UMR 6298 ARTEHIS Archéologie Terre Histoire Sociétés
BIOGÉOSCIENCES unité mixte de recherche CNRS / uB 5561

SETAC Asia/Pacific

September 2012

Bioaccumulation of trace metals deriving from historical mining in wood mice (*Apodemus sylvaticus*)

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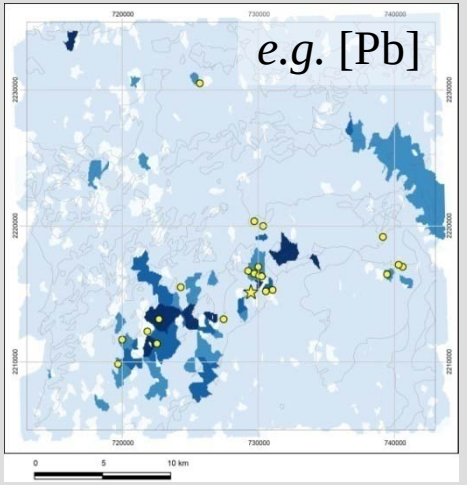
[Heinrich Gross, XVIe s.]

Background project

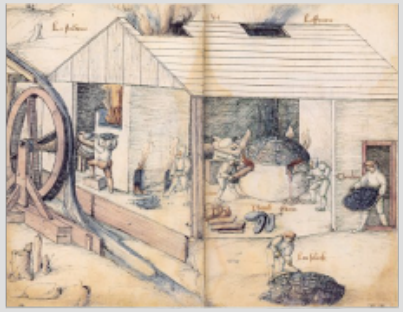
- Industrial history forgotten by local inhabitants
  - Ancient wastes may still represent a threat (Monna *et al.*, 2011)

- Our project
  - Discovering former mines
    - ⇨ **Prospectivity maps produced from geochemical databases**
    - ⇨ **Field surveys**



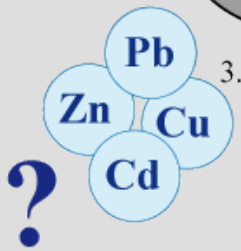
  - Assessing their impacts on present aquatic and terrestrial ecosystems
    - ⇨ **Biological survey on chosen sites**

More precisely…

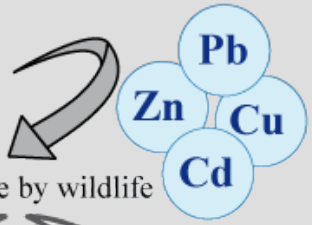


1. Mining and metallurgical activities

2. Abandoned wastes and tailings



3. Transfer of metal in soil



4. Uptake by wildlife

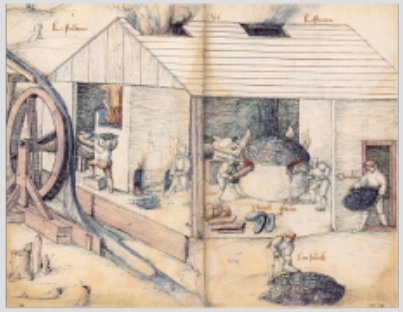
?

Aquatic ecosystem

Terrestrial ecosystem

- Local spatial distribution of trace metals in soils affected by past mining?

More precisely…



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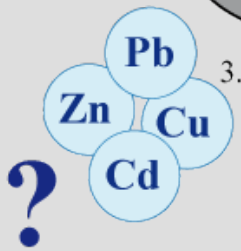

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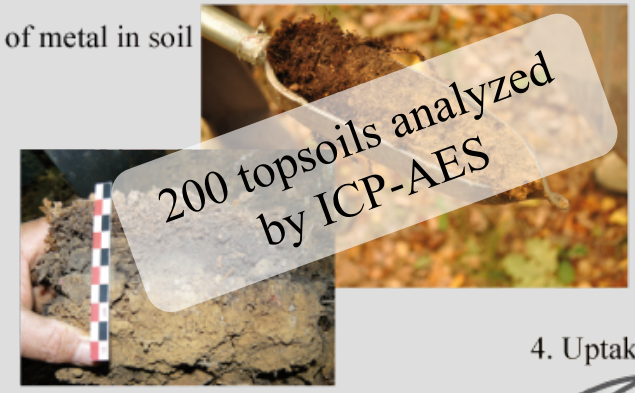

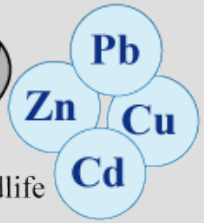

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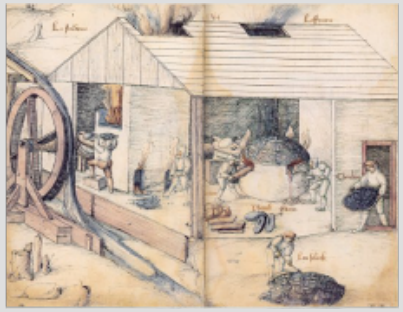

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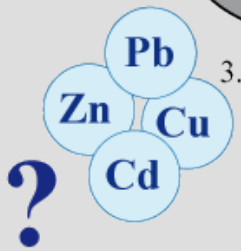

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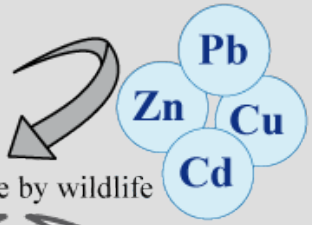

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- Consequences of long-term metal in soil on wildlife?

