Hydrogeological conceptual model of a crystalline thermo-mineral carbo-gaseous aquifer driven by a weathering profile and tectonic fractures

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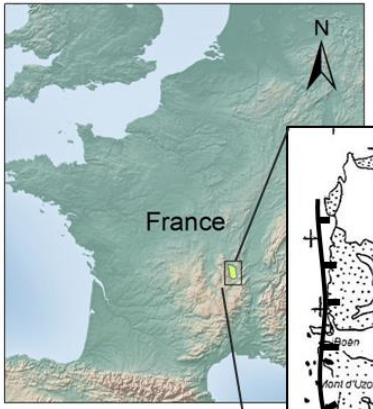
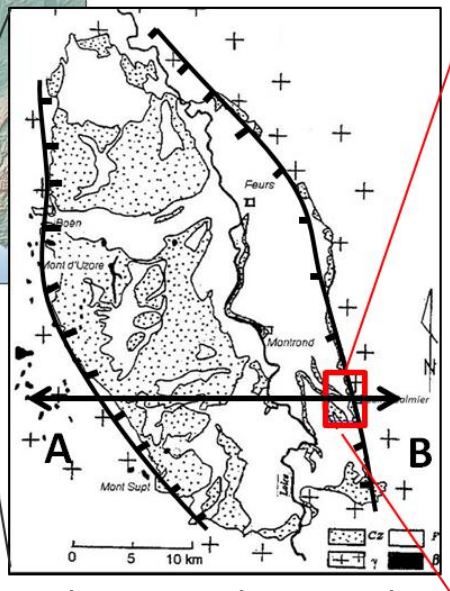
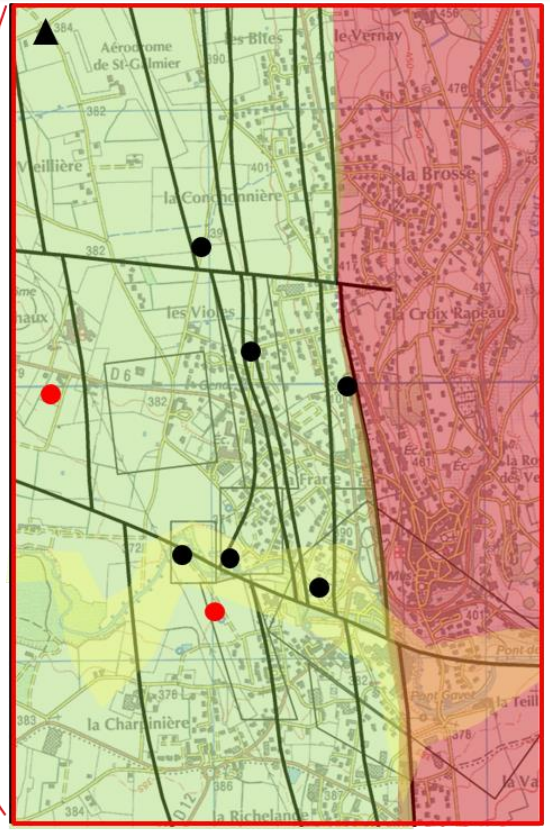
Badoit® aquifer system

Saint-Galmier, France

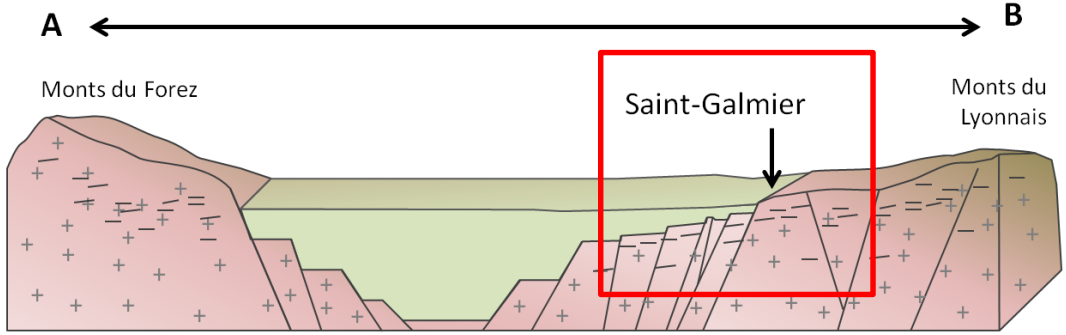




Forez plain: Perialpine graben



Badoit® Natural Mineral Water :
Sparkling Ca-HCO_3 to Ca-Na-HCO_3 type



Geology:
- Granite
-Sedimentary deposits (Cenozoic) up to 700m
Numerous tectonic faults

