

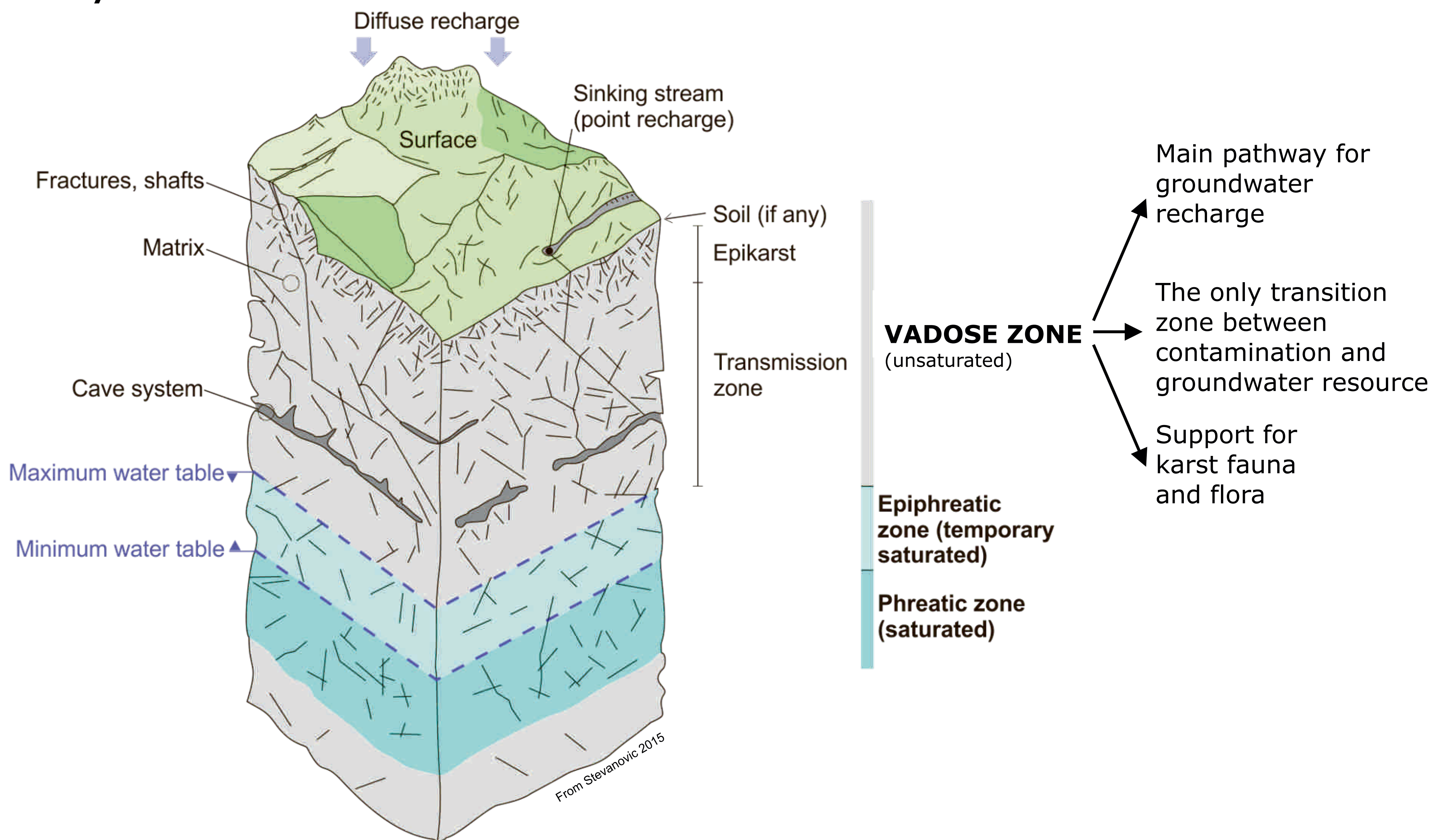
Factors influencing karst aquifer recharge as evidenced through vadose dye tracing

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Why do we care about karst vadose zone ?