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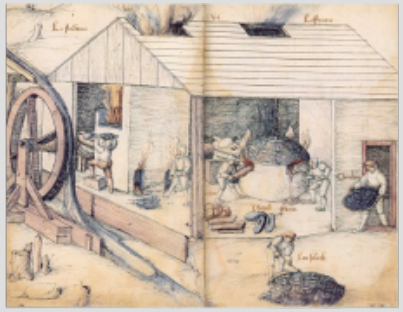

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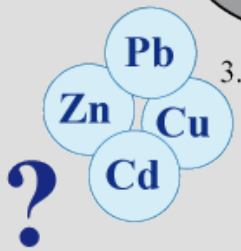

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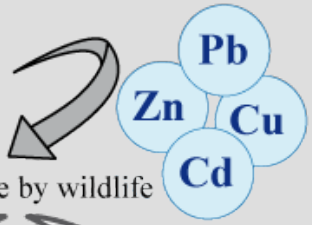

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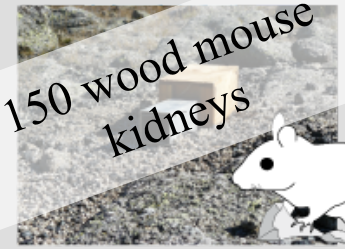
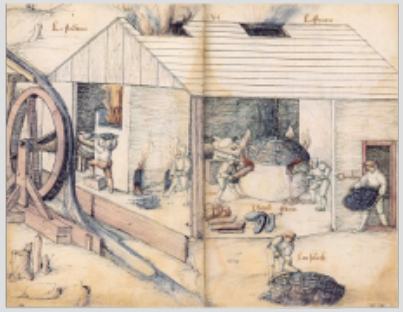
Aquatic ecosystem



Terrestrial ecosystem

More precisely…



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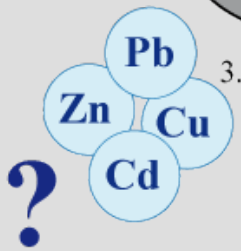

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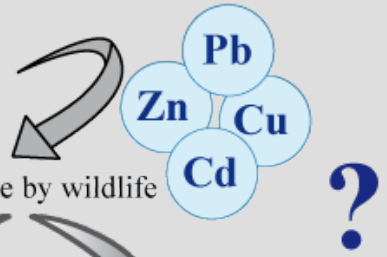


4. Uptake by wildlife

?

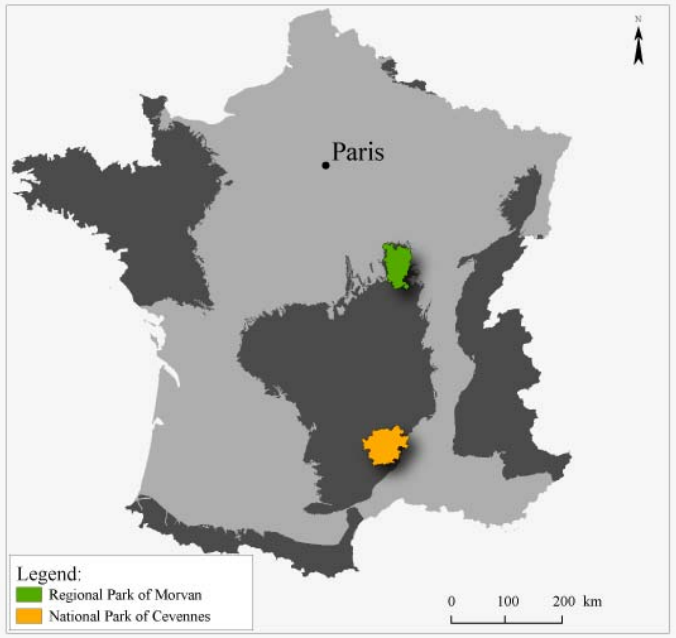
- Consequences of long-term metal in soil on wildlife?
- Developmental impact on wildlife?

Aquatic ecosystem

Terrestrial ecosystem

Study Sites

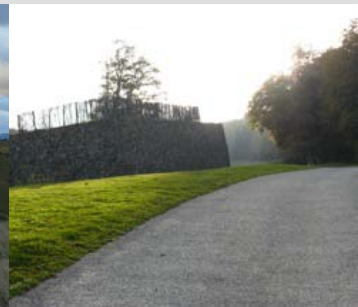
- Two distinct French regions
  - Massif Central replicates
  - Protected by constraining environmental policies
    - ⇨ **The National Park of Cevennes**
    - ⇨ **The Regional Park of Morvan**

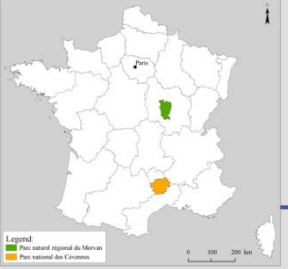


- Both areas experienced active metal mining and smelting activities from prehistory onwards