Geological data

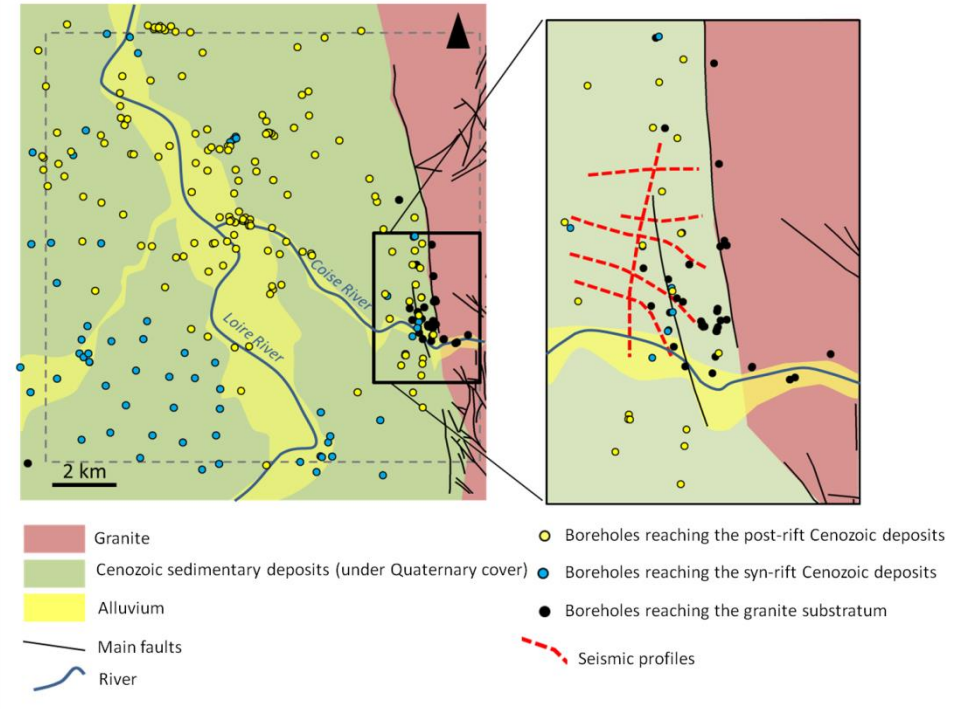
-Seismic profiles (6),

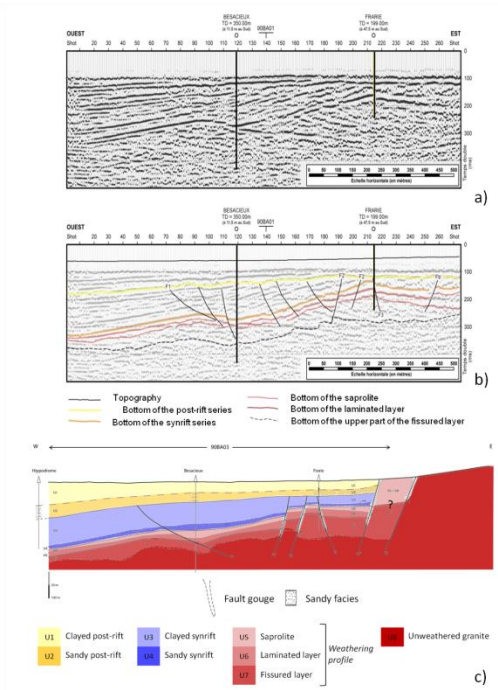
-Outcrops (27 sites),

-Boreholes (254),

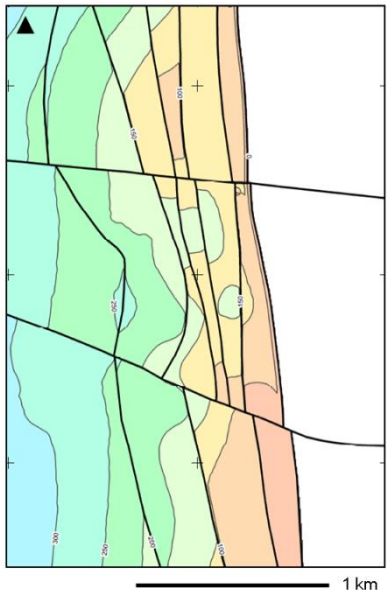
-Bibliographical data

→ **Geological and Structural models**





Seismic profiles interpretation



Structural model

- Evidence of an old poly-phased weathering profile
- Thickness >100 m (most fractured zone : 100-125 m)
- Its geometrical structure: shift by N-S fault resulting from graben
- Two phases sediments filling = post and syn-rift

Hydrogeological data

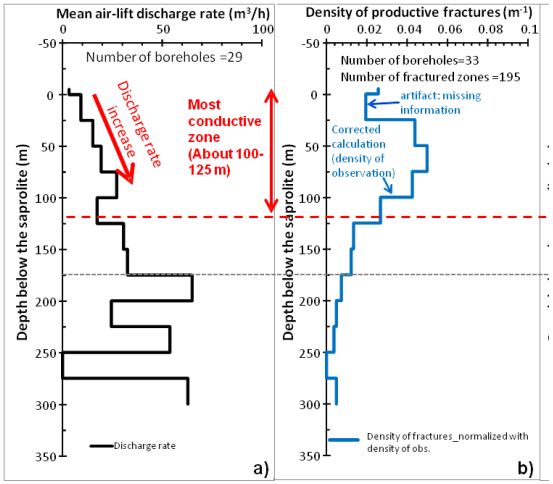
Air-lift data:

→**most conductive fractured zone until 100-125m depth**

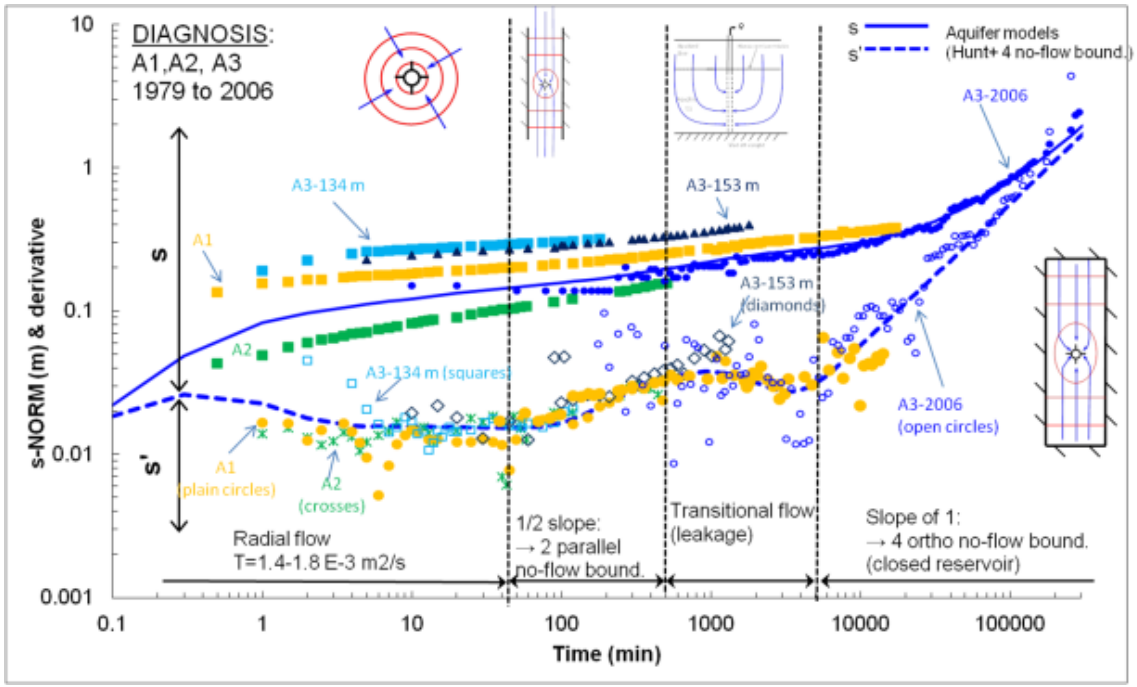
Pumping tests:

→**Hydraulic properties of sedimentary deposits and granite aquifers**

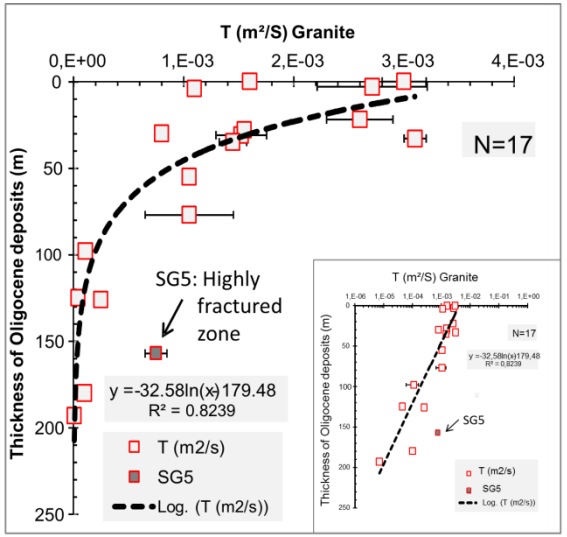
→**aquifer compartments' boundaries**



Air-lift data interpretation



Modelling of pumping tests

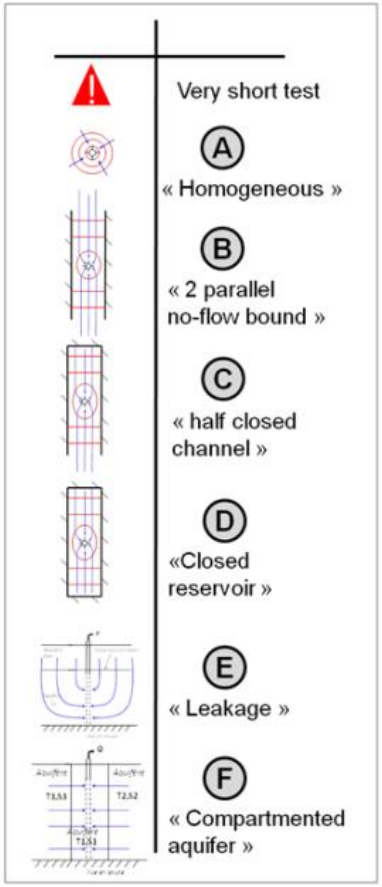


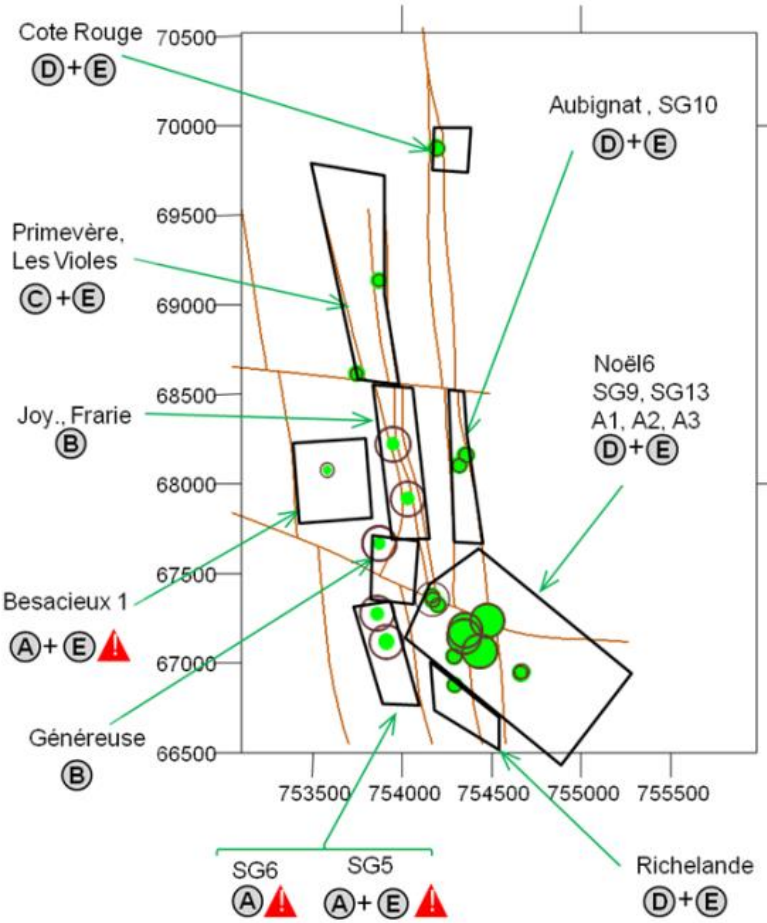
Transmissivity (granite)

Hydrogeological data

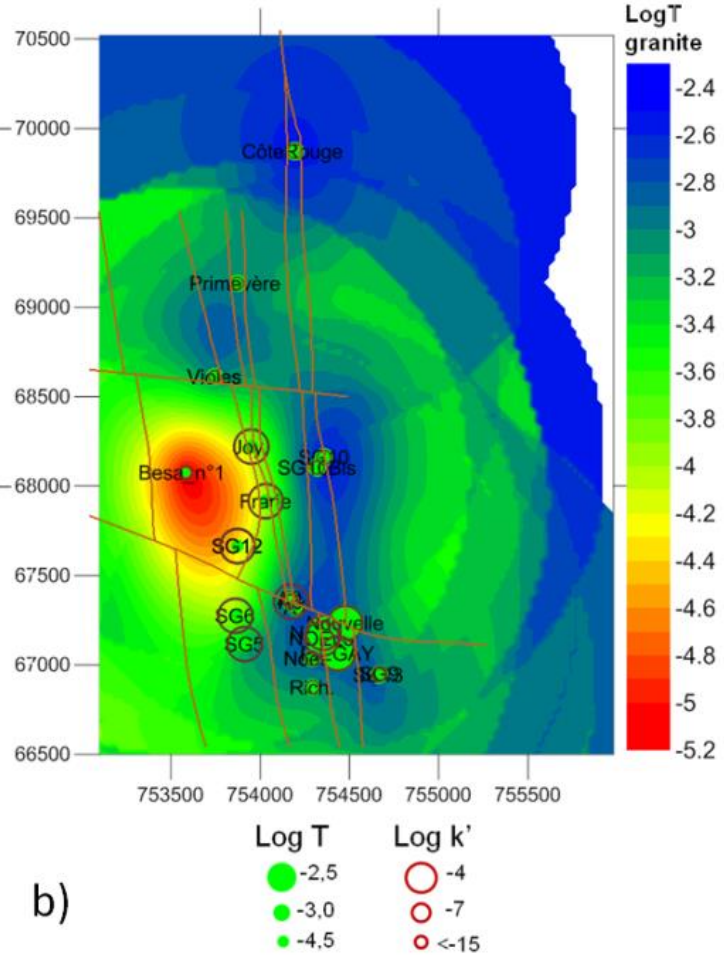
→Hydraulic properties of granite aquifers (multi-layered aquifers –Oligocene, saprolite, fissured granite)

→Compartments' boundaries (closed reservoirs)





a)



b)

Chemical data

- No clear relationships between aquifer lithology and major ions content

- Use of chemical indicators:
  - the content of Ca^{2+} vs. Na^{+} for sparkling water

