University of Liege – Faculty of Applied Sciences
ArGEnCo – Architecture, Geology, Environment and Constructions
GEO³ - Geotechnologies, Hydrogeology and Geophysical Survey

Measured and computed solute transport behaviour in the saturated zone of a fractured and slightly karstified chalk aquifer

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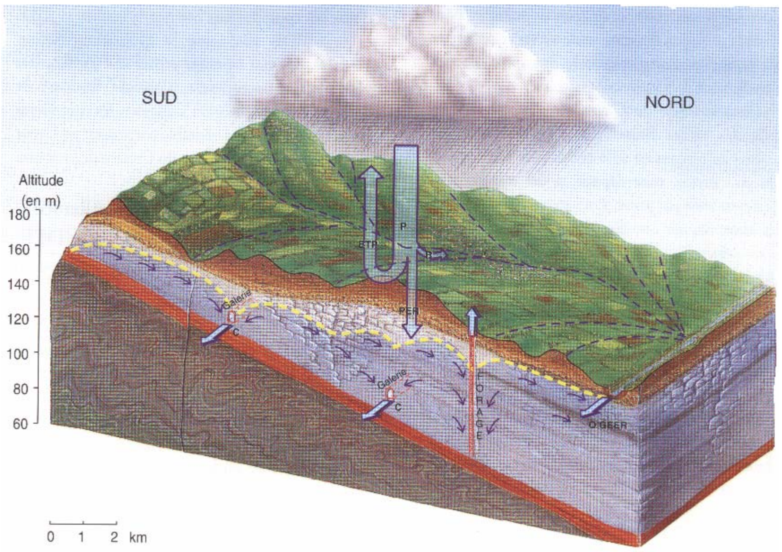
Outline

- Results from tracer tests in a fractured /slightly karstified chalk aquifer
- Experiencing two ways for modelling flow and solute transport with the 'Hydrogeosphere' code *(Therrien et al., 2010)*
- Case study: calibrations/simulation of the tracer tests
- Advantages and perspectives

Results from tracer tests in a fractured /slightly karstified chalk aquifer



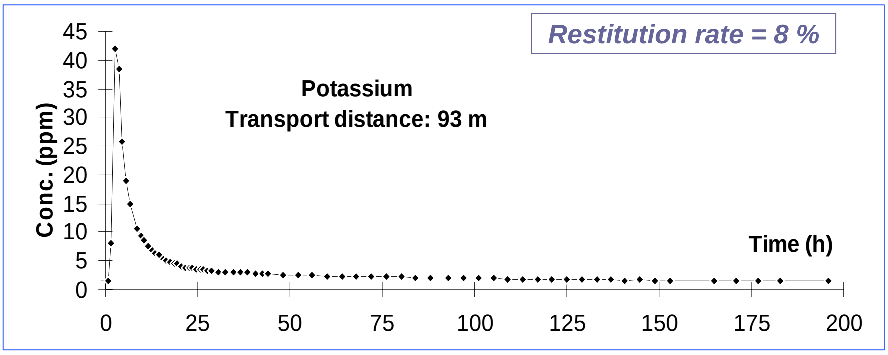
Results from tracer tests in a fractured /slightly karstified chalk aquifer

- 35 tracer tests distributed between 11 sites :
  - main objective of studying the local transport of solute contaminants
  - measured breakthrough curves show different behaviour linked to the coexistence of a porous matrix and fractures in the chalk aquifer
  - some of the fractures have been enlarged by dissolution so that the aquifer is often considered as slightly karstified

