

Evaluating offshore groundwater outflows: the weight of the salinity.

A case study in the South Aquitaine basin (France).

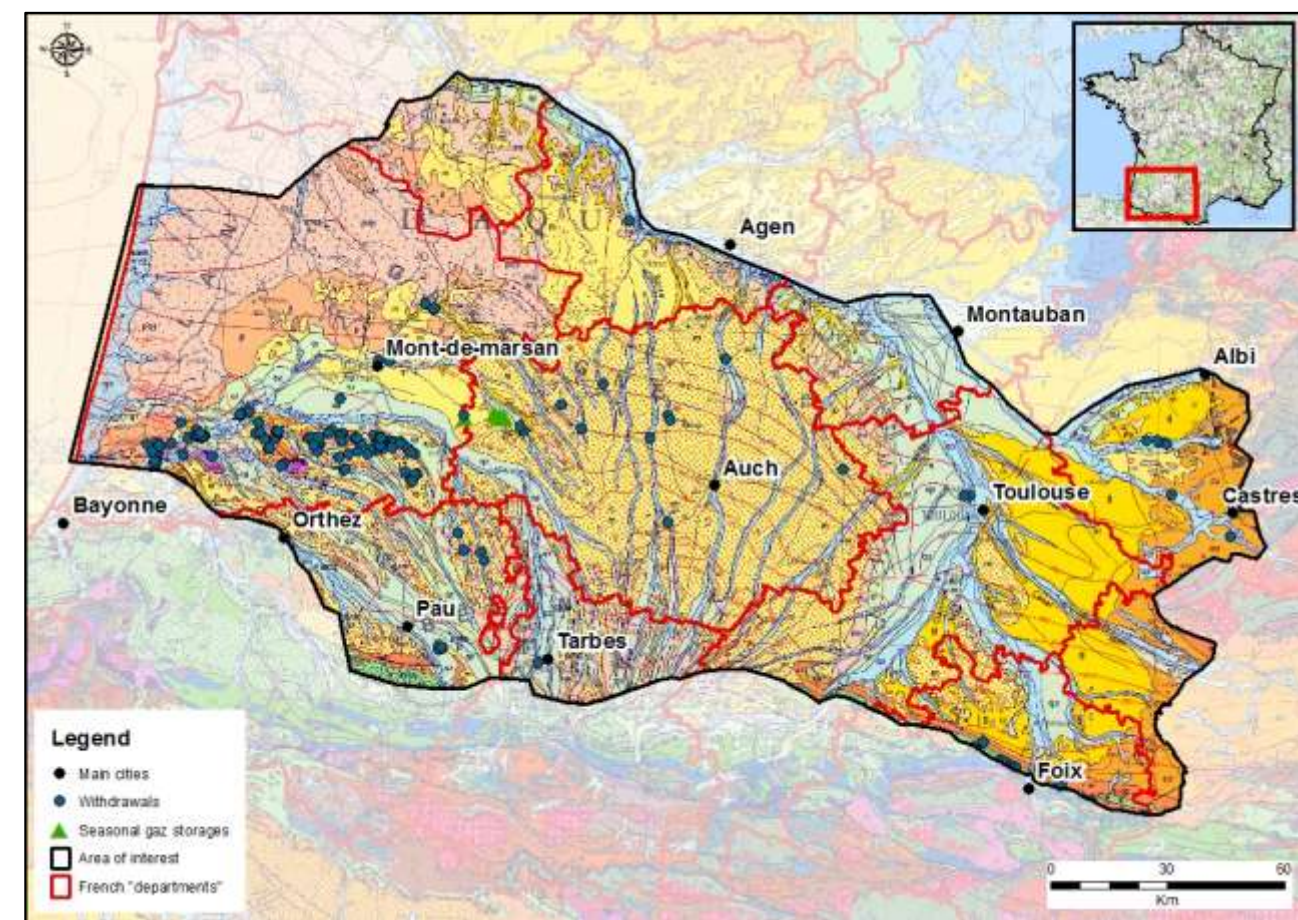
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1 In deep aquifers the complex flow pattern originating from the geological structure often leads to difficult predictions of the main flow paths, even regarding outflows. To this respect, on-shore discharge may be identified through springs gauging and geological assessment or, for more delicate cases, with the help of other earth science fields, such as visual and thermographic teledetection, geophysics (radon) or even hydrochemistry ranging from physicochemical parameters (temperature, electrical conductivity...) to geochemical tracers or isotopes. Similar tools are used to detect off-shore outflows. Fleury (2005) identified five methods, listed as follows: infrared thermographic teledetection, electrical conductivity and temperature onsite measurements, density measurements, radon concentration measurements and underwater visual observations. The latter, coupled with thorough investigations towards locals, especially the fishermen, is considered to be the best way for a first identification (Fleury, 2005). Indeed, off-shore outflows are often known since centuries or even millennium (Kohout, 1966). Fleury (2005) regretted the lack of advisement of the biogeochemical processes which are henceforth more integrated in the analyses (Dulai et al, 2016; Bishop et al, 2017).

