



# 59<sup>TH</sup> CEEC EVENT LYON

Speaker: Marc Blaizot

France Subsurface Transformation :  
from C&O&G exploration to new energies basins ?

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# Presentation Highlights

- **The France fossil energies key landmarks and productions**
- The thirst for coal and its consequences: extensions of Permian carboniferous basins and their sedimentary infills
- The start and deployment of the O&G exploration and production: Why ? Where ? How ?
- A very large C&O&G data base and geological knowledge: the keys for opening new subsurface doors for fresh water/geothermal/H<sub>2</sub> and He/gas storages/CBM and CMM
- Conclusions : Subsurface disciplines expansions : simpler or more complicated ?

# France fossil energies : key landmarks of an old but amazing journey

First **coal mining** : Cendras Abbey in... 1230 ? Close to Ales (Occitanie) but real coal mining in the XVIII and XIX centuries : St Etienne, Lorraine, North of France with the giant Anzin Mining Company

First **oil sands** : natural seeps then galleries in Pechelbronn (Alsace) : 1742

First **oil shales** production by pyrolysis (400 °C) in Autun (Burgundy) : 1824

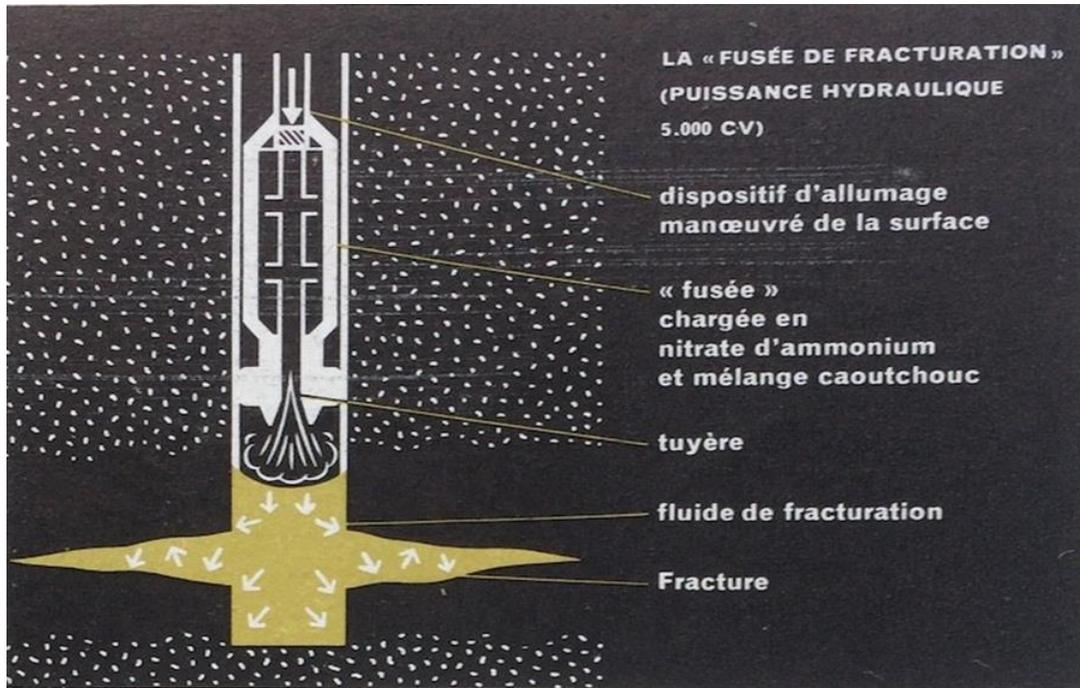
First **conventional oil** production (wells : 500 to 1500m deep; pumps, logging) : Pechelbronn : 1882

First **natural gas discovery** (1906) in Vaux en Bugey after a severe blow out in a well looking for salt or coal  
Gas utilised for St Gobain glass factory.

**Main Giant (sour) Gas discovery** : Lacq (Aquitaine : 9 Tcf in 1951) and **two big oil fields** :  
Parentis (Aquitaine-210 Mbo) in 1954 and Chaunoy (Paris Basin-100 Mbo) in 1983

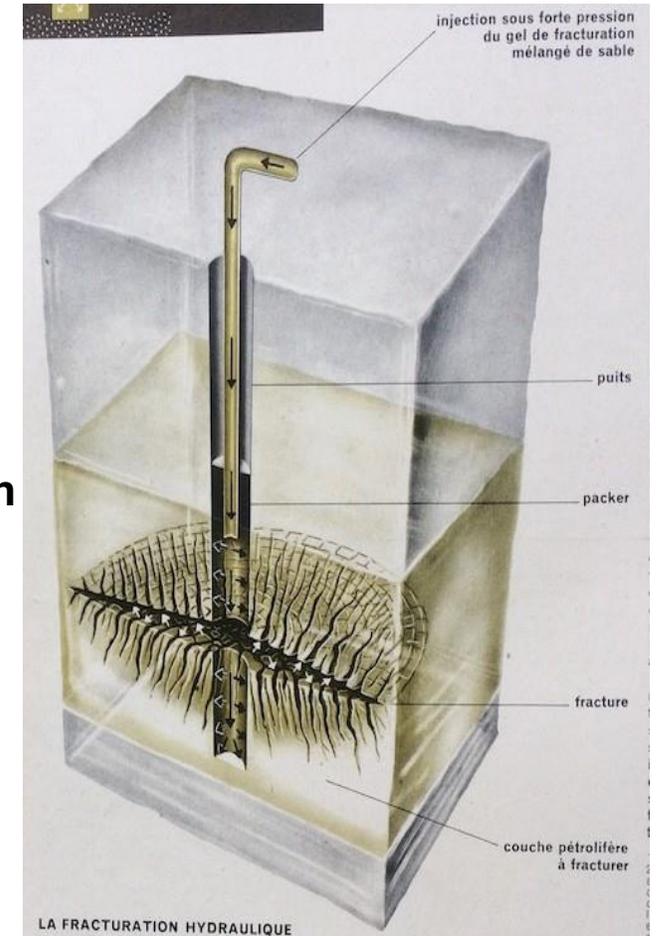
**First European hydraulic fracturing** in LTO : Parentis 1956.

# France : First massive fracking in LTO : Parentis 1956 and First worldwide... massive ban for O&G : Jacob's law in 2011



1- Fracturing

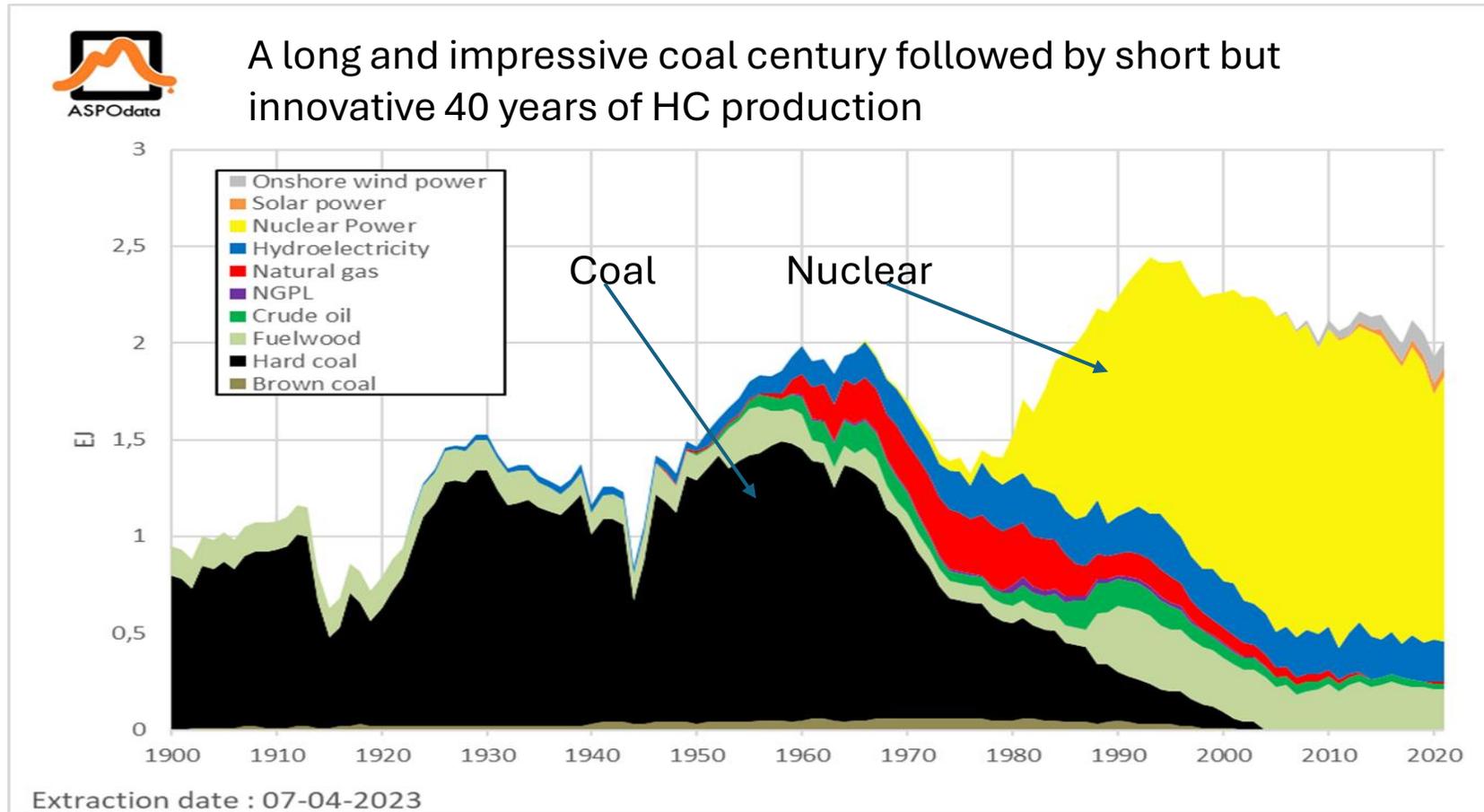
2-sand injection



From « Pétrole Progrès » Journal, N°36-1958,  
published by ESSO France ( Exxon Group).

