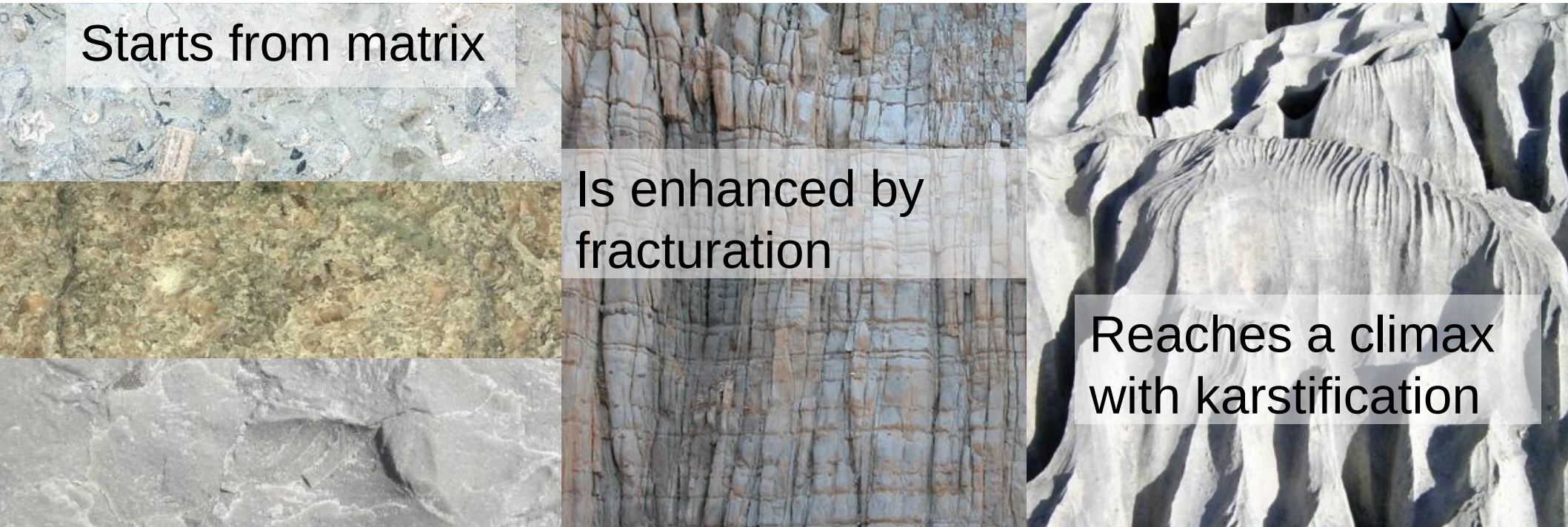
Water flow within the underground critical zone: multi-physics and multi-scale insights from LSBB platform.

Emblanch C. Mazzilli N., Chalikakis C., Danquigny C.

LSBB rock overburden : A key to low-noise signals… but also an object of study

LSBB rock overburden : A key to low-noise signals… but also an object of study

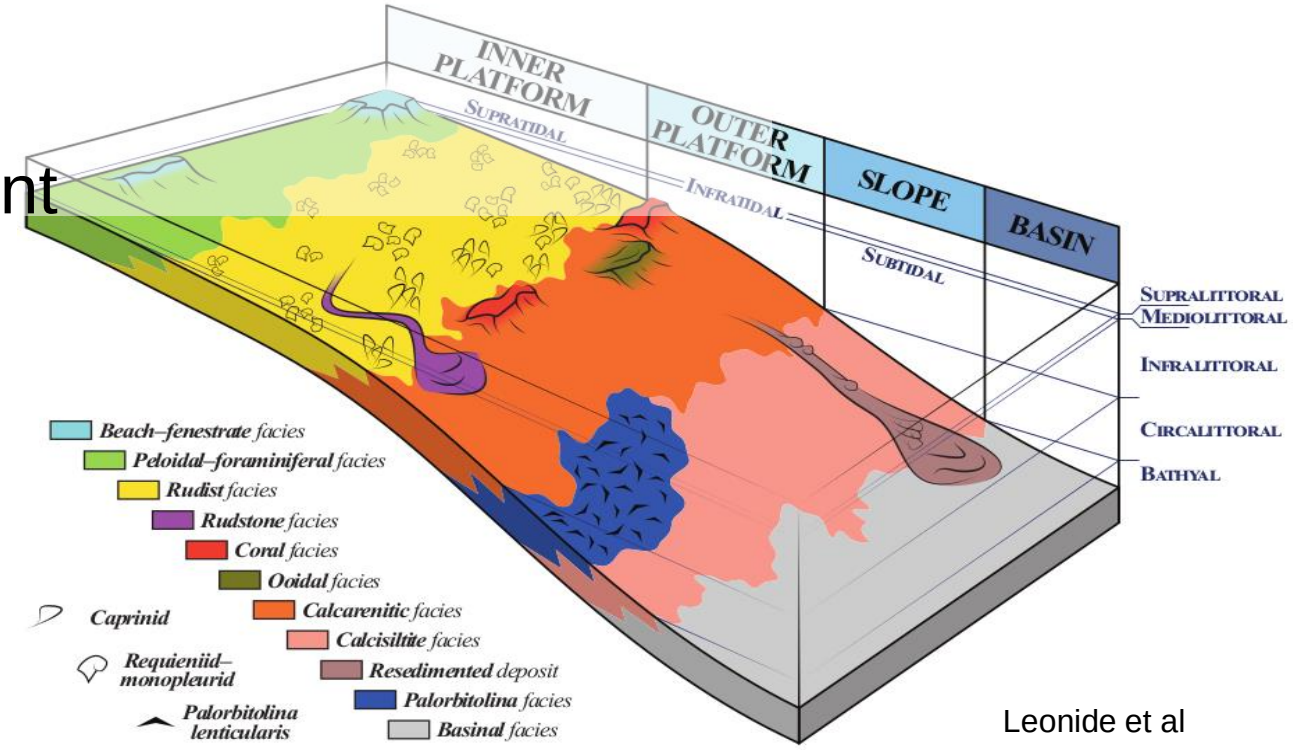
Heterogeneity of carbonates...



LSBB rock overburden : A key to low-noise signals… but also an object of study

At the roots of **carbonate matrix heterogeneity** :

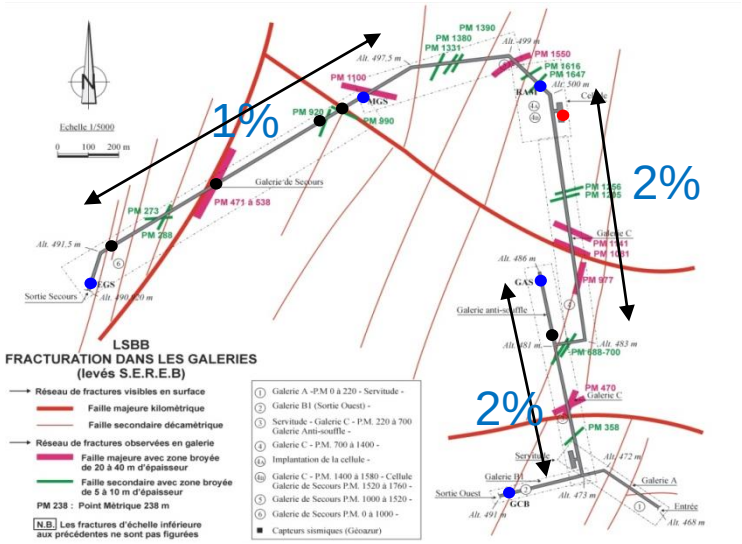
Variability
From deposits environment
To diagenesis

