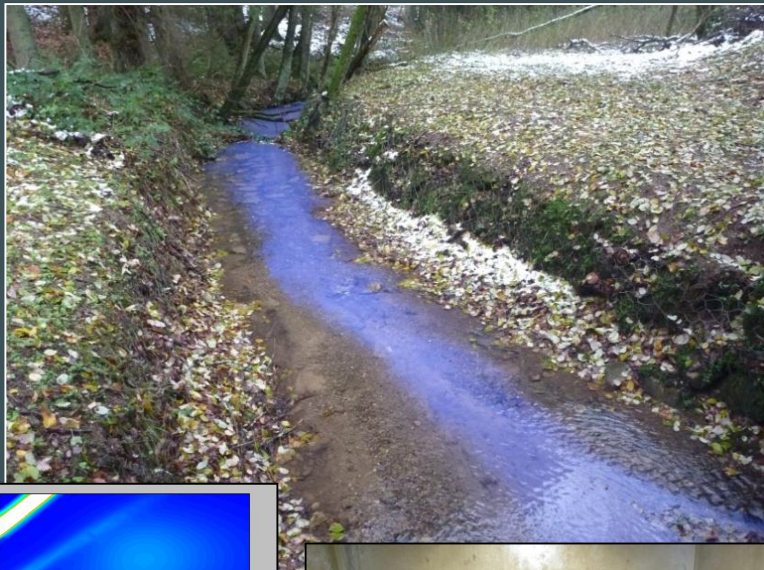
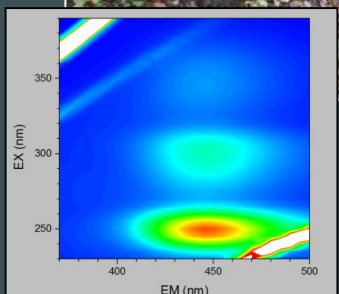


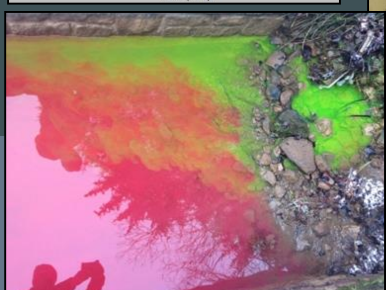
Fluorescence techniques to assess the immediate vulnerability of ground-waterworks

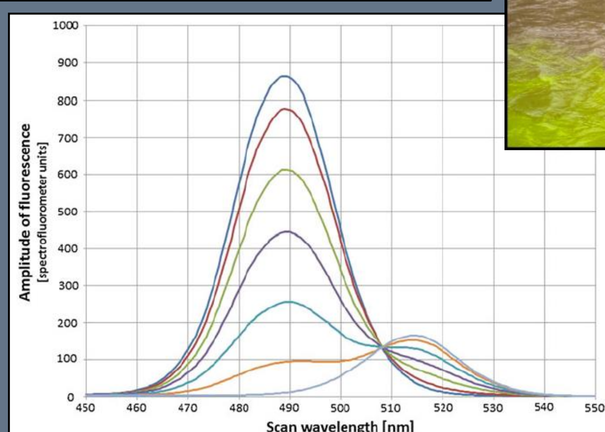
Philippe Meus

European Water Tracing Services sprl
& Aquapôle – University of Liège (Belgium)

GQ 2019 - Liège (Belgium)
9-12 September 2019







Aquapôle

LIÈGE université

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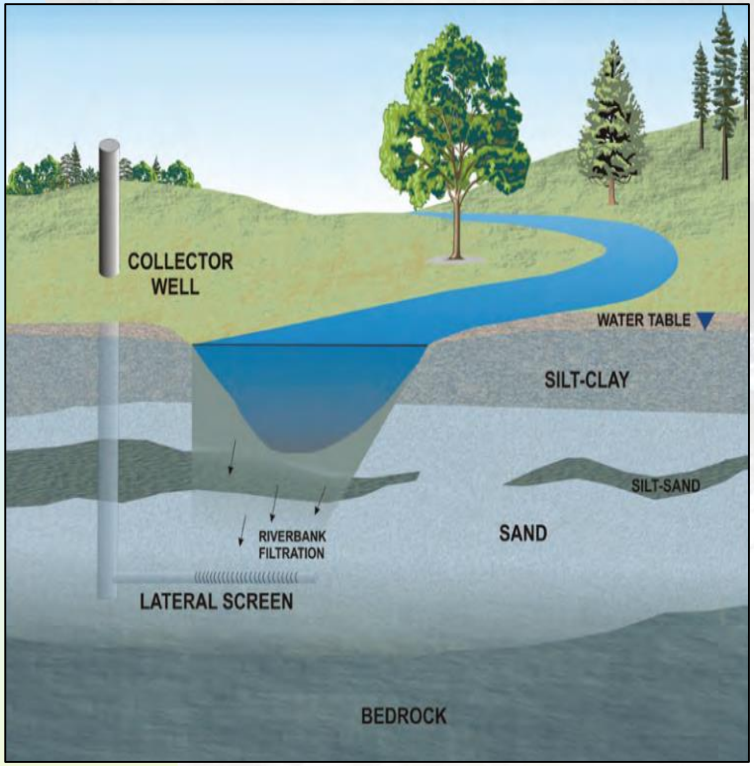
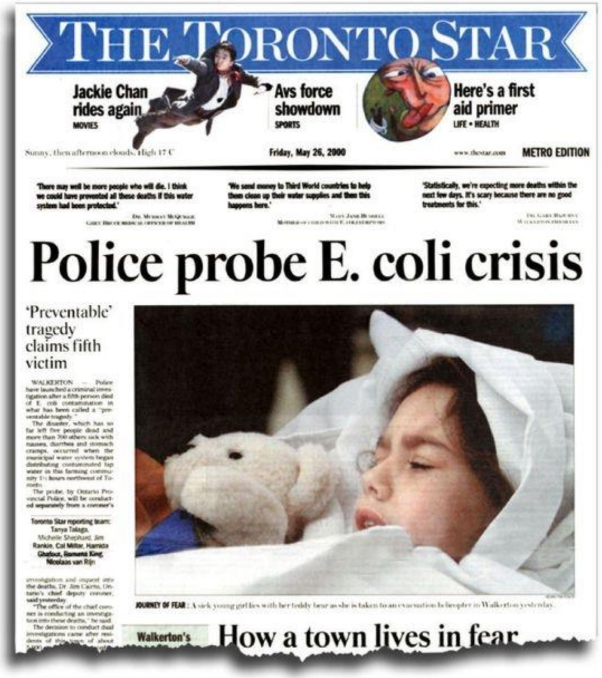


- Bank (bed) infiltration is an important mechanism for recharge, and fortunately, because otherwise groundwater ressources would be quite low
- Many drinking waterworks (mainly springs) are not so far from surface streams
- Situation at risk when shortcuts (preferential paths) do exist, especially in fissured and karst media
- This immediate vulnerability is often underestimated (or at least not localized) until some real crisis happens
- Need for specific methodologies for site characterization and dimensioning protection measures -> **do artificial tracer tests may help?**


THE TORONTO STAR

Jackie Chan rides again
MOVIES

Avs force showdown
SPORTS

Here's a first aid primer
LIFE • HEALTH

Friday, May 26, 2000

METRO EDITION

'There may well be more people who will die. I think we could have prevented all these deaths if this water system had been protected.'

'We send money to Third World countries to help them clean up their water supplies and then this happens here.'

'Statistically, we're expecting more deaths within the next few days. It's scary because there are no good treatments for this.'