Study areas

CEVENNES

No mining

MORVAN

Free of mining activity

Free of mining activity

Discrete mining

Metal exploited: Pb-Ag

Type of exploitation: smelting areas

Datation: the 11th - 14th centuries AD

Metal exploited: polymetallic sulfide

Type of exploitation: mines and smelting area

Datation: 19th - 20th centuries AD

Intense mining

Metal exploited: Pb -Zn

Type of exploitation: mines and ore-washing

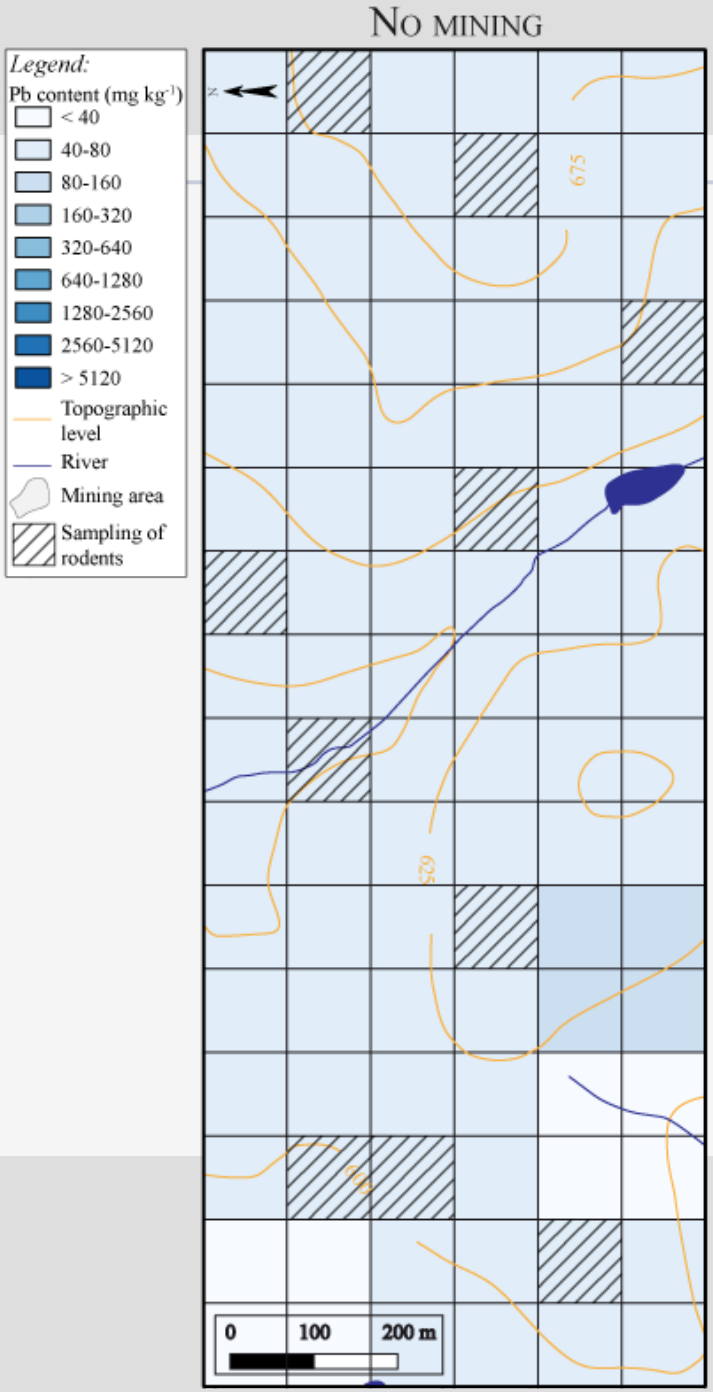
Datation: 19th - 20th centuries AD

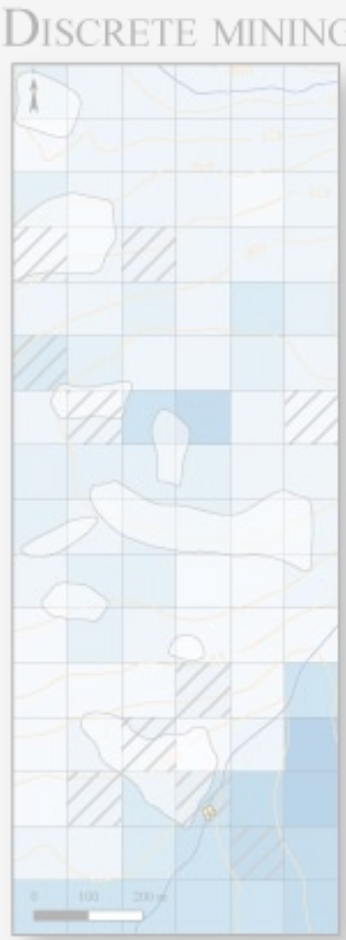
Metal exploited: Pb-Ag

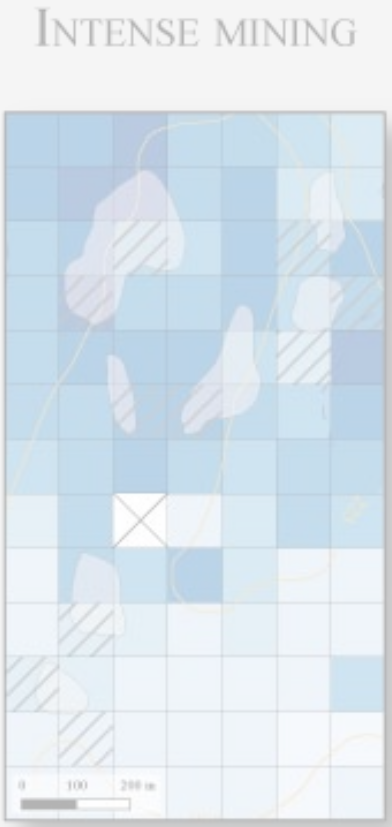
Type of exploitation: mines

Datation: 15th - 16th centuries AD.