« A grain of sand : Oil well fracturing technics in two snapshots «

# France Energies Production Journey (in Exa-Joules)

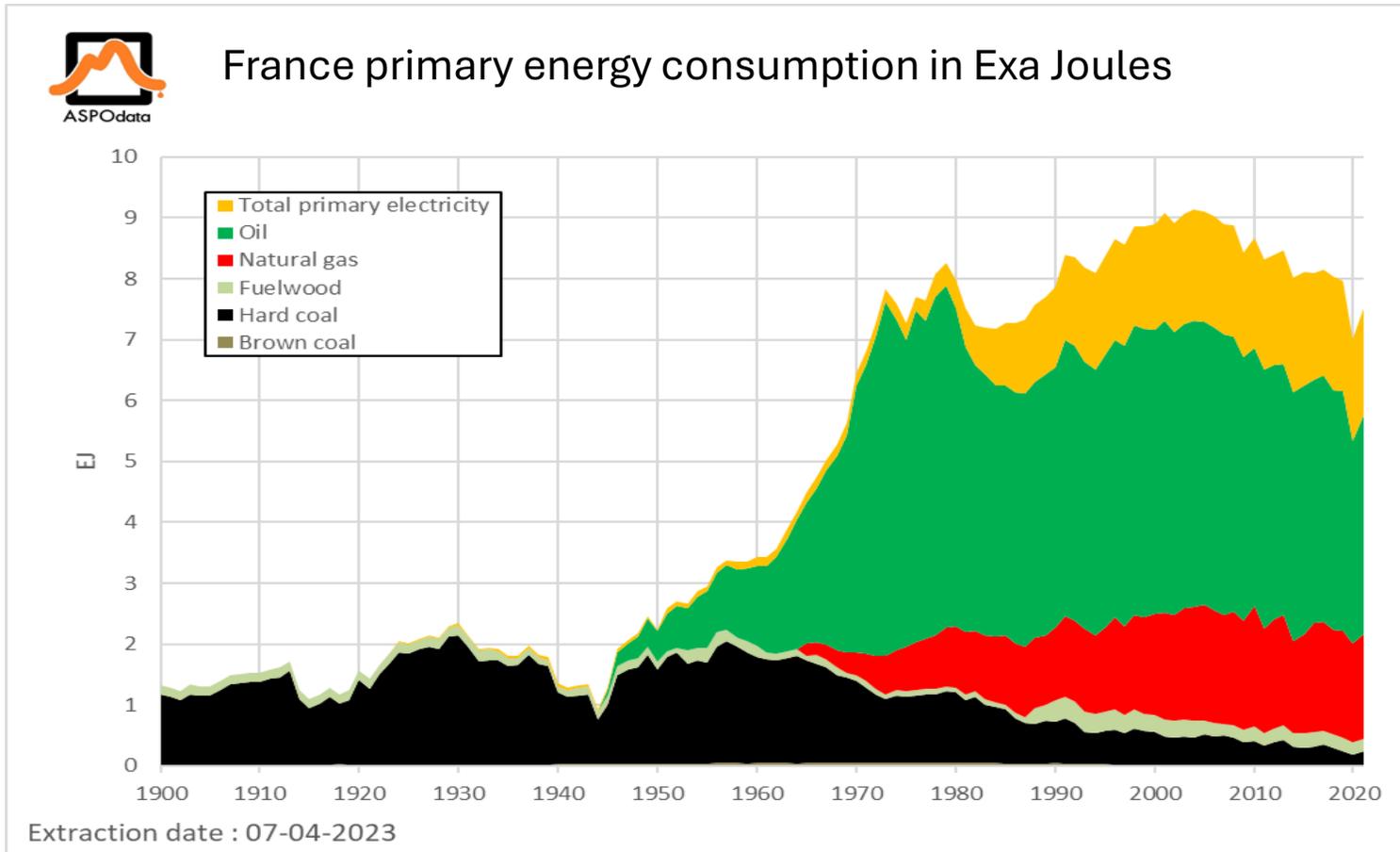


An exceptional and efficient Energy Transition : coal by nuk !

1 Exa-Joule = 278 TWh

Courtesy of ASPO France: <https://aspoFrance.org/>

# An innovative energy journey to relaunch



Even if coal has been displaced by nuclear electricity...  
Hydrocarbon consumptions still very high ! : 6 EJ !  
mobility, housing, industries

**Need for :**  
**Geothermal, natural**  
**Hydrogen and Helium,**  
**gas storages, CBM/CMM**

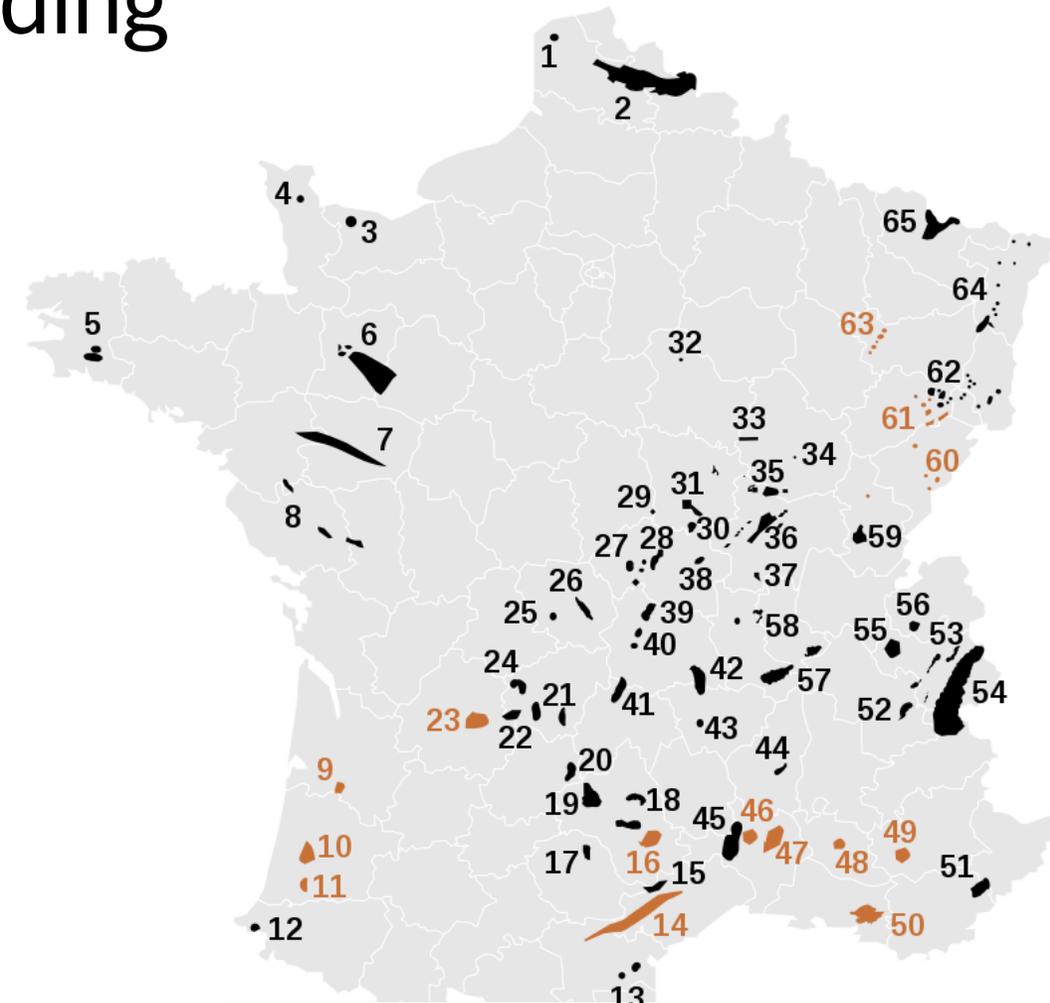
Courtesy of ASPO-France

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# Coal exploration and mining : a decisive contribution to sedimentary basin understanding

Well name	Depth	Date	Location	Company
<a href="#">Puits Vouters</a>	1 327 mètres	1958	<a href="#">Freyming-Merlebach</a>	<a href="#">Houillères de Lorraine</a>
<a href="#">Puits Reumaux</a>	1 138 mètres	1923	<a href="#">Freyming-Merlebach</a>	<a href="#">Houillères de Lorraine</a>
<a href="#">Puits Arthur-de-Buyer</a>	1 010 mètres	1900	<a href="#">Magny-Danigon</a>	<a href="#">Houillères de Ronchamp</a>
<a href="#">Puits Parran</a>	810 mètres	1880	<a href="#">Gagnières</a>	<a href="#">Mokta El Hadid</a>
<a href="#">Puits du Magny</a>	694 mètres	1878	<a href="#">Magny-Danigon</a>	<a href="#">Houillères de Ronchamp</a>
<a href="#">Puits Hottinguer</a>	623 mètres	1871	Autun	<a href="#">Houillères d'Épinac</a>