    ➡ a first classification with 3 kinds of breakthrough curves

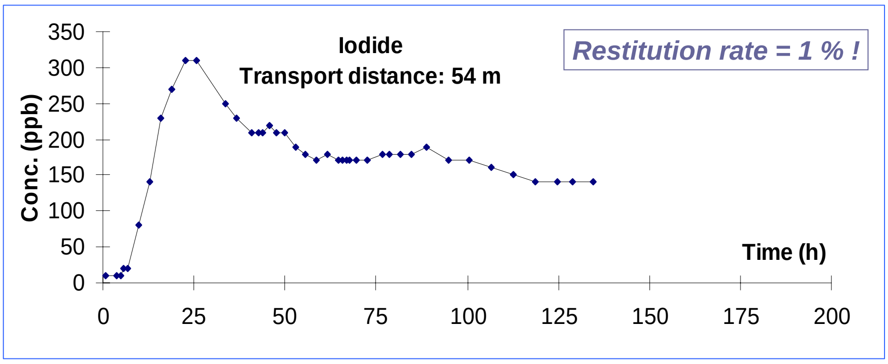
Results from tracer tests in a fractured /slightly karstified chalk aquifer

- dominant advective component, narrow and symmetrical breakthrough curves
- solute transport along solutionally-enlarged fractures
- very high velocity of tracers (between 10 and 110 m/h) for distances between 5 and 130 m for any type of tracer



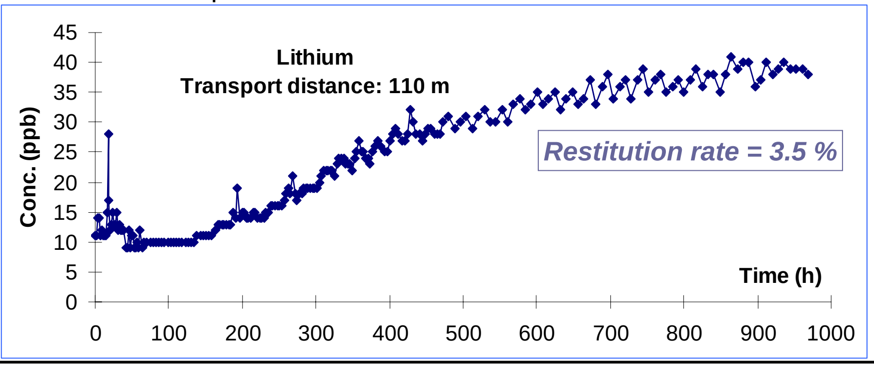
Results from tracer tests in a fractured /slightly karstified chalk aquifer

- important advective and dispersive components
- more spread-out breakthrough curves
- non-symmetrical trends induced by dual porosity (or immobile water) effect



Results from tracer tests in a fractured /slightly karstified chalk aquifer

- a dominant long term dispersive component and possibly immobile water effects
- at very short times, an advective peak can be sometimes detected
- result of combined effects of the porous and permeable chalk and of the open fractures.



Modelling groundwater flow and solute transport with 'Hydrogeosphere'

- REV based PARAMETERS with fracture zones discretized explicitely
  - Fracture zones distinguished by elongated zones of higher conductivity and very low effective porosity to reproduce groundwater velocity contrasts
  - Ask a more detailed discretization with distorded/elongated FE
  - May lead to choose unrealistic values for effective porosity

→ Model 1

Modelling groundwater flow and solute transport with 'Hydrogeosphere'

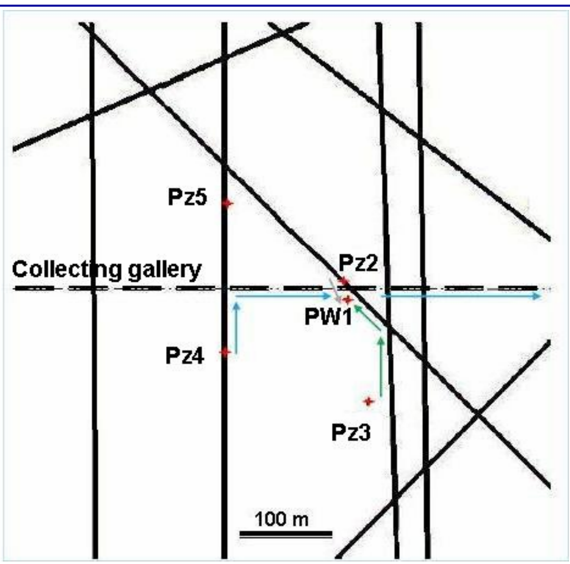
- DISCRETE APPROACH: modelling flow in the individual (discrete) fractures