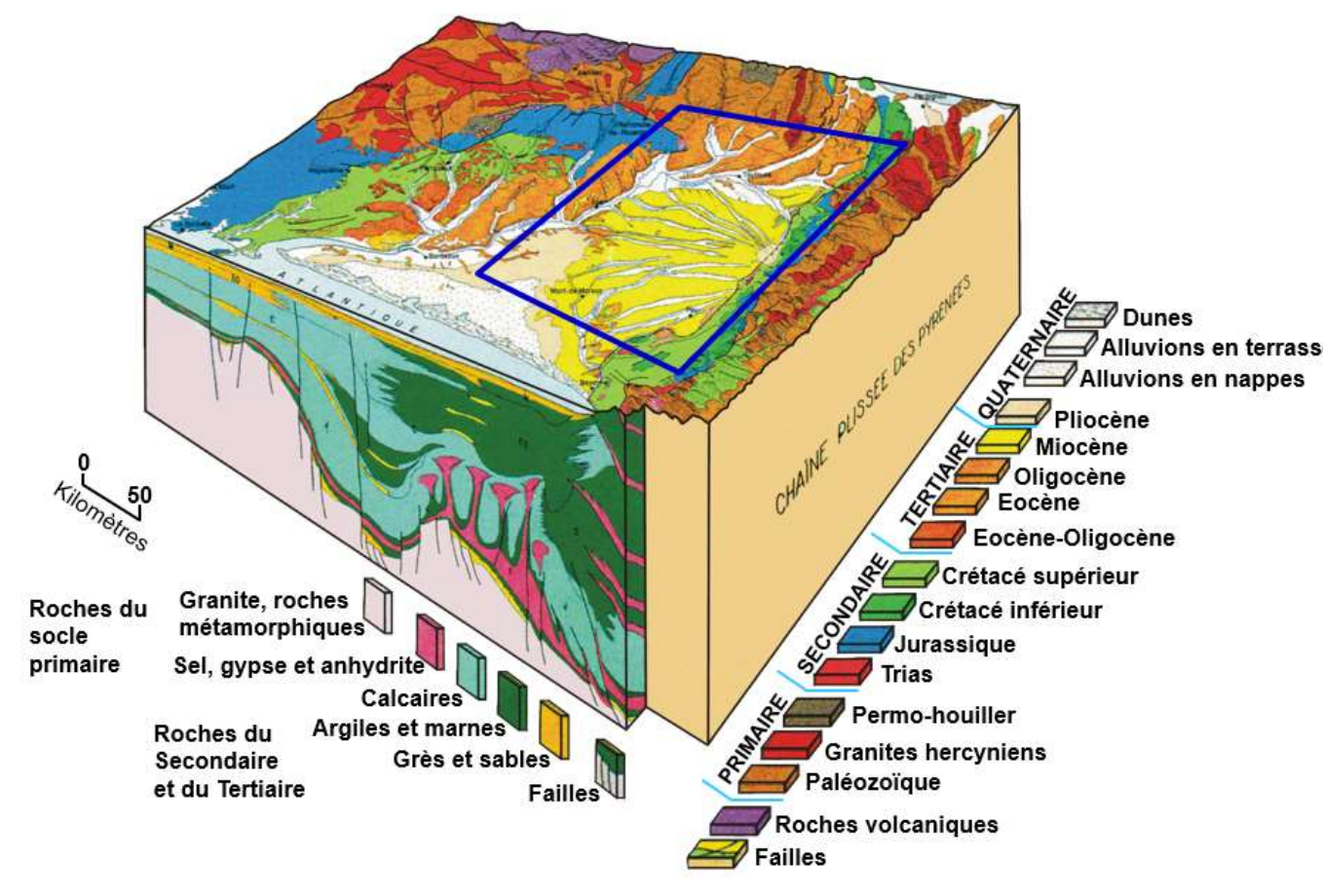
2 Context

The methodology hereafter presented has been applied to multilayered deep aquifers lying in the southern-west part of France: the Infra-Molassic Sands aquifer aging from Eocene and underlying ones (Paleocene and Upper Cretaceous).