# The permo-carboniferous basins in France : the input of C,O &G explorations

A huge (\*100 times) thickness and geographical extension versus tiny outcrops

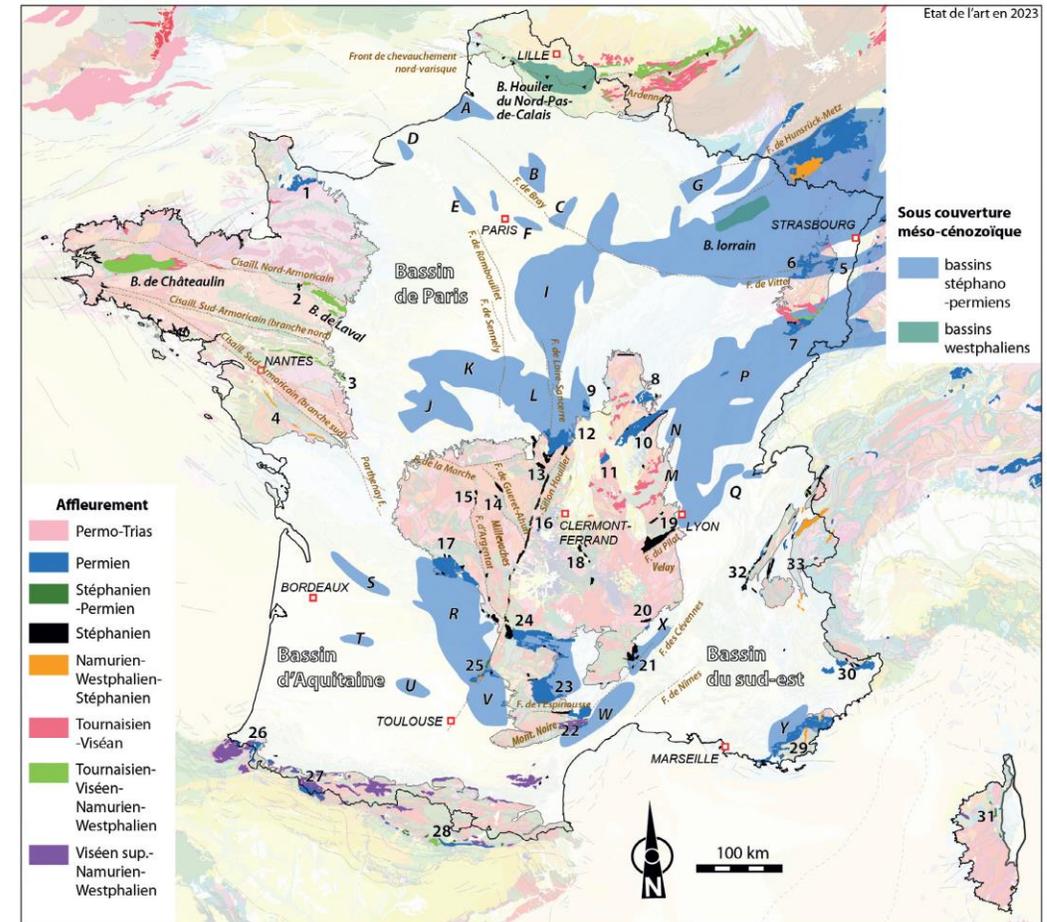
New mapping below Mezozoic basins

(Courtesy of Société Géologique de France-Geochronique December 2023),

Post orogenic basins after hercynian orogeny , uplift and granite intrusions

Very thick series of coal measures ( Upper Carboniferous : Stephanian) and bituminous coal or oil shales (Lower Permian : Autunian)

Les bassins carbonifères-permiens en France métropolitaine



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# Where and Why O&G exploration started (1952 leases map)

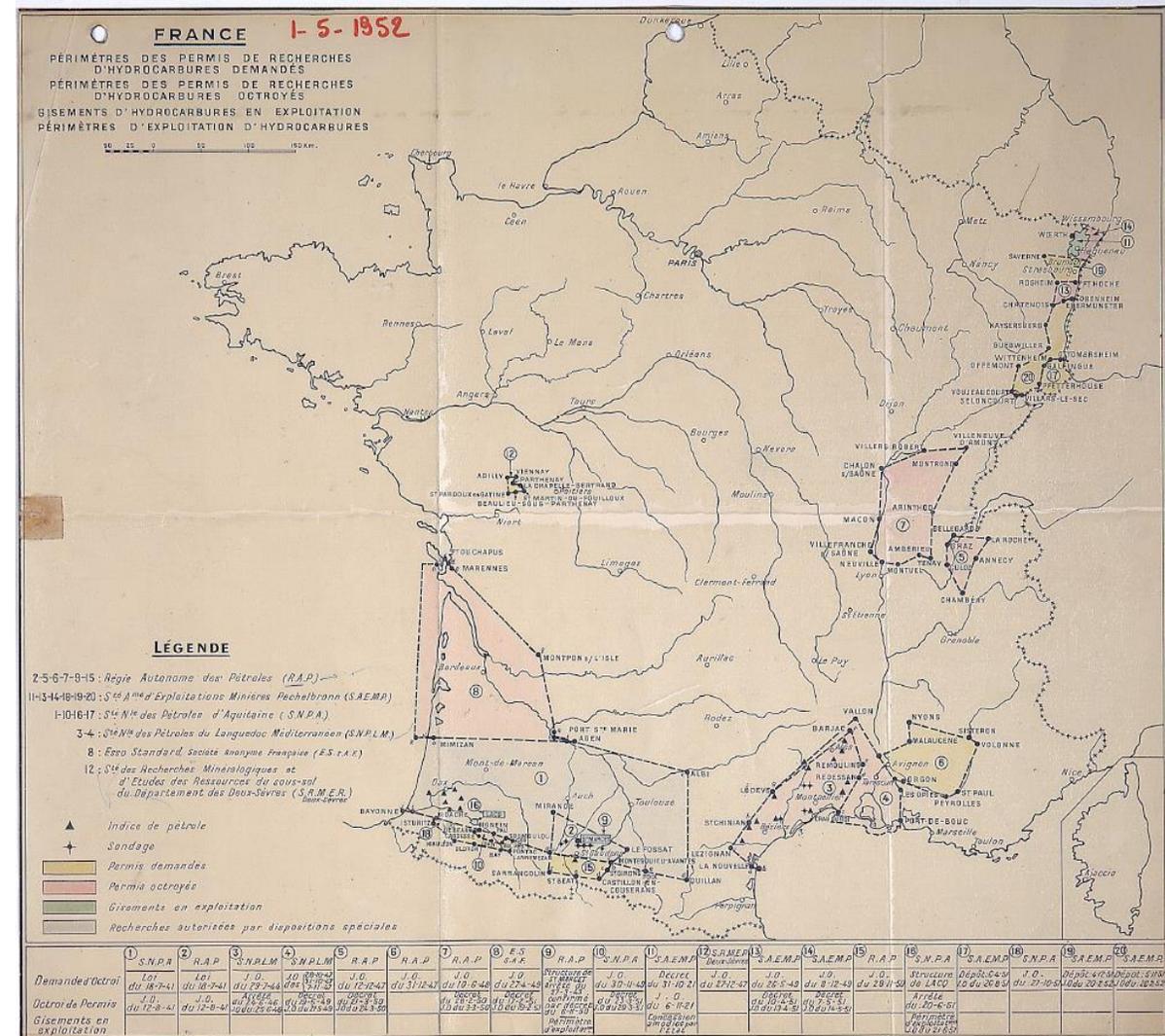
Just before the 2nd WW :

1-Exploration leases taken in Alsace, Jura, Languedoc and Aquitaine Basins where oil seeps were known  
 No permits in the Paris Basin ! : no seeps and no surface structures,

2-Very large leases with a few companies focused on geological/Fluid targets

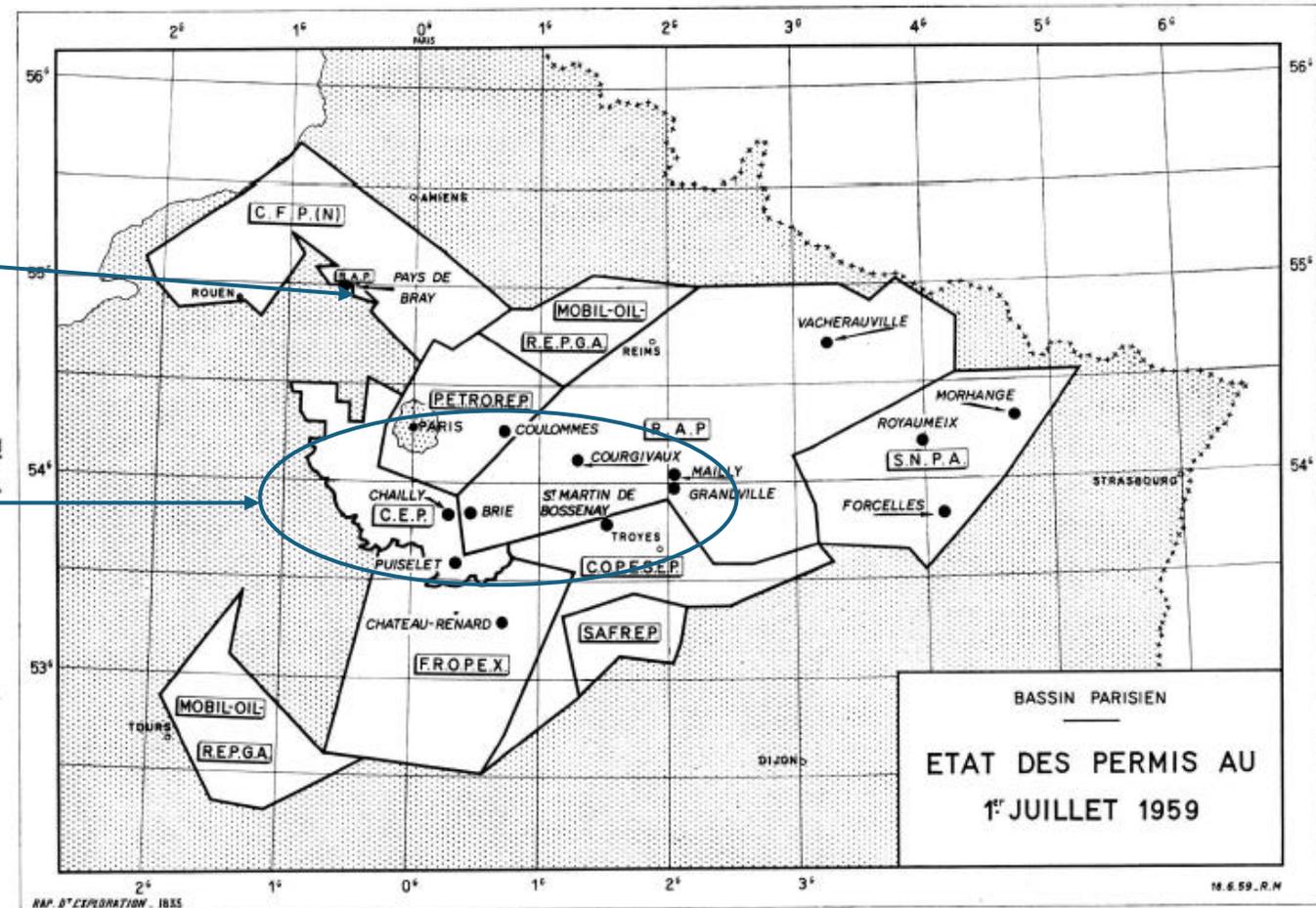
- 1-SNPA : Aquitaine South
- 2-RAP : Aquitaine SE and Jura-Alps for gas
- 3-Exxon France : Aquitaine North
- 4-SNPLM : Languedoc
- 5-SAEMP : Alsace

3-The first modern gas discovery (1939) : St Marcet (400 bcf) followed by two giants Lacq (7 tcf) in 1951 and Parentis (210 Mbo) in 1954 all in the Aquitaine Basin.



