GeoEnergy Days

THE GAIA-PROGRAM: A SCIENTIFIC APPROACH DEDICATED TO THE UNDERSTANDING OF THE DEEP GROUNDWATER CIRCULATIONS IN THE SOUTH AQUITAINE BASIN.

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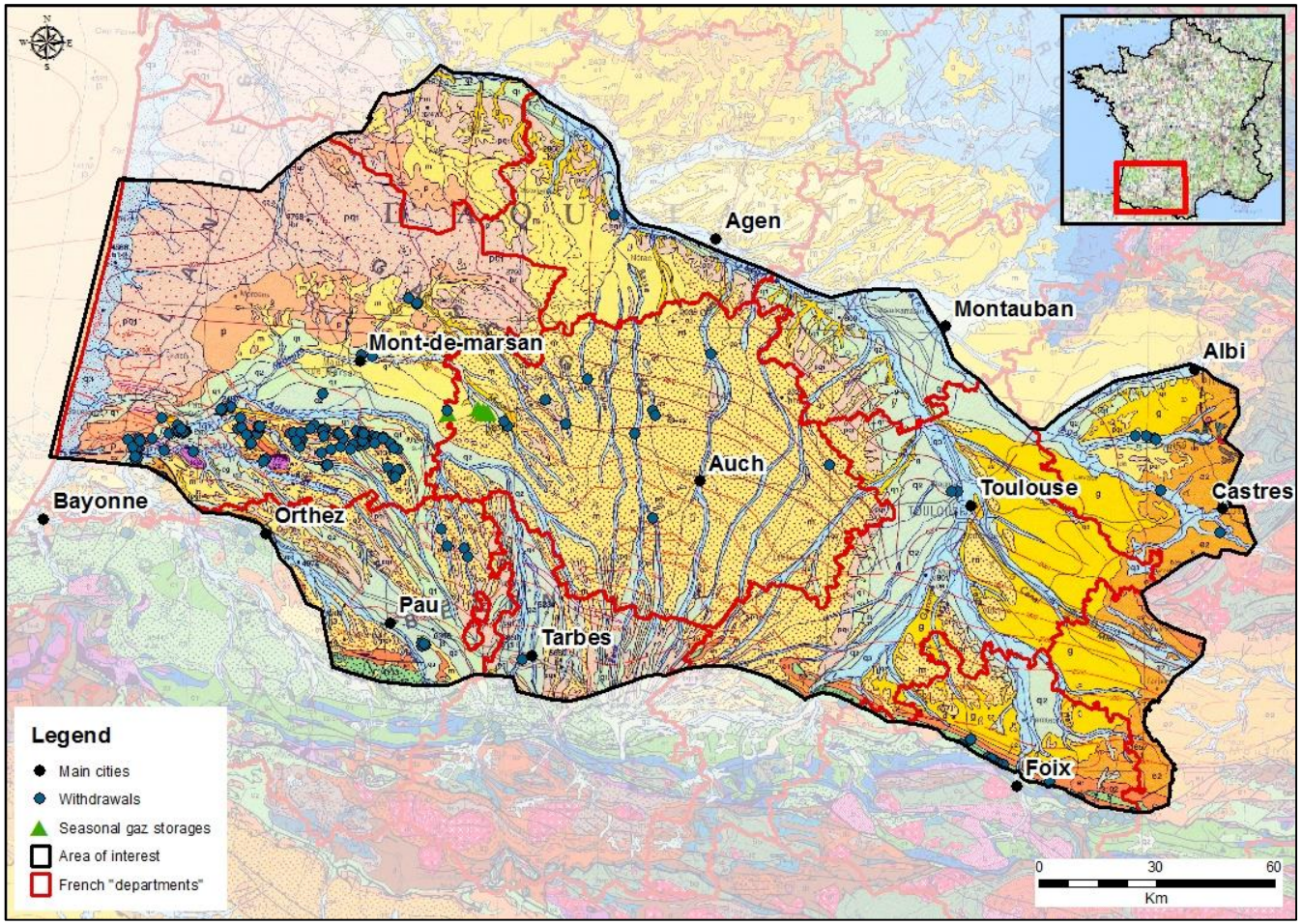
Hydrogeological context

So called “deep aquifers” (Eocene to upper Cretaceous) of the south Aquitaine Basin are used for multiple uses: drinking water, thermal and geothermic applications, irrigation and seasonal gas storage



