Workshops on Carbon Capture and Storage
Instituto de Ingeniería, UNAM

CO_2 Geological Storage, Hontomín site assessment

Ramon Carbonell

CSIC

GOBIERNO DE ESPAÑA
ciudad de la energía

The Compostilla Project
OXYCFB300

European Energy Programme for Recovery

March 2012

CIUDEN: Spanish government foundation to promote, among other things, Carbon Capture and Storage

Hontomin is the Tech Demonstration Plant of the Compostilla OXYCFB300 EEPR project, run by ENDESA, in collaboration with CIUDEN and FOSTER-WHEELER

EEPR “European Energy Programme for Recovery” facilitates investments on infrastructure and technology projects in the energy sector; helps improve the security of supply of the Member States and, promotes implementation of the 20/20/20 objectives for 2020.

CSIC is the “Spanish Agency for Scientific Research”, a network of research institutes.

The Players

The Research Team: , A. Pérez-Estaún [1,2], J. Alvarez-Marrón[2], D. Brown[2], R. Carbonell[2], D. Martí[2], J.A. Muñoz [3], P. Queralt [3], A. Marcuello [3], J. Ledo [3], J.L. Fuentes Quintanilla[4], J. Bueno[4], B. Buil[5], J.L. García Lobón[6], C. Ayala [6]

The Journalist: R. Carbonell[1,3].

1. Subprogram of CO2 Storage, Energy City Foundation

2. Institute for Earth Sciences Jaume Amera, Spanish Agency for Scientific Research, CSIC

3. Institute of Environmental Assessment and Water Research, CSIC

4. Association for Research and Industrial, Development of Natural Resources

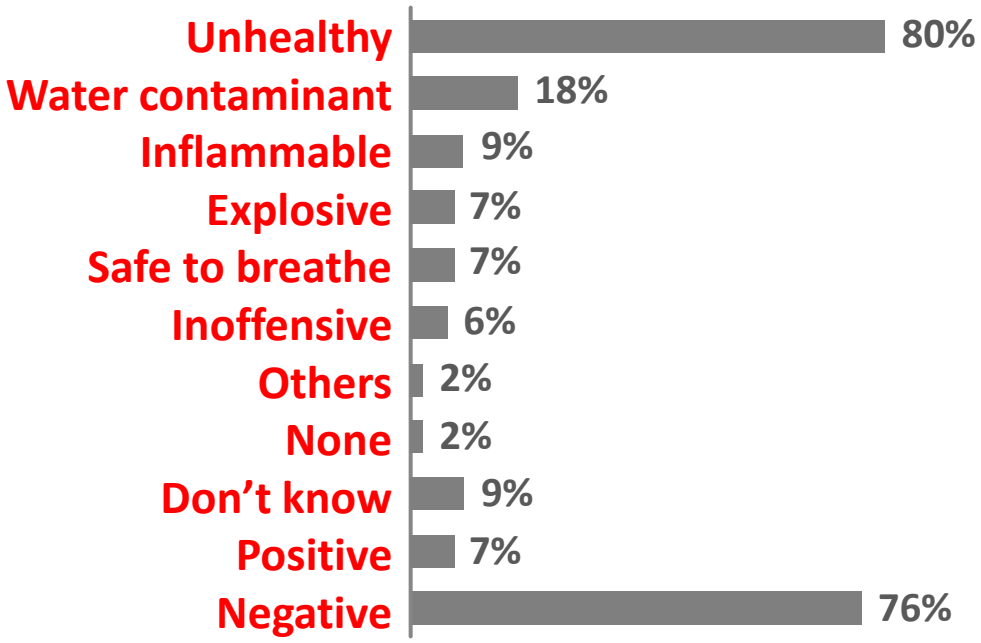
5. Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

6. IGME, Geological and Mining Institute of Spain

CO_2 Properties

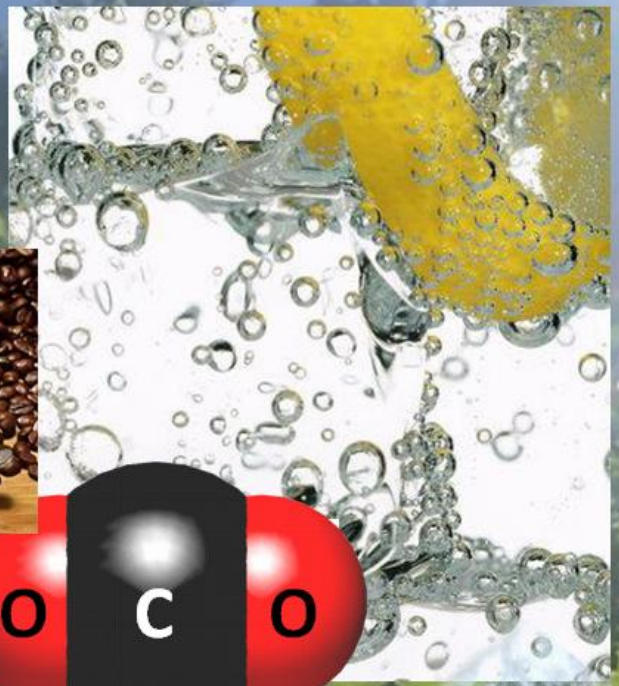
Reality vs **Perception**

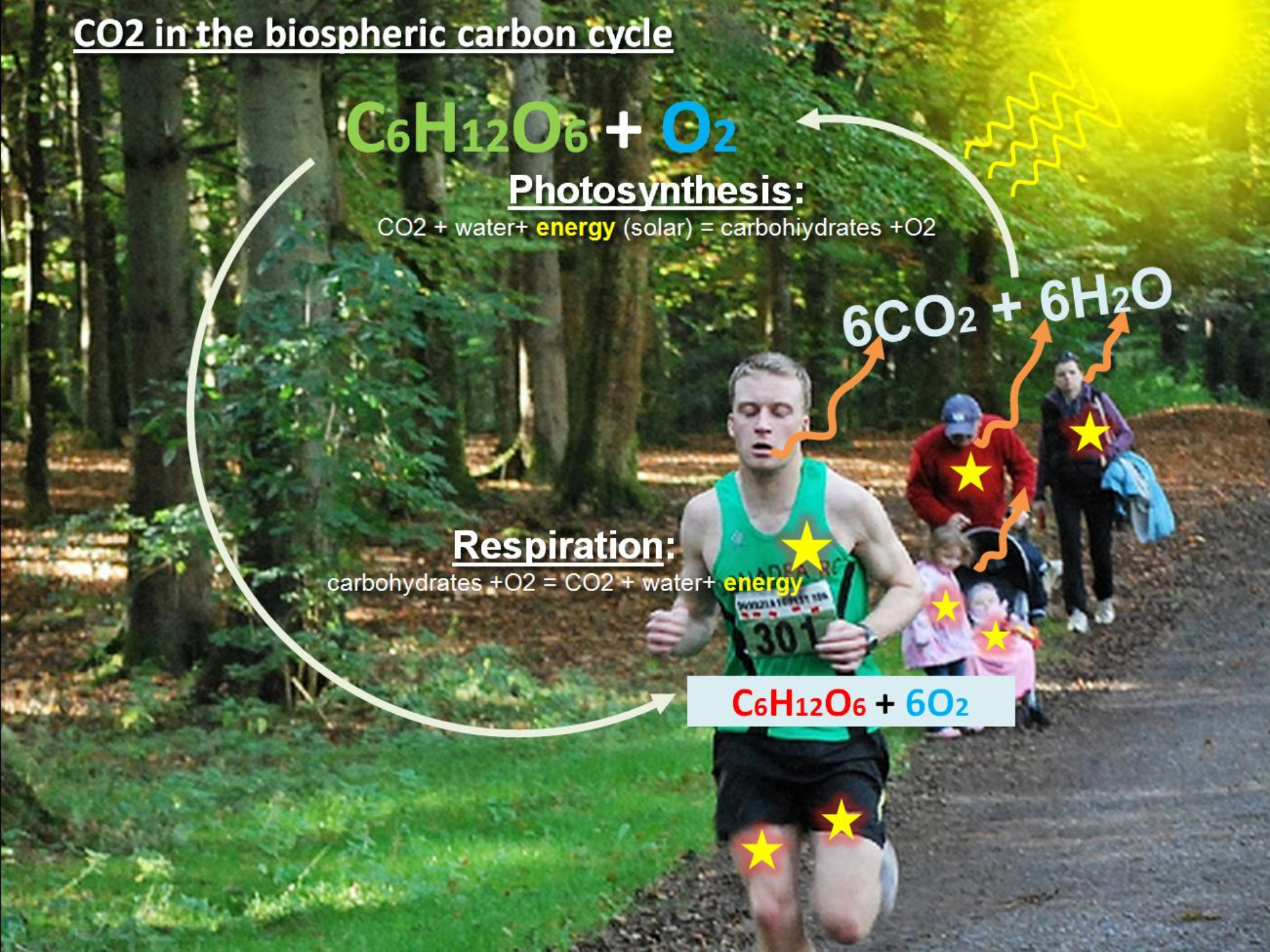
- Colorless
- Odorless
- Dense
- Non toxic
- Non inflammable
- Nonpolar
- Low reactivity
- Low viscosity
- High solubility



Source: Eurobarometer CCS, May 2011

CO_2 everywhere

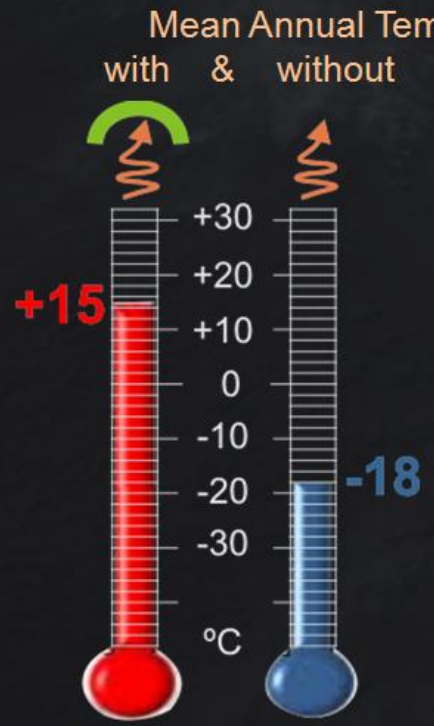



CO2 in the biospheric carbon cycle
C6H12O6 + O2
Photosynthesis:
CO2 + water+ energy (solar) = carbohiydrates +O2
6CO2 + 6H2O
Respiration:
carbohydrates +O2 = CO2 + water+ energy
C6H12O6 + 6O2

At night, the GHGases keep part of the sun heat

During the day the sun warms the Earth

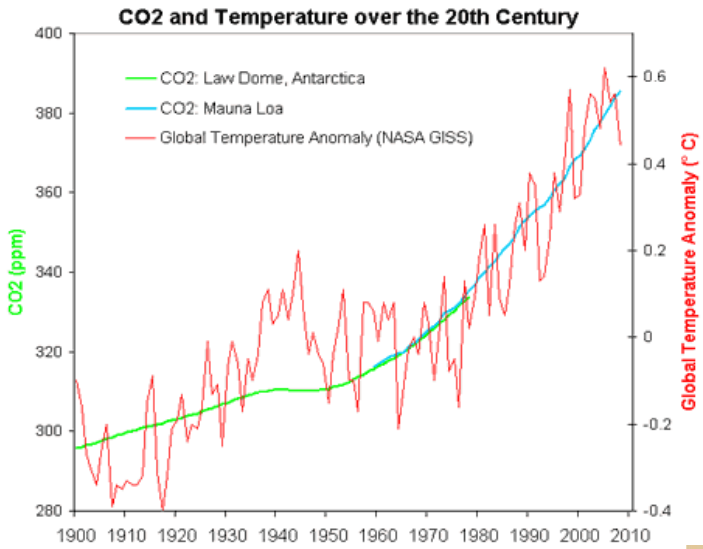
The Greenhouse effect tempers the climate

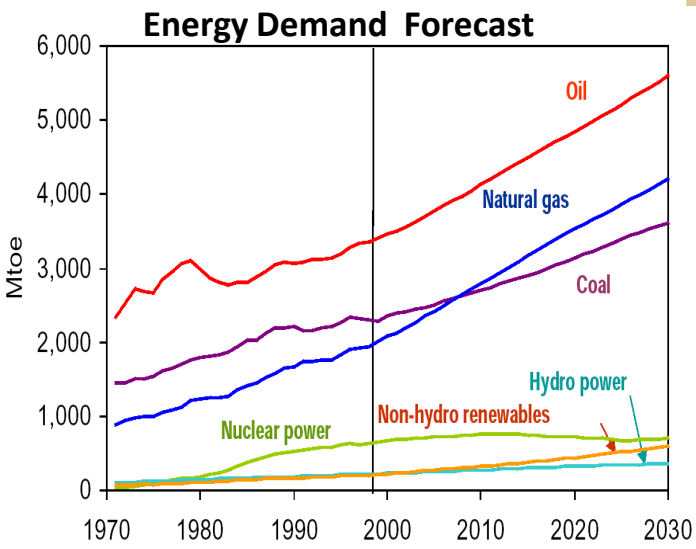


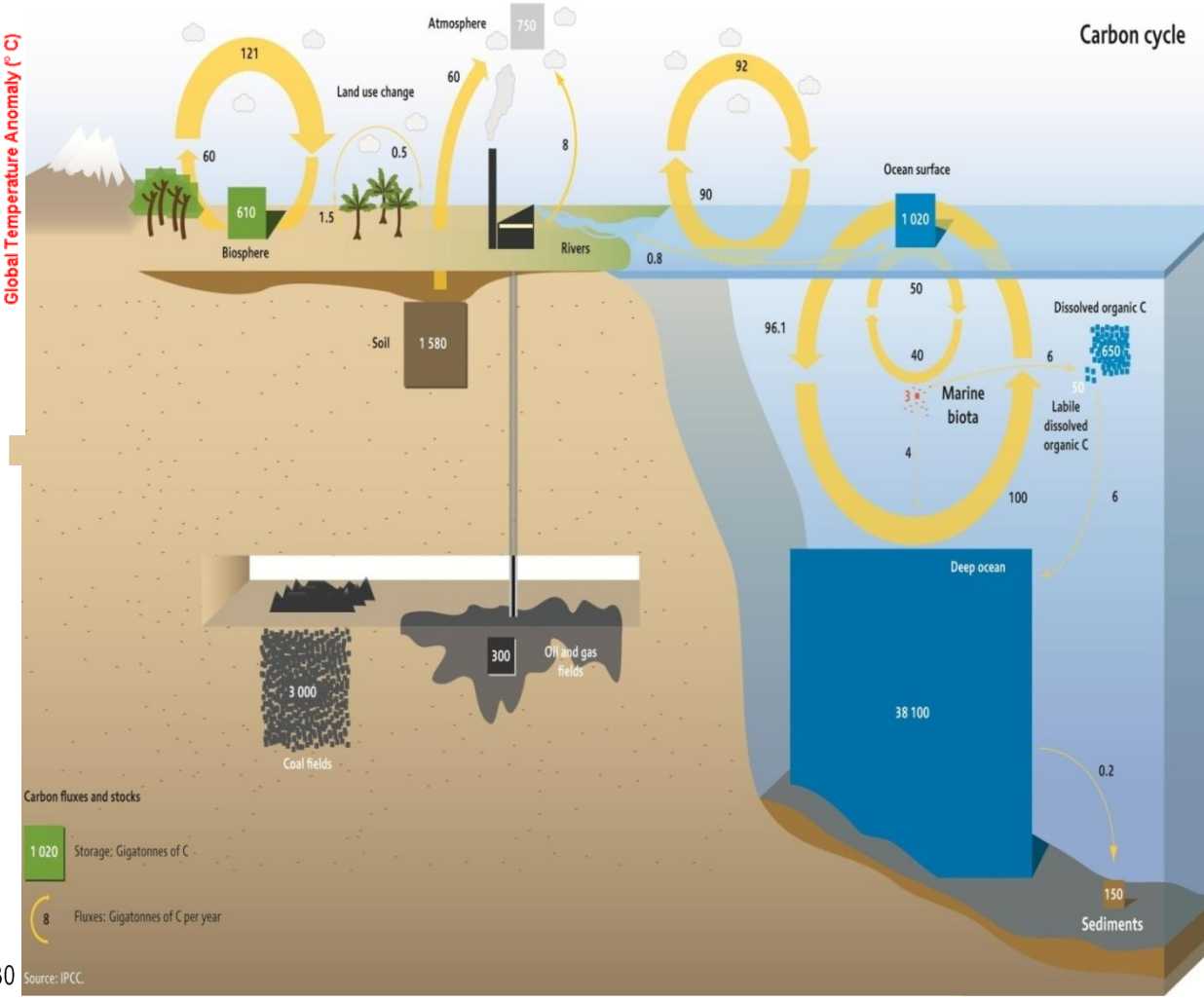
…So, what's the problem with CO_2?

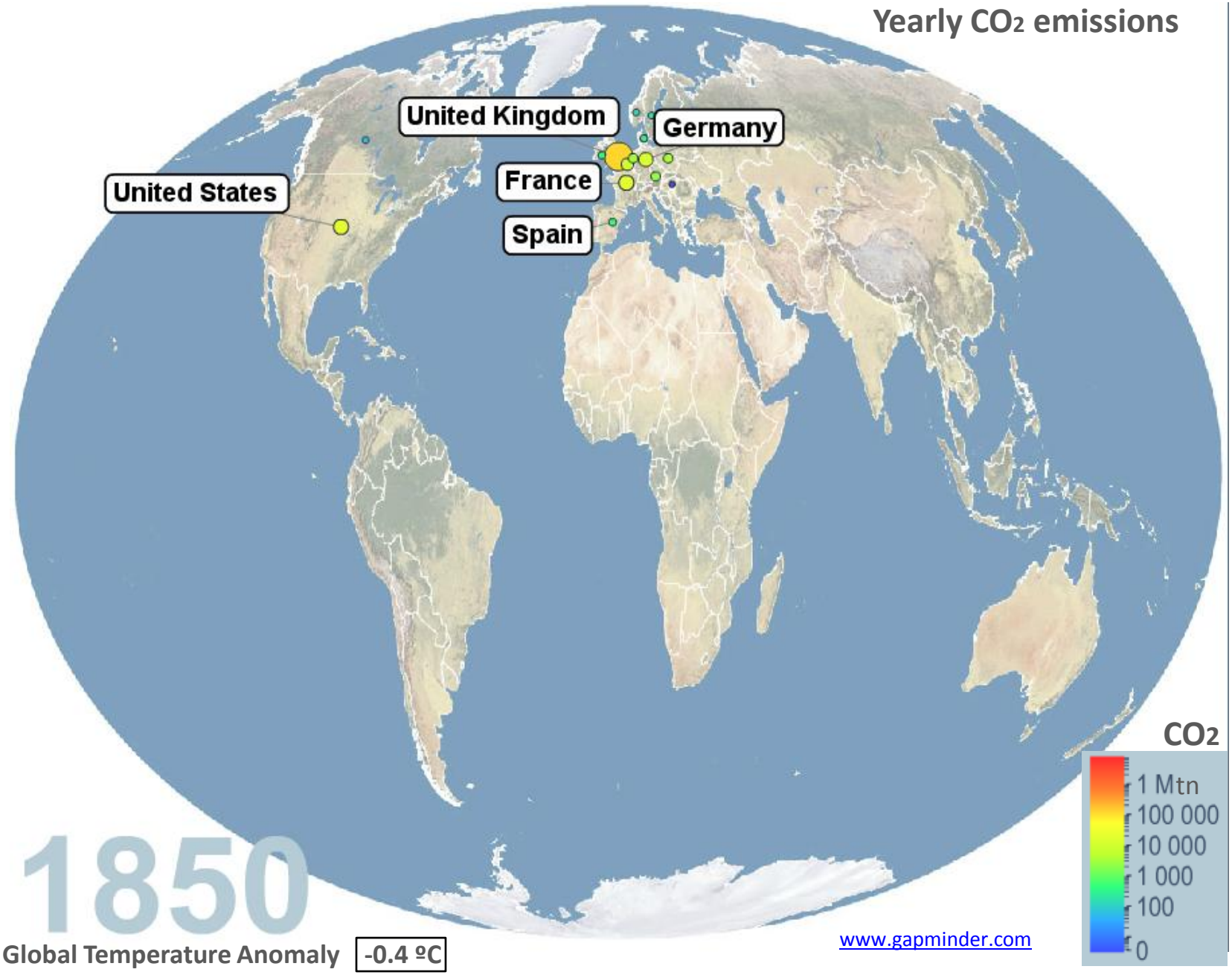
Burning fossil fuels introduces CO_2 in the natural carbon cycle.

