eurokarst 2022 MÁLAGA

Hydrogeological processes of karst-influenced multi-layered aquifers of northern Aquitaine basin, France

M. Quispe Sihuas (BRGM Bordeaux – I2M)

J.B. Charlier (BRGM Montpellier – G-Eau)
R. Lastennet (I2M)
O. Cabaret (BRGM Bordeaux)
B. Dewandel (BRGM Montpellier – G-Eau)
A. Denis (I2M)

Introduction

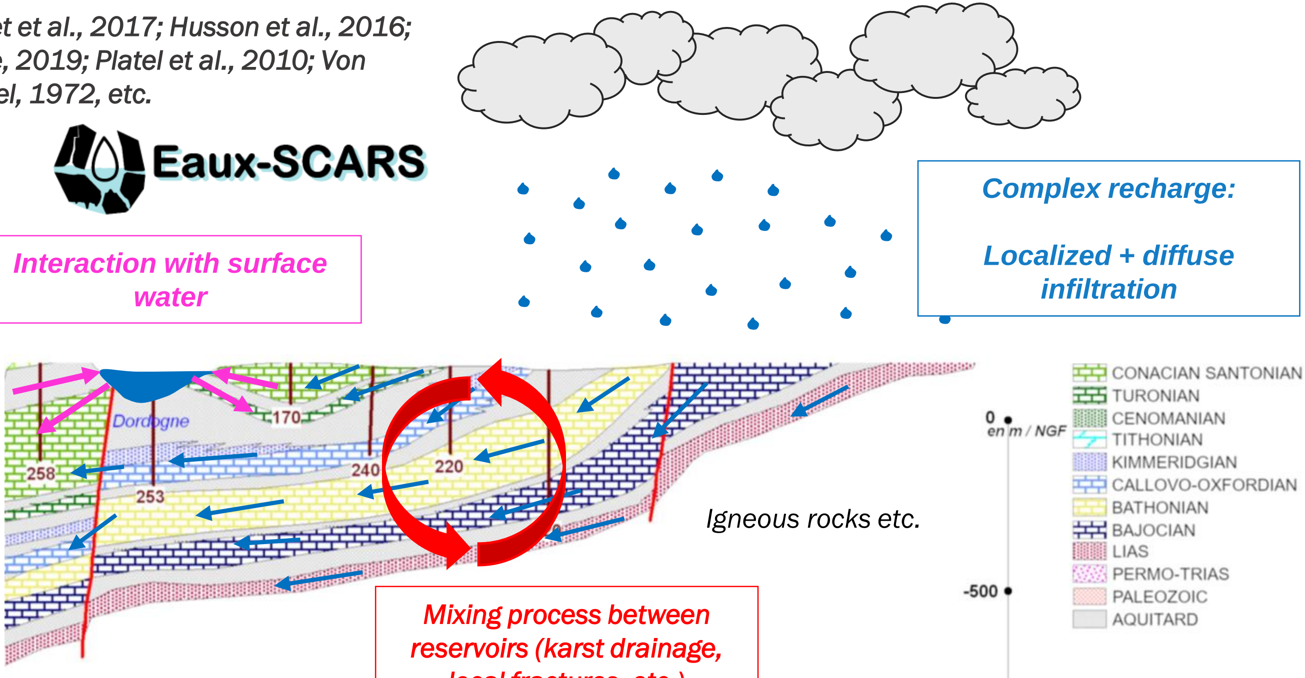
Cabaret et al., 2017; Husson et al., 2016; Lorette, 2019; Platel et al., 2010; Von Stempel, 1972, etc.

Eaux-SCARS

Interaction with surface water

Complex recharge:

Localized + diffuse infiltration



Mixing process between reservoirs (karst drainage, local fractures, etc.)