Area : 32 000 km²

Depth to aquifers: 0-3000m

About 200 exploitation boreholes for a cumulated volume reaching 25 to 30 Mm³/yr

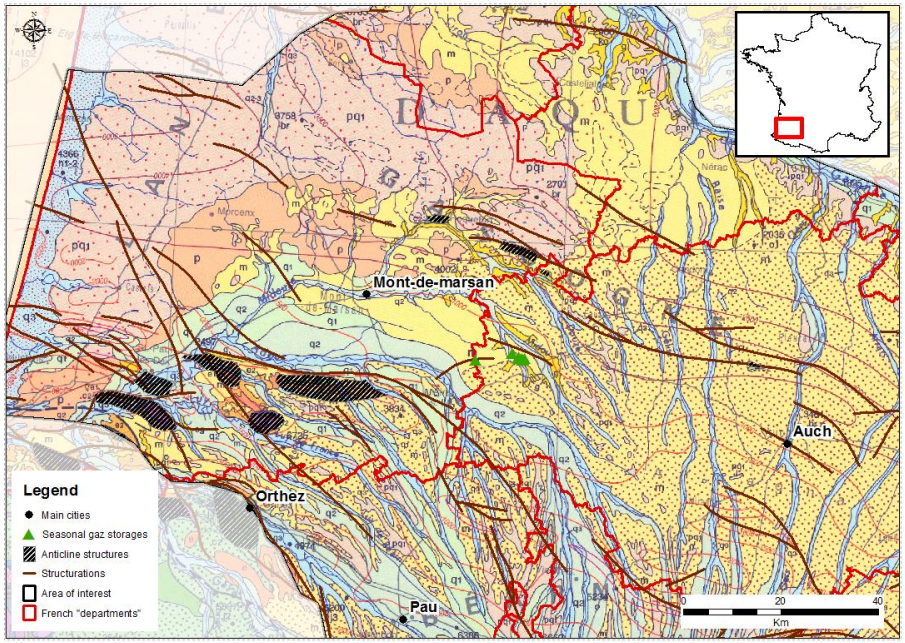
Uneven distribution of the boreholes

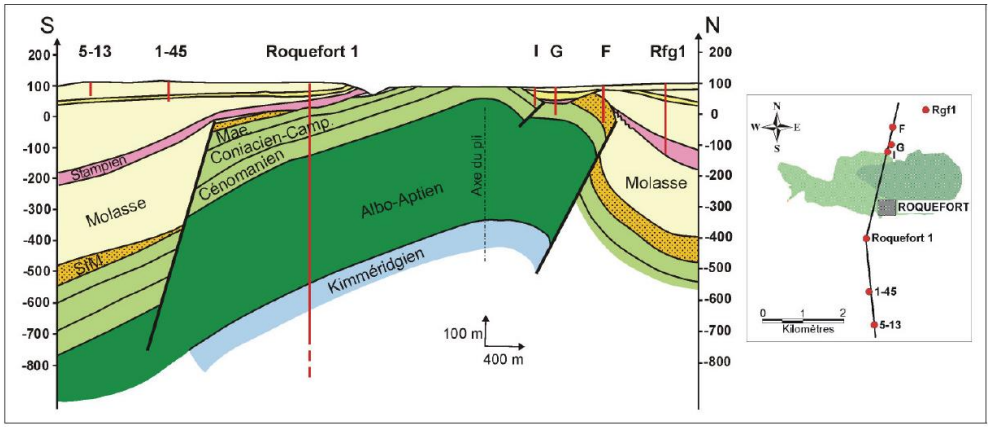
A complex aquifer system

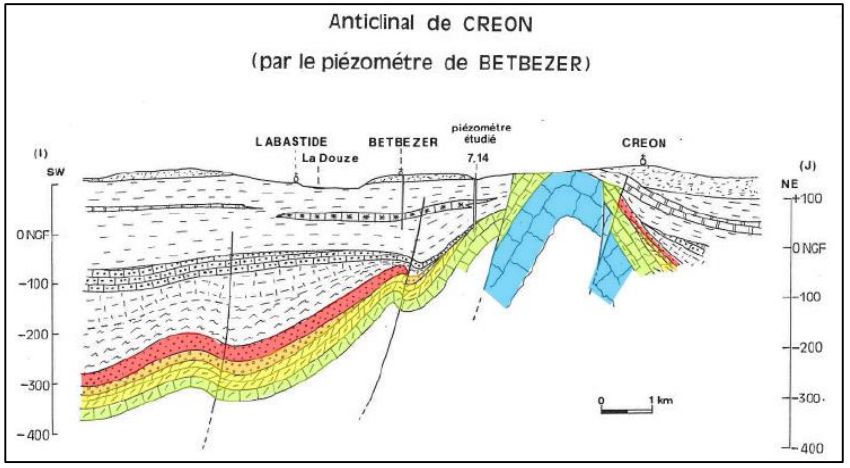
Specificity of the area: compression features inducing faults and folding, synclines and anticlines, as well as localized diapirism

Deep confined aquifers are connected at a local scale (anticlinal structures) and at a more regional scale for two of them (Under-Molassic Sands and underlying Paleocene aquifer)

(Douez, 2007)