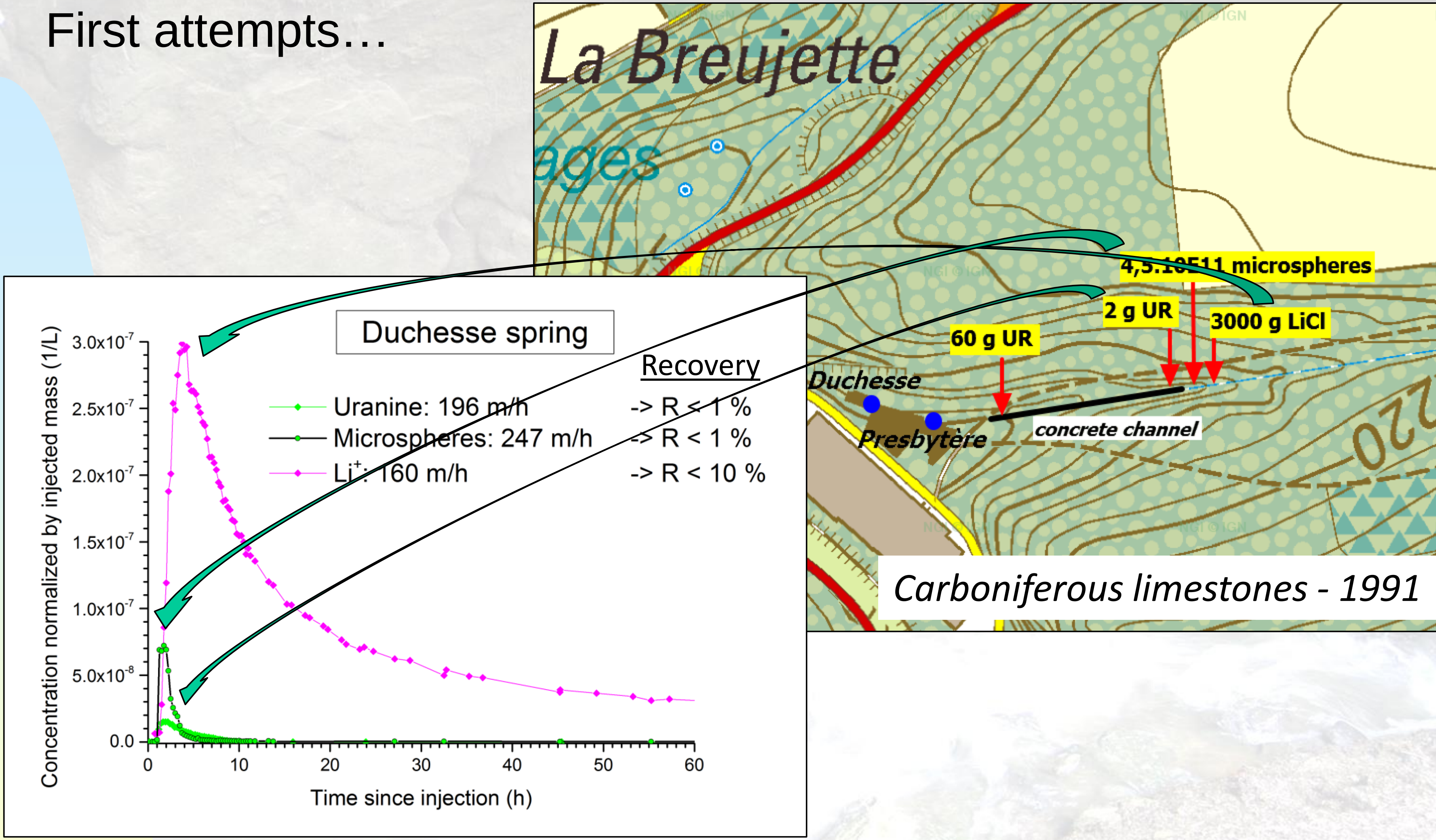
Police probe E. coli crisis

'Preventable' tragedy claims fifth victim

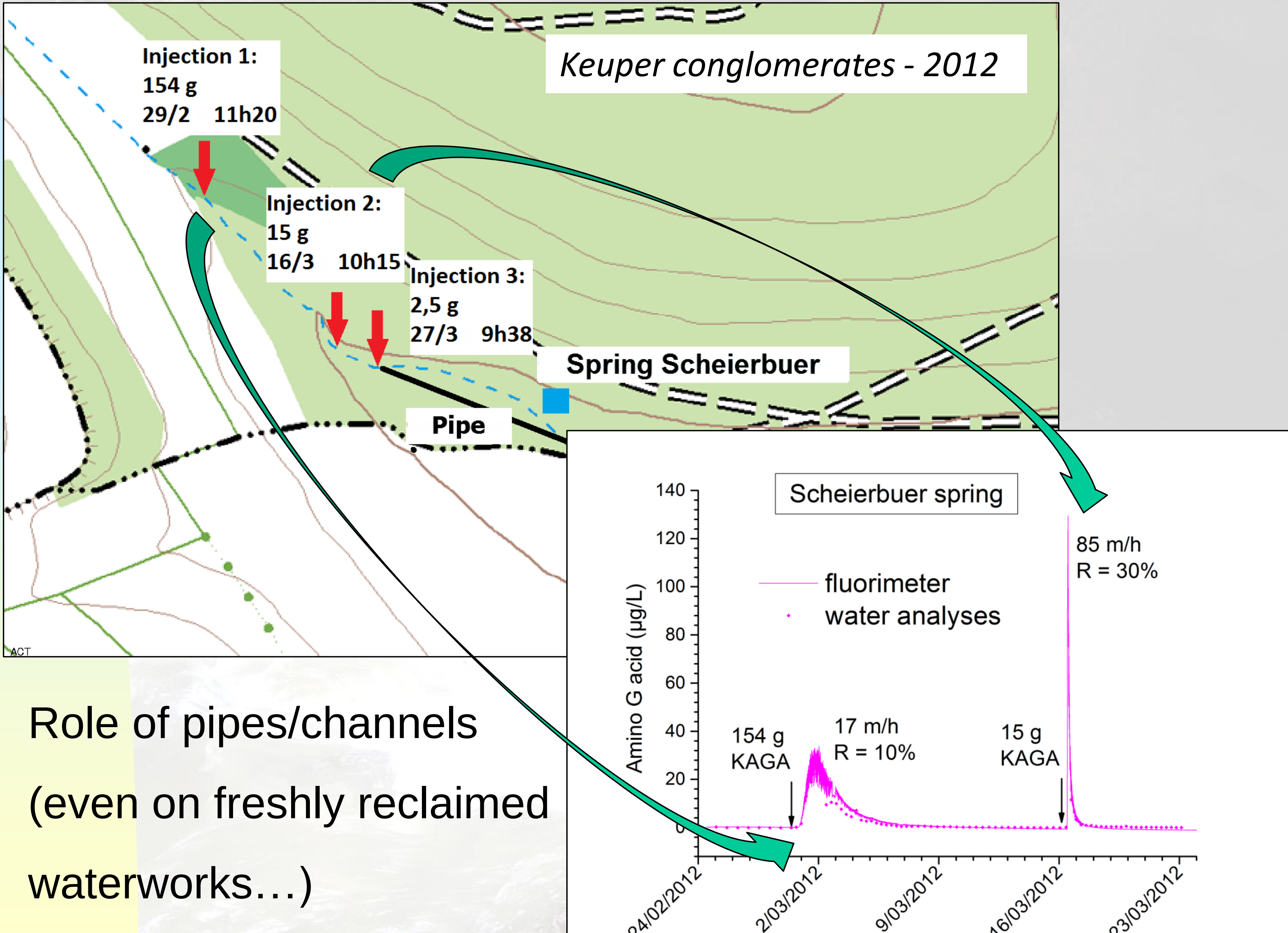
Walkerton's How a town lives in fear

- Walkerton crisis (Canada, May 2000)
- 2300 people ill, 7 people died
- Karst aquifer, wellhead protection zone based only on modelling
- conjunction of E. Coli from manure spreading and treatment default…

First attempts…



What is the most determinant, tracers themselves or their routes?