$$K_{fracture} = \frac{a^2 \rho g}{12\,\mu}$$

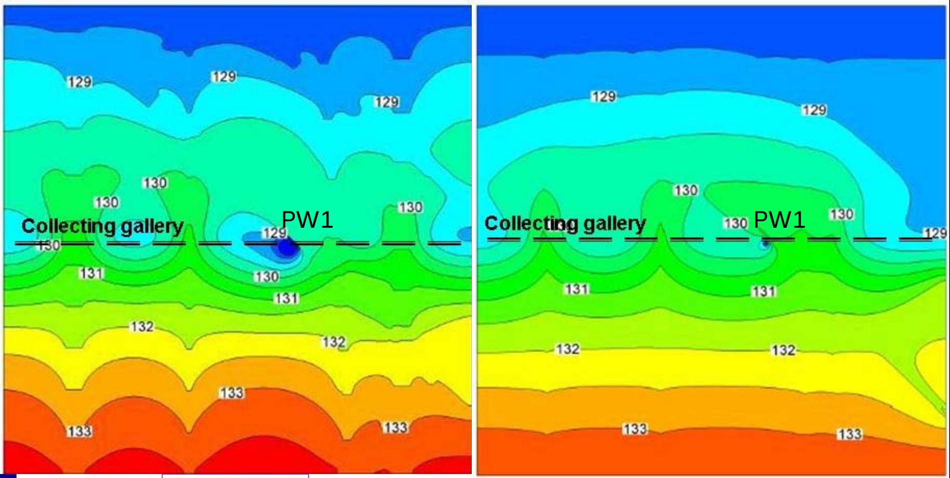
  - needs to identify the most significant fractures within a location
  - application of the fluid mechanics in modelling the flow in the resulting discrete fracture network
  - challenging issues: needed data about geometry, aperture of the fissures, rugosity, …

→ Model 2

Case study: calibrations/simulation of the tracer tests



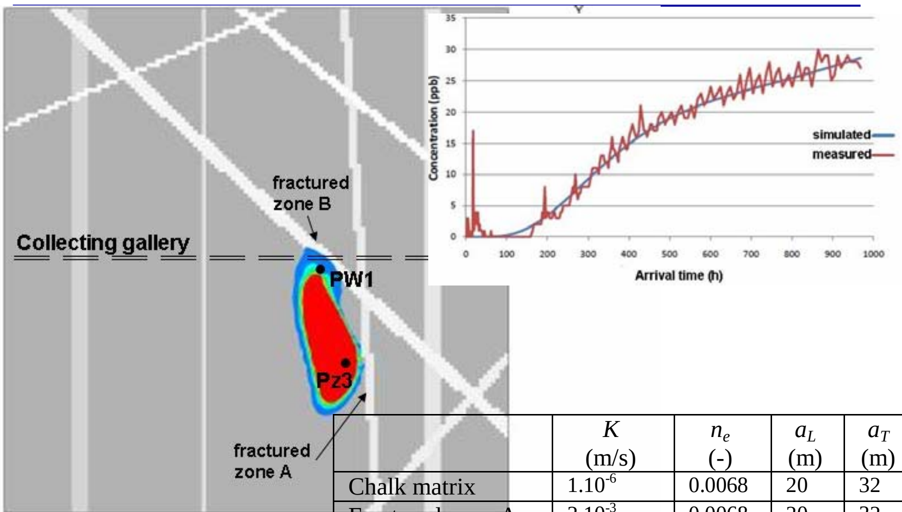
Case study: flow simulations with pumping in PW1