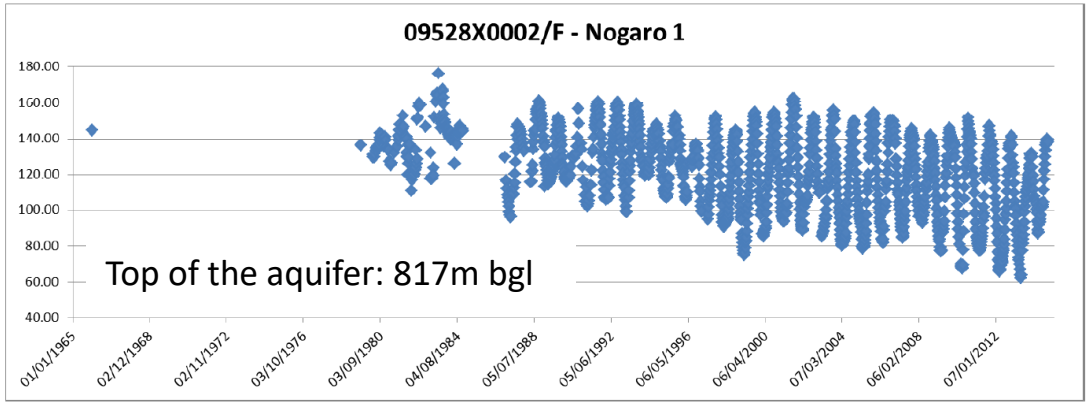






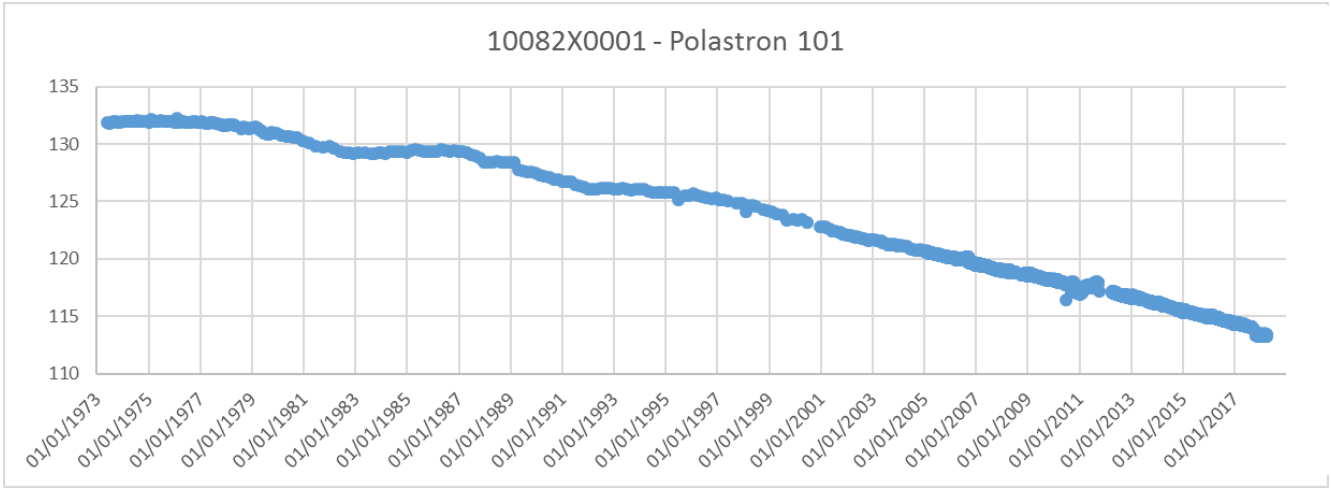
The main aquifer: the UMS

The Under-Molassic Sands (extension: about 15 000 km²) is the most solicited (12 Mm3/yr) and the siege of the gas storages that strongly influence the confined groundwater Piezometric level (tenth of kilometers)



Annual fluctuations: almost 80m

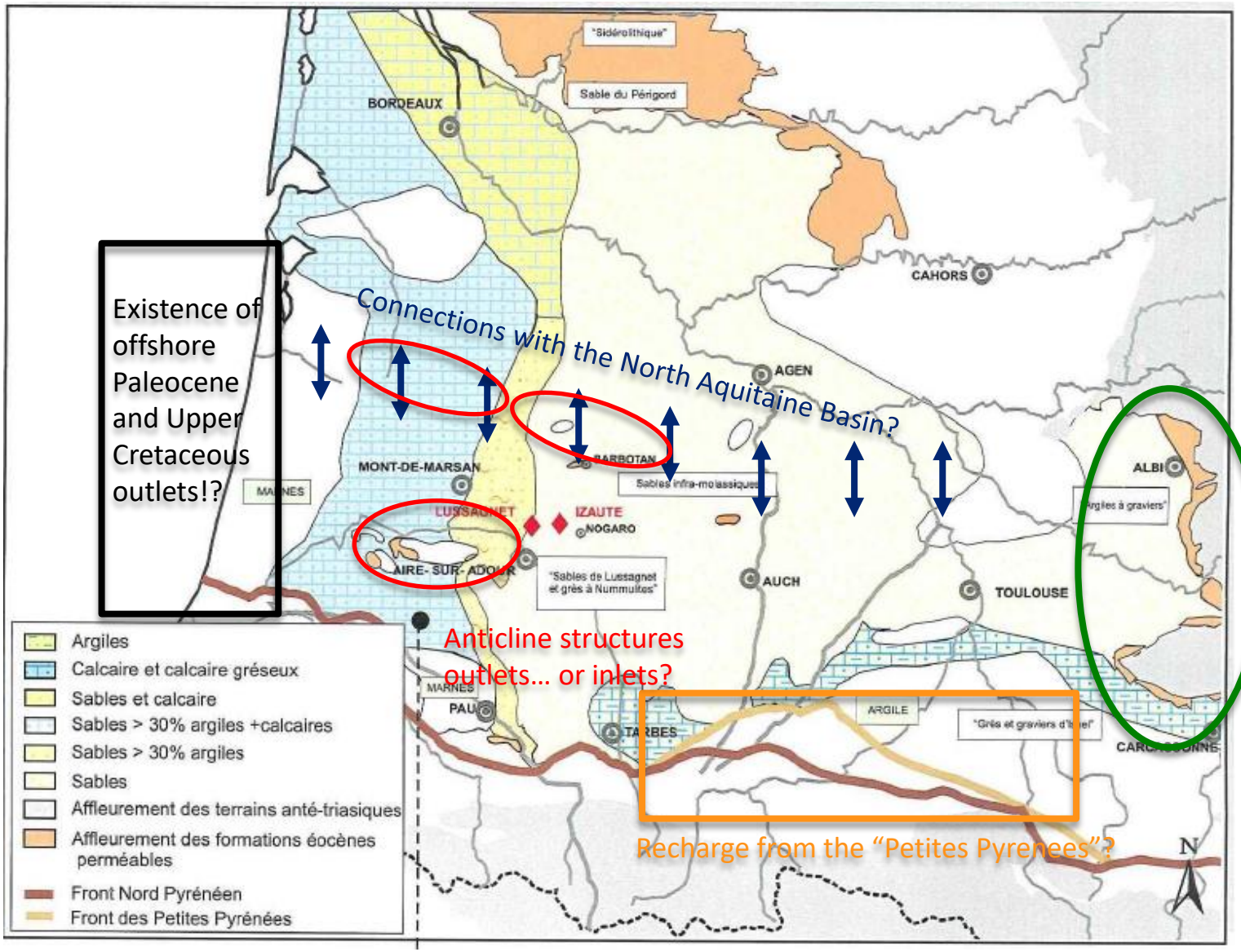
A decrease in the Piezometric level is recorded almost since the beginning of the monitoring (late 1960s), inducing disappearing of artesianism in some areas and the drying of thermal springs



