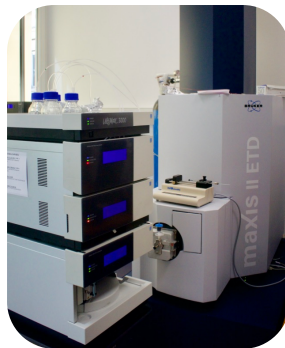
Chemical extraction

Decalcification  
Solubilization  
Solid phase extraction  
Enzymatic hydrolysis

Protein(s) characterization

Liquid chromatography coupled to tandem mass spectrometry

Bio-informatics



LC-MS/MS raw data

Accession	Score	Description
1 XP_011983013.1	3931	PREDICTED: collagen alpha-1(I) chain isoform X2 [Ovis aries musimanus]
52 XP_016113605.1	86	PREDICTED: collagen alpha-1(I) chain-like [Sinocyclocheilus grahami]
37 XP_010768975.1	214	PREDICTED: collagen alpha-1(I) chain-like [Notothernia coriiceps]
17 XP_015675448.1	850	PREDICTED: collagen alpha-1(I) chain [Protothorops mucrosquamatus]
36 XP_003964321.1	1293	PREDICTED: collagen alpha-1(I) chain [Gallus gallus]
12 XP_024999899.1	241	PREDICTED: collagen alpha-1(I) chain-like [Takifugu rubripes]
36 XP_003964321.1	280	SBR25582.1 collagen, type I, alpha 1a, partial [Nothobranchius kuhntae]
35 SBR25582.1	47	XP_003406222.1 collagen alpha-2(V) chain [Loxodonta africana]
61 XP_003406222.1	33	XP_017380675.1 PREDICTED: collagen alpha-1(XVIII) chain isoform X1 [Cebus capucinus imitator]
43 XP_017380675.1	33	XP_017380675.1 PREDICTED: collagen alpha-1(XVIII) chain isoform X1 [Cebus capucinus imitator]
8 spCOHUP7.HCO1A1_TOXSP	2026	spCOHUP7.HCO1A1_TOXSP RecName: Full=Collagen alpha-1(I) chain; AltName: Full=Alpha-1 type I collagen
48 XP_026171118.1	120	XP_026171118.1 collagen alpha-1(I) chain-like [Mastacembelus armatus]
5 JAV39636.1	2720	JAV39636.1 collagen alpha-1(I) chain precursor [Castor canadensis]
60 XP_013384968.1	49	XP_013384968.1 collagen alpha-1(VII) chain [Lingula anatina]
42 XP_010767913.1	182	XP_010767913.1 PREDICTED: collagen alpha-1(I) chain-like [Notothernia coriiceps]
19 XP_020649626.1	821	XP_020649626.1 collagen alpha-1(I) chain [Pogona vitticeps]
3 XP_00866824.1	3236	XP_00866824.1 PREDICTED: LOW QUALITY PROTEIN: collagen alpha-1(I) chain [Ursus maritimus]
30 XP_020388689.1	326	XP_020388689.1 collagen alpha-1(I) chain isoform X1 [Rhinocodon typlus]
51 XP_014459985.1	91	XP_014459985.1 PREDICTED: collagen alpha-2(X) chain isoform X2 [Alligator mississippiensis]
13 KFO34958.1	1290	KFO34958.1 Collagen alpha-1(I) chain [Fukomys damarensis]

Score	Expect	Method	Identities	Positives	Gaps
3414 bits(8852)	0.0	Compositional matrix adjust.	2083/2095(99%)	2086/2095(99%)	0/2095(0%)
Query 1	QLSYGYDEKSTG	ISVPGPMGSPGRGLPGPPGAPGQGGFPGPEPGASGPMGPRGP	60		
Sbjct 1	QLSYGYDEKSTG	ISVPGPMGSPGRGLPGPPGAPGQGGFPGPEPGASGPMGPRGP	60		
Query 61	PGPPGKNGDDGEAGK	PGRPGERGPPGQARGLPQTAGLPGMKGRHGFSGLDGAKGDAGP	120		
Sbjct 61	PGPPGKNGDDGEAGK	PGRPGERGPPGQARGLPQTAGLPGMKGRHGFSGLDGAKGDAGP	120		
Query 121	AGPKGEGSPG	ENGAPGQMGPRGLPGERGRPGAPGAPAGARGNDGATGAAGPPGPTGPAGP	180		
Sbjct 121	AGPKGEGSPG	ENGAPGQMGPRGLPGERGRPGAPGAPAGARGNDGATGAAGPPGPTGPAGP	180		
Query 181	PGFPGA	VGAKGEAGPQGRS	240		
Sbjct 181	PGFPGA	VGAKGEAGPQGRS	240		

international database and/or 'in-house' references

# Palaeoproteomics

A large range of applications to archaeological problematics

nature  
ecology & evolution

ARTICLES

<https://doi.org/10.1038/s41559-019-0909-z>

- Phylogenetic reconstruction

- Sex determination

- Origin of hominin genetic pool

- Residue analyses

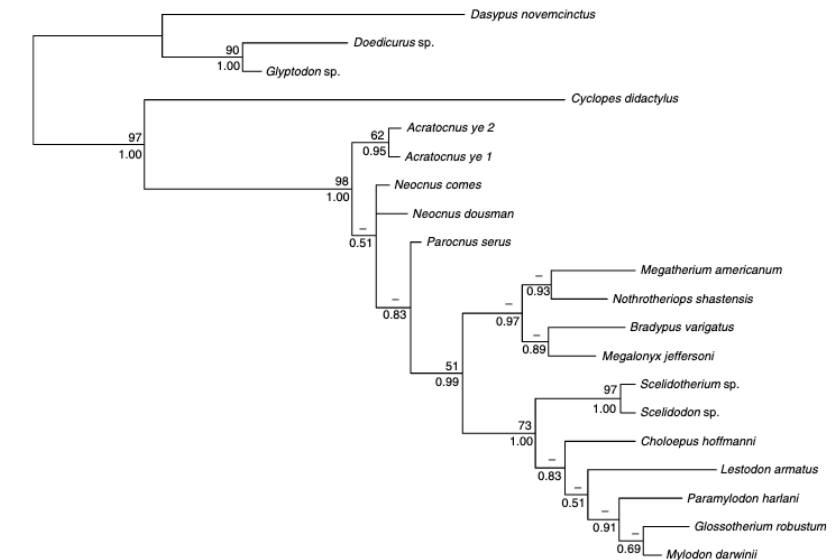
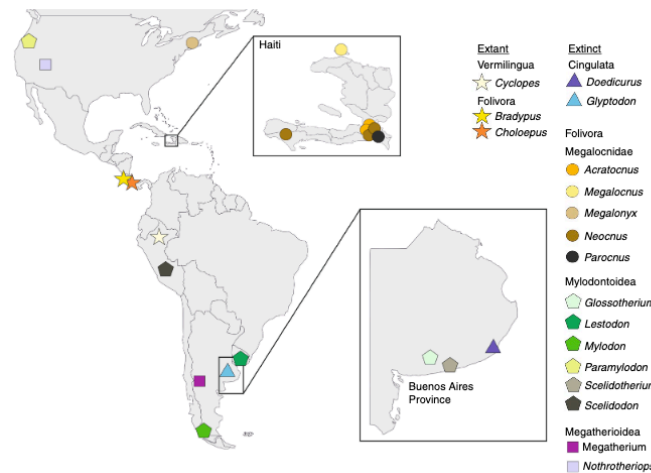
- Palaeopathologies characterization

- Species identification

## Palaeoproteomics resolves sloth relationships

Samantha Presslee<sup>1,2,3,24</sup>, Graham J. Slater<sup>4,24</sup>, François Pujos<sup>5</sup>, Analía M. Forasiepi<sup>5</sup>, Roman Fischer<sup>6</sup>, Kelly Molloy<sup>7</sup>, Meaghan Mackie<sup>3,8</sup>, Jesper V. Olsen<sup>8</sup>, Alejandro Kramarz<sup>9</sup>, Matías Taglioretti<sup>10</sup>, Fernando Scaglia<sup>10</sup>, Maximiliano Lezcano<sup>11</sup>, José Luis Lanata<sup>11</sup>, John Southon<sup>12</sup>, Robert Feranec<sup>13</sup>, Jonathan Bloch<sup>14</sup>, Adam Hajduk<sup>15</sup>, Fabiana M. Martin<sup>16</sup>, Rodolfo Salas Gismondi<sup>17</sup>, Marcelo Reguero<sup>18</sup>, Christian de Muizon<sup>19</sup>, Alex Greenwood<sup>20,21</sup>, Brian T. Chait<sup>7</sup>, Kirsty Penkman<sup>22</sup>, Matthew Collins<sup>3,23</sup> and Ross D. E. MacPhee<sup>2\*</sup>

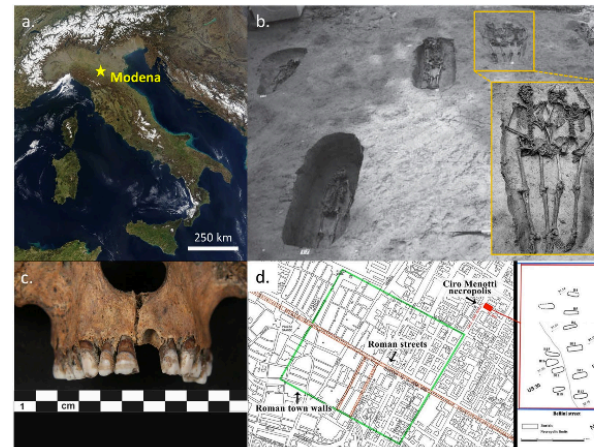
Extant and extinct taxa of Folivora group shed new light on phylogenetic history of the clade



# Palaeoproteomics

A large range of applications to archaeological problematics

- Phylogenetic reconstruction
- Sex determination
- Origin of hominin genetic pool