Model 1

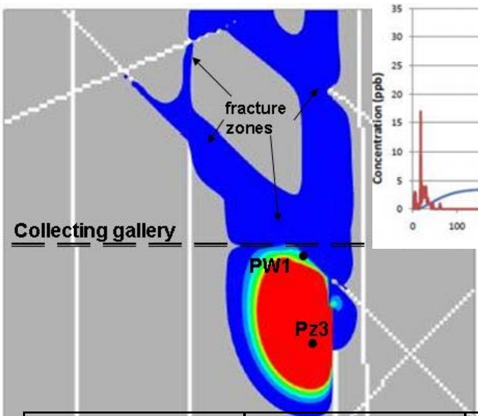
Model 2

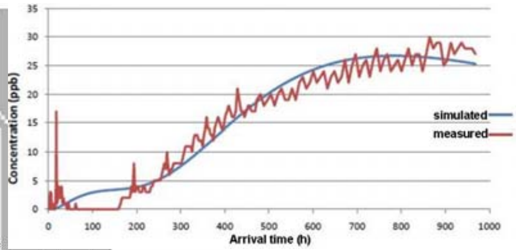
Model 1 - Computed plume of Li^+ 505 hours after injection in Pz3



	K (m/s)	n_e (-)	a_L (m)	a_T (m)
Chalk matrix	1.10^{-6}	0.0068	20	32
Fractured zone A	2.10^{-3}	0.0068	20	32
Fractured zone B	3.10^{-4}	0.0010	30	7

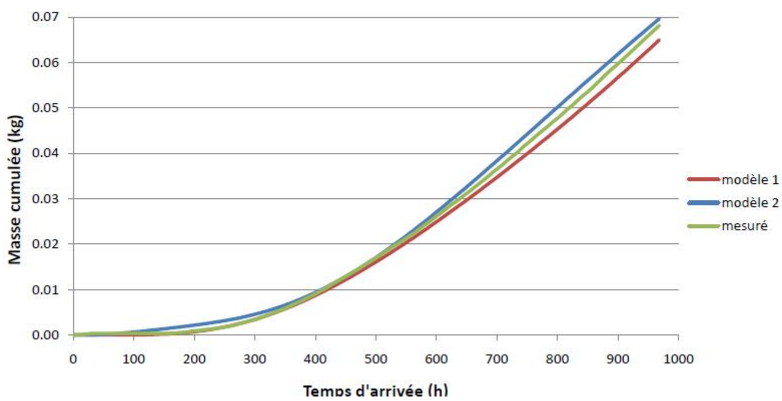
Model 2 - Computed plume of Li^+ 35 h and 505 h after injection in Pz3



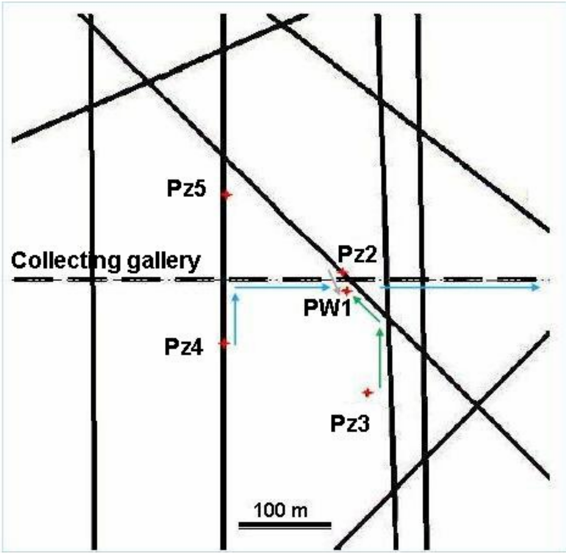


	K (m/s)	n_e (-)	a_L (m)	a_T (m)
Chalk	5.10^{-6} m/s	0.01	45	30
Fractures	a = 0.008 m		1	0.1