=> Water authorities expressed their need for a groundwater management model and a private company its interest for a better understanding

The main hydrogeological issues of the GAIA project

=> Geometry and water budget



Map from Elf Gaz de France and Aquila Conseil, 2001

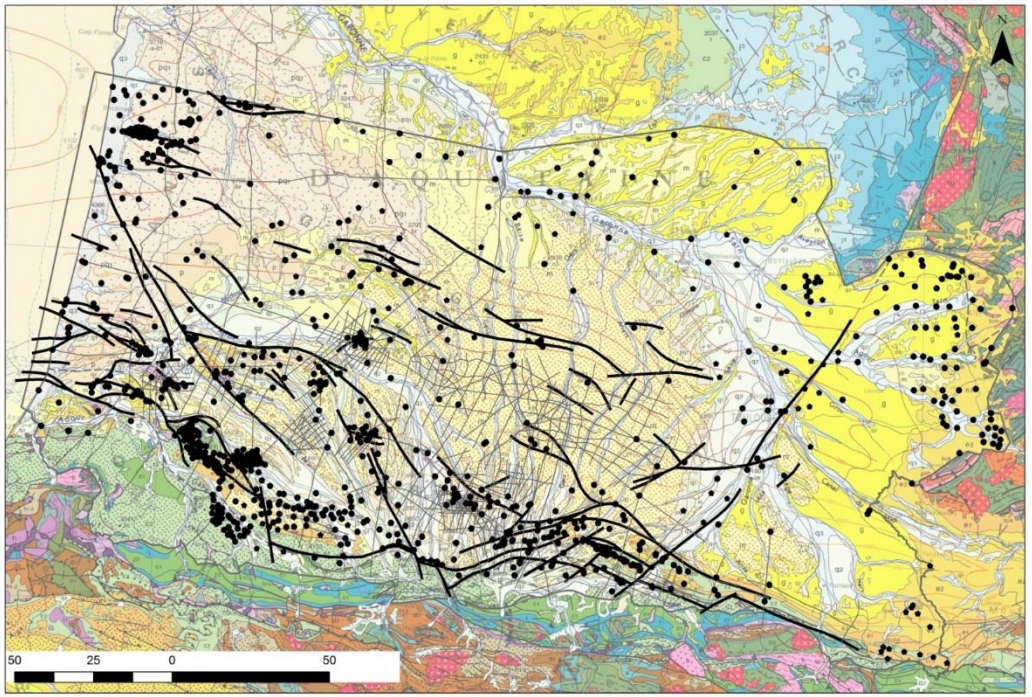
Recharge from the "Massif Central" and "Montagne Noire" foothills?

