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**FROM RECHARGE
TO OUTFLOWS:
UNDERSTANDING DEEP
AQUIFERS GROUNDWATER
CIRCULATIONS.
THE SOUTH AQUITAINE
BASIN CASE STUDY.**

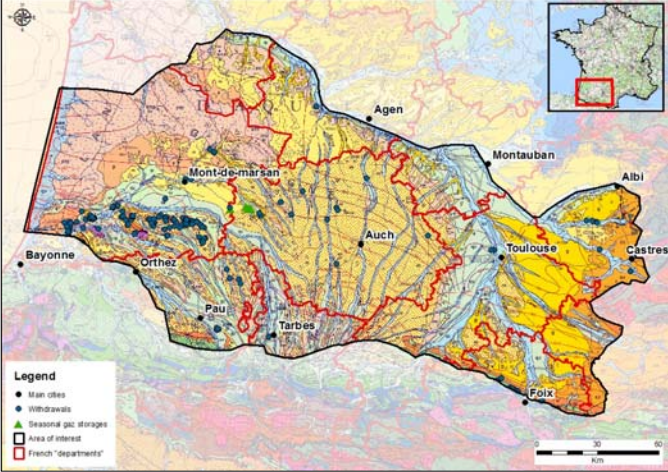
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Hydrogeological context

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*

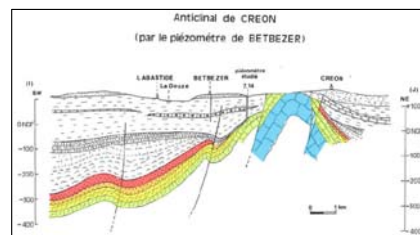
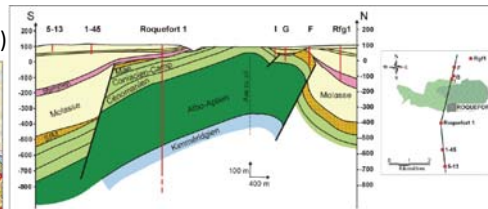
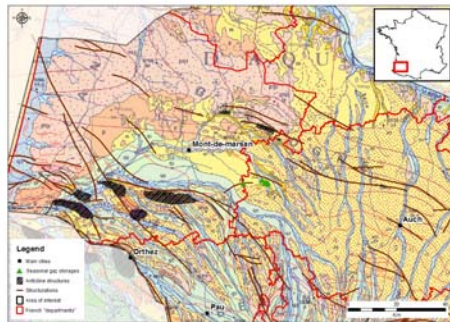
*Uneven
distribution of the
boreholes*

A complex aquifer system

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

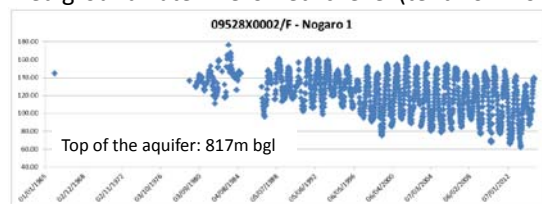
Deep confined aquifers are **connected at a local scale** (anticlinal structures) and **at a more regional scale** for two of them (Under-Molassic Sands and underlying Paleocene aquifer)

(Douez, 2007)



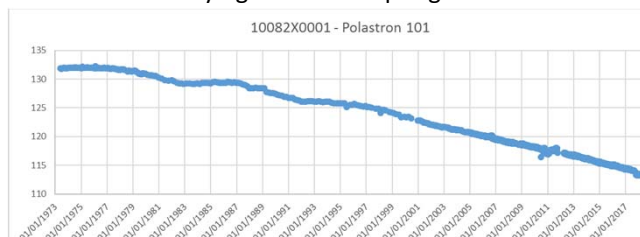
The main aquifer: the UMS

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

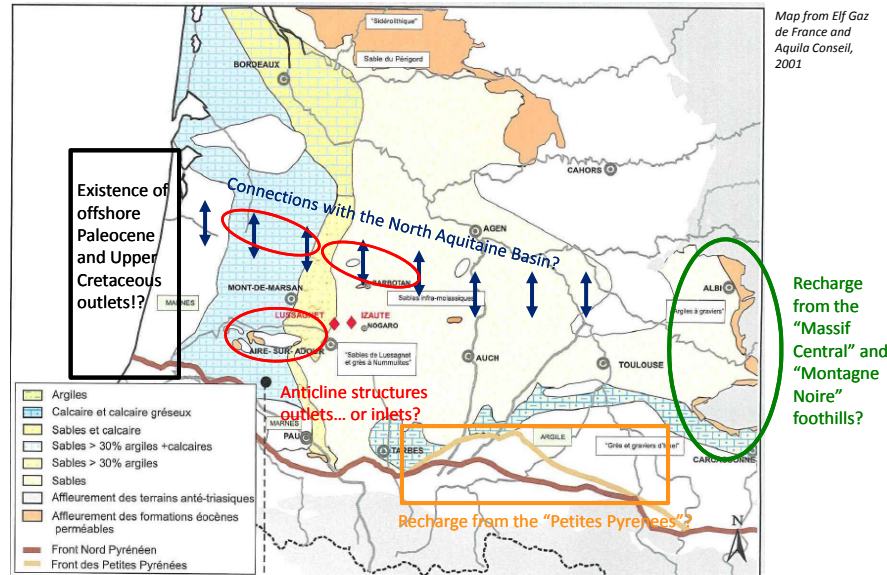
A **decrease in the Piezometric level** is recorded almost since the beginning of the monitoring (late 1960s), inducing disappearing of artesianism in some areas and the drying of thermal springs