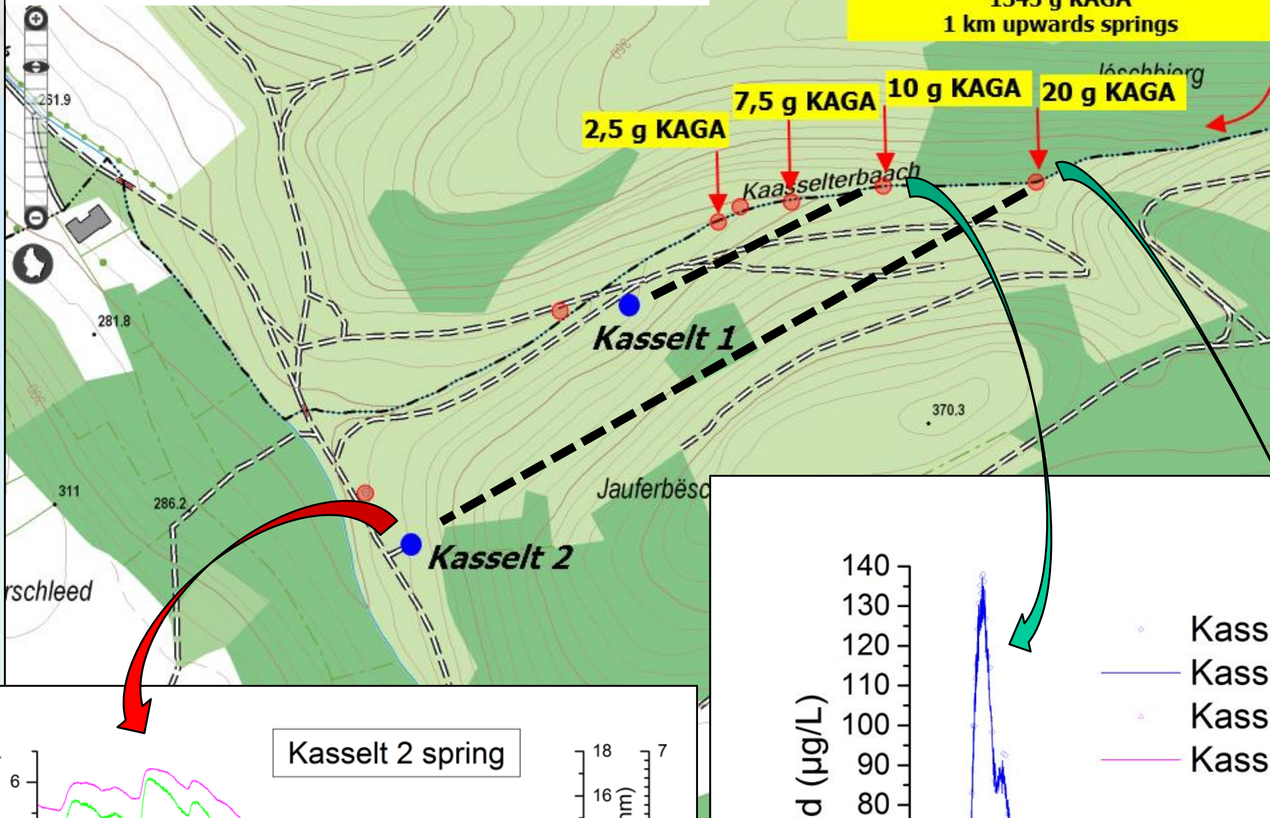
Role of pipes/channels

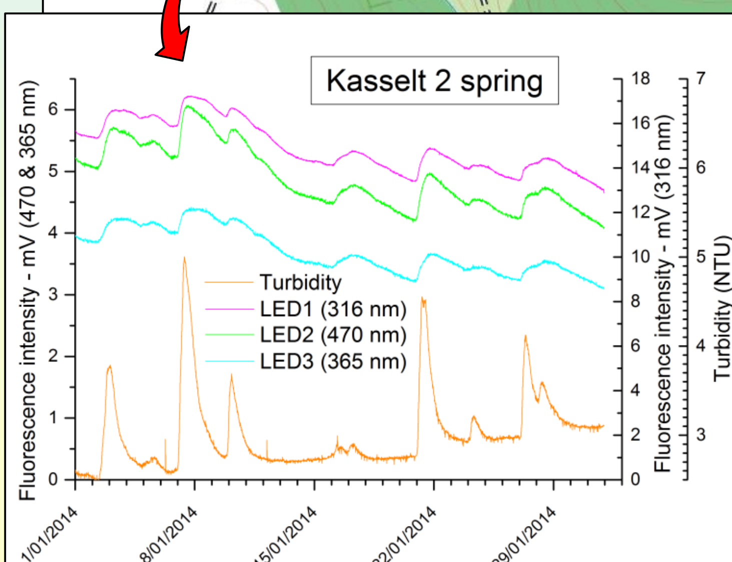
(even on freshly reclaimed

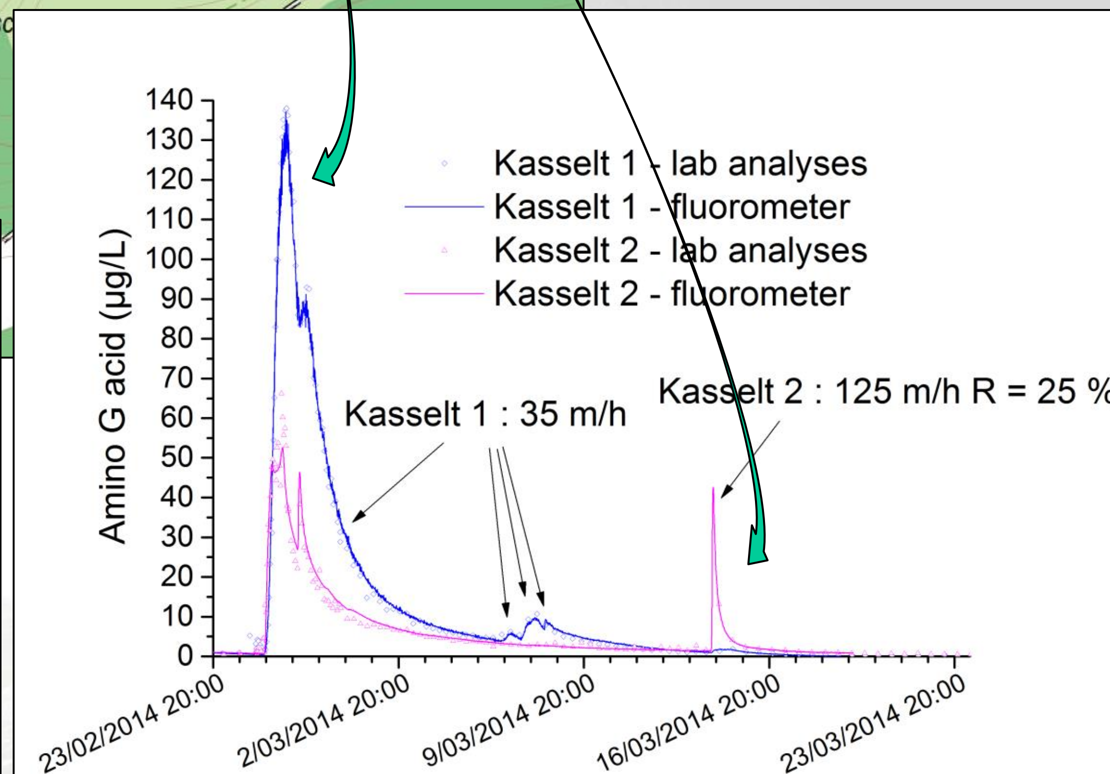
waterworks…)

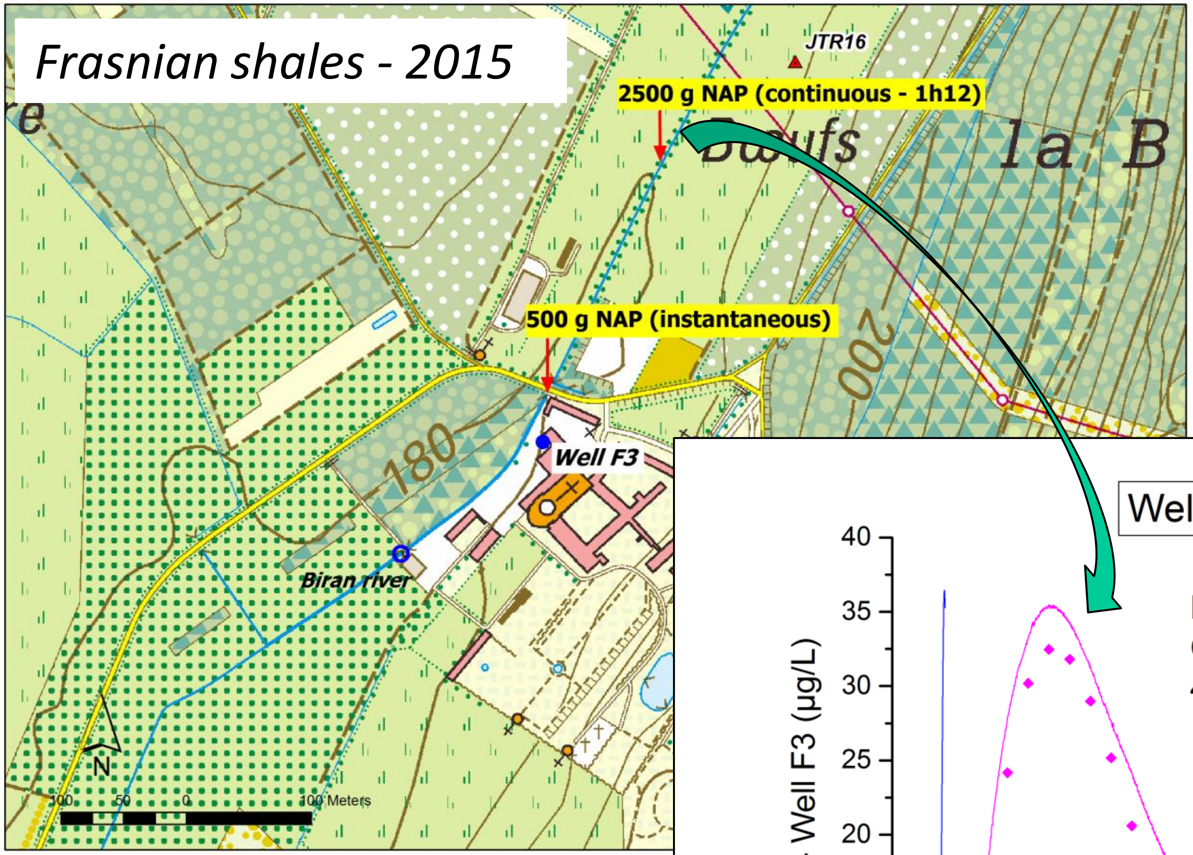
Sinemurian sandstones - 2014

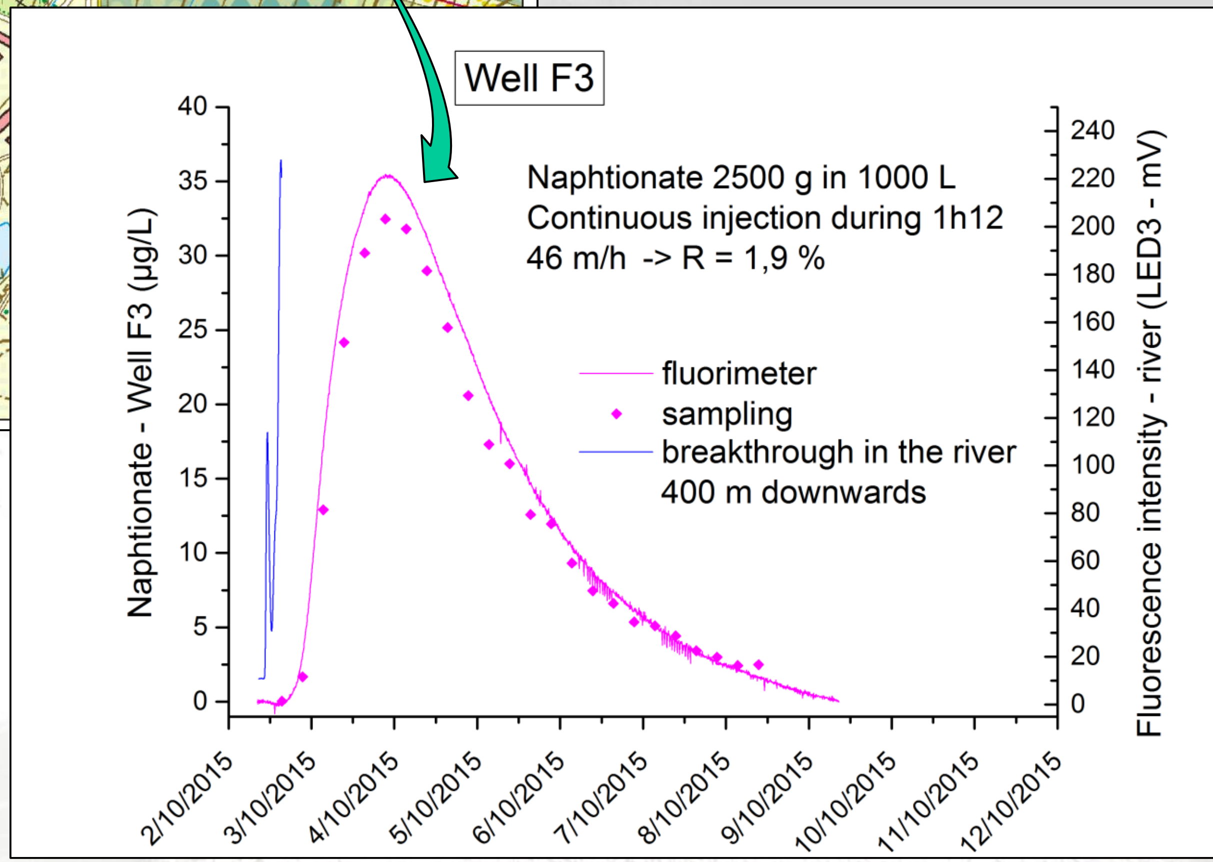
- Fluorescence monitoring with fluorometers
- Instantaneous versus continuous injection
- Role of fissuration