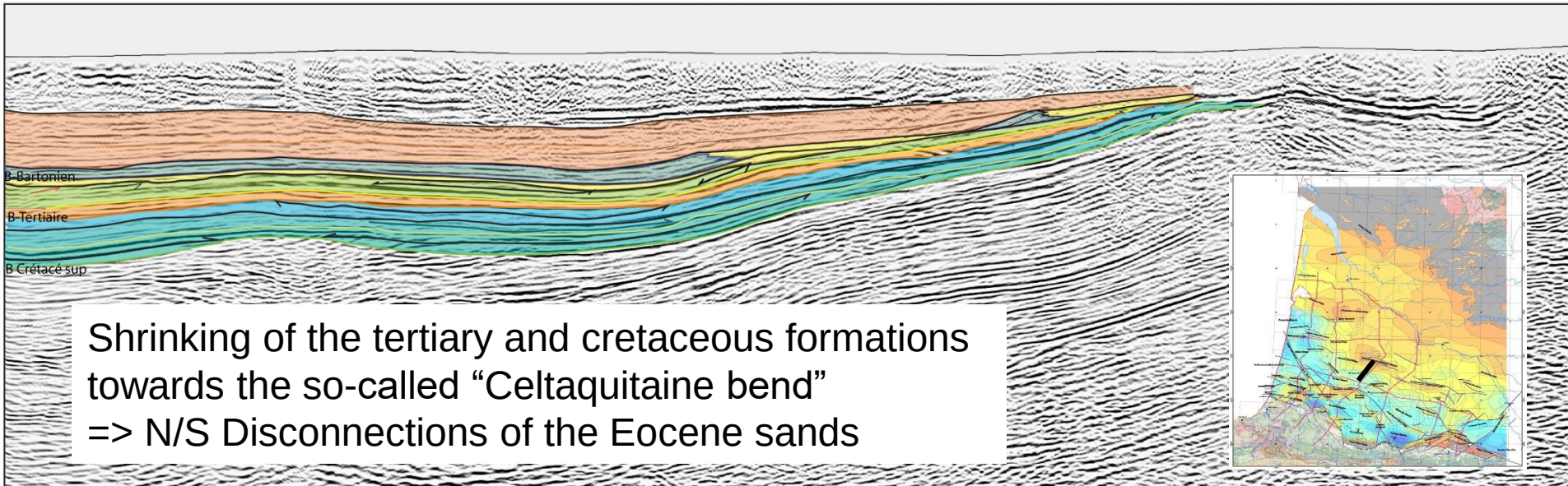
Geological data to build 3D geometry

Geological database

- 1050 re-interpreted deep boreholes.
- More than 1300 boreholes.
- More than 5000 km of seismic profiles.

(Lasseur et al, 2017)

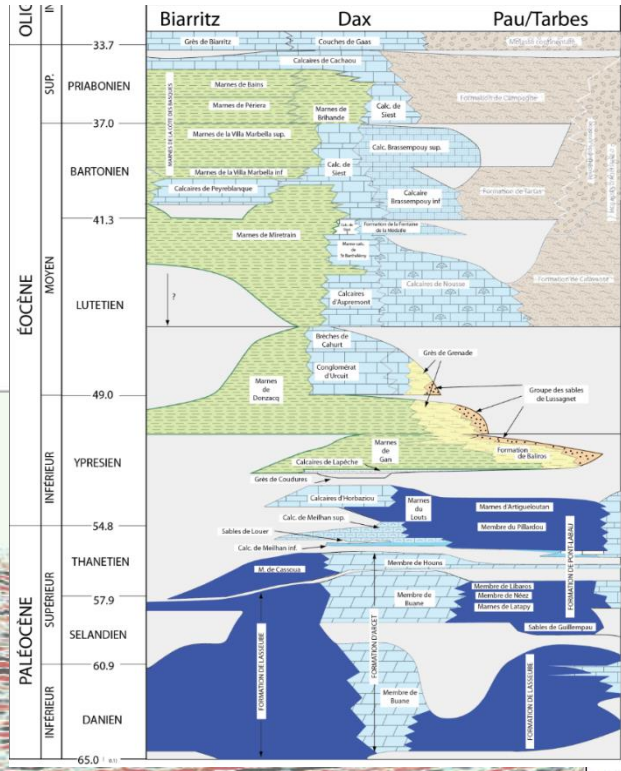




Shrinking of the tertiary and cretaceous formations towards the so-called “Celtaquitaine bend”
=> N/S Disconnections of the Eocene sands

Towards a 3D geological model

Based on the cross-sections and the constitution of litho-stratigraphic schemes, elaboration of a simplified representation of the aquifer system



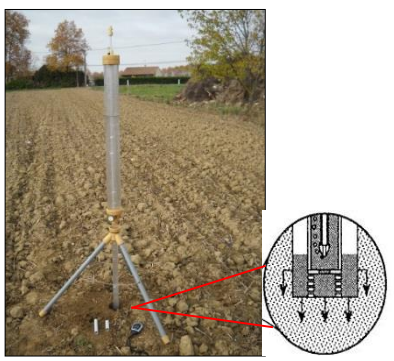
Hydrogeological investigations - Recharge

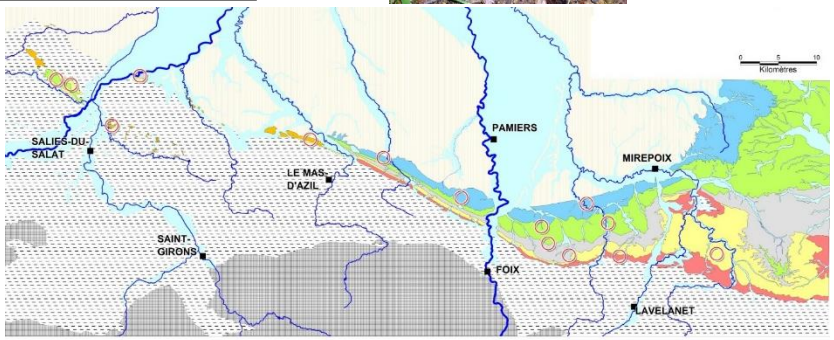
Recharge does not occur directly into the UMS but is transferred into it through bridging-formations: so-called “gravel clays” and the Palassou conglomerate, both heterogeneous

