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EGU General Assembly 2020

INFLUENCE OF DEPOSITIONAL ENVIRONMENTS ON THE CONTAMINATION RECORD OF FLUVIAL SEDIMENTS: A CASE STUDY FROM THE RHÔNE RIVER (FRANCE)

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Overview

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1. Introduction

1.1. Context

Sediments = potential **archives** of anthropogenic activities (land-use, contamination, river/coast engineering, etc.)

But using **fluvial** sediments as an archive is challenging:

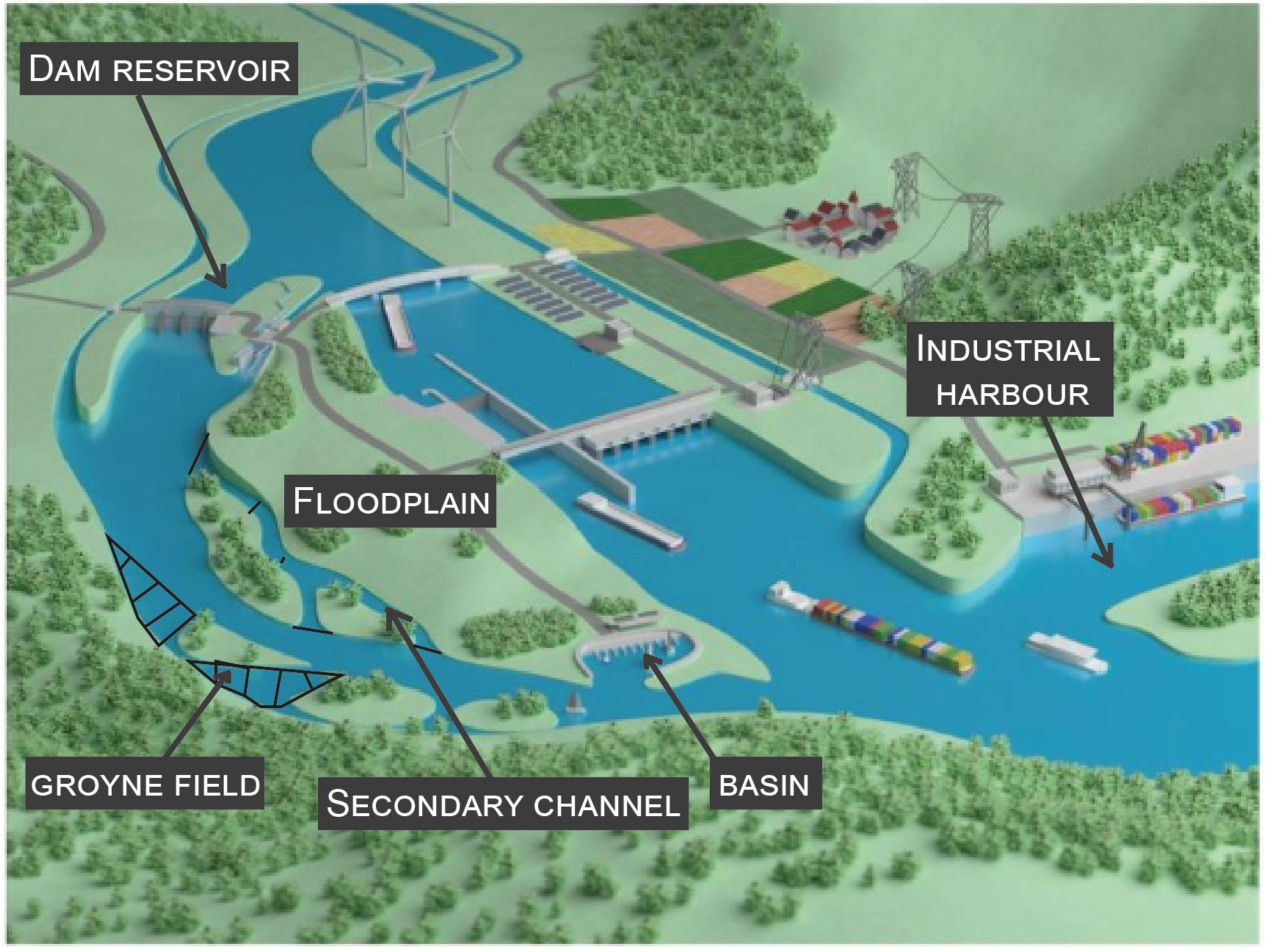
- Sedimentation rates depend on hydrological events (rarely uniform over time)

- Possible reworking of sediments (flood, human intervention)

→ issue with the **continuity** and the interpretation of records

- A large diversity of depositional environments (especially in highly anthropized river)

→ different records



Example of depositional environments in a highly anthropized river (source: modified from Compagnie Nationale du Rhône)

→ How do contamination chronicles recorded in fluvial sediments vary depending on the depositional environment?