# First steps in the Paris Basin (1955-1960)

- 1952 : large reconnaissance study by IFP confirming the good source rock potential in the Liassic series , probable carbonate réservoirs and possible anticlinal structures
- 1952 : first 2D seismic lines
- 1954 : first discovery but tiny oil production in Pays de Bray 101 by RAP
- 1952-1958 : numerous companies leases : SNPA, RAP, CFP (Total), Mobil, Shell...
- 1955-1960 : first valid discoveries mainly in Dogger carbonates, and Upper Triassic sandstones
- But trap definition concerns :
  - 1-2D seismics : isochrons are not in accordance with isobaths (vertical and spatial velocities anisotropies)
  - 2-geological : stratigraphic and hydrodynamism trap components



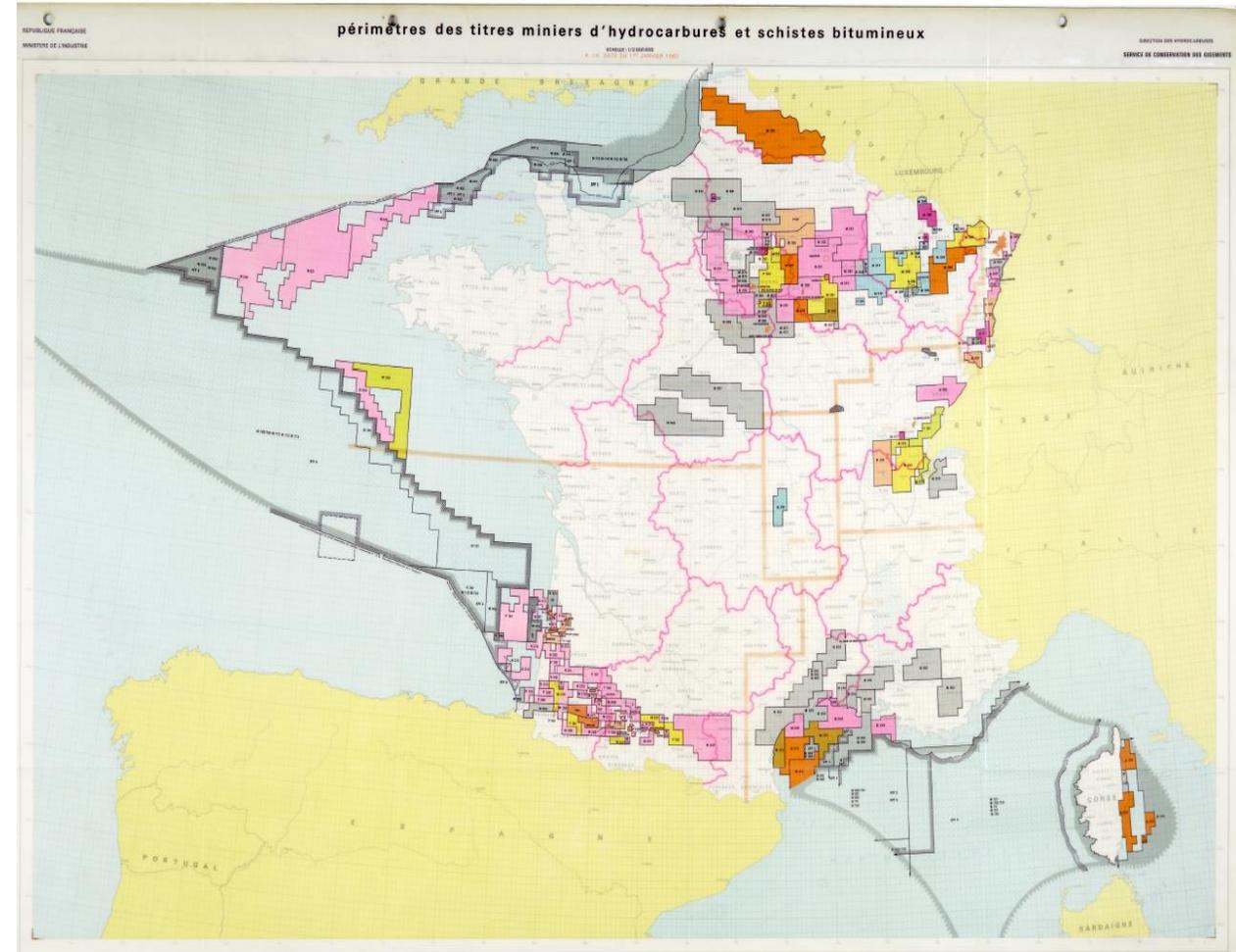
# 30 years later (1982) : the France great boom and the Paris Basin blossom

Starting offshore exploration in the Channel, the Western Approaches (Iroise) and Gulf of Lion (Méditerranée) : no results

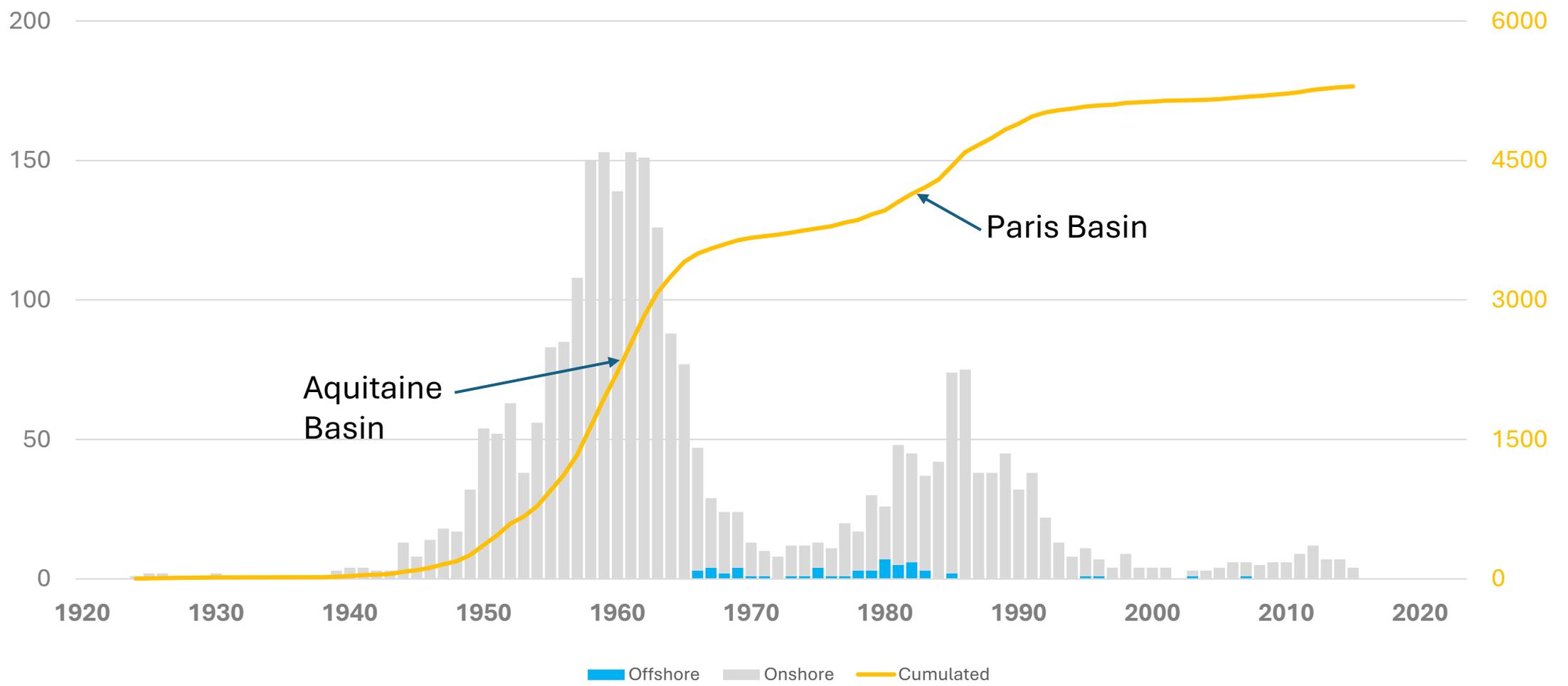
Focusing on the Paris Basin and finally thanks to multicore drills and 3D seismics : **the 2 big discoveries in 1983 !**

**Chaunoy (Exxon) in the Keuper sandstones : 100 Mbo**

**Villeperdue (TOTAL) in the Dogger Carbonates : 55 Mbo**



# Two exploration periods : the 50/60s and the 80s in two basins



Oil & gas exploration and appraisal wells drilled per year in France

# Presentation Highlights

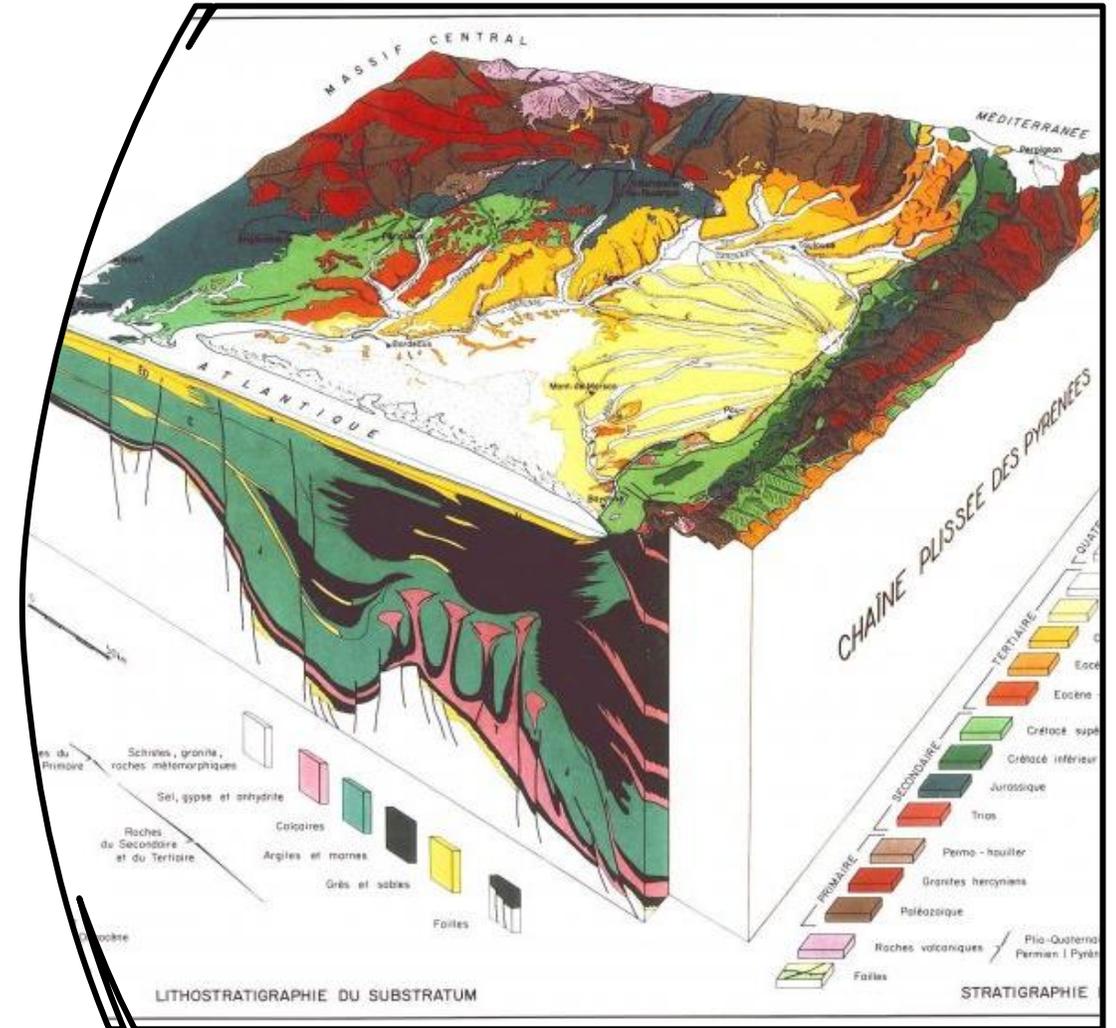
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# Subsurface knowledge from O&G exploration