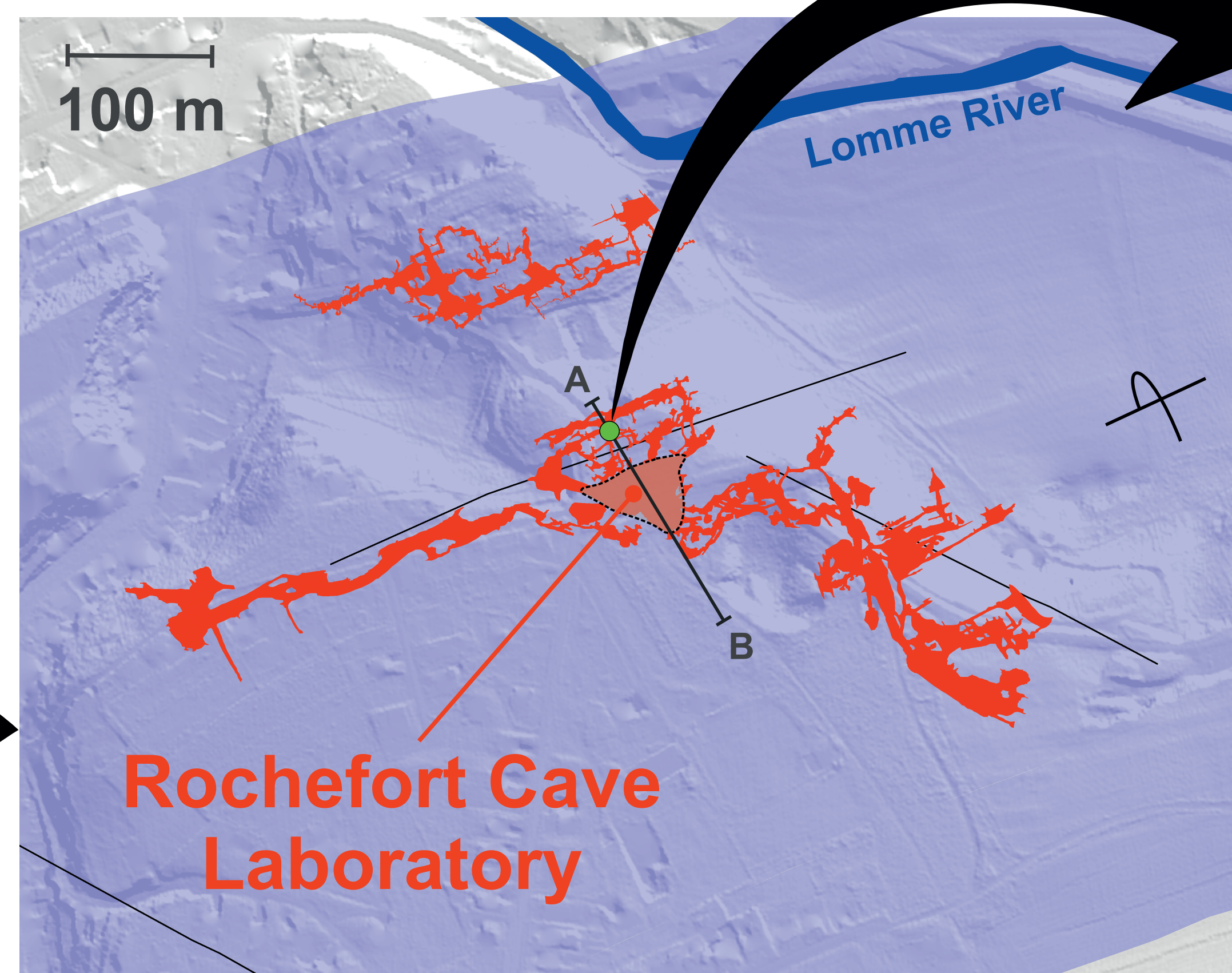