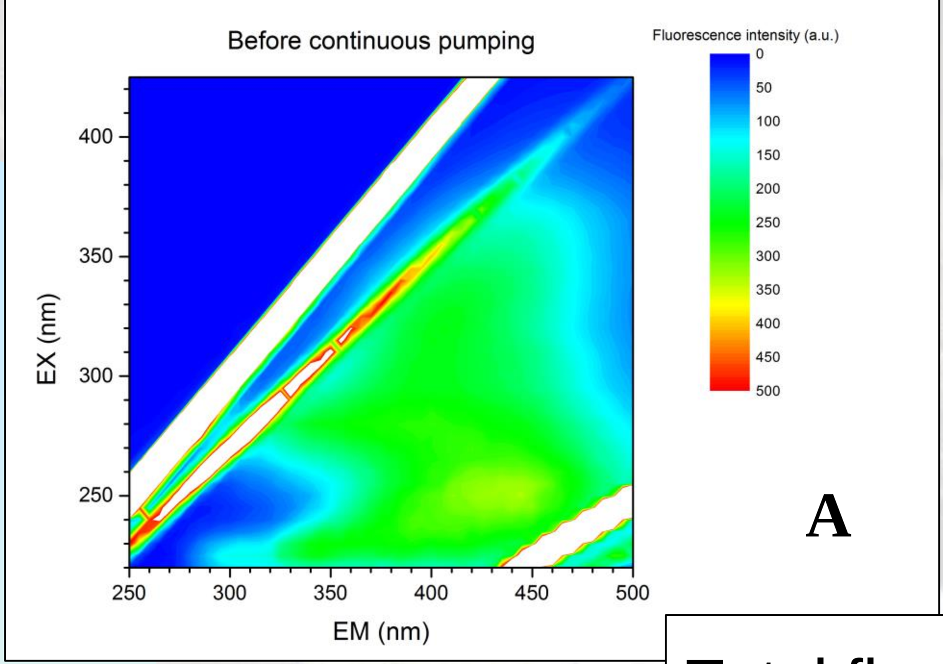


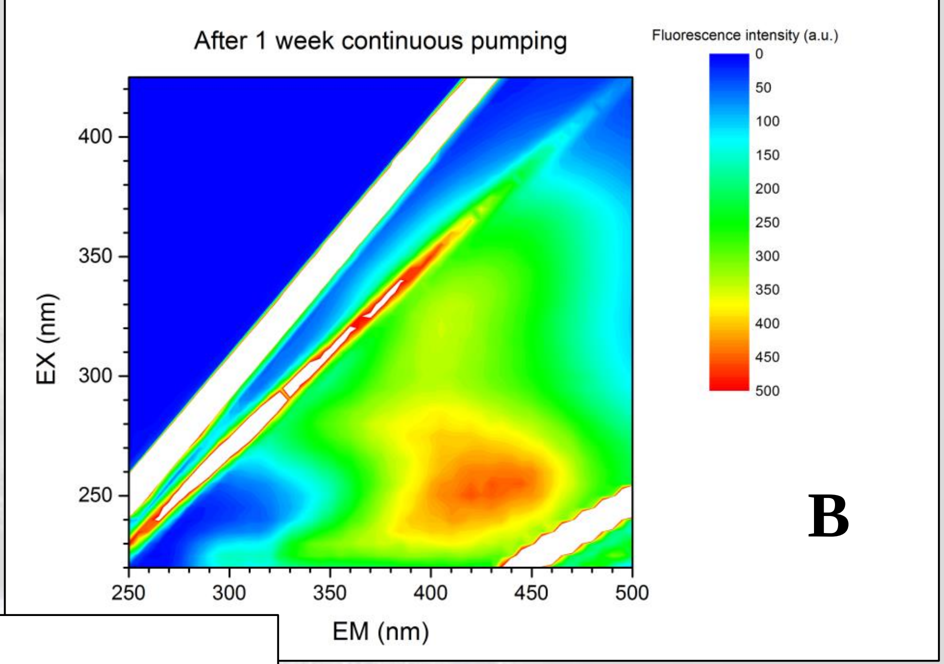




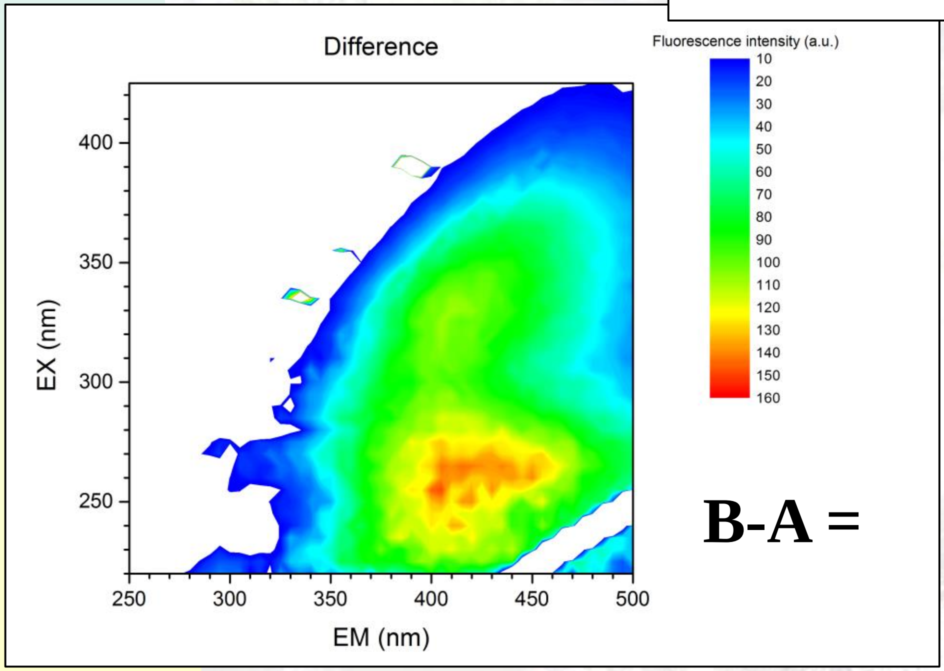
Capture by pumping

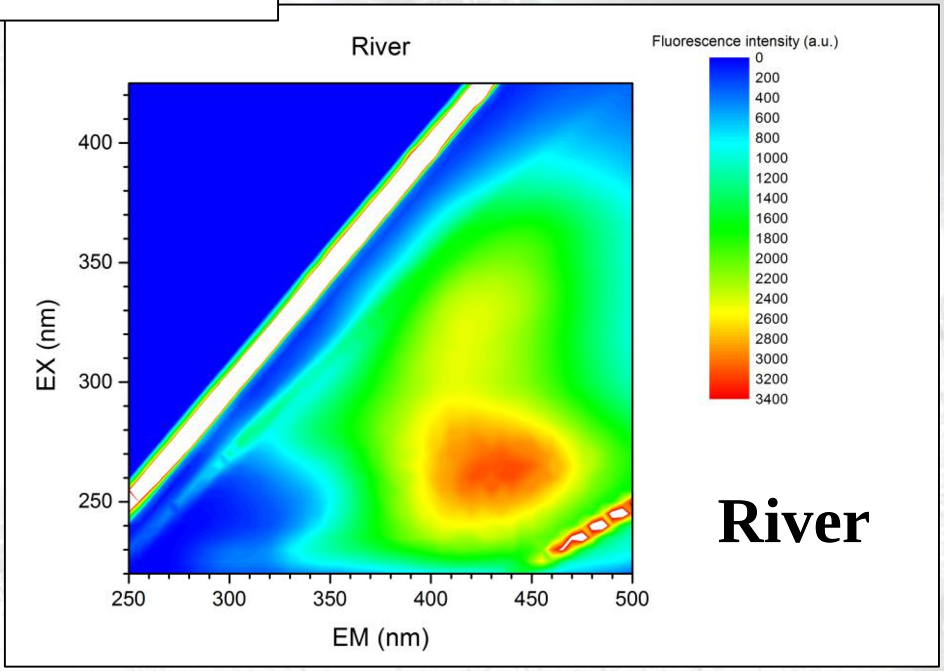
(22 m³/h)