## The Aquitaine Basin example : **from surface mapping to 3D model**

Following the varisc orogeny at 300 My (folding, metamorphism, granites and uplift)

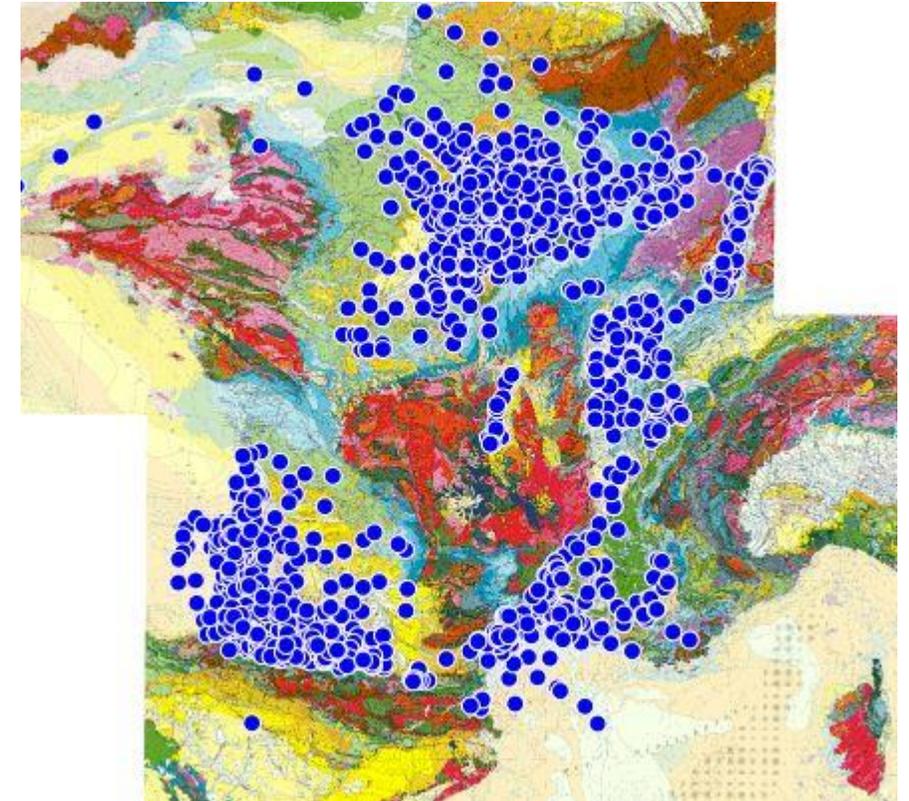
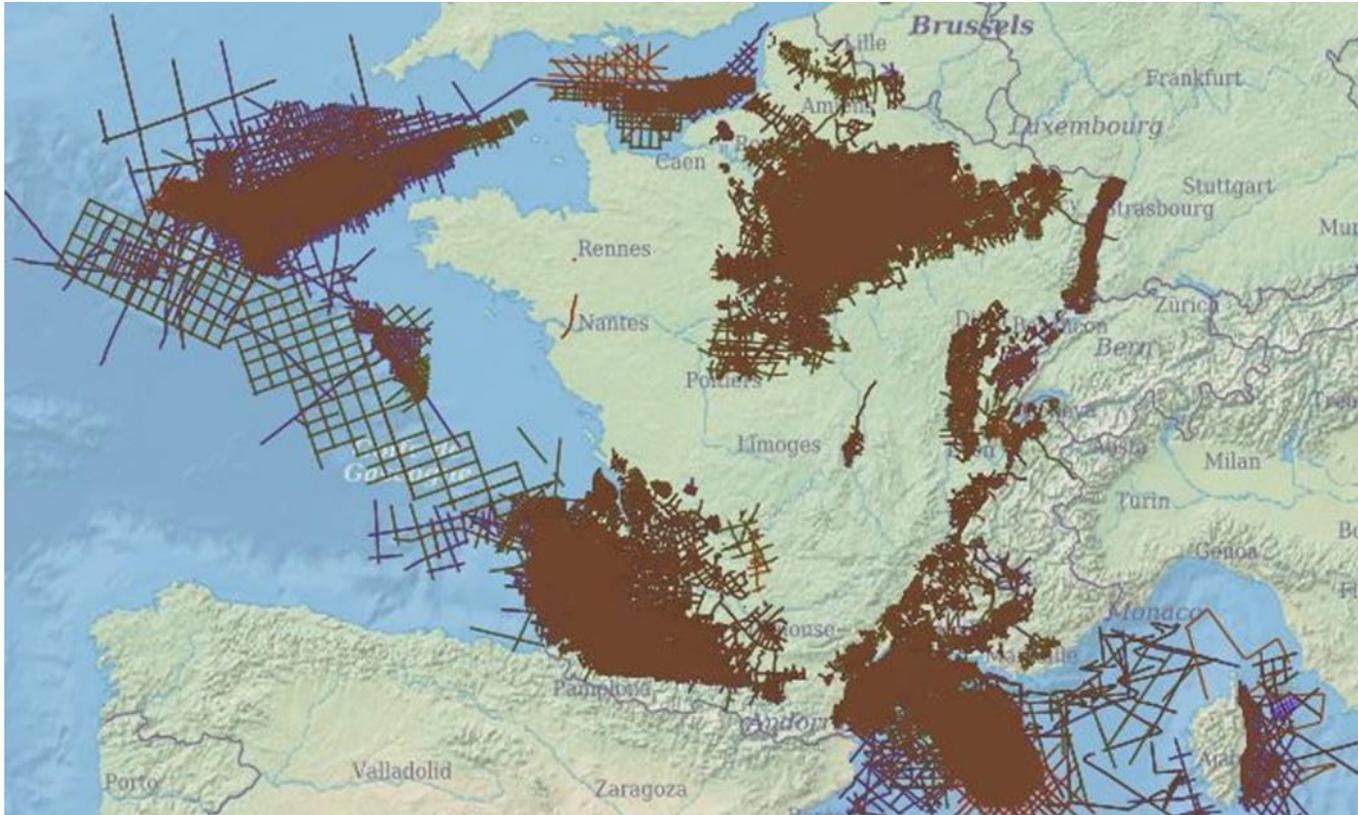
- 1-important depocenter from Triassic to Miocene mainly linked to Varisc belt erosion and Albian hyper extension and associated deep grabens with volcanism (lherzolites and basalts) and thick flysh remobilizing the Triassic salt in diapirs,
- 2-severe Eocene Pyrenean orogeny inducing FTB in the south and associated folding northwards : O&G traps



# A gigantic data base (seismics and O&G explo wells)

2D Seismics : 372000 km; 3D seismics : 4750 km<sup>2</sup>

O&G : 5300 E&A wells



The very base for understanding all sedimentary basins (Paris, Aquitaine, Alsace, Rhône, Jura...)

# And more about wells : cores and cuttings , geochemistry ( gas, waters...) in Boussens STC store, close to the gas discovery of St Marcet

Giant core house in Boussens (South-west France) with for France only :

- 153 000 m of cores
- 46 500 m of cuttings bags
- 100 000 m technical documents
- 2 000 000 pages scanned
  