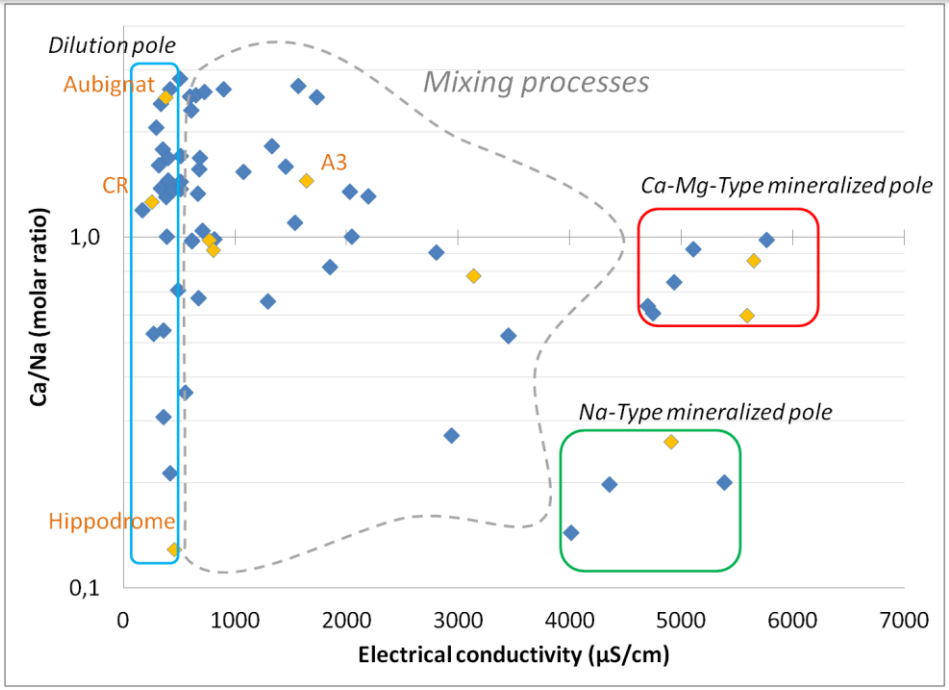
- End Member Mixing Analysis
  (Christophersen and Hooper, 1992)

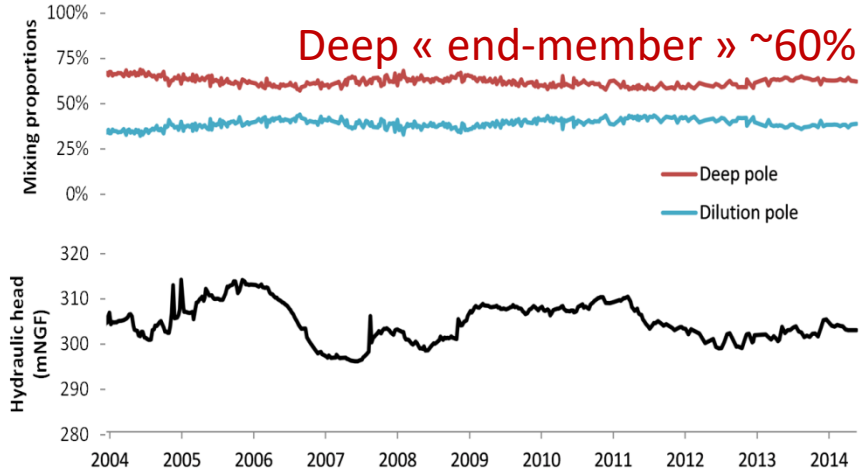
Assumptions:

Major ions = conservative tracers (…)