Morvan soils: Pb

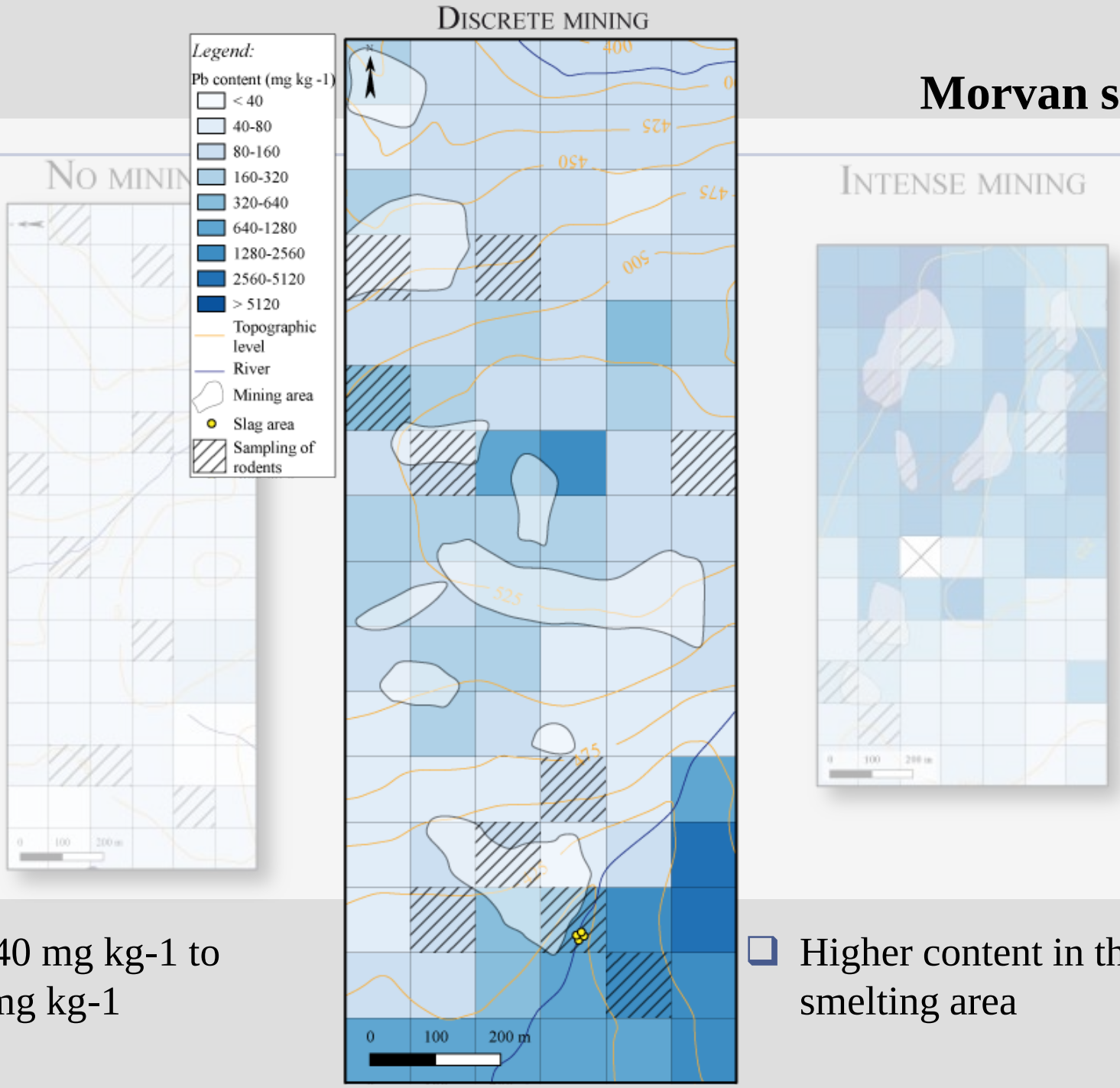




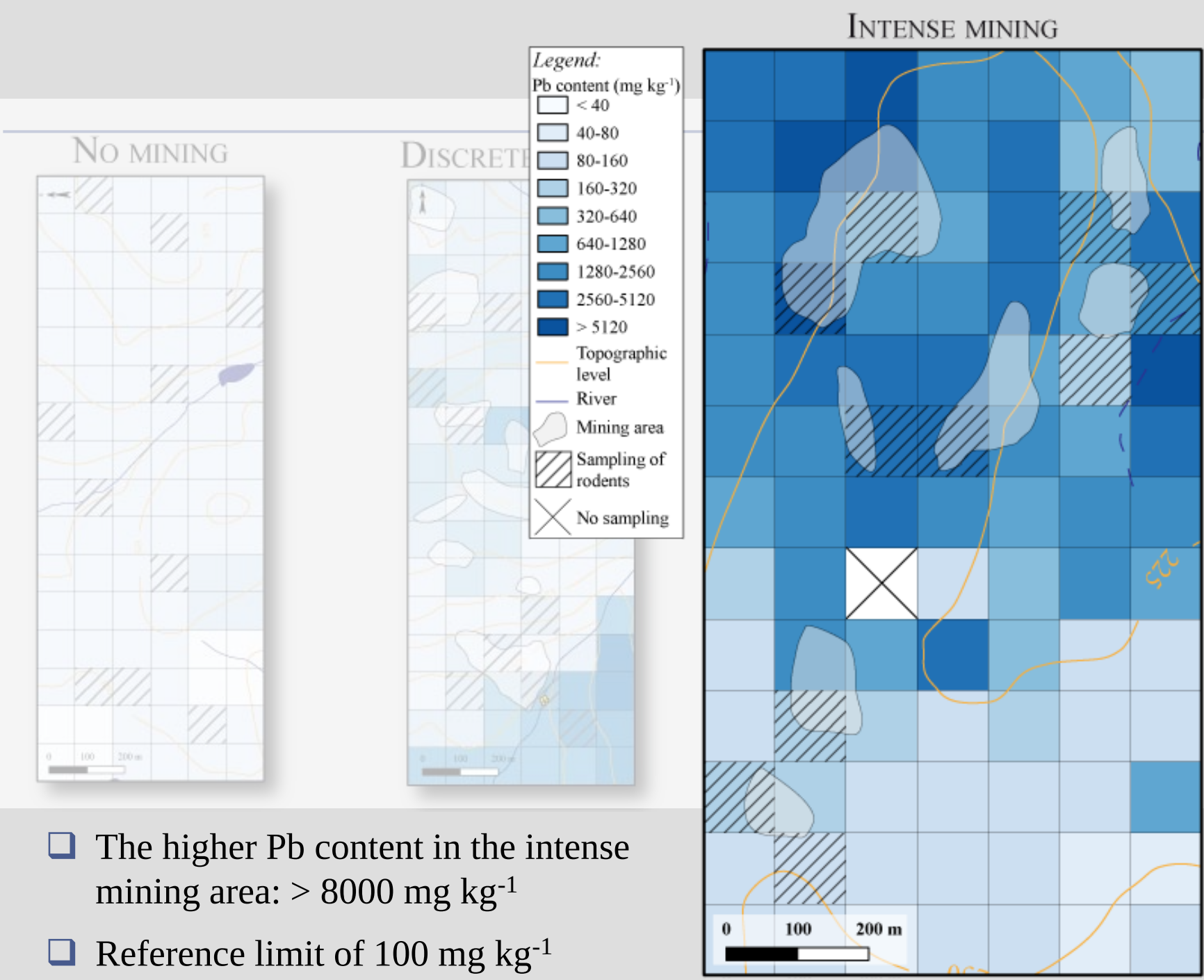


- the lowest Pb content in the no mining area
  - 30 mg kg^{-1}

Morvan soils: Pb