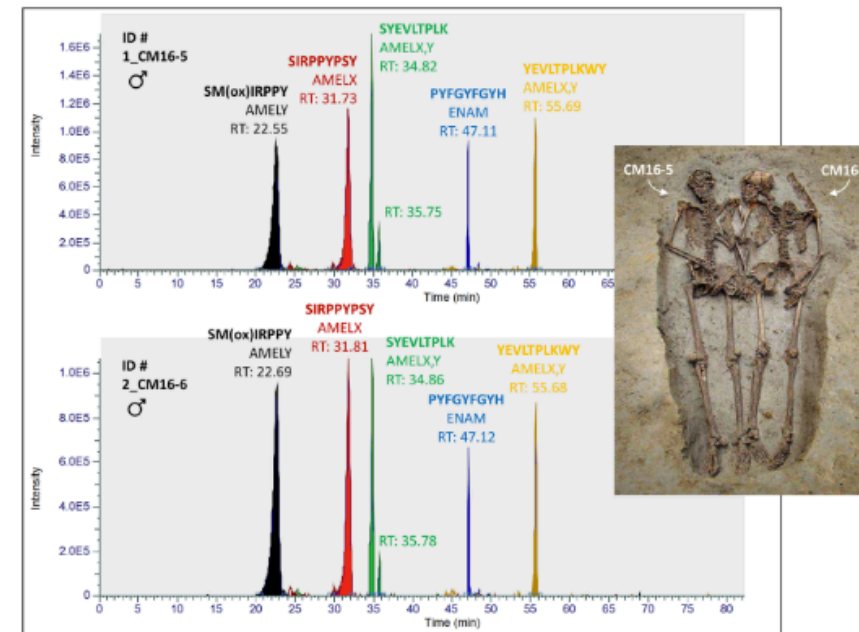


## Enamel peptides reveal the sex of the Late Antique 'Lovers of Modena'

Federico Lugli<sup>1,2</sup>, Giulia Di Rocco<sup>3</sup>, Antonino Vazzana<sup>1</sup>, Filippo Genovese<sup>4</sup>, Diego Pinetti<sup>4</sup>, Elisabetta Cilli<sup>1</sup>, Maria Cristina Carile<sup>1</sup>, Sara Silvestrini<sup>1</sup>, Gaia Gabanini<sup>1</sup>, Simona Arrighi<sup>1</sup>, Laura Buti<sup>1</sup>, Eugenio Bortolini<sup>1</sup>, Anna Cipriani<sup>2,5</sup>, Carla Figus<sup>1</sup>, Giulia Marciani<sup>1</sup>, Gregorio Oxilia<sup>1</sup>, Matteo Romandini<sup>1</sup>, Rita Sorrentino<sup>1,6</sup>, Marco Sola<sup>3</sup> & Stefano Benazzi<sup>1,7</sup>

Re-evaluation of the two 'Modena lovers' using enamel X and Y dimorphism

- Residue analyses
- Palaeopathologies characterization
- Species identification



# Palaeoproteomics

A large range of applications to archaeological problematics

- Phylogenetic reconstruction
- Sex determination
- **Origin of hominin genetic pool**
- Residue analyses
- Palaeopathologies characterization
- Species identification

PNAS

## Palaeoproteomic evidence identifies archaic hominins associated with the Châtelperronian at the Grotte du Renne

Frido Welker<sup>a,b,1</sup>, Mateja Hajdinjak<sup>c</sup>, Sahnra Talamo<sup>a</sup>, Klervia Jaouen<sup>a</sup>, Michael Dannemann<sup>c,d</sup>, Francine David<sup>a</sup>, Michèle Julien<sup>a</sup>, Matthias Meyer<sup>e</sup>, Janet Kelso<sup>f</sup>, Ian Barnes<sup>f</sup>, Selina Brace<sup>f</sup>, Pepijn Kamminga<sup>g</sup>, Roman Fischer<sup>h</sup>, Benedikt M. Kessler<sup>h</sup>, John R. Stewart<sup>i</sup>, Svante Pääbo<sup>g</sup>, Matthew J. Collins<sup>g</sup>, and Jean-Jacques Hublin<sup>a</sup>

<sup>a</sup>Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, 04103 Leipzig, Germany; <sup>b</sup>BioArch, University of York, York YO10 5DD, United Kingdom; <sup>c</sup>Department of Evolutionary Genetics, Max Planck Institute for Evolutionary Anthropology, 04103 Leipzig, Germany; <sup>d</sup>Medical Faculty, University of Leipzig, 04103 Leipzig, Germany; <sup>e</sup>Paris Unité Mixte de Recherche 7041, Archéologies et Sciences de l'Antiquité, Centre National de la

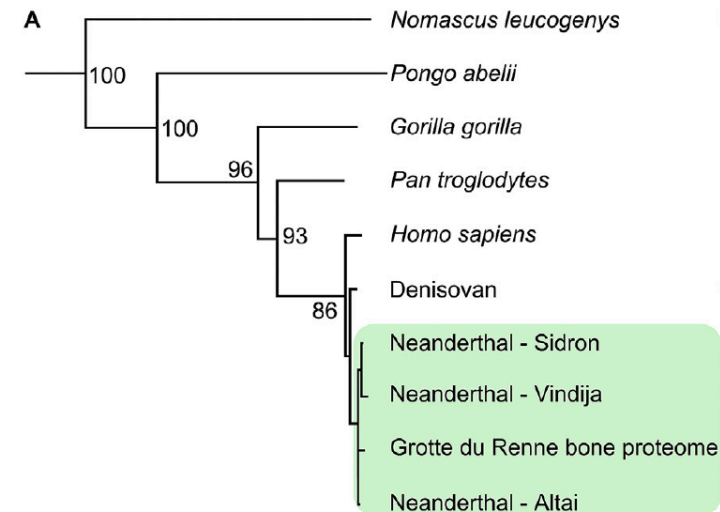


Palaeoproteomics for human evolution studies

Frido Welker<sup>a, b, \*</sup>



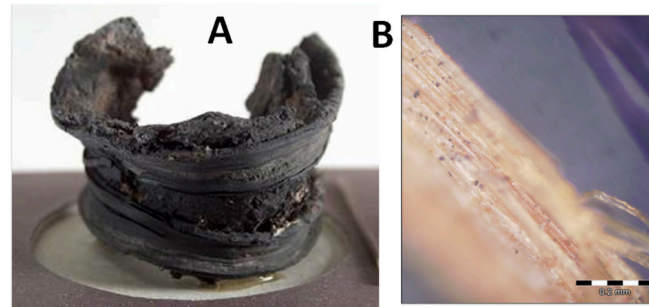
Identifying Neandertals' remains using collagen fingerprinting



# Palaeoproteomics

A large range of applications to archaeological problematics

- Phylogenetic reconstruction
- Sex determination
- Origin of hominin genetic pool
- Residue analyses
- Palaeopathologies characterization
- Species identification



Rapid Commun. Mass Spectrom. 2013, 27, 531–538  
(wileyonlinelibrary.com) DOI: 10.1002/rcm.6481

## Proteomics analysis of ancient food vessel stitching reveals >4000-year-old milk protein

Michael Buckley<sup>1\*</sup>, Nigel D. Melton<sup>2</sup> and Janet Montgomery<sup>2</sup>

Identification of keratins, collagen and alpha casein peptides from 4000 y. old vessel

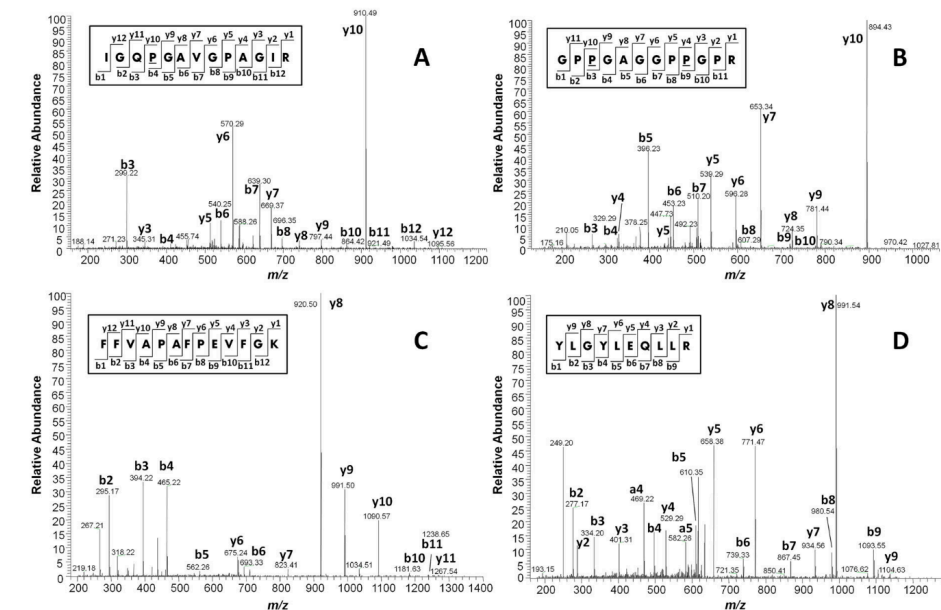


Figure 4. MS/MS spectra of (A) the bovine CO1A2 peptide, (B) CO3A1 peptide, and both bovine  $\alpha$ -S1-casein peptides (C) CASA<sub>138-49</sub> and (D) CASA<sub>1106-115</sub>.

# Palaeoproteomics

A large range of applications to archaeological problematics

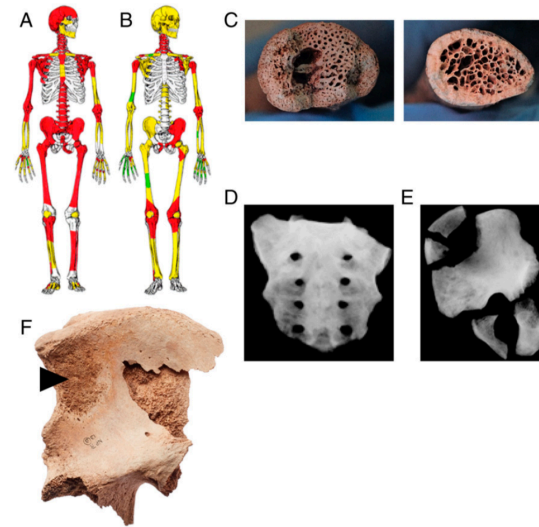
- Phylogenetic reconstruction
- Sex determination
- Origin of hominin genetic pool
- Residue analyses
- **Palaeopathologies characterization**
- Species identification