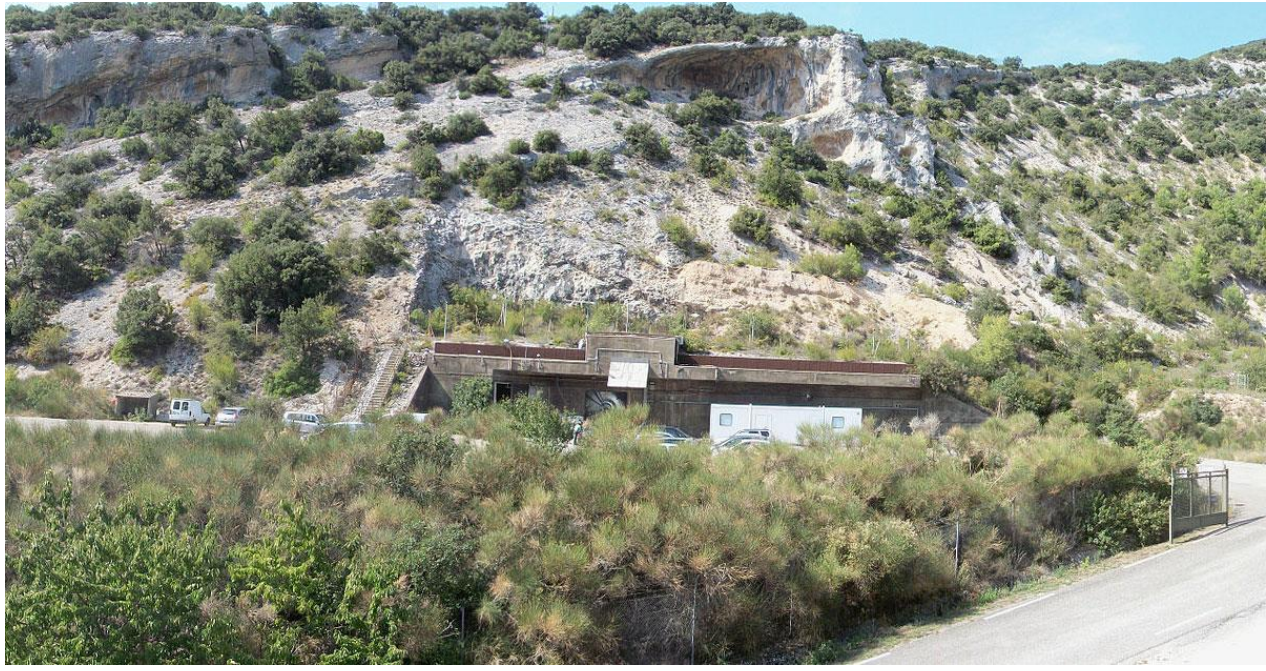


Leonide et al

LSBB rock overburden : A key to low-noise signals… but also an object of study

Fracturation :
A legacy of many stages of geodynamic evolution

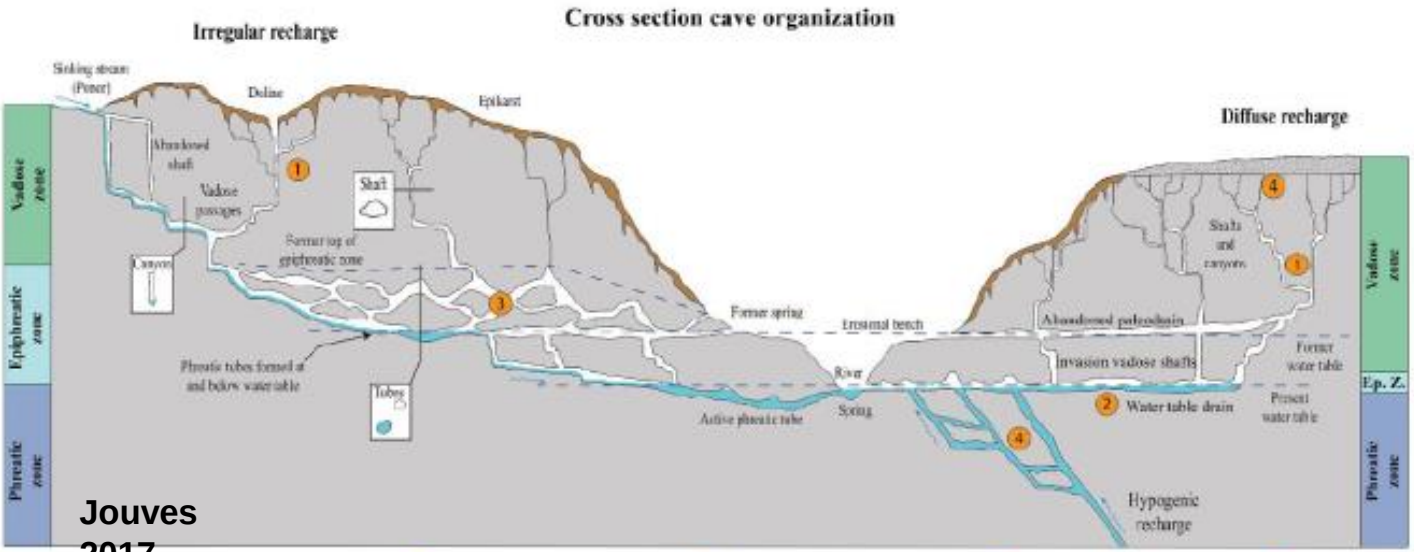




LSBB rock overburden : A key to low-noise signals… but also an object of study

Karstification :

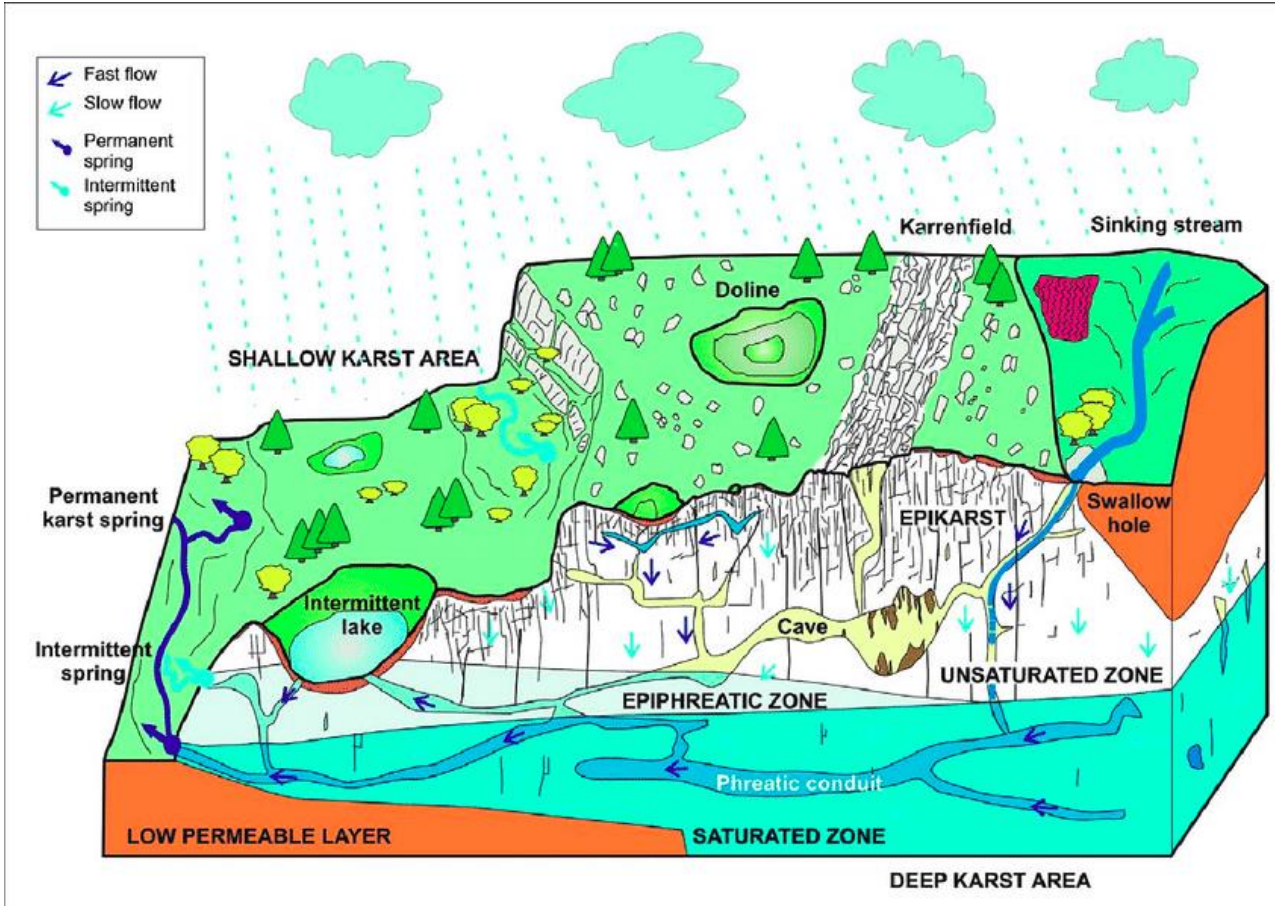
A rapid, self-organizing process



Jouves 2017

Water (and air) run through it

Flow in karst is complex because of the high degree of heterogeneity of karst medium



