

# Trace Metal Elements and Organic Compounds in the Eure River Watershed: Past and Actual Records of Anthropogenic Impacts

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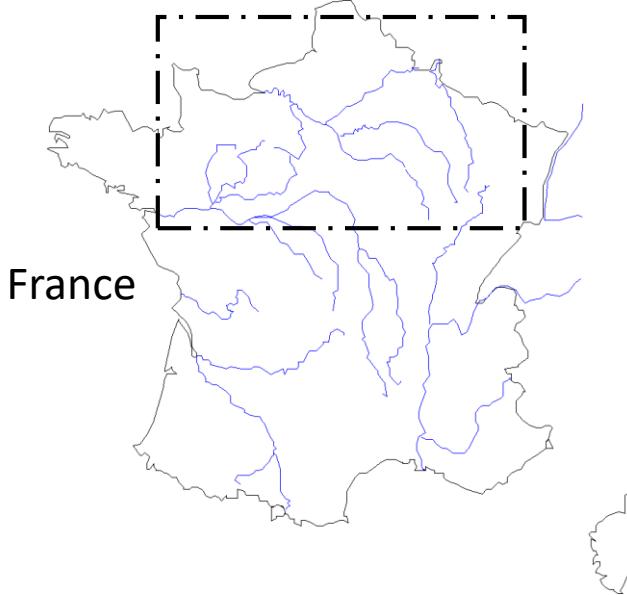
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<sup>6</sup>IFREMER, IUEM, Brest, France



# The Eure River Watershed Location

## ❖ The Seine River Watershed

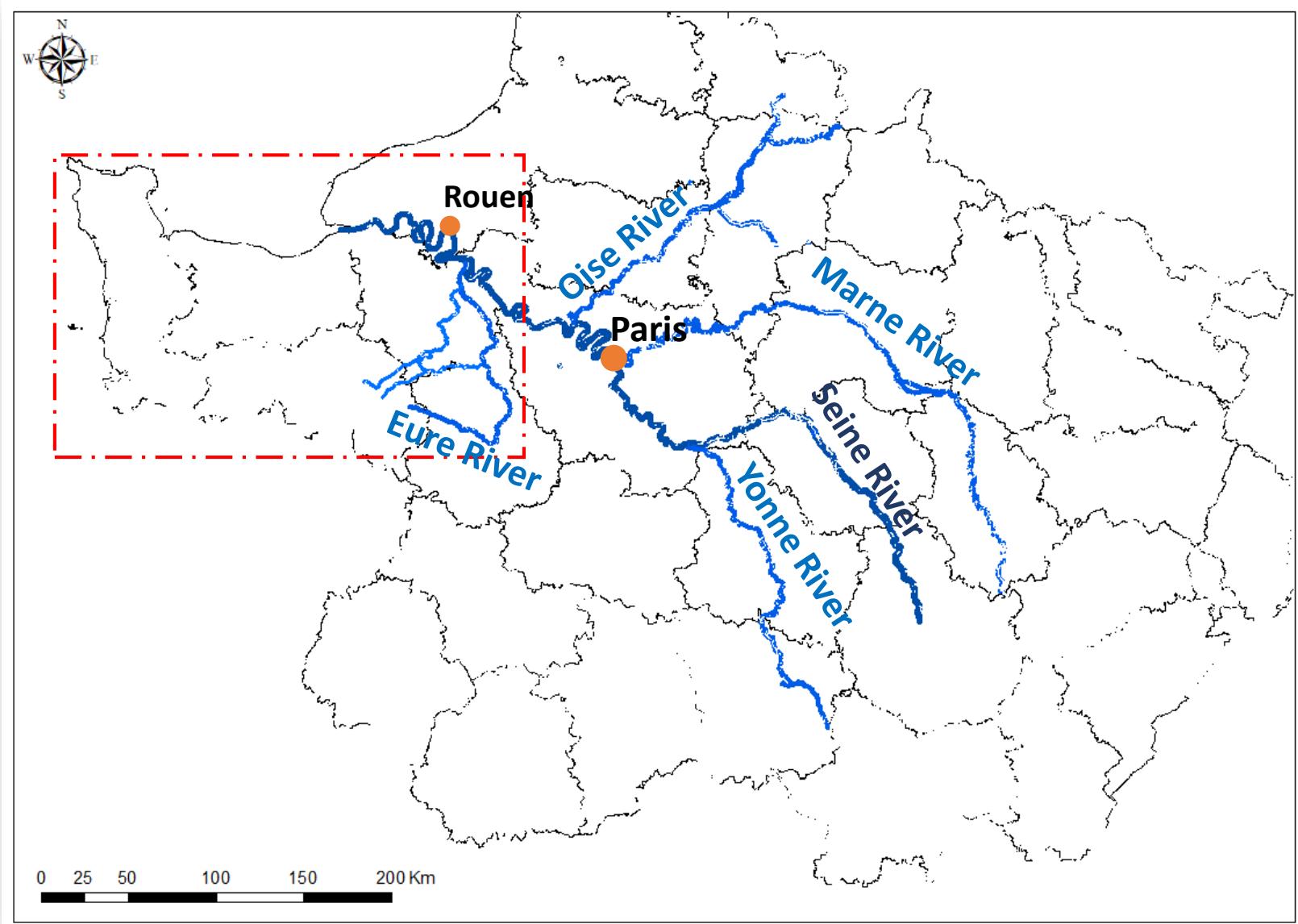


France

### Key Figures:

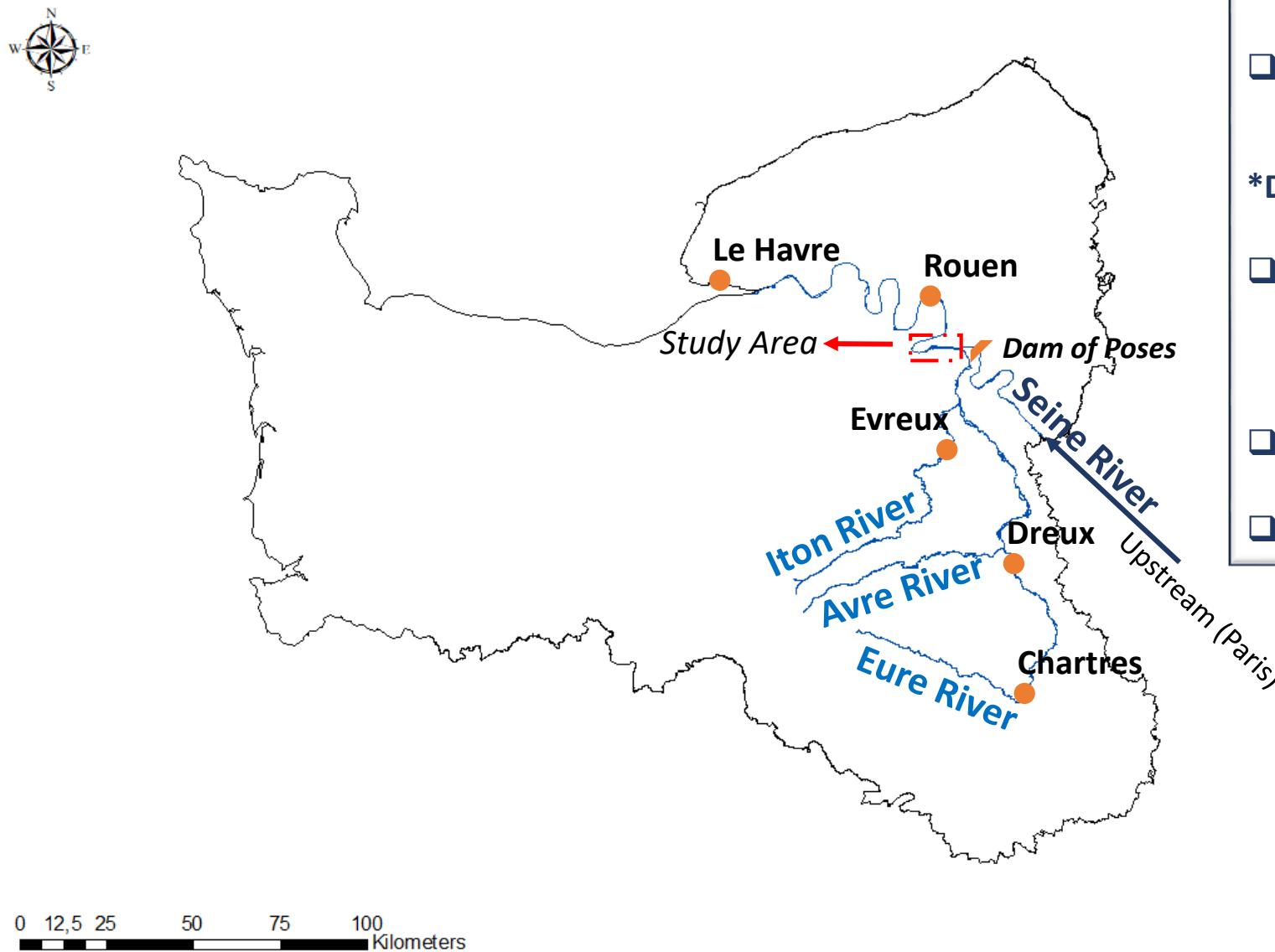
(Seine Normandie Water Agency)

- ~ 95,000 km<sup>2</sup> (18 % of France territory)
- 30 % of French population (18.3 M)
- 40 % of National Industry
- 25 % of French Agricultural Land



# The Eure River Watershed Location

## ❖ The Eure River Watershed in Normandie

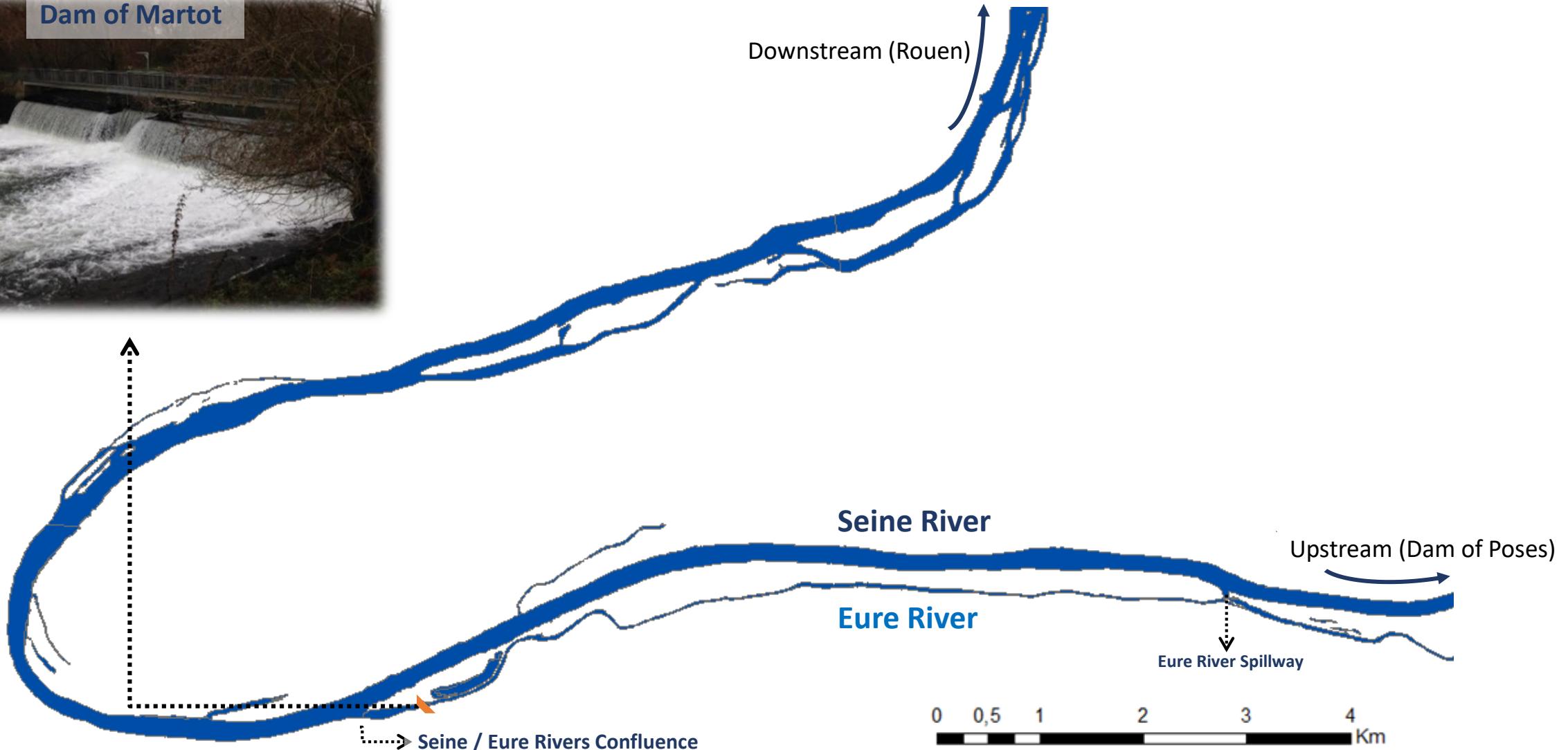


## The Eure River Watershed

- ❑ Main tributary of the Seine River downstream  
(Seine River downstream: Dam of Poses – Le Havre ; 170 km)
- \*Dam of Poses: physical limit of the tidal flow
- ❑ Area : 6,017 km<sup>2</sup>
  - ~ 70 %: Agricultural Land
  - ~ 1 million People
- ❑ 228.7 km long
- ❑ Tributaries: Iton and Avre Rivers