PNAS

## Molecular insights into an ancient form of Paget's disease of bone

Barry Shaw<sup>a,1</sup>, Carla L. Burrell<sup>b,c,1</sup>, Darrell Green<sup>d,1</sup>, Ana Navarro-Martinez<sup>a</sup>, Daniel Scott<sup>a</sup>, Anna Daroszevska<sup>e,f,g</sup>, Rob van 't Hof<sup>g</sup>, Lynn Smith<sup>h</sup>, Frank Hargrave<sup>b</sup>, Sharad Mistry<sup>i</sup>, Andrew Bottrill<sup>i</sup>, Benedikt M. Kessler<sup>i</sup>, Roman Fischer<sup>i</sup>, Archana Singh<sup>k</sup>, Tamas Dalmay<sup>k</sup>, William D. Fraser<sup>d,l</sup>, Kirstin Henneberger<sup>m</sup>, Turi King<sup>n</sup>, Silvia Gonzalez<sup>b</sup>, and Robert Layfield<sup>a,2</sup>

<sup>a</sup>School of Life Sciences, University of Nottingham, NG7 2UH Nottingham, United Kingdom; <sup>b</sup>Research Centre for Evolutionary Anthropology and Paleoeology, Liverpool John Moores University, L3 3AF Liverpool, United Kingdom; <sup>c</sup>Faculty of Archaeology, Leiden University, 2333 CC Leiden, The Netherlands



Protein sequestosome or p-62 involved in Paget's disease

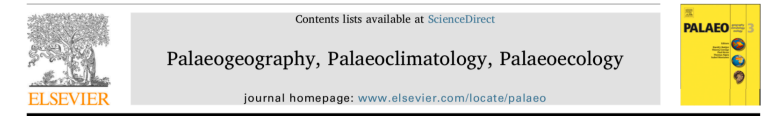
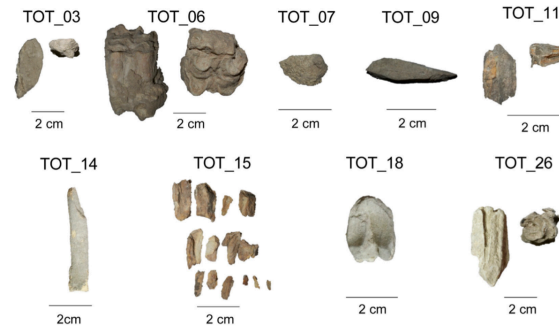
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1  MASLTVKAYL LGKEDAAREI RRFSCCSPE PEAEAEAAAG PGPCERLLSR 50
51  VAALFPALRP GGFQAHYRDE DGDLVAFSSD EELTMAMSYV KDDIFRIYIK 100
101 EKKECRDRHR PPCAQEAPRN MVHPNVICDG CNGPVVVGTRY KCSVCPDYDL 150
151 CSVCEGKGLH RGHTKLAFFS PFGHLSSEGS HSRWLRKVKH GHFGWPGWEM 200
201 GPPGNWSPRP PRAGEARPGF TAESASGPSE DPSVNFKNV GESVAAALSP 250
251 LGIEVDIDVE HGGKRSRLTP VSPSSSTEE KSSSQPSSCC SDPSKPGGNV 300
301 EGATQSLAEQ MRKIALESEG RPEEQMESDN CSGGDDDWTH LSSKEVDPST 350
351 GELQSLQMP ESEGPSLLDPS QEGPTGLKEA ALYPHLPPEA DPRLIESLSQ 400
401 MLSMGFSDEG GWLTRLQLTK NYDIGAALDT IQYSKHPPPL 440
    