Water (and air) run through it

Origin of hazards :

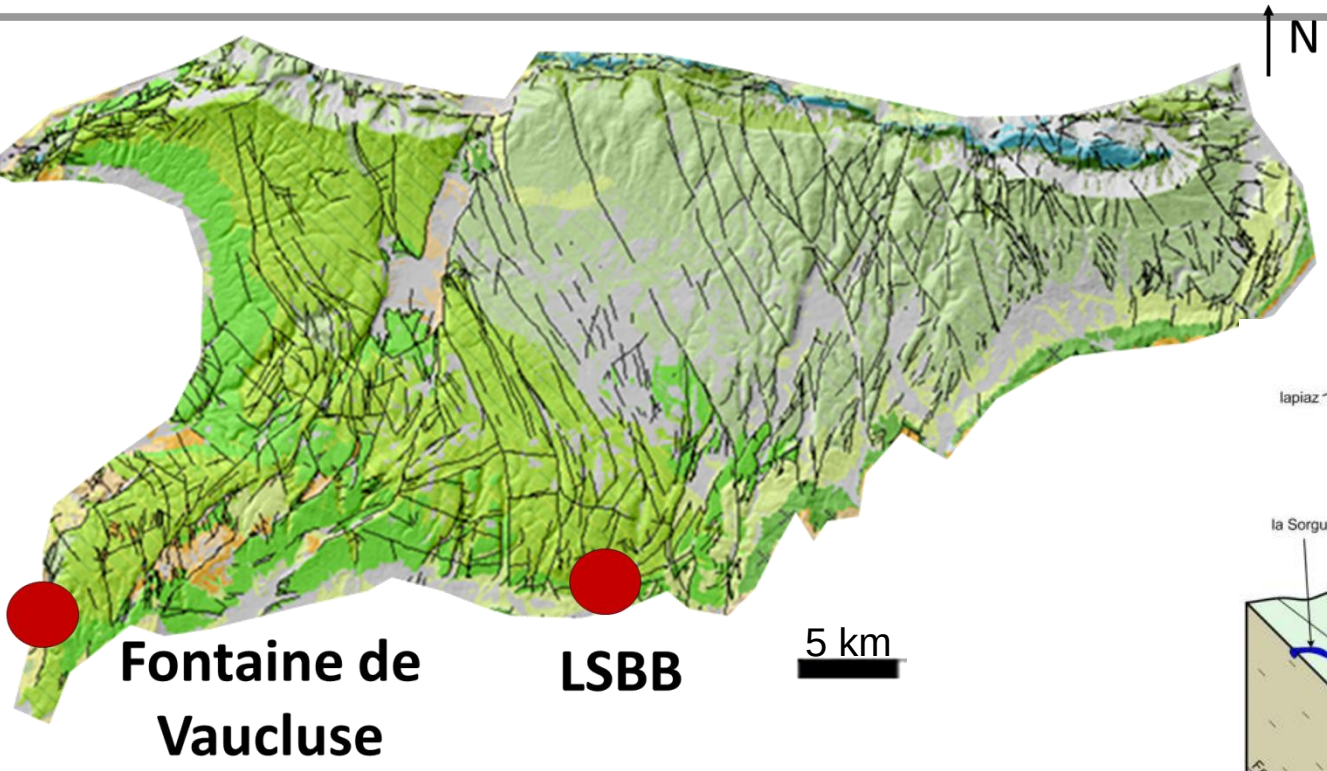
- Flash floods
- Vulnerability of fast flow paths to groundwater contamination

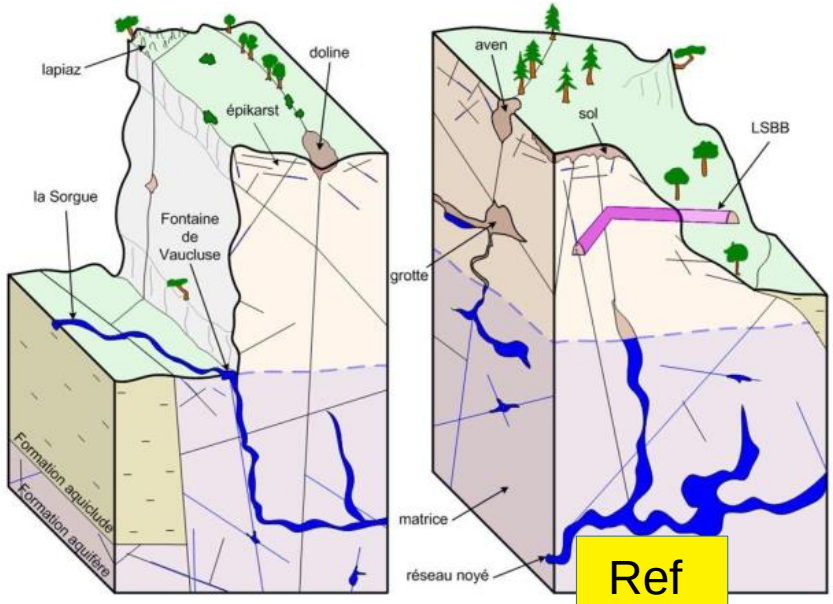
Valuable water resource :

- Provide 10 % of world's population drinking water
- Key ressource for many countries (up to 80 % of drinking water supply) & towns