Sedimentary basin

Multilayer reservoir feature + Karst feature

Very complex and heterogeneous system

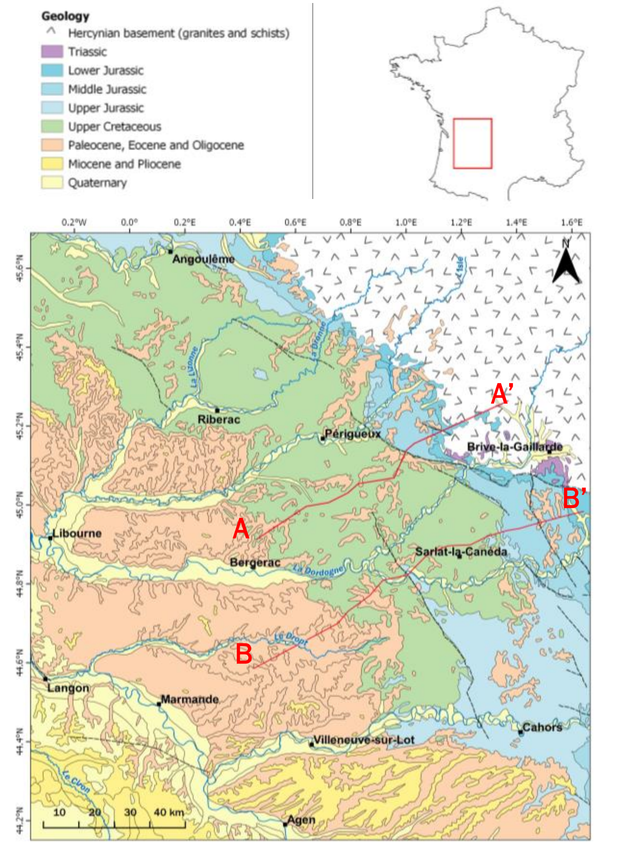
Objective 1: characterize the regional hydrodynamic and hydro chemical variability of multi-layer carbonate aquifers located in the basin edge by considering their karst feature.

Study Area

Northern Aquitaine Basin (AB) in Southwest France.

Sediments from Triassic to Upper cretaceous overly the Hercynian granite and schist basement

The alternation of aquifers and aquitards create a complex multilayer aquifer system, characterized by 2 main reservoirs:



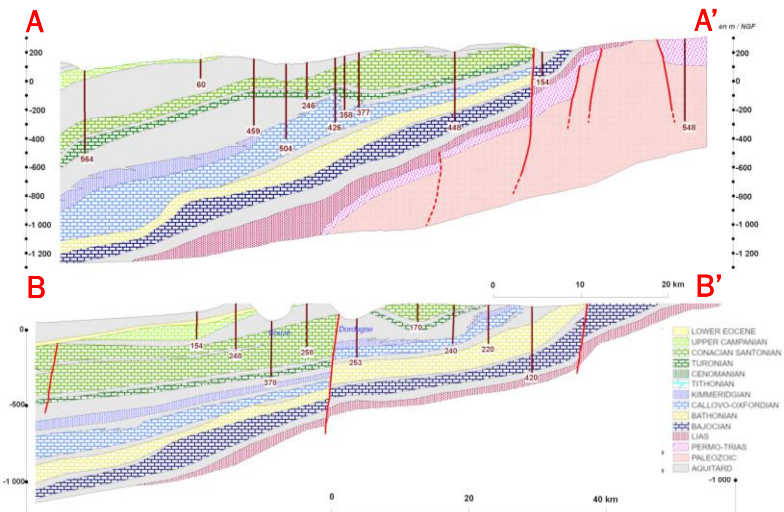
Study area in the edge North Aquitaine Basin (southwest France)