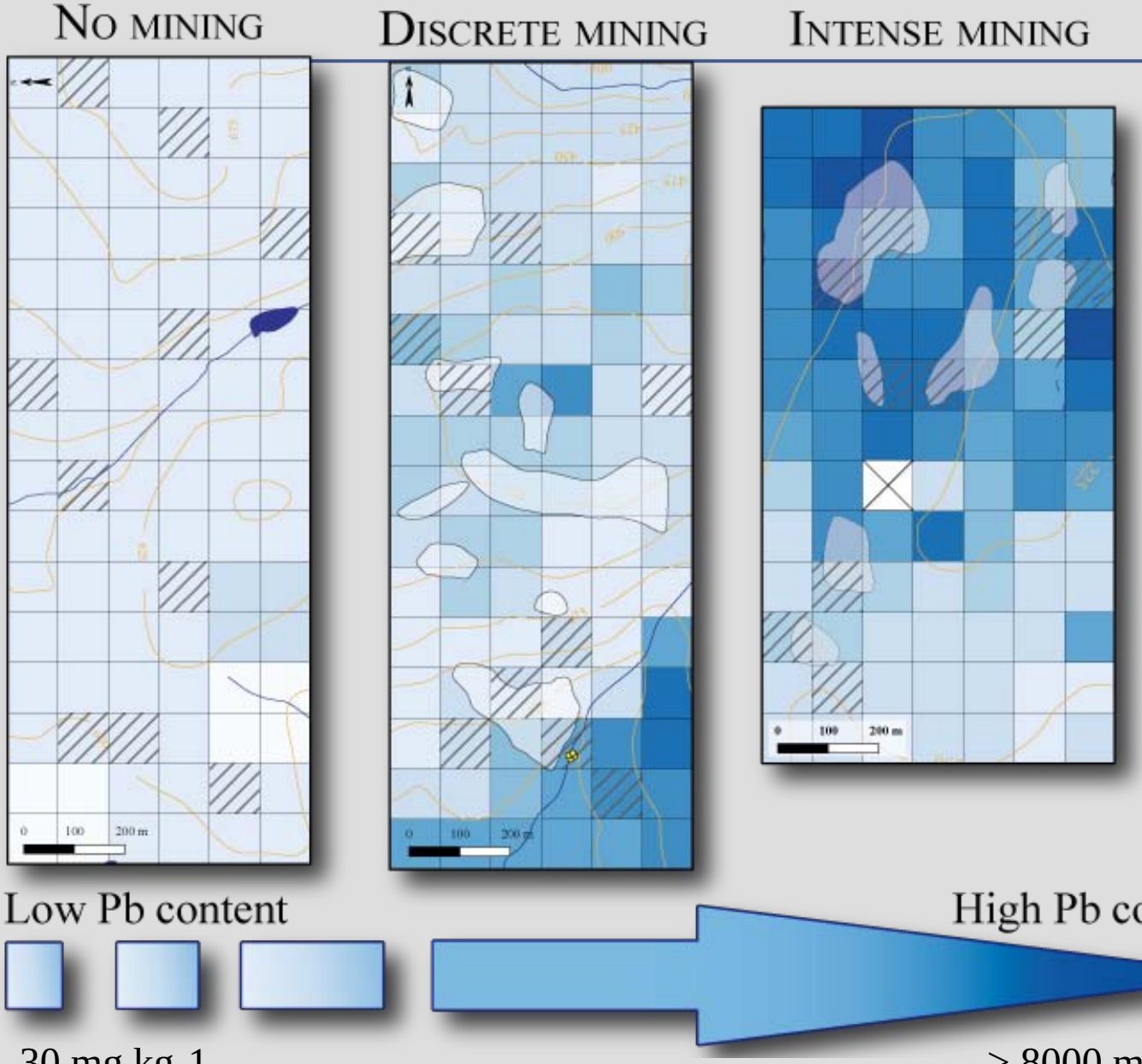


- From 40 mg kg-1 to 4500 mg kg-1
- Higher content in the smelting area



- The higher Pb content in the intense mining area: > 8000 mg kg^{-1}
- Reference limit of 100 mg kg^{-1}