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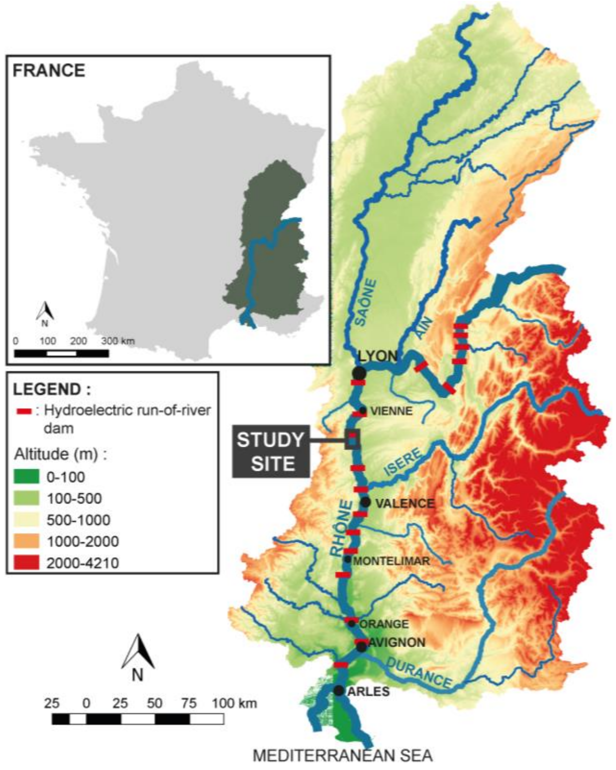
1. Introduction

1.2. Study area

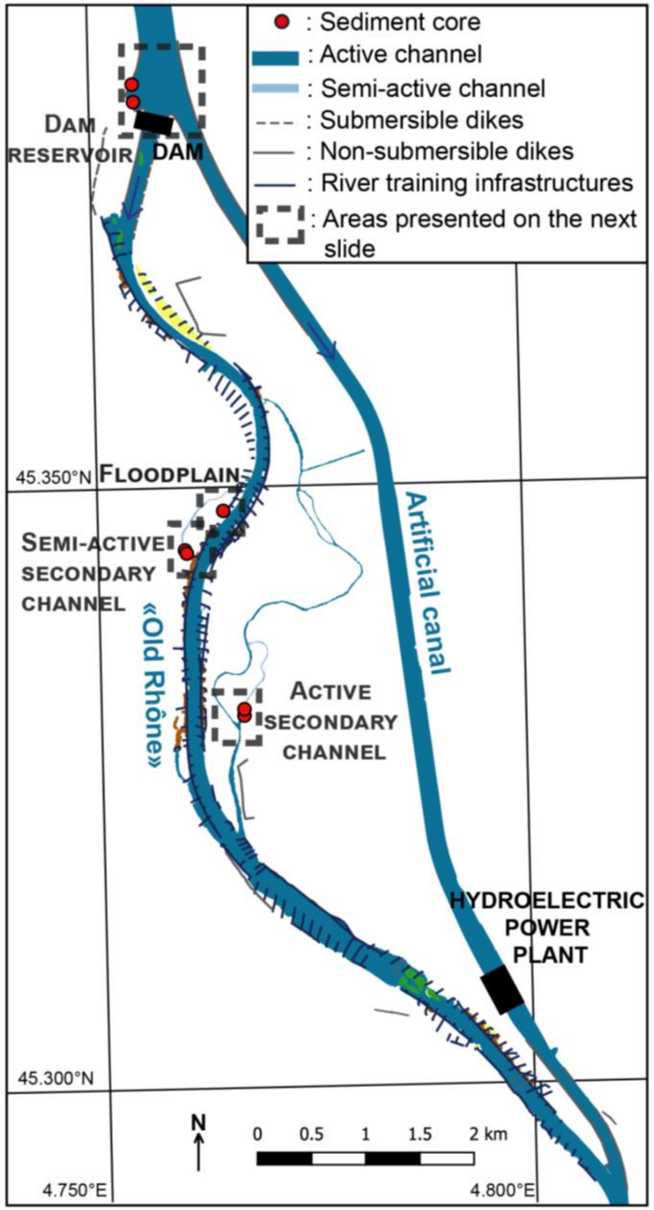
- The Rhône River is a highly anthropized river in France:
  - Urbanized and industrialized catchment
  - River training structures and 19 hydroelectric dams along the corridor

- The study site underwent two phases of engineering:
  - River training infrastructures were built in the 1880s (dykes and groynes)
  - A dam and bypass were implemented in 1978 to produce hydroelectricity and further facilitate river navigation.

- Four different depositional environments are studied:
  - a dam reservoir,
  - an active secondary channel,
  - a semi-active secondary channel,
  - a floodplain