Study Area

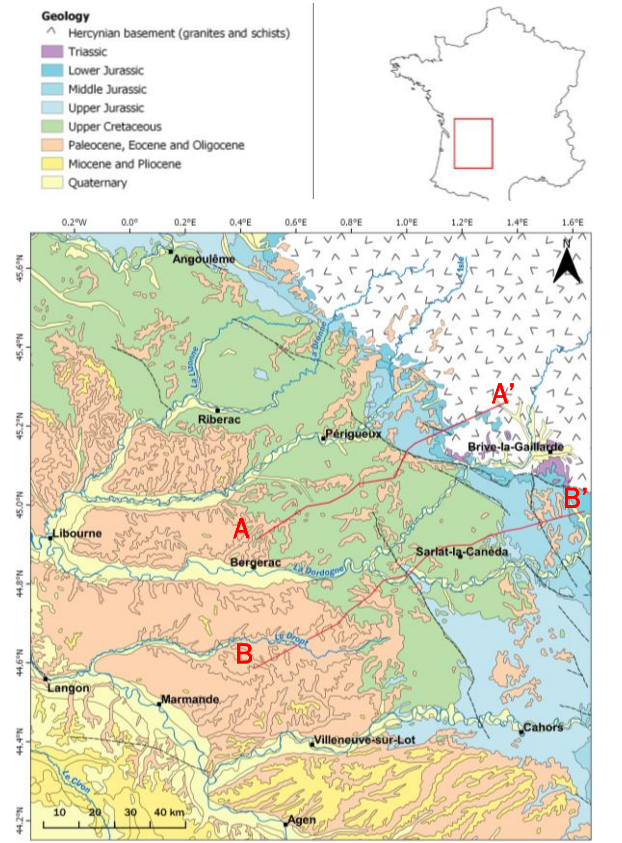
euro karst 2022 MÁLAGA

Upper cretaceous multi-layer system, mainly composed of fractured limestone and contains four aquifers: Cenomanian, Turonian, Coniacian-Santonian and Campanian.

Jurassic multi layer system, mostly dolomitized, and composed by 5 reservoirs: Lias, Bajocian, Bathonian - Callovian – Oxfordian (the thickest and the most important), Kimmeridgian and the local reservoir of Tithonian.



Hydrogeological cross sections (adapted from Platel et al., 2010).

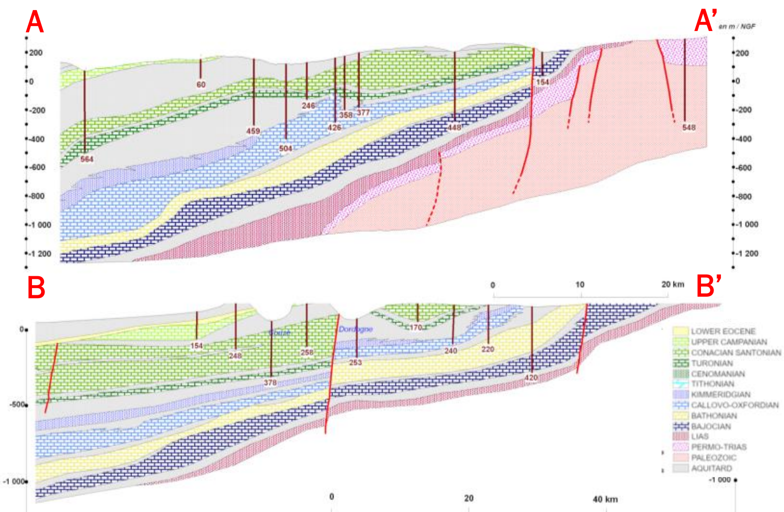


Study area in the edge North Aquitaine Basin (southwest France)

Study Area

Upper cretaceous multi-layer system, mainly composed of fractured limestone and contains four aquifers: Cenomanian, Turonian, Coniacian-Santonian and Campanian.

Jurassic multi layer system, mostly dolomitized, and composed by 5 reservoirs: Lias, Bajocian, Bathonian - Callovian – Oxfordian (the thickest and the most important), Kimmeridgian and the local reservoir of Tithonian.



Hydrogeological cross sections (adapted from Platel et al., 2010).

*These predominantly carbonate formations are **karstified**, both **outcrop and undercover***

Materials and methods

Groundwater and hydrological dataset was compiled from several public data-bases:

1. Hydrochemical data (major elements) and water levels
2. Geological and technical information from springs and wells

eaufrance

ades

InfoTerre

La Banque du Sous-Sol (BSS)

1. Piezometric maps

- 29 in Upper Cretaceous aquifers (Turonian and/or Coniacian Santonian and/or Cenomanian)
- 25 in Jurassic aquifers (Bajocian and/or Bathonian Callovian Oxfordian and/or Kimmeridgian)
- Dry and wet season 2017
- Standard Kriging interpolation