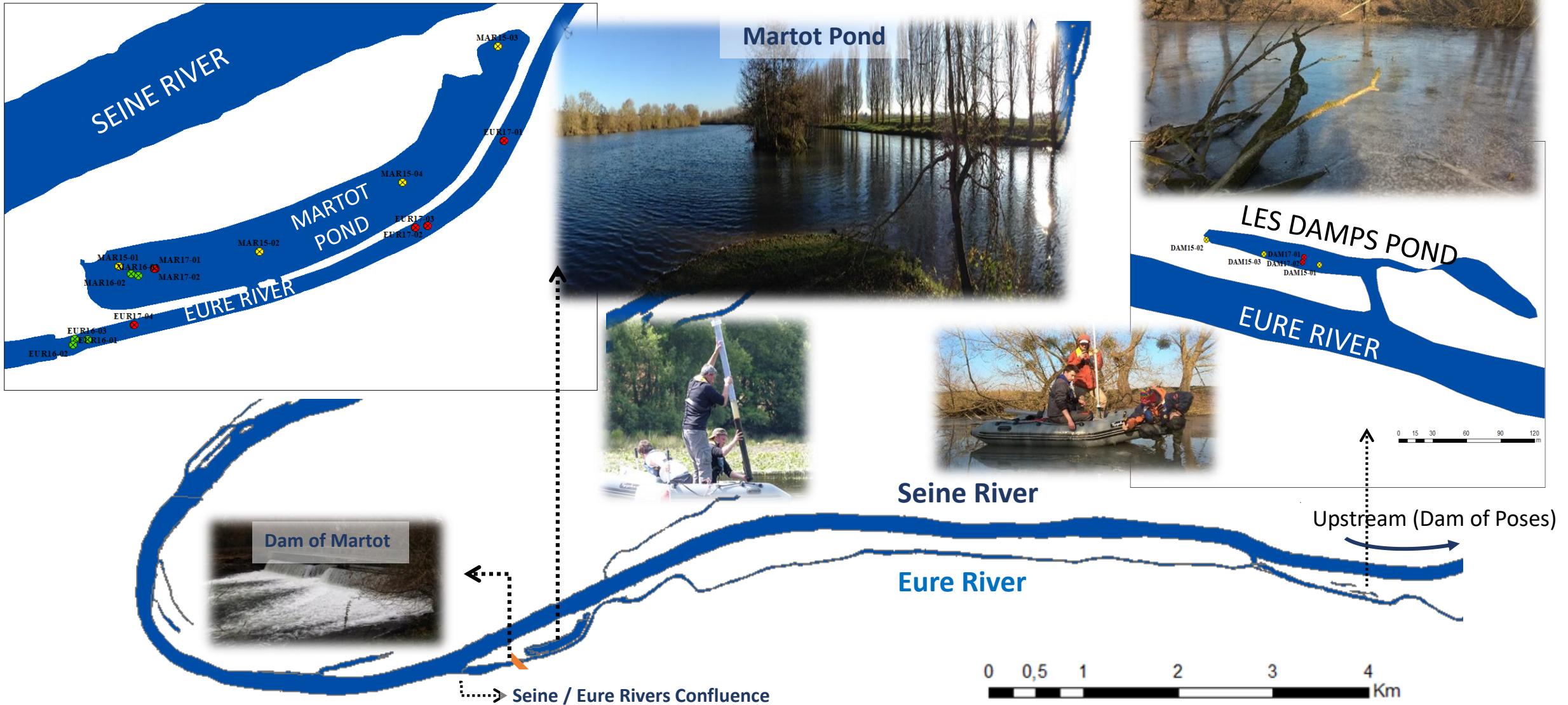
# Study Area in the Eure River Watershed

## ❖ The Eure River downstream



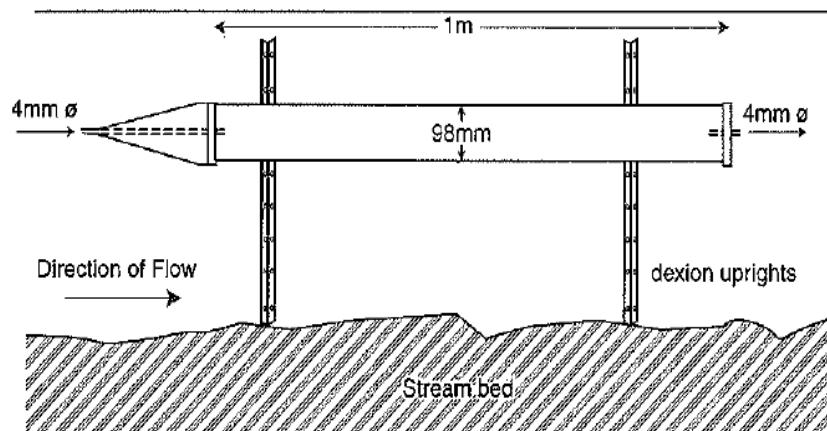
# Study Area in the Eure River Watershed

## ❖ Sedimentary cores Sampling

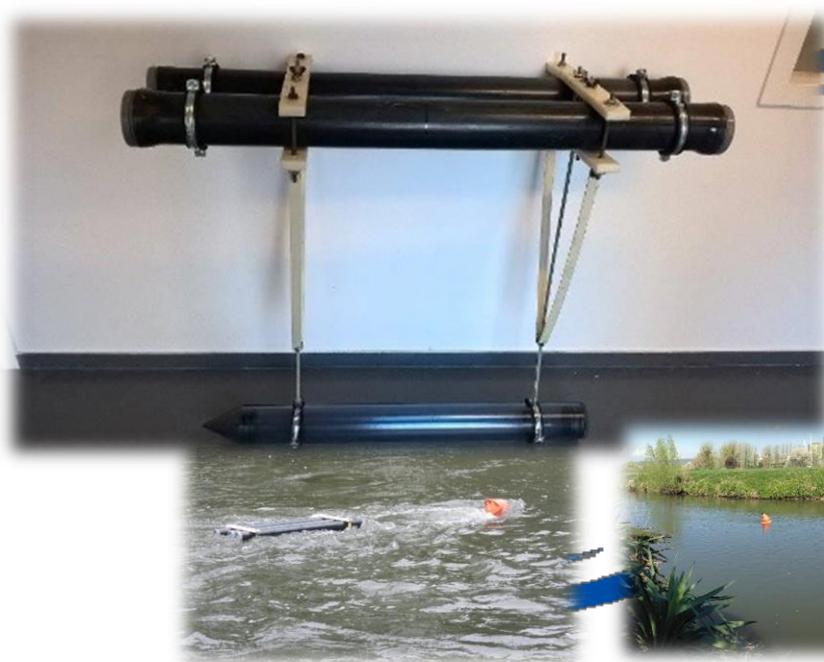


# Study Area in the Eure River Watershed

## ❖ S.P.M. Sampling & Monitoring



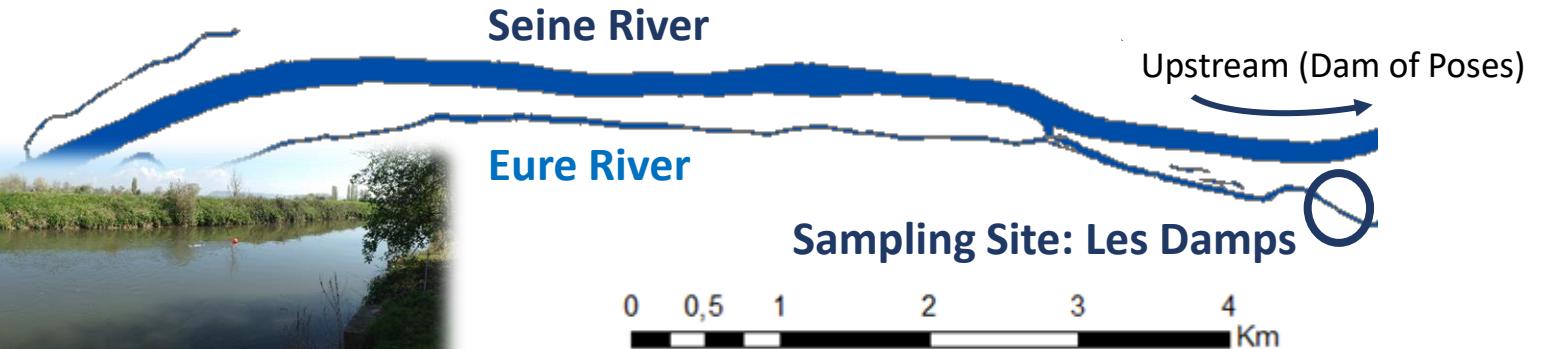
Philips et al., 2000 ; Russel et al., 2000



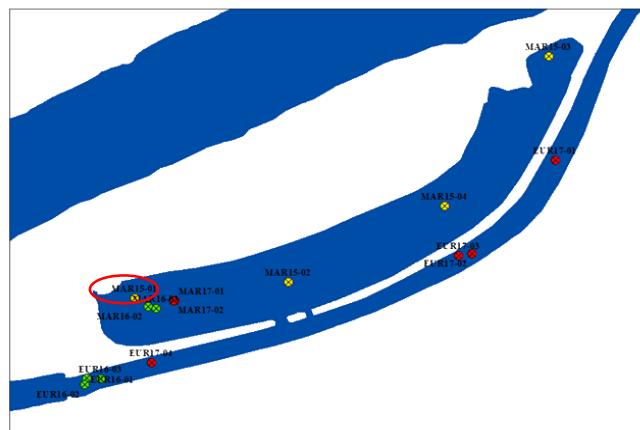
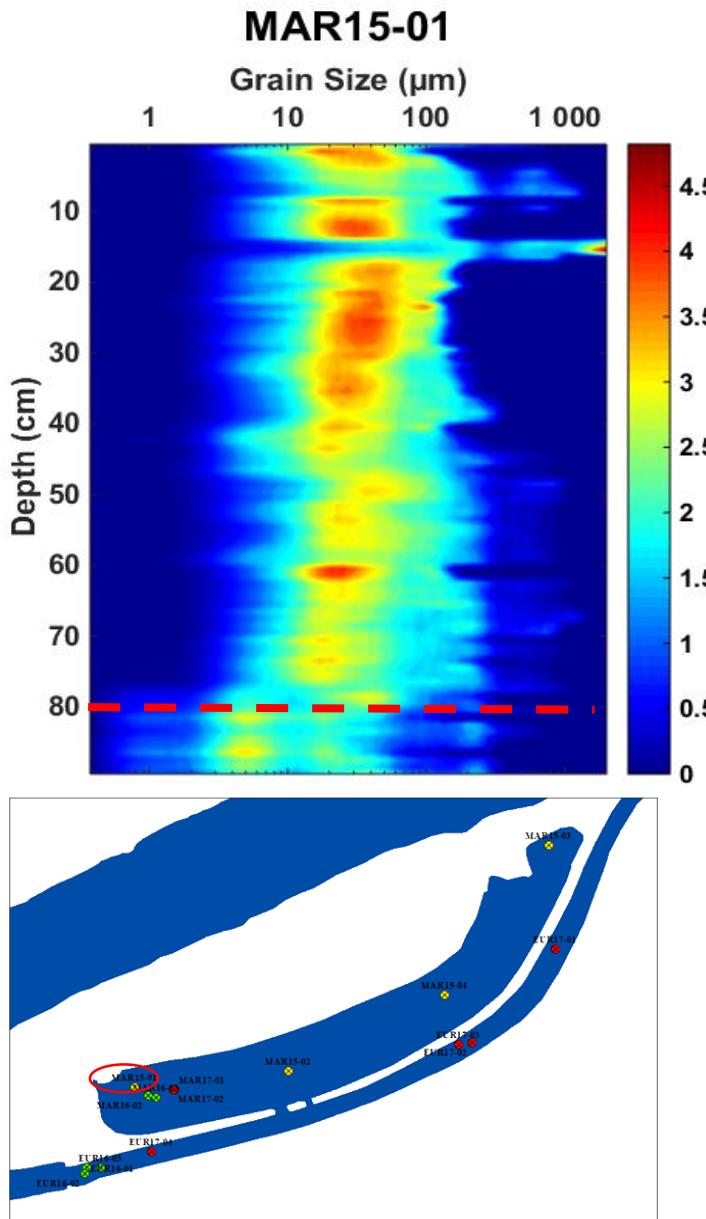
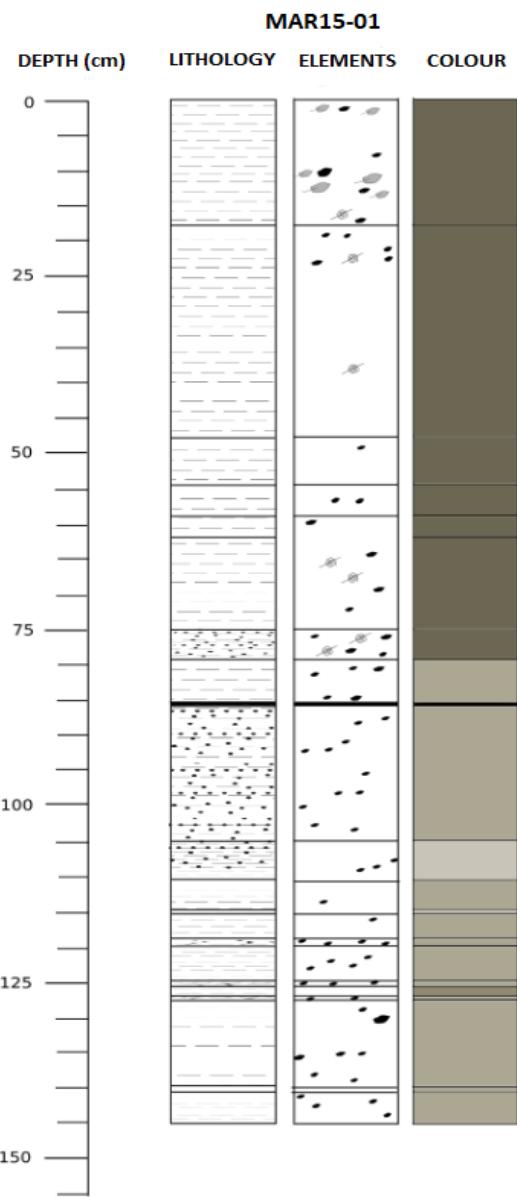
Thomas Gardes

### S.P.M. Sampling:

- **TIMS Sampler (Time-Integrated Mass flux Sampler)**
  - *Philips et al., 2000 ; Russel et al., 2000 ; Ankers et al., 2003 ; Lefrançois et al., 2005 ; Hatfield and Maher, 2008 ; Smith and Owens, 2010 ; Martilla et al., 2013 ; Perks et al., 2014*
  - Sampling non-stop ~ 1 month
  - Coupling with S.P.M. fluxes
    - Turbidity measurement (time step: 15 min)
    - River flow measurement (time step: 15 min)
- **T.M.E or Organic compounds fluxes ( $t \text{ month}^{-1}$ )**