The Rhône River catchment



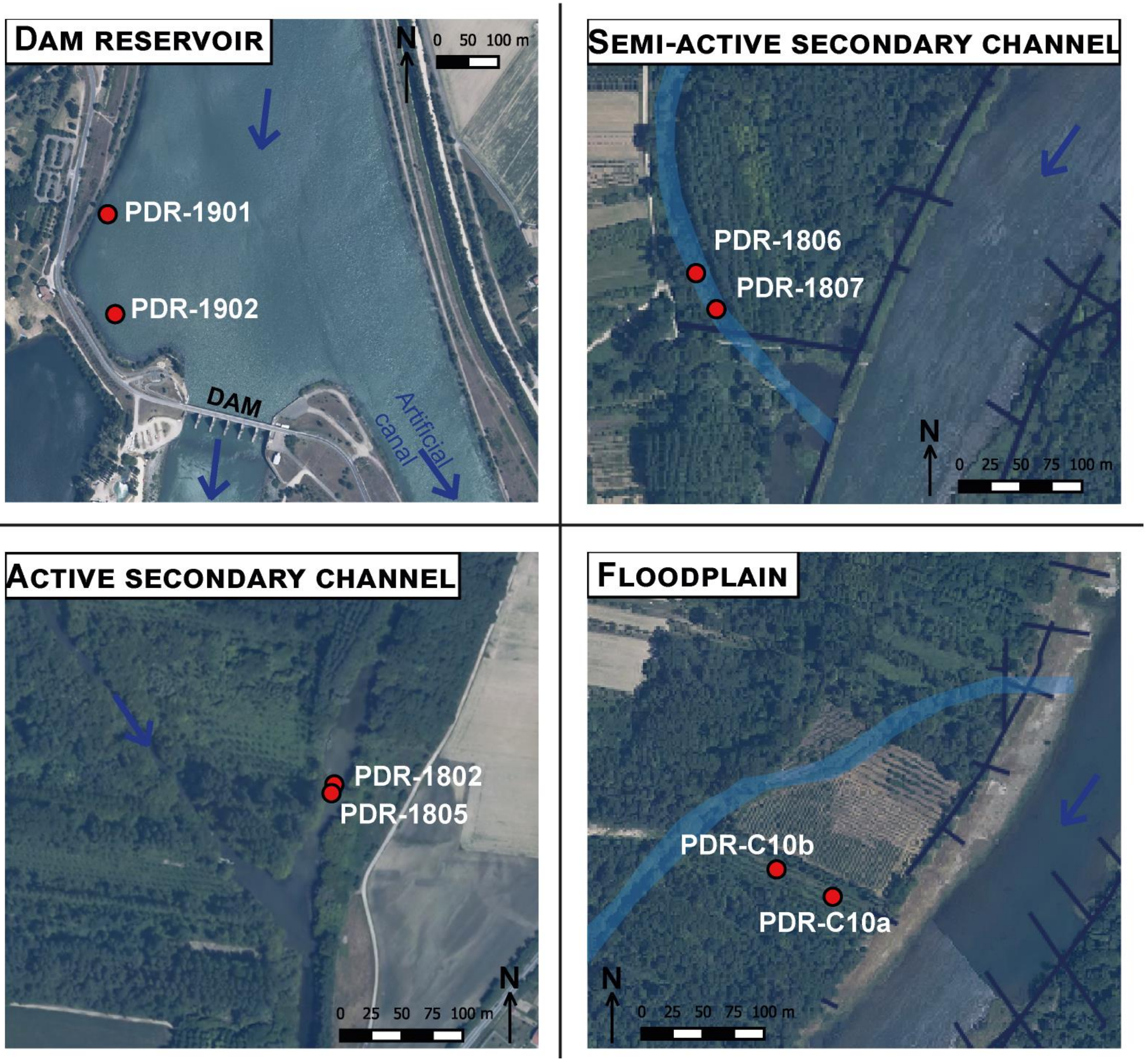
Study site with location of studied depositional environments and sediment cores (modified from Vauclin et al., 2019)

1. Introduction

1.3. Depositional environments

Dam reservoir:
- Built in 1978
- Sediment cores sampled in a recess zone never dredged where 5+ m of sediments accumulated

Active secondary channel:
- Upstream disconnection started in 1978 following the dam implementation
- Connected by its downstream end, underwater most of the year



Aerial photographs of the four studied depositional envronments (source: IGN)

Semi-active secondary channel:
- Progressively disconnected after dikes were built at its downstream and upstream ends in the 1880s
- Connected a few times a year under high discharge conditions

Floodplain:
- Terrestrial since before the 1880s (previous island)
- No overbank flow since the dam implementation in the late 1970s.

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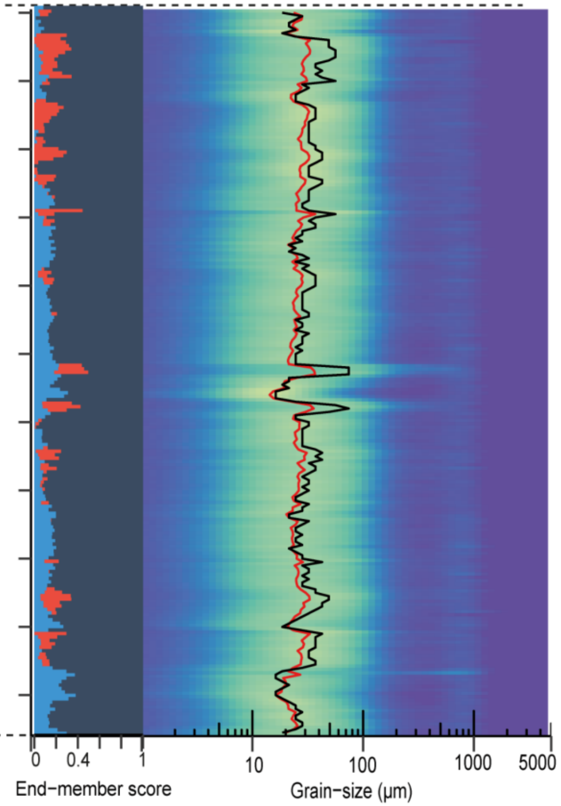
2. Material and methods



SEDIMENT CORE SAMPLING

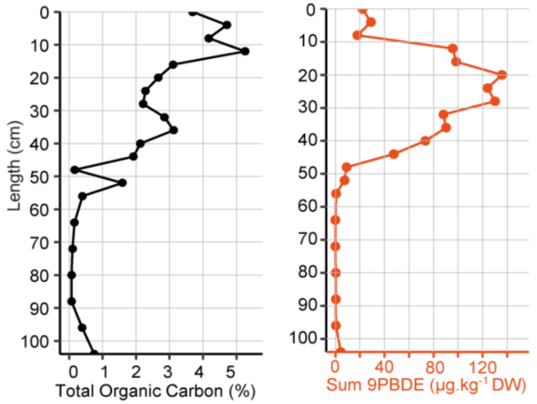
8 cores: 2 cores/environment
UWITEC® corer + 90 mm-diameter liner
OR
Cobra TT corer + 60 mm-diameter liner

GRAIN-SIZE ANALYSIS
(every 1 cm)

Heatmaps
+ End-Member Modelling Analysis (EMMA) *(not presented in this document)*