2. Hydrochemical maps and PCA

- 65 springs and shallow wells (max. 7 m depth), and 94 boreholes (up to 1.2 km in depth, 330 m in average)
- The boreholes screened both in the Jurassic and Upper Cretaceous aquifers were not selected
- A minimum of 5 samples per site over the 2000-2019
- Ionic balance greater than 5% was not accepted
- Temperature, pH, EC at 25 °C, and chemical analyses of major elements
- Use of the median value

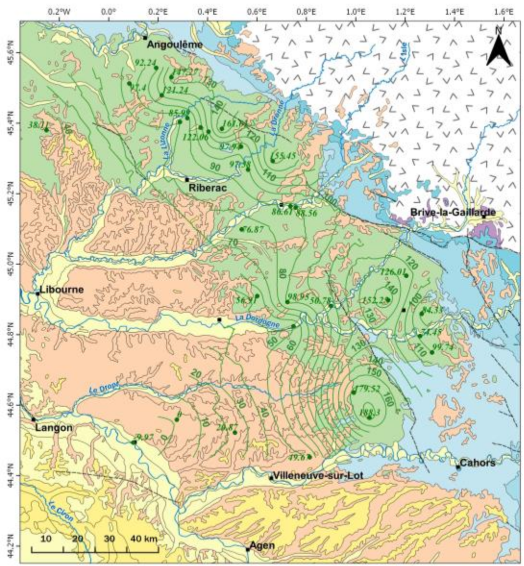
3. Geothermal gradient

- Simple linear regression
- Calculated from 81 sites (boreholes) with a screen at least at 25 m deep.
- The screened interval must be less than 100 m

Results and discussion : Hydrogeological characteristics

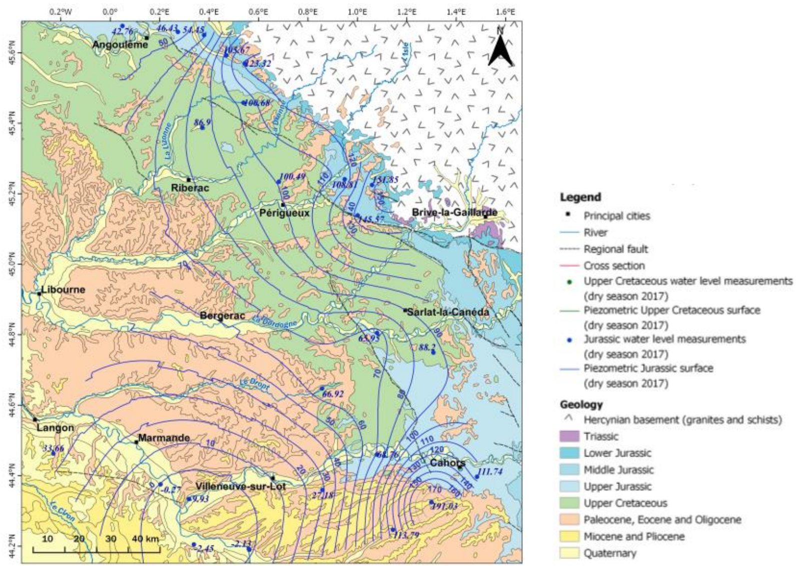
Upper cretaceous piezometric map dry season 2017

- Recharge zone on the Turonian and Conacian Santonian outcrops
- Rivers such as Dordogne, Lizonne, Dronne and Isle appear to drain the cretaceous aquifer.