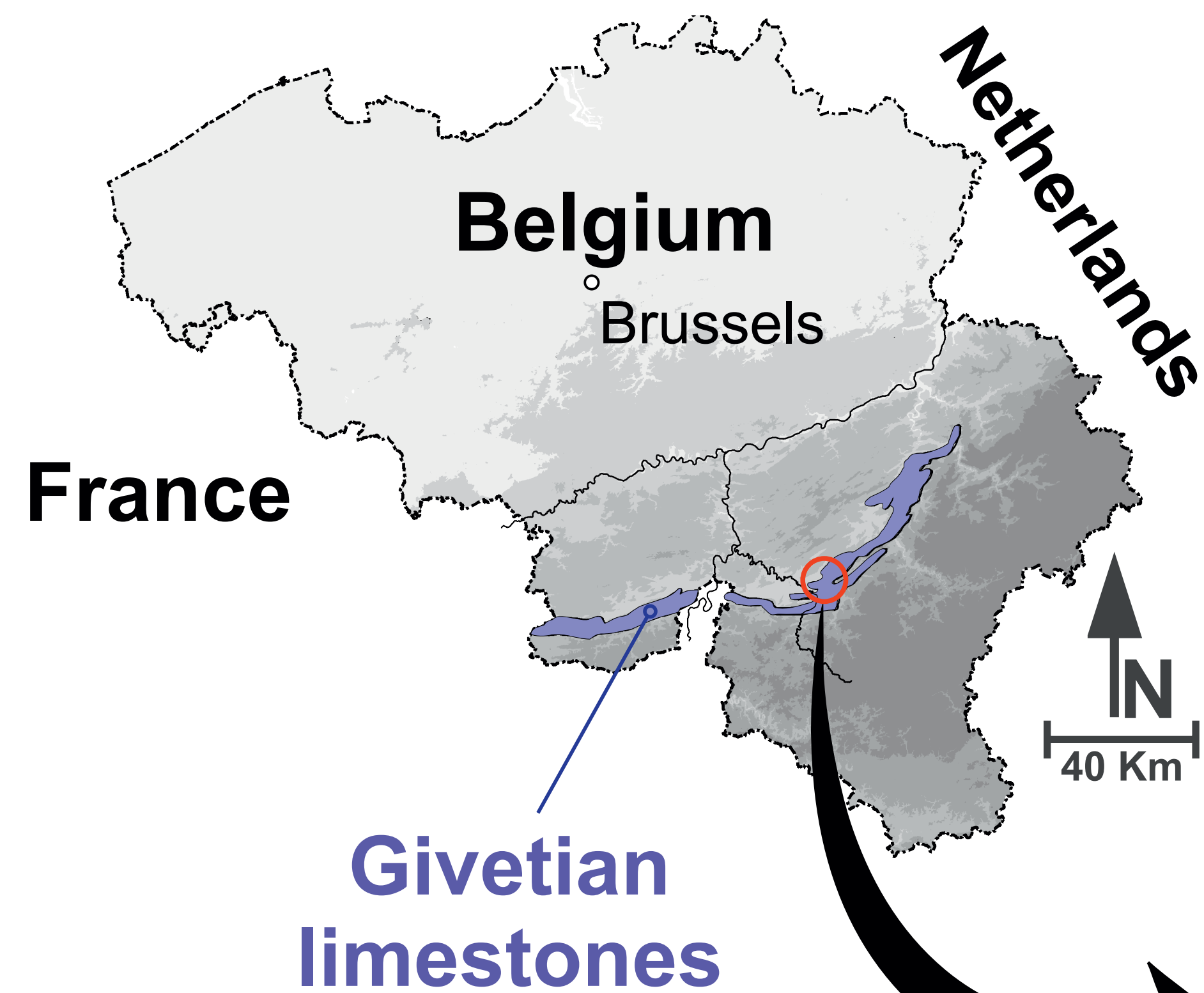