=> 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

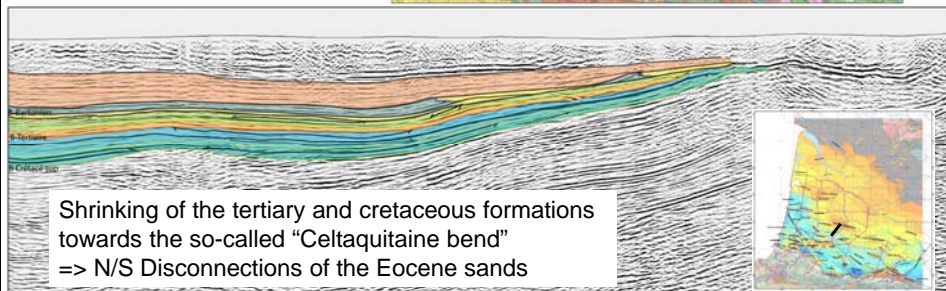
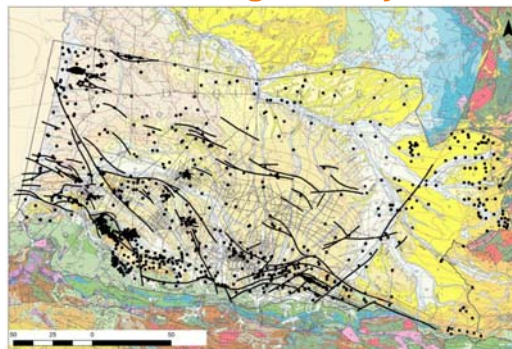


Geological data to build 3D geometry

Geological database

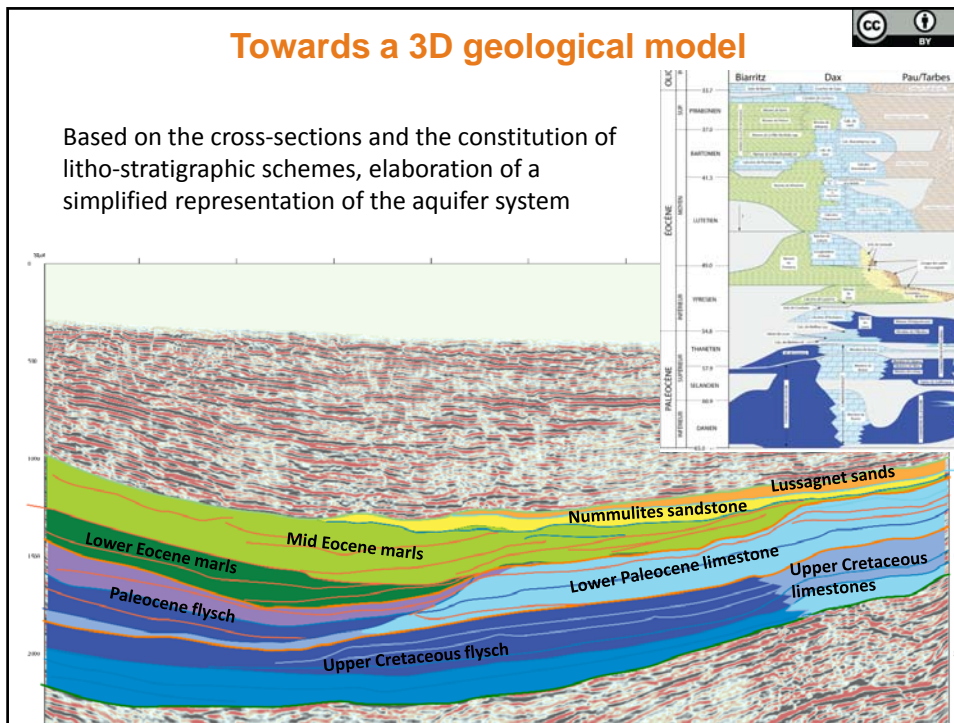
- 1050 re-interpreted deep boreholes.
- More than 1300 boreholes.
- More than 5000 km of seismic profiles.