Chen et al., 2017, Stevanovic, 2019, Goldscheider *et al., 2020*

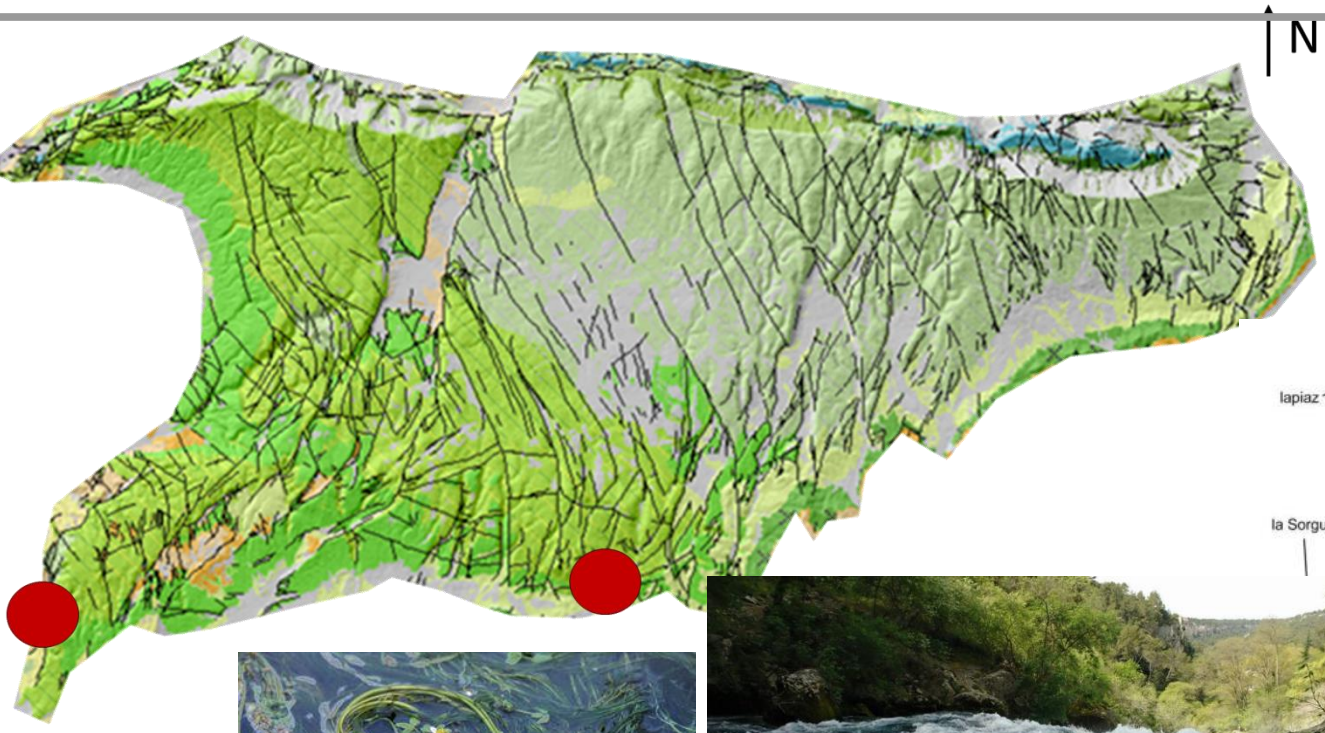
Water (and air) run through it

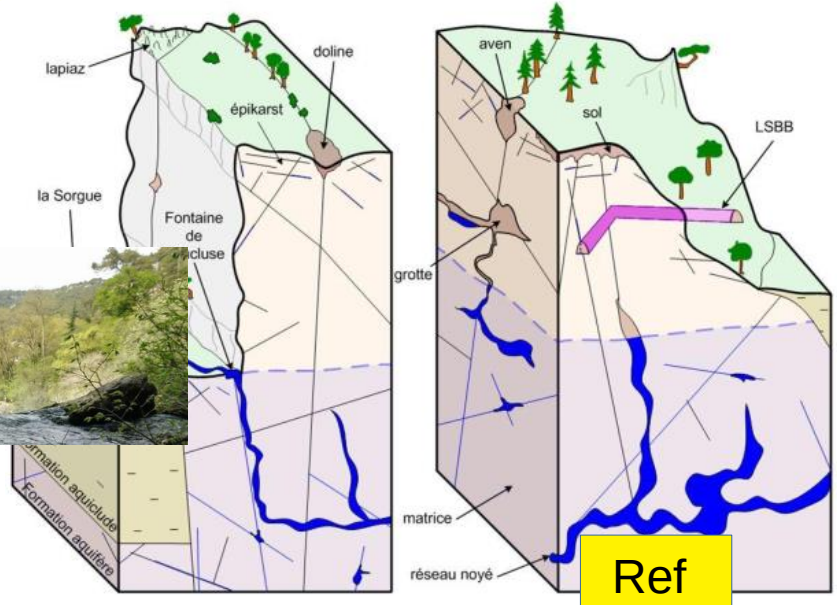




Ref

Critical Zone

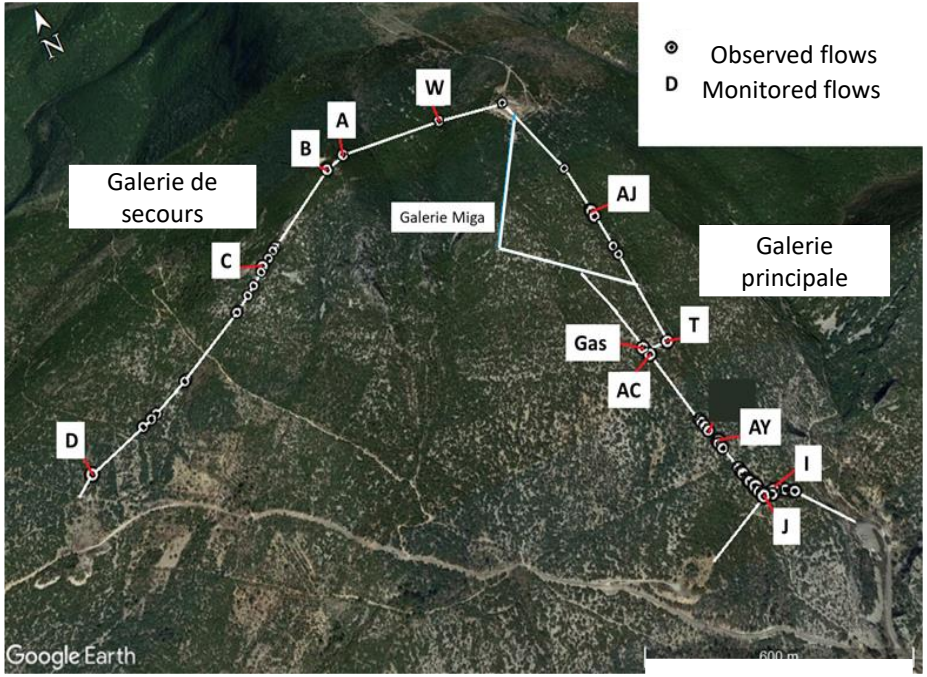


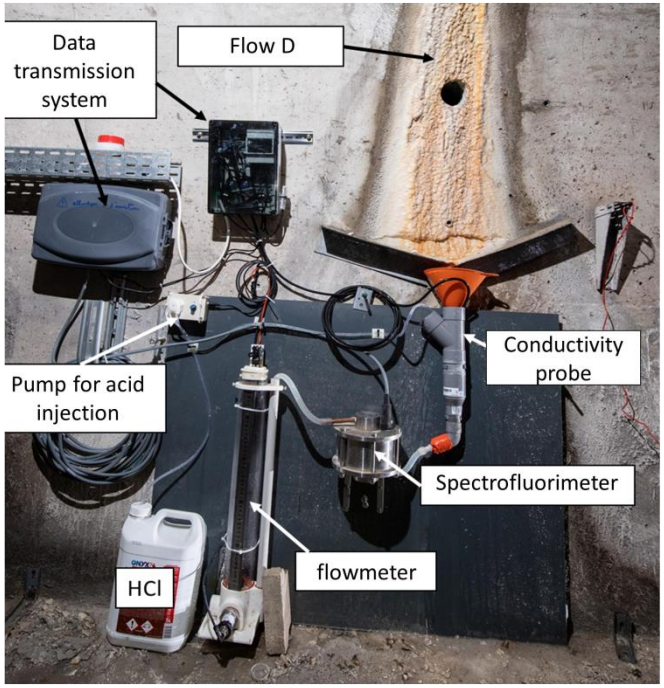


Ref

Flow monitoring at LSBB

- Within tunnel :
  - automated discharge, conductivity, natural fluorescence & temperature monitoring
  - Sampling & hydrochemical monitoring