# Sedimentary filling in the Martot Pond

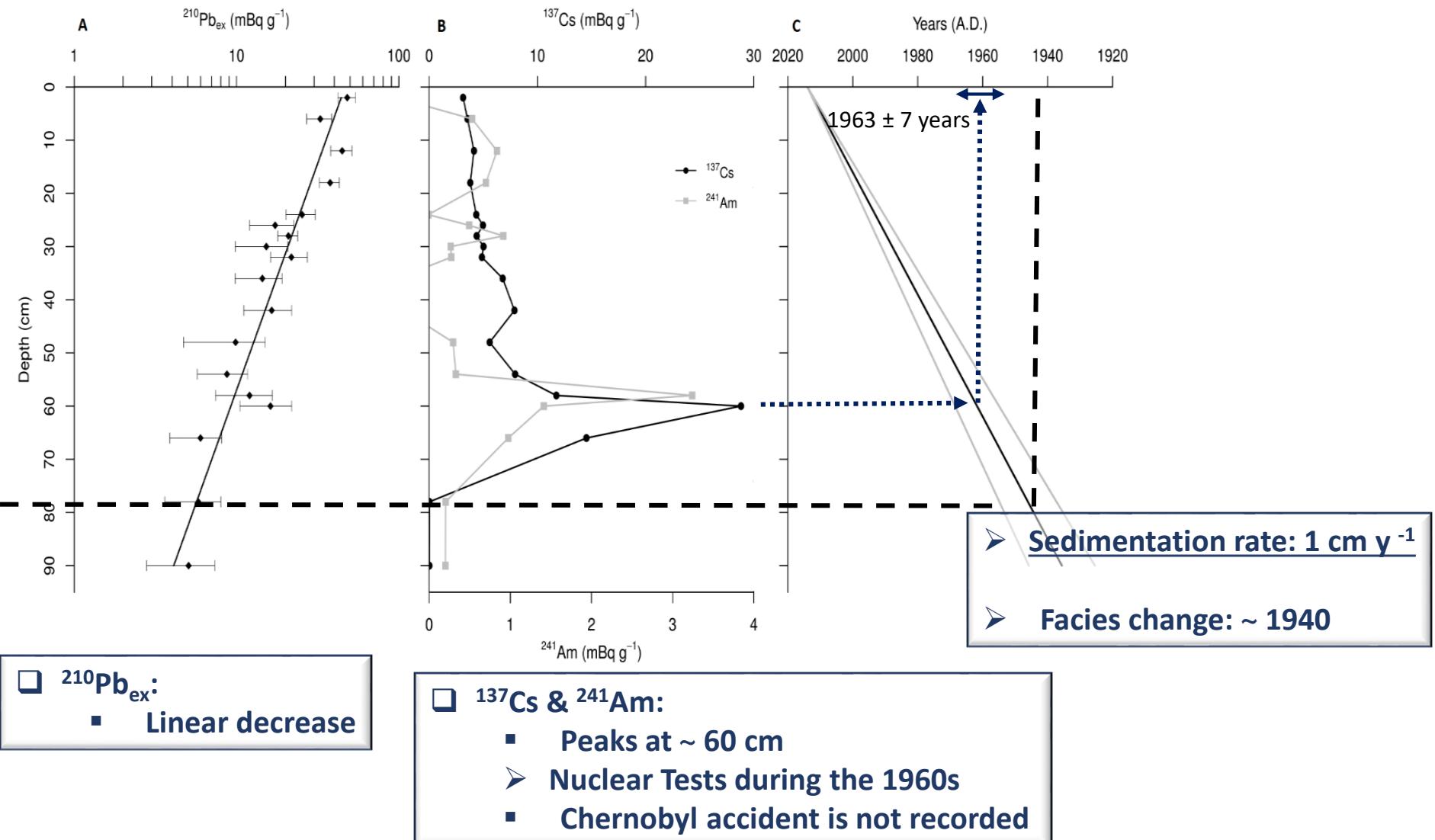
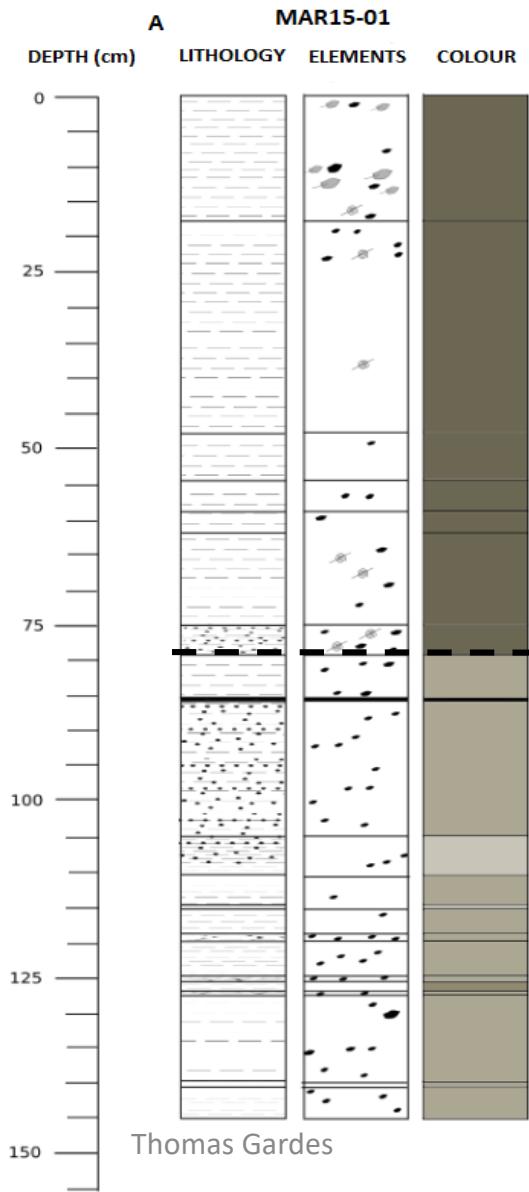


## Sedimentary Parameters:

- ☐ Bottom to  $\sim 80$  cm:
  - $D_{50} \sim 20 \mu\text{m}$
- Changes at  $\sim 80$  cm
- ☐ 80 cm to the top:
  - $D_{50} \sim 30 \mu\text{m}$
- Two sedimentary facies
- In the whole hydraulic annex.

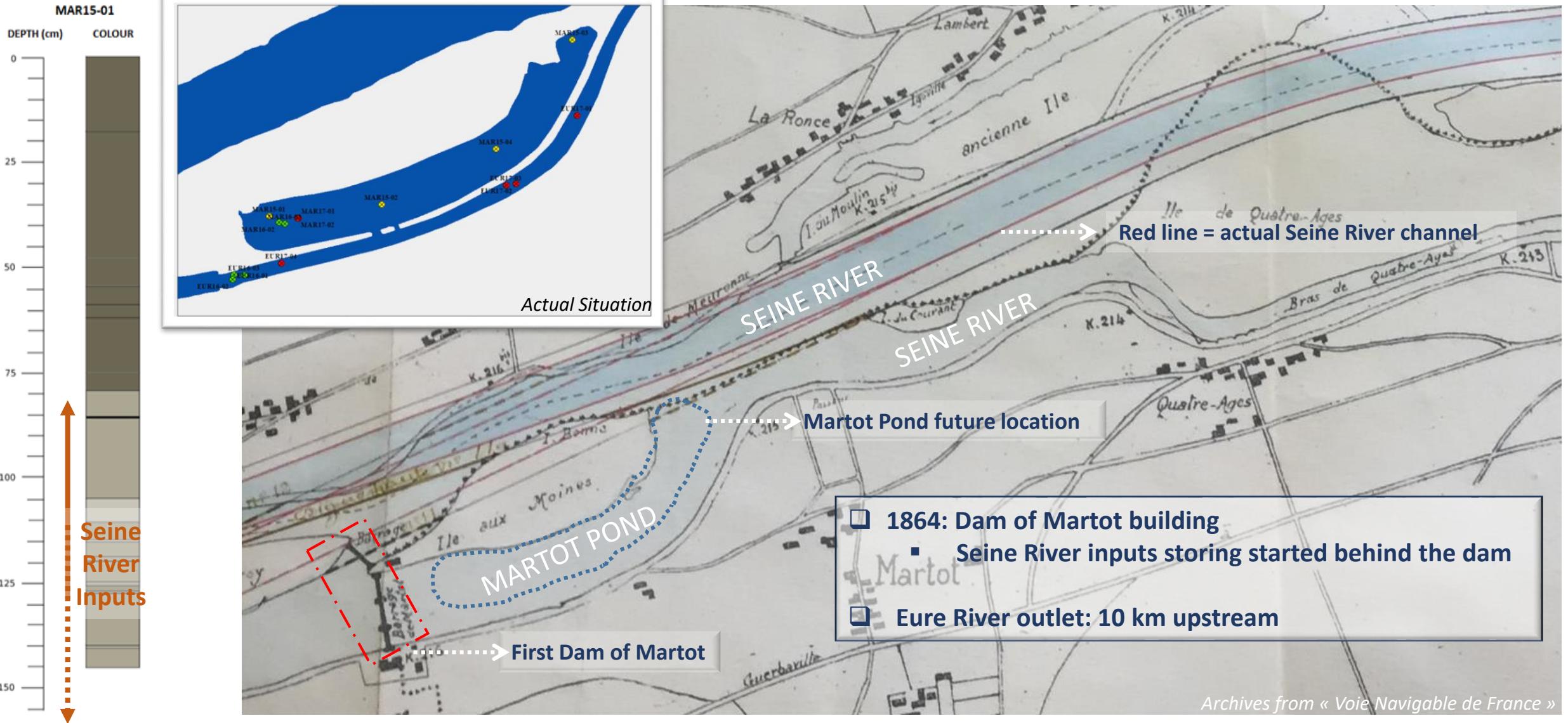
# Sedimentary filling in the Martot Pond

## ❖ Sedimentary core dating



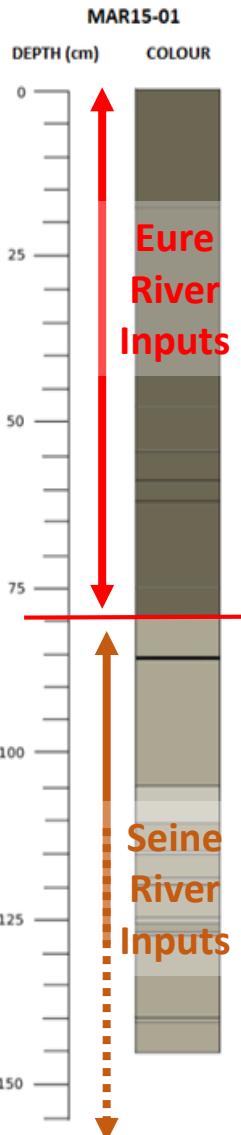
# Link between Seine River historical works and Sedimentary Archives

## ❖ Seine River inputs...

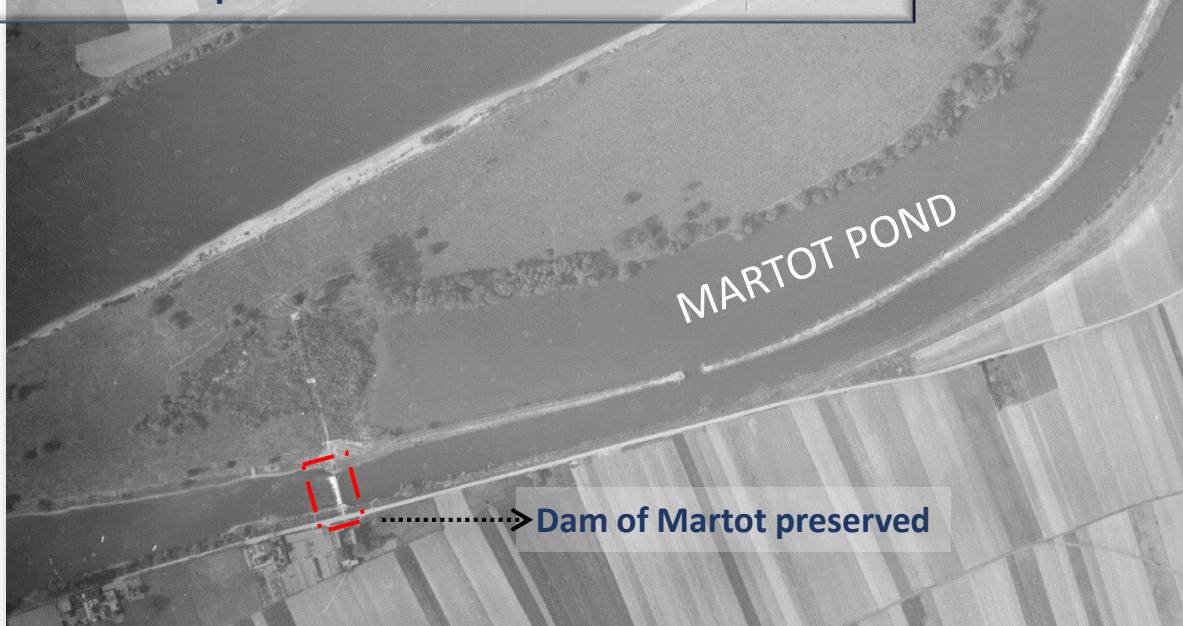


# Link between Seine River historical works and Sedimentary Archives

## ❖ ... Follow by Eure River inputs from 1942

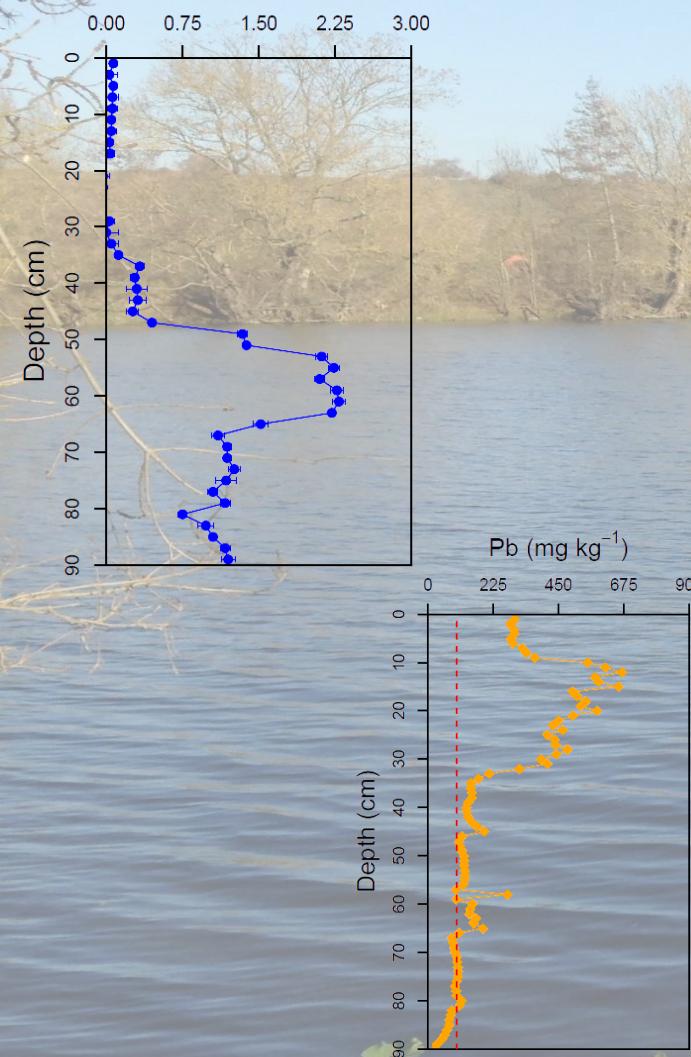


- 1931-1941: Seine River is dredged and channelized
  - Two distinct channels are formed with dredging sediments
  - The Dam of Martot is mostly removed (only the left part is preserved)
  - The Martot Pond was formed and disconnected from the Seine River
- 1942: The Martot Pond is connected to the Eure River
  - Eure River inputs start to be stored