It forms a **highly heterogeneous media**, with a heterogeneous hydrogeological behavior → difficult to study, conceptualize and model.

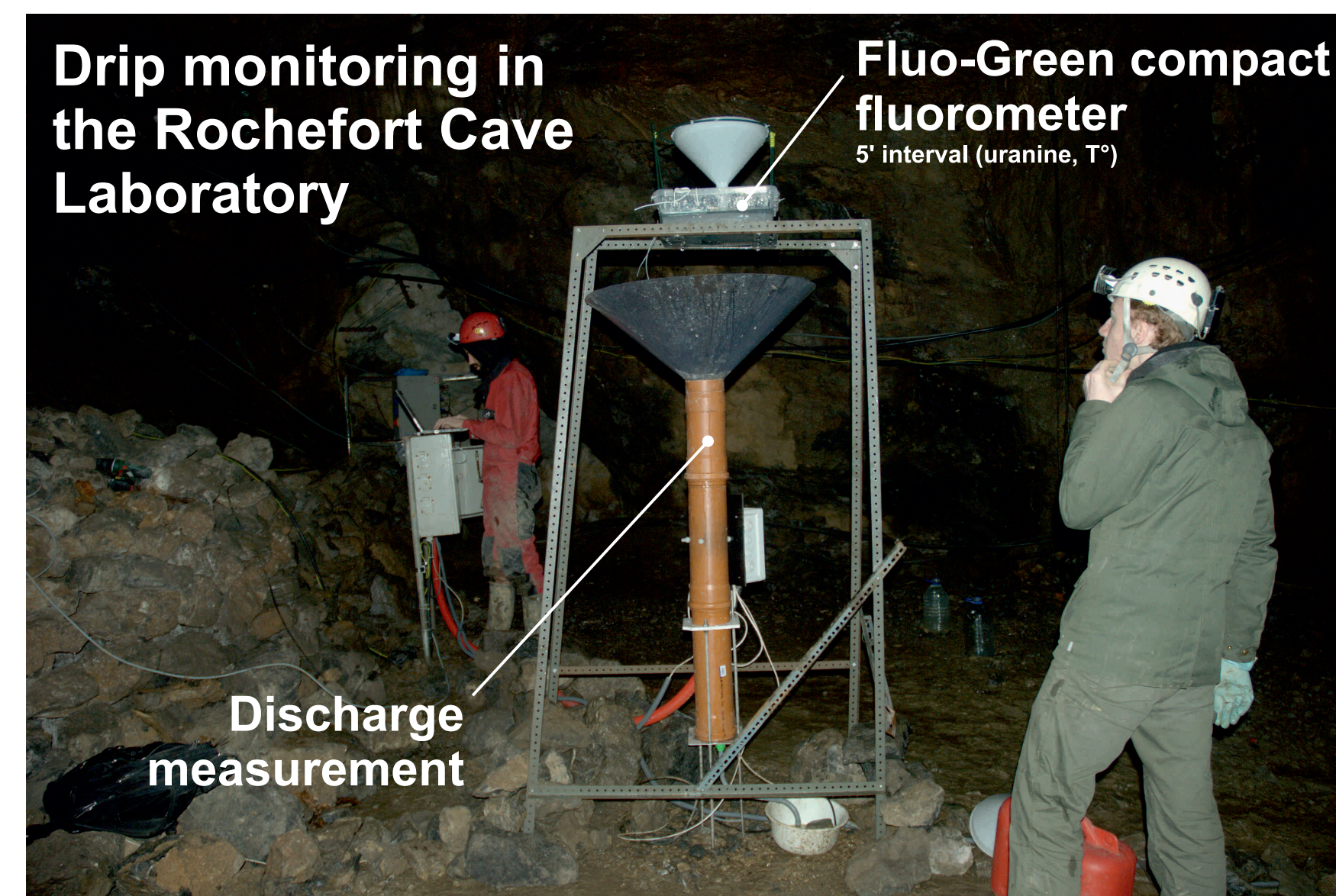
- What are its main **hydrogeological functions** ?
- What are the **factors influencing recharge and vulnerability** ?