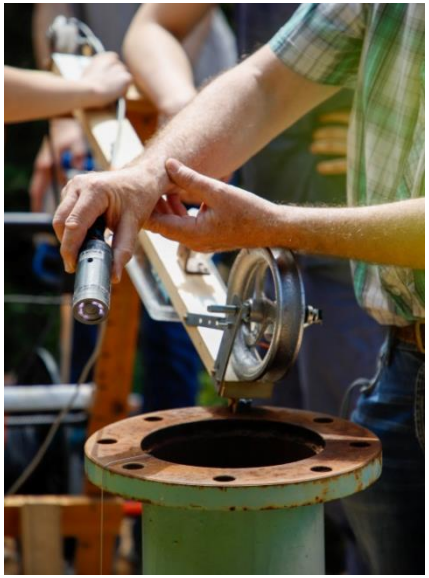


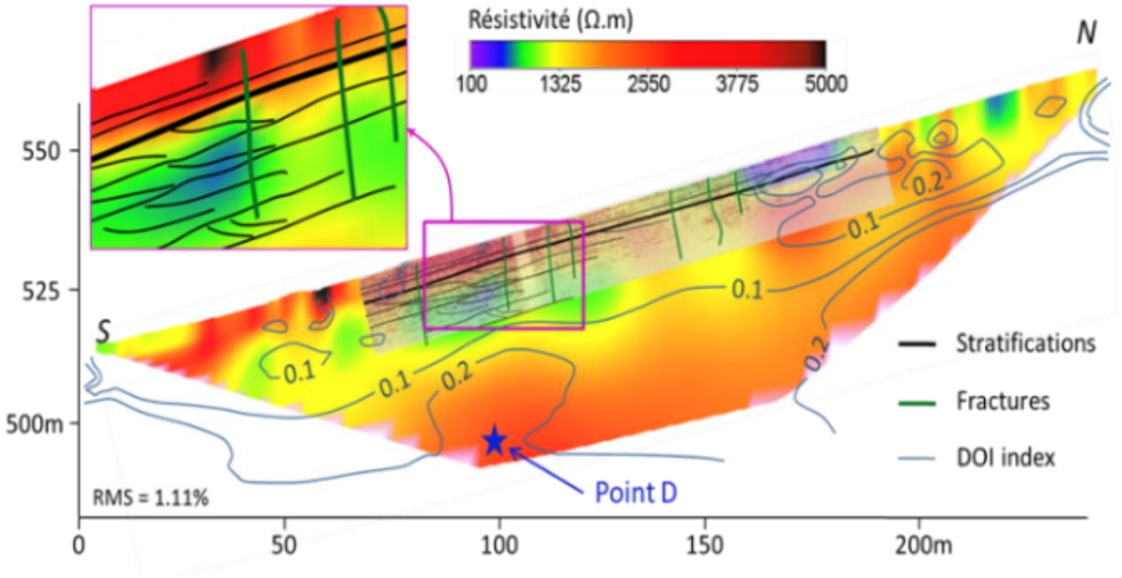


TotalEnergies

Flow monitoring at LSBB

- Within tunnel
- At the surface of exit gallery :
  - Triplet of wells in UZ, evidence of perched saturated zones
  - MRS, ERT, GPR, seismics, muography… experiments to image structure & monitor flows

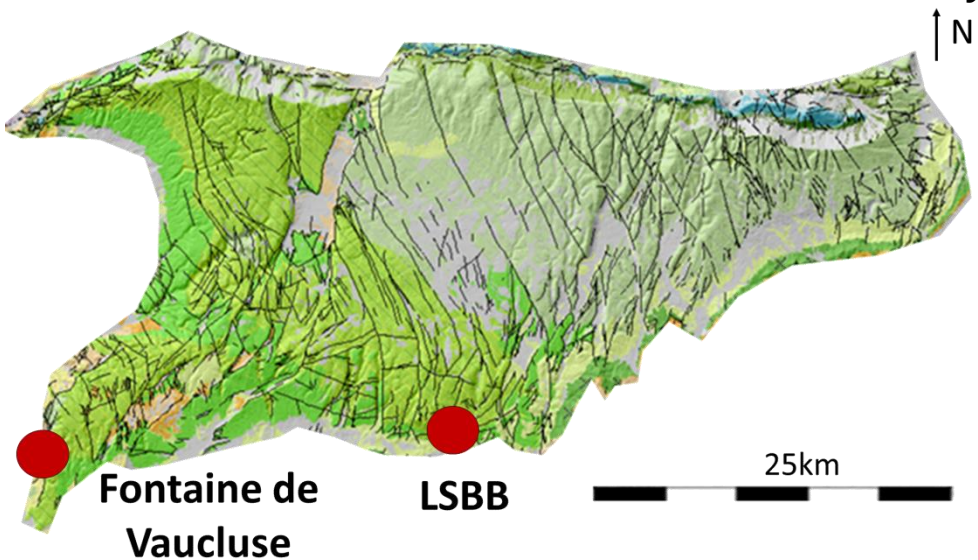




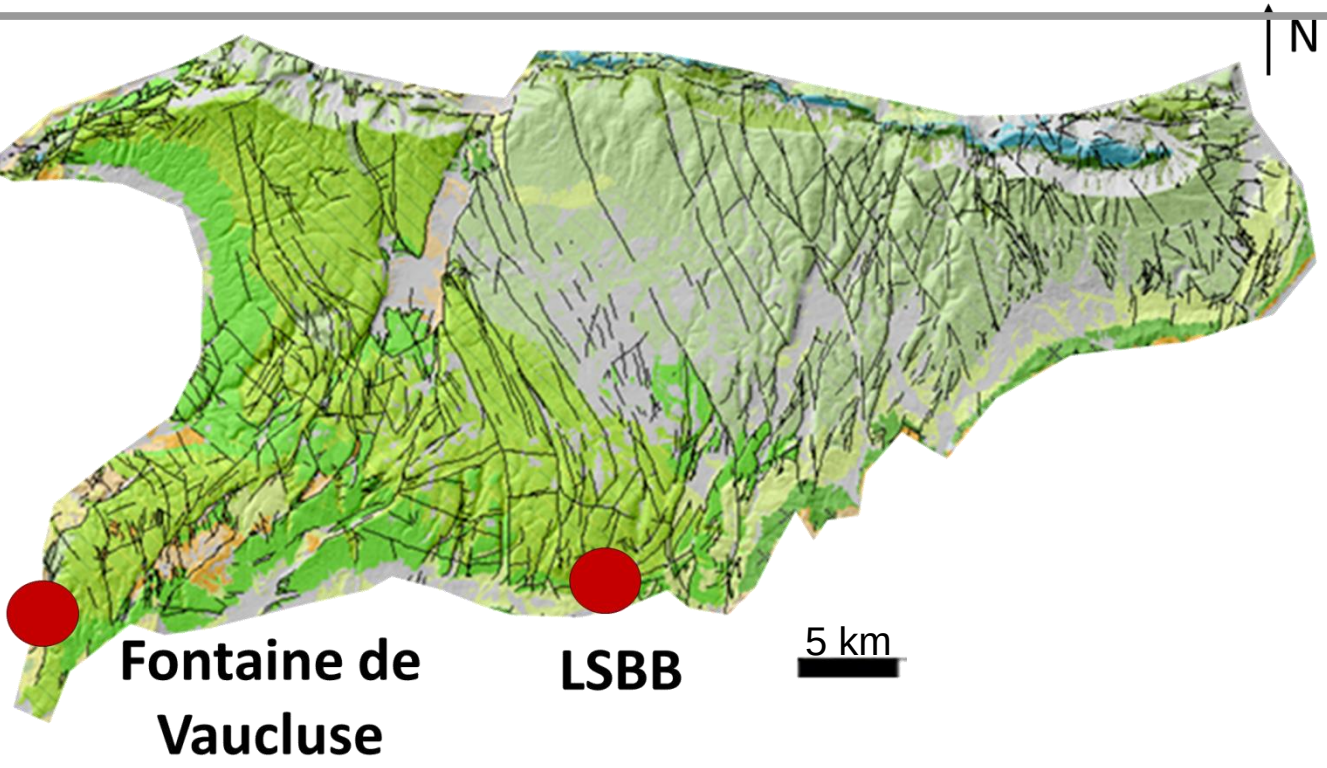
TotalEnergies

Flow monitoring at LSBB

- Within tunnel
- At the surface of exit gallery
- In a 450-m deep well reaching saturated zone
  - Close correlation with Fontaine de Vaucluse dynamics



Multi-scale insights from LSBB into Critical Zone



Multi-physics insights from LSBB into Critical Zone

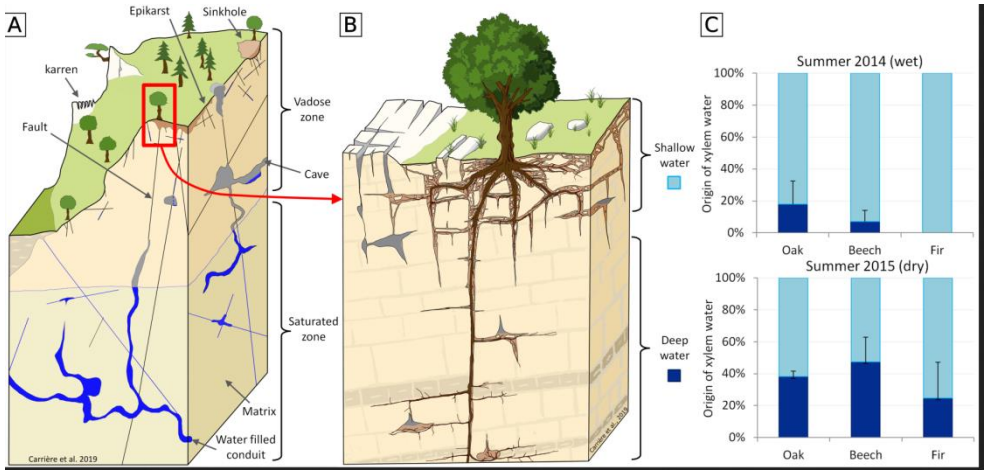
My signal is your noise

And

Your signal is my noise

Use of the LSBB knowledge and data (^{18}O) for understood deep of water used by vegetation

Colaboration with : URFM - UR629 Unité de Recherche écologie des Forêts Méditerranéennes



Contact : simon.carriere@upmc.fr

Référence : Carrière, S.D., Martin-StPaul, N.K., Cakpo, C.B., Patris, N., Gillon, M., Chalikakis, K., Doussan, C., Olioso, A., Babic, M., Jouineau, A., Simioni, G., Davi, H., 2020. The role of deep vadose zone water in tree transpiration during drought periods in karst settings–Insights from isotopic tracing and leaf water potential. Science of the Total Environment 699, 134332.