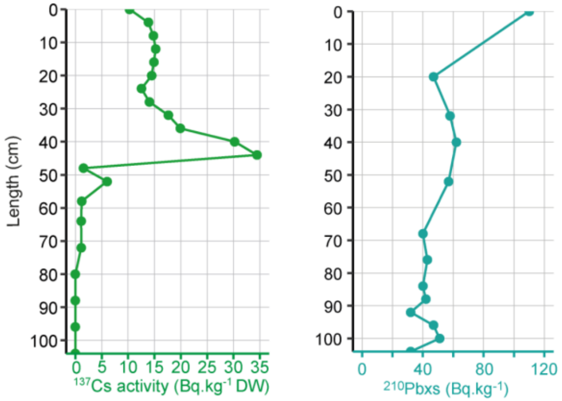
GEOCHEMICAL ANALYSES
Every 4 cm

VERTICAL PROFILES OF GEOCHEMICALS CHARACTERISTICS OF THE SEDIMENT CORES



Total organic carbon
Organic contaminants : polychlorobiphenyls (**PCBs**), polybrominated diphenylethers (PBDEs)

Every 4 cm
DATING METHODS

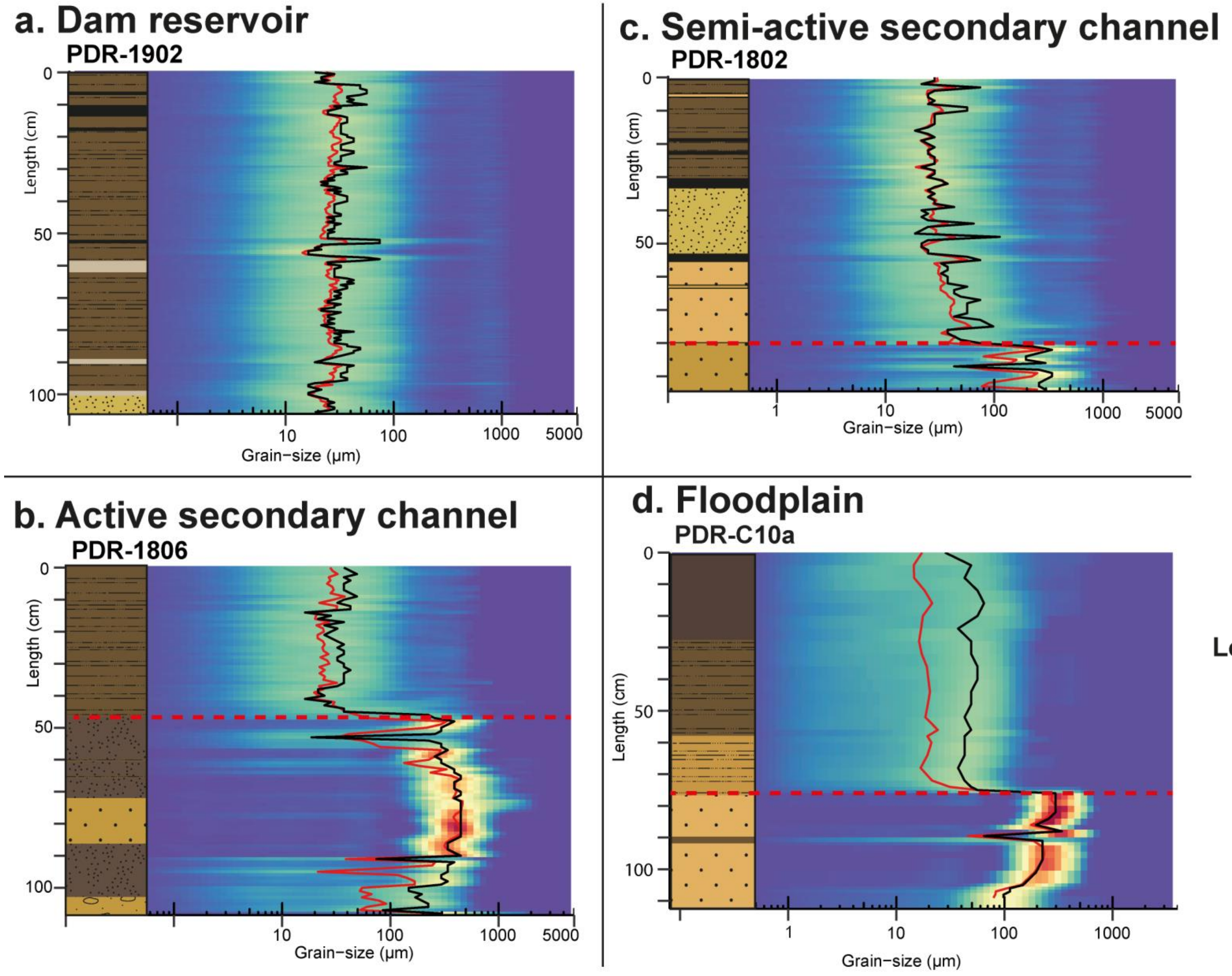


^{137}Cesium, ^{210}Pbxs

DATA USED FOR AGE-DEPTH MODELLING
R package "clam"
(classical age-depth modelling),
Blaauw, 2010

3. Results

3.1. Grain-size results



Stratigraphic description and heatmaps for one sediment core per depositional environment