Study site & methodology

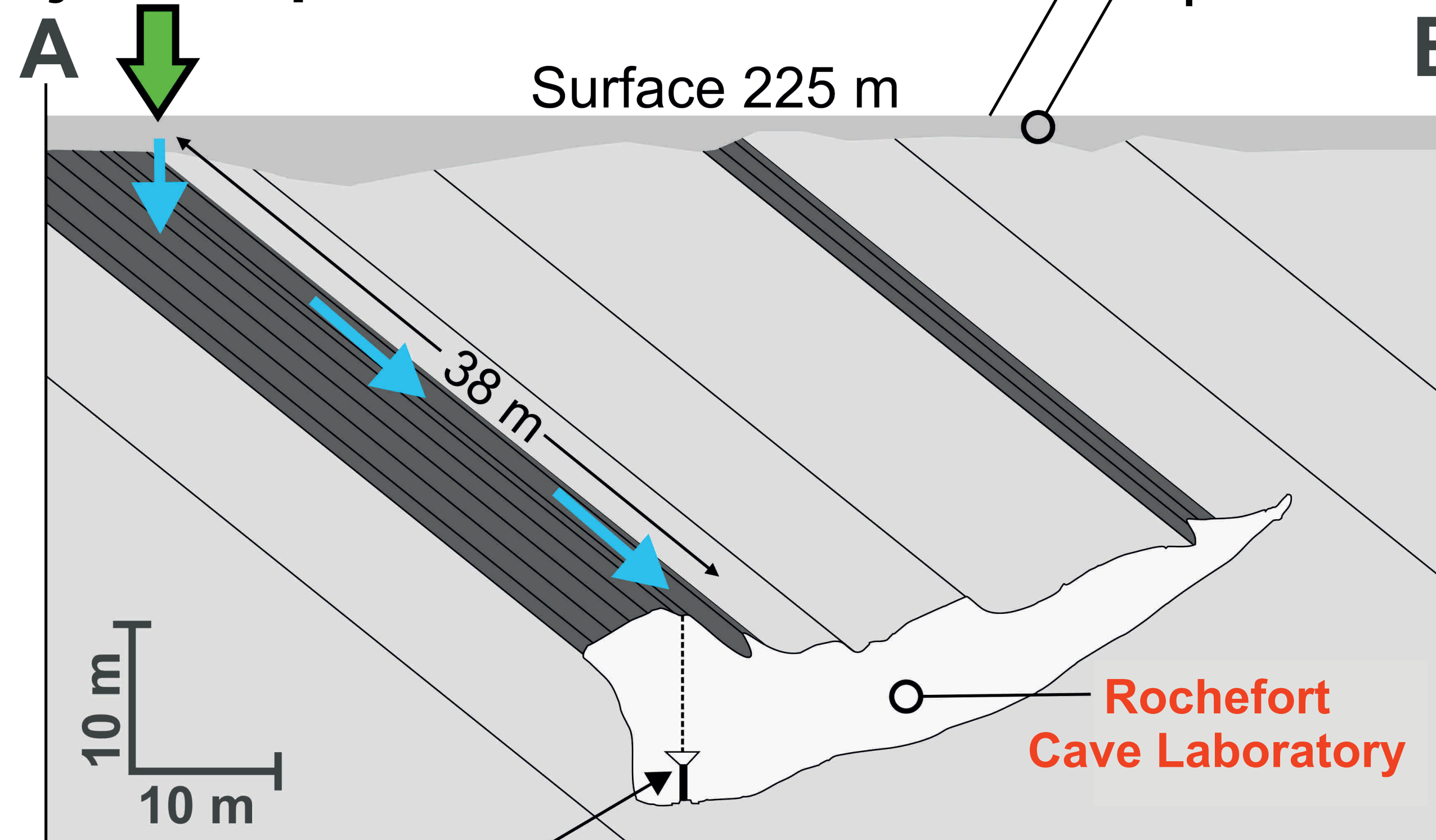
Poulain et al. 2017



Surface dye injection
Uranine - 500g



Dye injection point



Drip monitoring and fluorometer