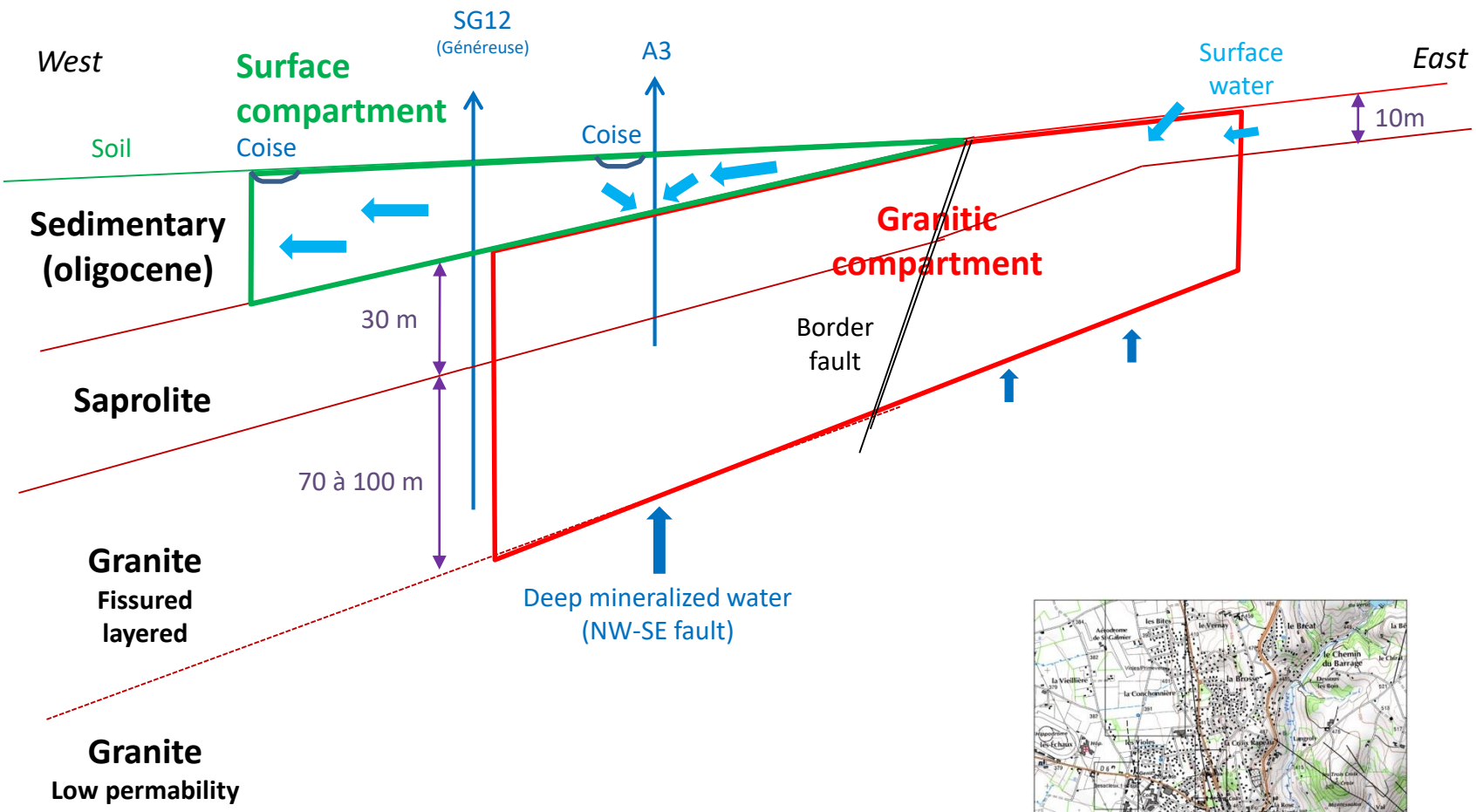
Limitations

End-Members are “relative” but are considered as “absolute” End-Members, even if they originates from mixing





Conceptual model



Deterministic hydrogeological model construction

- **MARTHE_7.4© BRGM finite differences code**
- **Geometry and meshing**

4 aquifer layers: Sedimentary deposits, saprolite and granite

50*50 m mesh

- **Hydrodynamic properties**

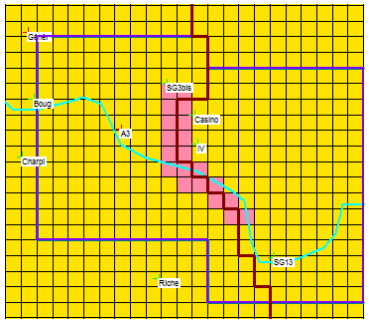
Permeabilities given by pumping test analysis.

- **Boundary conditions**

Head is set to DEM-1.5m for the West boundary of the Oligocene layer

Recharge is imposed on outcrops (Saprolite + Oligocene)

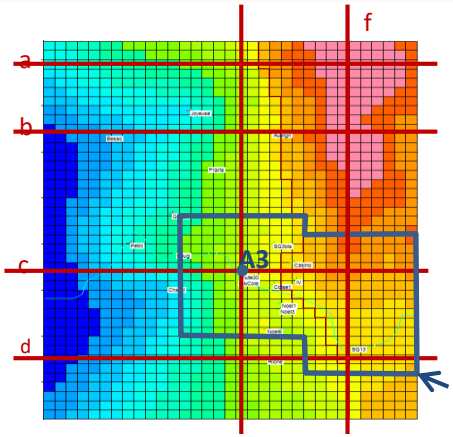
Deep mineralized water : imposed flux distributed over 20 meshes