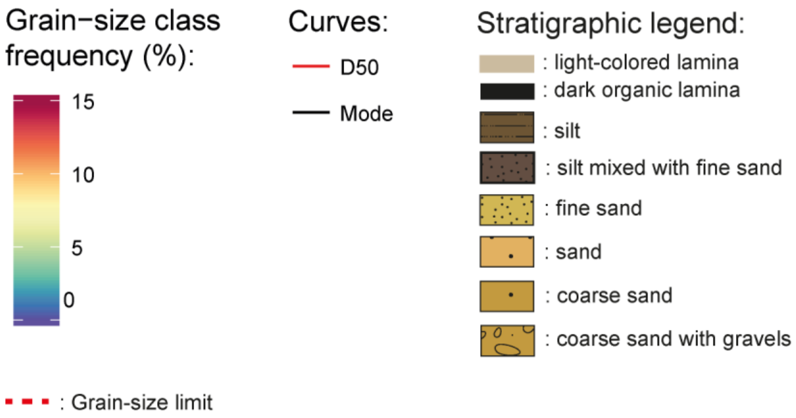
An abrupt **grain-size change** (dotted red line) can be identified in all cores except the two from the dam reservoir.

→ **In the floodplain:** due to the implementation of the river training infrastructure in the 1880s (demonstrated in Vauclin et al., 2019).

→ **In the secondary channels: likely** due to the implementation of the dam and bypass in 1978 (to be confirmed with other time-markers).

→ The sediments above the limits are **infrastructure-induced legacy sediments.**

Legend:



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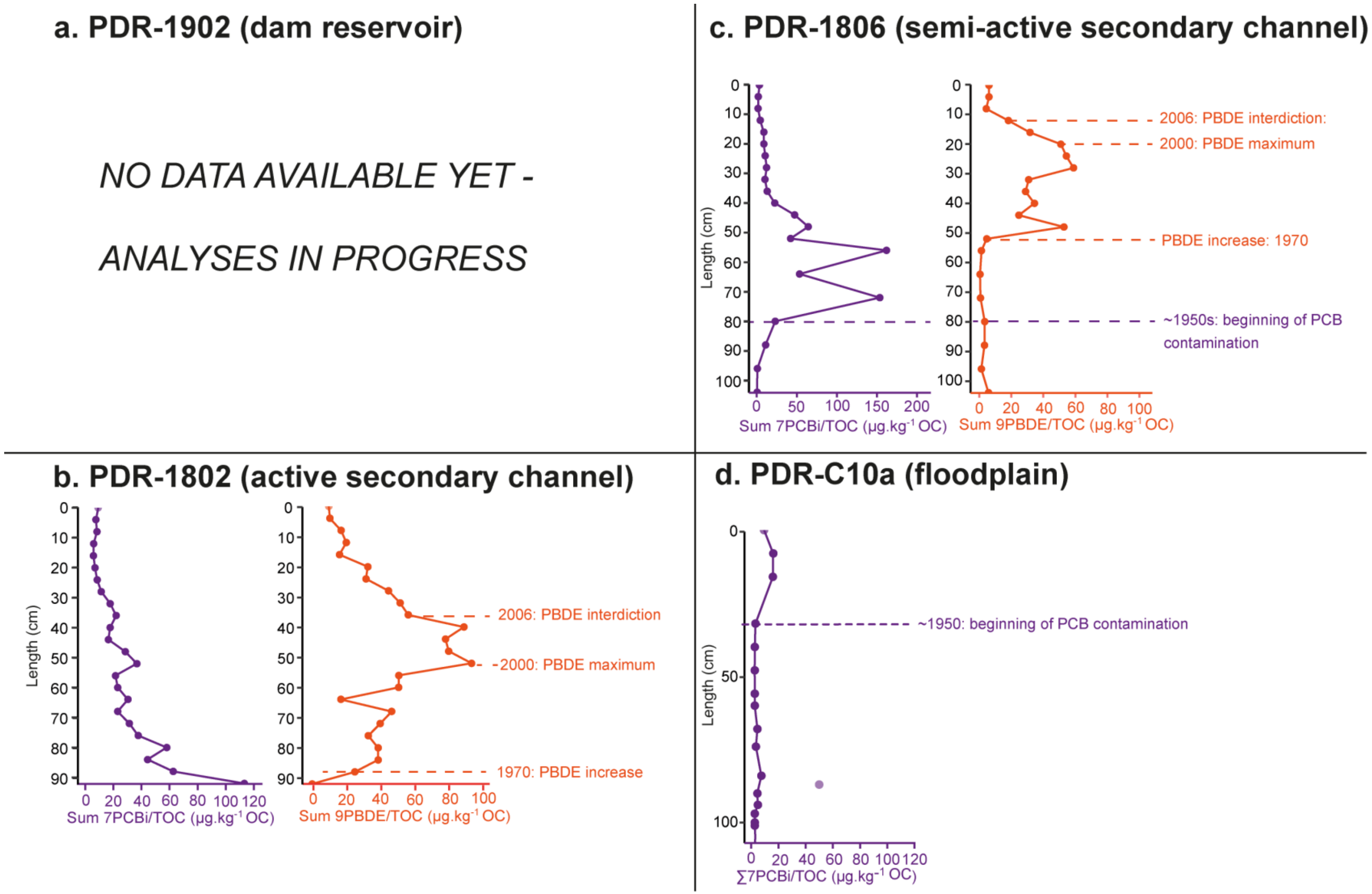
3. Results

3.2. Vertical trends in organic contaminants



Vertical trends in PCBs and PBDEs normalized to total organic carbon

- **PCBs:**

Each depositional environments recorded a different stage of the contamination trend but the results are temporally consistent:
Floodplain = beginning of the temporal trend only.
Semi-active channel: entire temporal trend.
Active channel: late decreasing trend only.

- **PBDEs:**

Consistent trends between the two channels and in regards to the PCBs trends.
Both cores highlight the **shift from PCBs to PBDEs as the predominant contaminant**, presumably in the 1970s.