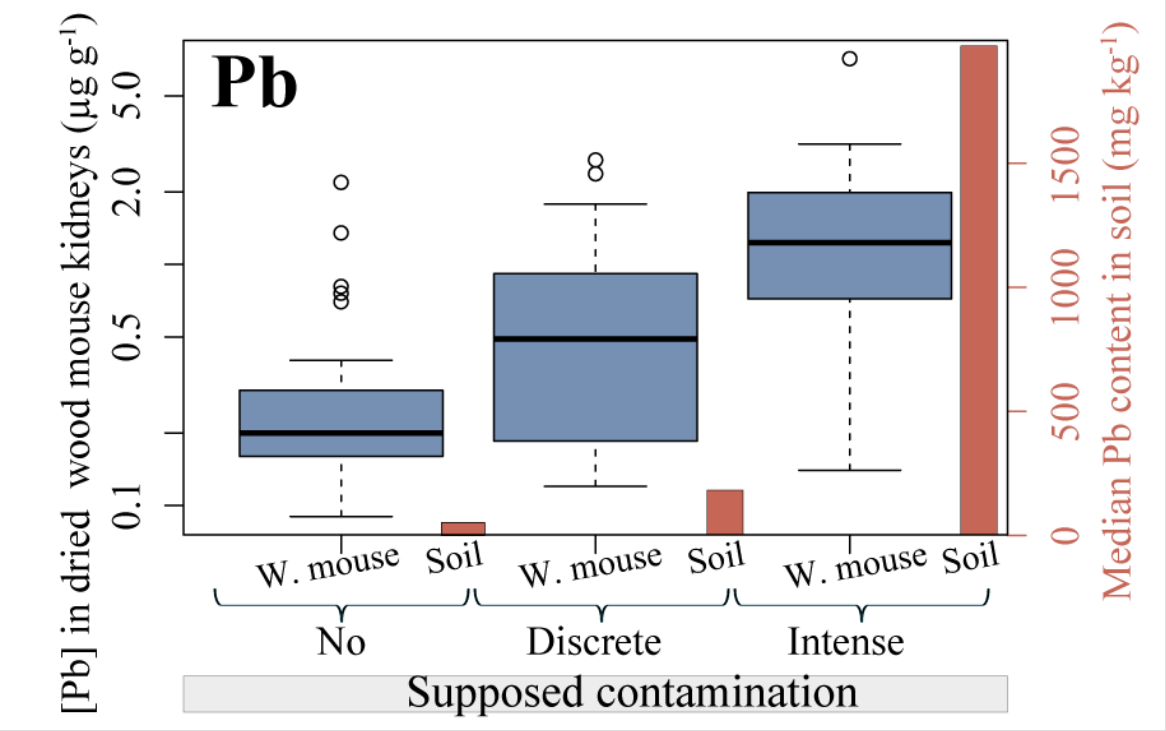
Morvan soils: Pb



- Good congruence between Pb in soil and the supposed contamination degree
- Pb content mirrors the presence of archaeological sites
- Same pattern for other metals
  - Cd, Cu, Zn

The wood mouse: results at population scale

- General distribution of metal in wood mice according to the sampled site
  - Significant statistical differences between sites

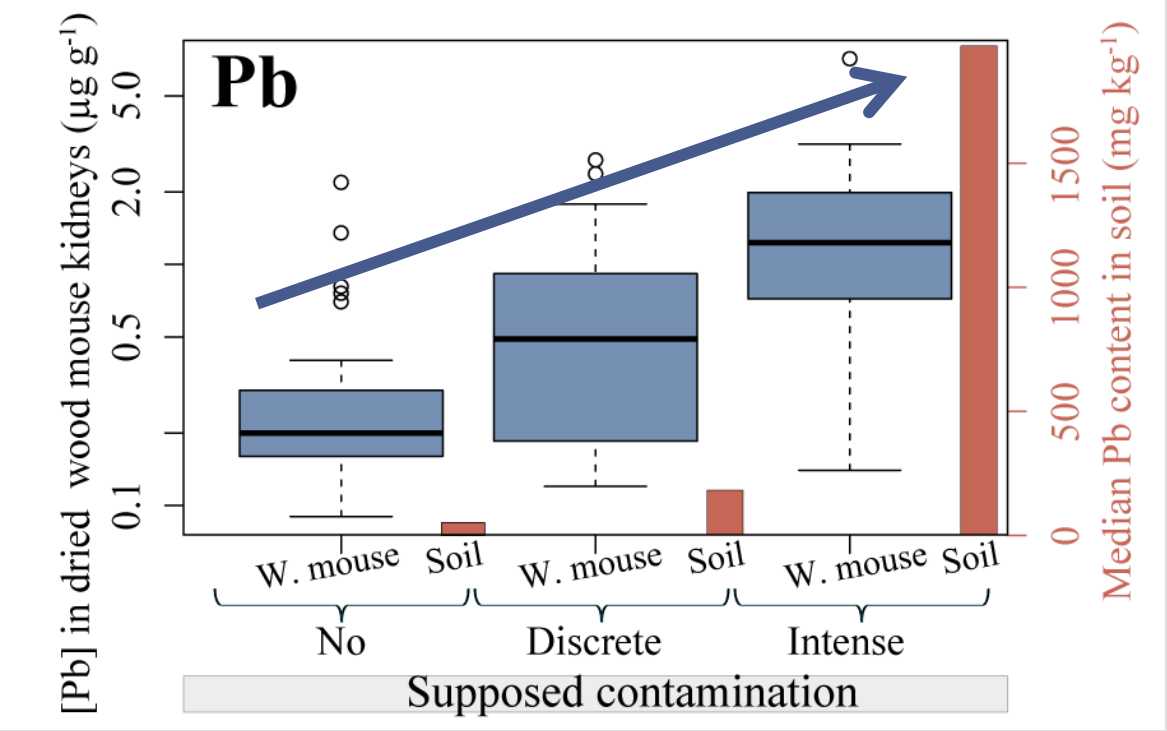


Barplot: median Pb content in soils where wood mice where sampled
Boxplot: Pb distribution wood mouse kidneys

No mining area: n = 30
Discrete mining area: n = 31
Intense mining area: n = 30

The wood mouse: results at population scale

- Significant statistical differences between sites
- Pb contents in wood mouse kidneys mirror Pb in soil



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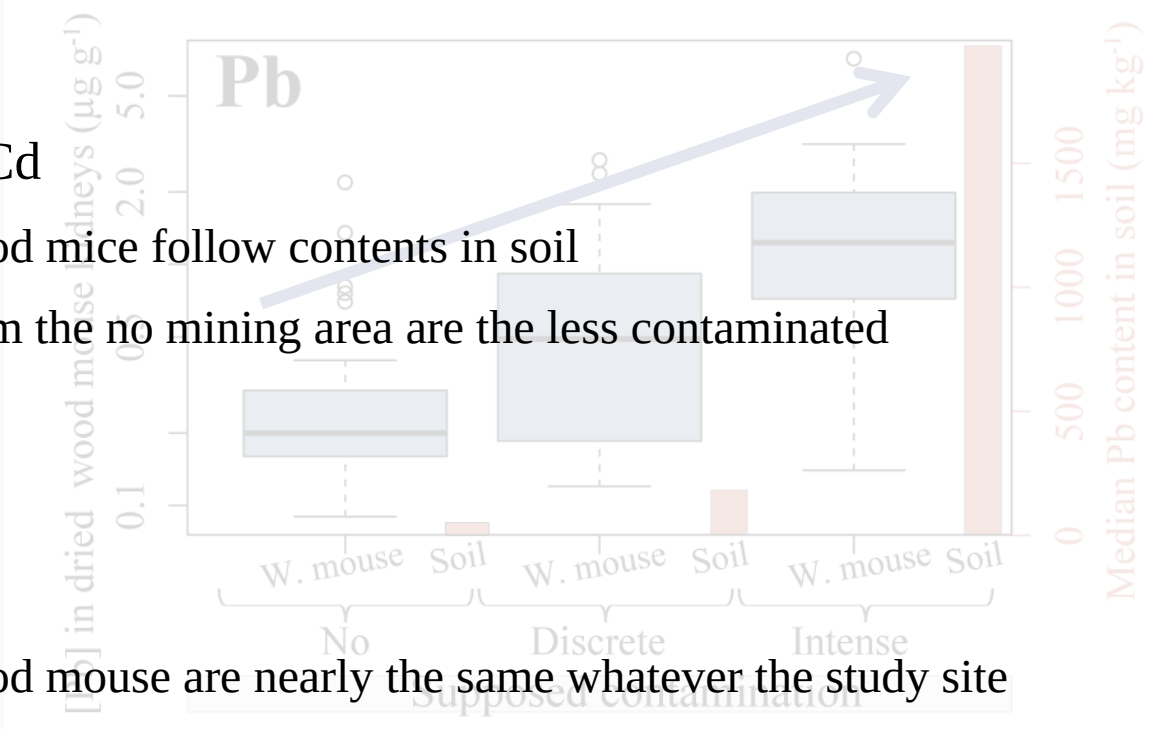