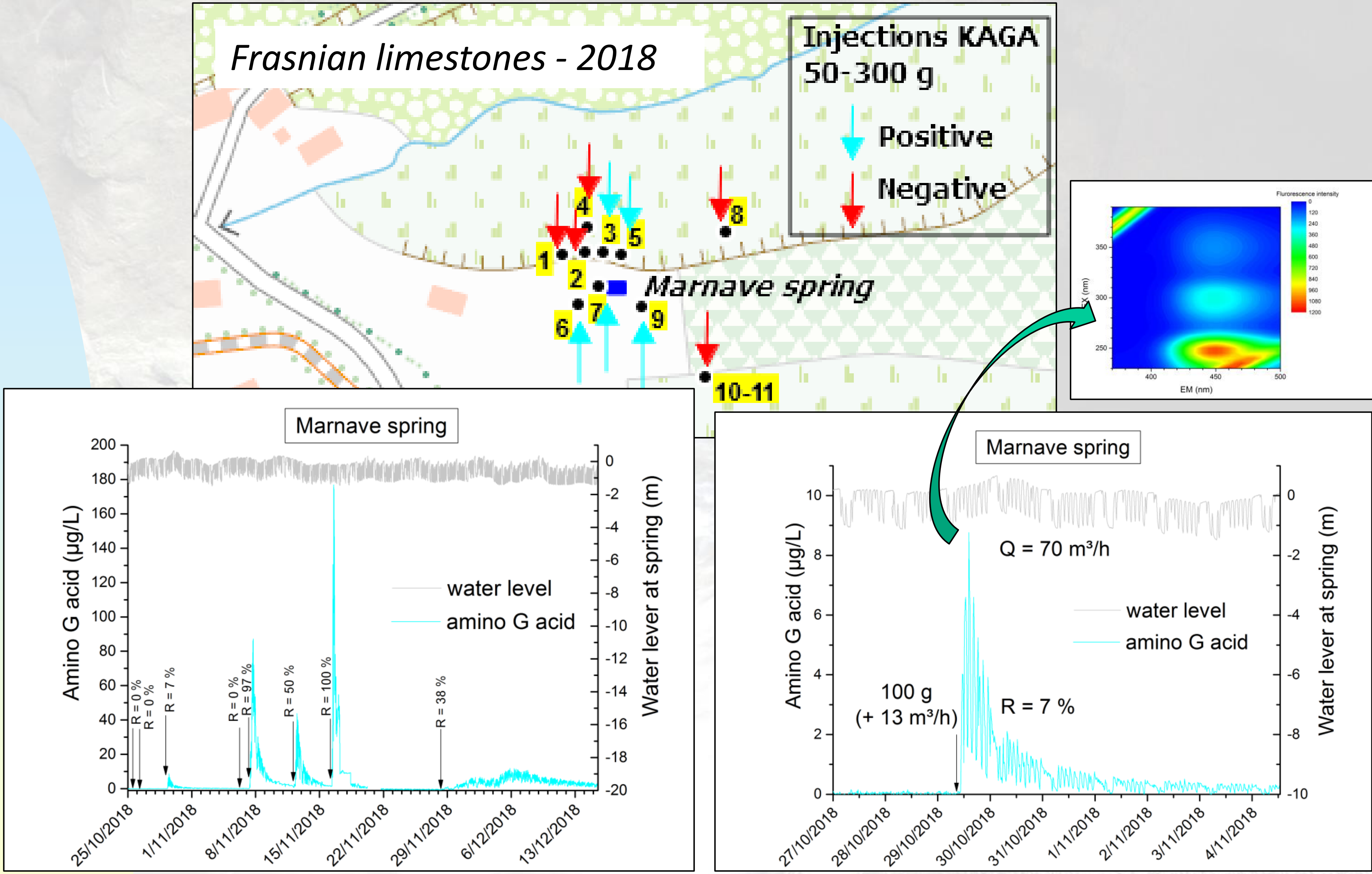




Total fluorescence

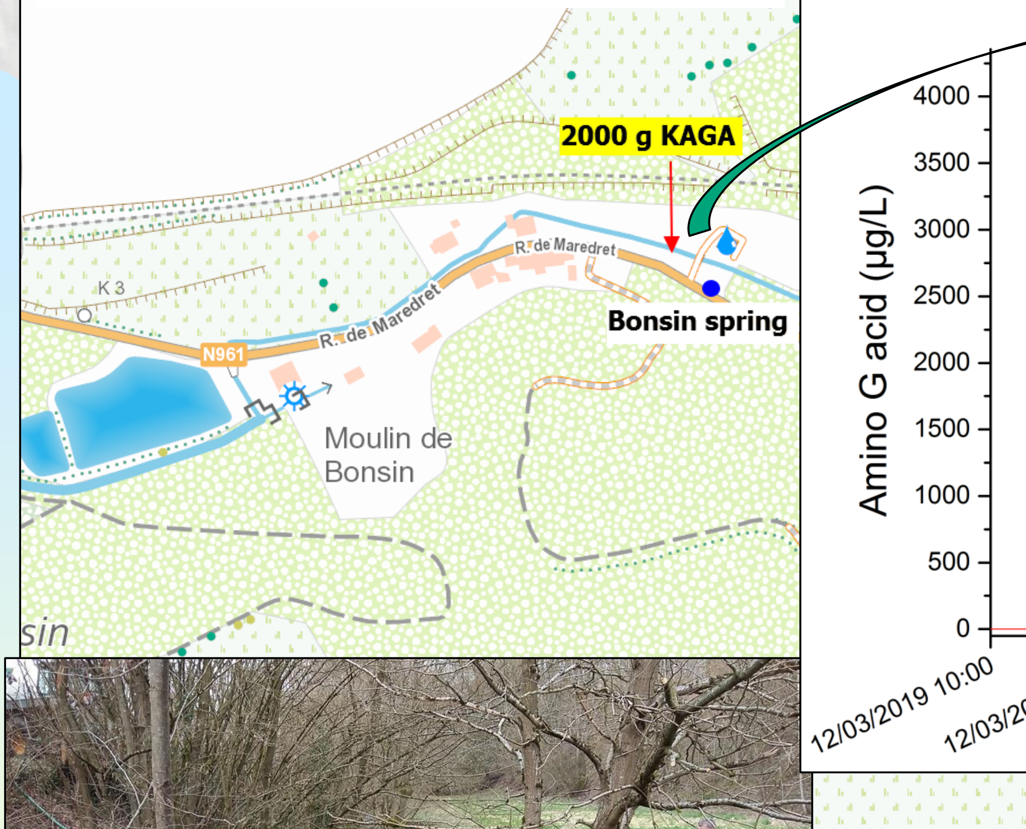


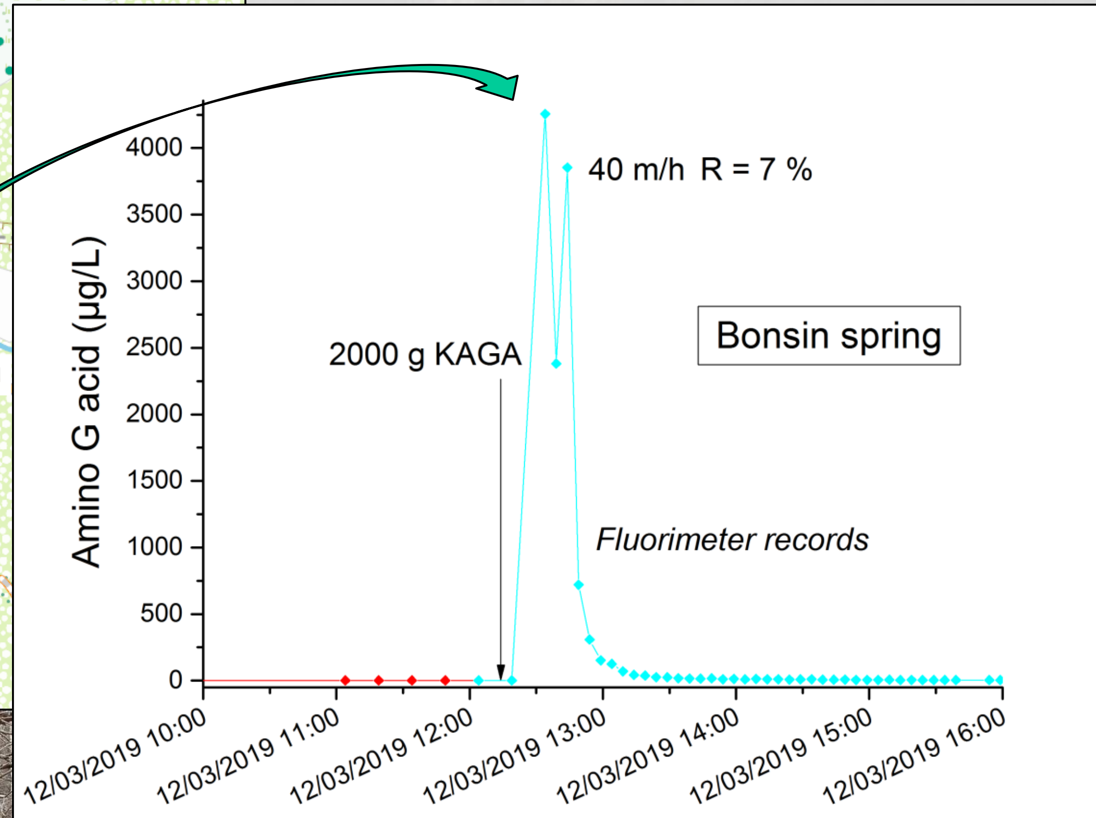


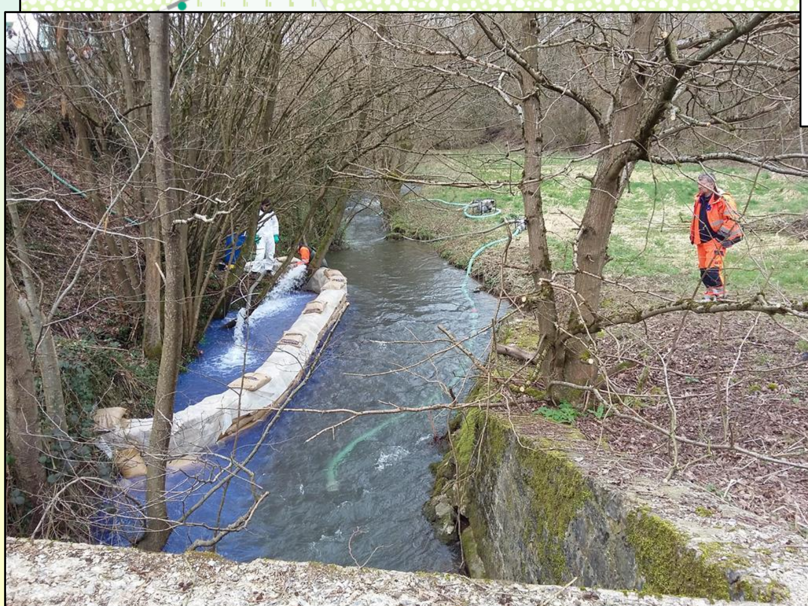


Successive tests with the same tracer (amino G acid) in multiple points for testing immediate vulnerability in a flood plain