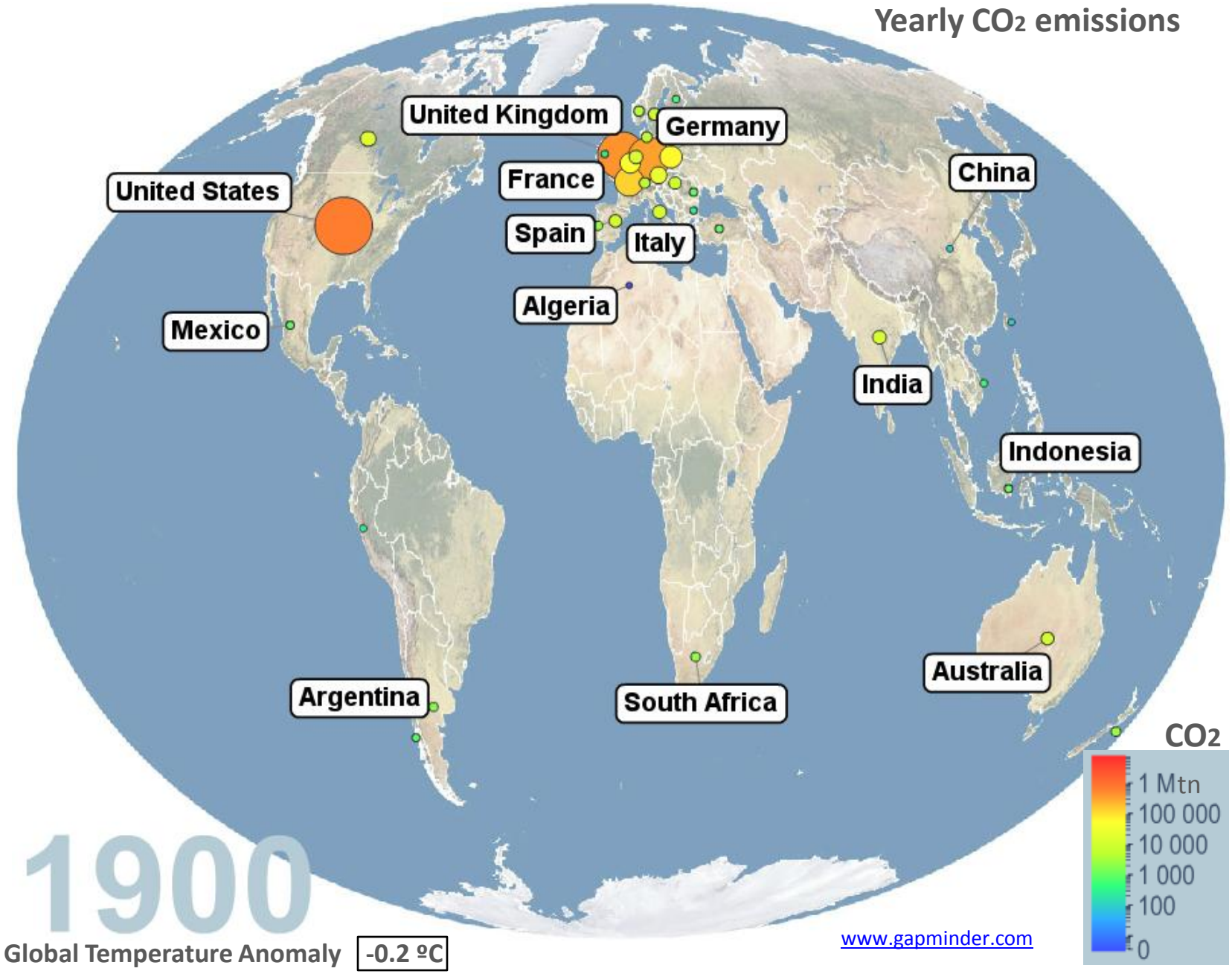
- increasing 20% atmospheric CO2 → + 1ºC Tm.
- at present increase rate (~0.2ºC/10y)→ ~ 50 years

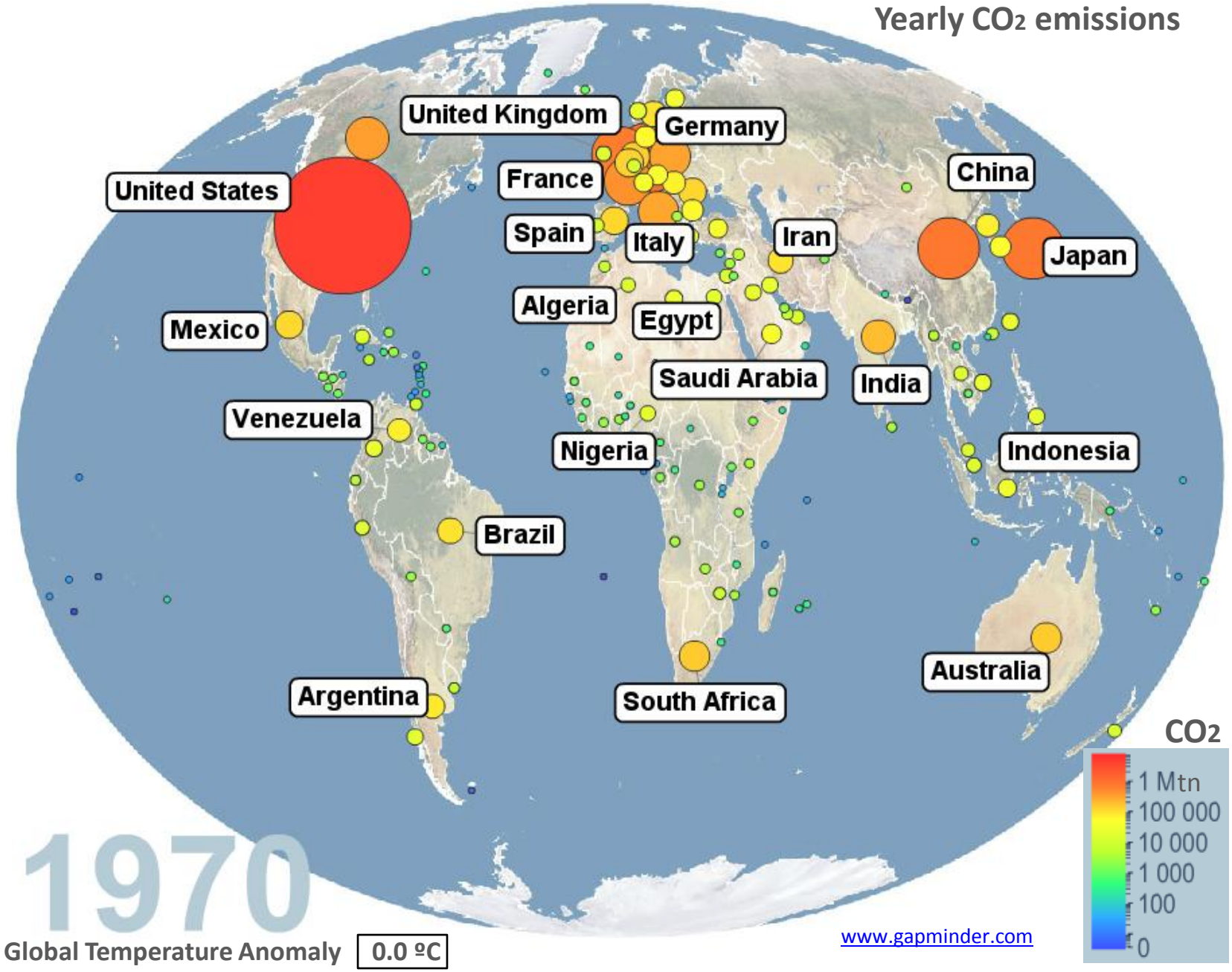


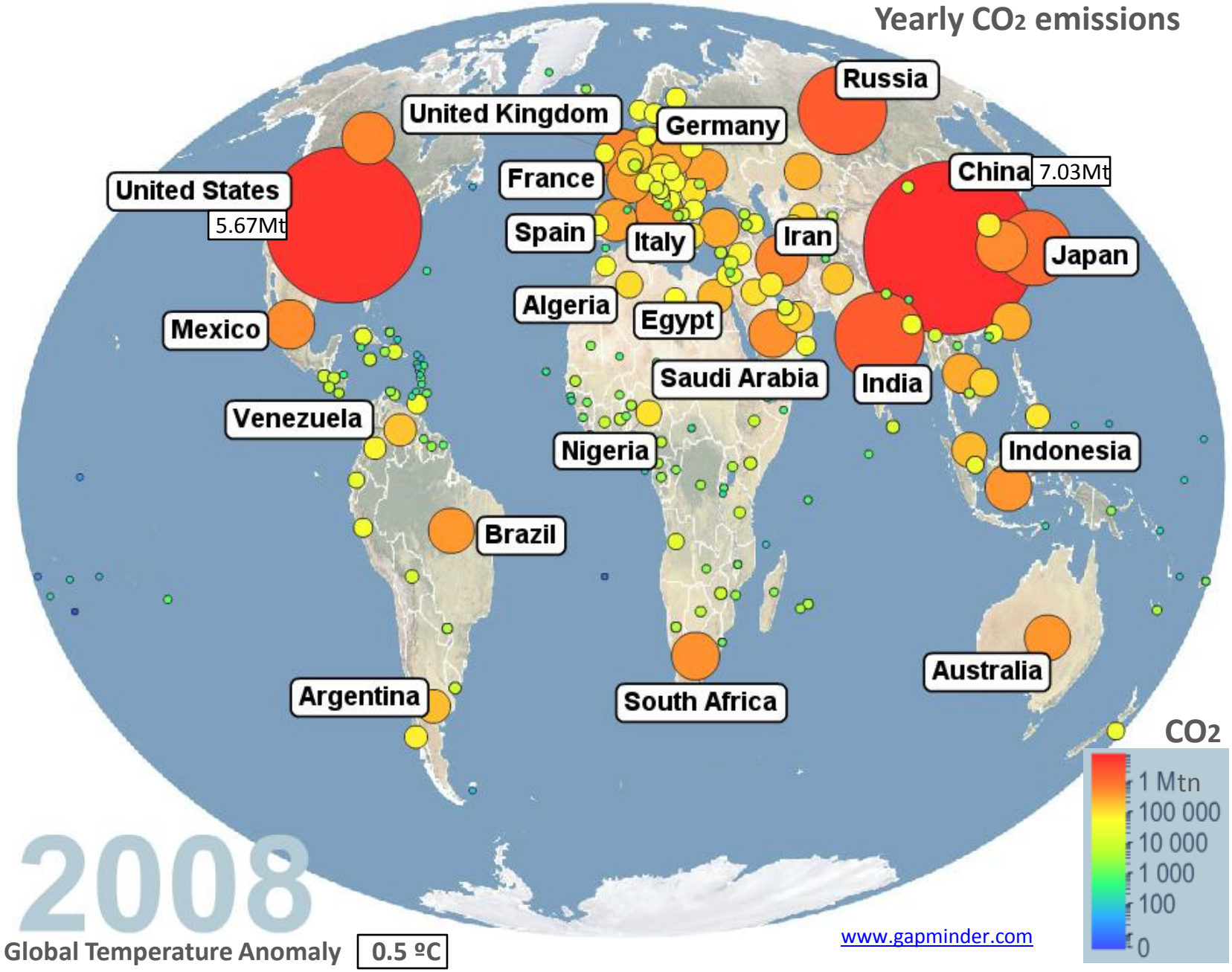





Yearly CO2 emissions
United Kingdom
Germany
France
United States
Spain
CO2
1 Mtn
100 000
10 000
1 000
100
0
1850
Global Temperature Anomaly
-0.4 ºC
www.gapminder.com


Yearly CO2 emissions
United Kingdom
Germany
France
United States
China
Spain
Italy
Algeria
Mexico
India
Indonesia
Australia
Argentina
South Africa
CO2
1 Mtn
100 000
10 000
1 000
100
0
1900
Global Temperature Anomaly
-0.2 ºC
www.gapminder.com


Yearly CO2 emissions
United Kingdom
Germany
United States
France
China
Spain
Italy
Iran
Japan
Algeria
Egypt
Mexico
Saudi Arabia
India
Venezuela
Nigeria
Indonesia
Brazil
Australia
Argentina
South Africa
CO2
1 Mtn
100 000
10 000
1 000
100
0
1970
Global Temperature Anomaly
0.0 ºC
www.gapminder.com


Yearly CO2 emissions
Russia
United Kingdom
Germany
United States
5.67Mt
France
China
7.03Mt
Spain
Italy
Iran
Japan
Algeria
Egypt
Mexico
Saudi Arabia
India
Venezuela
Nigeria
Indonesia
Brazil
Australia
Argentina
South Africa
CO2
1 Mtn
100 000
10 000
1 000
100
0
2008
Global Temperature Anomaly
0.5 ºC
www.gapminder.com

In the last century, Mean Global Temperature has increased by 0.7ºC
Exceeding 2ºC, will break the climate equilibrium, activating irreversible processes:

- warming feedback processes (less glace reflectivity, more water vapor)
- extreme climates
- big rains and droughts
- new wind regime
- ice melting
- increase sea level
- change of ocean currents
- oceans acidification
- changes in ecosystems and agriculture
- …

UE Solutions

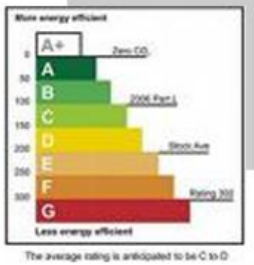
+20

+20

-20

EU strategy against CO2 emissions

Energy efficiency + **Renewable energies** + **Carbon Capture and Storage CCS**



CCS could deliver 19% of global emissions reductions by 2050 (IEA)

CO2 STORAGE-HUNTING

In February 2008 Spanish administration opened-up a geological storage-hunting inside the Compostilla Project (capture, transport and storage)

Overal objective:

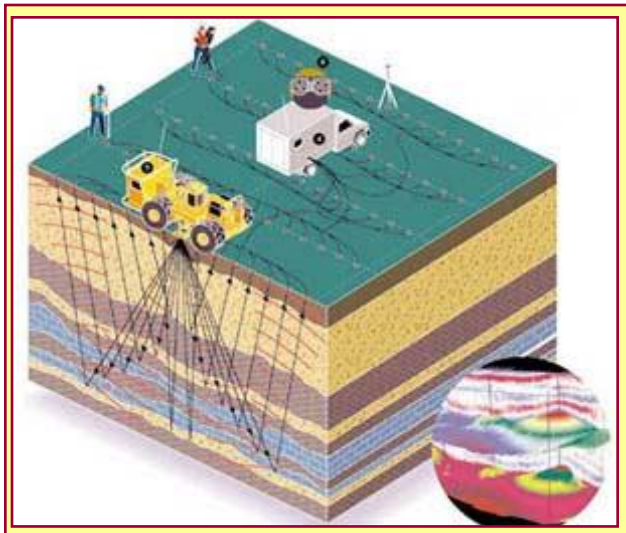
reduce CO2 industrial emissions (Power plant, cement plant, refineries, …)

Requirements:

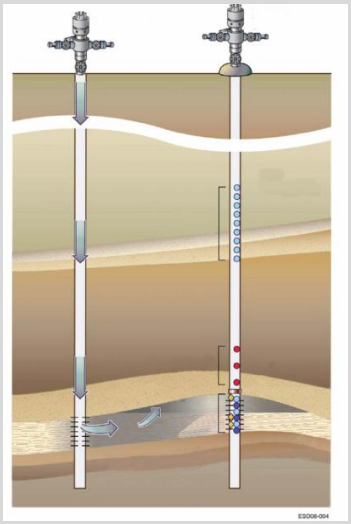
- **permanent CO_2 storage**
- **environment friendly**
- **economically viable**

Life-cycle of a Geological Storage of CO_2

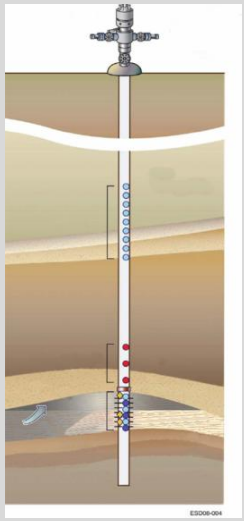
Pre-operational	Operational	Post-operational	Transfer to state