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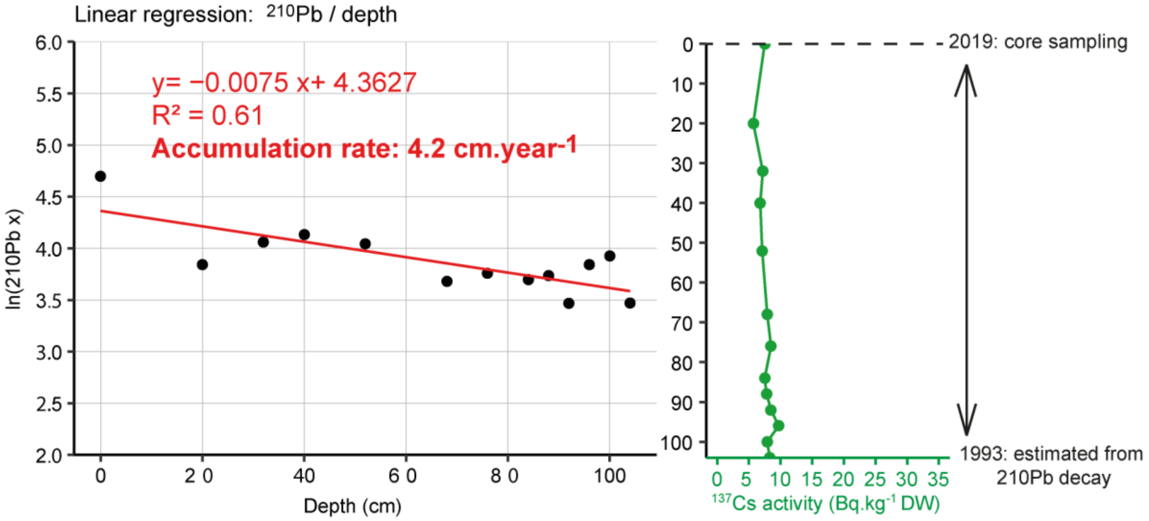
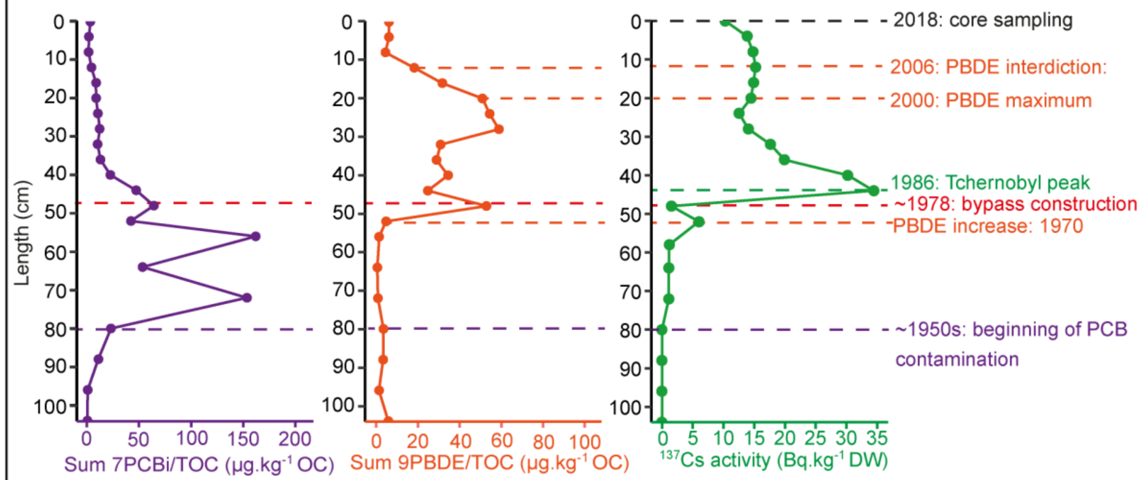
3. Results

3.3. Dating of the sediment cores

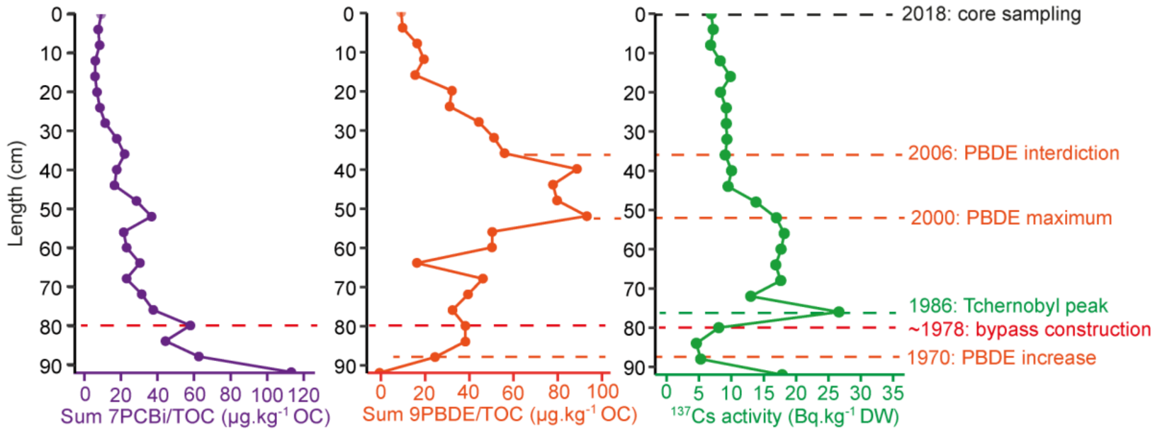
a. PDR-1902 (dam reservoir)