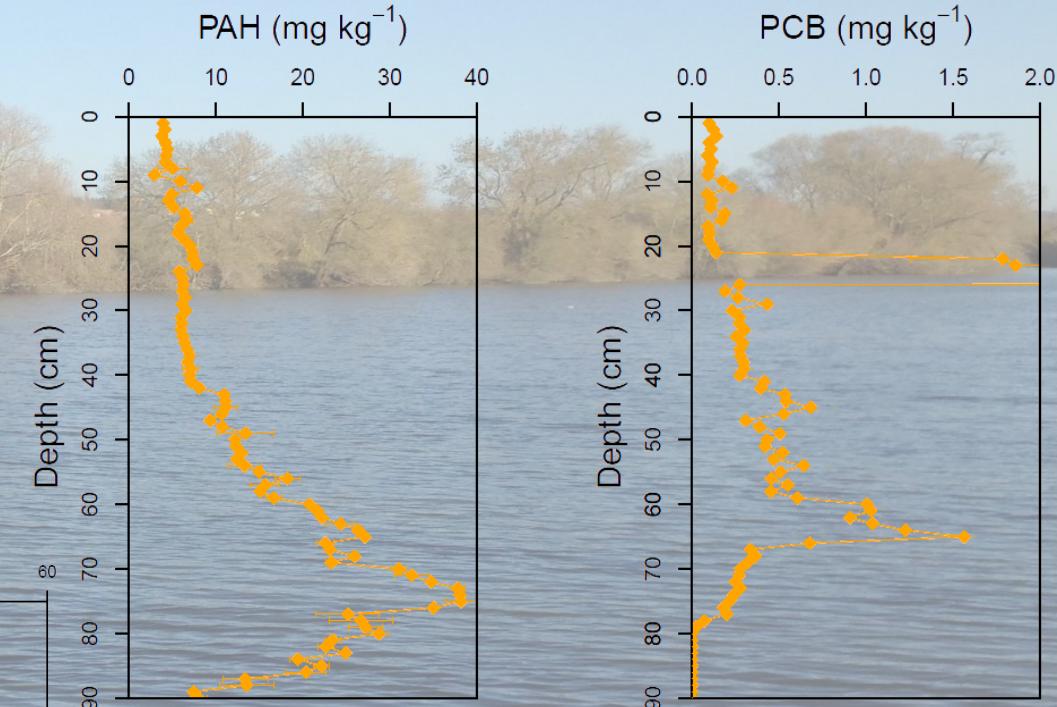


# Multi - Contamination recorded in Sedimentary Archives

## ❖ Trace Metal Elements: As, Cd, Cr, Cu, Mn, Pb, Zn and Hg



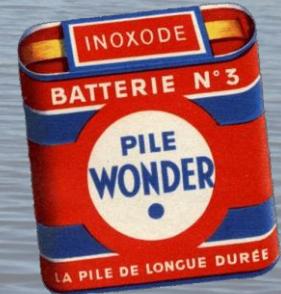
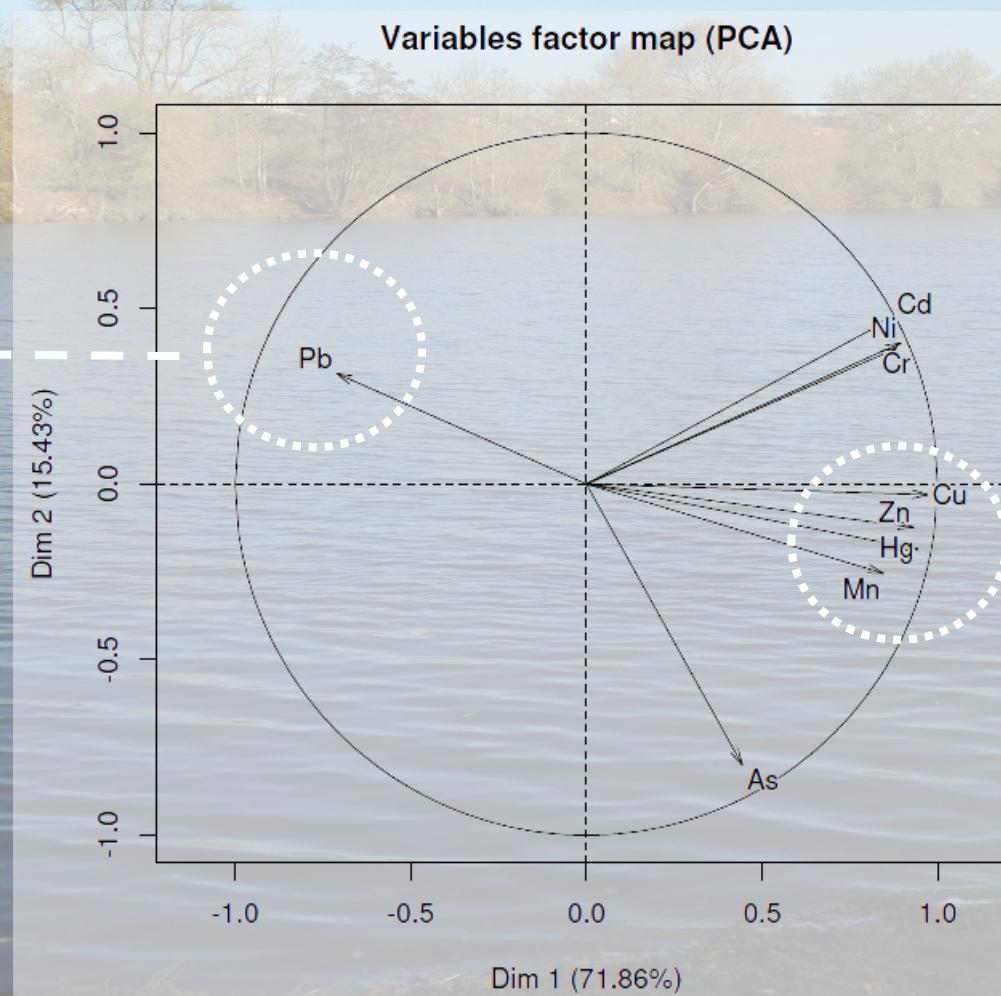
## ❖ Organic Compounds: PAHs and PCBs



# Multi - Contamination recorded in Sedimentary Archives

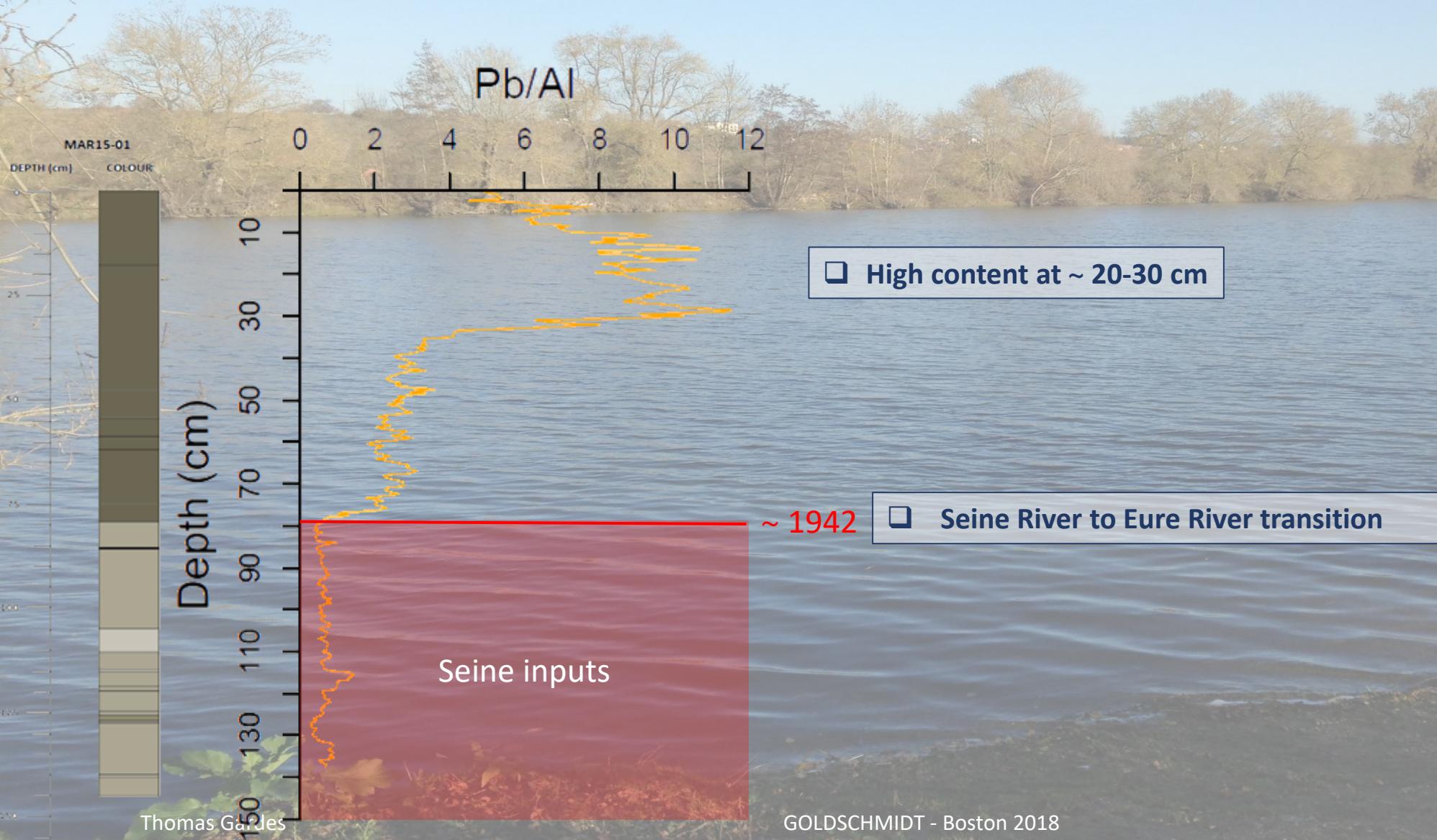
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?



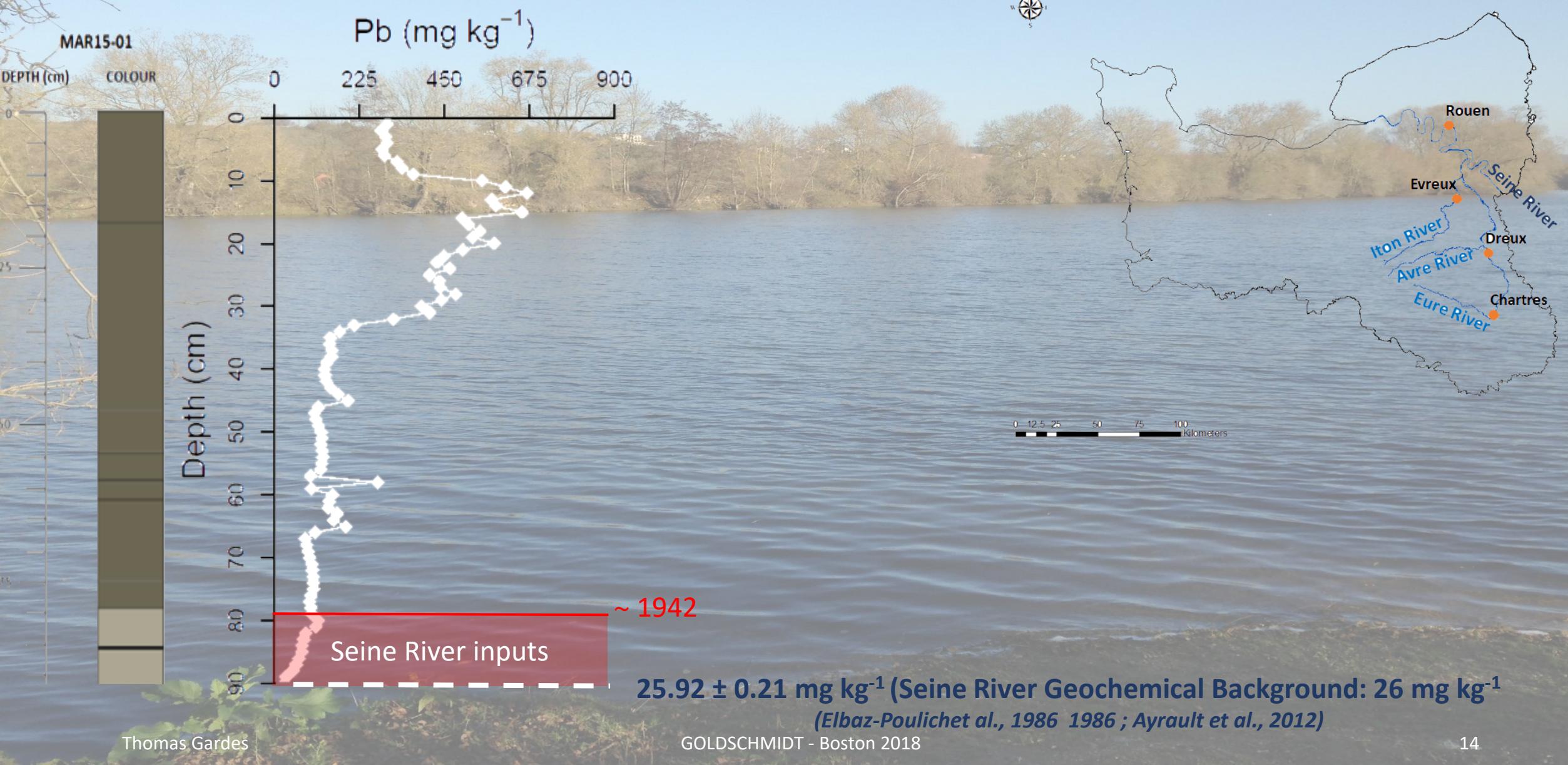
# Lead Contamination recorded in Sedimentary Archives