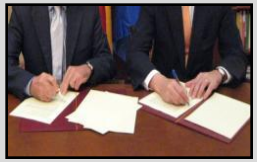
Site selection and characterisation



Injection and monitoring wells



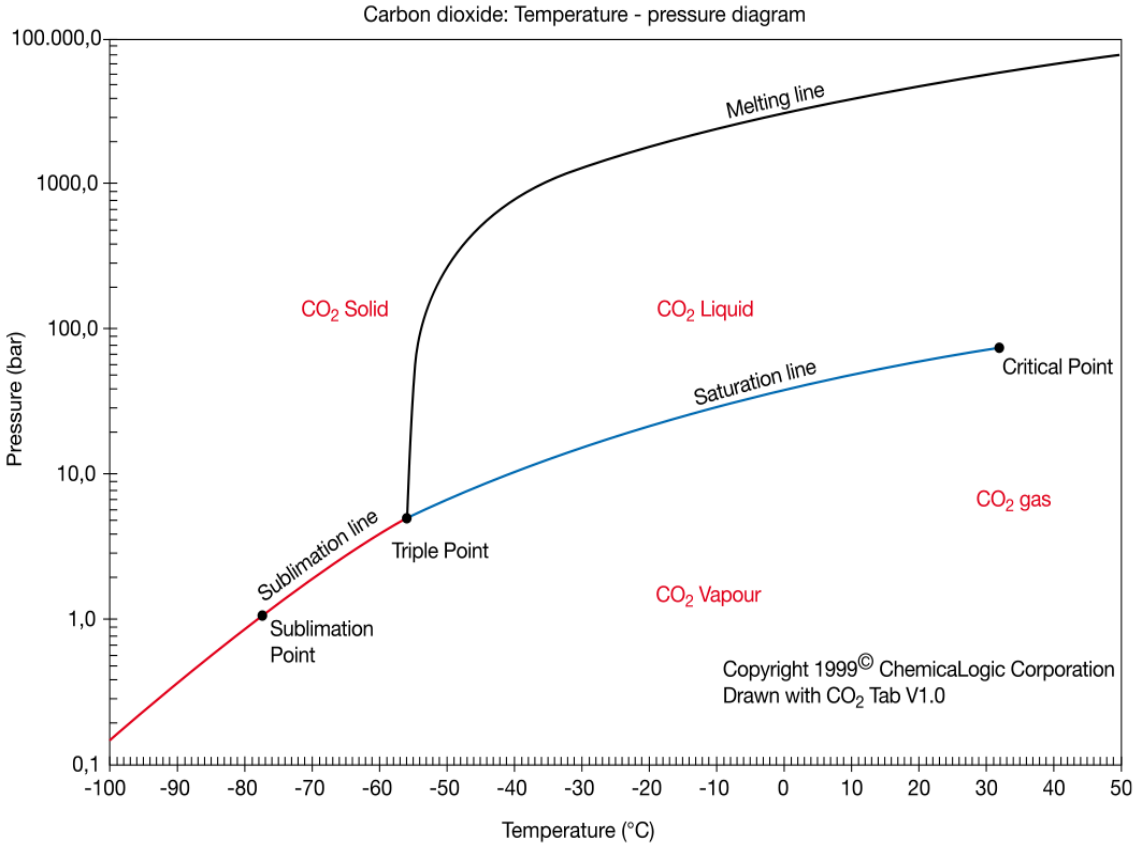
Monitoring CO2

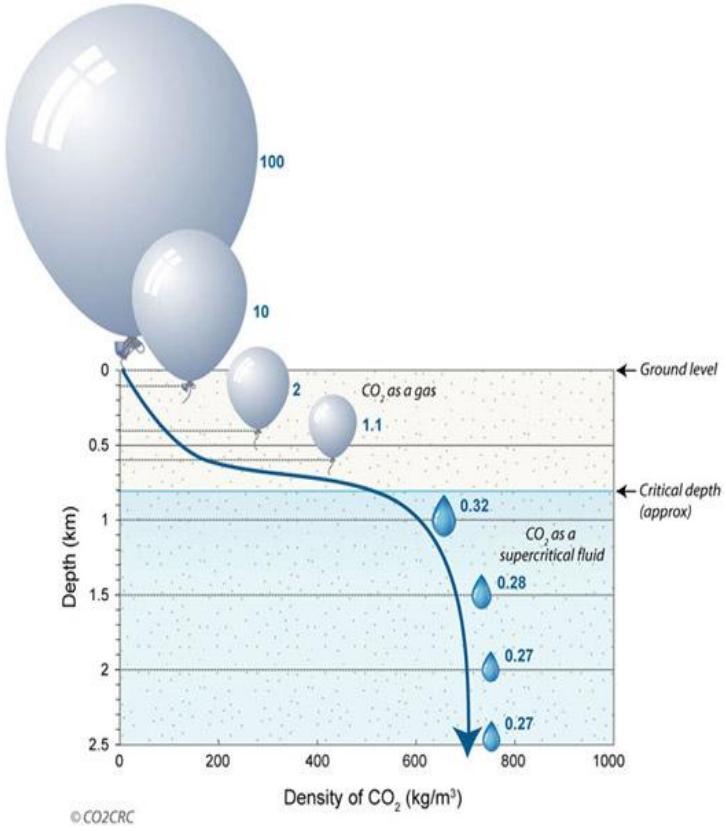


Transfer of responsibility to the State

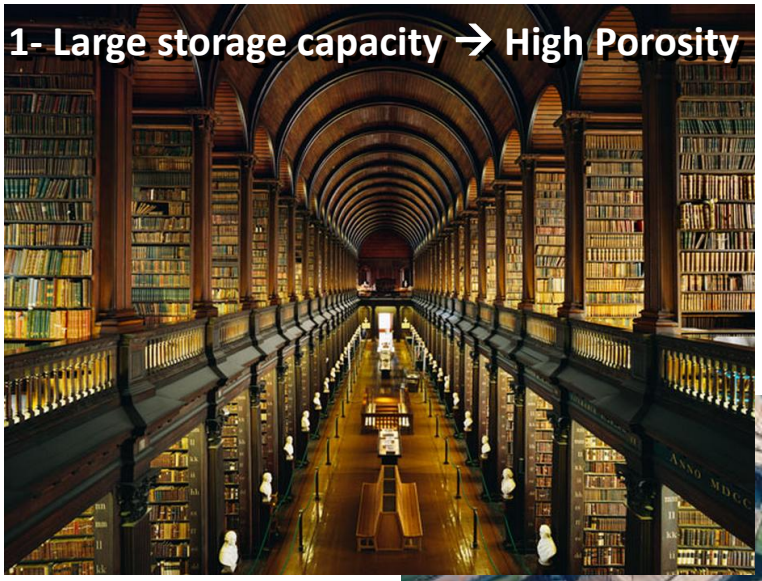
Identification → Storing → Closing → Transfer

CO2 storage properties



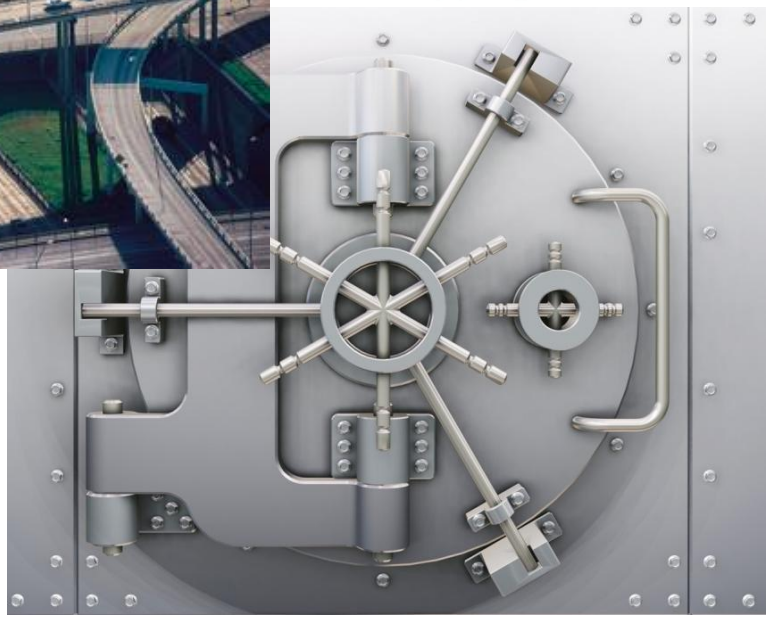


Geological CO2 storage requirements



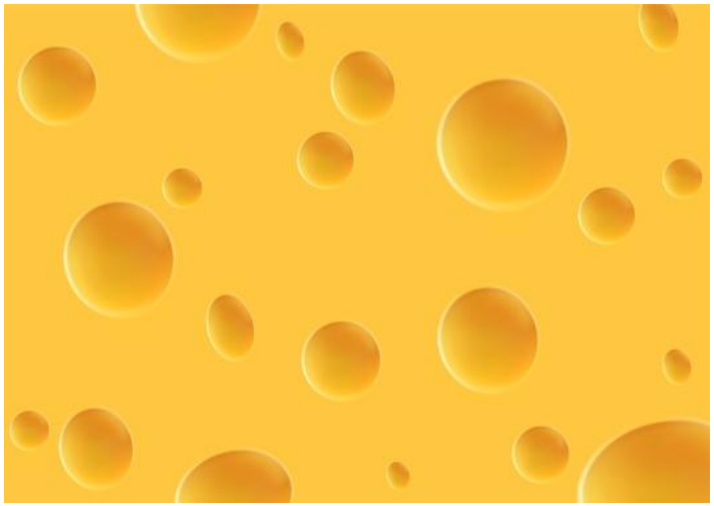
2- Good fluid conductivity →
High permeability

3- Good confinement →
Trapping mechanism



Porosity & permeability

seal



High porosity & low permeability: clay, basalt

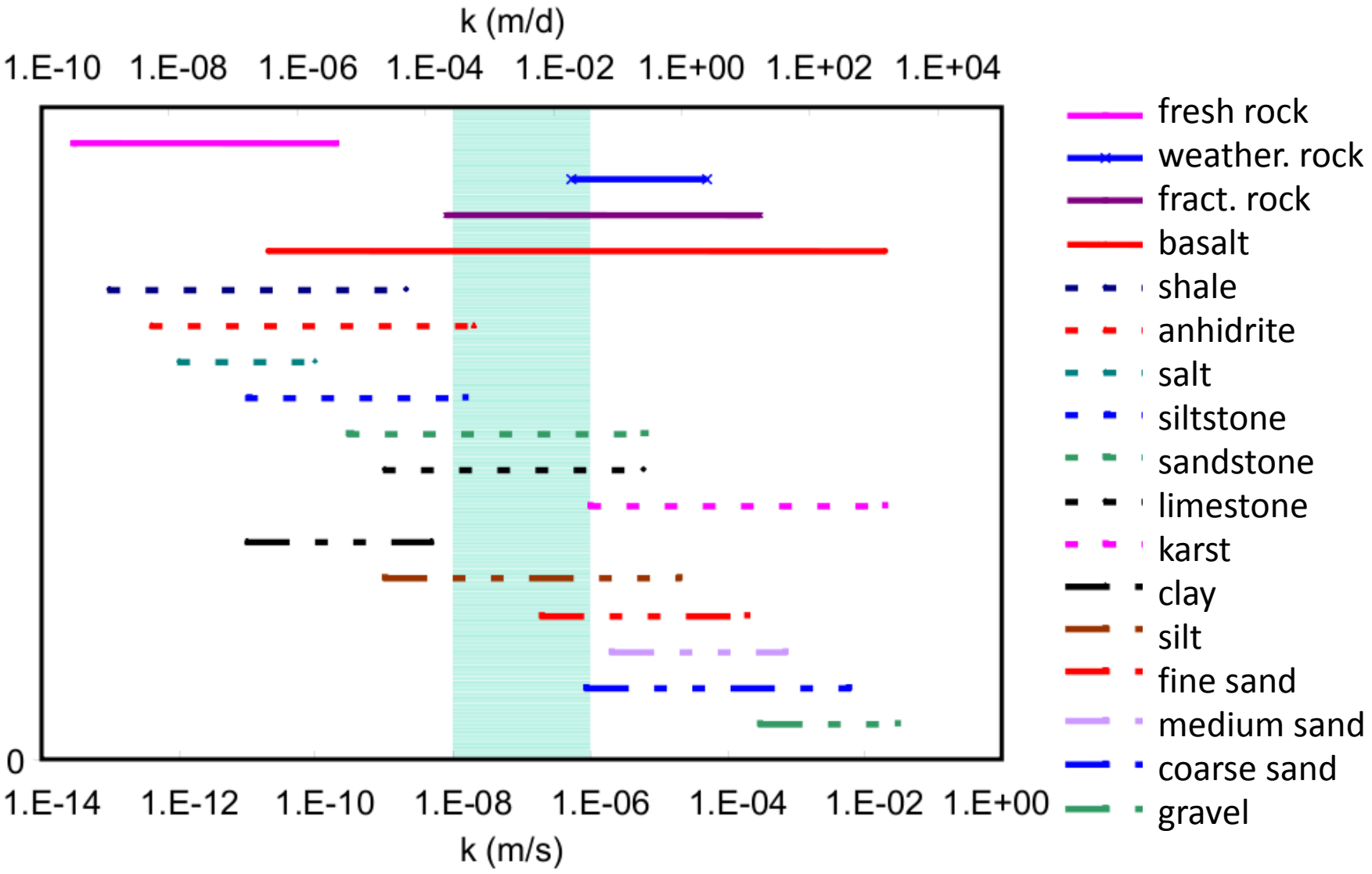
Low porosity & low permeability: fresh rock, salt

reservoir

High porosity & high permeability: sand

High secondaty porosity & high permeability: fracture rock, karst.

Permeabilty



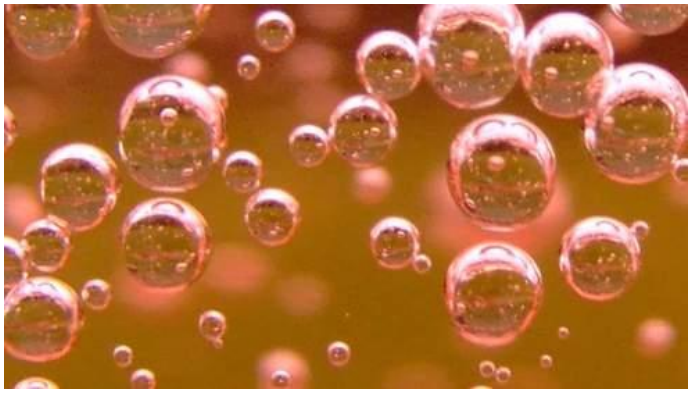
Trapping mechanism

Structural

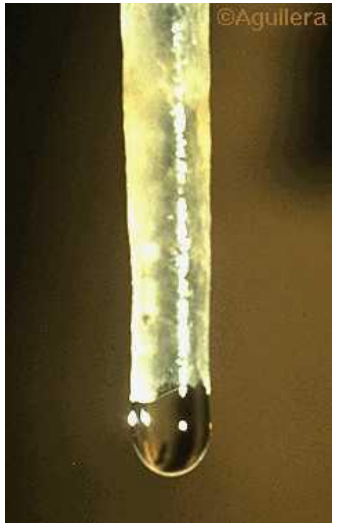
Hydrodinamic (m/y)

Residual (Wetting)

Solubility



Mineral

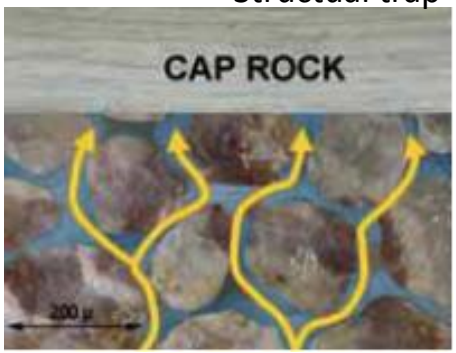


CO_2 behavior inside the storage rock

4 Trapping Mechanism

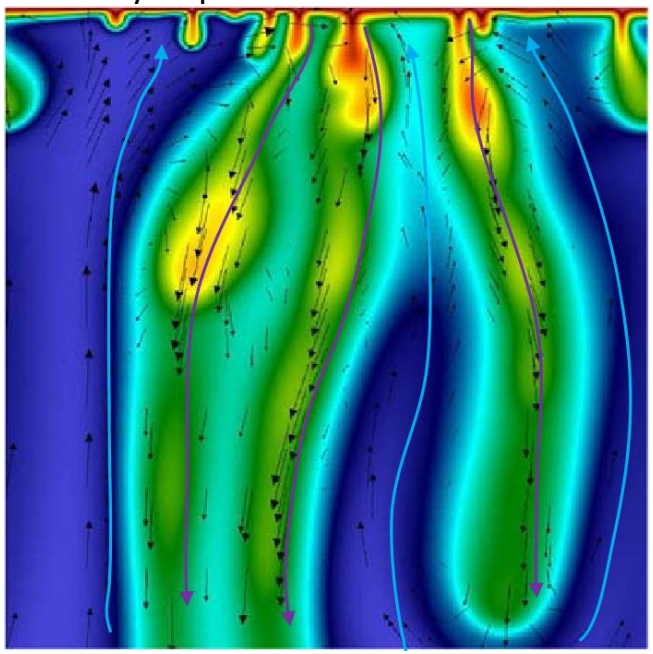
Structual	**trap by an impermeable seal, immediate action but dependent on seal stability**
Residual	**capilar trapping into rock pores, immediate action but dependent on seal stability**
Solubility	**dissolves in the aquifer increasing water density and sinking, medium term but low dependent on seal stability**
Mineral	**precipitating as new chemical compounds, long term but permanent**

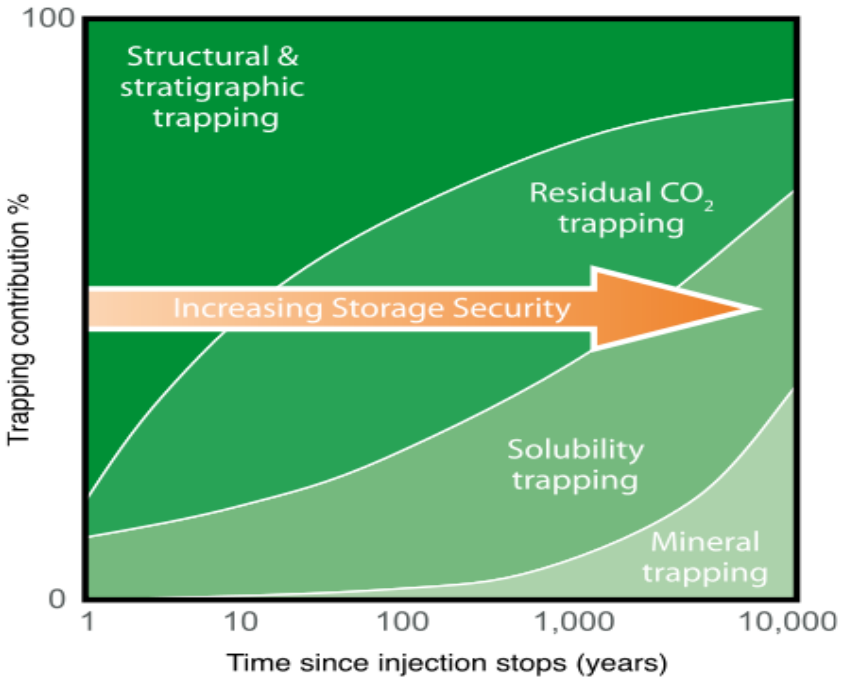
Structual trap



Residual trap

Solubility trap





Rocks & storage quality

	Permeability	Trapping
Igneous	Secondary = tectonic and weathering	Structural – poor under complex tectonics Residual – poor in fractures Mineral – low in acidic high in mafic
Metamorphic	Secondary = tectonic and weathering	Structural – poor under complex tectonics Residual – poor in fractures Mineral – low in siliceous high in carbonates
Sedimentary	Primary & secondary	Structural – very frequent (clay or evaporites layers) Residual – high in micropores Mineral – low in siliceous high in carbonates

Reservoir-Seal system

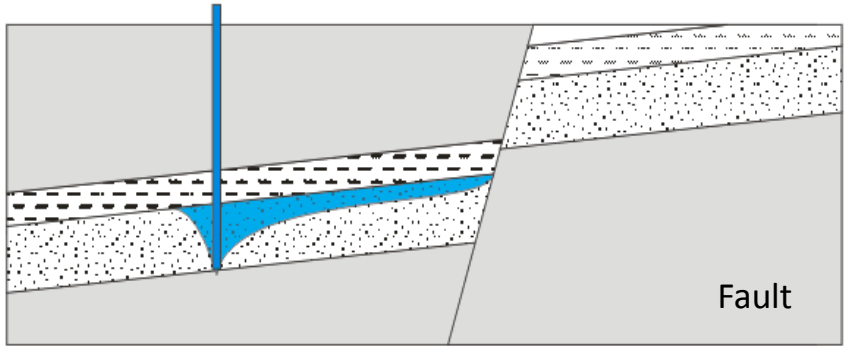
Seal = impervious and plastic (warranting integrity)