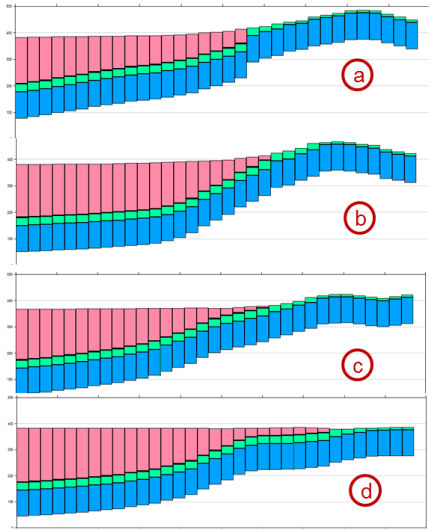


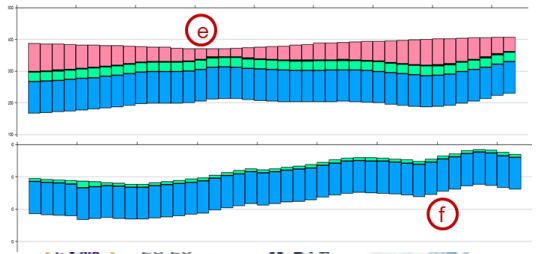
1&2 Oligocene & wall

3 Saprolite

4 Granite

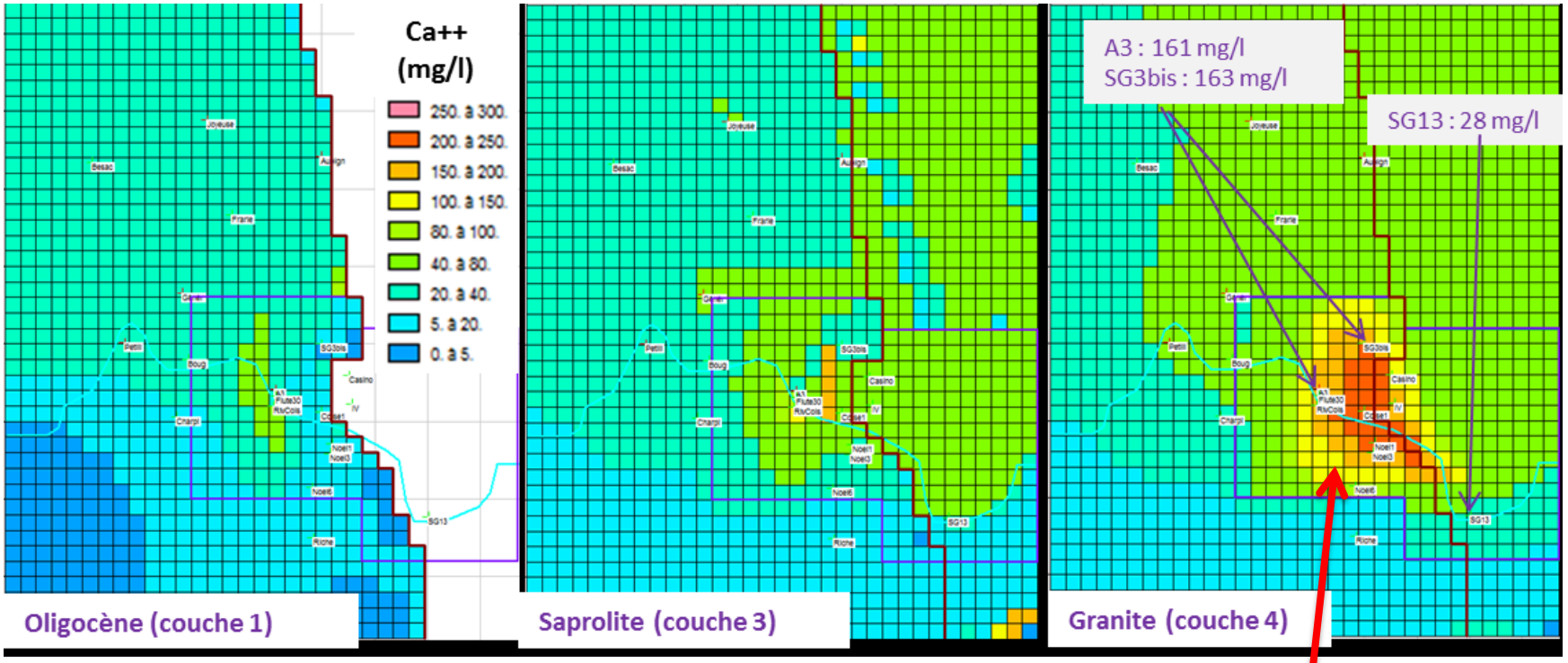






Model calibration and validation (steady state)

- **Validation: piezometric levels and chemistry**



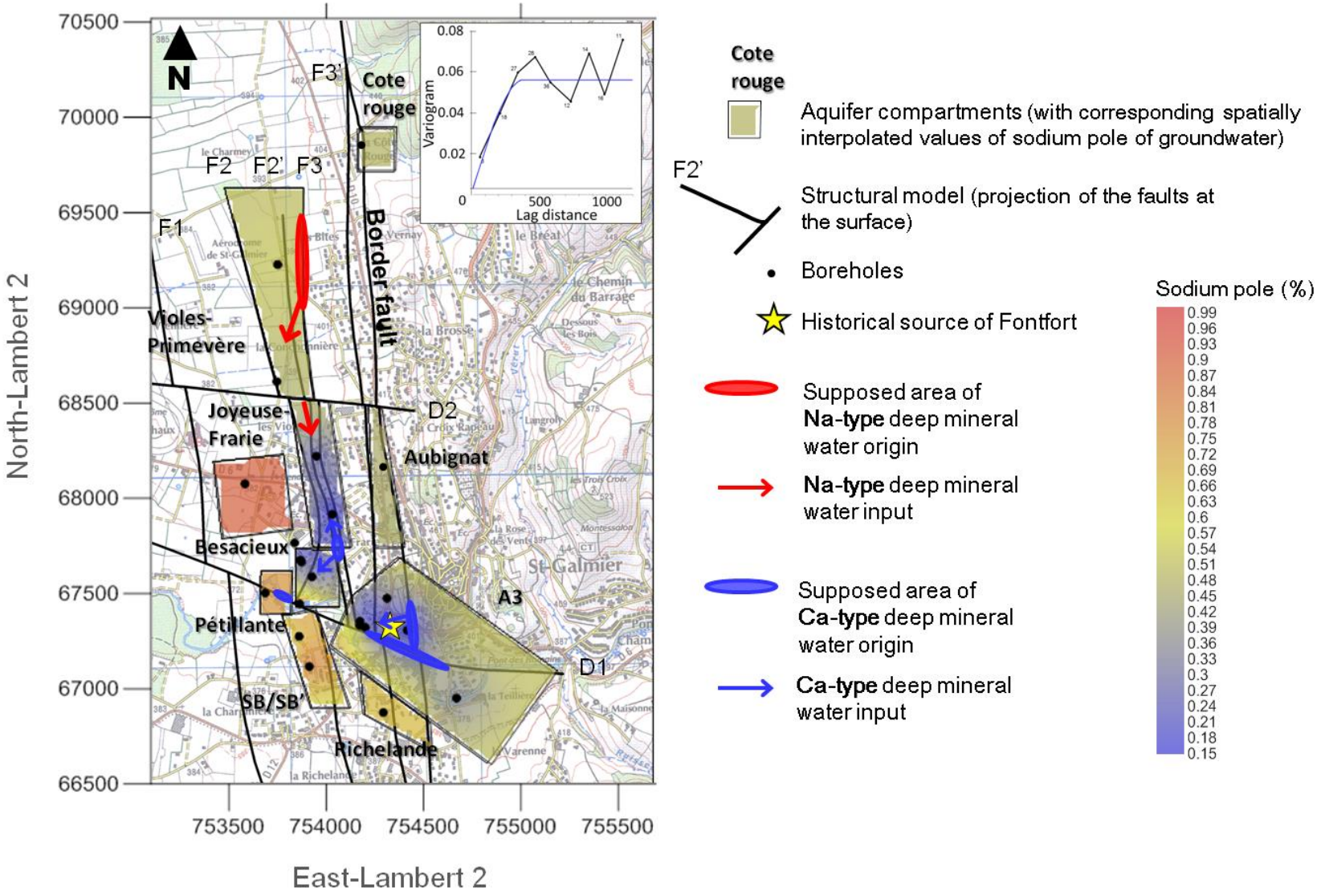
Reconstitution of the mineralized water plume