Use of trace elements to distinguish flows from different types of carbonated rocks

Leïla Serène[1], Christelle Batiot-Guilhe[1], Naomi Mazzilli[2], Philippe Léonide[3], Christophe Emblanch[2], Eléonore Resongles[1], Rémi Freydier[1], Léa Causse[4], Milanka Babic[2], Julien Dupont[2], Roland Simler[2], Matthieu Blanc, Gérard Massonnat[5]

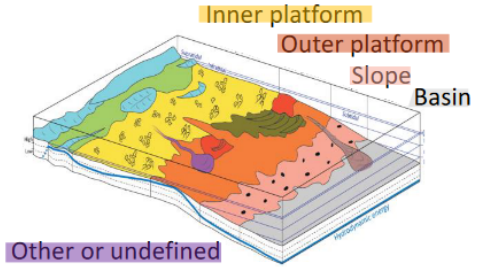
1. HydroSciences Montpellier (HSM), Univ Montpellier, CNRS, IRD, Montpellier, France
2. UMR 1114 EMMAH (AU-INRAE), Université d'Avignon, 84000 Avignon, France
3. Aix Marseille Univ, CNRS, IRD, INRAE, CEREGE, Aix-en-Provence, France
4. OREME, Univ Montpellier, CNRS, INRAE, IRD, Montpellier, France
5. TotalEnergies, CSTJF, Avenue Larribau, CEDEX 64018 Pau, France

IAHS – Montpellier 2022 – Wednesday, 1 June 2022, 11:00, session S17, IAHS2022-329

Clustering of rock samples

Clear link between clustering and deposit environments

→ This signal may be transmitted to karst water



Correlation Between Evapotranspiration and Gravity at a Daily Time Scale

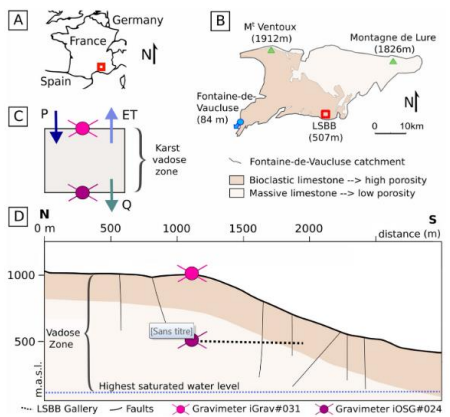


Figure 1. Site presentation: (a) Location map of the experimental site in France. (b) LSBB experimental site located in th Fontaine-de-Vaucluse catchment with a simplified geological context. (c) Simplified water balance of the system included between the two gravimeters where P is precipitation, ET is evapotranspiration, and Q is deep water discharge. Runoff is commonly neglected due to the very high permeability of the karst. (d) Simplified geological cross-section showing gravimeter locations and the influence cone of 90% of gravity signal.

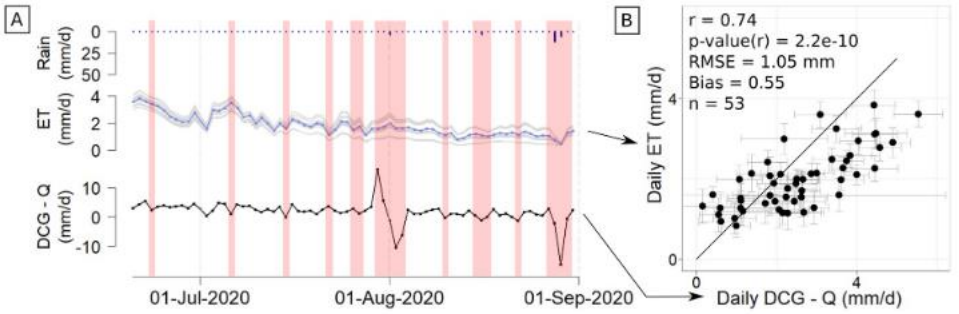


Figure 3. Comparison of measured surface-to-depth gravimetry signal minus discharge (Q) measured at the Fontaine-de-Vaucluse spring with the modeled evapotranspiration (ET). (a) Temporal graphs. The red areas are periods excluded from the analysis because they are affected by various phenomena (earthquake, storm, rain and explosion). ET gray lines are individual pixel time series and the sky blue line is the mean value calculated within 15 pixels surrounding the SGs. The cumulated daily flow at Fontaine-de-Vaucluse was divided by the surface of hydrosystem (1,200 km) to express discharge in mm/d. P is precipitation. (b) Correlation between daily ET modeled and daily DCG–Q measured (r: Pearson correlation; RMSE: root mean square error; n: number of value).

Contact : simon.carriere@upmc.fr

First Evidence of Correlation Between Evapotranspiration and Gravity at a Daily Time Scale From Two Vertically Spaced Superconducting Gravimeters

Simon D. Carrière, Bertille Loiseau, Cédric Champollion, Chloé Ollivier, Nicolas K. Martin-StPaul, Nolwenn Lesparre, Albert Olioso, Jacques Hinderer, Damien Jougnot

Geophysical Research Letters, Research Letter, https://doi.org/10.1029/2021GL096579

Magneto hydro sysmique

Tomographic Research of Underground and large STructures with Muographic Expertise (TRUST-ME)

CNRS INNOVATION

LSBB Laboratoire Souterrain à Bas Bruit
Low Noise Inter-Disciplinary Underground Science & Technology

cnrs

AVIGNON UNIVERSITÉ

Clément Risso | Ignacio Lázaro Roche

How long baseline tiltmeters Tilt fluctuations can potentially reflect the response of karst hydrosystems

Contact :

Nolwenn Lesparre,[1,2]
Fr´ed´erick Boudin, [3]

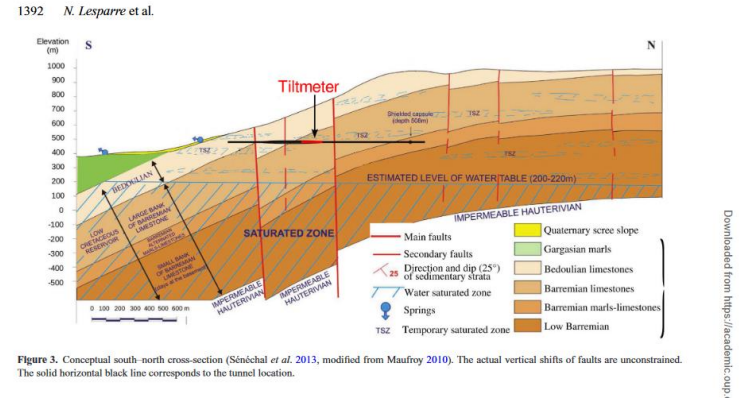


Figure 3. Conceptual south–north cross-section (Sénéchal *et al.* 2013, modified from Maufroy 2010). The actual vertical shifts of faults are unconstrained. The solid horizontal black line corresponds to the tunnel location.