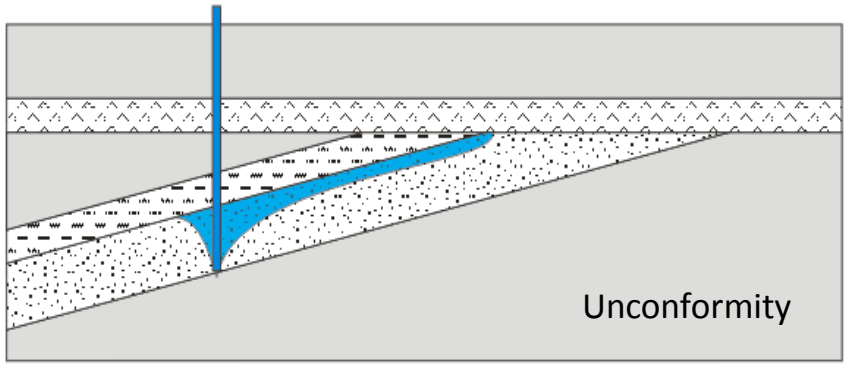
Reservoir = high porosity and permeability

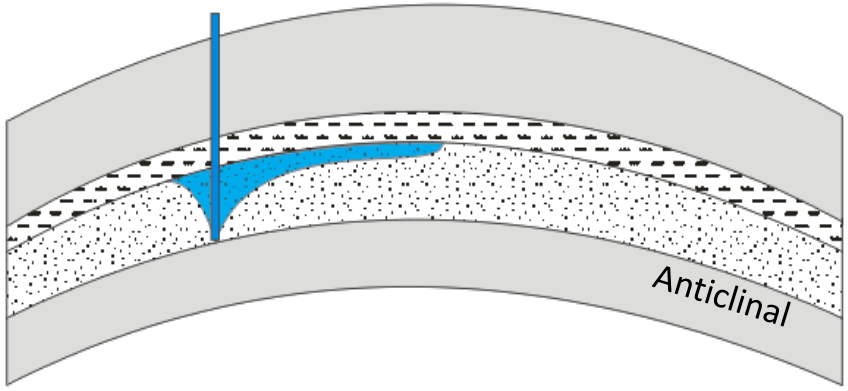
Geological structures for CO2 storage

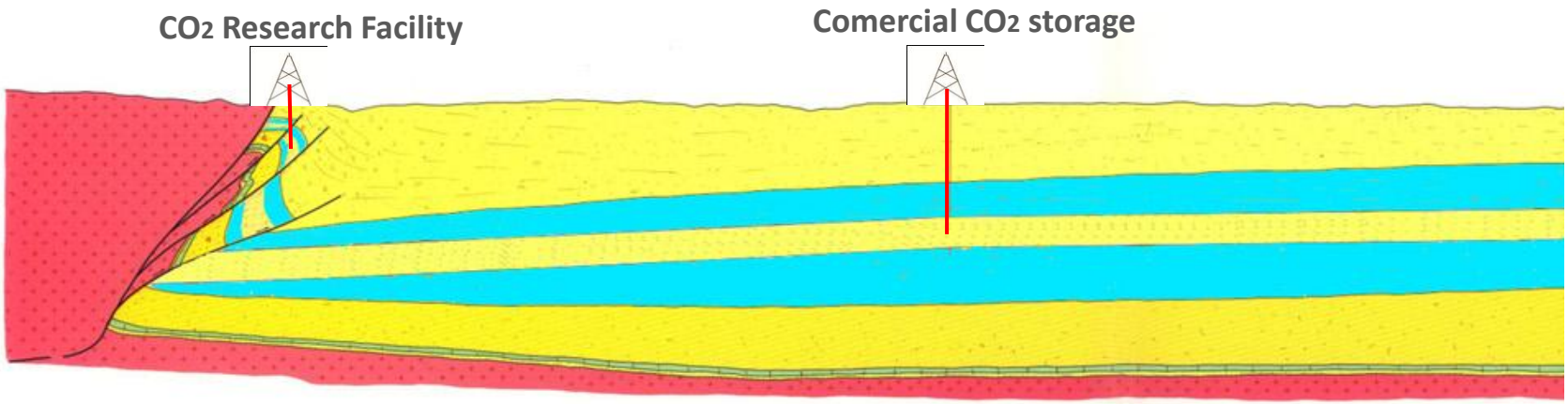
Seal: impervious, integrity

Reservoir: high porosity, high permeability







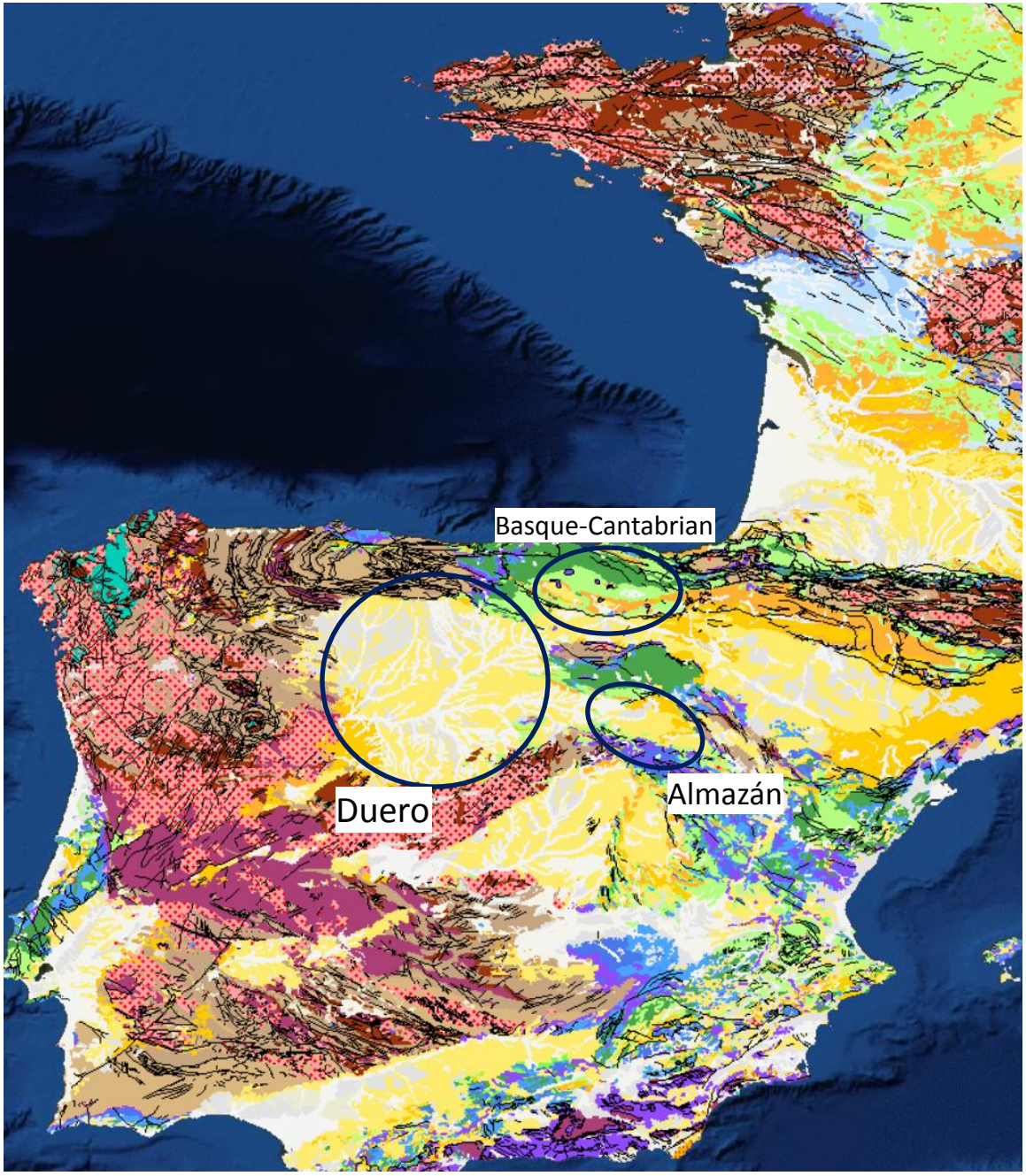


	CO2 Research Facility	Comercial CO2 storage
Objectives	• Demonstrate long term feasibility-security for geological CO2 storage • Develop monitoring technologies for CO2 tracking inside the reservoir • Develop early detection technologies for environmental impact • Improve geological CO2 storage costs until economical viability	• Industrial CO2 storage • Commercial profit • Storage guaranteed
Capacity	Limited to < 100 000 t	Hundreds Mt
Requirements	• > 800 m deep • Isolate salty aquifer • Thick seal • Laboratory size (tractable)	• > 800 m deep • Isolate salty aquifer • Thick seal • The larger the better

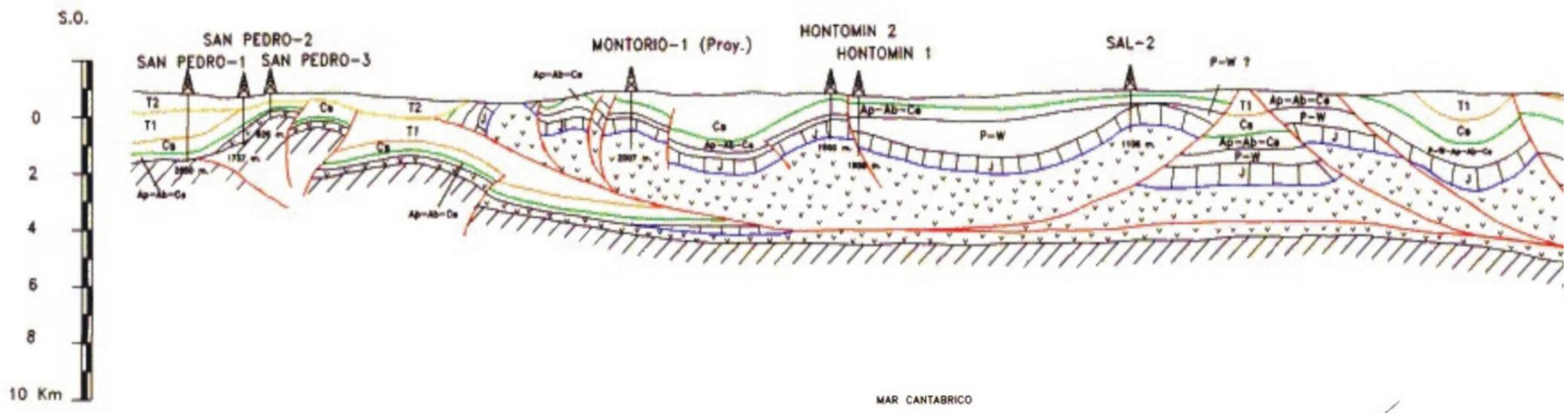
Surveyed Basins for the Research Facility location:

From
- Geological mapping
- Hidrogeologic & hidrochemic data
- Geological profile
- Stratigraphic & sedimentologic surveys
- Seismic data
- Wells and logs data

More than 46 location have been studied in Basque-Cantabrian basin, Duero Basin and Almazán basin.

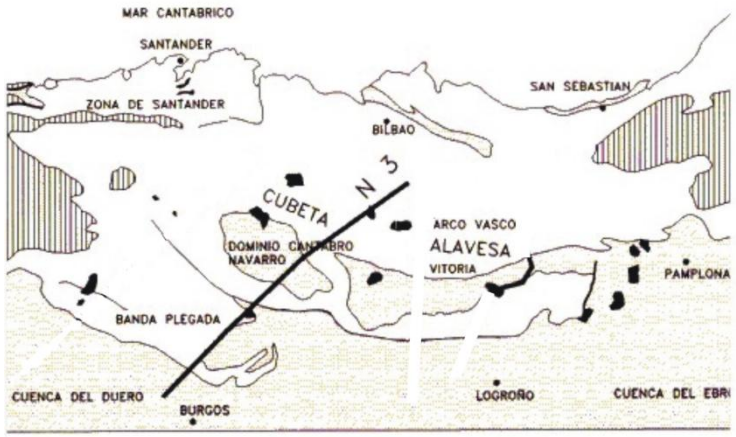


Basque-Cantabrian basin



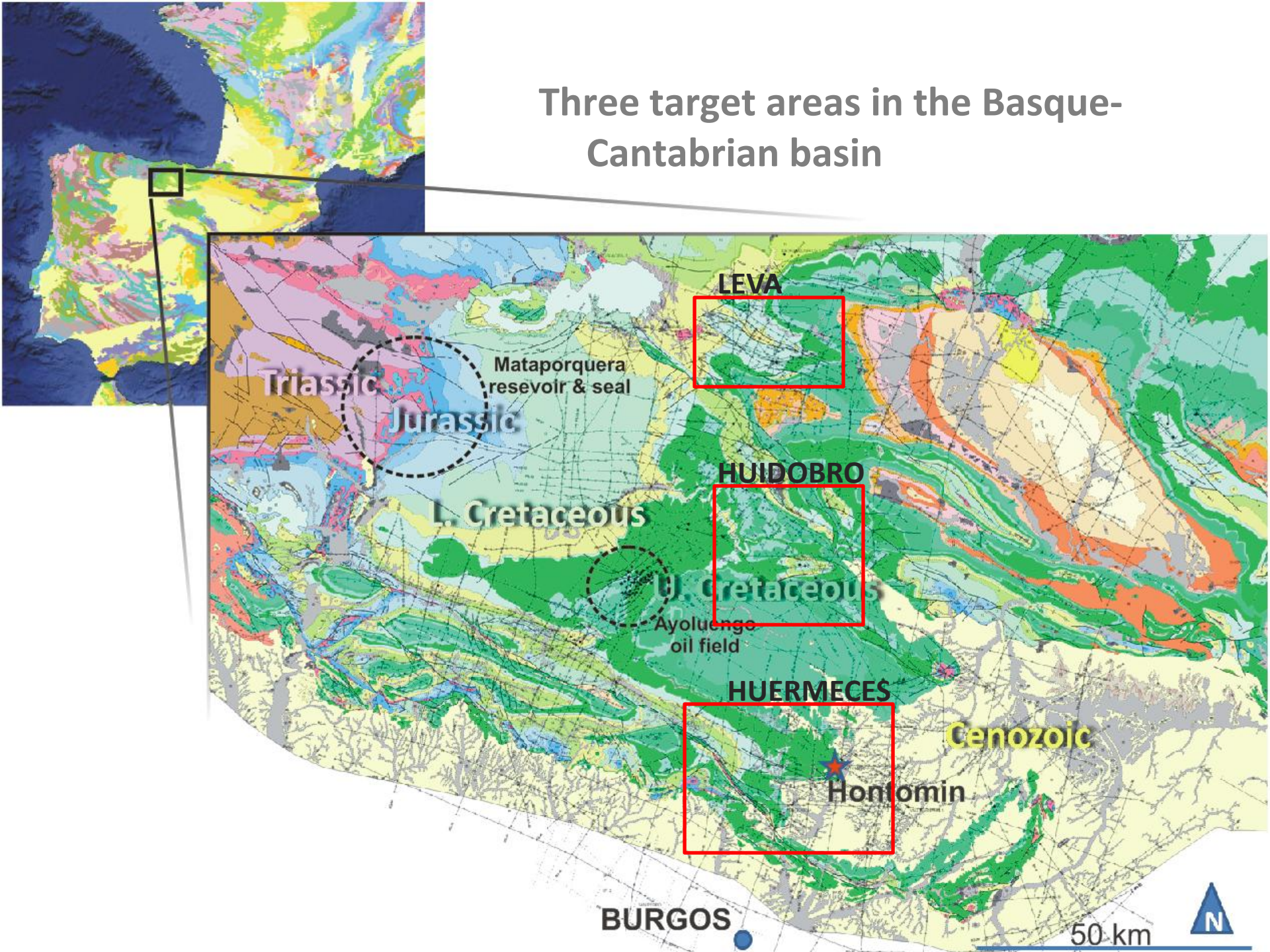
Selection criteria:

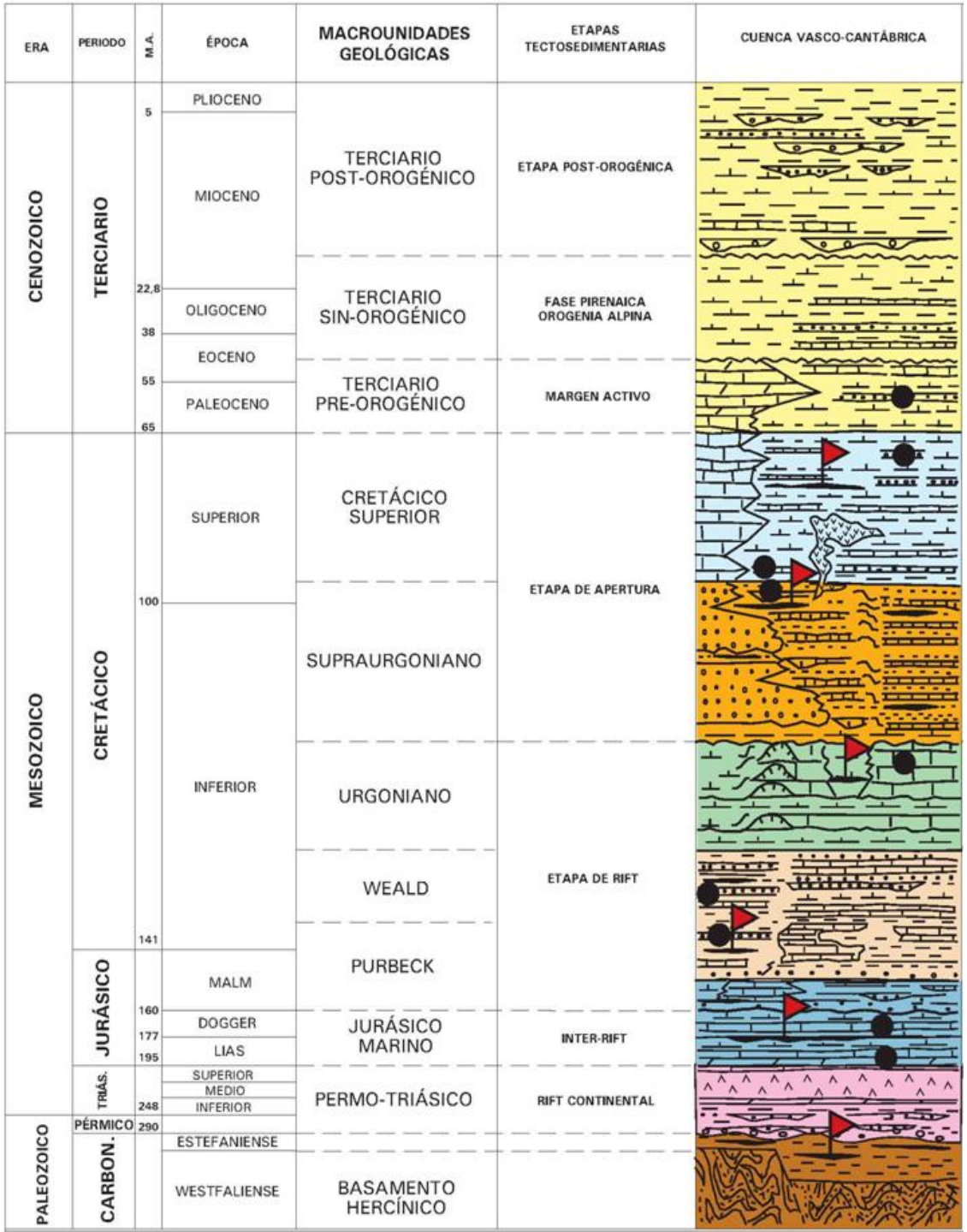
- Good geological knowledge
- Good estructural knowledge
- Existing oil traps
- Low sismicity
- Easy accesibility