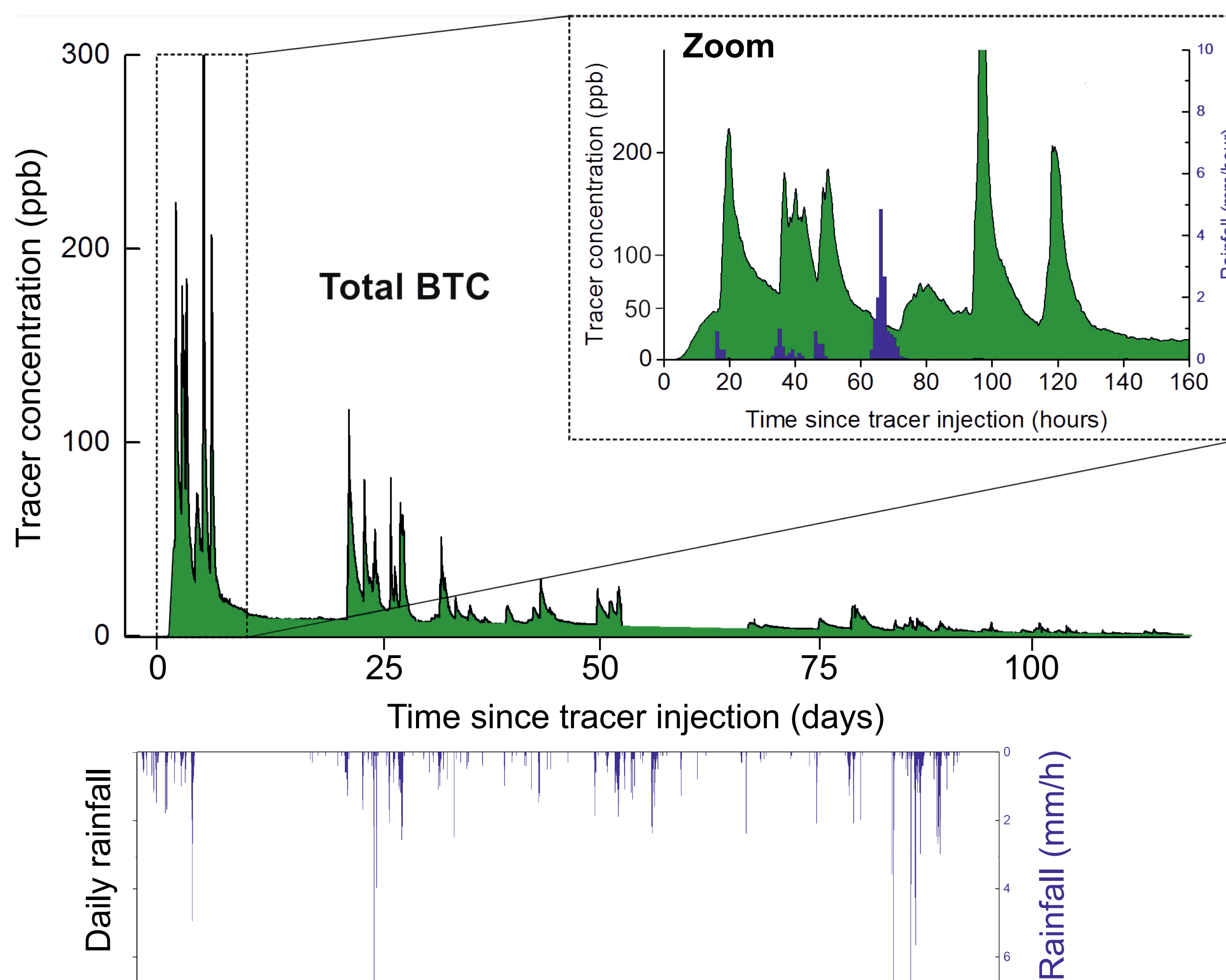
- Massive limestones
- Clayey limestones

→ Supposed direction of infiltration

What influences karst aquifer recharge ?