- Associated with a petrographical laboratory



<https://www.stc-archivage.fr/en>

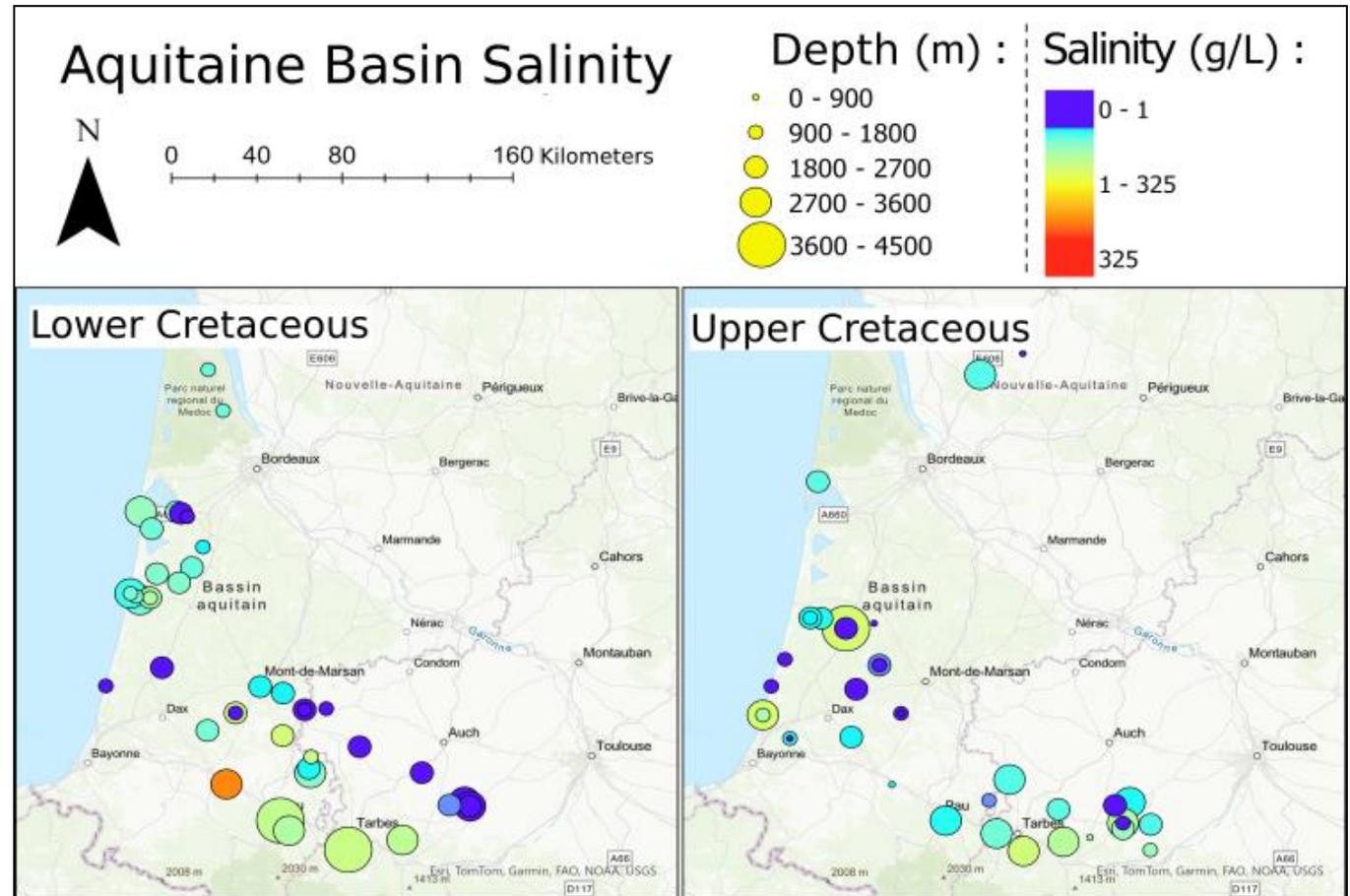
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# Fresh groundwaters in deep subsurface: salinities computed from O&G wells

Large aquifers with fresh waters even at important depths ,  
An enormous fresh water reserves and  
a valuable input for next water scarcity climatic periods

Courtesy of AVENIA (2024)



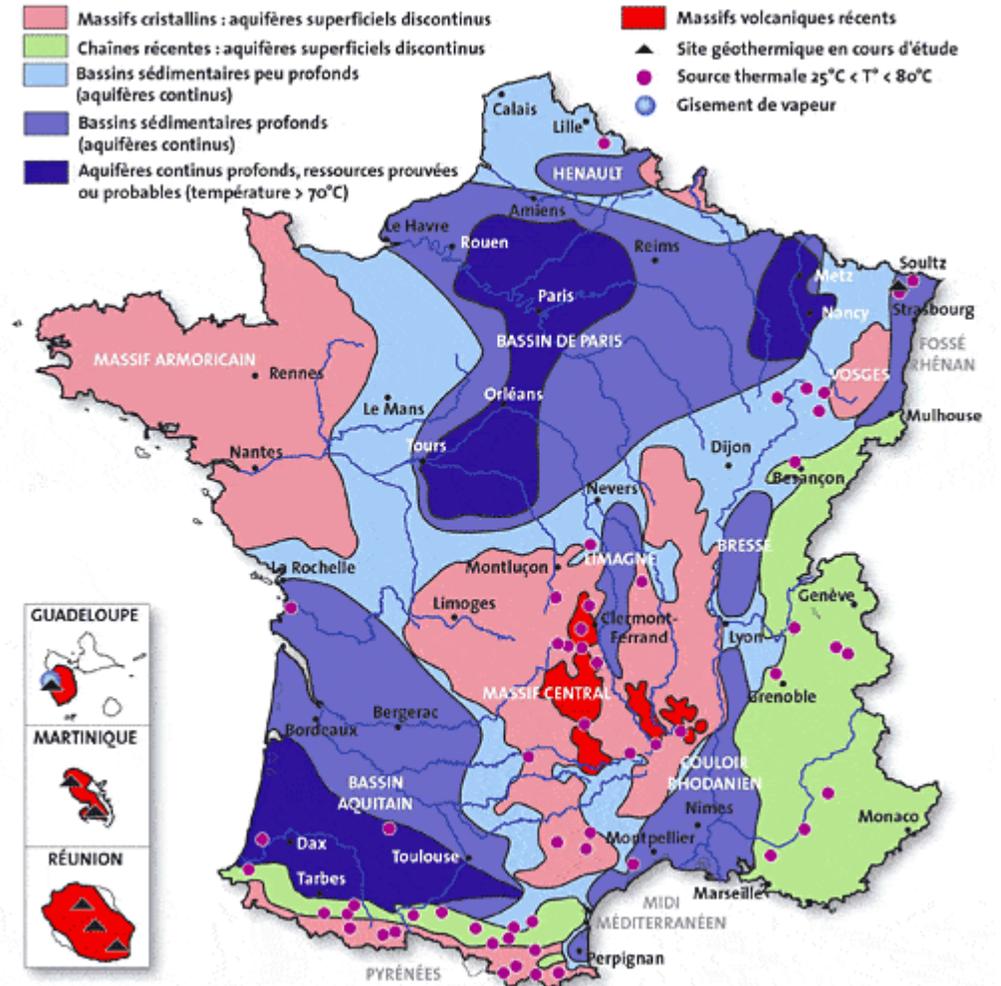
# A fresh water discovery, already in our glass

- Les Abatilles water (close to Bordeaux) was discovered in one of the first oil exploration well in 1924 at 470m deep,
- In production since 1926 ;
- 50 000 000 liters/y in 2022 or around 1000 bwpd
- **Better rewards than any O&G business !**



# France : deep Geothermal potential

- Subsurface temperatures map directly issued from O&G wells records
- Water productivity can be assessed from O&G tests and permeability measurements (done or to be performed on cores)
- Geothermal potential =  $T * K$
- HSE risks can be avoided thanks to pressure measurements (PWD) within O&G wells
- Main targets : sedimentary basins : Paris, Aquitaine, Alsace, Limagnes, South-East



<http://ericjarrot.free.fr/carte-ecologique-des-ressources-geothermiques-en-France.htm>

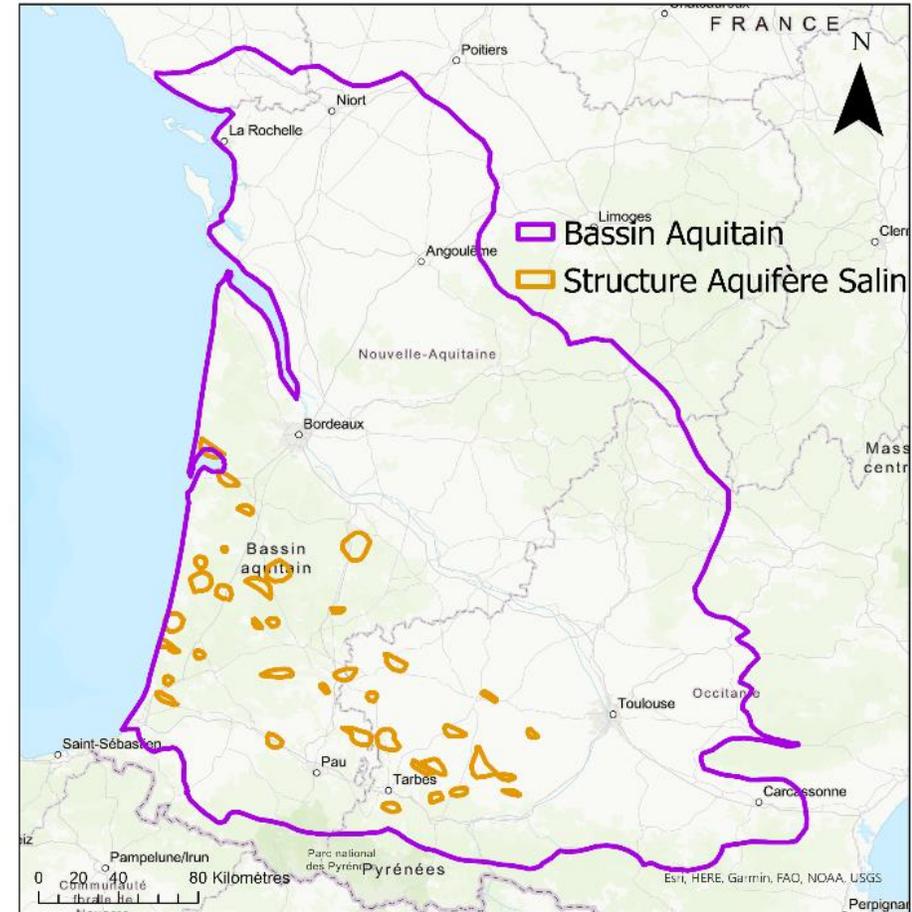
# CCS in Saline Aquifers

Aquitaine basin :  
Thanks to O&G explorations

More than 30 structural traps have  
been recognized as potential CO2  
underground storages

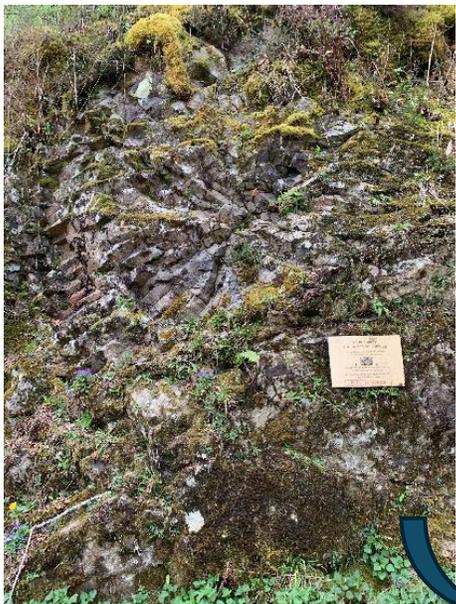
All the structures are mapped  
thanks to seismics and calibrated  
through wells exhibiting good  
reservoir-seal pairs