```

# Palaeoproteomics

A large range of applications to archaeological problematics

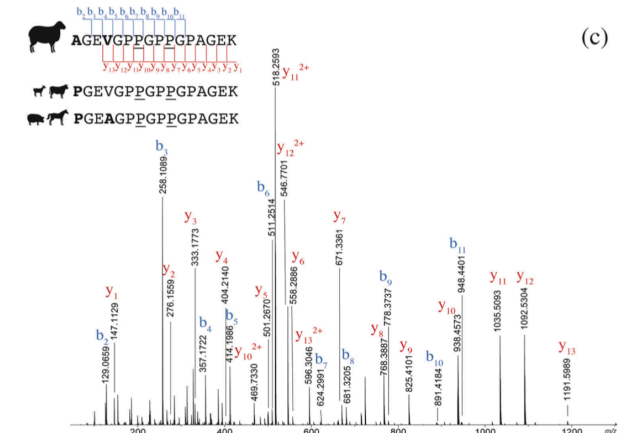
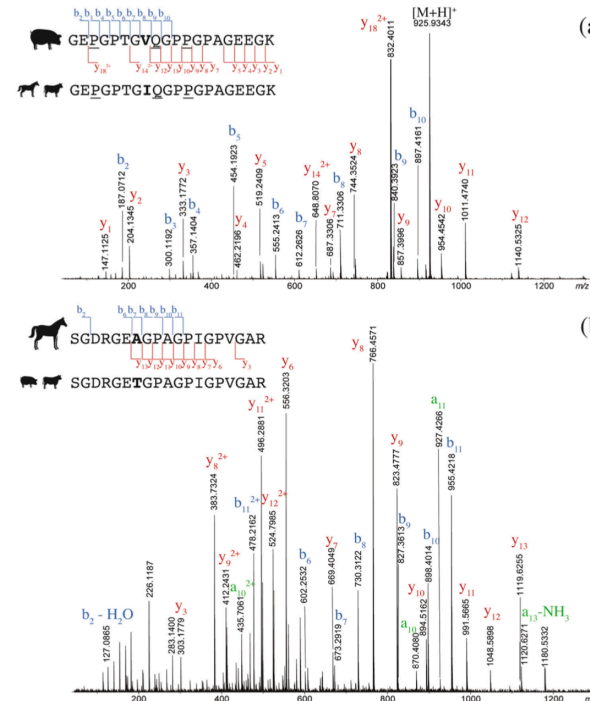
- Phylogenetic reconstruction
- Sex determination
- Origin of hominin genetic pool
- Residue analyses
- Palaeopathologies characterization
- **Species identification**



Identification of degraded bone and tooth splinters from arid environments using palaeoproteomics

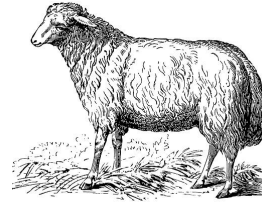
Louise Le Meillour<sup>a,b,c</sup>, Antoine Zazzo<sup>a</sup>, Joséphine Lesur<sup>a</sup>, Sophie Cersoy<sup>c</sup>, Arul Marie<sup>b</sup>, Matthieu Lebon<sup>a</sup>, David Pleurdeau<sup>d</sup>, Séverine Zirah<sup>b</sup>

Species identification of splinters based on collagen sequences





# Introduction and diffusion of domestic caprines in Africa



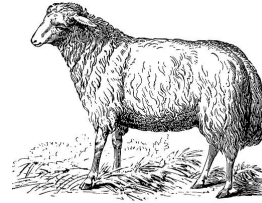
*Ovis aries*

Caprines



*Capra hircus*

# Introduction and diffusion of domestic caprines in Africa



*Ovis aries*

Caprines

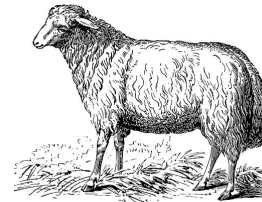
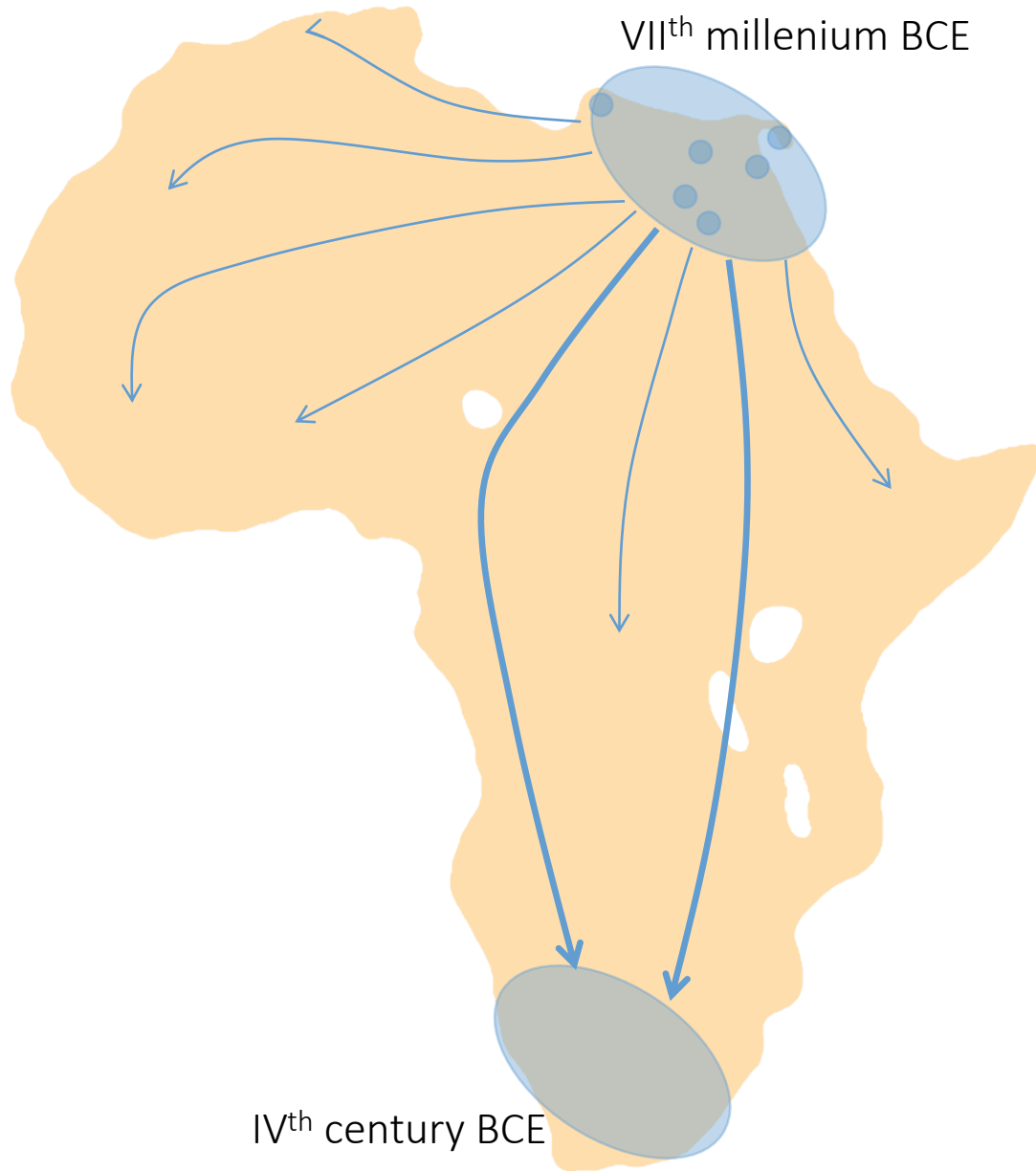


*Capra hircus*

introduction from the Near East at the  
end of 7th millenium BCE

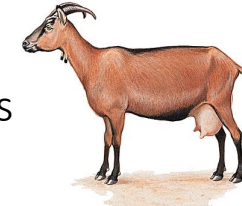
Key species:  
economy, societies

# Introduction and diffusion of domestic caprines in Africa



*Ovis aries*

Caprines



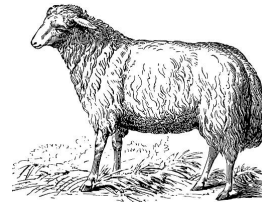
*Capra hircus*

Diffusion of caprines herding to Southern Africa?

- Percolation or population migration?

- Eastern or Western route?

# Introduction and diffusion of domestic caprines in Africa



*Ovis aries*

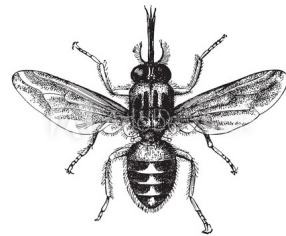


*Capra hircus*

Caprines

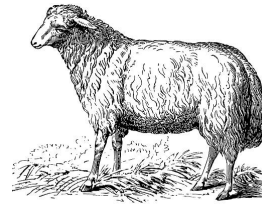
Links between Eastern and Southern Africa

- environmental and ecological constraints



*Glossina morsitans*

# Introduction and diffusion of domestic caprines in Africa



*Ovis aries*