Carboniferous limestones - 2019

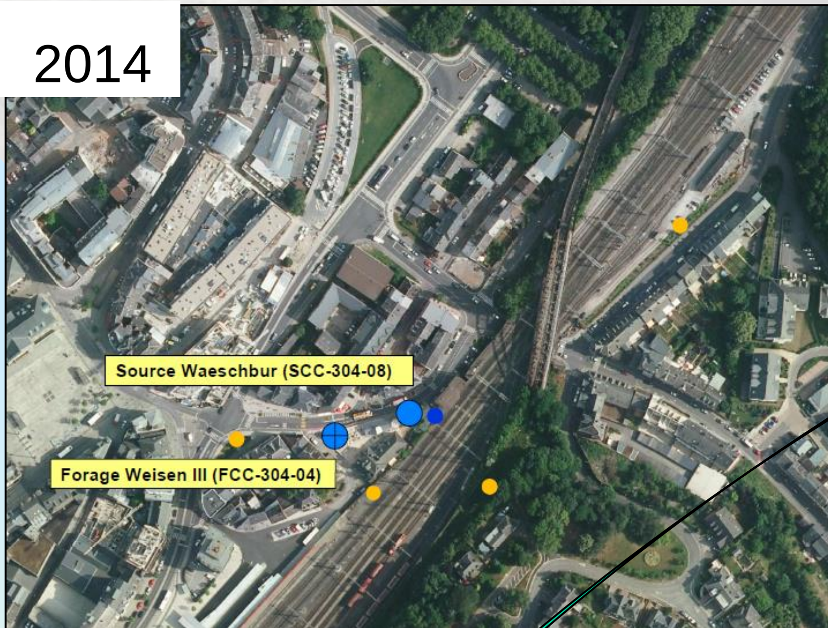


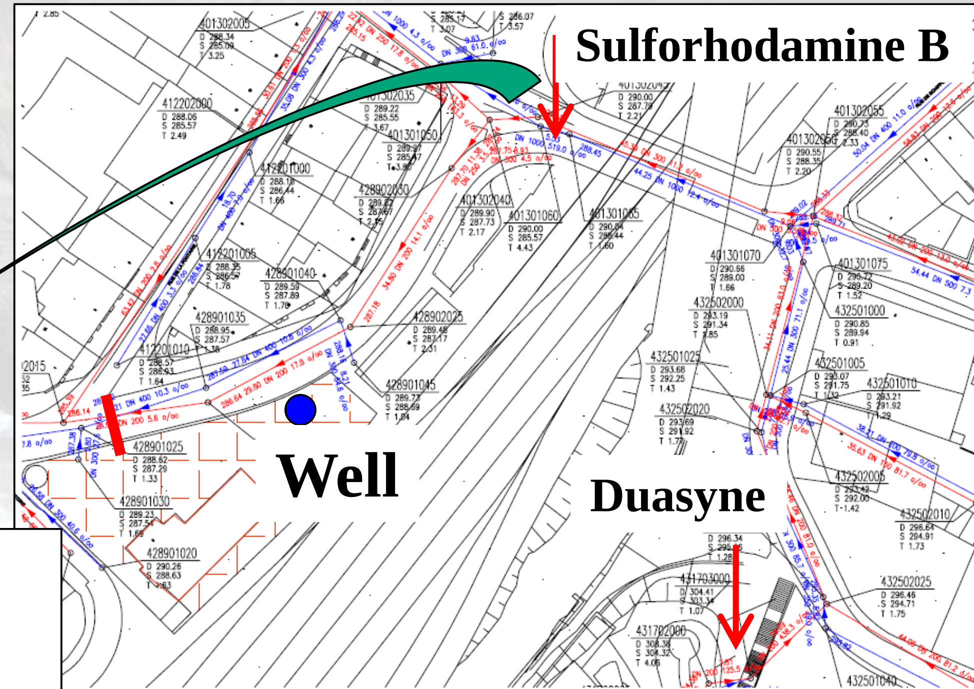


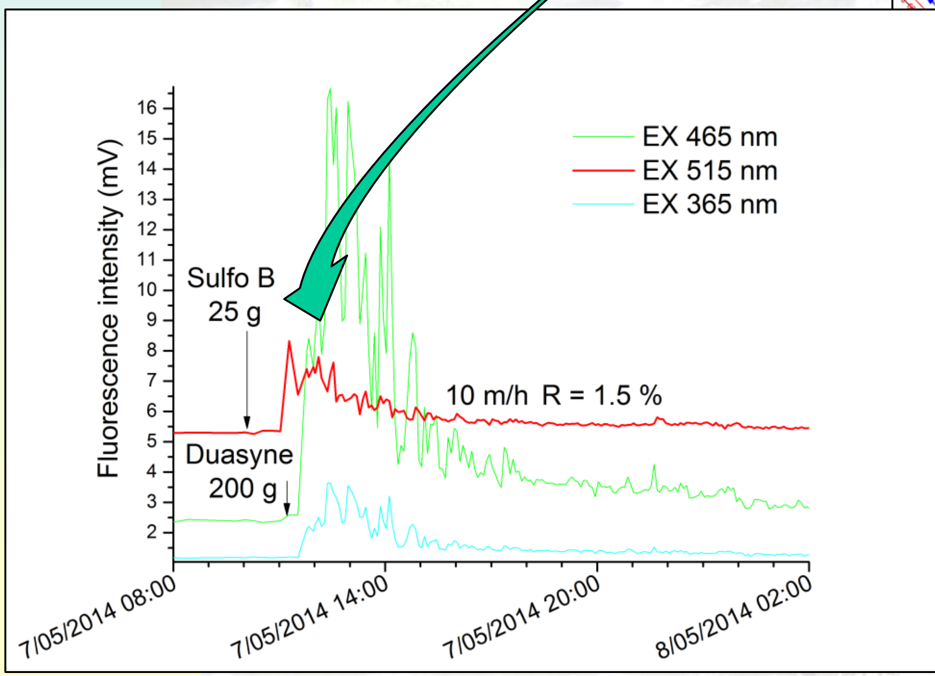


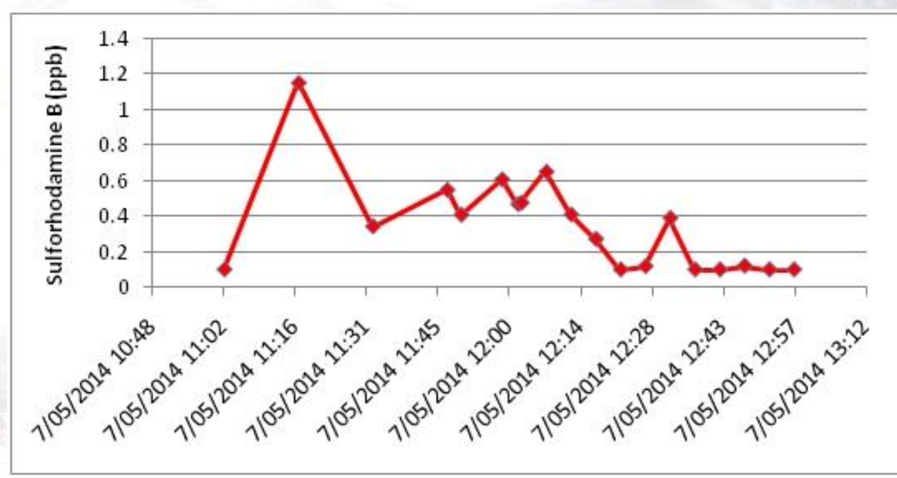
- Use of a dam to concentrate injection
- Quick response -> need of fluorometer