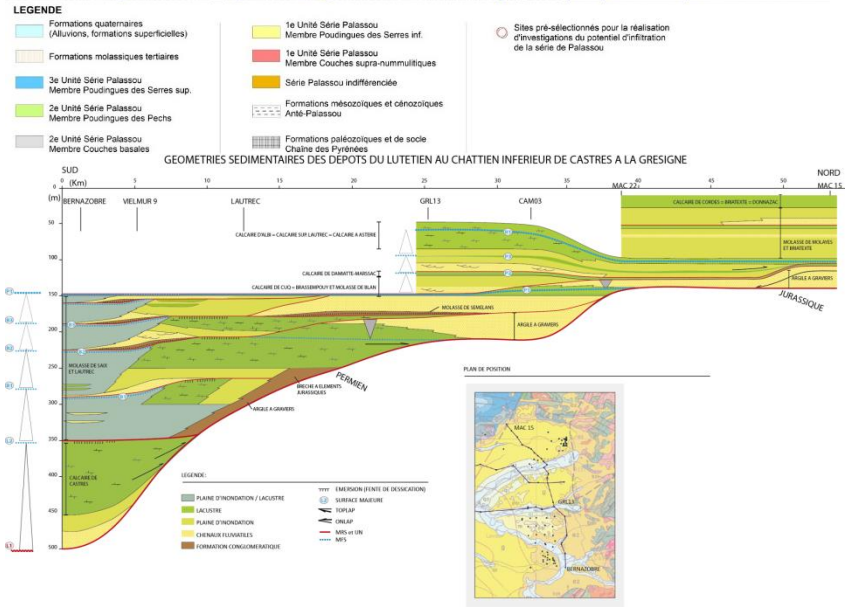
Permeability tests were performed in the field, showing for instance a 9.10^{-5} to 2.10^{-7}m/s permeability for the “gravel clays”

Upstream-downstream gauging are performed during low-flow periods in order to identify river recharge