*Capra hircus*

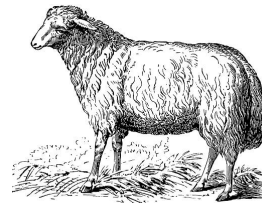
Caprines

Links between Eastern and Southern Africa

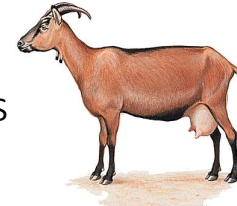
- environmental and ecological constraints

- linguistic

# Introduction and diffusion of domestic caprines in Africa



*Ovis aries*



*Capra hircus*

Caprines

Links between Eastern and Southern Africa

- environmental and ecological constraints

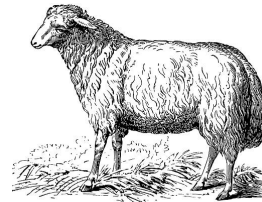
- linguistic

- populations genetics

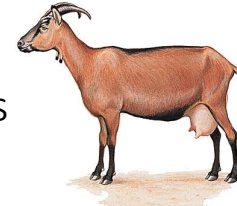
Lactase persistence allele



# Introduction and diffusion of domestic caprines in Africa



*Ovis aries*



*Capra hircus*

Caprines



Adal  
Ethiopia



Damara  
Namibia

Links between Eastern and Southern Africa

- environmental and ecological constraints

- linguistic

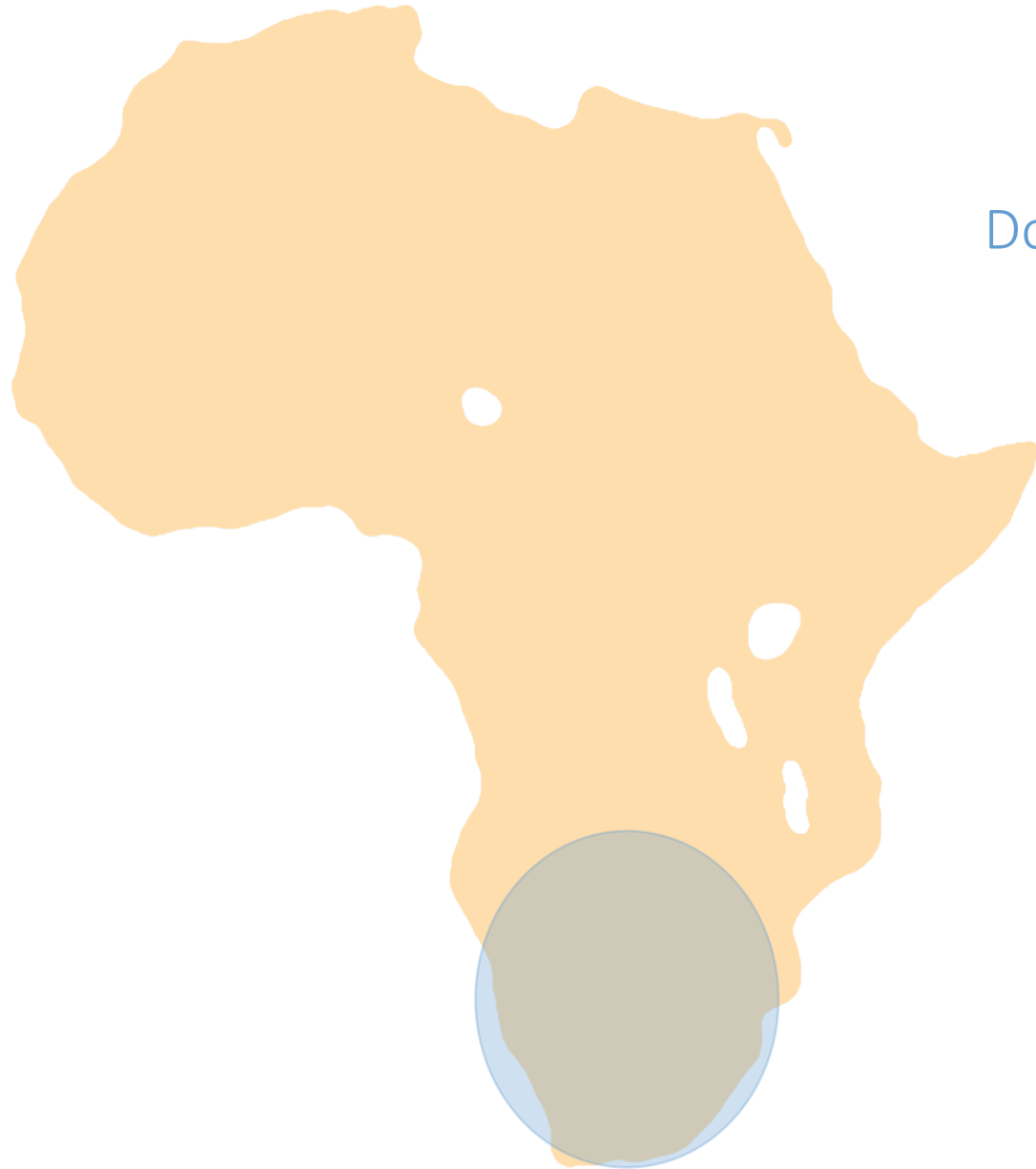
- populations genetics

Lactase persistence allele

- caprines breeds

Fat-tailed breeds

# Introduction and diffusion of domestic caprines in southern Africa



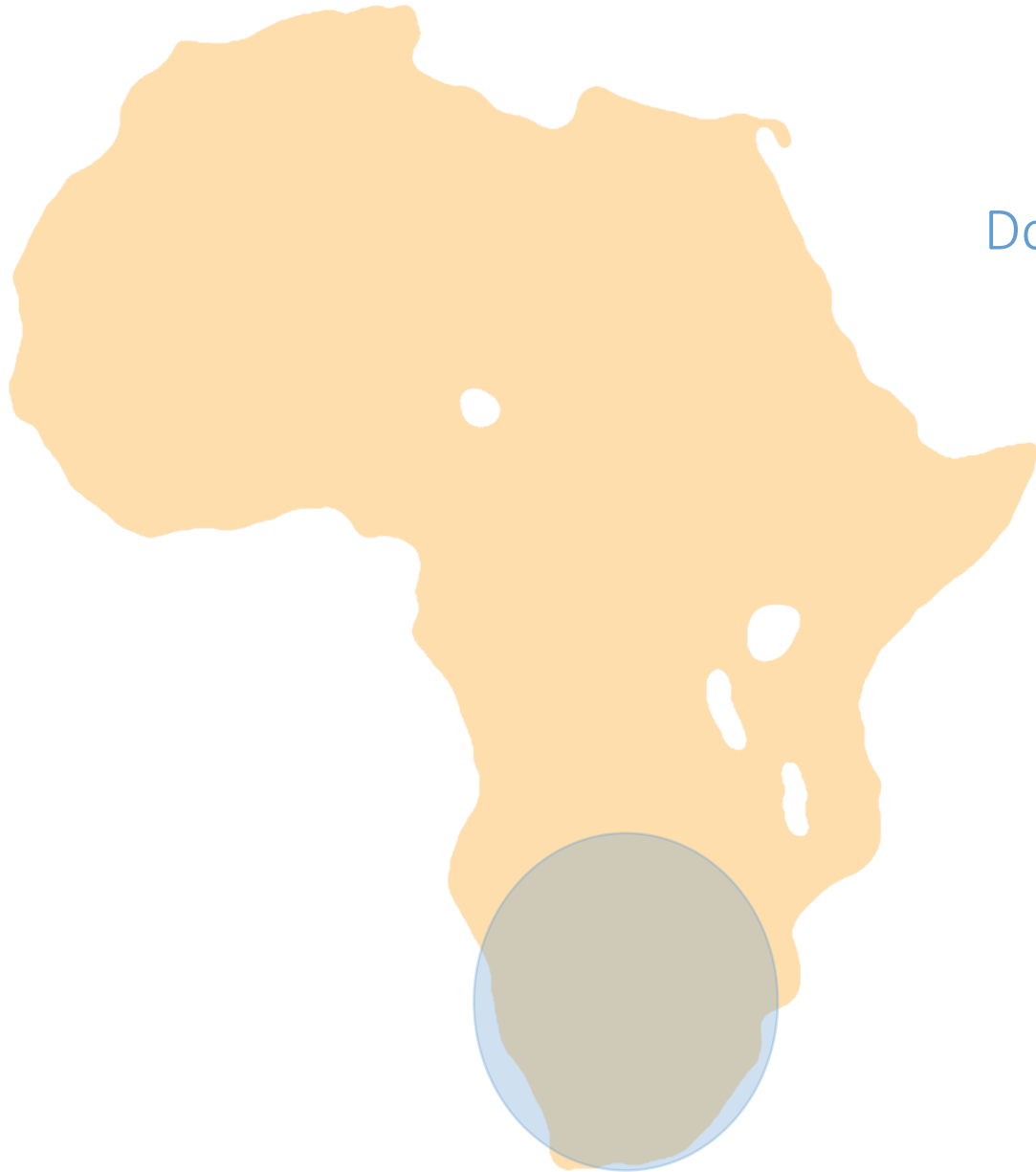
Documenting first herding practices in southern Africa



direct dating of first domesticated animals



# Introduction and diffusion of domestic caprines in southern Africa



Documenting first herding practices in southern Africa

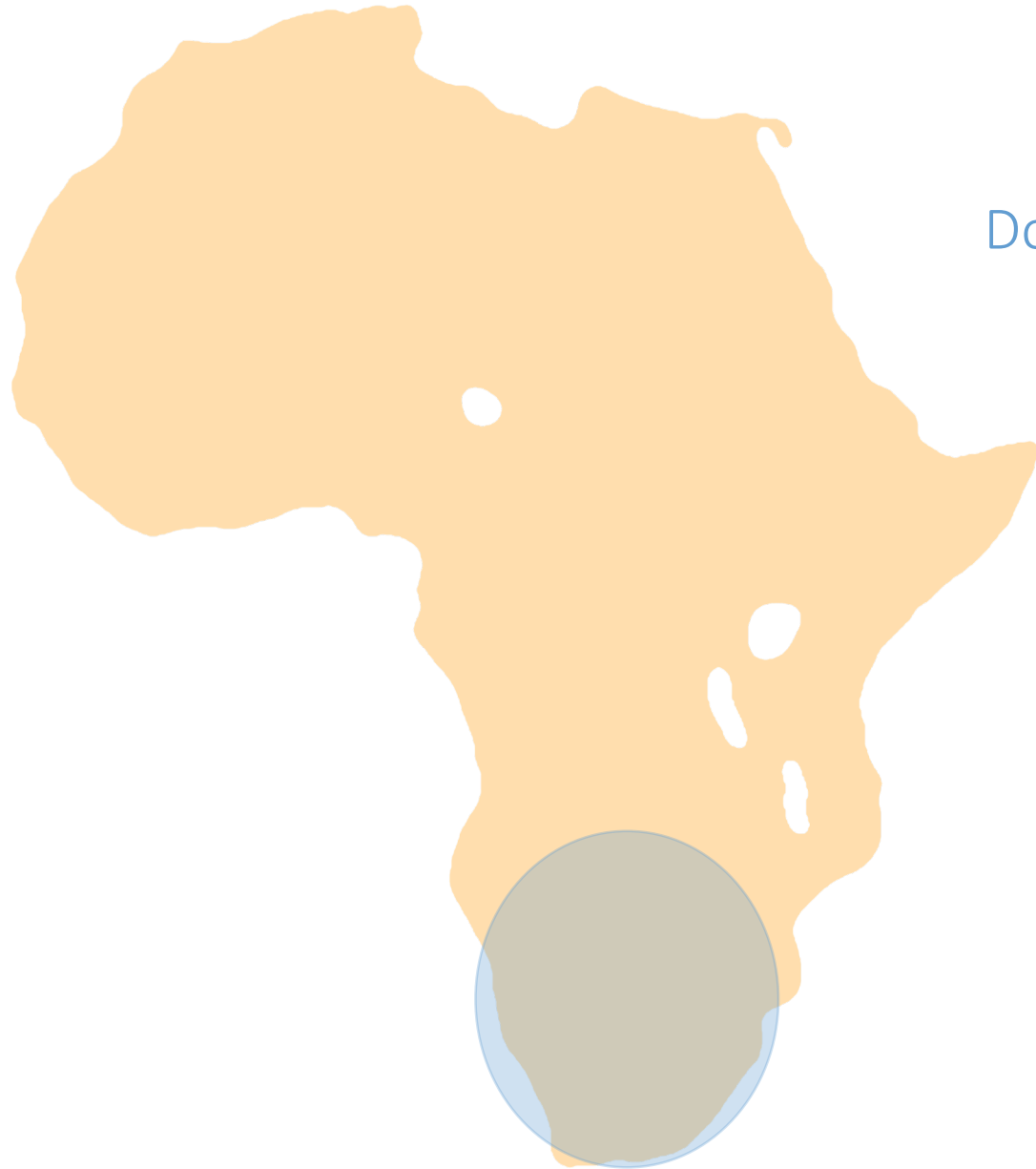


direct dating of first domesticated animals



clear identification of archaeological material

# Introduction and diffusion of domestic caprines in southern Africa



## Documenting first herding practices in southern Africa

➔ direct dating of first domesticated animals

➔ clear identification of archaeological material

**Counting and miscounting sheep: genetic evidence for pervasive misclassification of wild fauna as domestic stock**

<sup>1</sup>K. Ann Horsburgh, <sup>2</sup>J. Víctor Moreno-Mayar and <sup>3</sup>Richard G. Klein