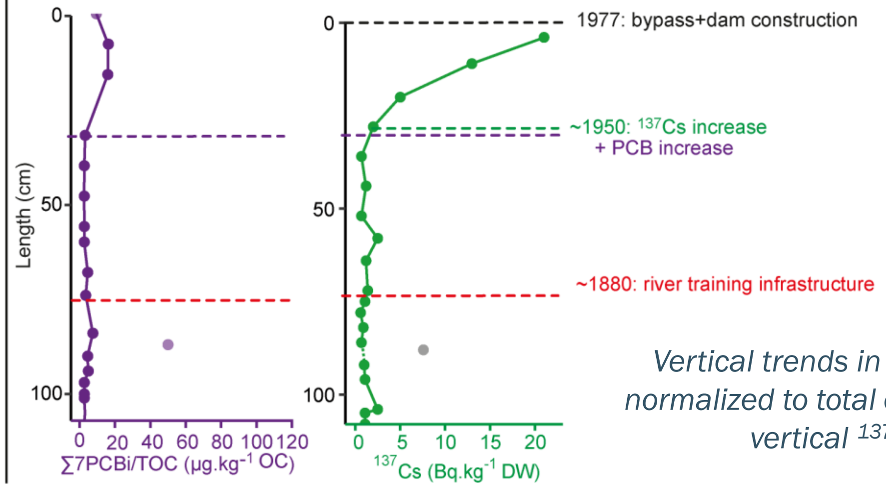
c. PDR-1806 (semi-active secondary channel)



b. PDR-1802 (active secondary channel)



d. PDR-C10a (floodplain)

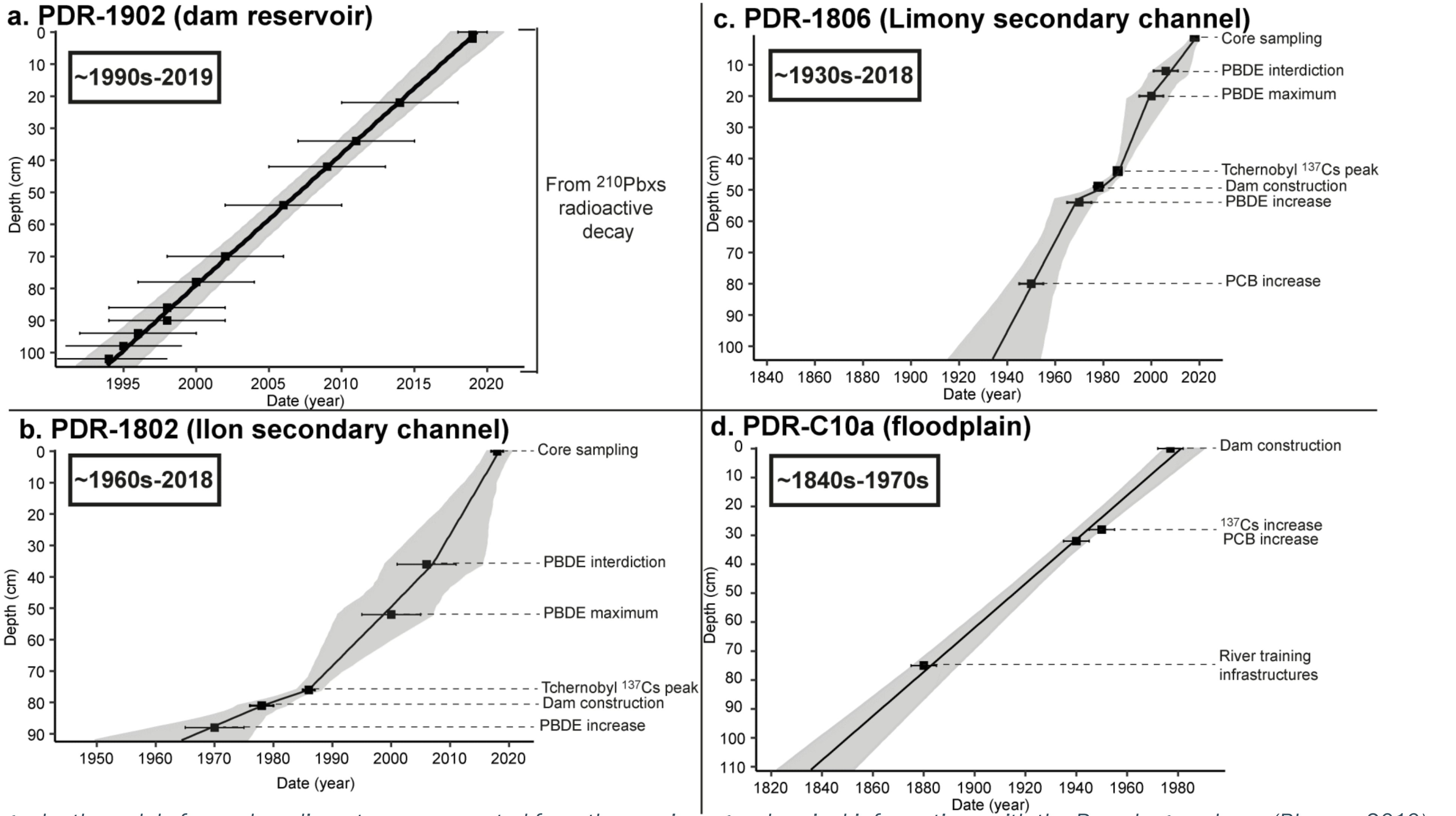


Vertical trends in PCBs and PBDEs normalized to total organic carbon and vertical ^{137}Cs trends