❖ XRF Core Scanner data



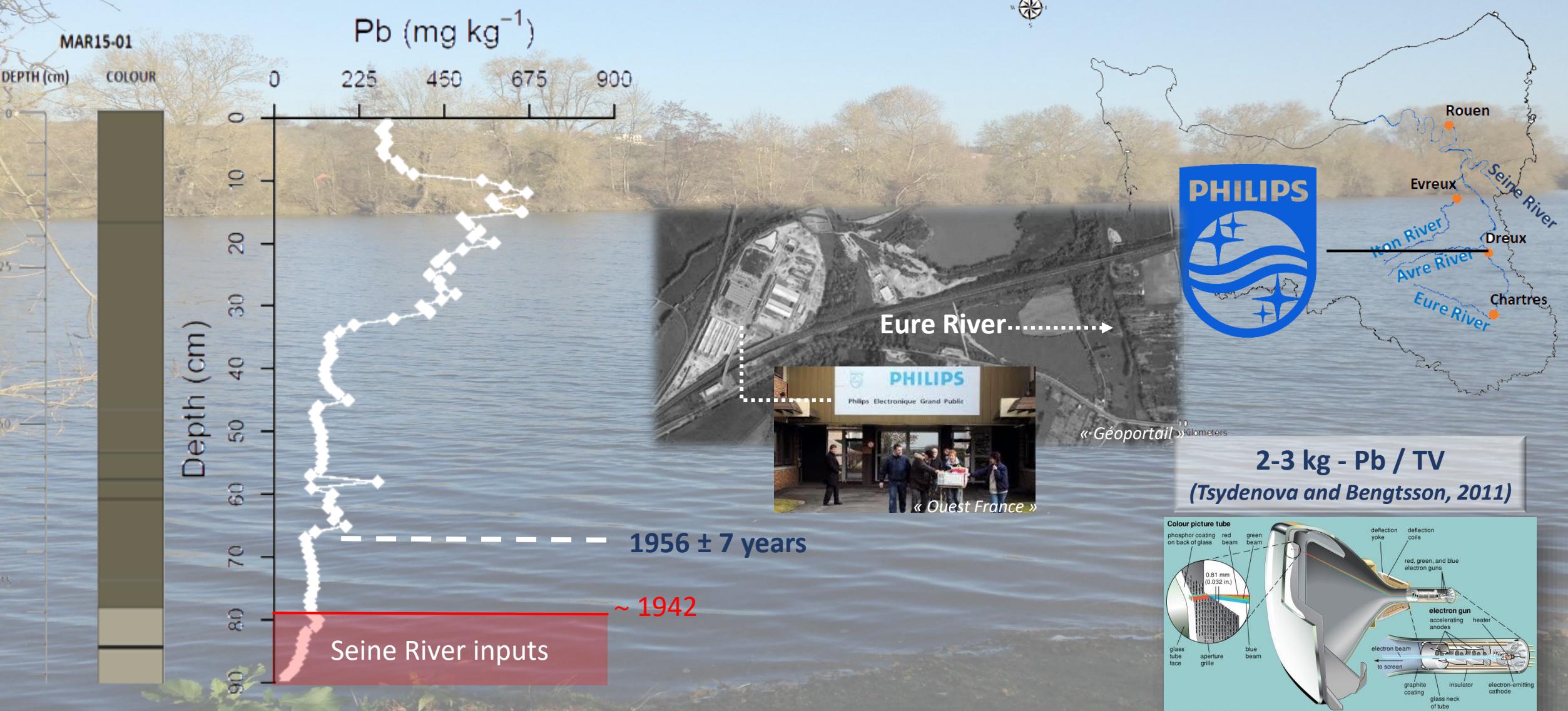
# Lead Contamination recorded in Sedimentary Archives

## ❖ Pb Quantification



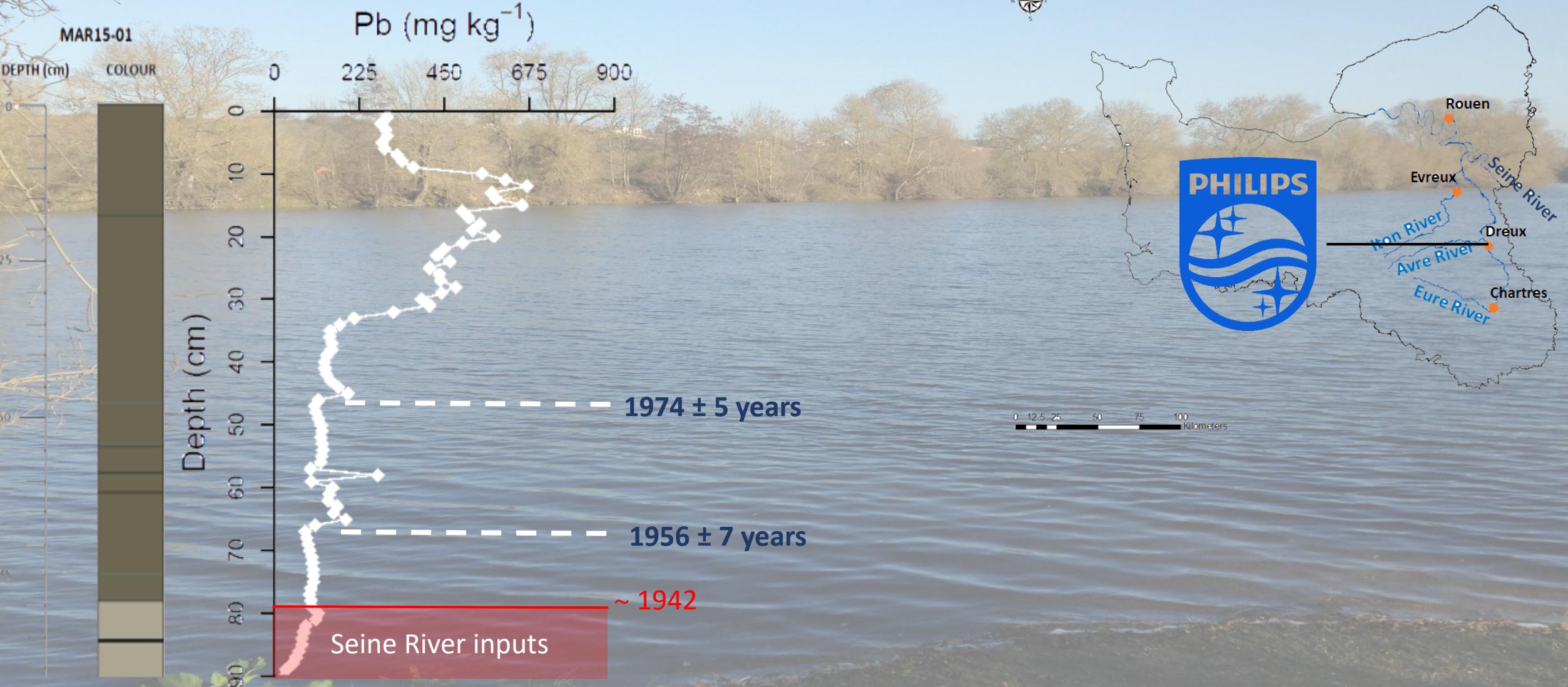
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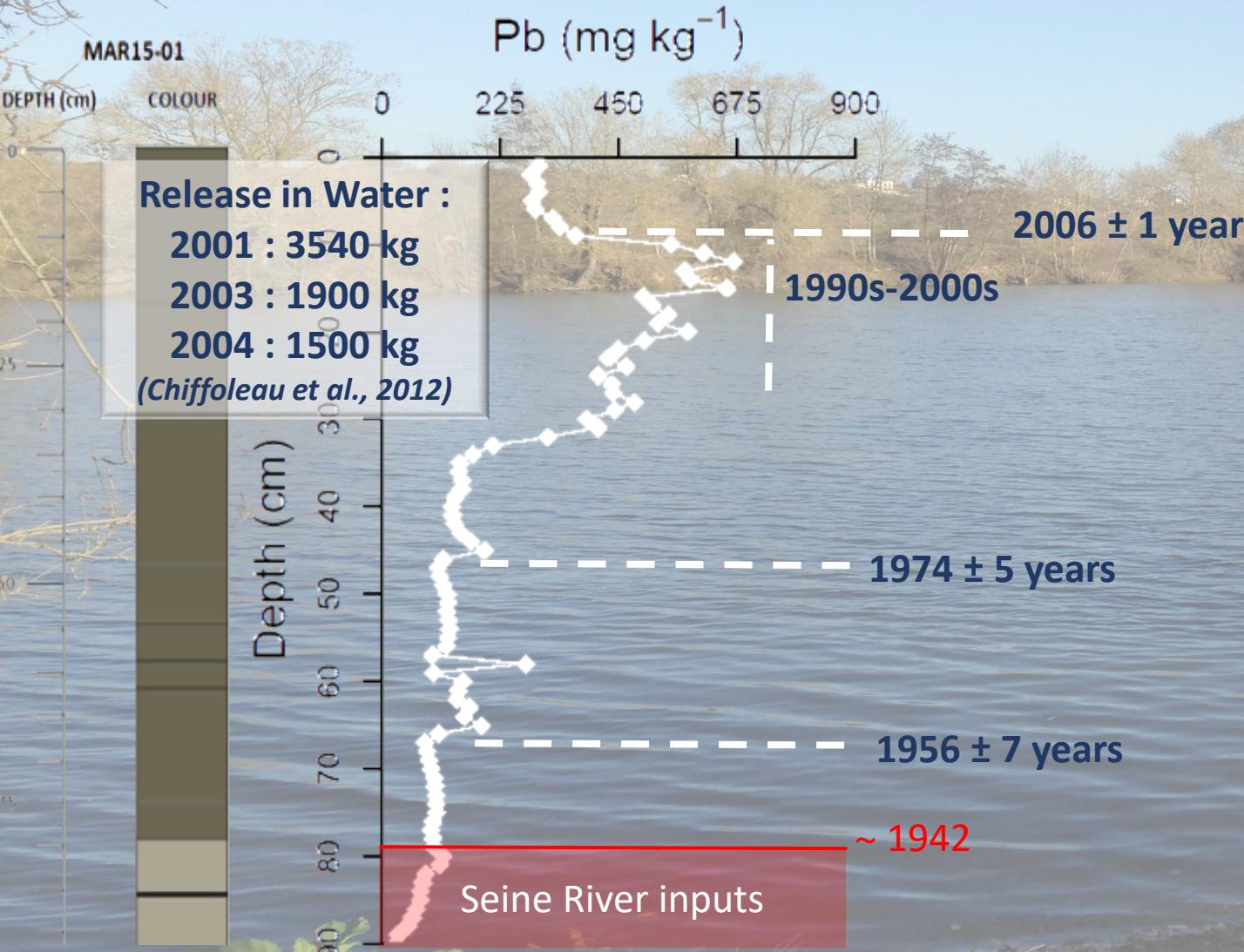
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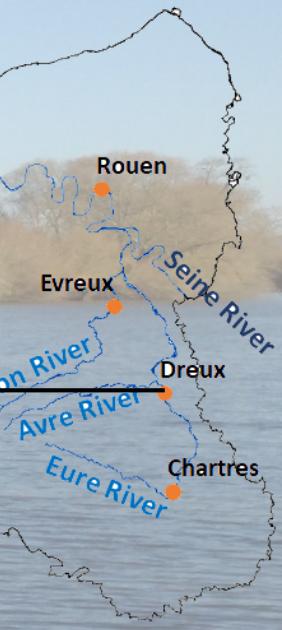


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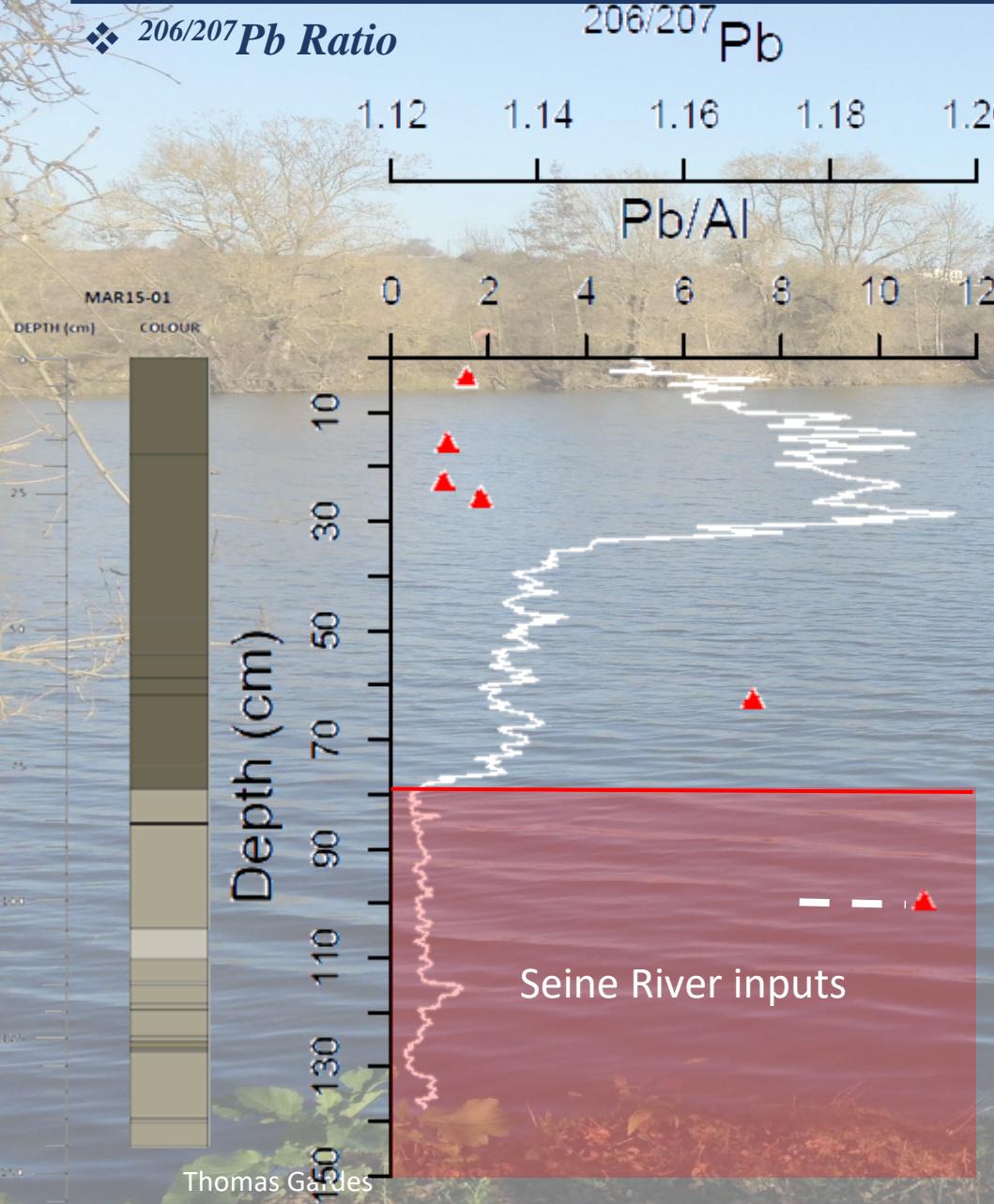
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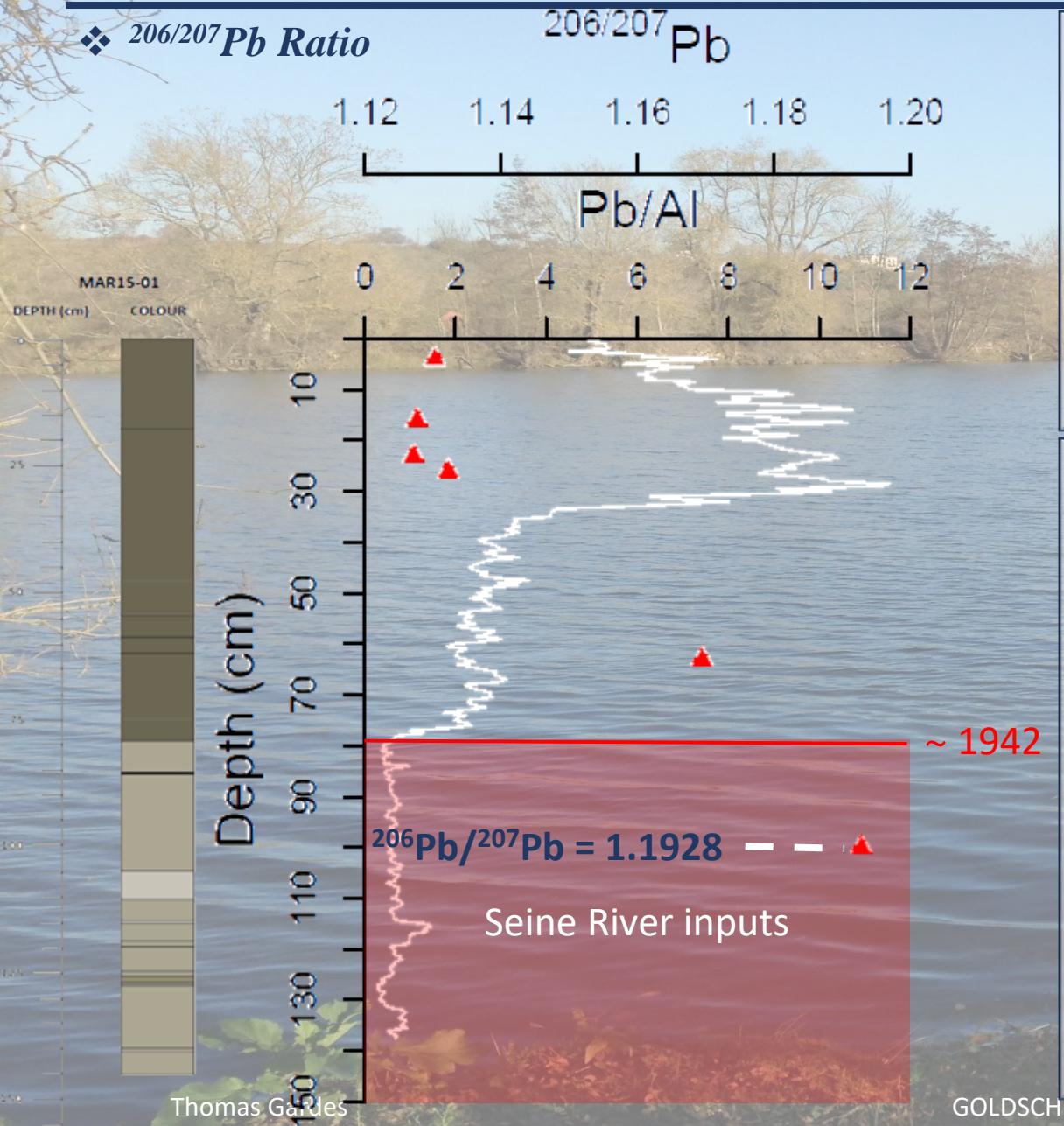
0 12.5 25 50 75 100 Kilometers