(Lasseur et al, 2017)



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



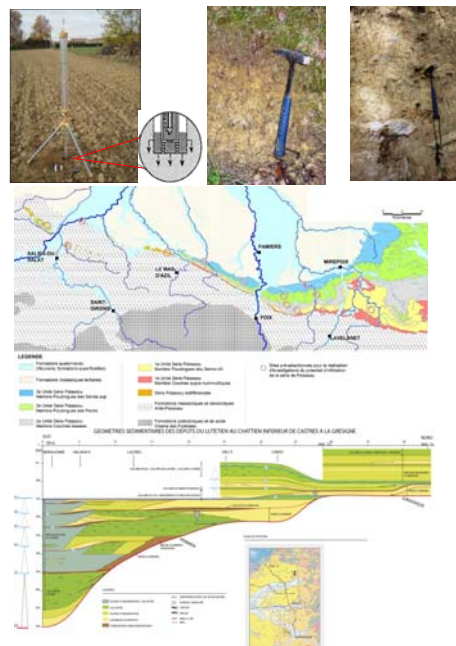
Hydrogeological investigations - Recharge

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 $9 \cdot 10^{-5}$ to $2 \cdot 10^{-7}$ m/s permeability for the “gravel clays”

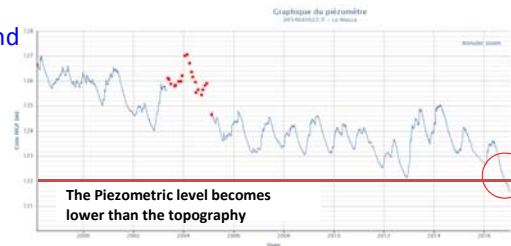
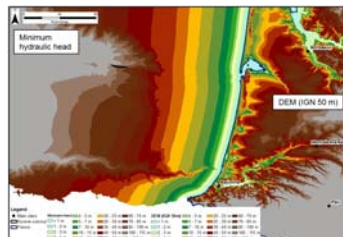
Upstream-downstream gauging are performed during low-flow periods in order to identify river recharge

Recharge pathways are inferred from litho-stratigraphic cross-sections



Hydrogeological investigations - Outflows

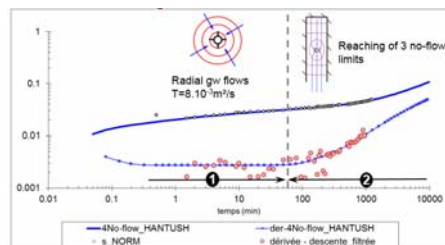
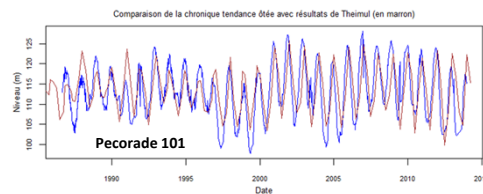
- Study of anticline structures:
Piezometric and chemistry analyses,
Upstream-downstream gauging
- Modification of the hydrodynamic behavior as the groundwater level drops: springs dry out and what was an outlet becomes a recharging area. Diminution of the groundwater age, change in the water chemistry
- 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



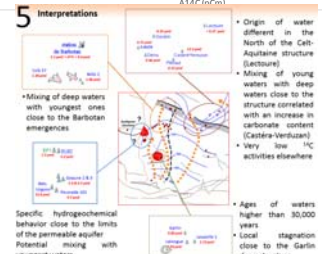
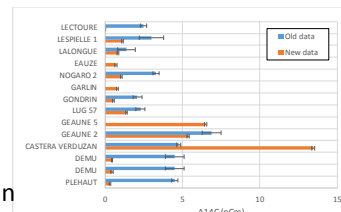
Groundwater age

^{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)

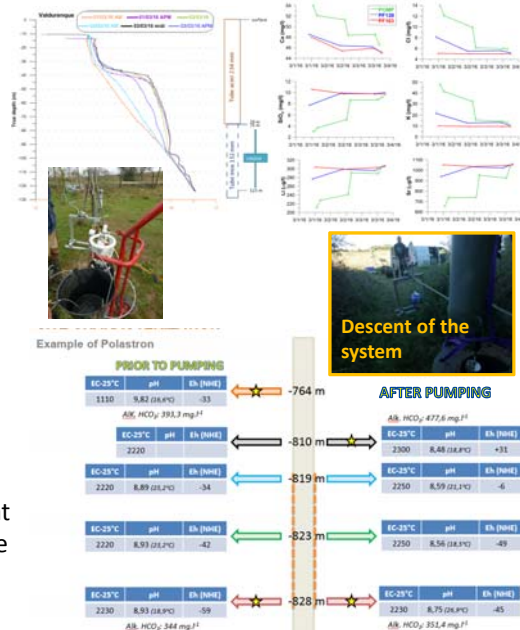


How to get reliable data from low-productive wells?

- ✓ 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)



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

Furthermore, it provides scientific arguments helping the decision makers to federate and adopt **converging positions towards a shared management of the groundwater resources**

To this respect, 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 a.wuilleumier@brgm.fr