Let's now start the specific works :  
geomecanics, wells integrity,

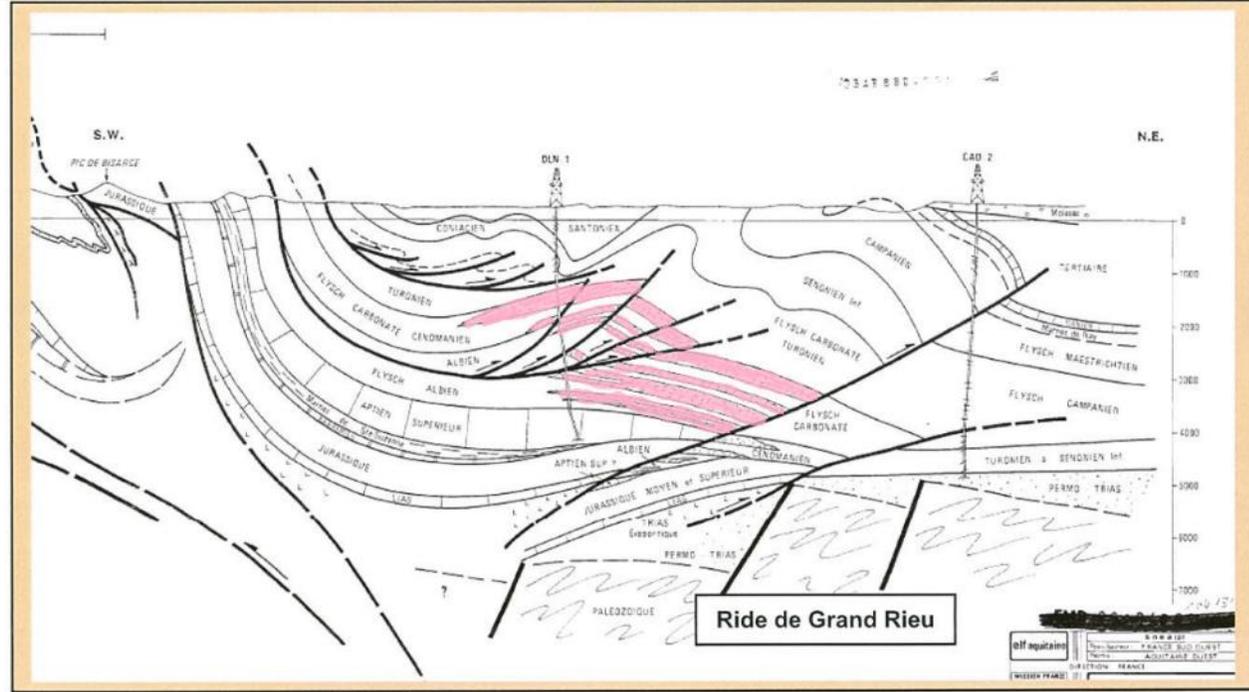


Courtesy of AVENIA (2024)

# CO2 mineralization in Aquitaine volcanics : the AVENIA Pycafix project



Near pyrenean fronts (France and Spain), in Albo-Cenomanian graben like basins, thick and large basalts and dolerites injected and mappable thanks for O&G seismics and wells, Ideal rocks for fixing anthropogenic CO2 at reasonable depth (2000m) but R&D Question : Can old (100 Ma) and cold (60°C) volcanic rocks have sufficient characteristics (phi, K) to precipitate massive carbonates ?



# H2 Storage in Salty layers : main evaporitic periods in France : Triassic, Oligo-Miocene

The Triassic evaporites are influenced by the climatic, the structural context at time of deposition, and halokinetic motions (Albo-Cenomanian extension and Cretaceous subsidence)  
Diapiric structures could be favorable for storage in saline caverns

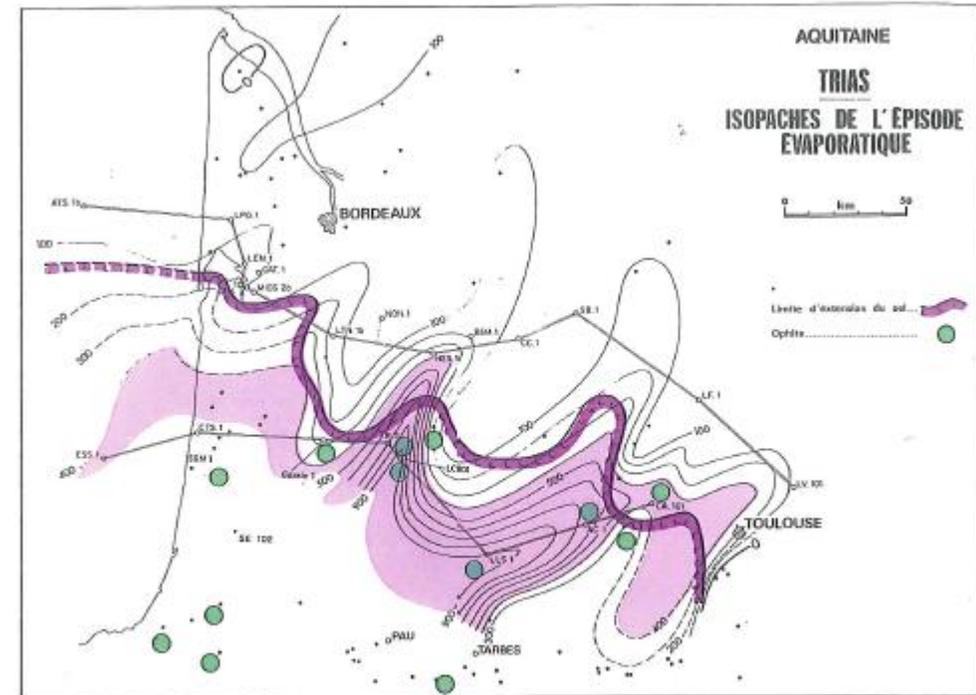
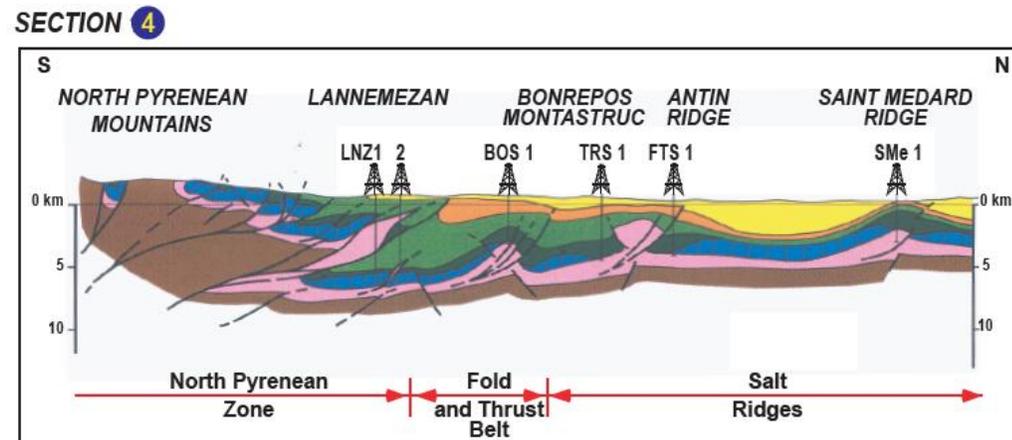
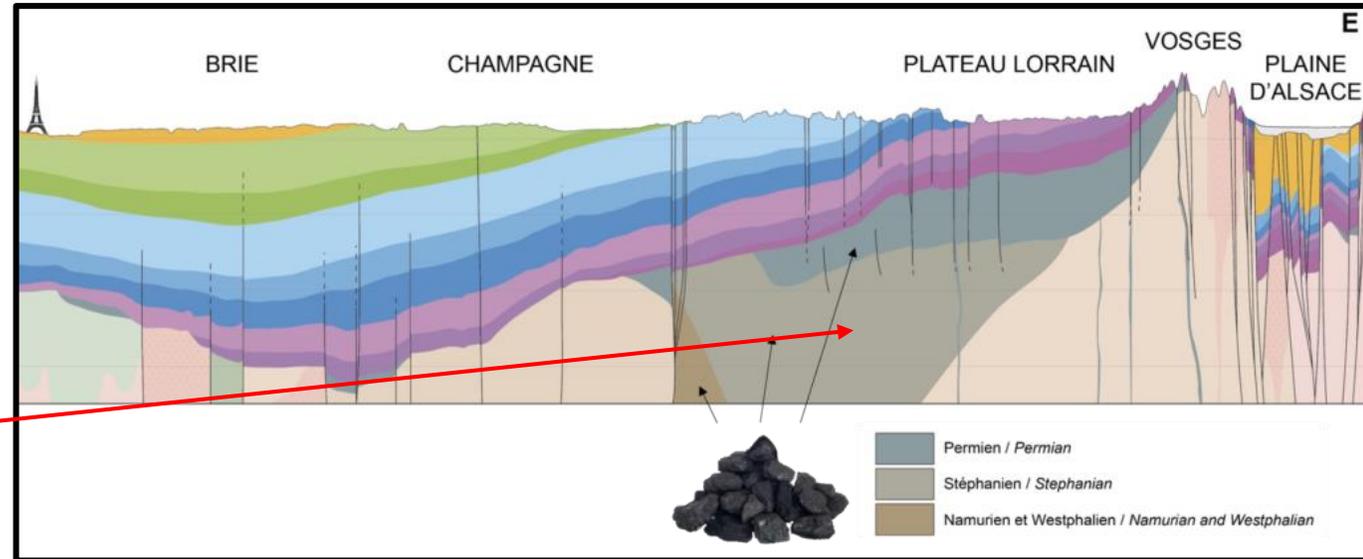


FIGURE 4  
Trias : isopaches de l'épisode évaporitique  
Triassic : isopachs of the evaporitic formations