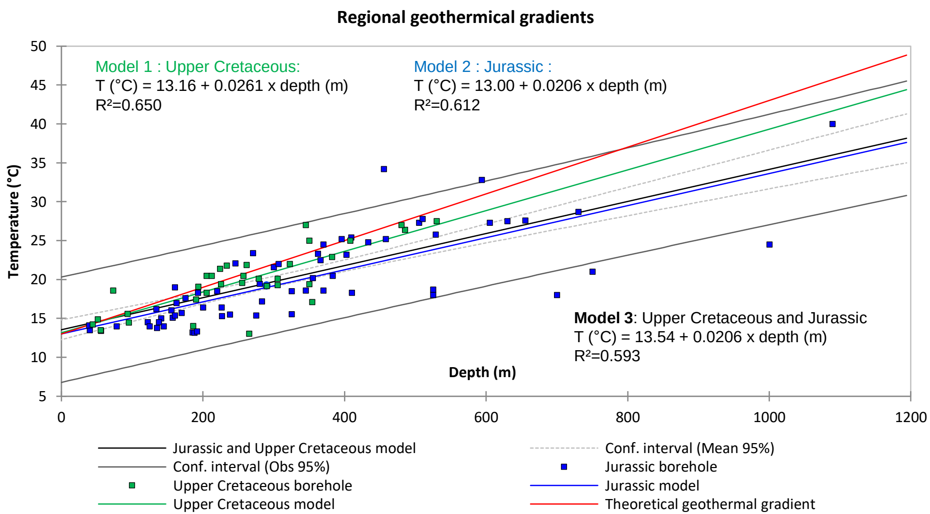


Jurassic piezometric map dry season 2017

- Two main flow direction are observed : EW (Perigueux area) and NE-SW between Sarlat-la-Canéda and Cahors
- Dividing line seems accentuated by the piezometric depression



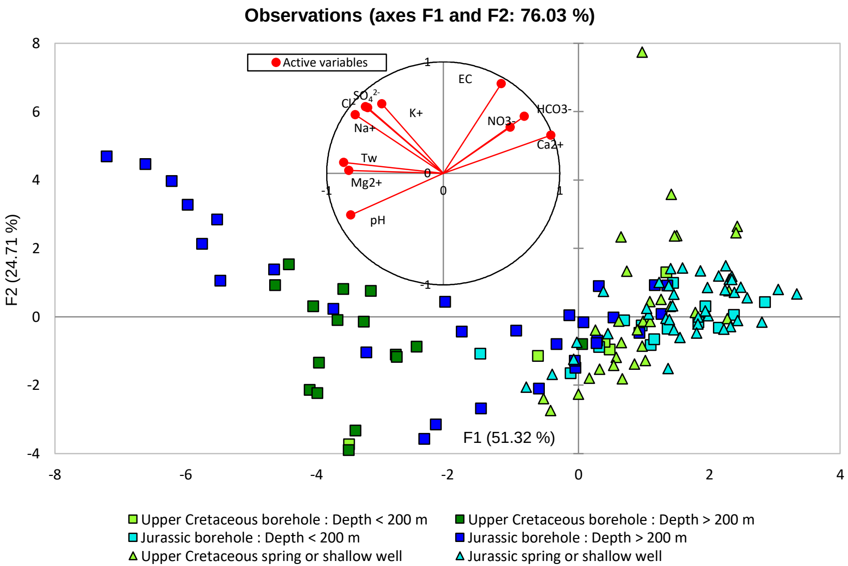
Results and discussion : Geothermal gradient



- Temperature variability in the Upper Cretaceous and Jurassic aquifers; 13.5 to 40 °C
- Global regional geothermal gradient of 2.060 °C/100 m

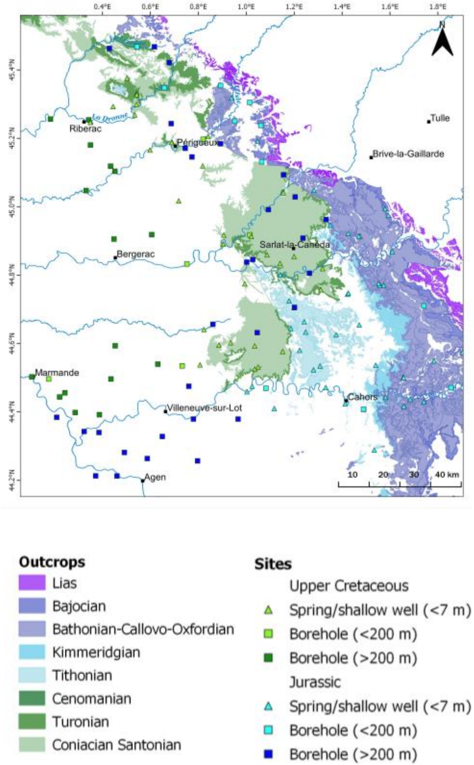
Cold-water anomalies at important depths