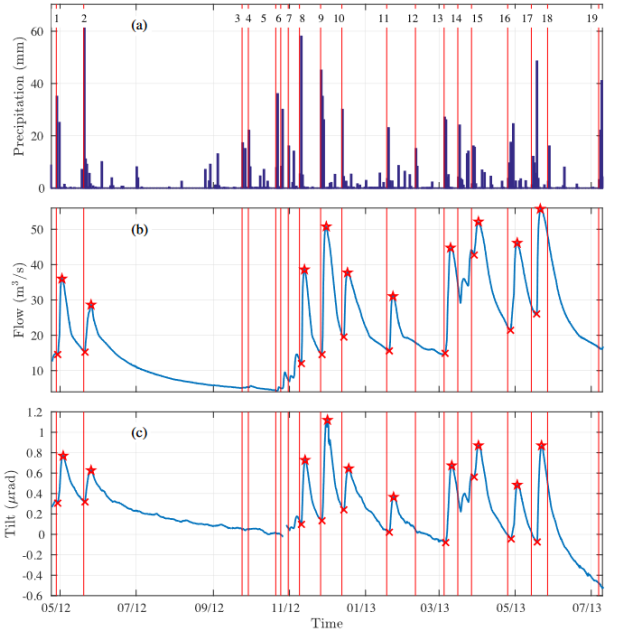


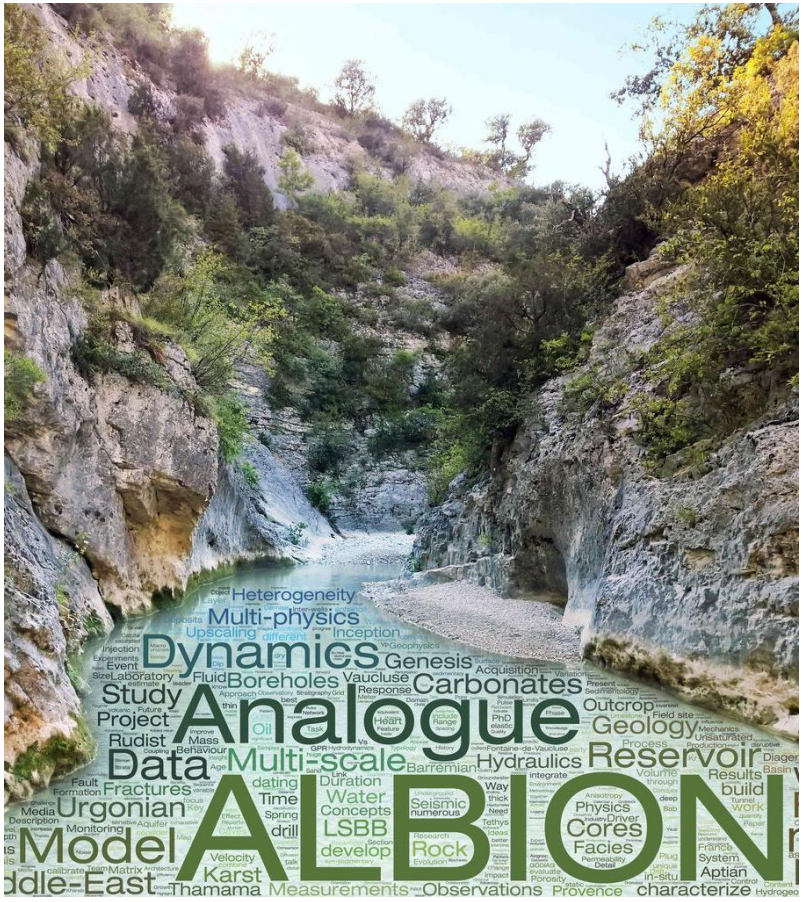
Figure 4. (a) Pluviometry data in mm d^{-1}. (b) Flow at the FdV outlet. (c) Tilts measured along the 350°N direction with the long base of about 150 m. An increase of the tilt indicates that the southern block rises up. Red lines indicate rain events with precipitations higher than 15 mm. Tilt variations higher than 0.3 μrad are marked by red stars. The red crosses denote the starting of the flow and tilt increase on the plots (b) and (c), respectively.

1 OREME, G´eosciences Montpellier, CNRS, Univ. Montpellier, Montpellier, France. E-mail: nolwenn.lesparre@ulg.ac.be
2 ArGEnCo Department, Applied Geophysics, University of Li`ege, Li`ege, Belgium
3 Laboratoire de G´eologie de l'ENS, UMR CNRS 8538, ´Ecole Normale Sup´erieure, Paris, France

New insights on fractures deformation from tiltmeter data measured inside the Fontaine de Vaucluse karst system
Nolwenn Lesparre,1,2 Fr´ed´erick Boudin, 3 C´edric Champollion,1 Jean Ch´ery,1
Charles Danquigny, 4,5 Han Cheng Seat, 6 Michel Cattoen, 6 Franc¸oise Lizion 6
and Laurent Longuevergne

Geophys. J. Int. (2017) 208, 1389–1402 Advance Access publication 2016 December 1.GJI Gravity, geodesy and tide
doi: 10.1093/gji/ggw446

ALBION:
The LSBB & the Fontaine-de-Vaucluse aquifer, as a dynamic analogue of Barremian-Aptian carbonate platforms



TotalEnergies

cnrs

LSBB
Laboratoire Souterrain à Bas Bruit
Low Noise Inter-Disciplinary Underground Science & Technology

UGA
Université
Grenoble Alpes

Aix*Marseille
université

UNIVERSITÉ
DE PAU ET DES
PAYS DE L'ADOUR

modis

AVIGNON
UNIVERSITÉ

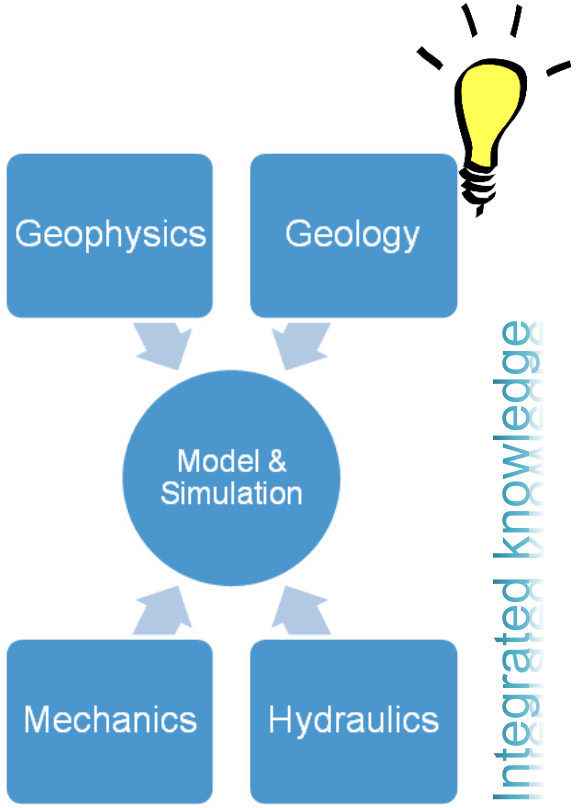
ALBION: key figures

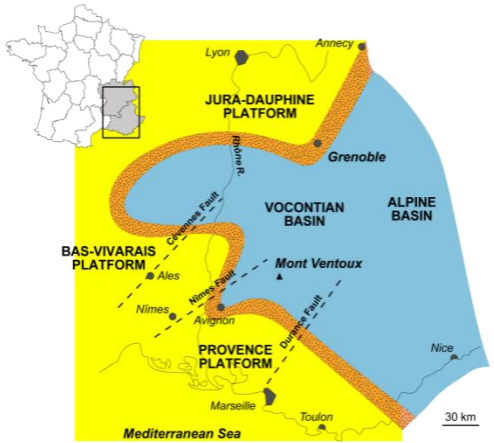
- Geological heterogeneity VS diagenesis
- Karst genesis VS geology
- Hydrodynamics VS geology