- Same pattern for Cd
  - Contents in wood mice follow contents in soil
  - Wood mice from the no mining area are the less contaminated
- For Zn and Cu
  - Contents in wood mouse are nearly the same whatever the study site

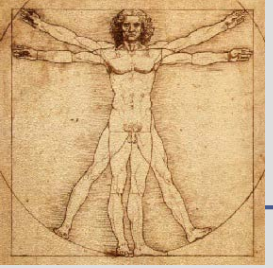
Barplot: median Pb content in soils where wood mice where sampled
Boxplot: Pb distribution wood mouse kidneys

No mining area: n = 30
Discrete mining area: n = 31
Intense mining area: n = 30

The wood mouse: at individual scale

- Models were performed to test:

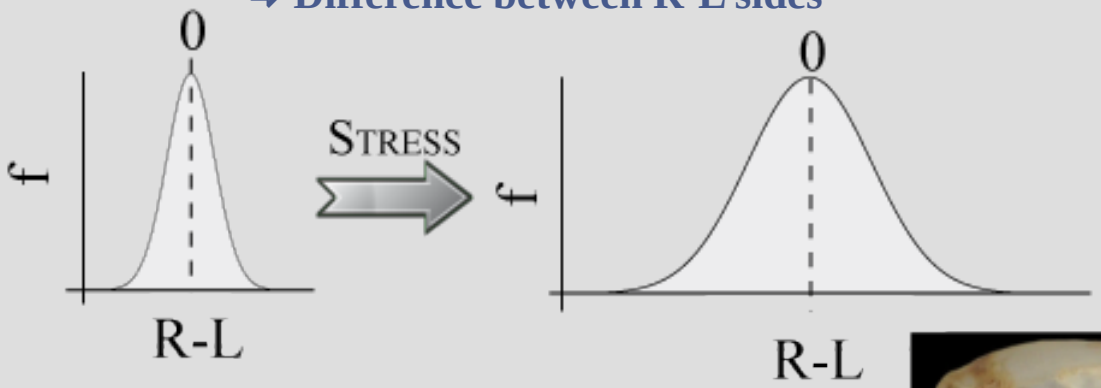
	Pb	Zn	Cd	Cu
Sex	-	$p = 0.009$ **	-	$p = 0.01$ *
Mass	-	$p < 0.001$ ***	$p < 0.001$ ***	$p < 0.001$ ***
Metal in soil	$p < 0.001$ ***	-	$p = 0.02$ **	-
Sex:Mass	-	$p = 0.005$ **	-	$p = 0.01$ *
Sex:Metal	-	-	-	-
Mass:Metal	-	-	$p = 0.006$ **	-
	⇩	⇩	⇩	⇩
	Metal content in soil	*Mass & sex*	*Metal & mass*	*Mass & sex*



Fluctuating asymmetry (FA) parameters

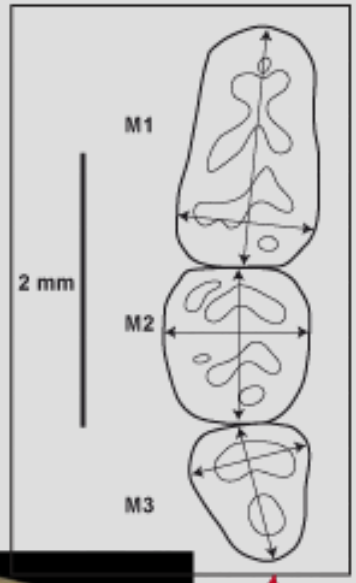
- Developmental instability
  - Reflects the inability of organisms to correct errors occurring during their development
  - Assessed by fluctuating asymmetry (FA)

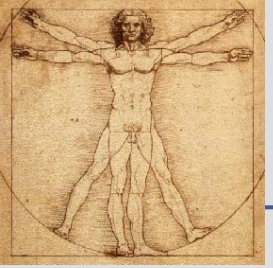
⇨ **Difference between R-L sides**



- Indicator of environmental stress
  (Polak, 2003, Leary and Allendorf, 1989)

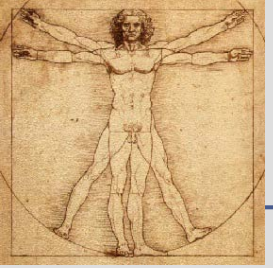
- 6 metrical traits
  - Length and width of the three lower molars





Fluctuating asymmetry (FA)

- Usual tests were performed
  (Palmer, 1994)
  - Data compatible with the FA study