Results and discussion : Hydrochemical variability

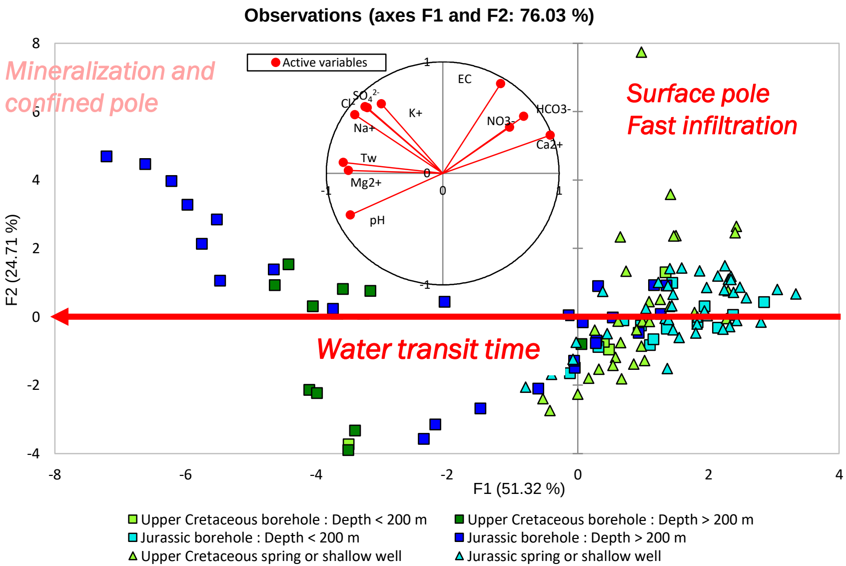


Plot based on principal components analysis of hydrochemical sampling from springs and boreholes

Sites localization



Results and discussion : Hydrochemical variability



Plot based on principal components analysis of hydrochemical sampling from springs and boreholes

Variables: Mg^{2+} well correlated with Tw and negatively correlated with Ca^{2+} , HCO^{-} and NO_3^{-} .

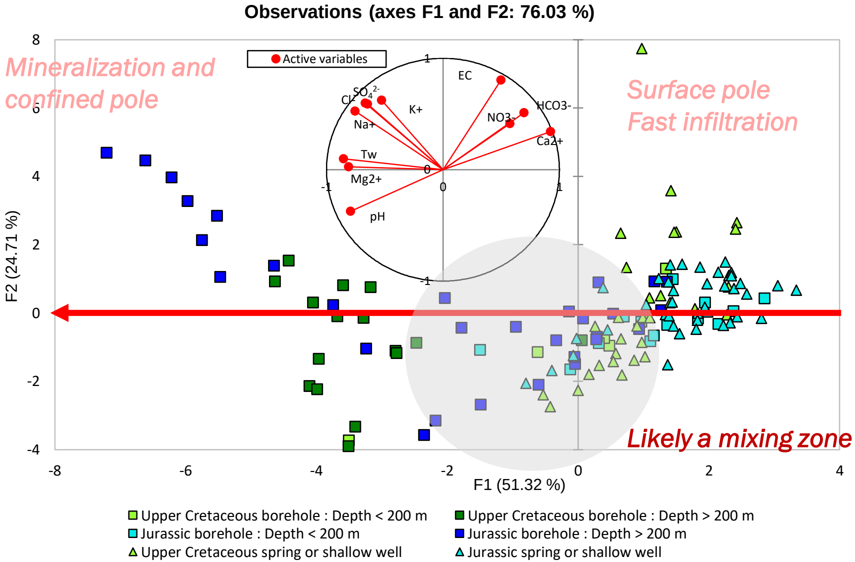
Na^{+} , Cl^{-} , K^{+} and SO_4^{2-} are well correlated.