The sandstone reservoir is of great interest because it has multiple uses, including drinking water, irrigation, geothermal applications and seasonal gas storage (André et al., 2002; Douez, 2007).



Area of interest and uses
(1M geology base map)



3D geology of the area (BRGM-ANDRA)

3 Implemented methodology

The methodology is based on a regional spatial approach aiming at identifying the capacity of a groundwater outflow under seawater. It relies on the evaluation of the minimum hydraulic head at the shoreline which is able to balance seawater pressure and ensure a minimum gradient in the aquifer towards the potential outlets.

First, the hydraulic head able to balance seawater pressure on seafloor is calculated according to the bathymetry (Homonim project, SHOM) and the following relation:

$$P_{gw} > P_{sea} \Rightarrow \rho_{sea} * g * h_{sea} > \rho_{gw} * g * (h_{sea} + h_{gw})$$

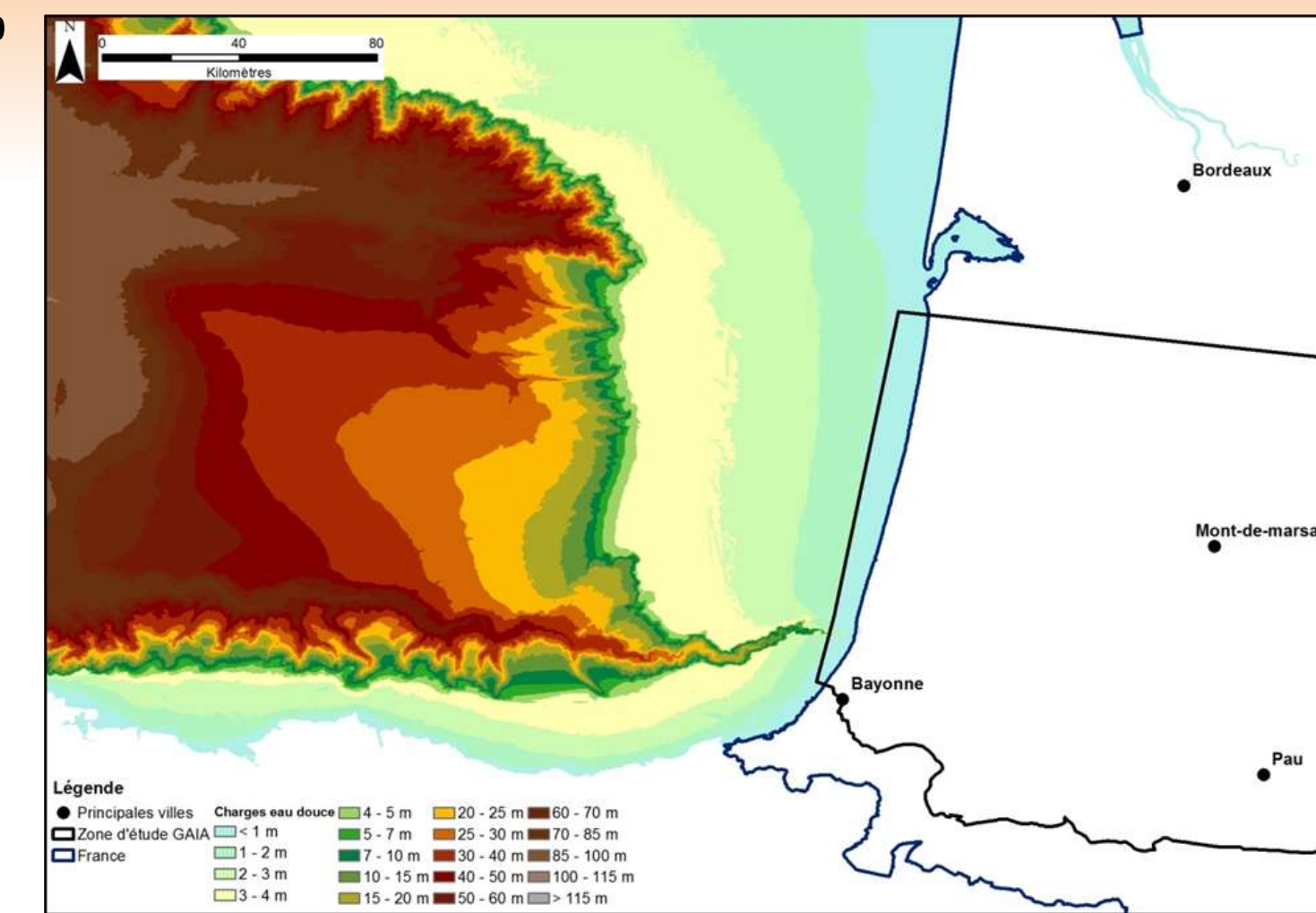
$$\Rightarrow h_{gw} > h_{sea} * \left[\left(\frac{\rho_{sea}}{\rho_{gw}} \right) - 1 \right]$$