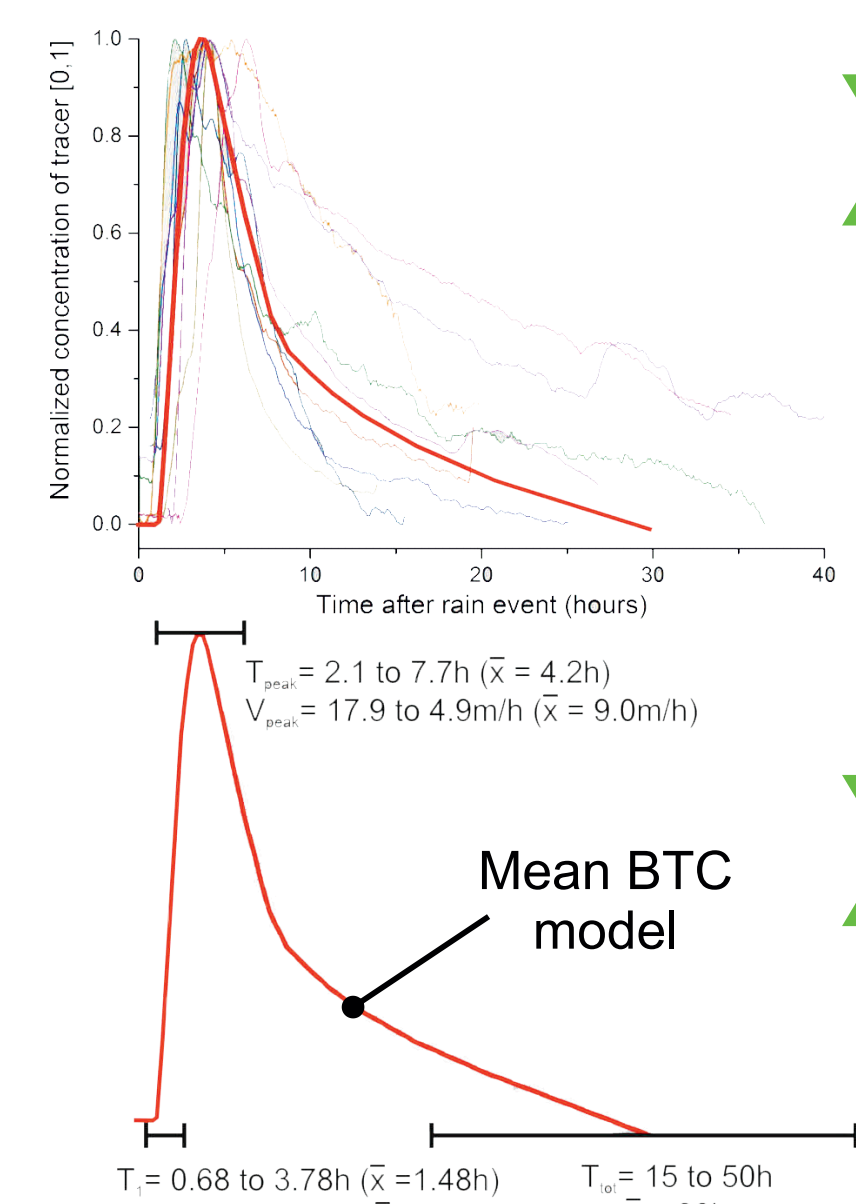
Field results

Poulain 2017
Poulain et al. 2018



- Multimodal breakthrough curve with **decreasing dye concentration**
 - Dye concentration is **highly correlated** with drip discharge variation and surface rainfall
- First arrival** : 3h45 after injection (max. velocity 10 m/h)
Already a quick infiltration in absence of rainfall !
- Sharp increases of dye concentration** due to rainfall events
- Quick decreases of dye concentration after the rainfall events
Total recovery rate : 0.07%
- 16 secondary dye peaks** triggered by rainfall were identified
The maximum dye concentration decreases with time → defined amount of dye that is remobilized by rainfall