Triassic Isopach map and salt extension in Aquitaine

# Permo-Carboniferous coal basins : a revival ?

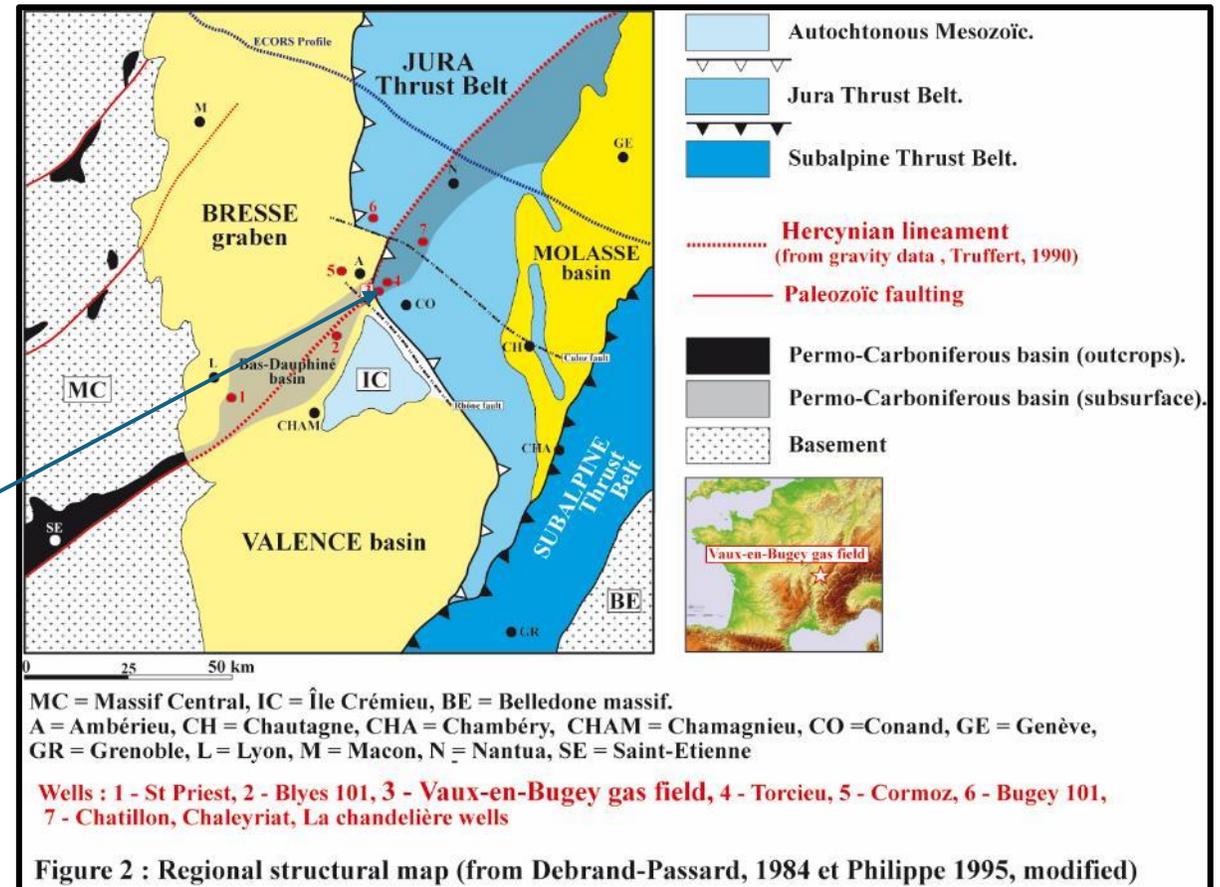
- 1-CMM methane extraction from old galleries : already in production in North of France
  - Why not in other basins ?
- 2-CBM associated with CCS ?
- The Regalor Project in Lorraine



# Permian basins : the fairways to He and H2 discoveries ?

## A unique configuration !

- Radiolytic (H<sub>2</sub>) and radiogenic (He) generation from radioactive permian SR (hot shales) and granitic basement
- Mechanical generation (H<sub>2</sub>) from deep seated faults (SW-NE) permian faults,
- Already proved in the oldest french gas field : Vaux en Bugey
- CH<sub>4</sub> : 80% ; C<sub>2</sub>H<sub>4</sub> : 5%, C<sub>3</sub>H<sub>6</sub> : 3%; CO<sub>2</sub> : 5 %, N<sub>2</sub> : 5% ;
- **H<sub>2</sub> : 0.5 to 5%**



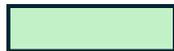
The Vaux en Bugey gas field : Structural Context (Courtesy of SGF) – Géologues Journal-N° 213-June 2022

# 2024- An emerging new underground world !

Leases



O&G



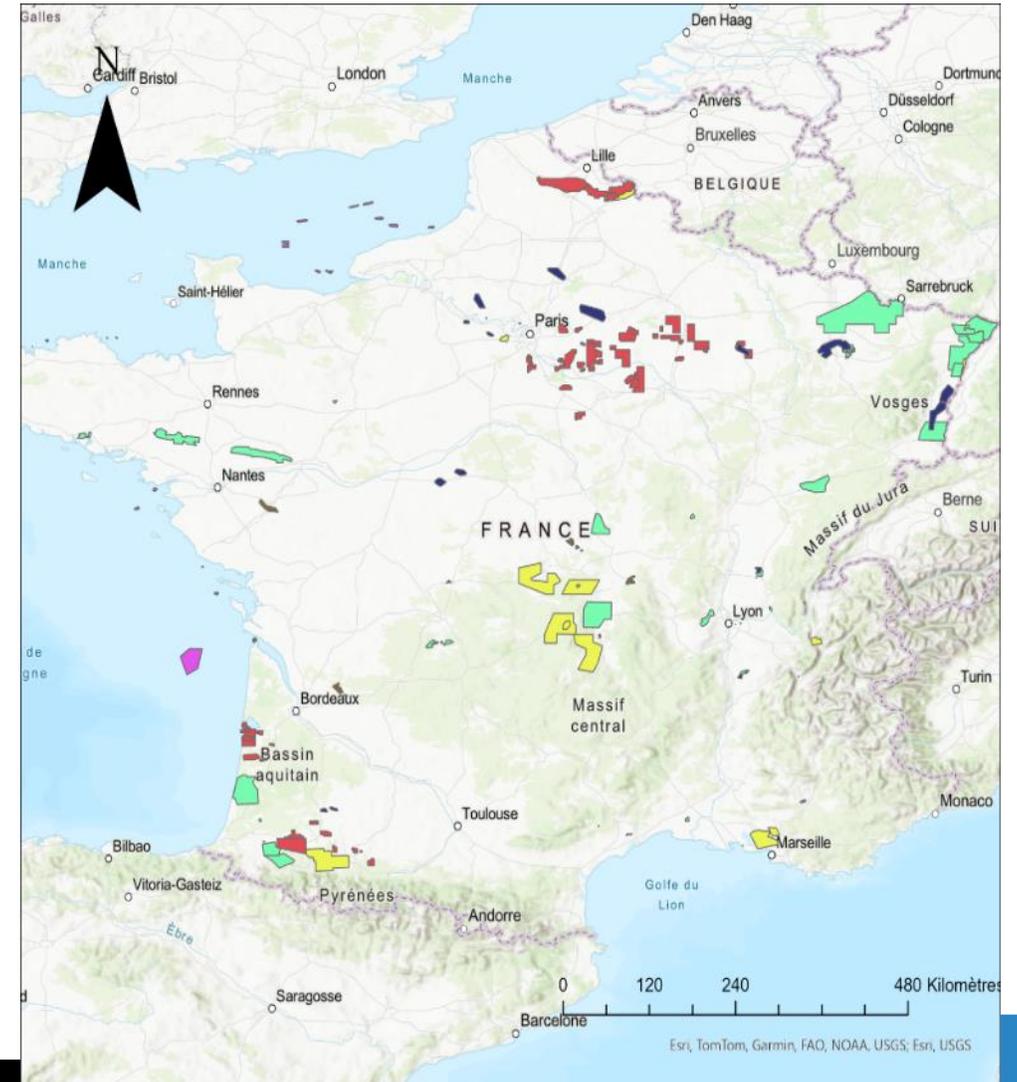
H2 and He



Deep geothermal



Storages



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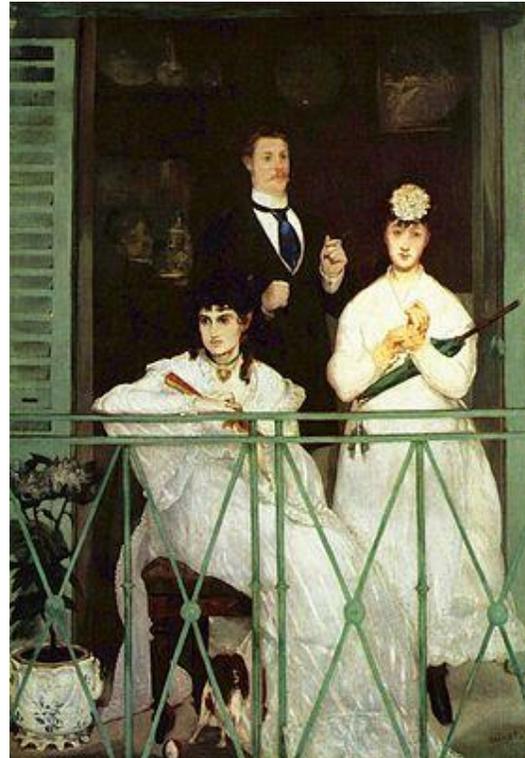
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# Conclusion (1) : Subsurface disciplines expansion

Goya, 1808, *Majas on a Balcony*



Manet, 1868, *The Balcony*



Magritte, 1950, *Manet's Balcony*



From Fossils Exploration:  
Hidden/Complex/Risky

But thanks to initial data and  
to Synthesis/Creativity

Go to simpler , clearer  
and less risky

# Conclusion (2): subsurface disciplines expansion and new energies basins in France : simpler if

- 1- **Free and easy access to O&G data (seismics, wells, cores,,)**
- 2- **Promotion of the underground** description and usages and associated benefits/risks to all stakeholders (teachers,students, politicians, general public...)
- 3-**Creation of a subsurface regulation body** ( regional agencies) for the different subsurface claims (sometimes in conflicts or synergies) arbitrating the future intense demands for underground spaces on a value for society basis,
- 4- **Clear leases attribution process** (international calls for tenders) in every subsurface domains : storages, H2 and He exploration, CBM/CMM, geothermal, fresh groundwater , mineral mining,...
  - a) technical leases proposals realized by the BRGM
  - b) detailed public debates and reports ( CNDP mode : Commission National Débat Public )
  - c) Regulation body : CFT invitation and advertising, evaluations (with BRGM expertise), selection and follow-up
- 5-**An underground twin 4D model** for the understanding of the subsurface uses **for each french energy basin**

# MERCI pour votre ATTENTION

Thanks to:

\*Ministère de l' Ecologie, de l'Énergie et des Territoires/ Direction Générale Énergie et Climat

\*French Geological Survey (SGF) : <https://www.geosoc.fr/>

\*AVENIA, the French Underground Cluster : <https://www.pole-avenia.com/fr>

\*ASPO (Association for Study of Peak Oil) : <https://aspofrance.org/>

**E-mail : [marc.blaizot@gmail.com](mailto:marc.blaizot@gmail.com)**



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