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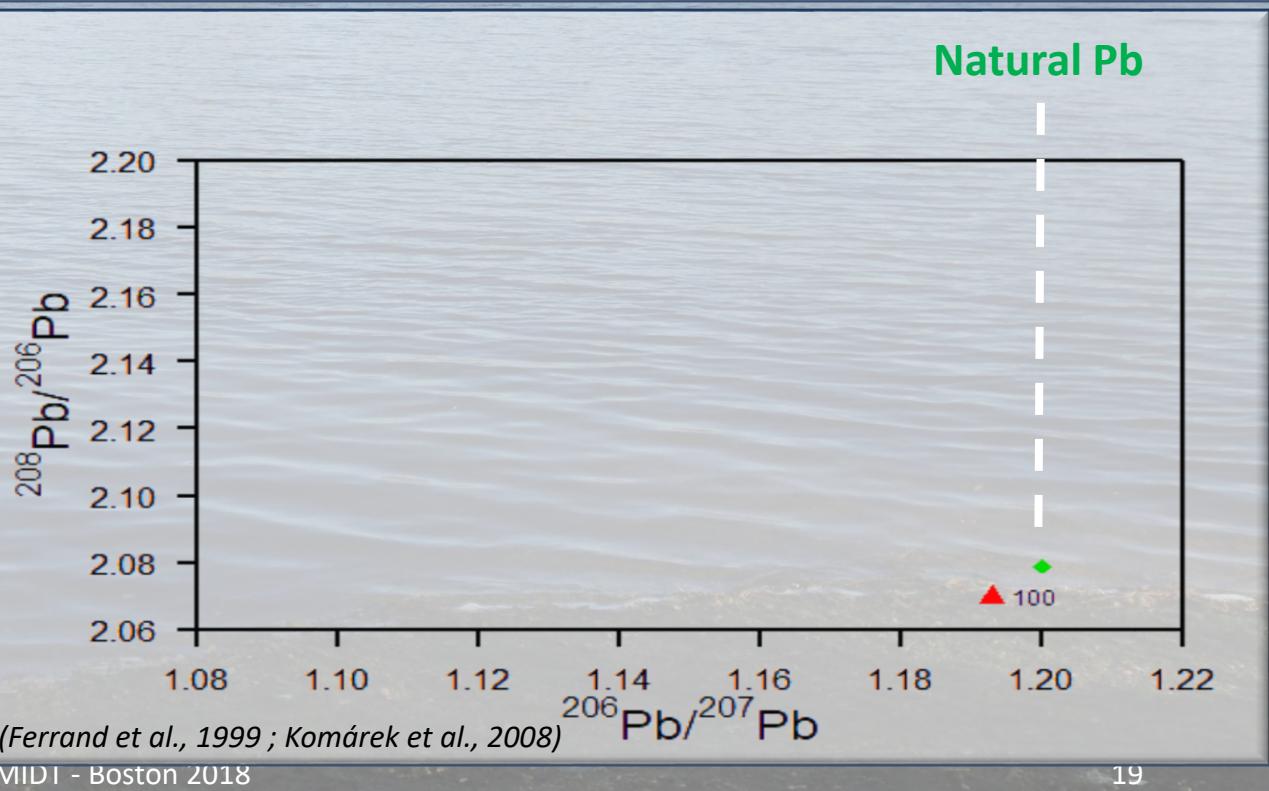


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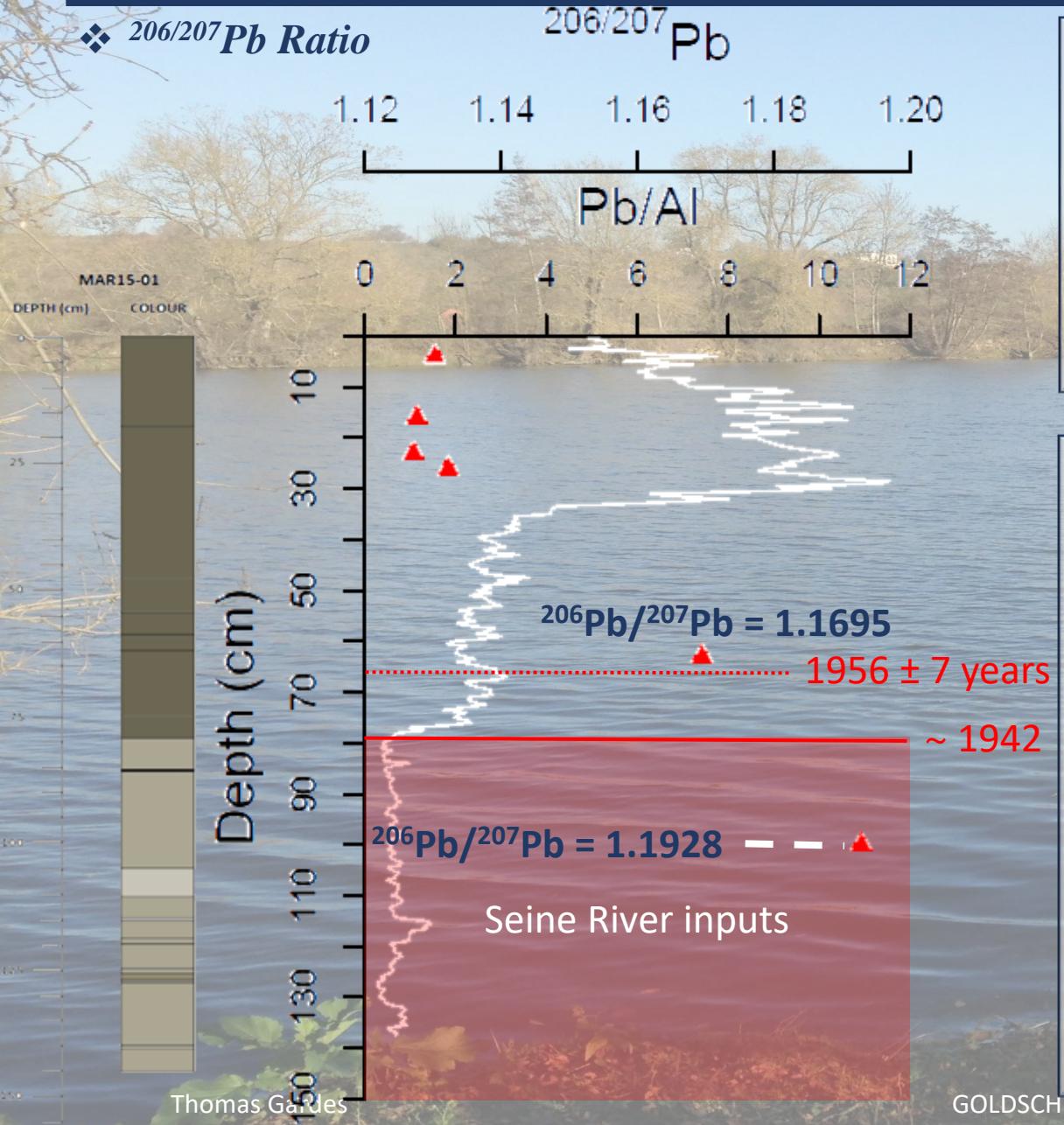


## Seine River sediments:

- $^{206}\text{Pb}/^{207}\text{Pb}$  ratio is close to:
  - Regional geochemical background
  - Seine River geochemical background =  $1.2007 \pm 0,0011$  (*Elbaz-Poulichet et al., 1986 ; Ayraut et al., 2012*)
  - « Natural Pb » ( $^{206}\text{Pb}/^{207}\text{Pb} = 1.195-1.233$ ) according to *Ferrand et al., 1999 ; Chiffolleau et al., 2012*

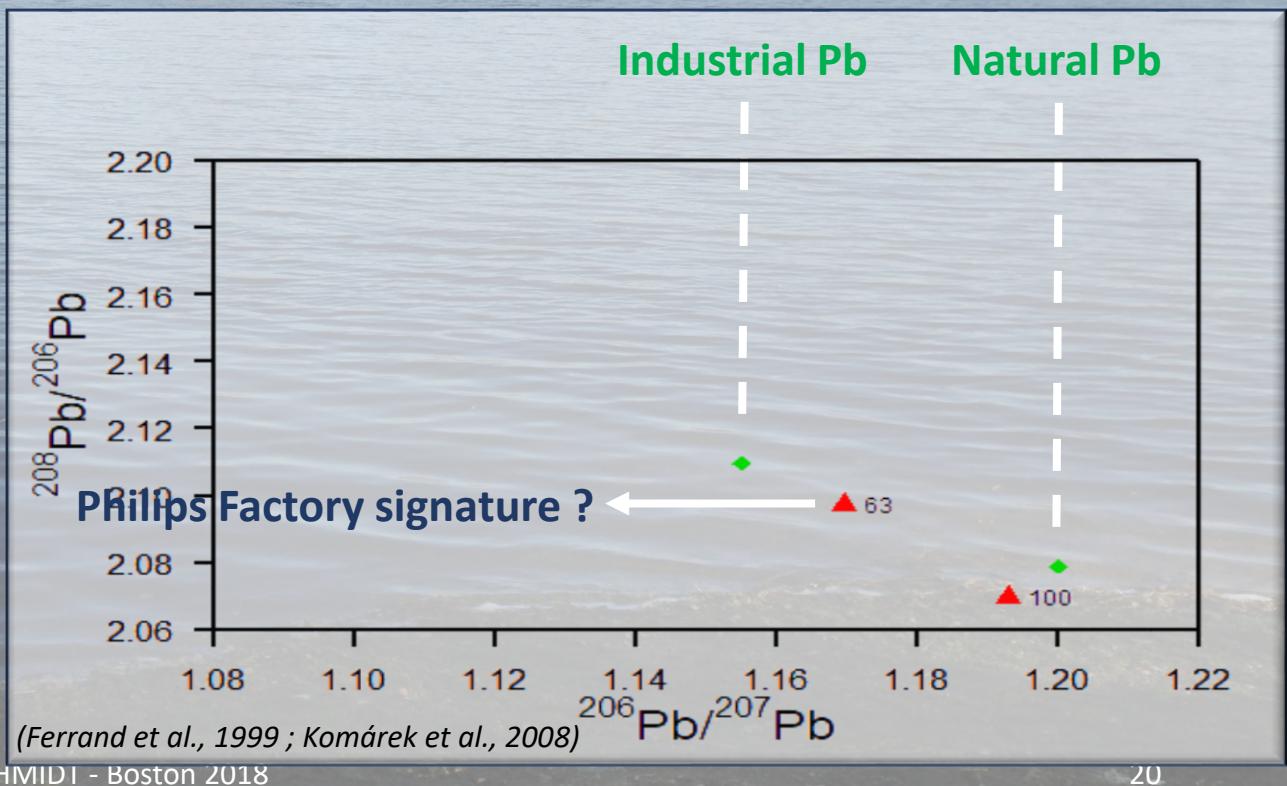


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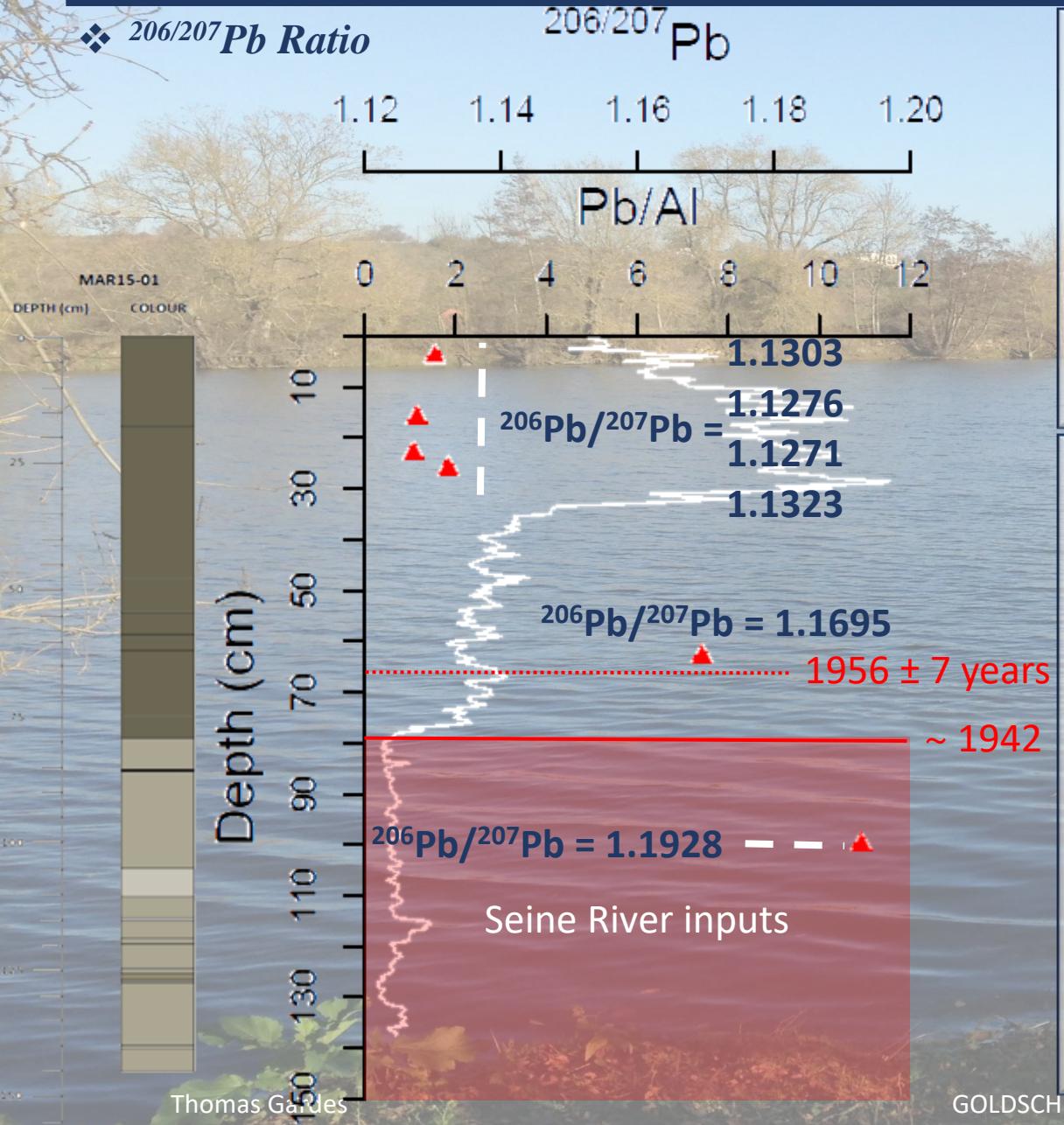