Blydefontein, South Africa

# Like two peas in a pod: the issue of identification

- Bones and teeth fragmentation
  - Diagenesis



2 cm



2 cm

Toteng – Botswana

© L. Le Meillour



© A. Zazzo

Goats, Djibouti



© F. Déroit

Sheep, Namibia

# Like two peas in a pod: the issue of identification

- Bones and teeth fragmentation
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2 cm



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Sheep, Namibia



*O. oreotragus*

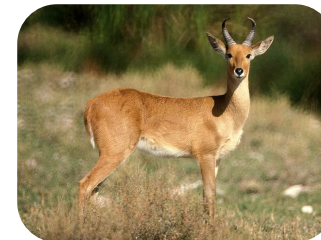
*A. nasomaculatus*



*C. nubiana*



*G. soemmeringi*

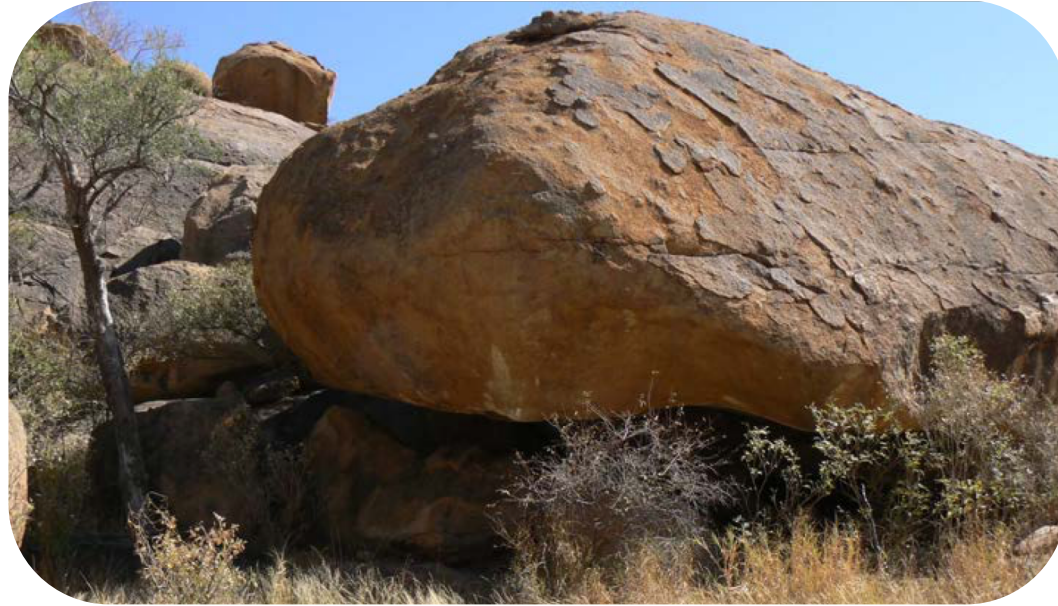
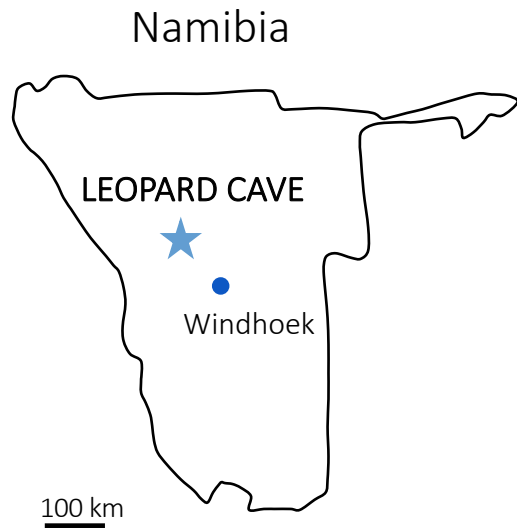


*R. redunca*



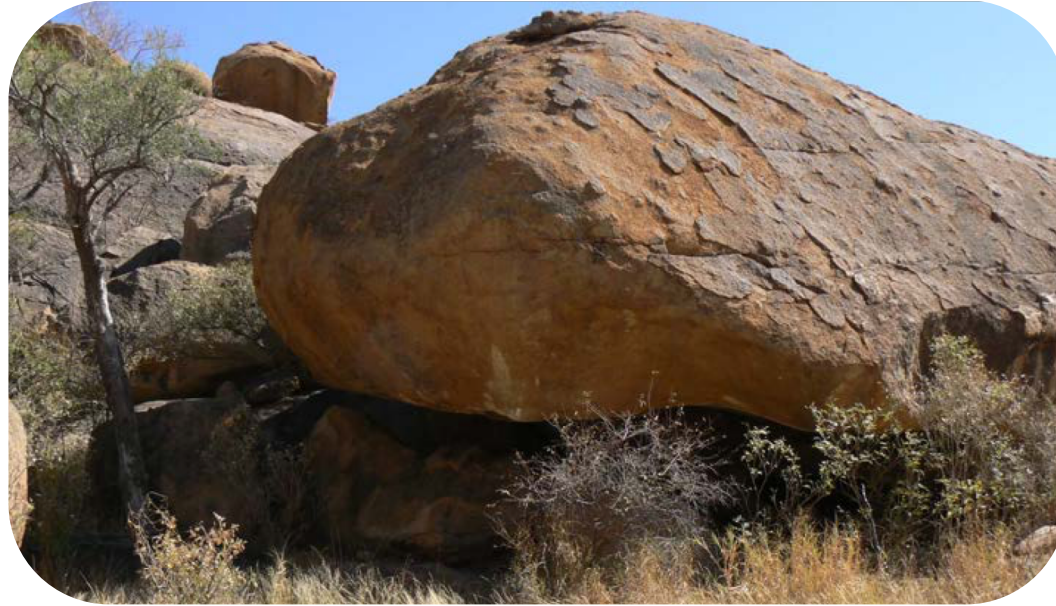
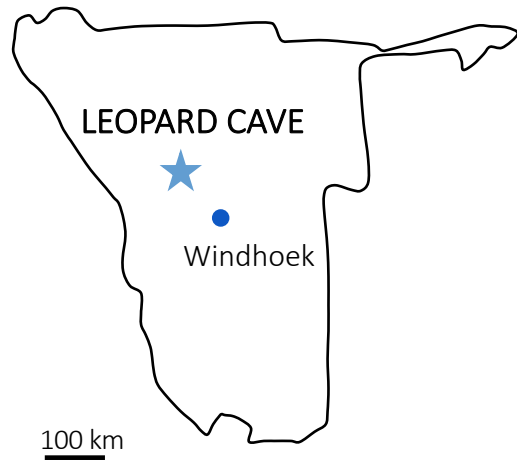
*A. marsupialis*

# Leopard Cave: early herding in Namibia?



# Leopard Cave: early herding in Namibia?

Namibia



Rock art



Lithic industry



Artefacts

Bone points, ostrich eggshell beads



# Leopard Cave: early herding in Namibia?



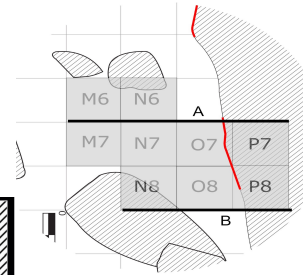
OPEN ACCESS Freely available online



## “Of Sheep and Men”: Earliest Direct Evidence of Caprine Domestication in Southern Africa at Leopard Cave (Erongo, Namibia)

David Pleurdeau<sup>1\*</sup>, Emma Imalwa<sup>2</sup>, Florent Détroit<sup>1</sup>, Joséphine Lesur<sup>3</sup>, Anzel Veldman<sup>2</sup>, Jean-Jacques Bahain<sup>1</sup>, Eugène Marais<sup>2</sup>

25 small bovids remains



½ mandible R.



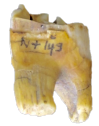
5 cm

M3 inf. R.

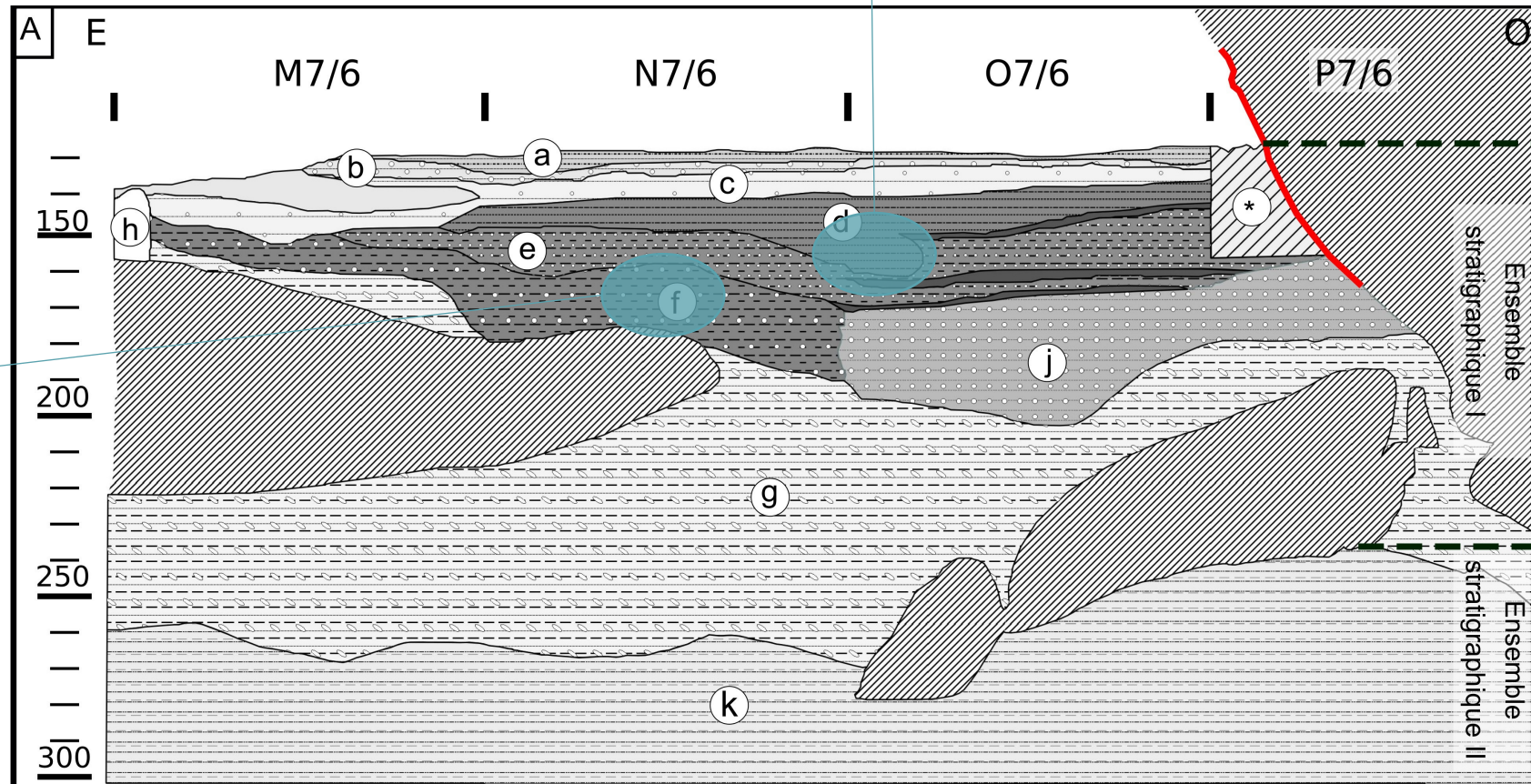


5 cm

M2 sup. R.



5 cm



# Leopard Cave: early herding in Namibia?



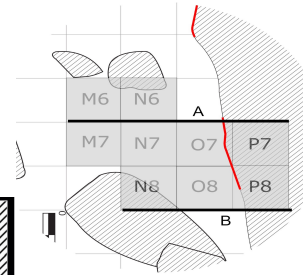
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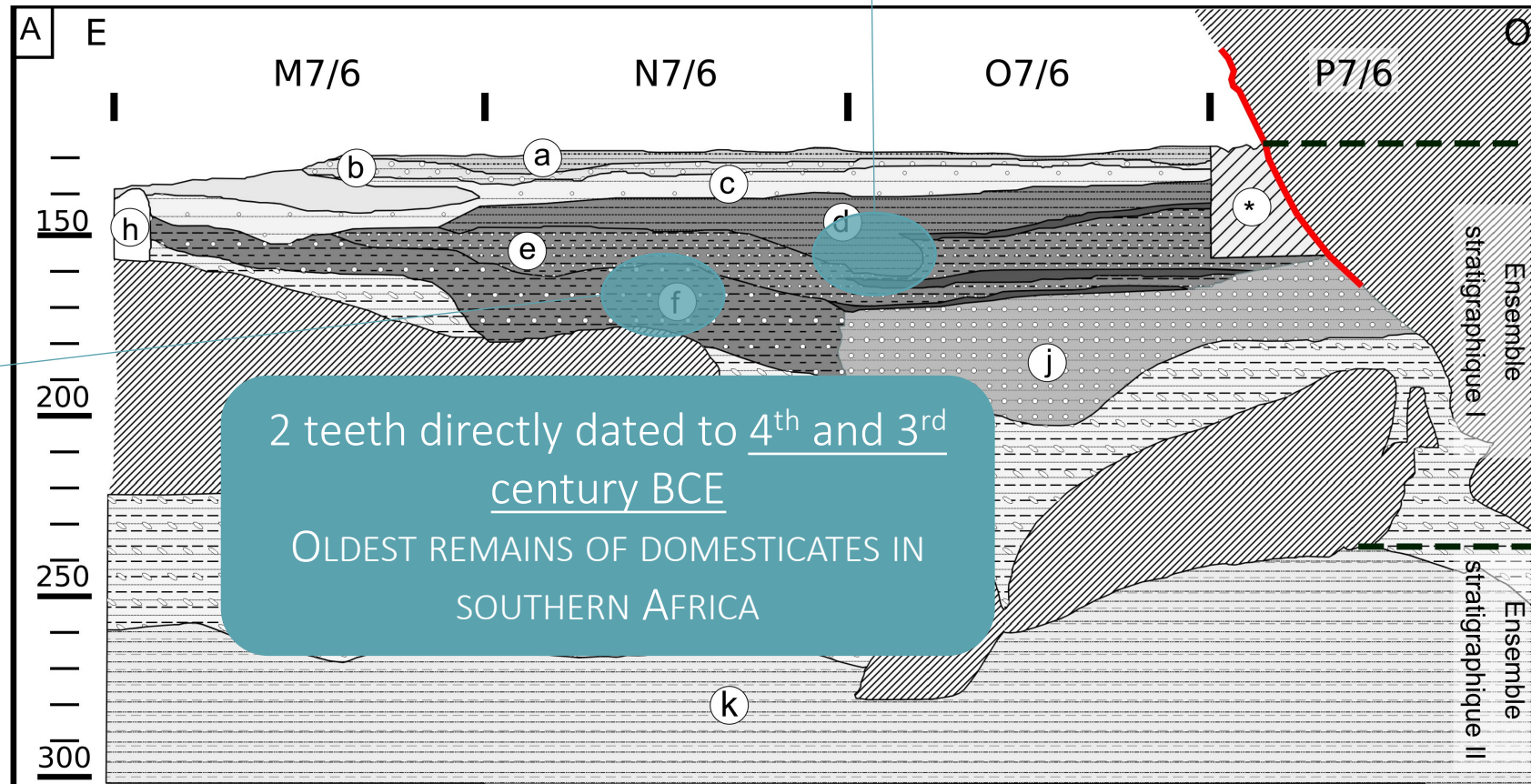


5 cm

M2 sup. R.



5 cm





# Leopard Cave: early herding in Namibia?

½ mandible R.