Where P stands for hydraulic pressure, ρ for density and h for the height of the water column

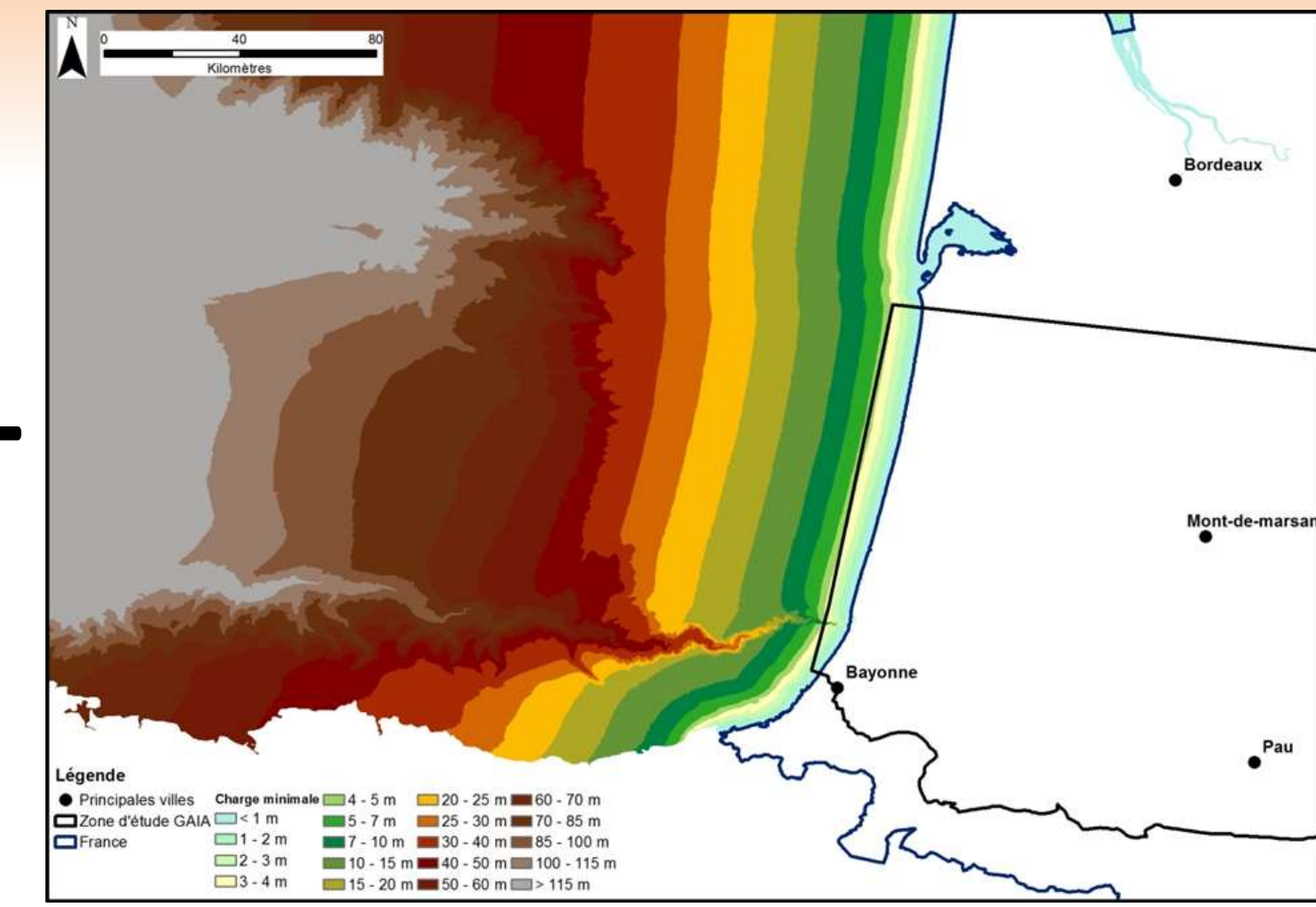
Thus, the minimum hydraulic head at the shoreline to ensure a hydraulic gradient of 0.5 ‰ is calculated for each seafloor emerging zone.