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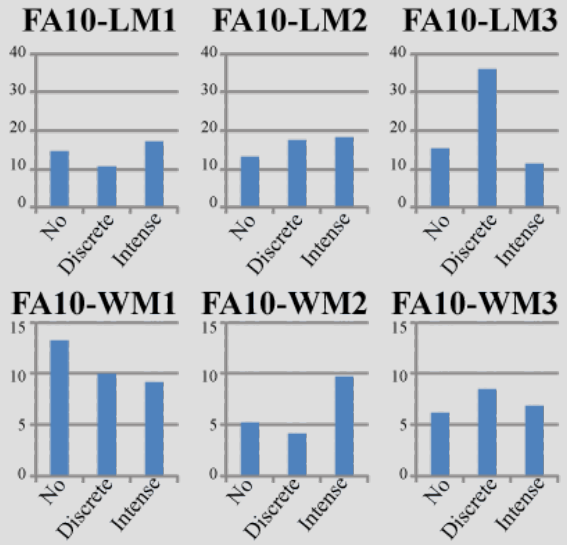
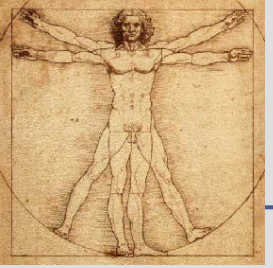
- Population approach
  - No significant fluctuating asymmetry for any trait between sites





Fluctuating asymmetry (FA)

- Usual tests were performed (Palmer, 1994)
  - Data compatible with the FA study
- Population approach
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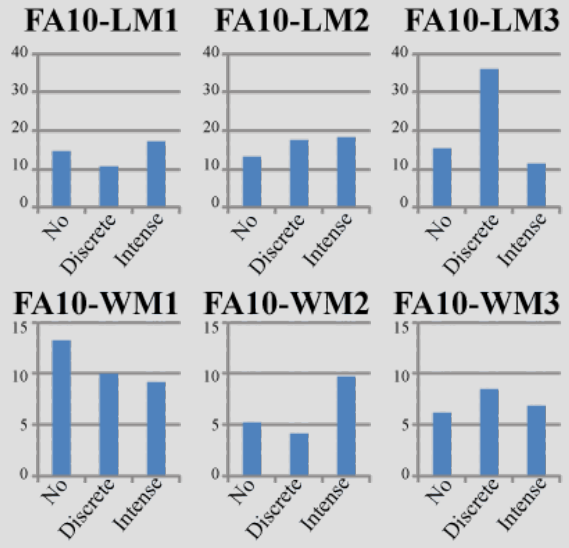
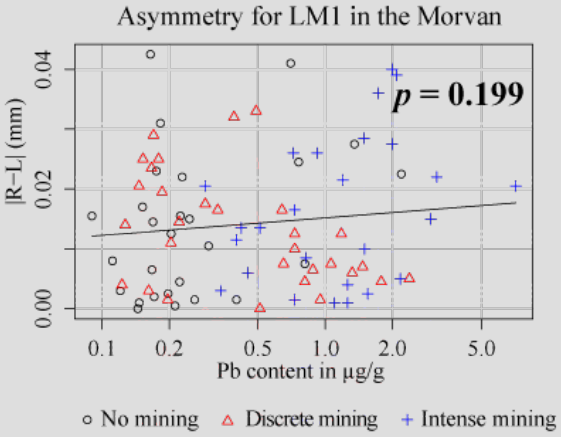
- Individual approach
  - No significant relationship between |R-L| variations and Pb contents in wood mice





Discussion/Conclusion

- SOIL
  - Long after the industrial activities have ceased, trace metals can still be found in soils
    - ⇨ **For all study metals (Pb, Cd, Zn, Cu)**

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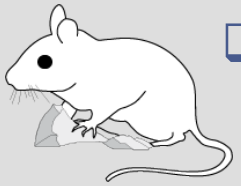

- WOOD MICE
  - Cu and Zn seem to be well regulated by wood mice
    - ⇨ **Homeostatic regulation (Rogival et al., 2007)**
  - Pb and Cd
    - ⇨ **Kidneys contents are correlated with the presumed contamination degree**
  - Individual Pb content
    - ⇨ **reflects the Pb concentration in soils**

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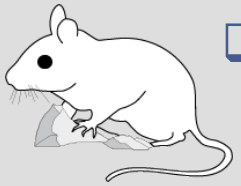

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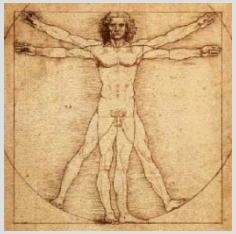
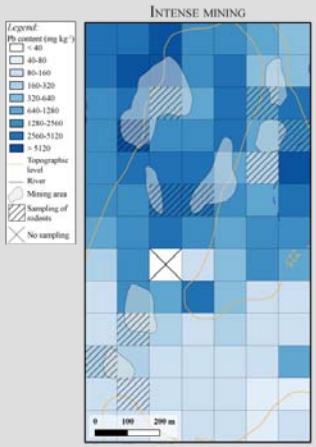


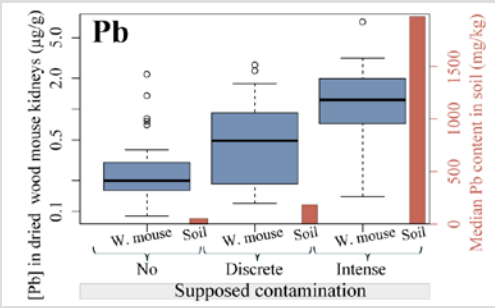
- No signal for FA
  - Contamination levels not high enough ?
  - Environmental factors (food access, habitat …) may have a stronger influence on development

Take Home message

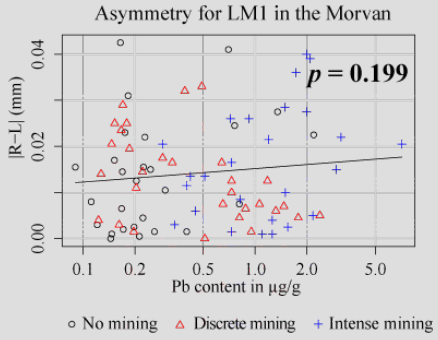
- Spatial distribution of trace metal in soil mirrors the archaeological mining and metallurgical areas



- Pb contents in wood mouse kidneys correlate the lead contents in soil



- No FA differences



Thank you for your attention

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BIBRACTE

Bourgogne Conseil régional

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DREAL BOURGOGNE

Direction régionale de l'Environnement, de l'Aménagement et du Logement

Présent pour l'avenir