# INVESTIGATING THE INFRASTRUCTURE-INDUCED LEGACY SEDIMENTS ALONG THE RHÔNE RIVER (FRANCE)

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### WHAT ARE LEGACY SEDIMENTS?

- Relatively recent terminology: first used in *Novotny, 2004.*
- Various meanings in the literature: sediments contaminated with « legacy pollutants », sediment deposited as a result of past human activity, etc.
- The definition we use :

« **Legacy sediments** are those for which the location, volume, and/or presence of contaminants results from past and contemporary **human activities**. » (*Wohl, 2015*)



Example of legacy sediments found in the Mid-Atlantic area (USA) : accumulation of fine overbank sediments Source : Department of Environmental Protection of Pennsylvania



Possible legacy sediments identified in a secondary channel of the Rhône River in Péage-de-Roussillon (France) Source : Sophia Vauclin

### SOME EXAMPLES OF LEGACY SEDIMENTS

CHARACTERISTICS	CAUSE(S)	SOURCE(S)
<b>Important contamination</b> (metallic elements, POPs)	<ul><li>Urbanization</li><li>Industrialization</li><li>Mining activities</li></ul>	<ul> <li>Coxon et al., 2016</li> <li>Martin, 2015</li> <li>Pavlowsky et al., 2017; Davies et al., 2018</li> </ul>
Increased organic carbon content	Catchment deforestation	Dalton et al., 2014
Fine sediments deposition with higher accumulation rate	Land clearance (agriculture)	Starkel et al., 2006; Brown et al., 2013; Dalton et al., 2014
Decreased overbank sedimentation	Implementation of dikes	Meade and Moody, 2009

#### WHY FOCUS ON RIVER INFRASTRUCTURES?

Hydraulic and hydroelectric infrastructures (e.g. dams, weirs, dikes, groynes, embankments, etc.) are ubiquitous on most large rivers!



An overview of the hydraulic/hydroelectric infrastructures implemented on large European rivers (Source : data from *Rivers of Europe, Tockner et al., 2009*)

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#### → Can we identify legacy sediments caused by river infrastructures?

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## THE BYPASSED RHÔNE, A HIGHLY ENGINEERED SYSTEM

Girardon

infrastructures =

longitudinal dykes +

transversal groynes

(1880-1900)



Girardon infrastructures on the Rhône River in Irigny (1957) (Source : © SMIRIL)



Girardon infrastructures on the Rhône River in Péage-de-Roussillon (Source : © IGN)



A typical bypass configuration on the Rhône River (Source : © CNR)













- A sudden change in stratigraphy, grain-size repartition and EMMA is observed in 5 out of 6 cores (red line).
- The sediments above this limit are **homogenous** and **rather peculiar**:
- fine,
- poorly classified,
- D50 and mode are separated,
- only EM1 and EM2 are represented



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#### Hypothesis:

This grain-size change was caused by engineering work on the river (either the Girardon infrastructures or the bypass)

<u>NB</u>: Core C3 where the limit was not observed was excluded from further analyses



Grain-size (um)

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- <sup>137</sup> Cs peak attributed to the 1960s (nuclear tests)
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- $\rightarrow$  The top 30 cm from the cores dates corresponds to the 1950s or earlier!



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- → Grain-size limit = Girardon infrastructures!





The grain-size limit also corresponds to a **major reflector** on the GPR surveys

 $\rightarrow$  Infrastructure-induced legacy sediments form a continuous layer in study area 2

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<sup>137</sup>Cs, PCBi and PCDD/Fs in cores C3c and C18b in study area 1 (PBN)

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 $\rightarrow$  based on those first time-markers (more data coming), the limit in both areas does not correspond to the implementation of either infrastructure!

- > Natural disconnection?
- Delayed effect from infrastructures?
- Responses to infrastructure in different study areas might differ based on the initial hydraulic connectivity

Work in progress!



### CONCLUSIONS AND OUTLOOKS

- Hypothesis validated: infrastructure-induced legacy sediments were identified in the 3 study areas:
  - > They were dated and attributed to the Girardon infrastructures in study area 2
  - Sediments with similar characteristics were found on the remaining two areas; *however* they could not be chronologically linked to either river infrastructure *yet*.
- The methodology (geophysics + analysis of sediment cores) allows the investigation of fluvial sediments in a time and cost-efficient manner.
- Challenges in relation with infrastructure-induced legacy sediments:
  - ➤ Disconnectivity channel/flooplain → Biodiversity? Flood risk management?
  - ➤ Ground creation → Property? Contamination?
  - > Ubiquitous on engineered rivers?

### THANK YOU FOR YOUR ATTENTION!

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#### SUPPLEMENTARY INFORMATION: PCA ON X-RAY FLUORESCENCE





contamination levels in the different cores



F1 coordinates

Supplementary information

### SUPPLEMENTARY INFORMATION: XRF RESULTS IN STUDY AREA 1



Supplementary information

### SUPPLEMENTARY INFORMATION: XRF RESULTS IN STUDY AREA 3



Supplementary information