4D characterization methods

- Scales & Upscaling

Coupled modelling





Late Barremian

Inner platform rudist bearing carbonates

Outer platform bioclastics

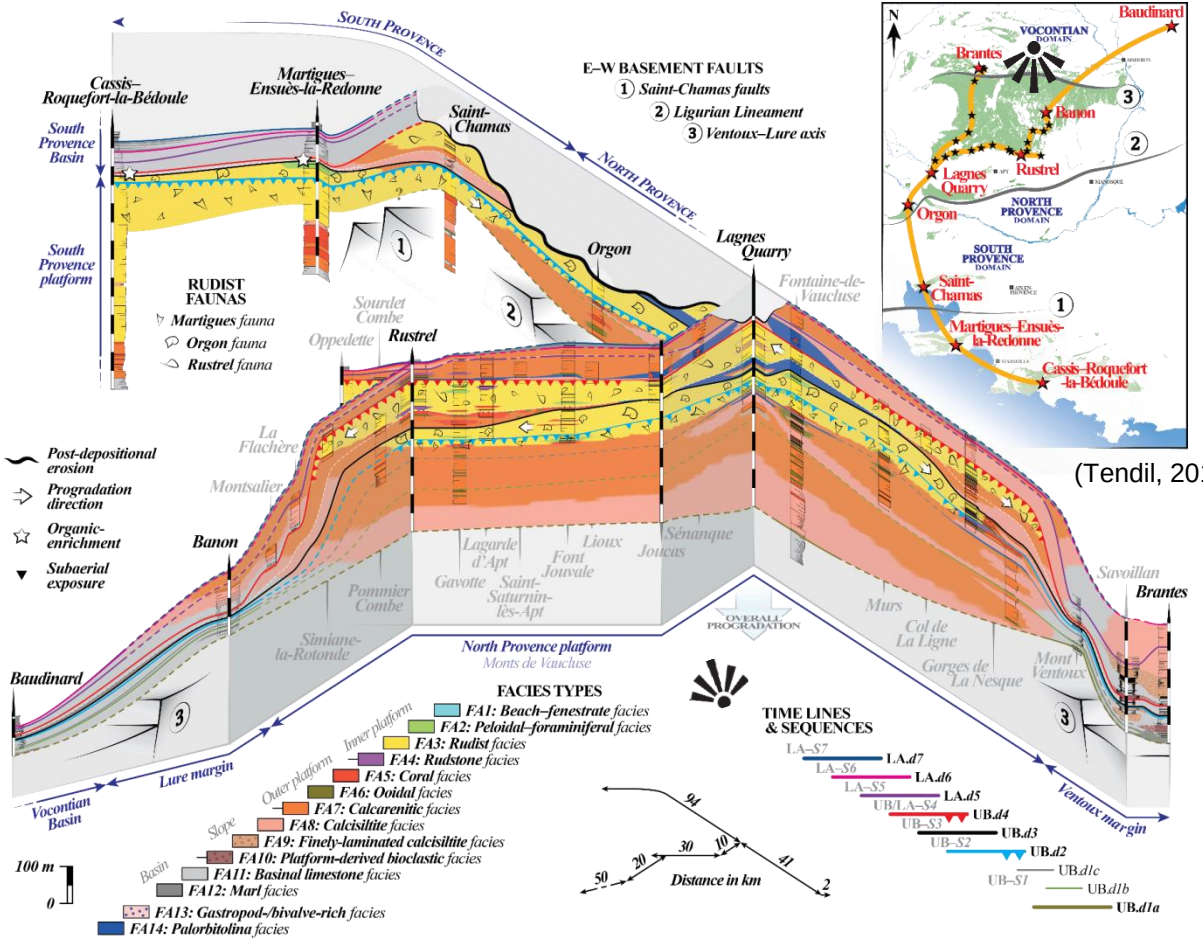
Outer shelf and pelagic basin

MIDDLE - LATE BARREMIAN PALEOGEOGRAPHY, *SE FRANCE.* *(FROM MASSE & FENERCI-MASSE, 2006).*

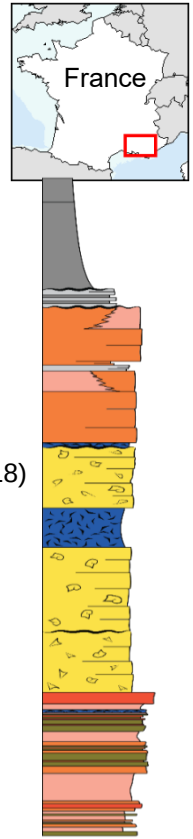
Well-studied area for years

⬇

Regional stratigraphic model



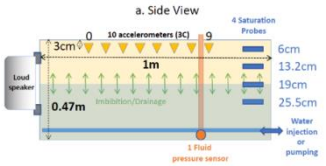
(Tendil, 2018)

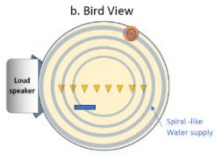


NORTH PROVENCE *(FONTAINE-DE-VAUCLUSE SECTION)*

Upscaling

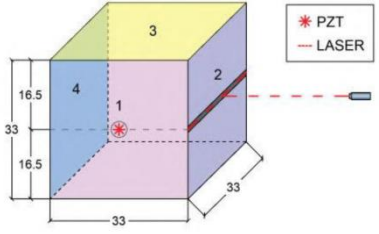
Lab-scale studies

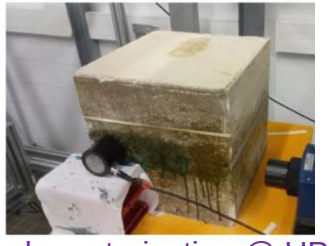




e.g. Passive seism @ UPPA Sandbox

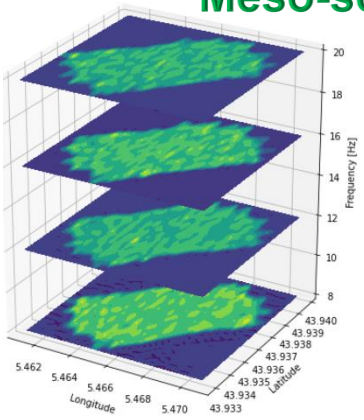
UNIVERSITÉ DE PAU ET DES PAYS DE L'ADOUR





e.g. Blocks acoustic & EM characterization @ UPPA Lab

Meso-scale studies @LSBB



e.g. Geobodies characterization with Passive seismic tomography @ LSBB – Buissonnière

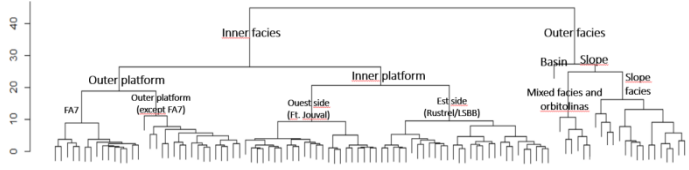
Reservoir Monitoring & upscaling Synthesis

Reservoir Flow Simulation

Flow concepts & simulations

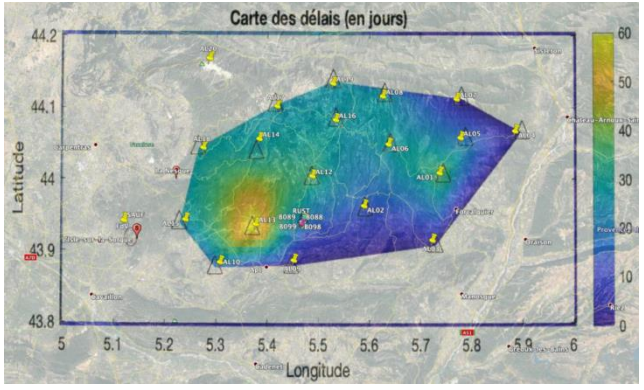
e.g. Traces elements in rock & fluids (PhD L. Serene)

16 selected elements :
Li, B, S, V, Cr, Co, Ni, Cu, Zn, As, Rb, Sr, Cd, Ba, Pb, U

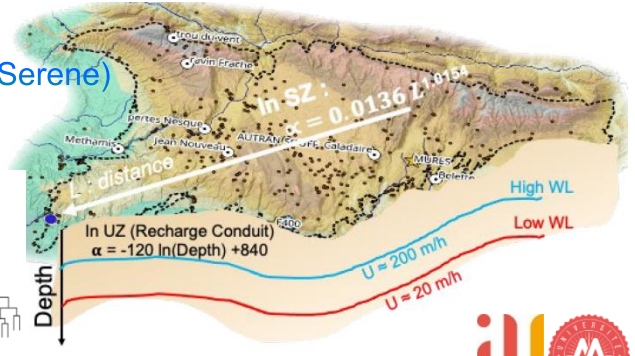


Input & Constraints for flow simulations

UGA Université Grenoble Alpes



e.g. Passive seismics: Ambient noise intra-corre



e.g. Unsaturated vs saturated zone parameters characterization

AVIGNON UNIVERSITÉ


MERCI