→ Validation of the conceptual model !!!

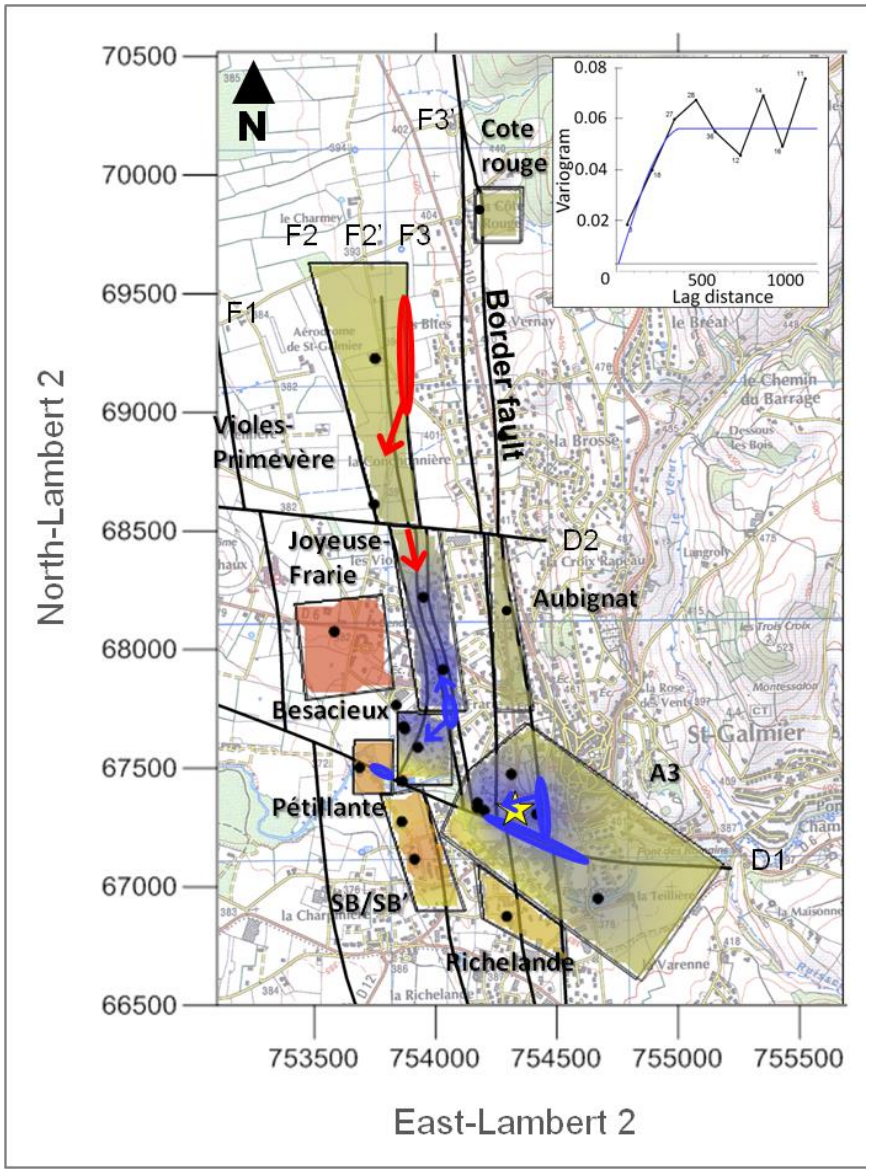
Conceptual model

-Identification of mixing

-Identification and location of deep fractures providing Ca-type and Na-type mineralized waters



Conclusion



- **Multidisciplinary approach** to understand a complex thermo-mineral hydrosystem
- The **weathered fissured layer** of the granite aquifer plays a major hydrodynamic role
- Various **roles of faults**: **impervious boundaries** (limits of the aquifer compartments) and **low permeable zone** (uprising of deep mineralized water and gas)
- **Identification and location** of deep fractures providing Ca and Na-types mineralized waters

UQÀM geotop water institute by evian Géosciences pour une Terre durable brgm

Complete study submitted

B. Dewandel, M. Alazard, P. Lachassagne, V. Bailly-Comte, R. Couëffé, S. Grataloup, B. Ladouche, S. Lanini, J-C. Maréchal, R. Wyns**.**

Respective roles of the weathering profile and the tectonic fractures in the structure and functioning of a crystalline thermo-mineral CO_2-rich aquifer

Thank you

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