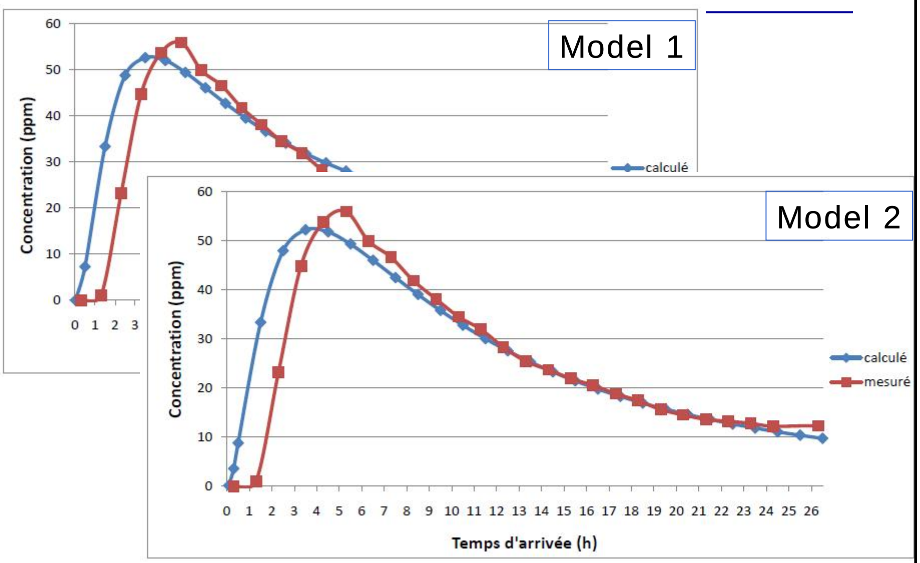
Computed recovery for Li^+ injected in Pz3