- No ^{137}Cs trend in the dam core but linear regression from ^{210}Pbxs → accumulation rate estimated at 4.2 cm.year^{-1}
- The other ^{137}Cs activity trends are consistent with the contaminants temporal trends

3. Results

3.3. Dating of the sediment cores



Age-depth models for each sediment core, computed from the previous geochemical informations with the R package « clam » (Blaauw, 2010)

→ Each depositional environment recorded a different time-period and display different accumulation rates

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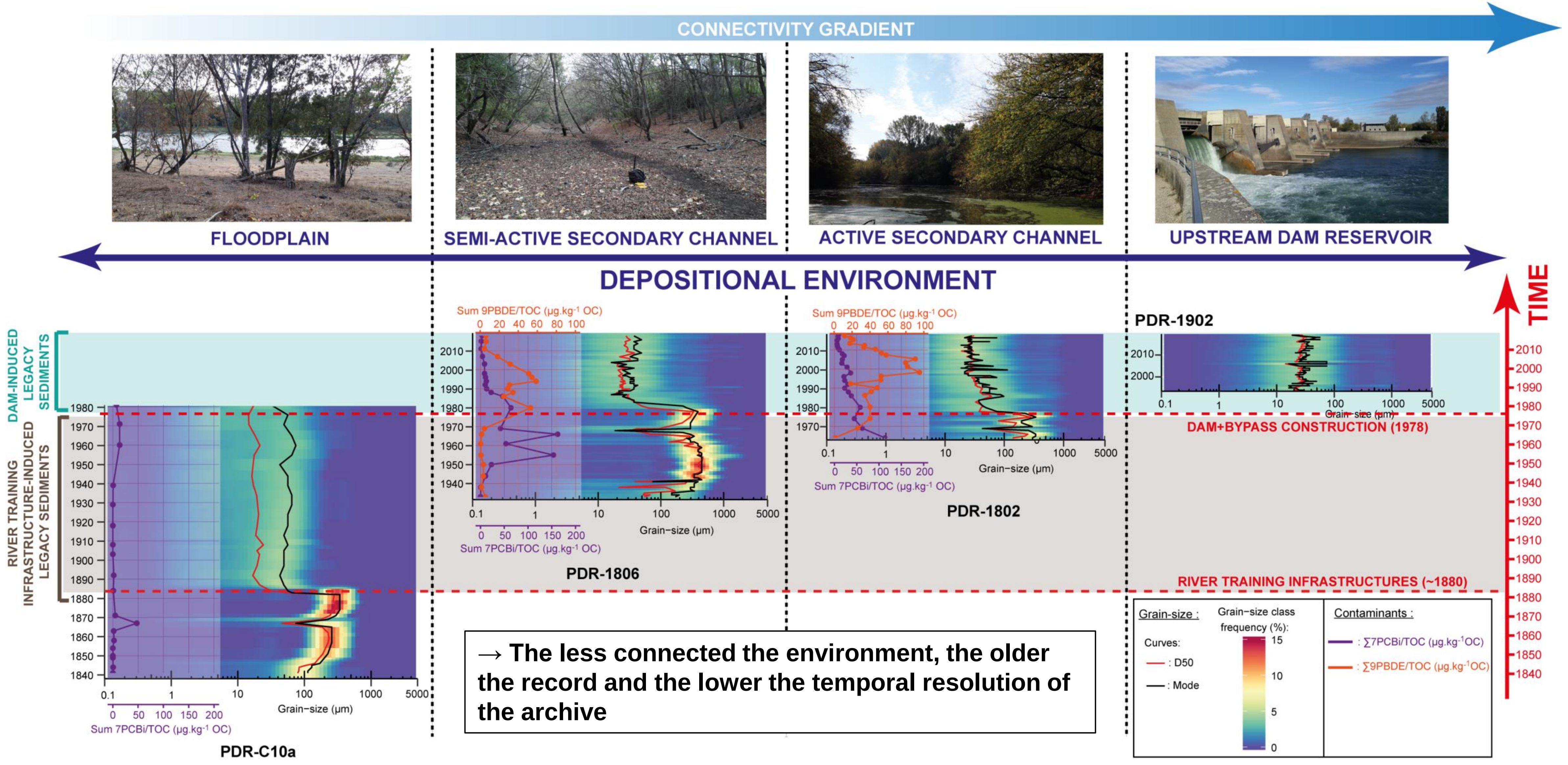
4. Conclusions

4.1. Graphical summary of the results



A summary of the temporal contamination trends and grain-size events recorded in each of the four studied depositional environments.
NB: in this figure, the vertical scale is time rather than depth, using the results from the age-depth models

4. Conclusions

4.2. Take-home messages and outlooks

- Four sedimentary depositional environments in a highly anthropized river recorded four different time-periods

  → **different contamination and human impact archives depending on the depositional environment**

- In our case, the hydraulic **connectivity of the depositional environment** appears as the main explicative factor for the sediment archive characteristics:
  - a highly connected environment creates a short-term, high-resolution chronicle;
  - a poorly connected environment creates a long-term, lower-resolution archive.

- A **shift from the PCBs to the PBDEs as the predominant contaminant in the 1970s** was observed in both secondary channel cores. Besides, PBDEs appear to have a clear and temporally consistent pattern

  → *may be used more systematically as a time-marker in the future?*

- This study illustrates:
  - The **need to understand the nature and dynamics of a depositional environment** when sampling a sediment core in a fluvial context e.g. through **historical analysis** of the study site, **geophysical surveys**, etc.
  - The interest of **sampling multiple sediment cores in various depositional environments** for a full characterization of the archive of a fluvial system.

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