Urban context - leaking sewage pipes

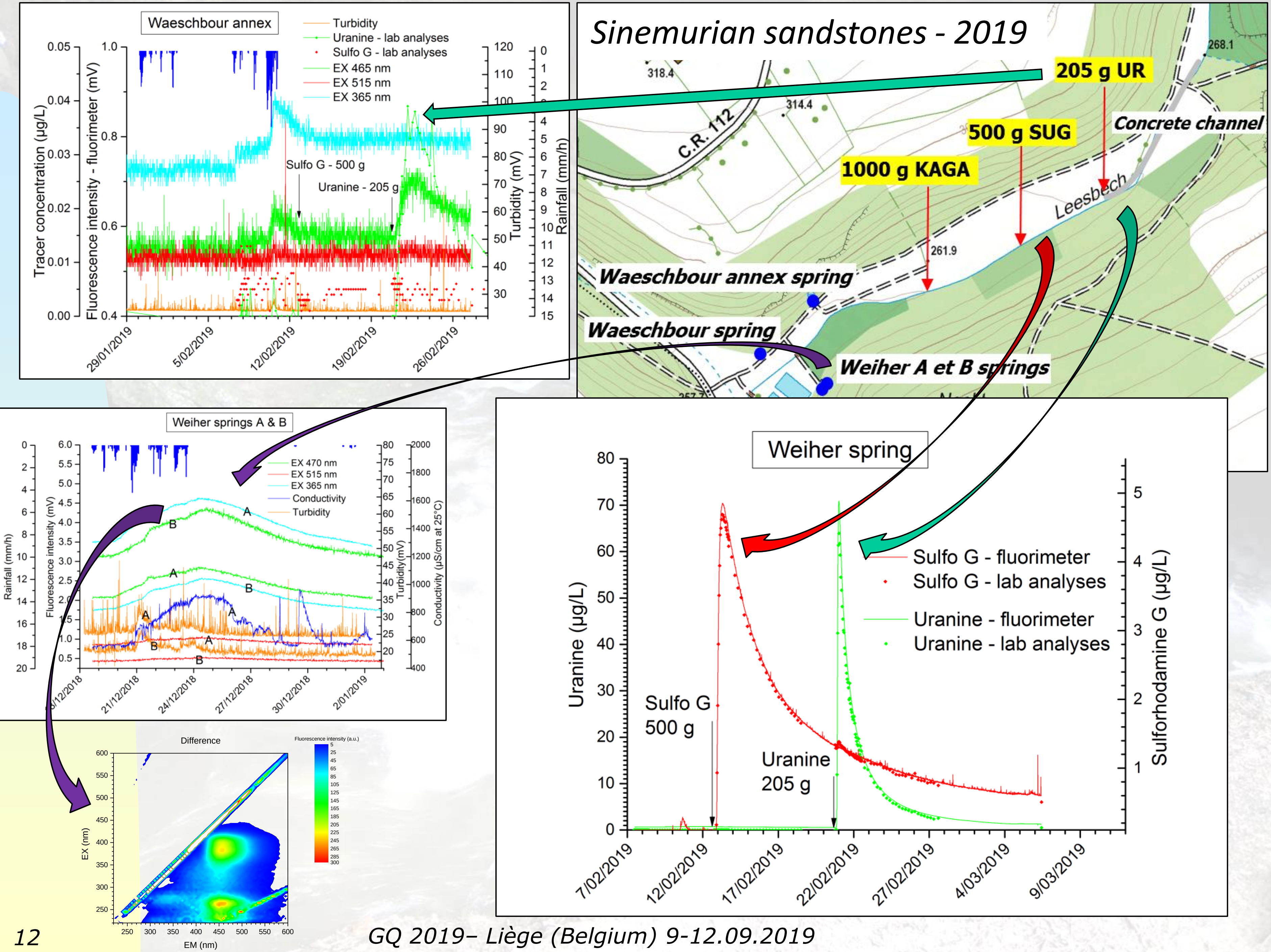


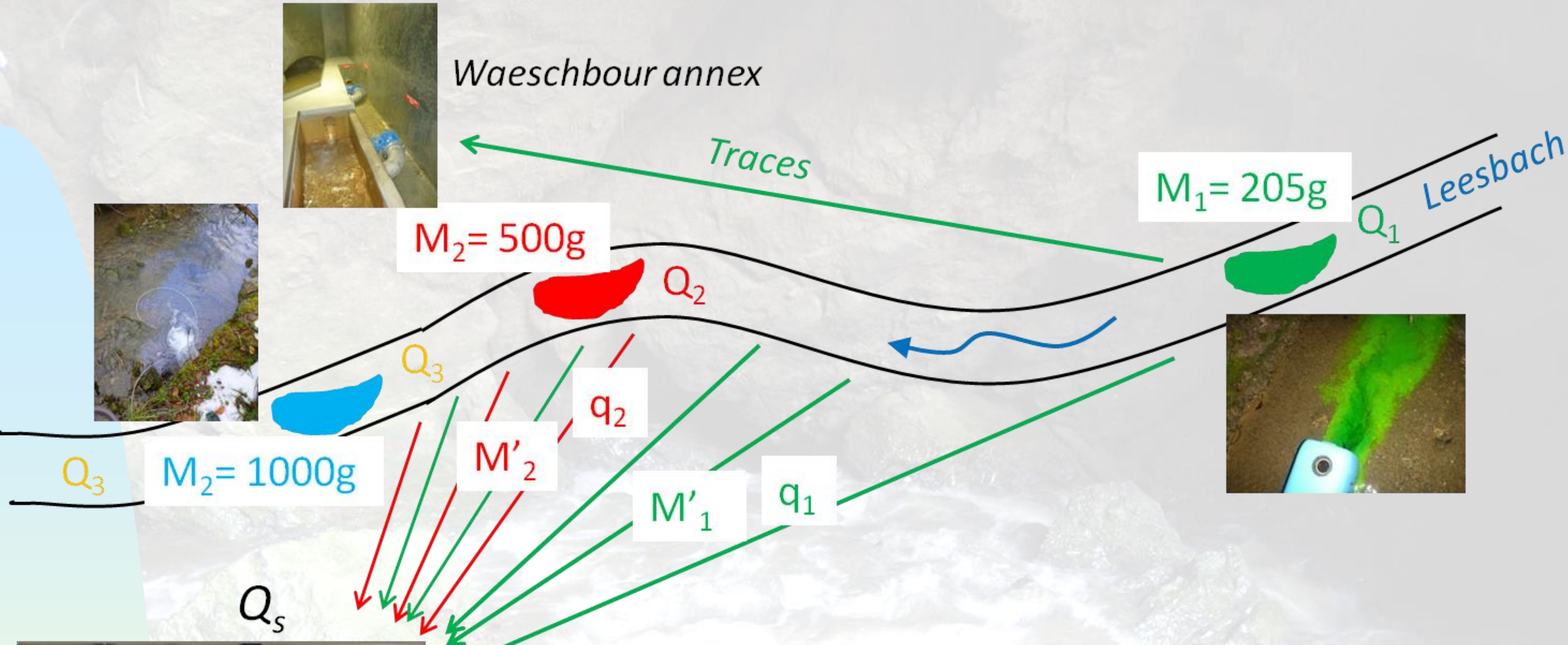






Sinemurian sandstones - 2019





$$M'_1 = \frac{\int C_1 Q_s dt \,.M_2 - \int C_2 Q_s dt \,.M_1}{M_2 - \int C_2 Q_s dt} = 32.9g$$

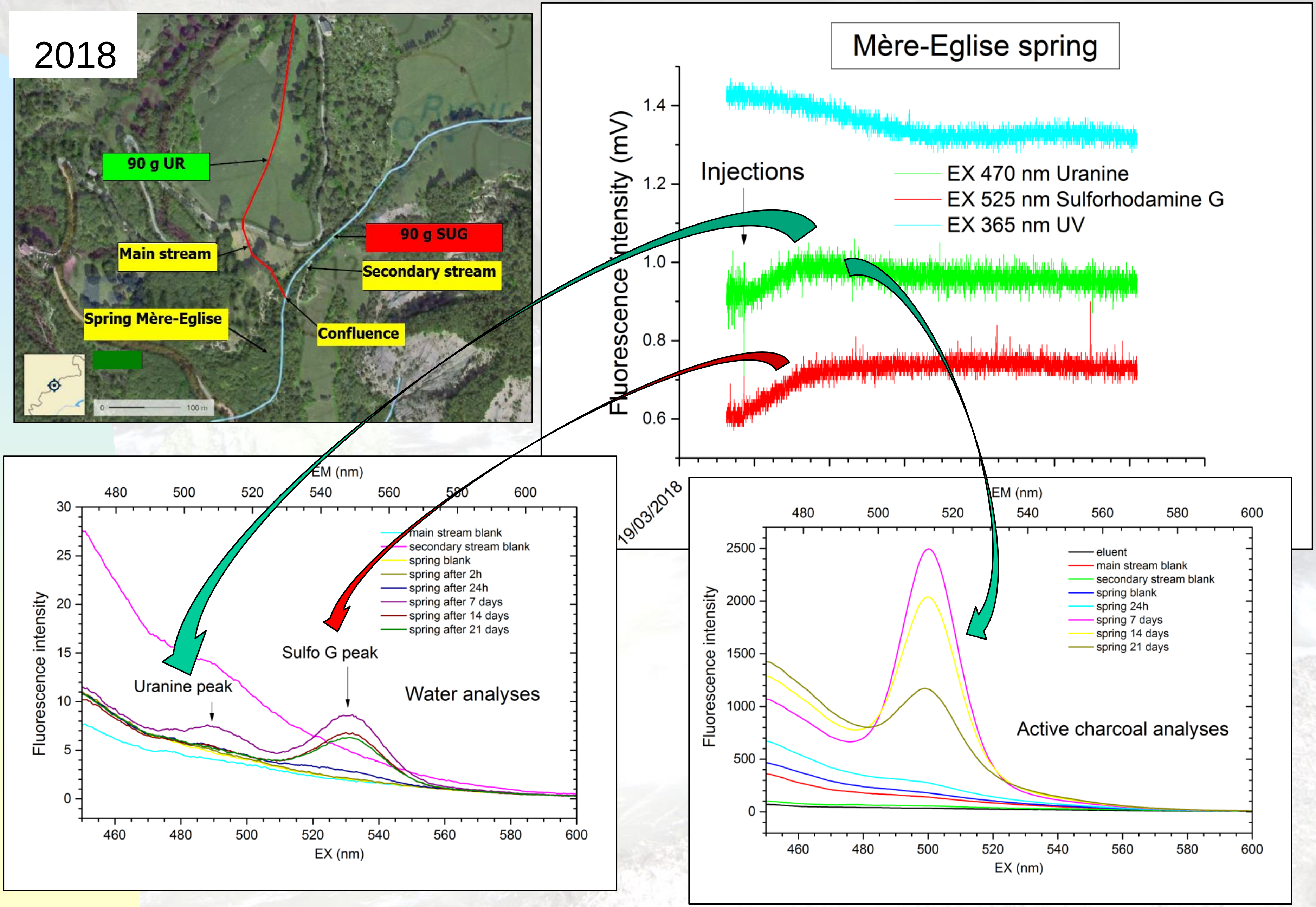
$$Q_2 = \left(1 - \frac{M'_1}{M_1}\right).Q_1 = 0.84 \,.\, Q_1$$