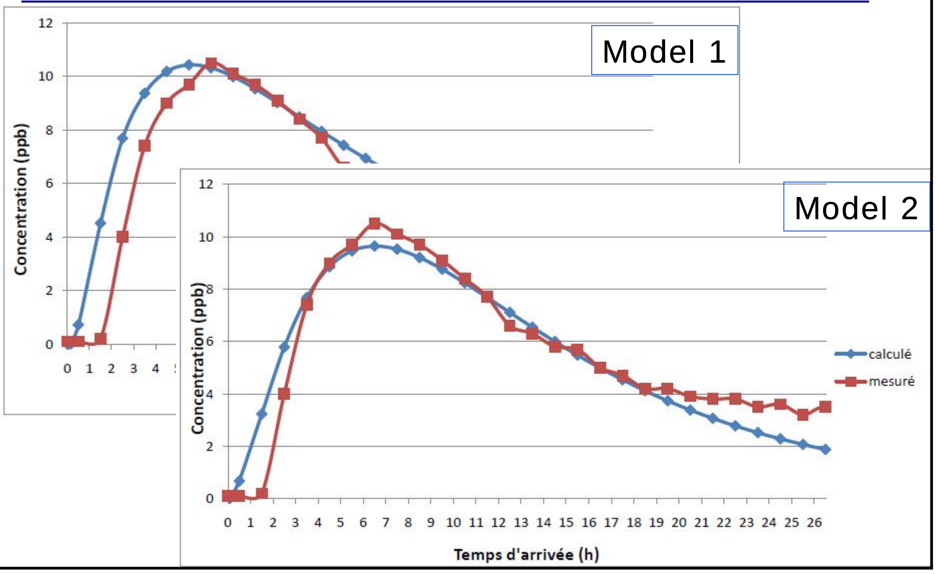
Other results for Iodide Pz2-PW1



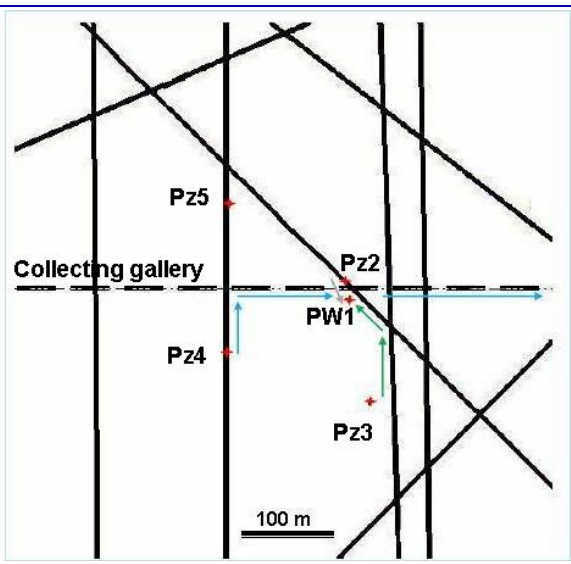
Other results for Iodide Pz2-PW1



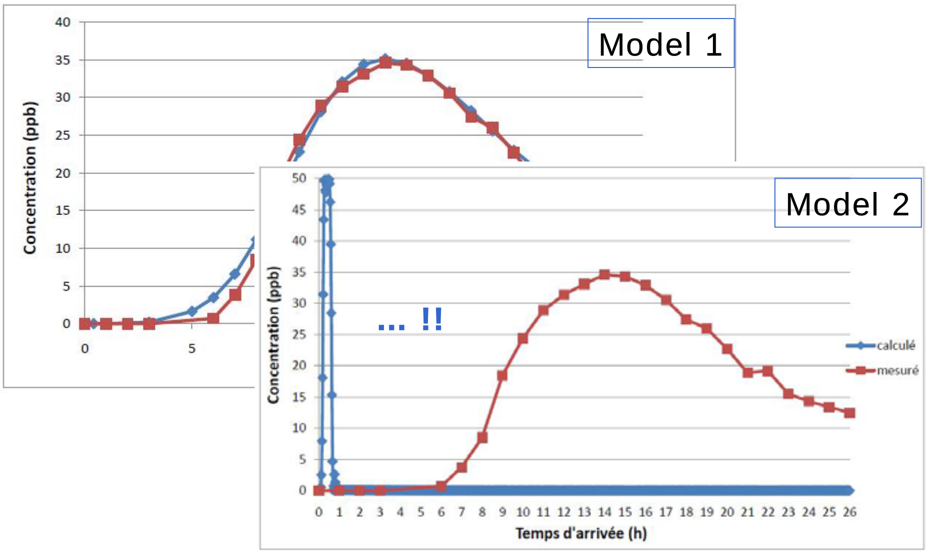
… Rhodamine Pz2-PW1



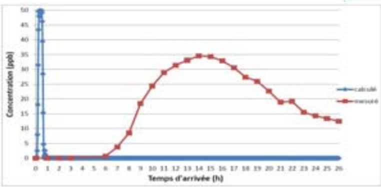
Other results for Naphtionate Pz4 – collecting gallery

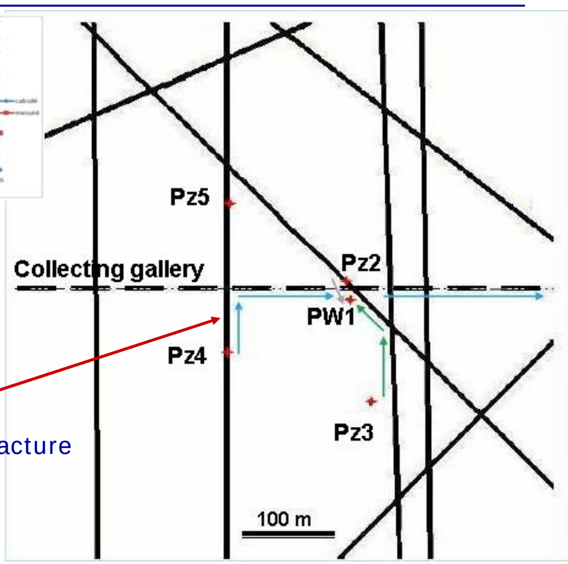


Naphtionate Pz4 – collecting gallery



Naphtionate Pz4 – collecting gallery





... we need to close this fracture

Lesson

- when different tracer test results are available: calibration can become difficult … but … at the end: more reliable

  (it is not yet the case here)

- combining groundwater flow situations and transport breakthrough curves as calibration targets… is constraining a lot

- can become tricky … operations should be optimized by inverse modelling procedures

Conclusions and perspectives

- Conclusions:
  - three main categories of breakthrough curves
  - promising results using a discrete approach for representing the fractures
  - not a large freedom in calibrating parameters
  - an aperture of the order of the millimeter is enough for creating clearly a fast advective peak combined with a long highly dispersive component due to the chalk matrix.
- Perspectives:
  - Improve and optimize calibration using UCODE_2005 or PEST
  - Test on other data sets
  - Upscale to the whole aquifer

Thank you for your attention!

Université de Liège

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