Gessal

Three target areas in the Basque-Cantabrian basin





Standard stratigraphy in Basque-Cantabrian basin

Reservoir

Seal

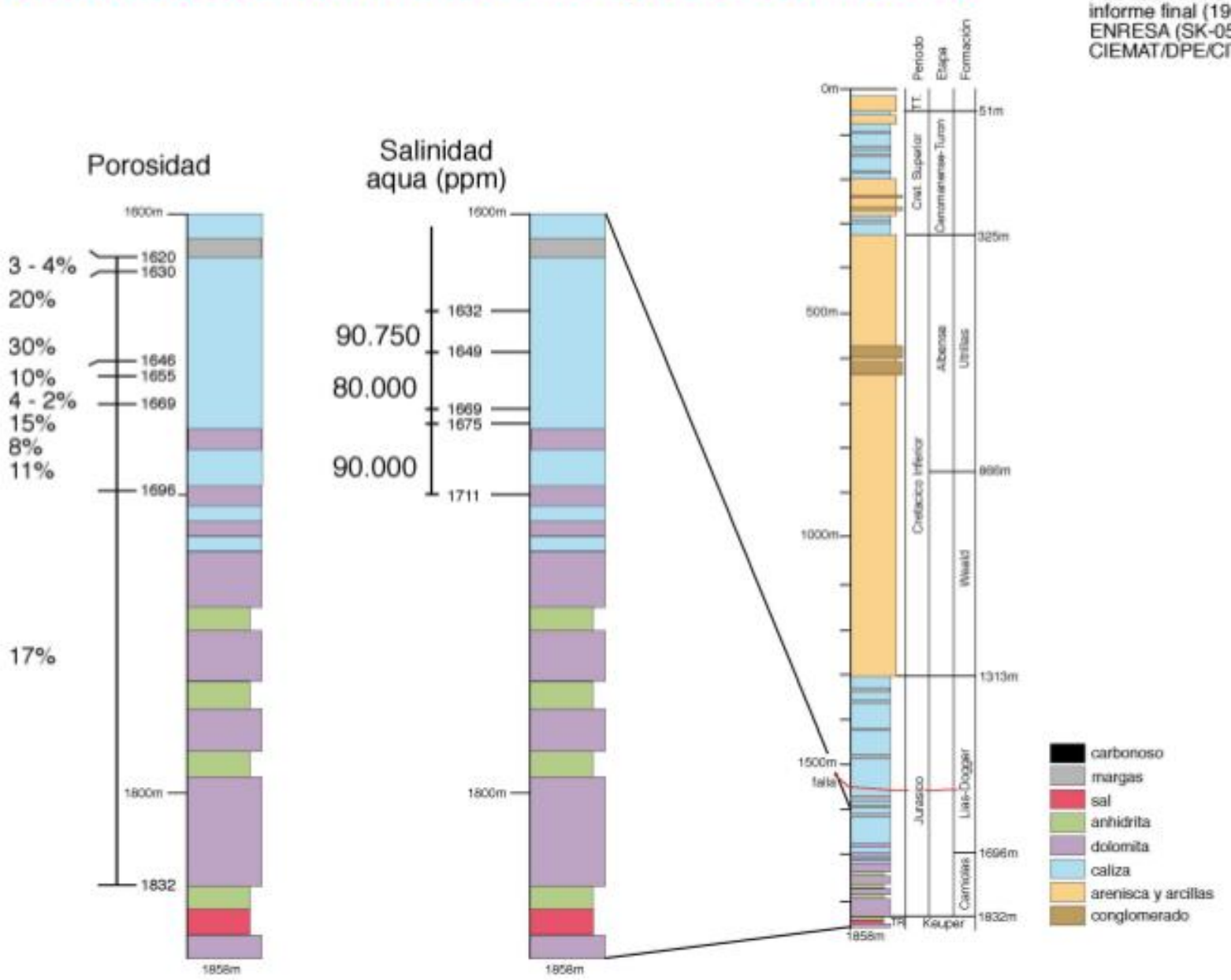
Target level:

- >1000
- Marl & limestone
- Salty aquifer
- Oil + brine

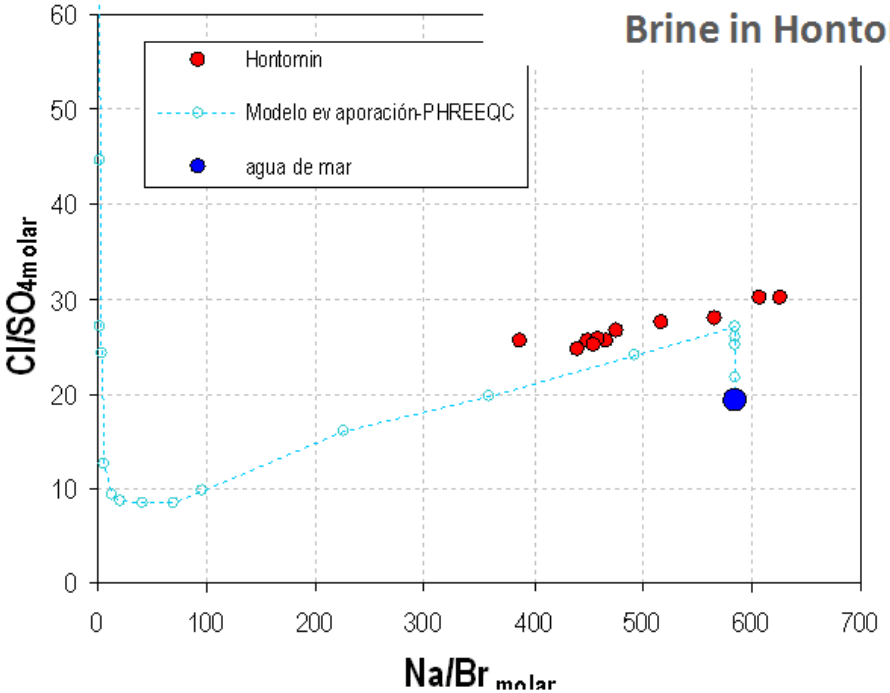
SHESA

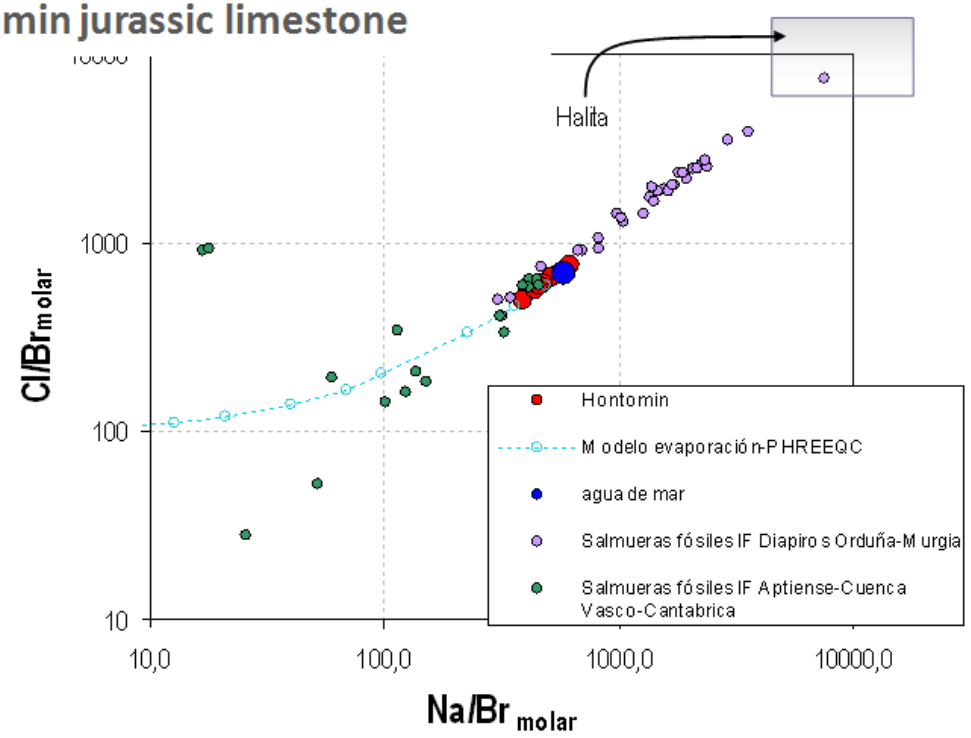
Datos del sondeo Hontomín 1, HUERMECES

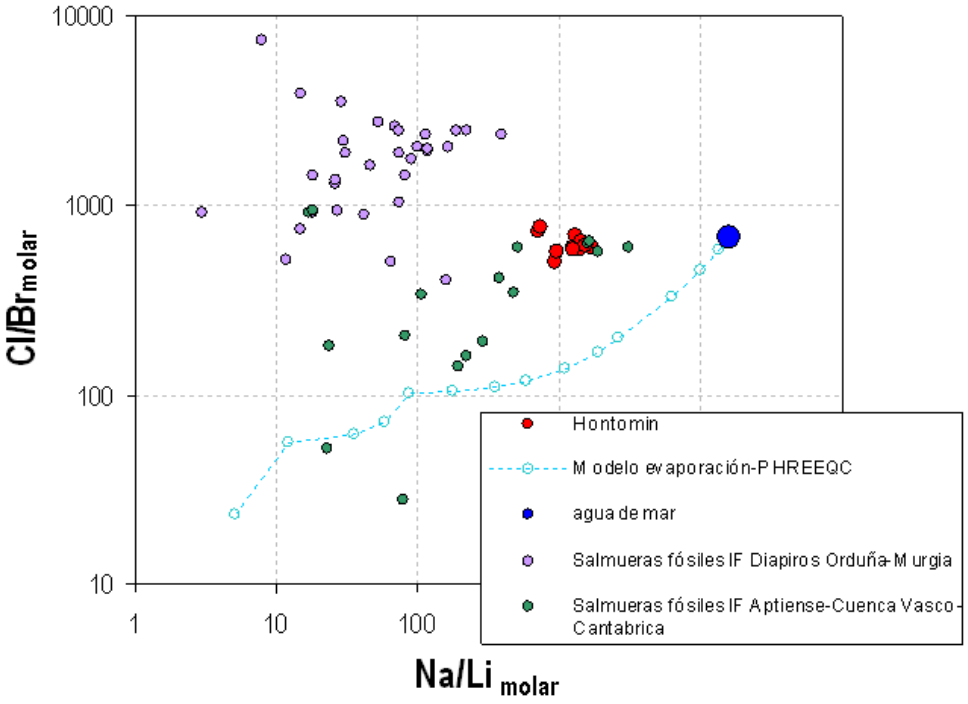
Fuentes: Am. Oversea Pet.(Spain) informe final (1966)
ENRESA (SK-05)
CIEMAT/DPE/CITA/AG (Mayo 2007)

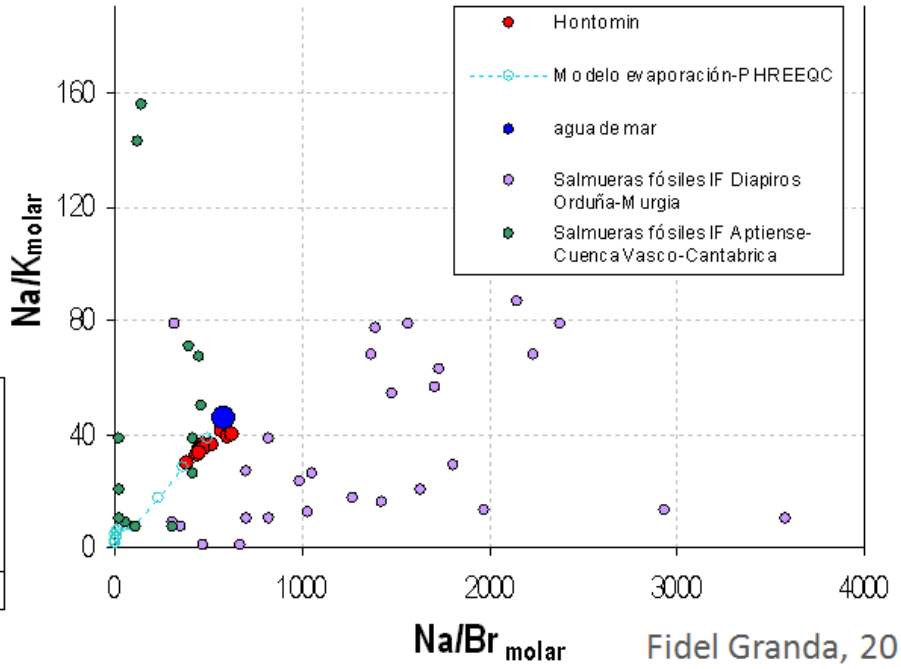


Brine in Hontomin jurassic limestone



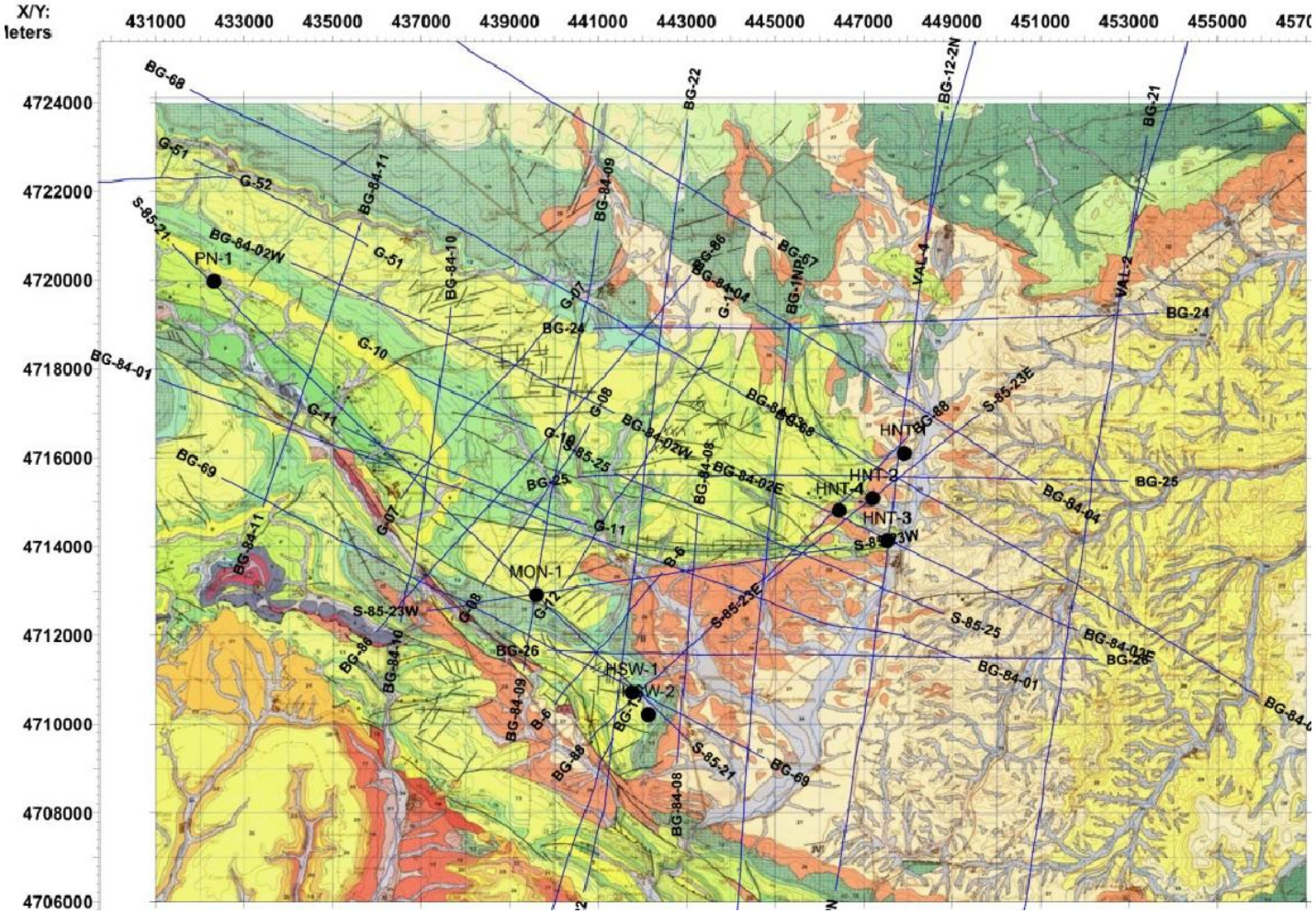






Fidel Granda, 2011

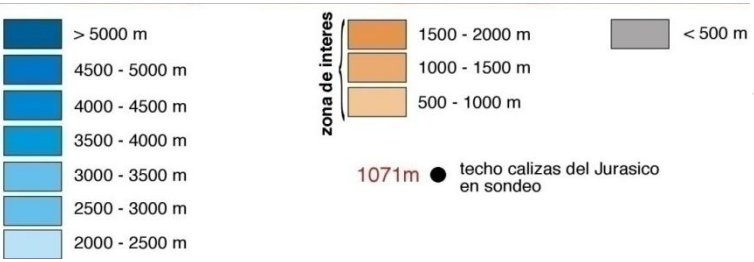
Huermeces



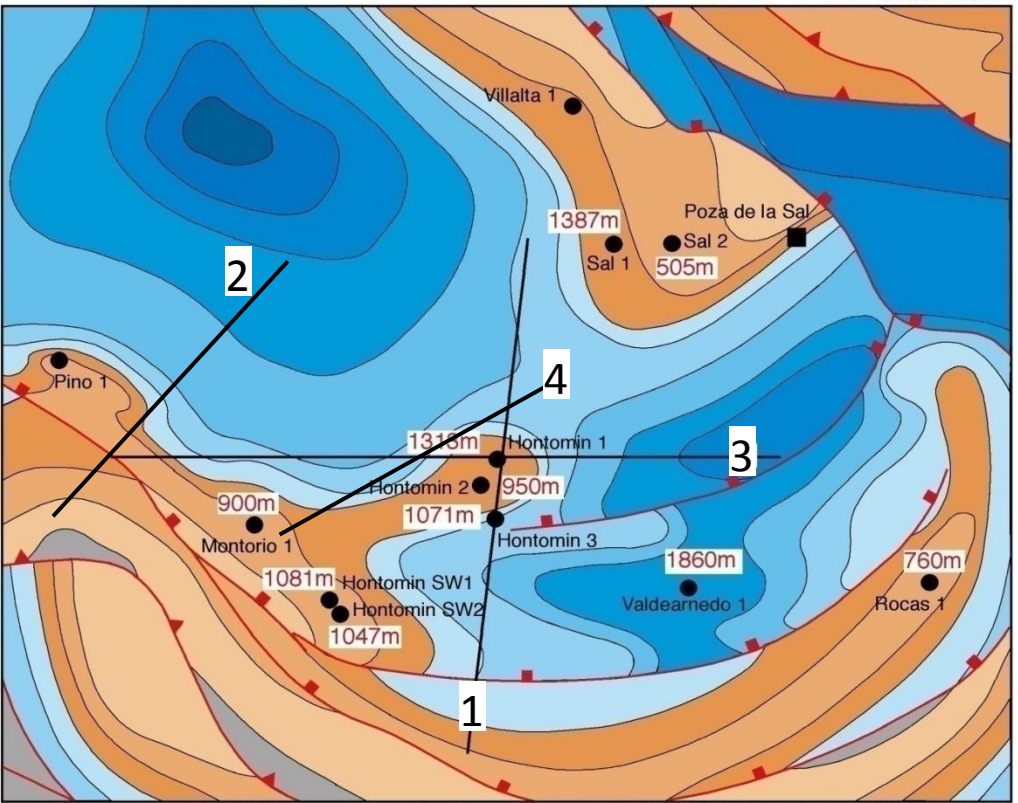
Selection criteria

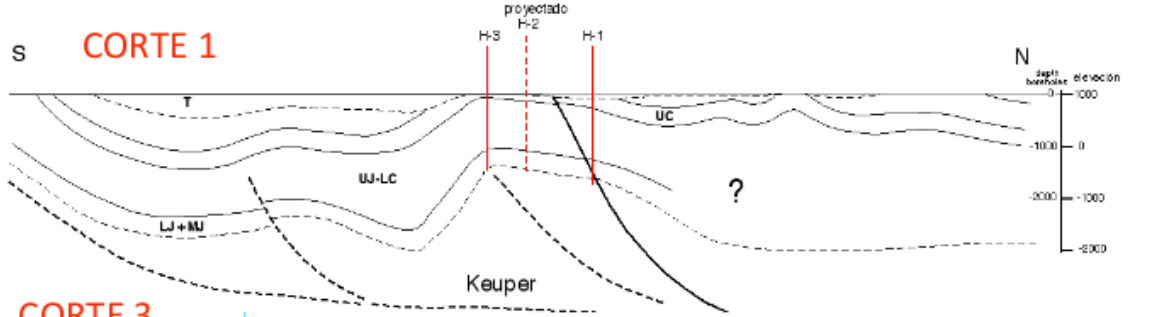
- Good preexisting seismic data
- Preexisting oil wells
- Good reservoir: jurasic dolomites ~ 100m thick, high porosity
- Seal: jurasic marls, ~ 200m thick
- Formation salty water guarrantee sealing
- Good depth, ~ 1500m