5 cm

M3 inf. R.



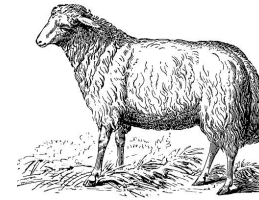
5 cm

M2 sup. R.



5 cm

+ 25



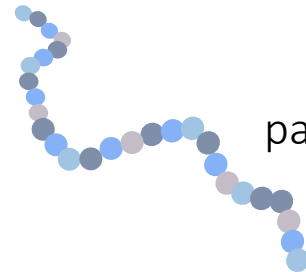
*O. aries*

or



*C. hircus*

## Species preferential exploitation by early herders?



palaeoproteomics



radiocarbon dating

# Exploring wild antelopes markers



*A. marsupialis*



*A. melampus*



propose new *de novo*  
reconstructed sequences of type I  
collagen

*O. aries* breed  
Namibia (Brandberg)

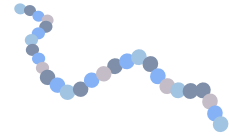


*C. hircus* breed  
Namibia (Brandberg)



+ type I collagen sequences of bovids available

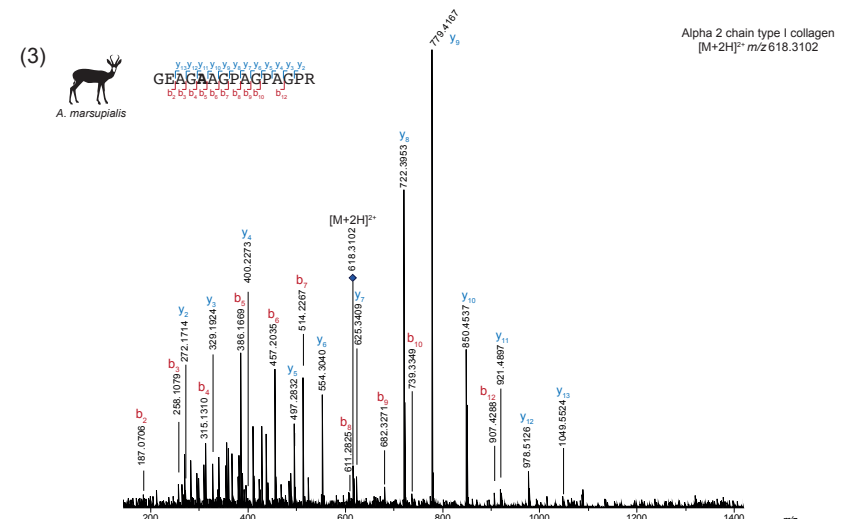
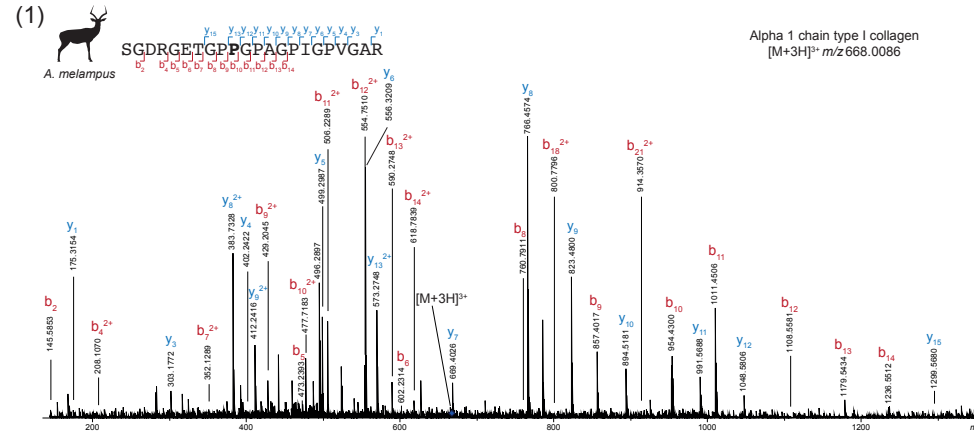
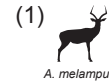
# Exploring wild antelopes markers



## Proteomics



*A. marsupialis*     *A. melampus*



### Alpha 1 chain of collagen type I

*A. marsupialis* 1064 ... SGDRGETG**P**PAG**P**AG**I**GPVGAR ... 1085

*A. melampus* ... SGDRGETG**P**PAG**P**AG**I**GPVGAR ...

### Alpha 2 chain of collagen type I

*A. melampus* 590 ... GPPGESGAAG**P**TGP**I**GSR ... 607

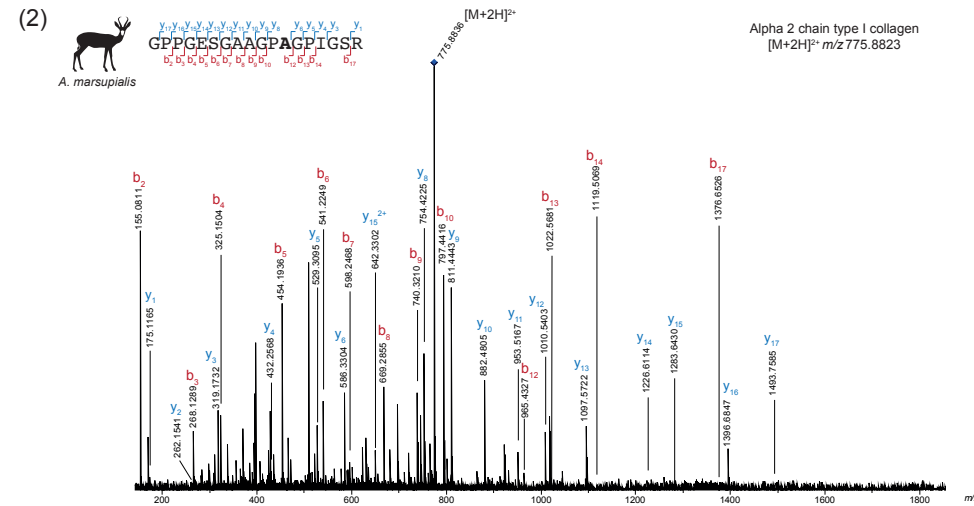
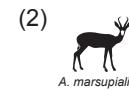
*A. marsupialis* ... GPPGESGAAG**P**TGP**I**GSR ...

*A. melampus* 692 ... GEAG**P**AGPAG**P**AG**R** ... 706

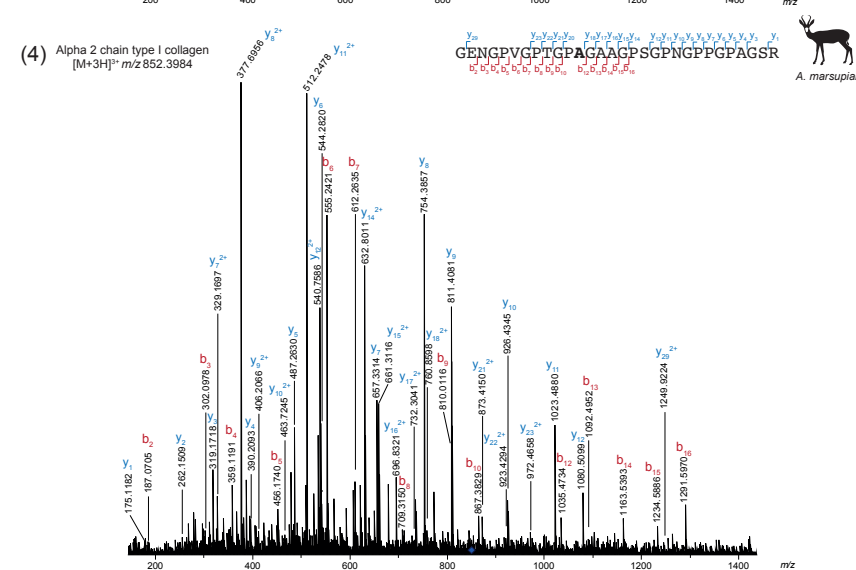
*A. marsupialis* ... GEAG**P**AGPAG**P**AG**R** ...

*A. melampus* 743 ... GENGPVGP**T**GPVGAAG**P**SG**P**NG**P**PG**P**AG**S**R ... 775

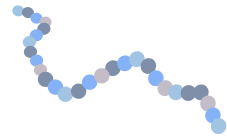
*A. marsupialis* ... GENGPVGP**T**GPVGAAG**P**SG**P**NG**P**PG**P**AG**S**R ...



(4) Alpha 2 chain type I collagen  
[M+3H]<sup>+</sup> m/z 852.3984



# Exploring wild antelopes markers



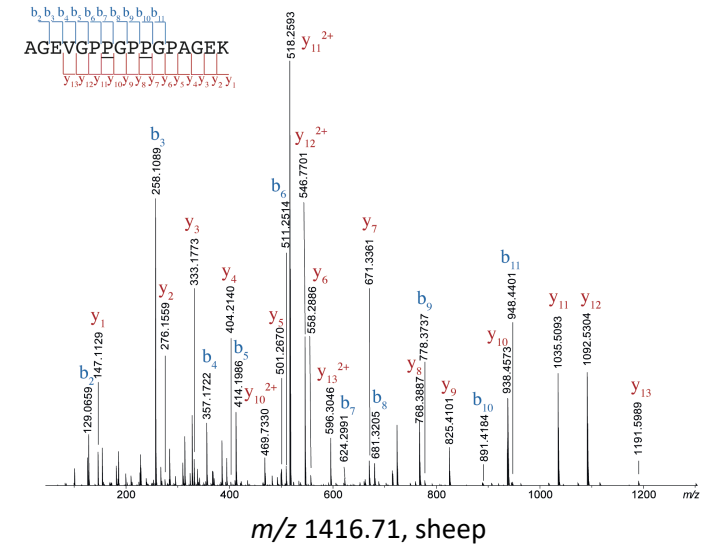
## Proteomics

Alpha 1 chain  
type I collagen



921 **A**GEVGPPGPPGPAGEK 936

921 **P**GEVGPPGPPGPAGEK 936

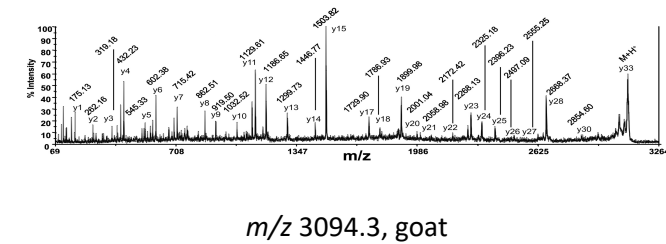