Recharge pathways are inferred from litho-stratigraphic cross-sections

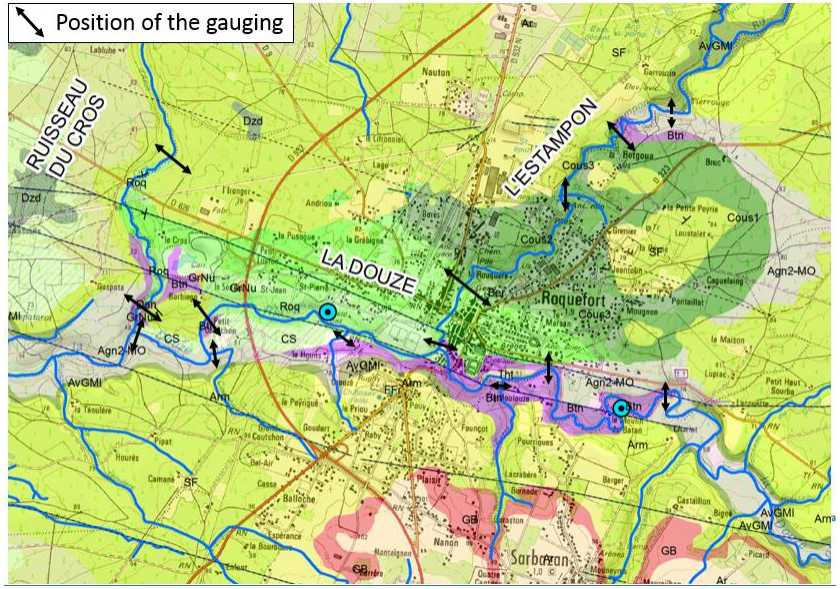


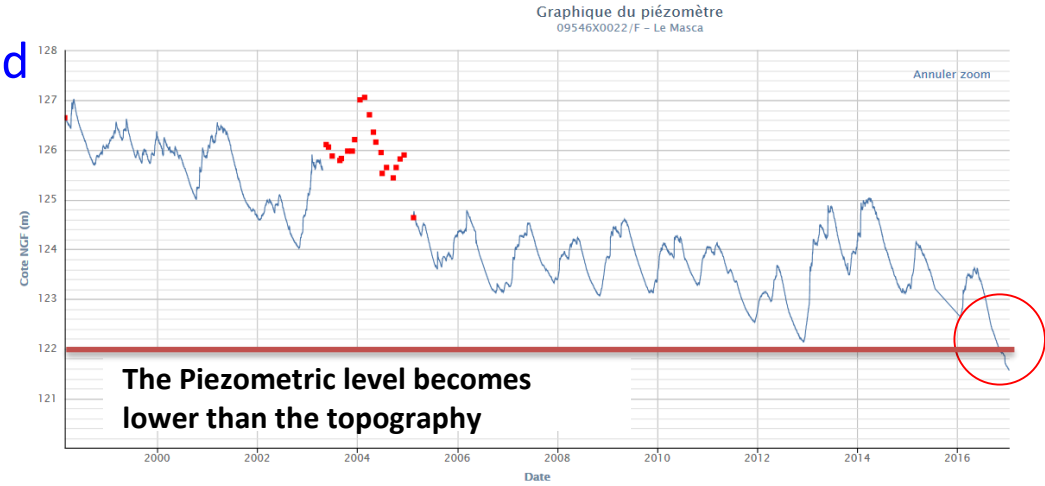


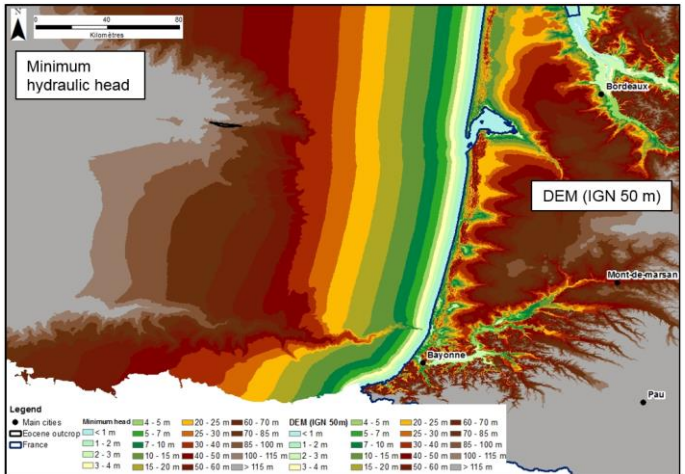


Hydrogeological investigations - Outflows

- Study of anticline structures: Piezometric and chemistry analyses, Upstream-downstream gauging
- Modification of the hydrodynamic behavior as the groundwater level drops: springs dry out and what was an outlet becomes a recharging area. Diminution of the groundwater age, change in the water chemistry
- Off-shore outflows have been considered regarding feasibility and divers observations



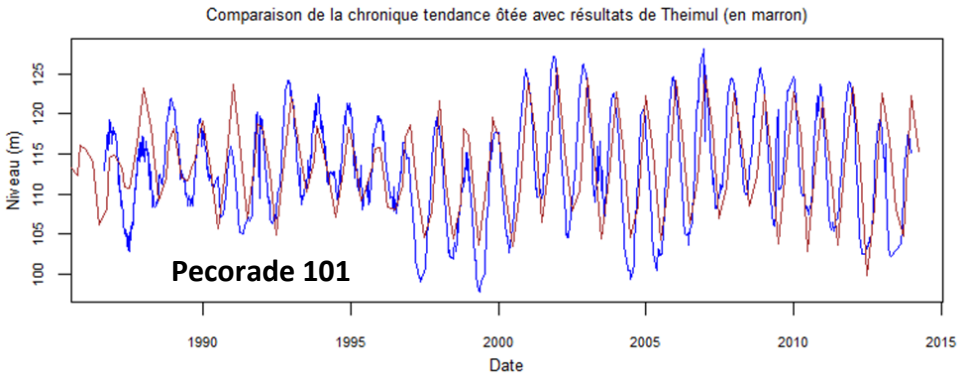




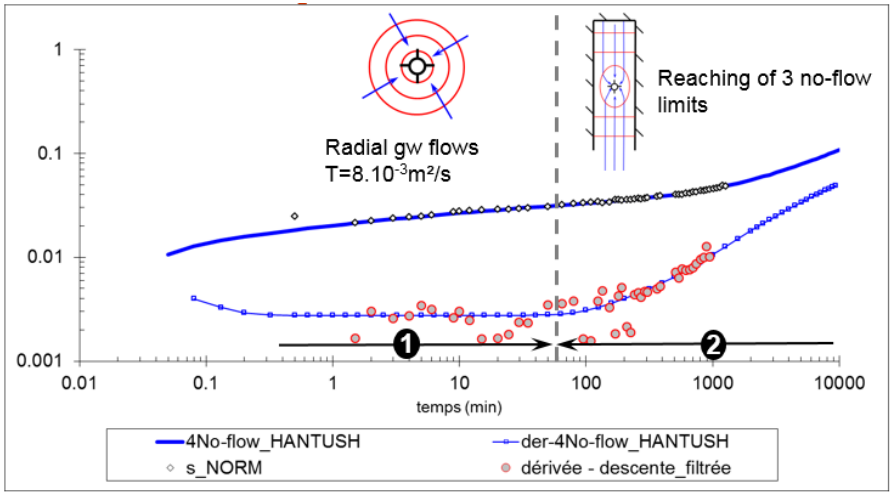
(Wuilleumier, n°EGU2018-7622)

Hydrogeological investigations – hydrodynamic properties

- Exploitation of the propagation of the pressure wave from the gas storages through the UMS aquifer to infer storage coefficient and transmissivity over large areas (tenth of km)



- Re-interpretation of old pumping test data using the drawdown derivative method (Bourdet, 1983) in order to get a diagnosis of the groundwater circulations around the borehole before modeling the pumping test. => to infer local transmissivity