## Eure River sediments:

- $^{206}\text{Pb}/^{207}\text{Pb}$  ratio at 63 cm is close to:
  - Rio Tinto signature = 1.1633 – 1.1635 (*Marcoux, 1998, Ayrault et al., 2012*)
  - « Industrial Pb » ( $^{206}\text{Pb}/^{207}\text{Pb} = 1.155$ ) according to *Monna et al., 1997 ; Chiffolleau et al., 2012*

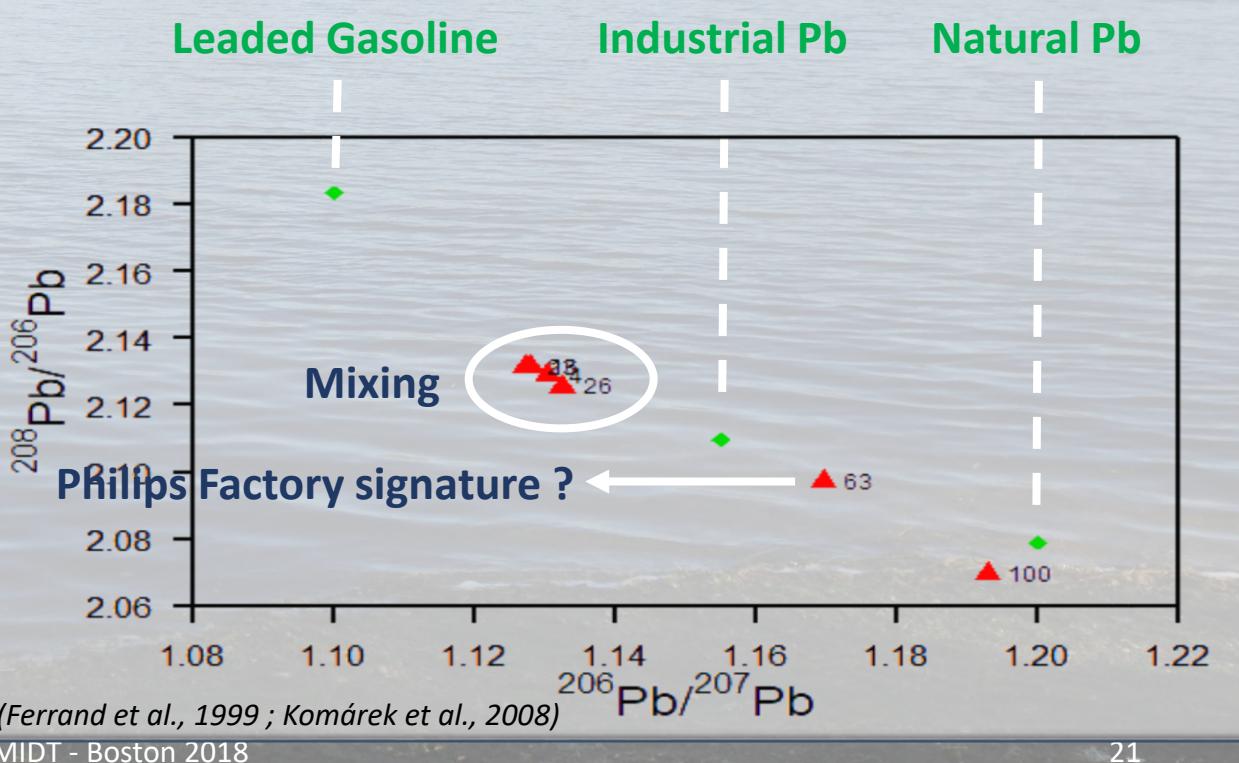


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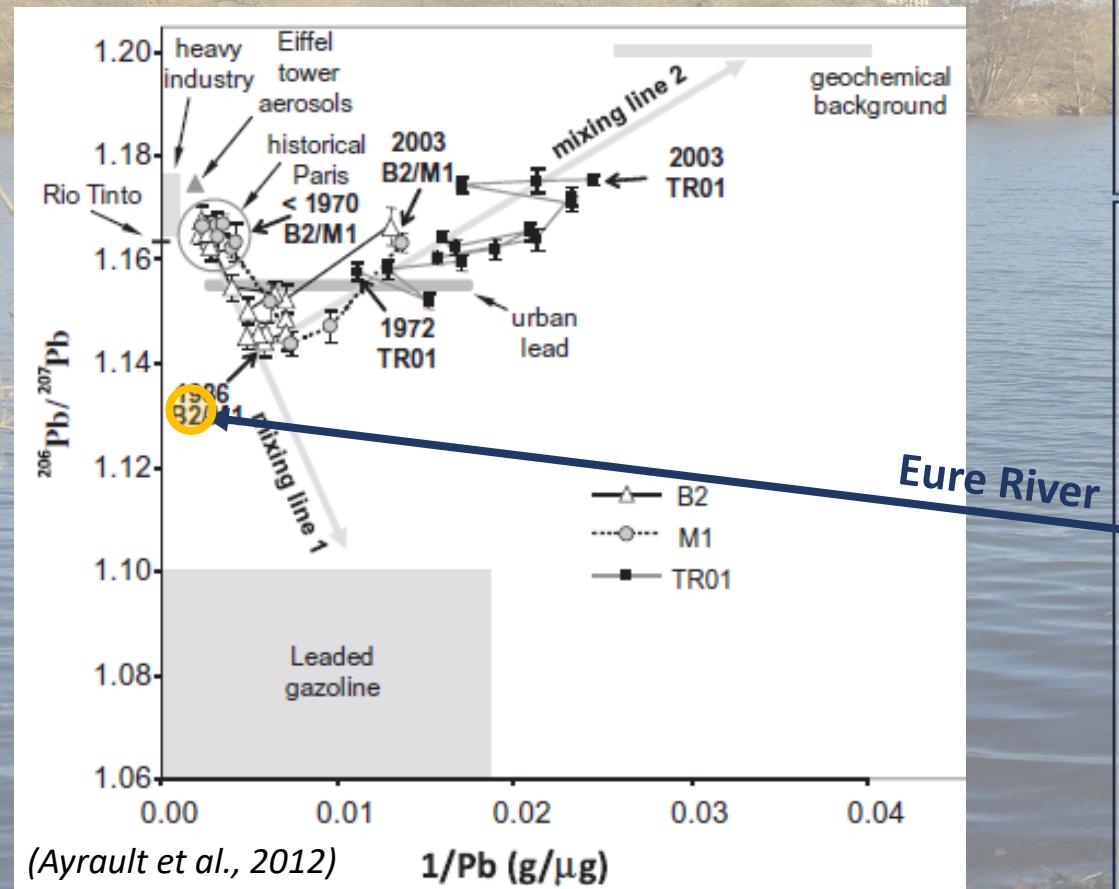
## Eure River sediments:

- 206/207Pb ratios at 0-30 cm: Mixing between industrial and leaded gasoline
  - « Industrial Pb » ( $^{206}/^{207}\text{Pb} = 1.155$ ) according to *Monna et al., 1997 ; Chiffolleau et al., 2012*
  - « Pb Gasoline » ( $^{206}/^{207}\text{Pb} = 1.10-1.11$ ) according to *Monna et al., 1997 ; Chiffolleau et al., 2012*
- *Philips Factory impacts: 53 ± 4 %*



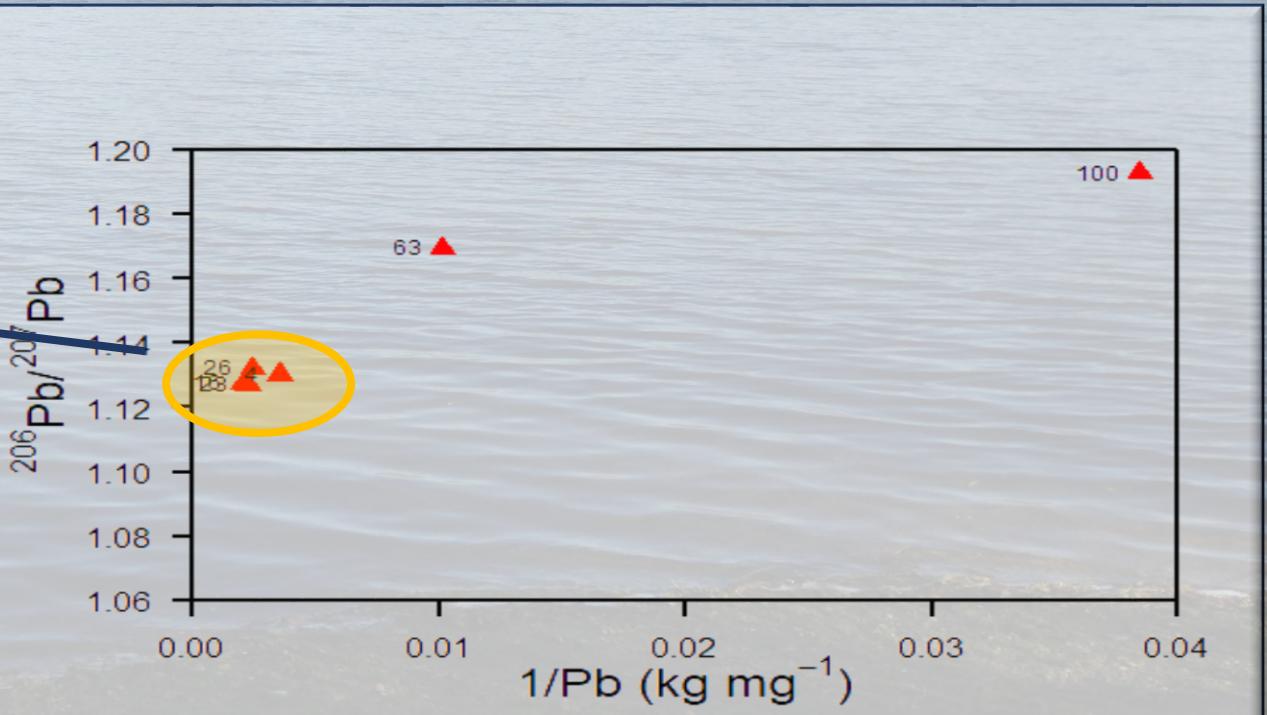
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## ❖ $^{206}/^{207}\text{Pb}$ Ratio



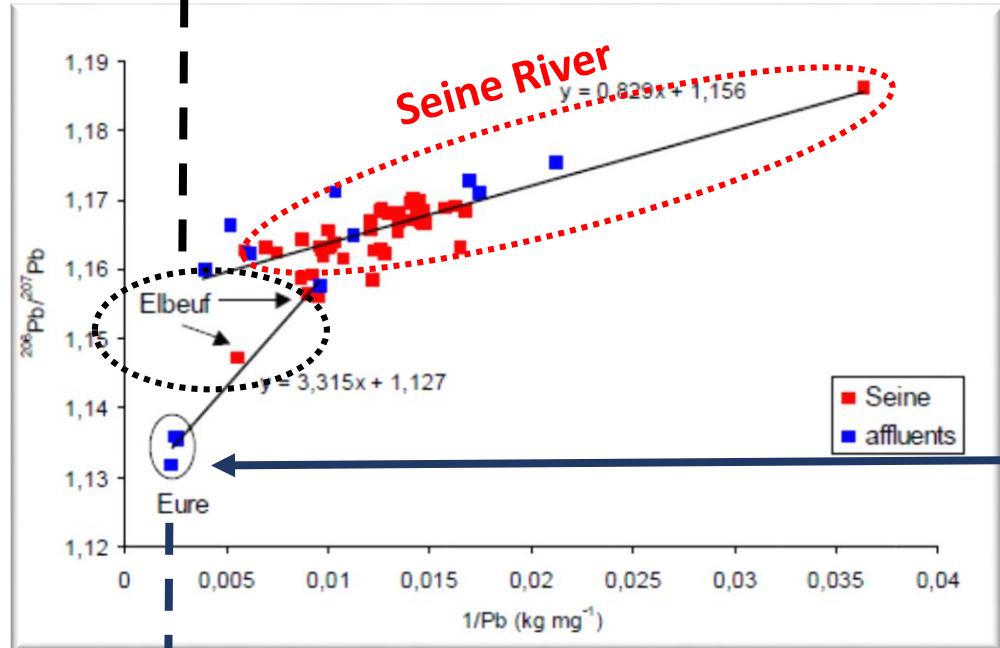
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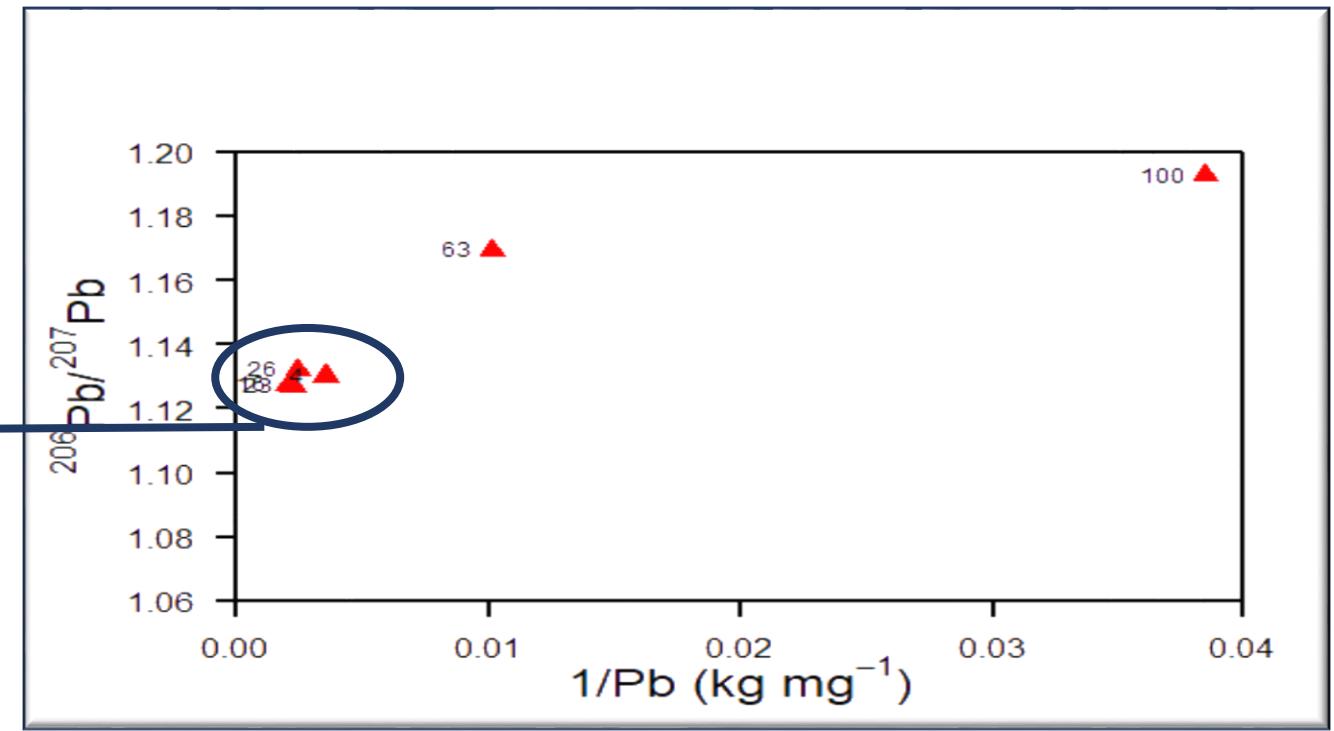