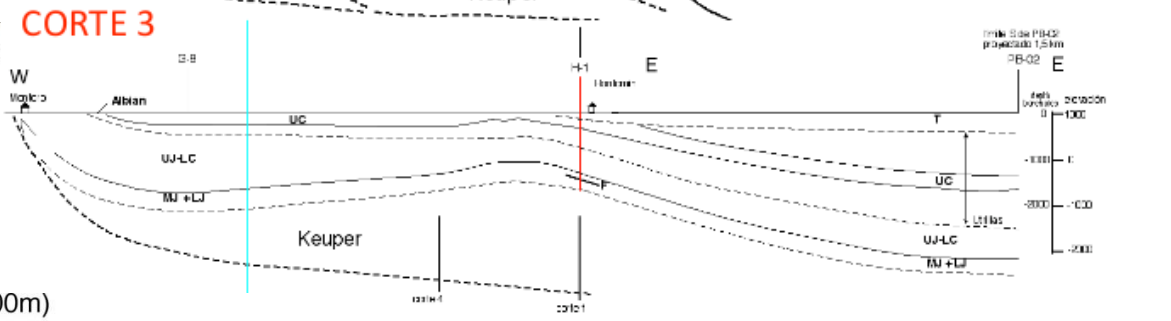
Huermeces

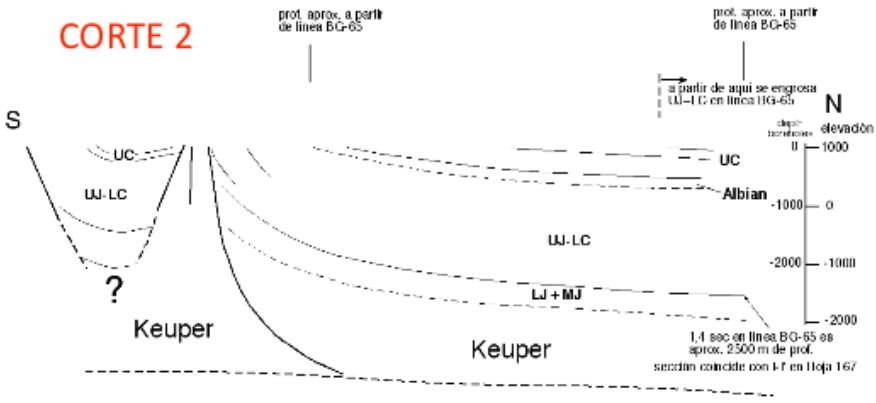


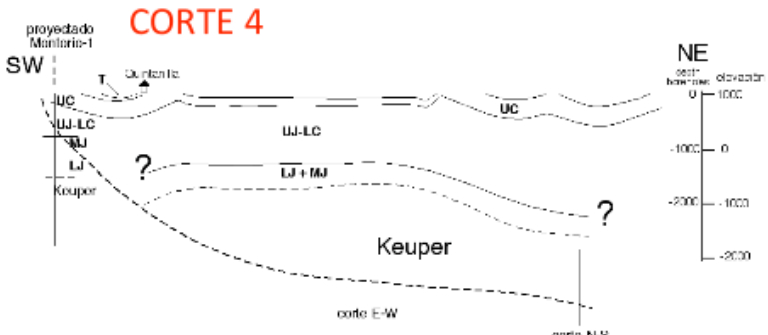
Isobatas del techo del Triasico (DATUM - 1000m)



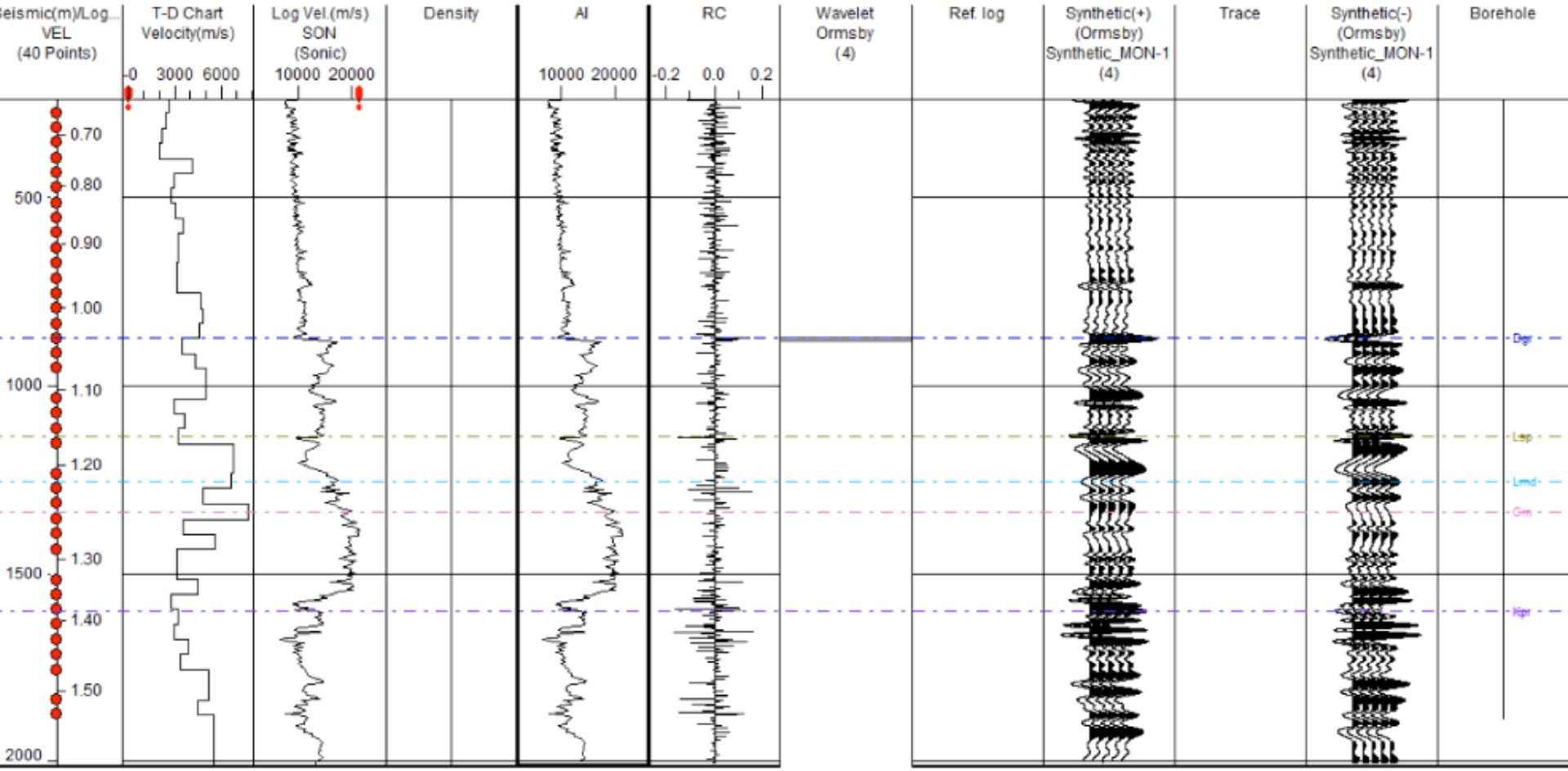


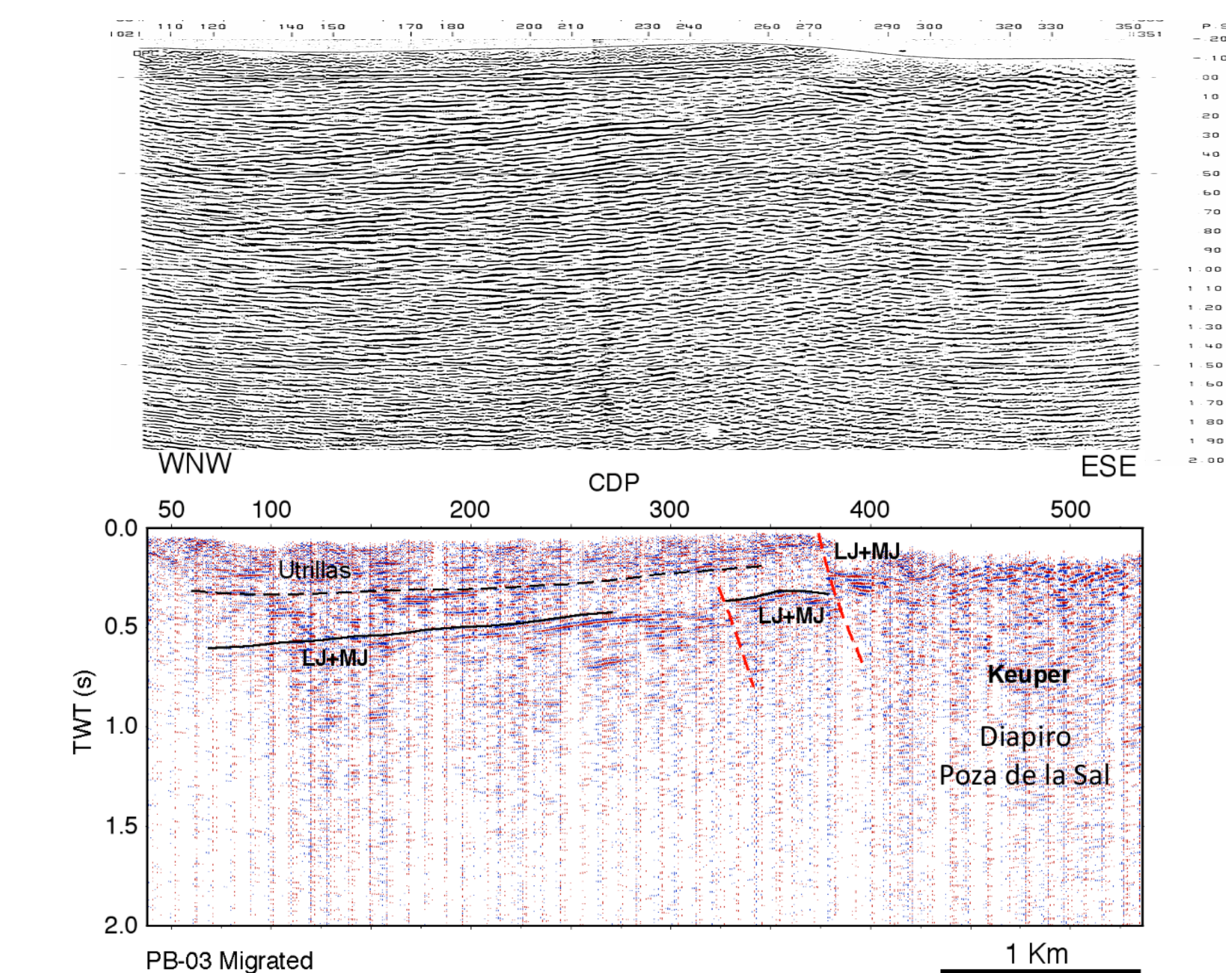




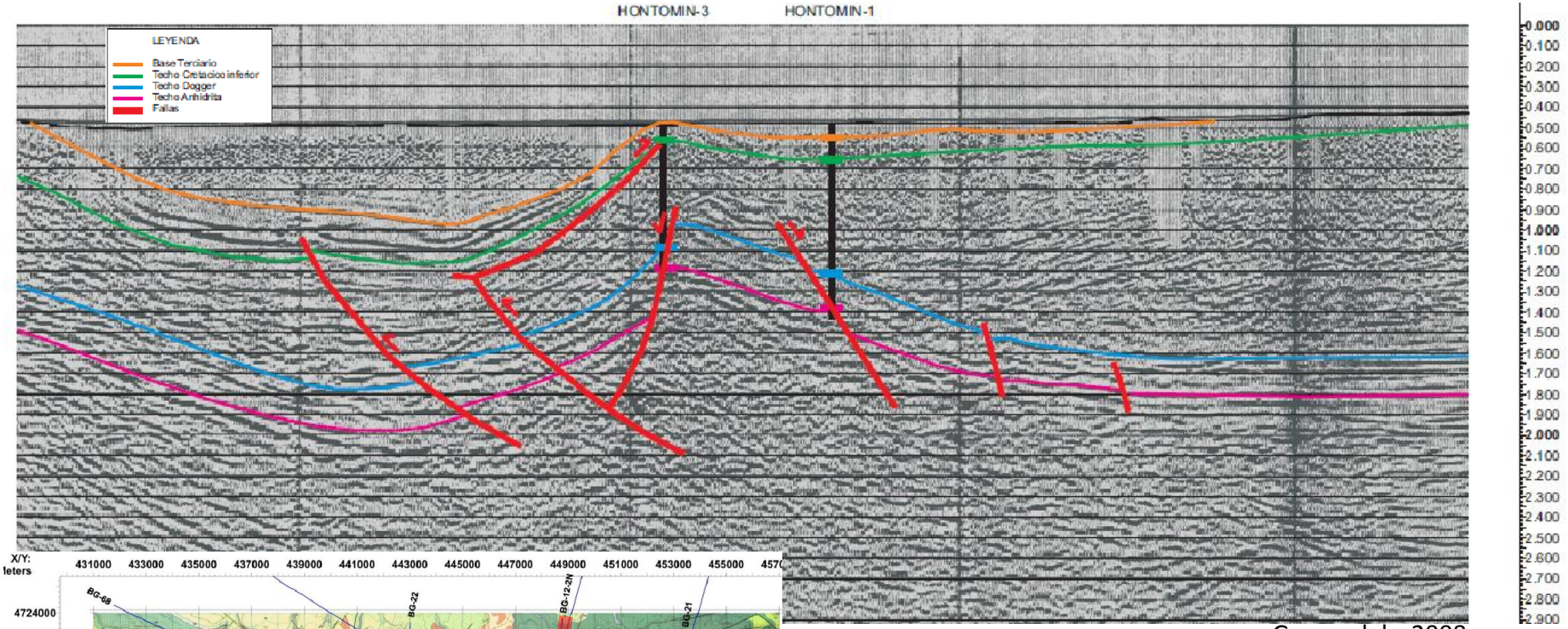


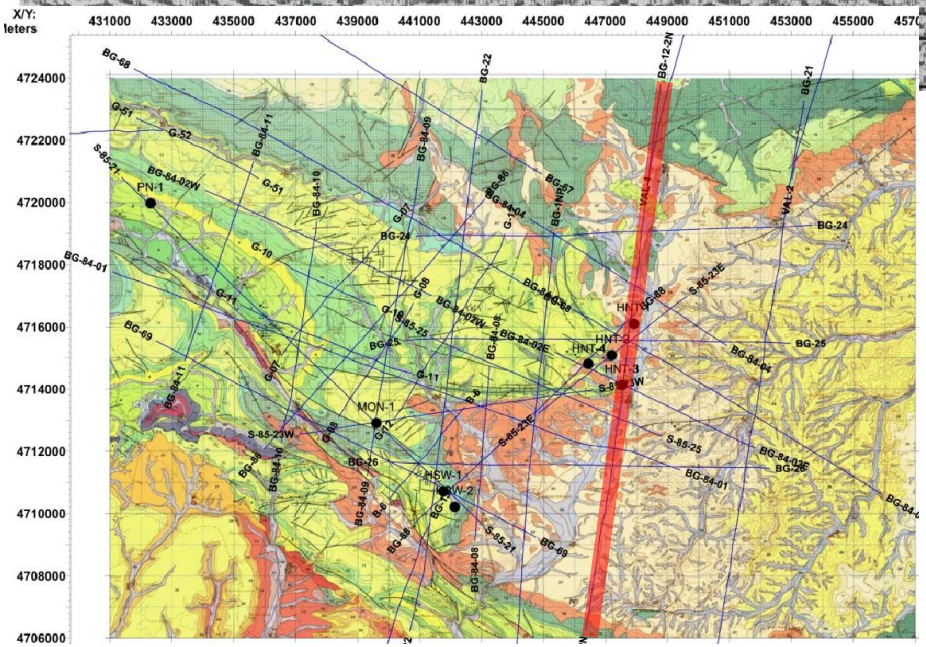
Montorio-1 (ejemplo de sismograma sintético)




WNW
ESE
CDP
50
100
200
300
400
500
0.0
0.5
1.0
1.5
2.0
TWT (s)
Utrillas
LJ+MJ
LJ+MJ
LJ+MJ
Keuper
Diapiro
Poza de la Sal
PB-03 Migrated
1 Km