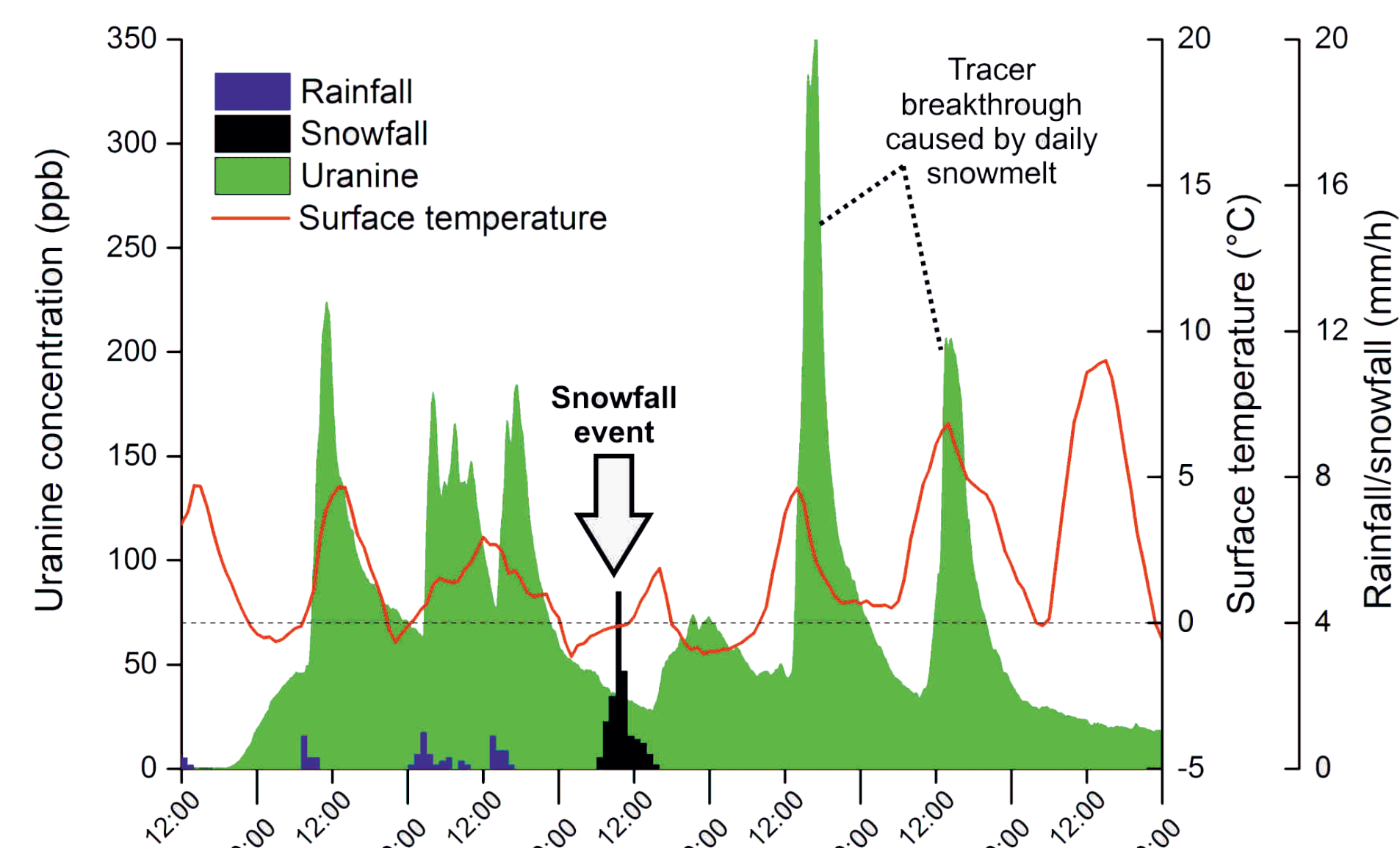
Rainfall intensity effect



- Normalized on a [0 to 1] scale from the time of the rain event they exhibit similar characteristics (1st arrival, peak time).
- The **remobilization of dye** by rainfall follows a defined dynamic, the recharge behavior is the same.
- The **mean behavior** of secondary restitution peaks triggered by rainfall :
 - Mean first arrival : 1h30 (25 m/h)
 - Mean peak time : 4h10 (9 m/h)

We highlight two factors influencing the recharge of karst aquifer through the vadose zone

Snowmelt effect

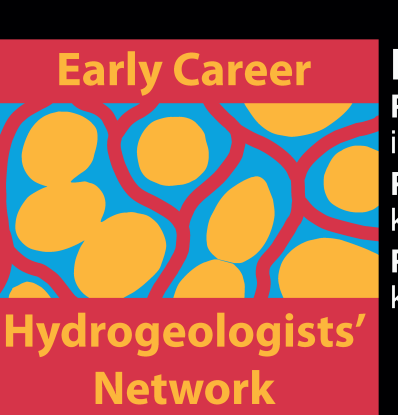


- Two secondary peaks are triggered by snow cover melting as the temperature goes > 0°C
- Dye concentration of snowmelt-triggered peaks is different than rainfall-triggered peaks
- It does not follow the decrease in dye concentration observed for rainfall
- ! Only two occurrences, should get more observation to draw representative conclusions...but...

Snowmelt has a different behavior than rainfall when infiltrating through vadose zone

Take home message

- Diffuse recharge is a **quick process** in karst vadose zone (10 to 55 m/h)
- Vadose zone is **not** a protection media
- Contamination may be quick but has long-term consequences (slow remobilization)
- Residence time may be very long (months-years)
- **Two factors for infiltration/recharge control** : **Rainfall intensity + type of input (rain or snow)**
- **What is the impact of extreme climatic events, water cycle change, heavy rainfall... on the karst groundwater resources recharge and quality ?**



References
Poulain et al. 2017 - A compact field fluorometer finds its application to dye tracing in karst environments. *Hydrogeology Journal*
Poulain 2017 - Flow and transport characterization in vadose and phreatic zones of karst aquifers. PhD Thesis, University of Namur, Belgium.
Poulain et al. 2018 - Assessment of groundwater recharge processes through karst vadose zone by cave percolation monitoring. *Hydrological Processes*

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