$$M'_2 = \int C_2 Q_s dt = 13.7g$$

$$Q_3 = \left(1 - \frac{M'_2}{M_2}\right).Q_2 = 0.97 \,.\, Q_2$$

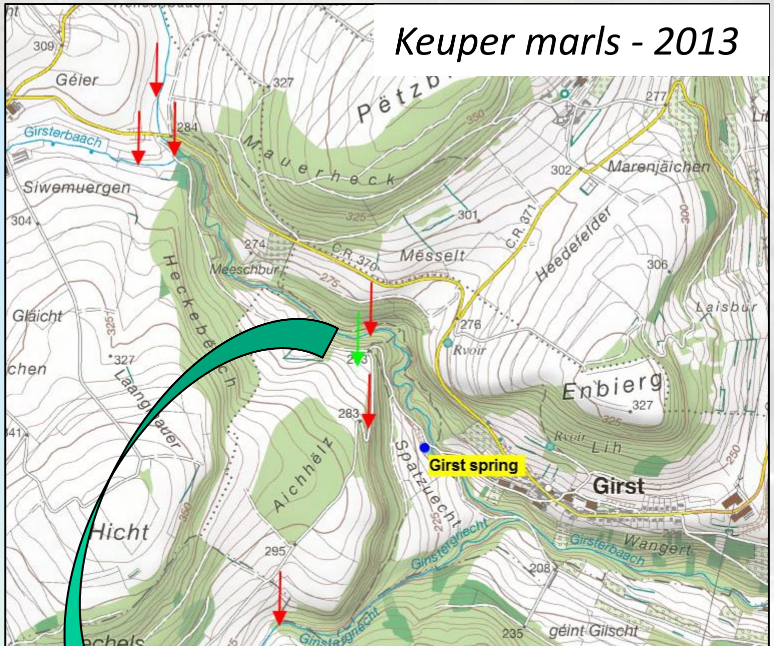
$$\int C_1 Q_s dt = 37.6g$$

Not so obvious…

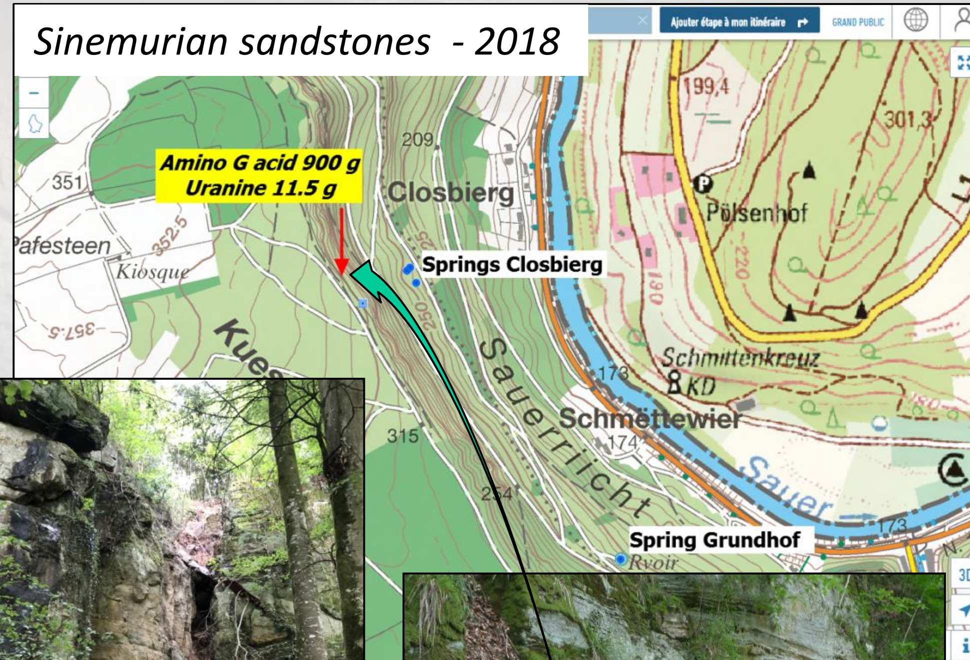


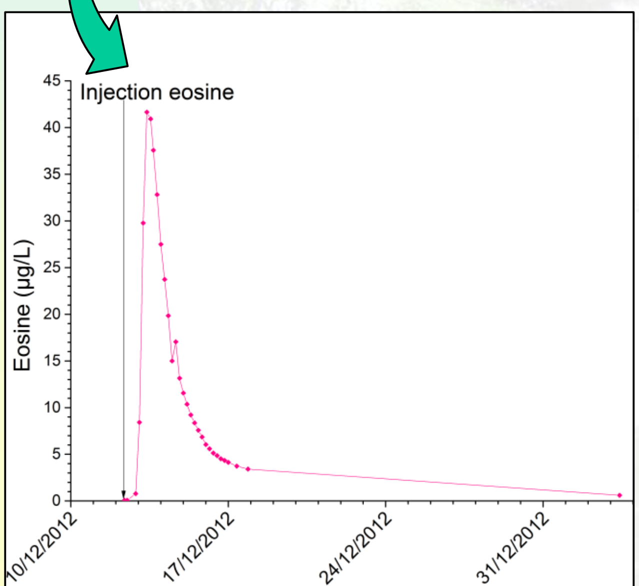
More difficult cases…

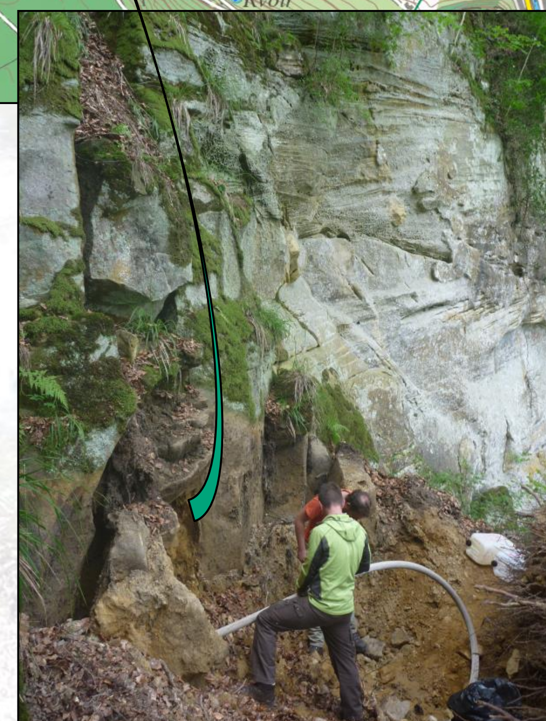
Keuper marls - 2013



Sinemurian sandstones - 2018







Synthesis

Springs	Aquifer	Tracer	M (g)	d (m)	Q (L/s)	Vmax (m/h)	Cmax(µg/L)	R (%)	Cmax.Q/M
Duchesse	Carboniferous limestones (karstic)	Uranine	2	180	4.5	196	0.03	0.10	6.75x10E-8
Duchesse	Carboniferous limestones (karstic)	Fluorescent microspheres	4.55x10E11	180	4.5	247	32760	0.08	3.24x10E-7
Duchesse	Carboniferous limestones (karstic)	Lithium	500	180	4.5	160	150	8	1.35x10E-6
Scheierbuer	Keuper conglomerates (porous)	Amino G acid	15	85	3.1	85	129	30	2.66x10E-5
Bonsin	Carboniferous limestones (karstic)	Amino G acid	2000	10	33	40	4255	7	7.02x10E-5
Waeschbur	Dogger limestones (fissured)	Sulforhodamine B	25	10	36	10	1.2	1.5	1.73x10E-6
F3 (well)	Frasnian shales (fissured)	Naphtionate	2500	250	6	46	35	1.9	8.4x10E-8
Kasselt	Sinemurian sandstones (karstic)	Amino G acid	20	542	5.5	125	43	25	1.18x10E-5
Marnave	Carboniferous limestones (karstic)	Amino G acid	50-300	5-20	19	20	176	100	4.46x10E-5
Mère-Eglise	Mountain context	Sulforhodamine G	90	270	10	10	< 0.001	<0.001	1x10E-10
Weiher	Sinemurian sandstones (karstic)	Uranine	205	300	5	300	71	16	1.73x10-6

M = injected mass, d = distance, Q = spring discharge, Vmax = maximum velocity, Cmax= maximum concentration, R = recovery

Conclusions

- fluorescent artificial tracing is a useful tool for characterizing the immediate vulnerability of ground-water catchments by localizing fast routes of infiltrations
- such tracer tests are very specific: types of tracers, quantities (avoid coloration), **methods of injection, exact places of injection**, periods of injection (runoff, level of river, pumping regime…), detection capacities (relative to time intervals and limits of detection)

- preliminary fluorescence monitoring is an advantage for the conceptualization of the tests, as well as the use of total fluorescence spectra (microbiology can also be used)
- budgetting the tracers can be useful to quantify infiltrations along rivers (i.e for sealing purpose)
- can clarify the episodic occurrence of some contaminants coming from surface streams

Practice will improve our knowledge, so that future crises can be avoided...

Thanks for listening!

Acknowledgements to all companies who trusted !