# Lead Contamination recorded in Suspended Particles Matter

~ 1 km downstream the Eure/Seine Rivers confluence



(Chiffolleau et al., 2012)



This study

$^{206}\text{Pb}/^{207}\text{Pb}$  in S.P.M from Eure River ~ 1.13 – 1.14  
(Chiffolleau et al., 2012)

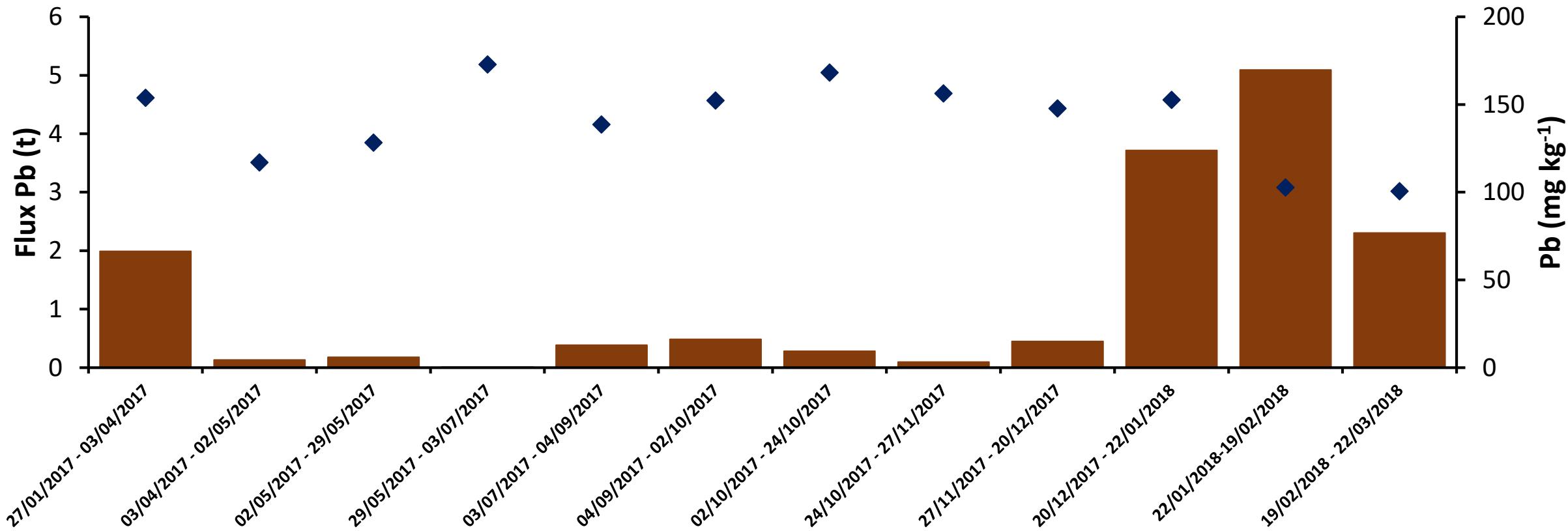
# Lead Contamination recorded in Suspended Particles Matter

## Pb (mg kg<sup>-1</sup>) at Les Damps (Eure River) in 2017:

- Pb<sub>average</sub> ≈ 140,94 ± 1,00 mg kg<sup>-1</sup> (January 2017 – January 2018)
  - < top of sedimentary archives

## Pb fluxes at Les Damps (Eure River) in 2017:

- Sum ≈ 7.73 t an<sup>-1</sup> (January 2017 – January 2018)
  - ~ 8 % Pb fluxes in the Seine River (1994-2003) at Poses (*Thévenot et al., 2007*)



## Summary

- ❑ Past and Actual contamination: Philips factory
- ❑ Philips Factory impacts: Downward trend ?
  - Pb concentration decreasing
- Eure River impact ↴

BUT...

# Lead Contamination in the Eure River: “Back to the future” after dam removal ?

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October 2017

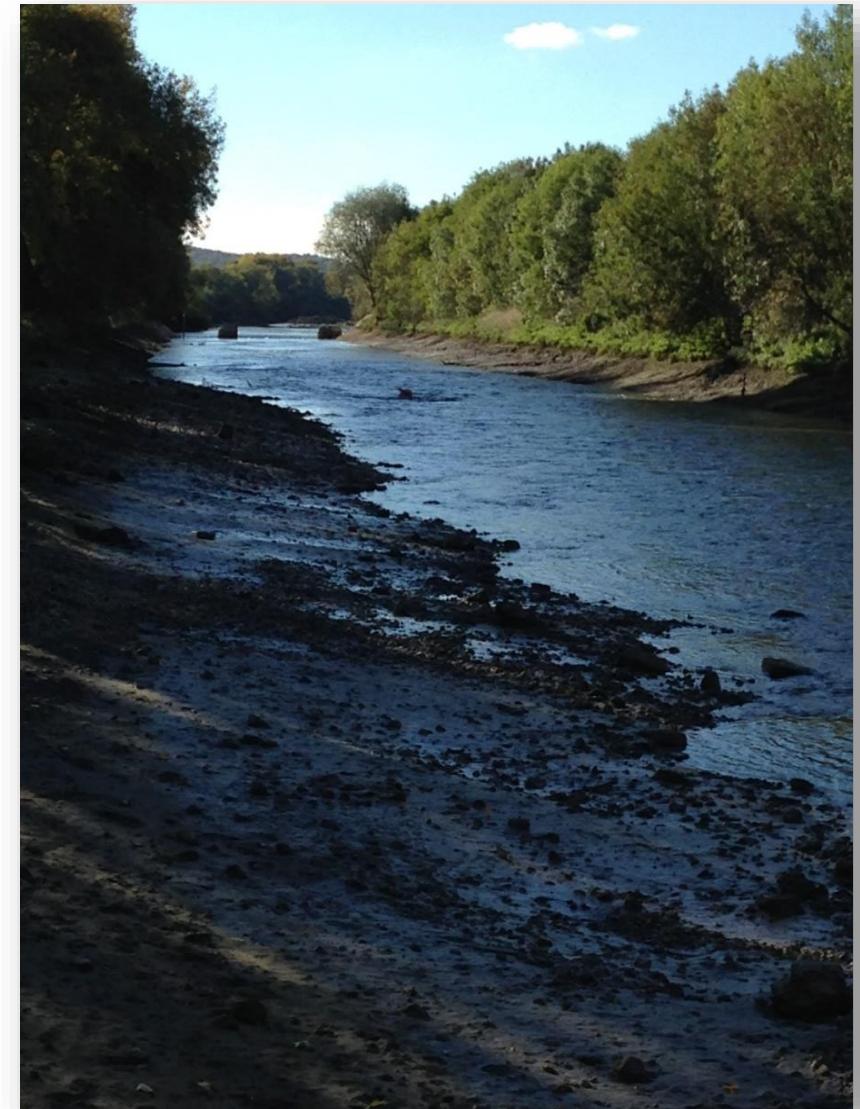


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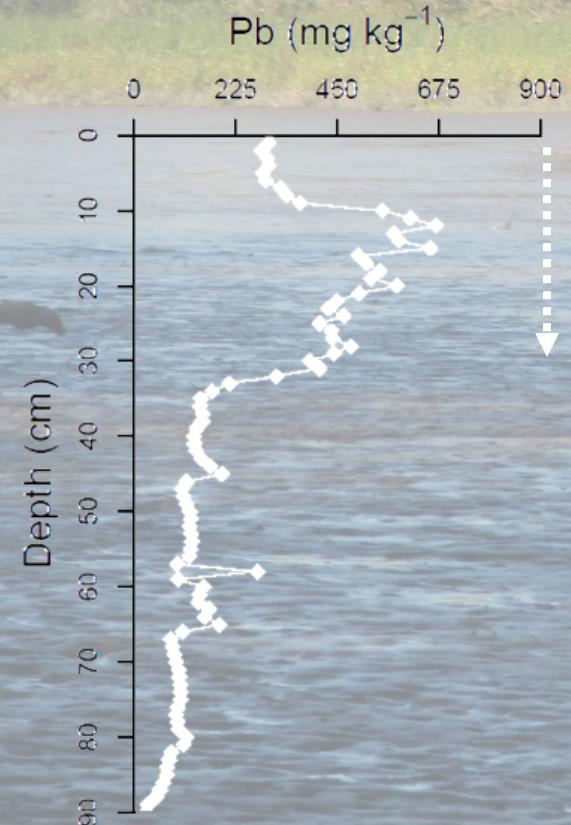
BUT...

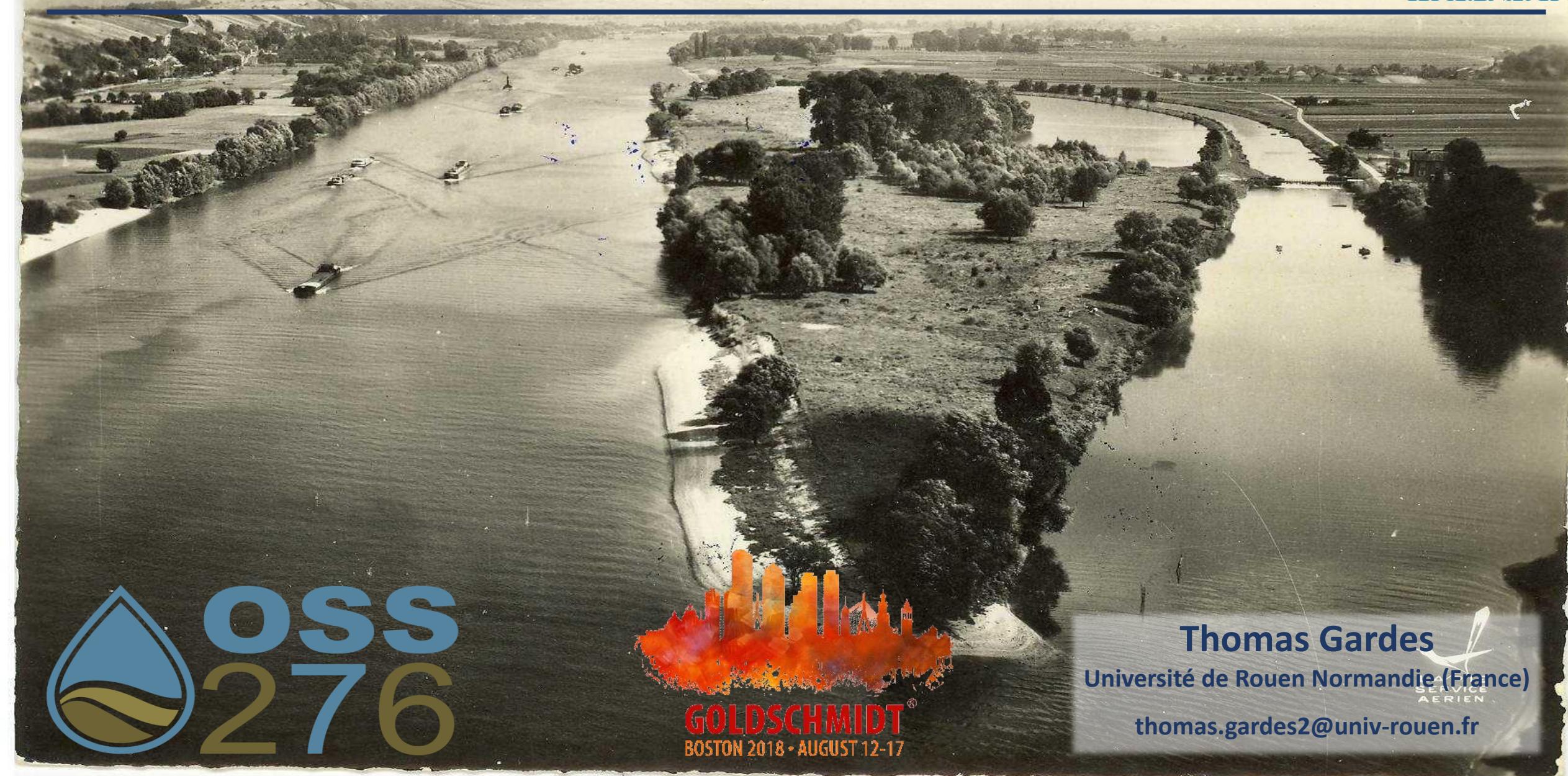


# Lead Contamination in the Eure River: “Back to the future” after dam removal ?

## Pb resuspension ?

- Martot Pond and Eure River channel: erosion
- Impact on Seine River will increase (again) ?





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BOSTON 2018 • AUGUST 12-17

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