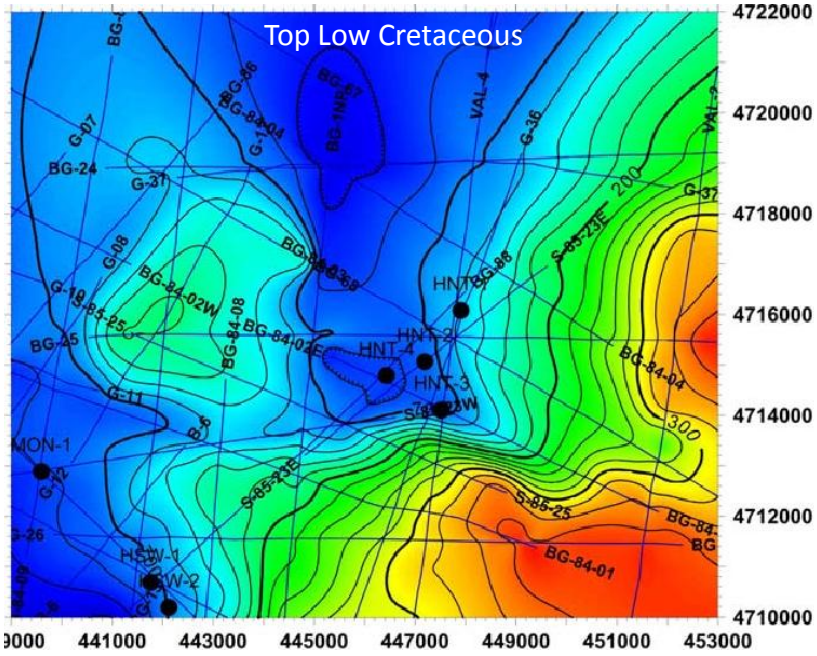
Hontomín

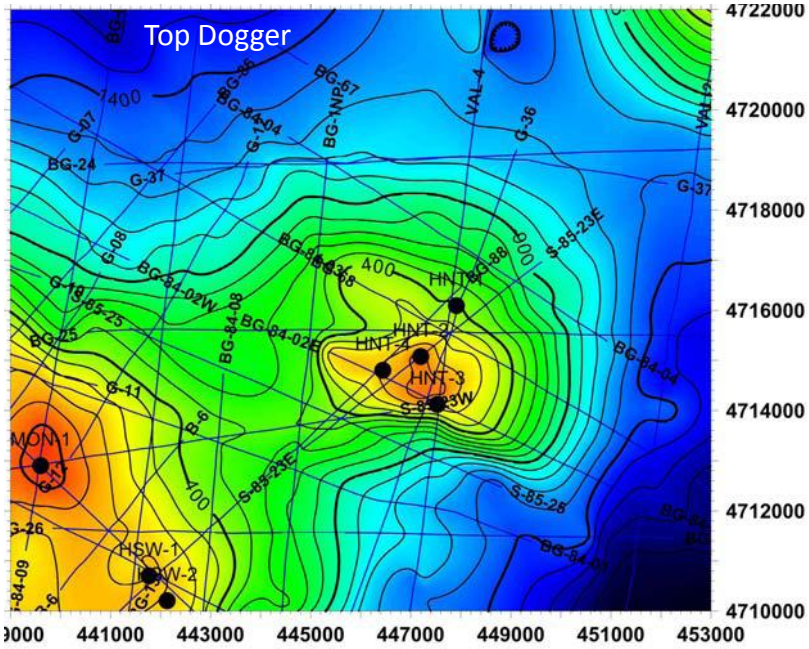


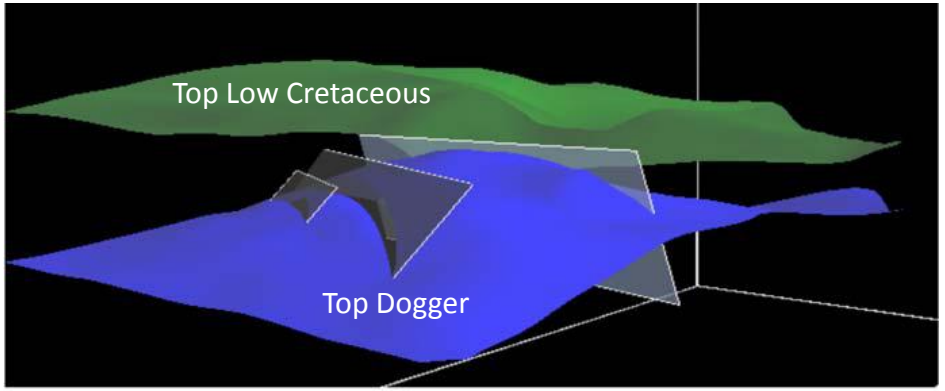


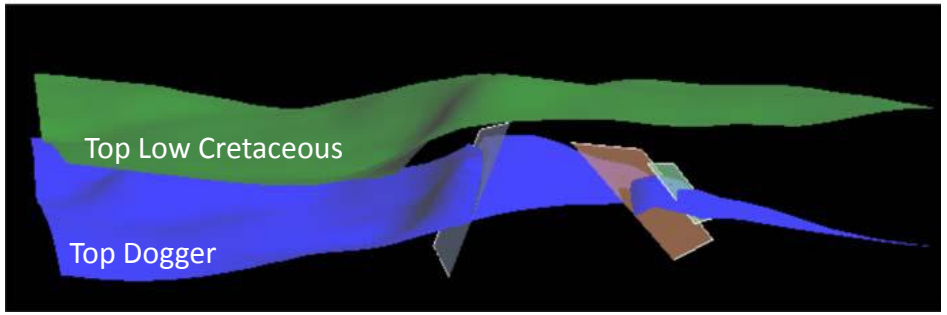
Geomodels, 2008

Jurassic small dome-like structure near Hontomín town shows ideal for the CO_2 research facilities.





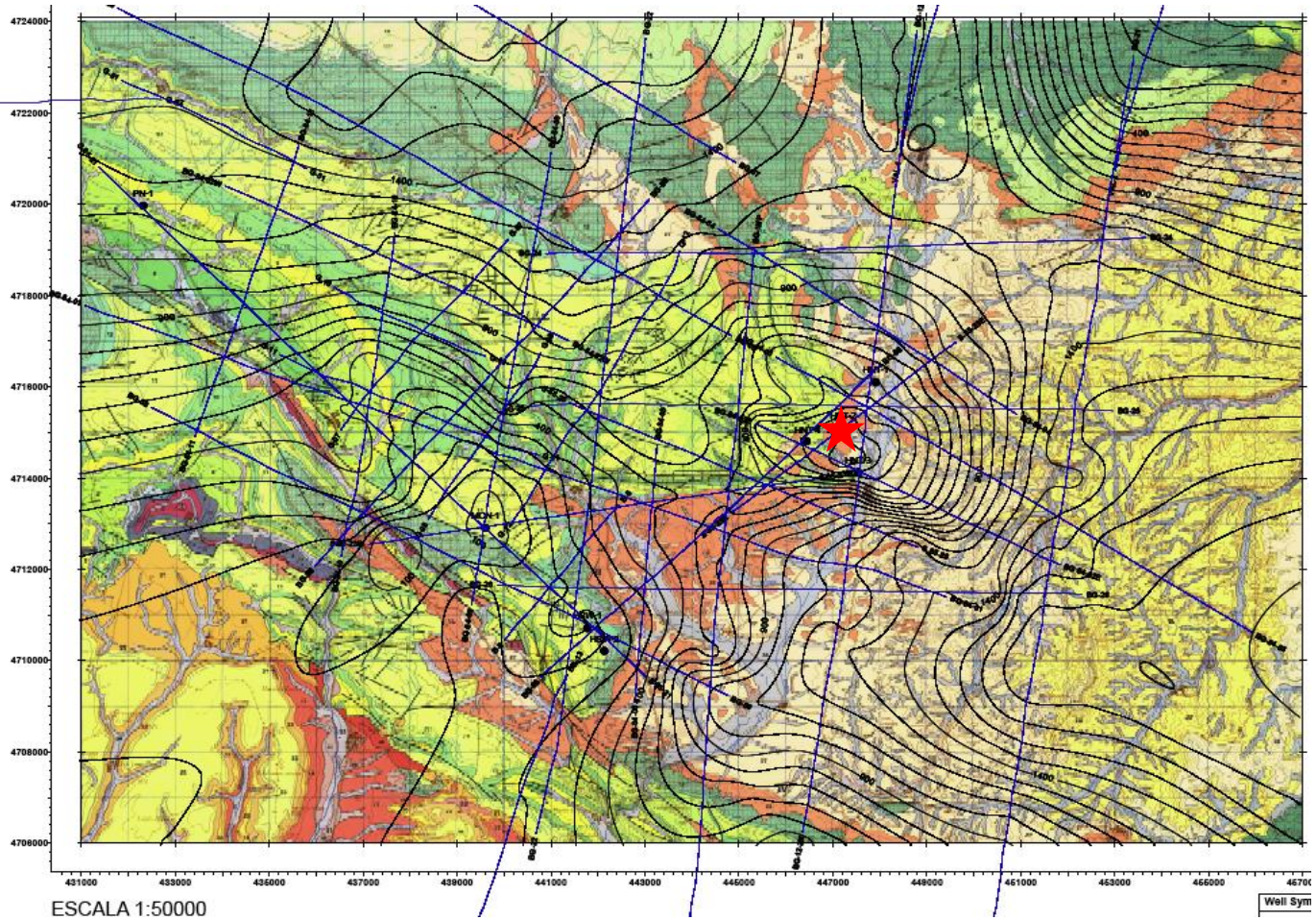




UB-Geomodels 2009

During the Alpine compression small-scale inversion structures detached along the Triassic evaporites. In Hontomín, an elongated dome at the Jurassic level bounded by several faults defining a horst of about 5 km^2.

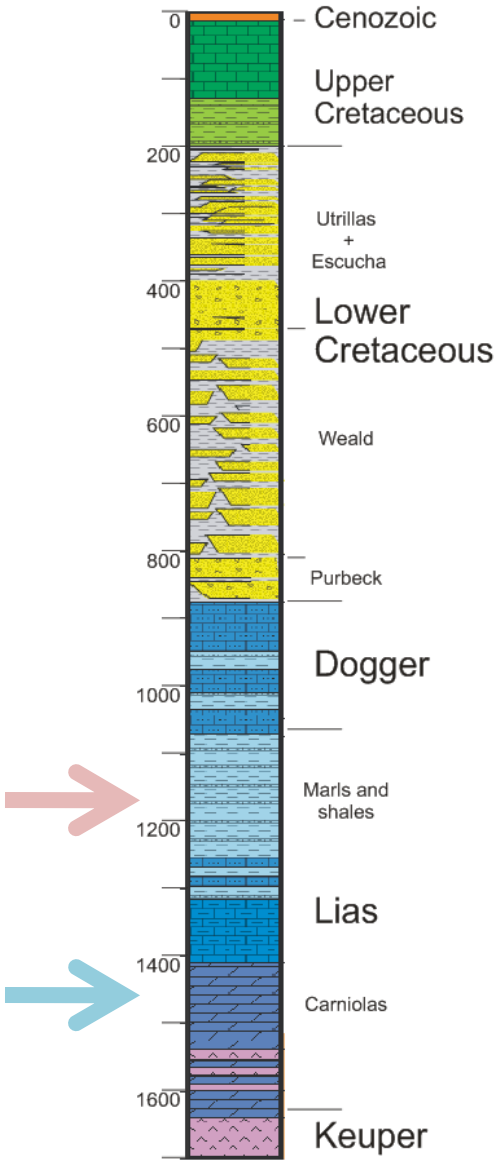
During Lower Cretaceous a progressive unconformity is developed, covering the dome structure and some related faults. Field and laboratory studies show that these faults are sealed.



The target reservoir is a saline aquifer set in Early Jurassic (Lias) carbonates, around 150 m thick and 1500m deep. The structure is dome-like structure folds during Cretaceous. The sequence is strongly dolomitized and is highly porous in the basal “Carniolas Unit”, therefore envisaged as injection level.

The main seal is formed by more than 200 m of interlayered Early to Middle Jurassic marlstones and marly limestones.

Hontomín stratigraphy



TDP Characterization 2009-2011

Geological and structural mapping
Petrophysical studies
3D seismics
Electromagnetic survey 3D
High resolution gravimetry
3D geological model

Structural studies

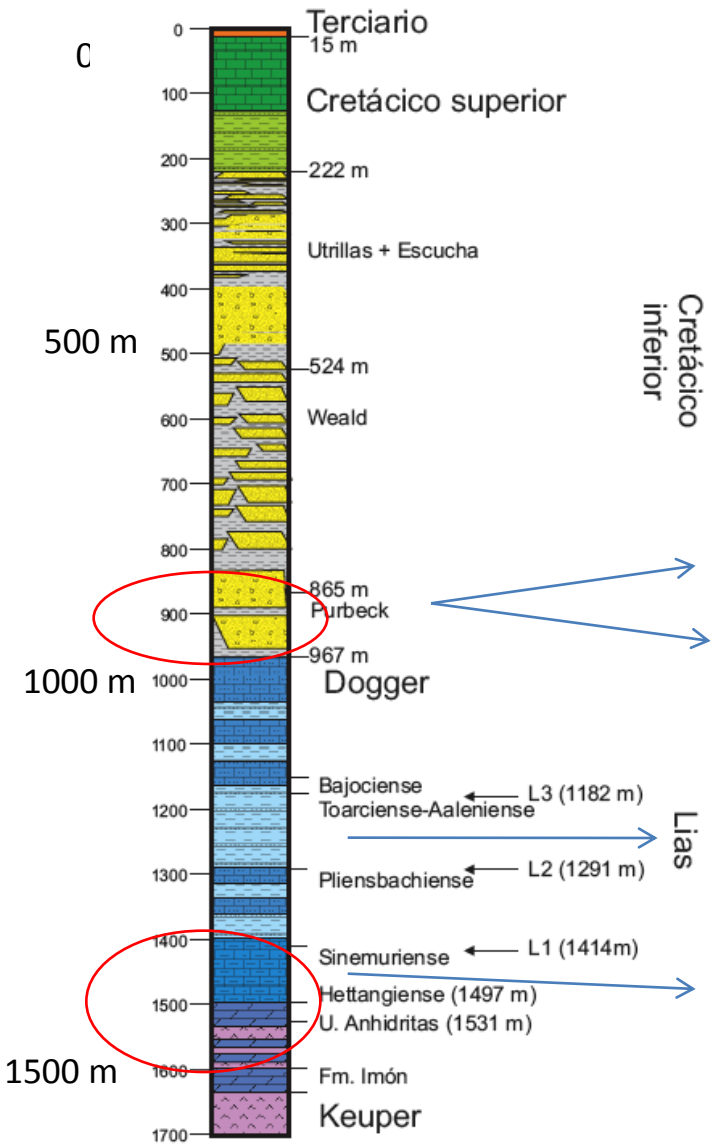
Hydrogeology and hydrochemistry
Natural gas emissions
Seismicity
Geothermal studies
Surface deformations by SAR
Floral Biodiversity
Bio-indicators
….