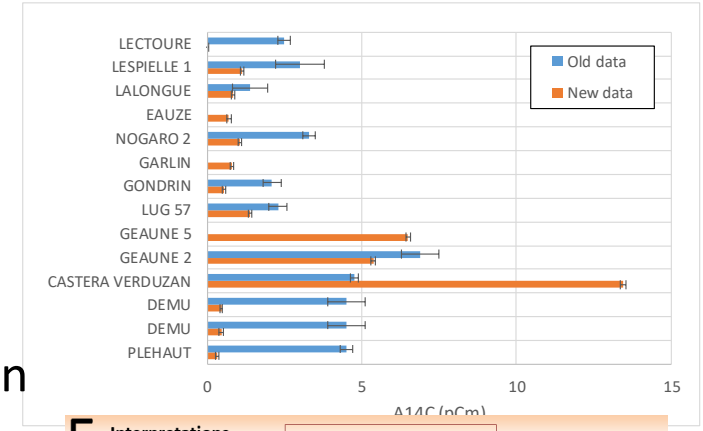


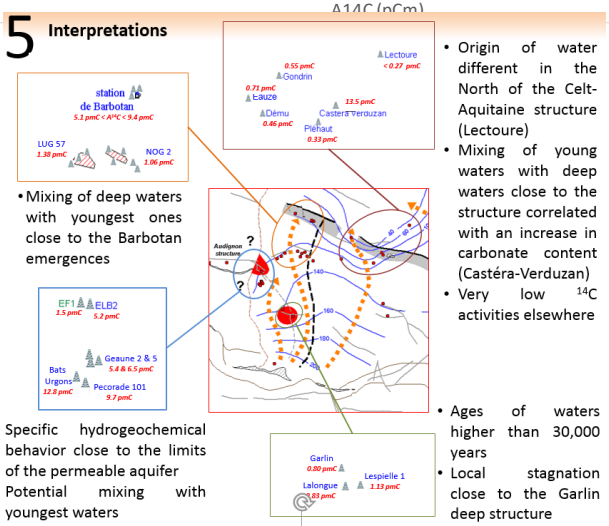
Groundwater age

^{14}C measurements have been made over 14 boreholes, using a specific sampling method to ensure a perfect isolation of the water from the atmosphere during the sampling period.

^{14}C activities are almost always lower than the ones determined in previous investigations and correspond to ages older than 30,000 years.

Considering the scarcity of hydrogeological data in some areas, groundwater ages are useful tools to identify pathways and build hypotheses for establishing a conceptual hydrogeological model





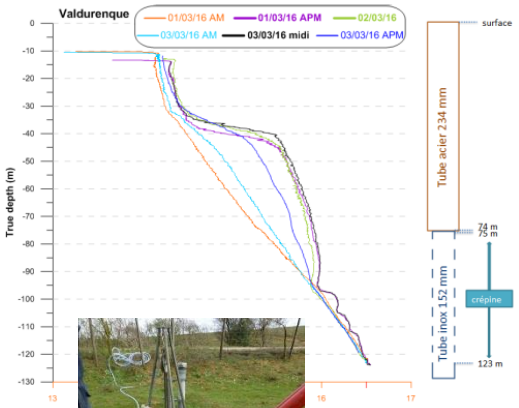
(André et al, n°EGU2018-7811)

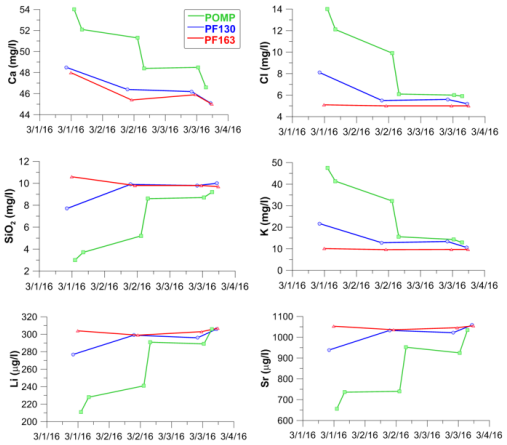
How to get reliable data from low-productive wells?

- ✓ Part of the piezometers are former hydrocarbon exploration wells (>4000m) plugged to a certain depth and converted by perforating their casings (over a tenth of meters).
- ✓ => generally low-productive, do they provide reliable data?
- ✓ Cyclic investigations were made in deep boreholes: well logging, deep sampling at selected depths, borehole stimulation by pumping, deep sampling again.

=> deep samplings, performed at the right depth, provides reliable data

(Gal et al, n°EGU2018-7116 and 7172)





Example of Polastron

PRIOR TO PUMPING				AFTER PUMPING		
EC-25°C	pH	Eh (NHE)		EC-25°C	pH	Eh (NHE)
1110	9,82 (16,6°C)	-33	-764 m	2300	8,48 (18,8°C)	+31
Alk. HCO_3: 393,3 mg.l^{-1}				Alk. HCO_3: 477,6 mg.l^{-1}		
EC-25°C	pH	Eh (NHE)	-810 m	EC-25°C	pH	Eh (NHE)
2220				2250	8,59 (21,1°C)	-6
EC-25°C	pH	Eh (NHE)	-819 m	EC-25°C	pH	Eh (NHE)
2220	8,89 (25,2°C)	-34		2250	8,56 (18,5°C)	-49
EC-25°C	pH	Eh (NHE)	-823 m	EC-25°C	pH	Eh (NHE)
2220	8,93 (23,2°C)	-42		2230	8,75 (26,9°C)	-45
EC-25°C	pH	Eh (NHE)	-828 m	Alk. HCO_3: 351,4 mg.l^{-1}		
2230	8,93 (18,9°C)	-59				
Alk. HCO_3: 344 mg.l^{-1}						

Conclusions

Understanding groundwater circulations in deep aquifers which are characterized by few access opportunities need to combine investigations methods, using the different fields of the earth sciences

It reinforces our abilities to understand groundwater circulations and provides useful objective constraints to calibrate the future groundwater model solicited by the water authorities

All investigations made in the frame of the GAIA project are reported into public technical reports and available online (http://infoterre.brgm.fr)

More investigations complete the full-picture of the project, in the frame of geology, hydrogeology and hydrogeochemistry

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