Observations:

1. Boreholes deeper than 200 m (with a few exceptions)
Strong concentrations of Mg^{2+} , Na^{+} , Cl^{-} and SO_4^{2-} ->mineralization

2. Springs, shallow wells and boreholes of shallow depth (<200 m) wigh high values of Ca^{2+} and bicarbonates

Results and discussion : Hydrochemical variability



Plot based on principal components analysis of hydrochemical sampling from springs and boreholes

Variables: Mg^{2+} well correlated with Tw and negatively correlated with Ca^{2+} , HCO^{-} and NO_3^{-} .

Na^{+} , Cl^{-} , K^{+} and SO_4^{2-} are well correlated.

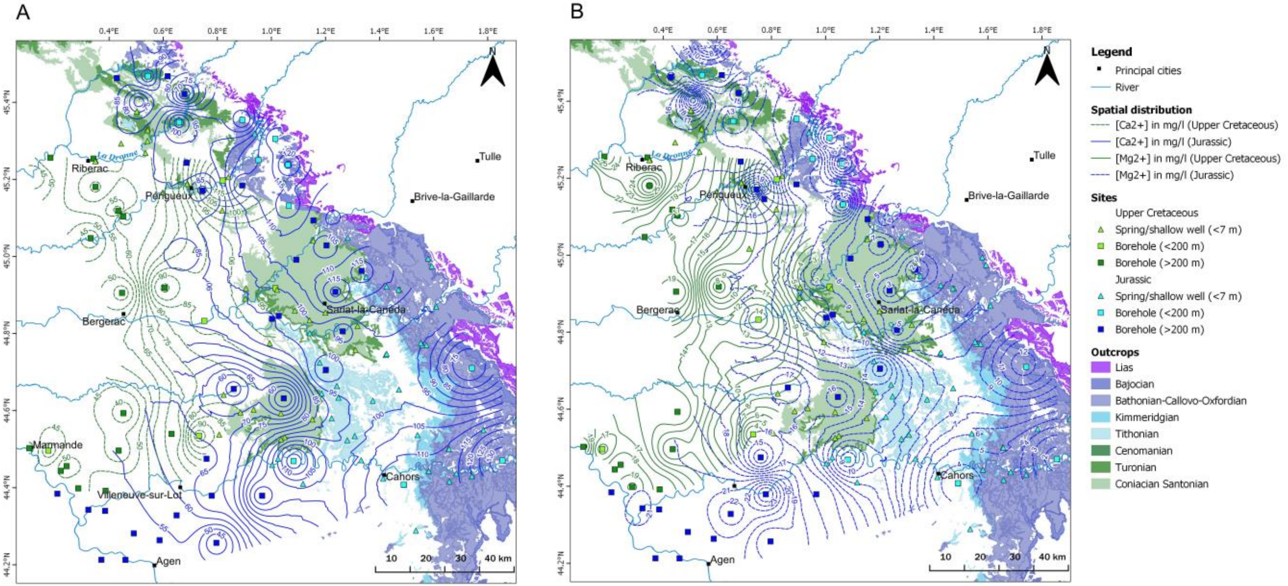
Observations:

1. Boreholes deeper than 200 m (with a few exceptions)
Strong concentrations of Mg^{2+} , Na^{+} , Cl^{-} and SO_4^{2-} ->mineralization

2. Springs, shallow wells and boreholes of shallow depth (<200 m) wigh high values of Ca^{2+} and bicarbonates

Results and discussion : Spatial variability

Spatial variability of Ca (a) and Mg (b) concentrations in both Upper Cretaceous and Jurassic aquifers.



- High concentrations of Ca2+ (around 120 mg/L)
- Ca2+ decrease from East to West and Southwest

- Low concentration of Mg2+ at the outcrops.
- Mg2+ increase from East to West and Southwest

Conclusions:

- The Upper Cretaceous and Jurassic aquifers are widely heterogeneous.
- The hydrogeochemistry varies according the lithology facies, the residence time, the depth, and very likely because of the karstic feature.
- Our results show evidences of mixing zones between the two main Cretaceous and Jurassic reservoirs.
- This is probably due to the karstic and fractured natures of the carbonate formations that allow a fast infiltration through vertical drainage of water from the surface towards the deep parts of the aquifers
- The isotopic method (87Sr/86Sr) shows encouraging results to quantify the contribution of carbonate aquifers to the principal rivers.