The map of the hydraulic heads is compared with the nature of the outcropping geological formations on the seabed. The result is afterwards compared with field observations as the methodology only provides hints for potential outflows.

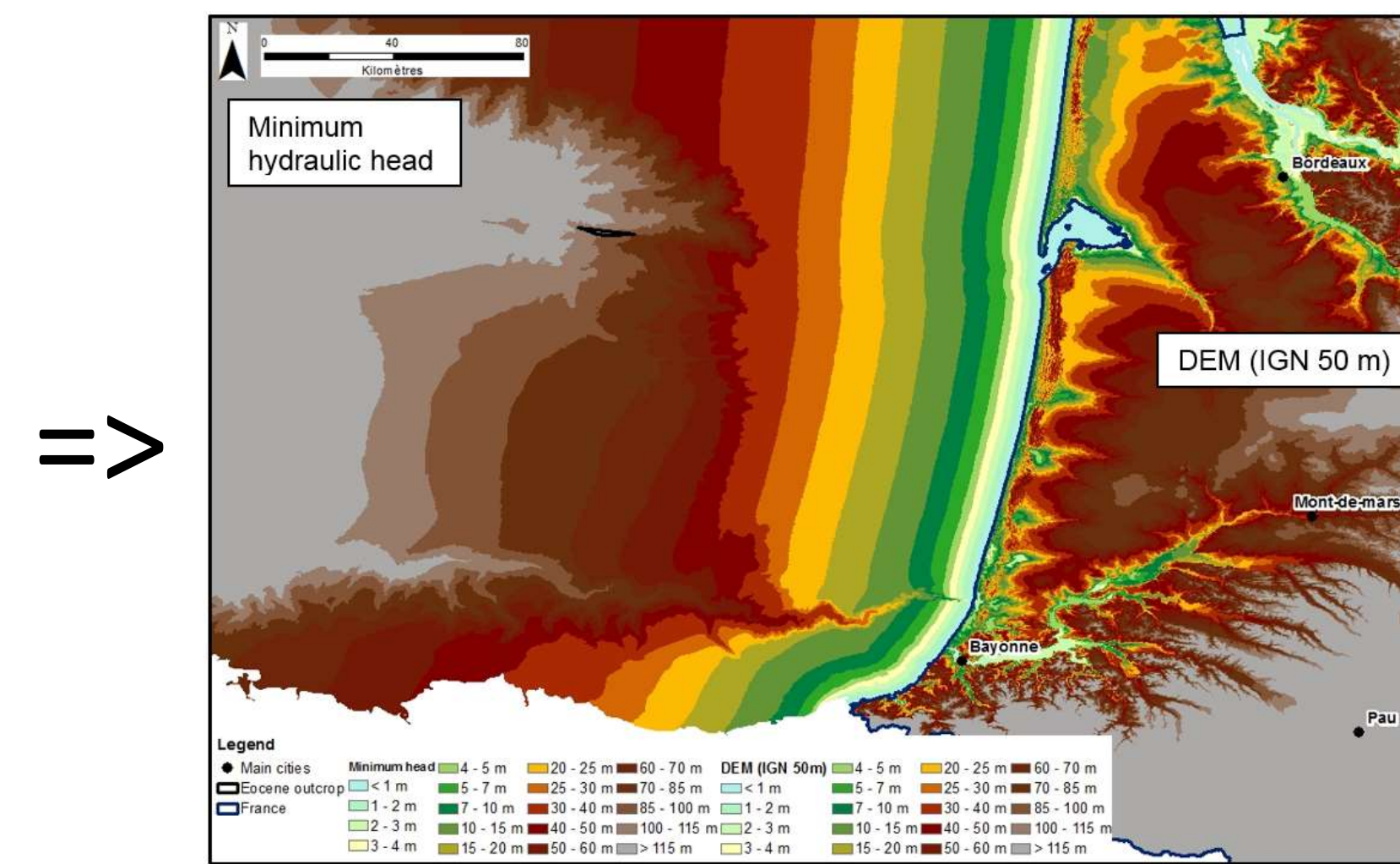
4 Results



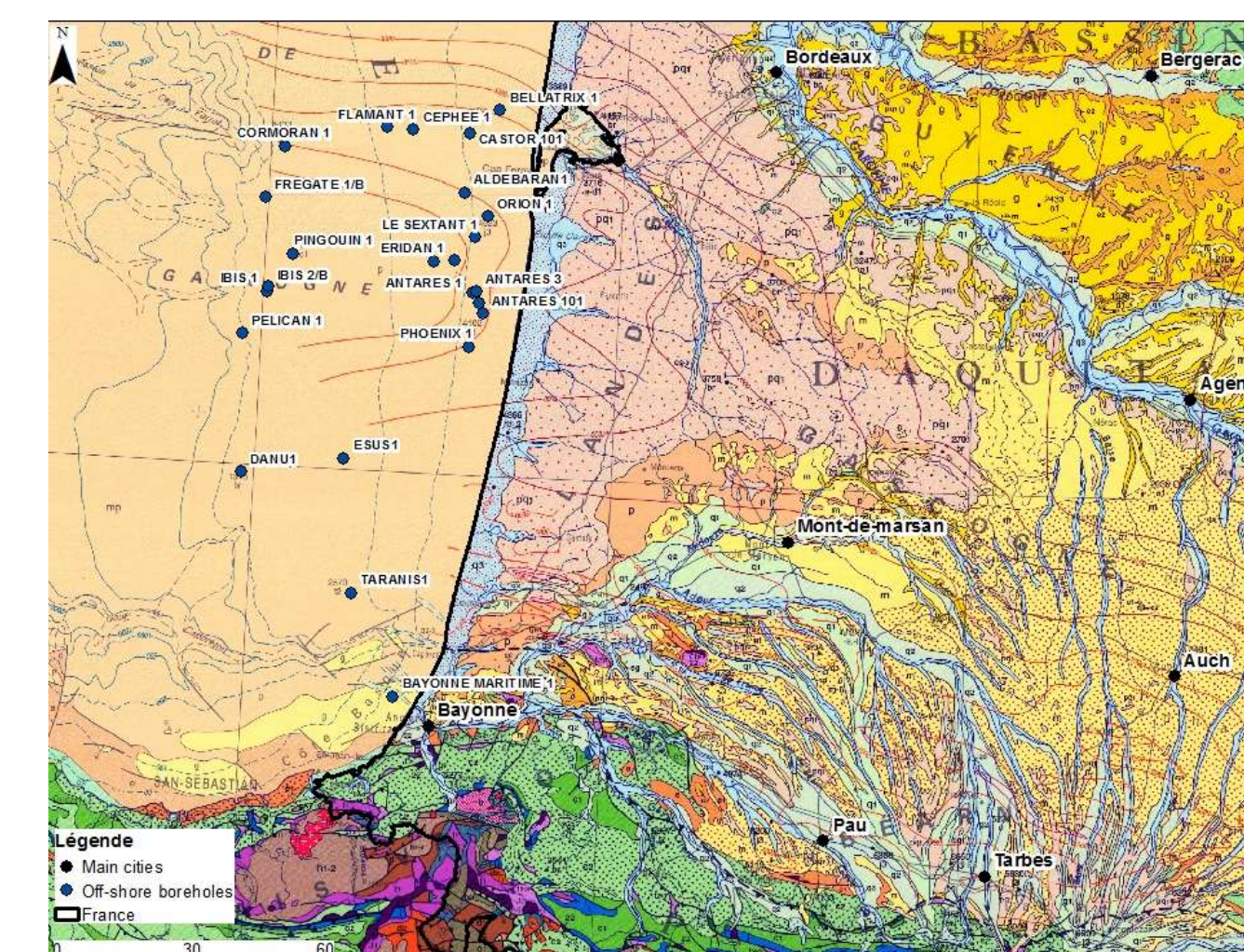
1/ Minimum hydraulic head able to balance seawater pressure



2/ Minimum hydraulic head at the shoreline to ensure a hydraulic gradient of 0.5 ‰



3/ Minimum hydraulic head able to generate groundwater offshore outflow



4/ Comparing with geological data

6 References

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5 Discussion and conclusion

In the case of the south Aquitaine basin, one area (the Basque seaboard) is identified for undergoing potential groundwater outflows. Nevertheless, the investigations towards local knowledge, especially karst divers (Vanara et al, 2007), did not confirm the existence of groundwater outlets in this area. As a consequence, the potential of groundwater submarine outflows has been considered as weak in the studied zone.

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