Alpha 2 chain  
type I collagen



845 GPSGEPGTAGPPGTPGPQ**L**LG**A**PGFLGLPGSR 877

845 GPSGEPGTAGPPGTPGPQ**F**LG**P**PGFLGLPGSR 877



# Exploring wild antelopes markers

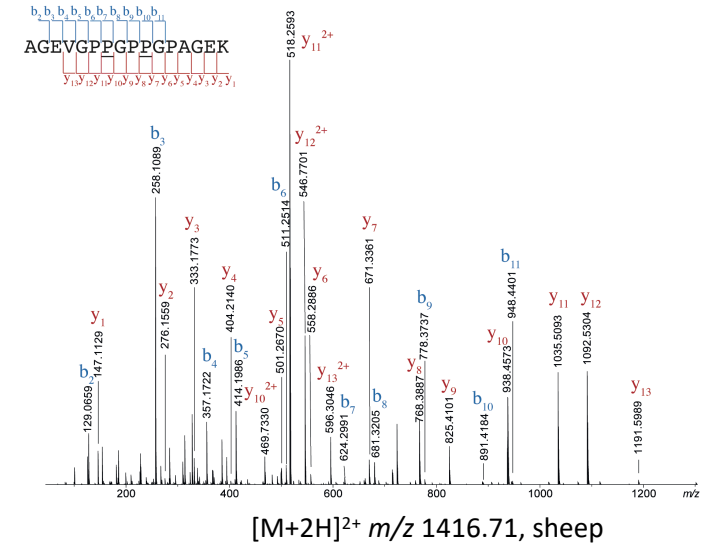


Alpha 1 chain  
type I collagen



921 **A**GEVGPPGPPGPAGEK 936

921 **P**GEVGPPGPPGPAGEK 936

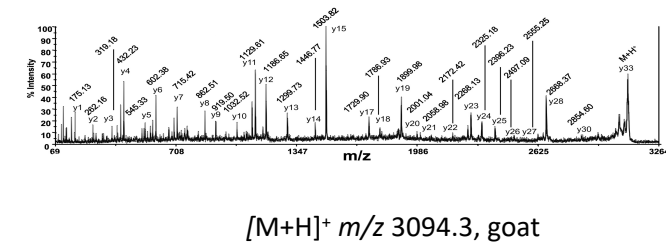


Alpha 2 chain  
type I collagen



845 GPSGEPGTAGPPGTPGPQ**L**LG**A**PGFLGLPGSR 877

845 GPSGEPGTAGPPGTPGPQ**F**LG**P**PGFLGLPGSR 877



# Exploring wild antelopes markers

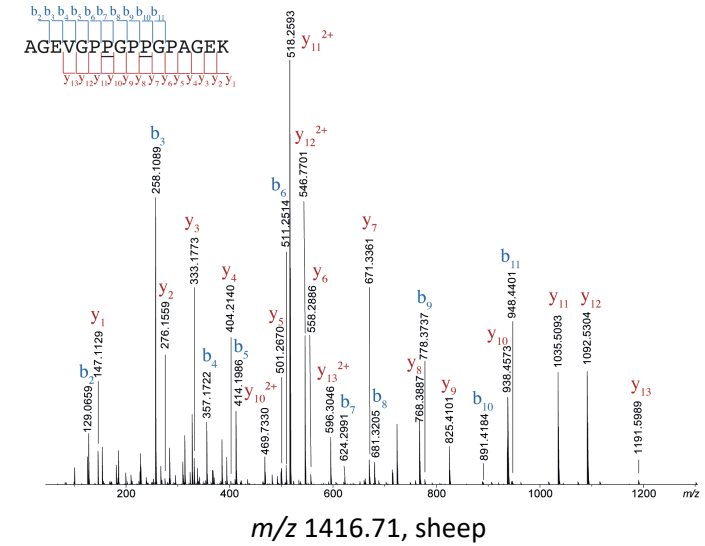


Alpha 1 chain  
type I collagen



921 **A**GEVGPPGPPGPAGEK 936

921 **P**GEVGPPGPPGPAGEK 936

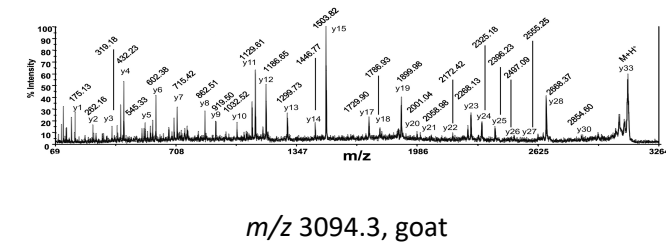


Alpha 2 chain  
type I collagen



845 GPSGEPGTAGPPGTPGPQ**L**LG**A**PGFLGLPGSR 877

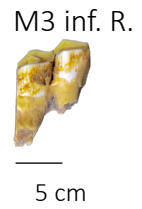
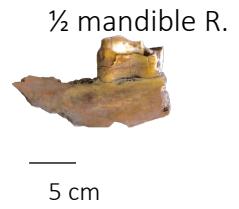
845 GPSGEPGTAGPPGTPGPQ**F**LG**P**PGFLGLPGSR 877



# Leopard Cave: 'Of sheep and men'?



28 remains



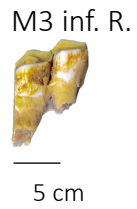
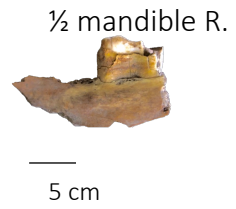
+ 1 bone



# Leopard Cave: 'Of sheep and men'?



28 remains



+ 1 bone



*A. marsupialis*



# Leopard Cave: 'Of sheep and men'?



28 remains



+ 1 bone

24



*A. marsupialis*



*O. aries*

# Leopard Cave: 'Of sheep and men'?

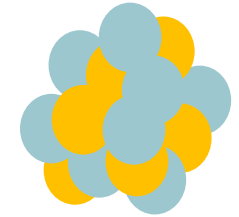


28 remains



+ 1 bone

24



$^{14}\text{C}$

Talus



1 cm

3rd phalanx



1 cm



*A. marsupialis*

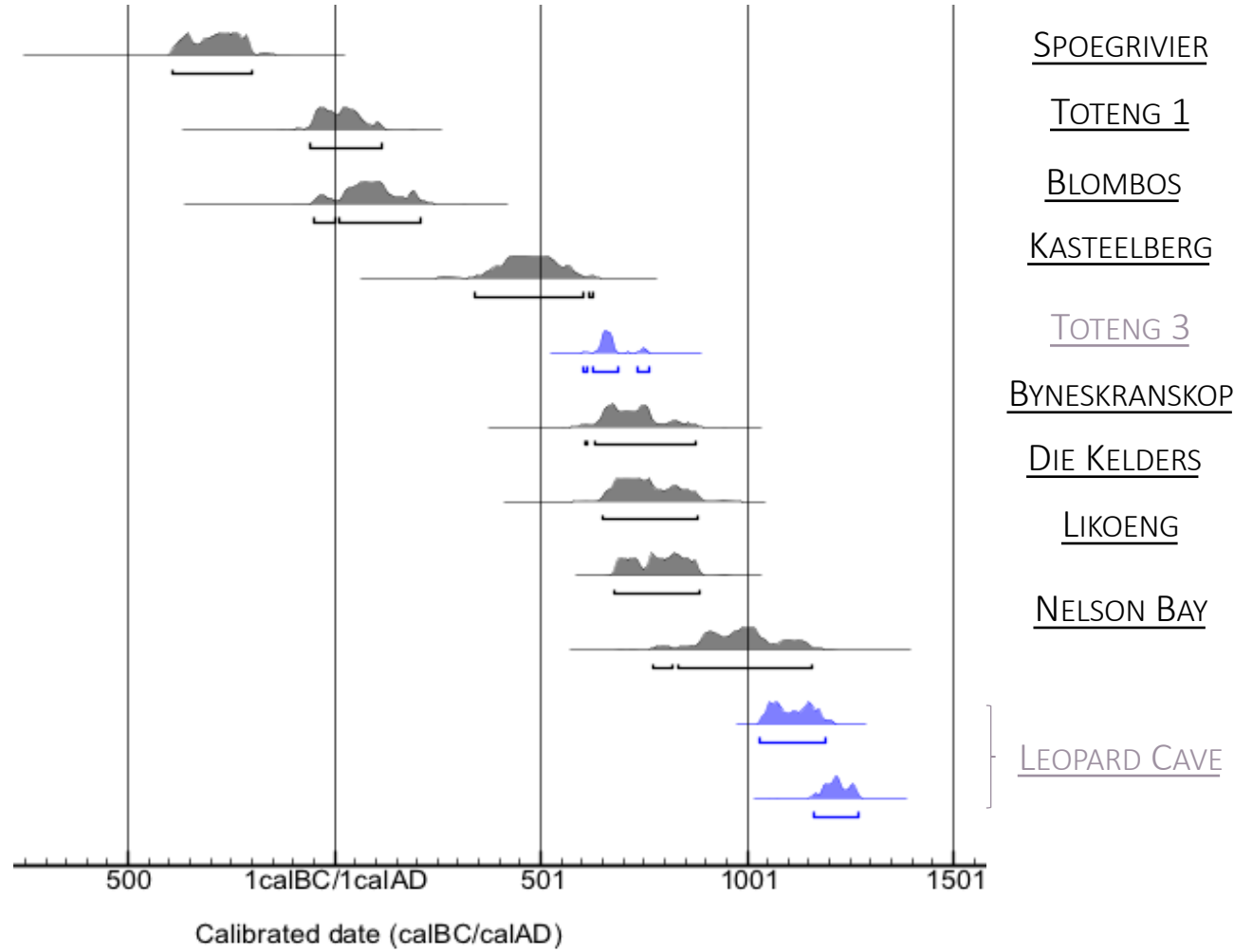


© F. Déroit

*O. aries*

XI<sup>th</sup> and XII<sup>th</sup> century CE

# What implication for early herding in southern Africa?



# End of the story?



- palaeoproteomics can be applicable even in constraint environments and splinters



- 'Beware the antelopes'!

- the case of Leopard Cave opens new interrogations regarding remains identifications



Thank you for your  
attention!