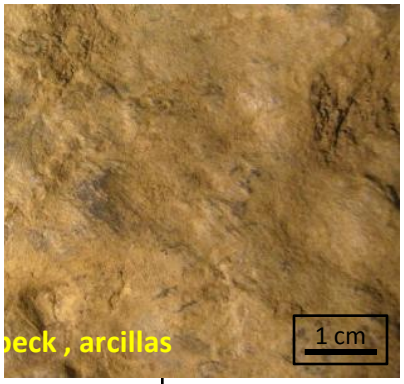
Baseline studies


3

Estratigrafía Hontomín - 5

Prognosis Sondeo Hontomín-5

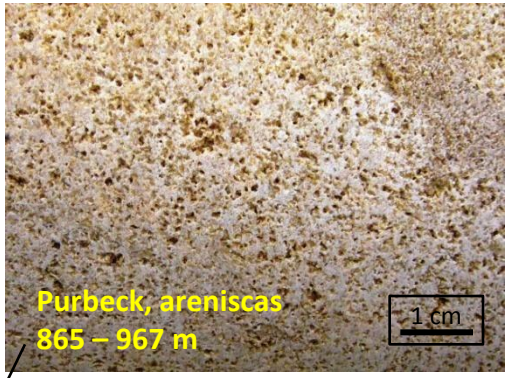




beck , arcillas

Sello 2

Almacén 2



Purbeck, areniscas
865 – 967 m

Lias – Dogger, margas y pizarras bituminosas

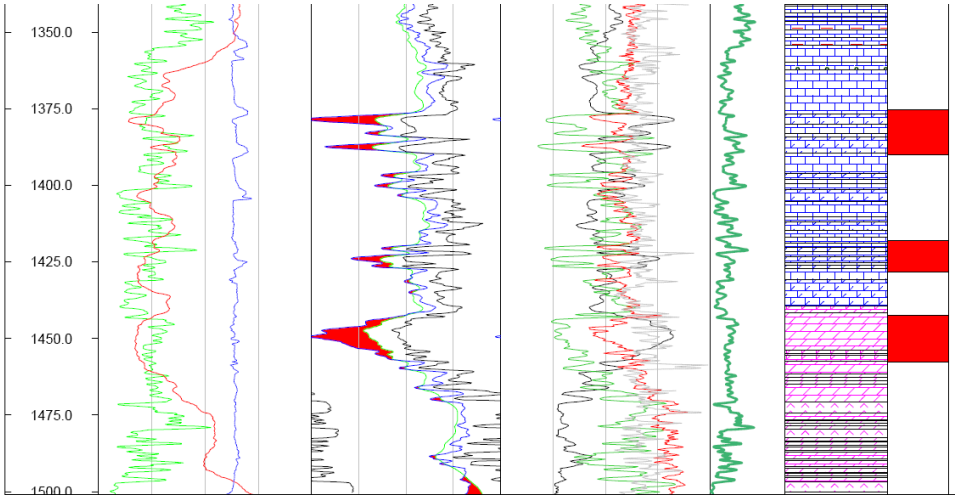
Sello 1

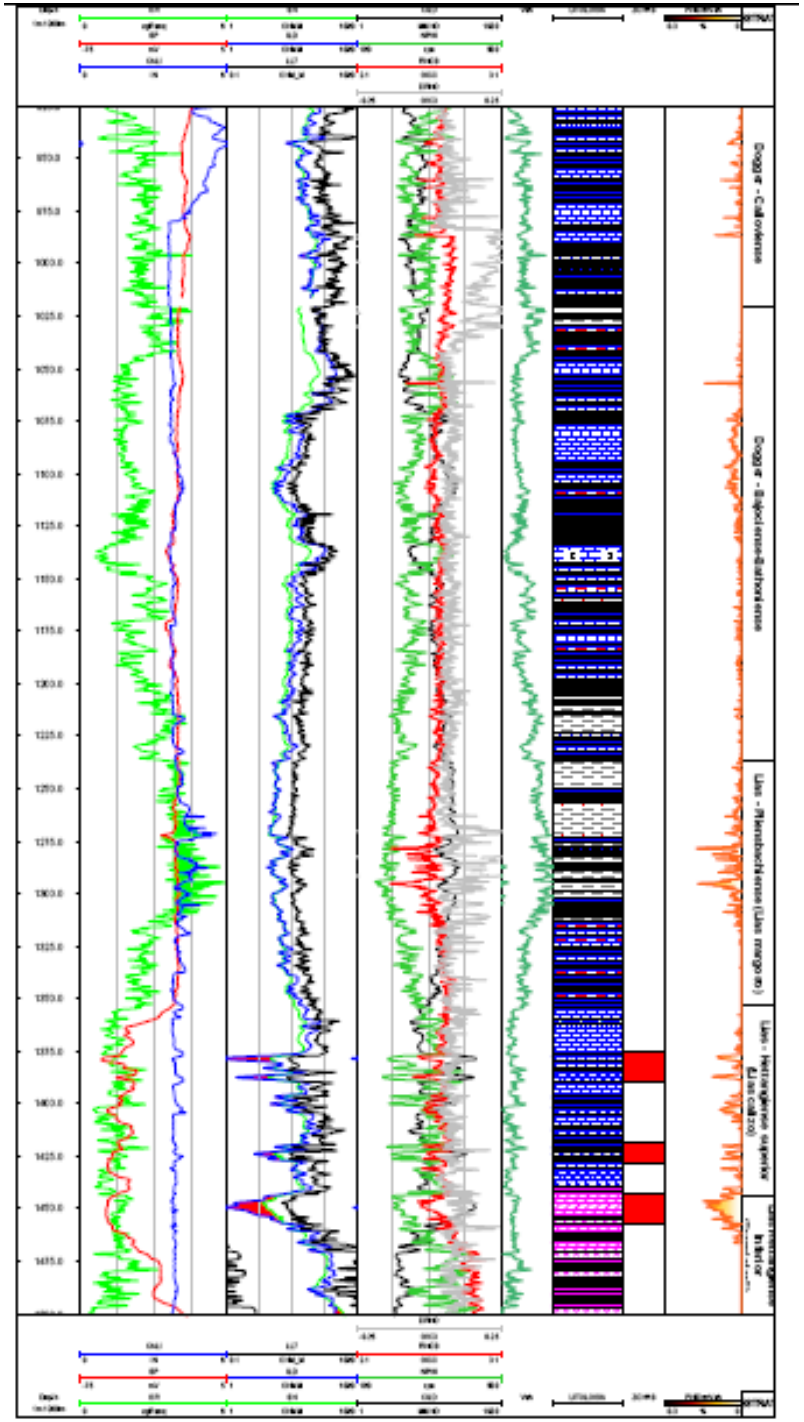
Almacén 1

Jurassic , calizas
1415 – 1487 m

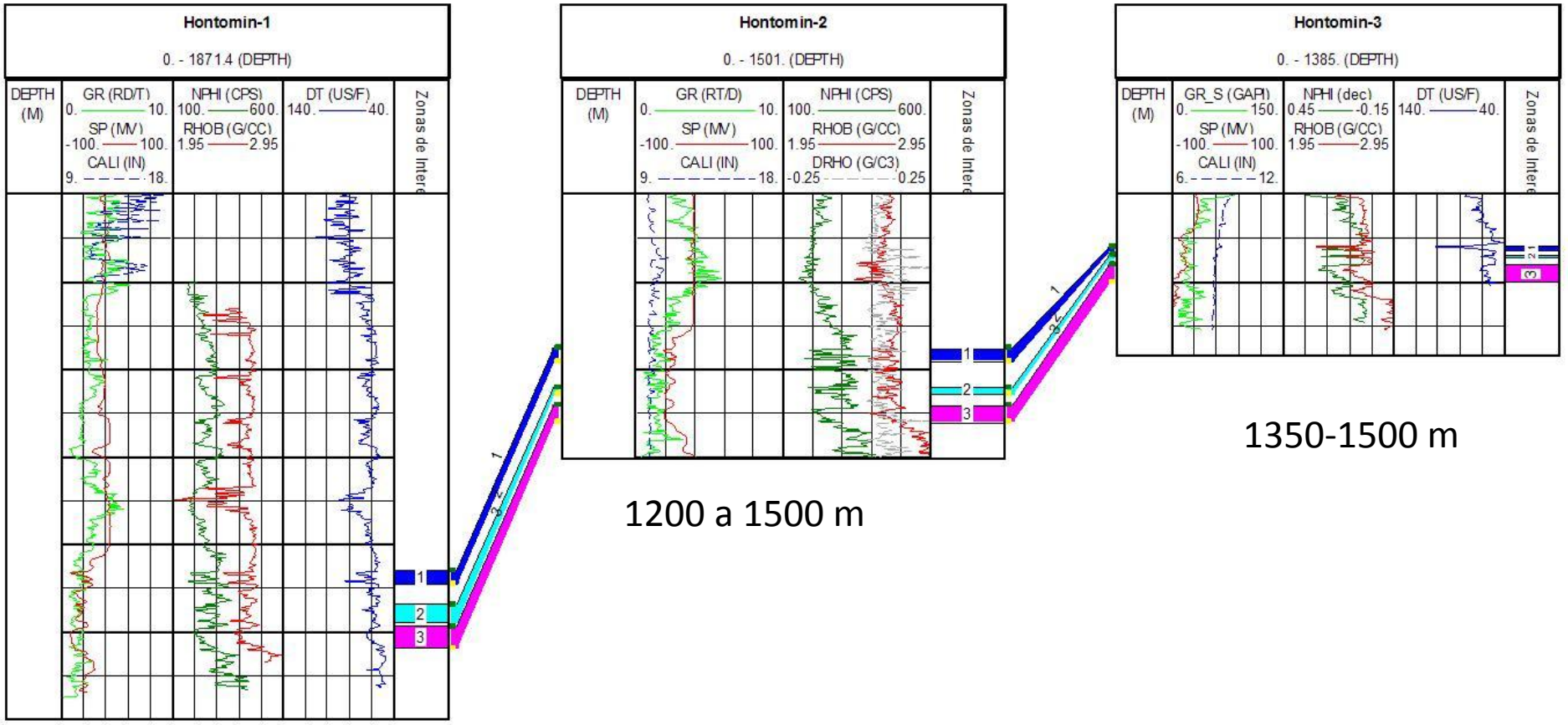
Logging Hontomin 2

925 a 1500 m





Niveles con mayor porosidad

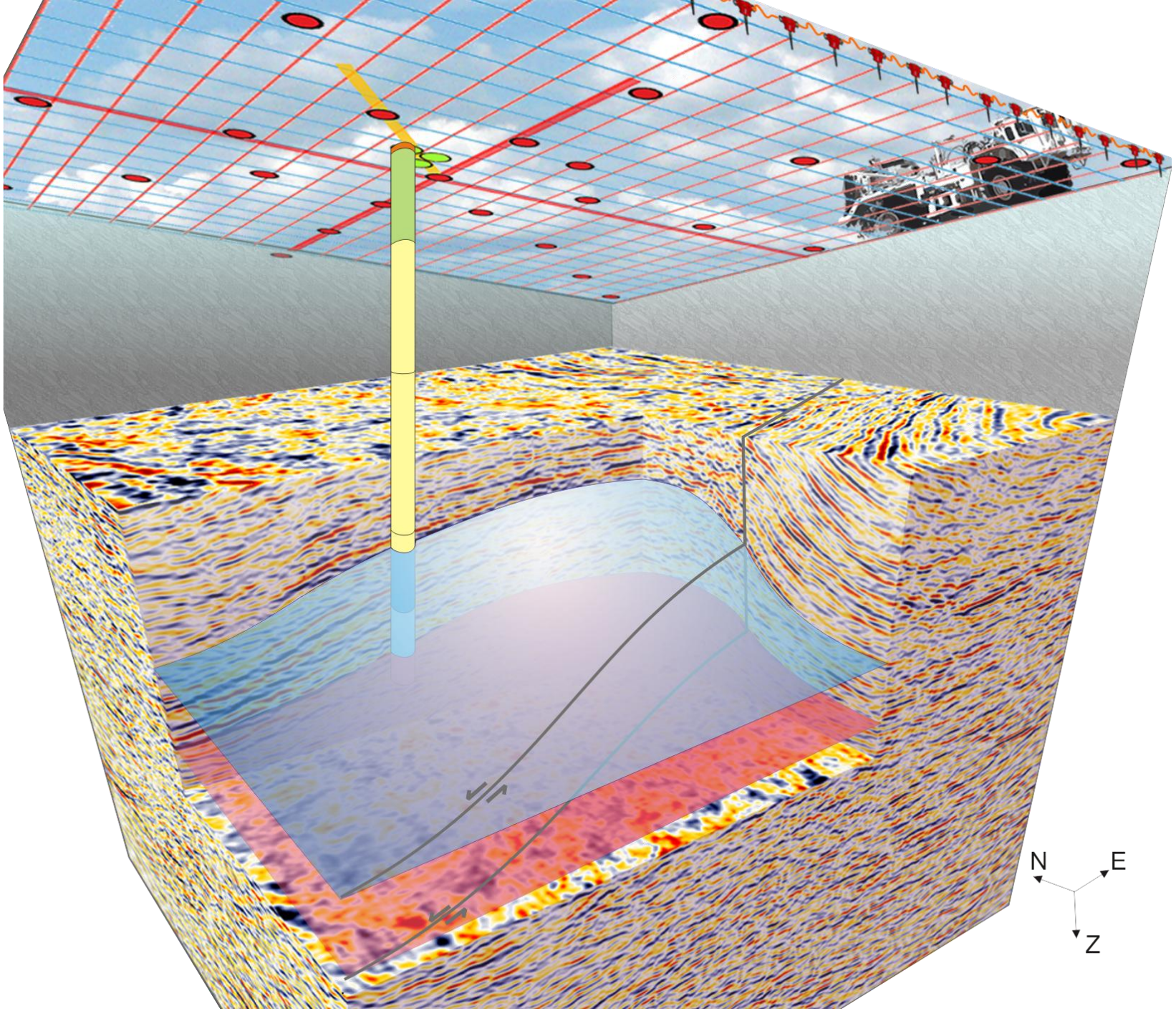


1200-1800 m

1200 a 1500 m

1350-1500 m

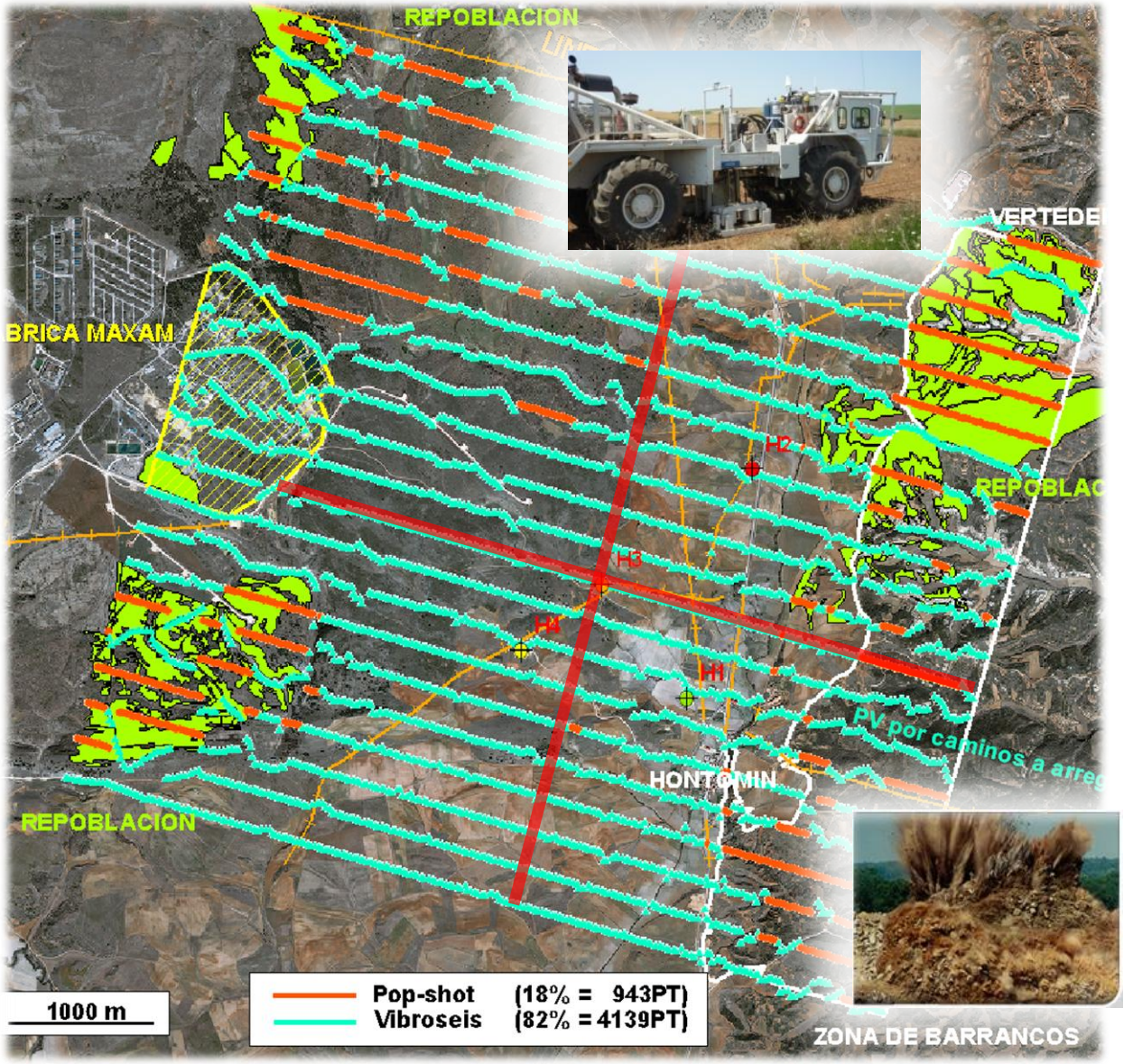
Marquez & Jurado, 2011. ICTJA-CSIC

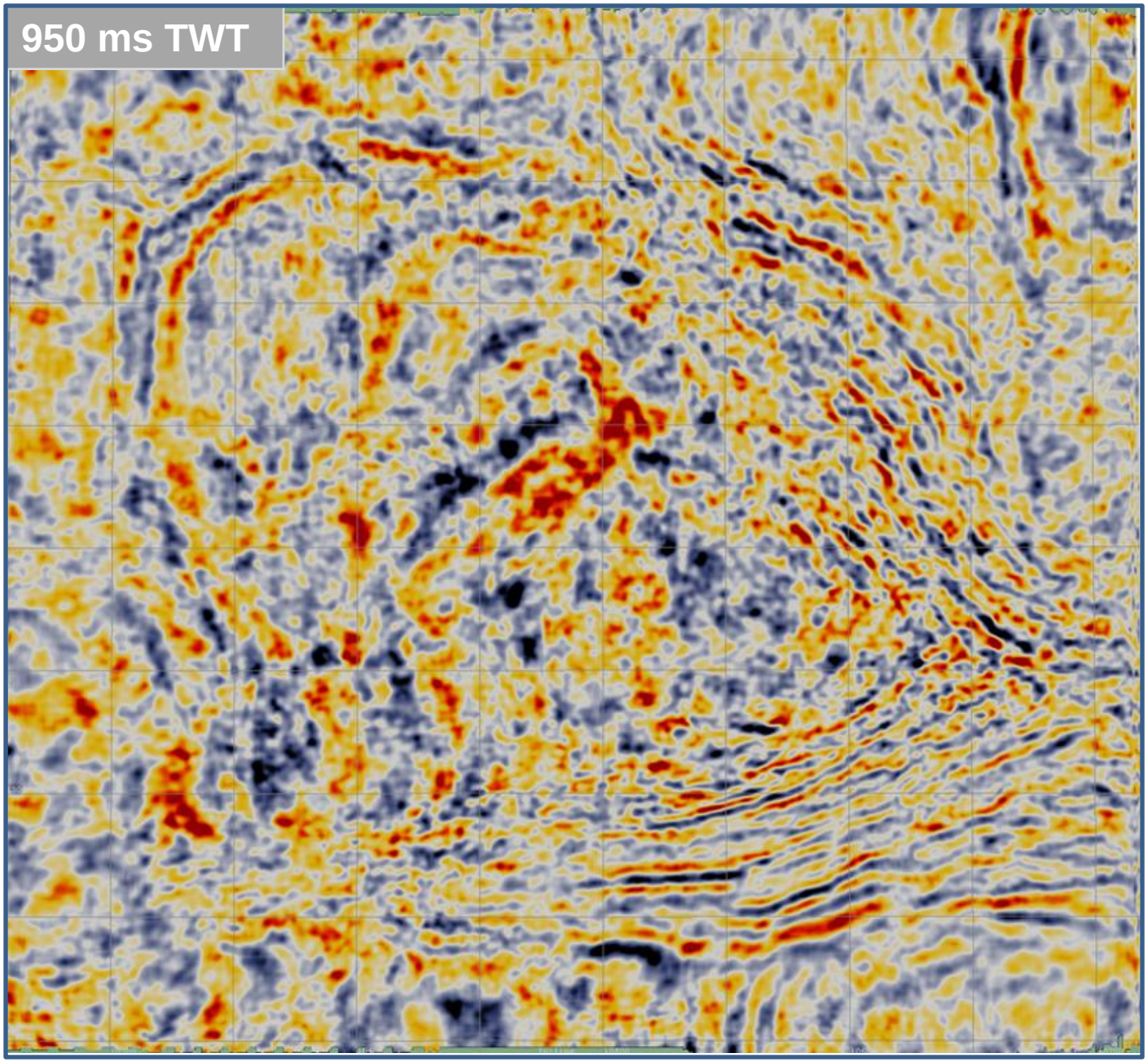

N
E
Z

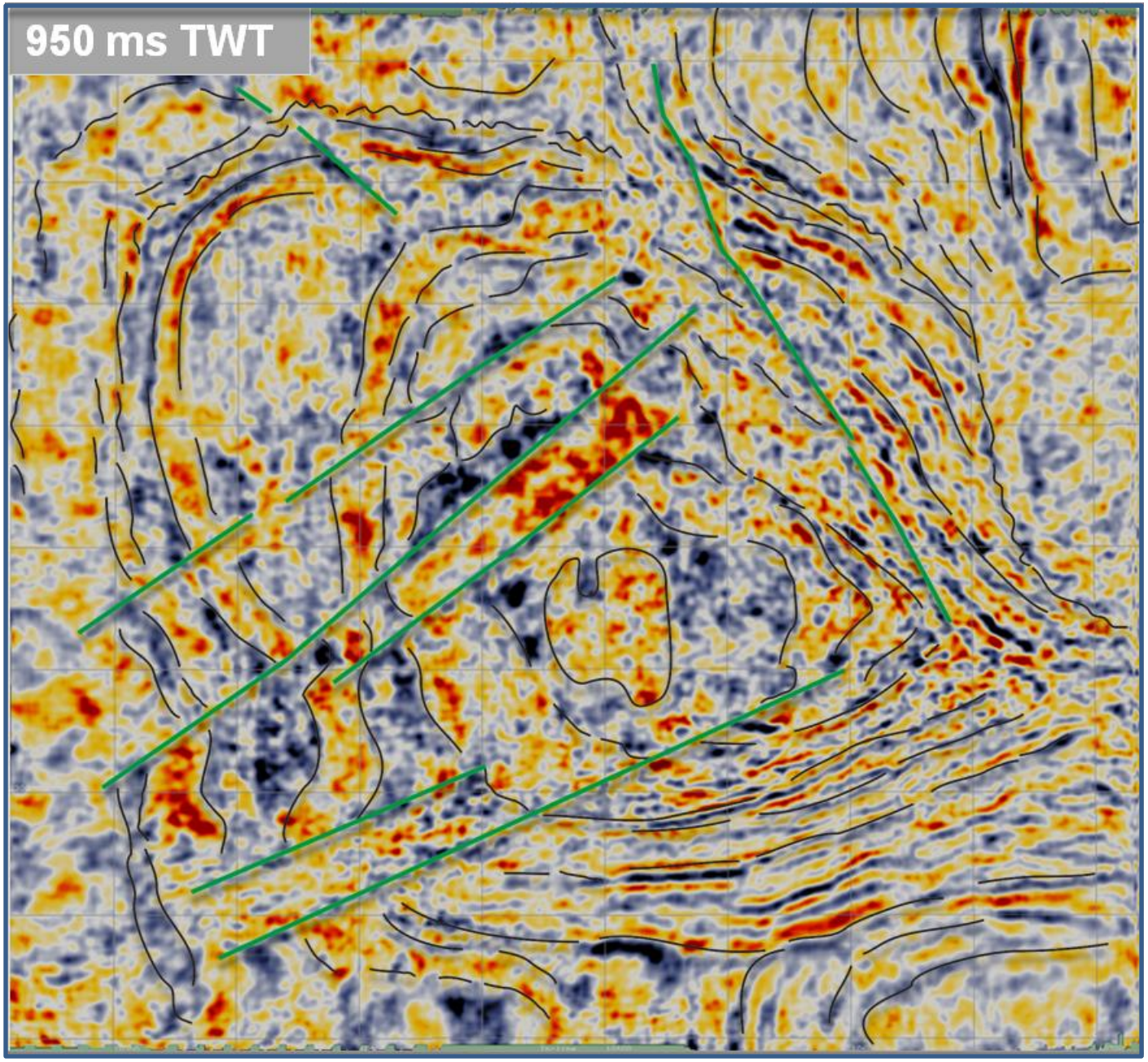
3D seismic

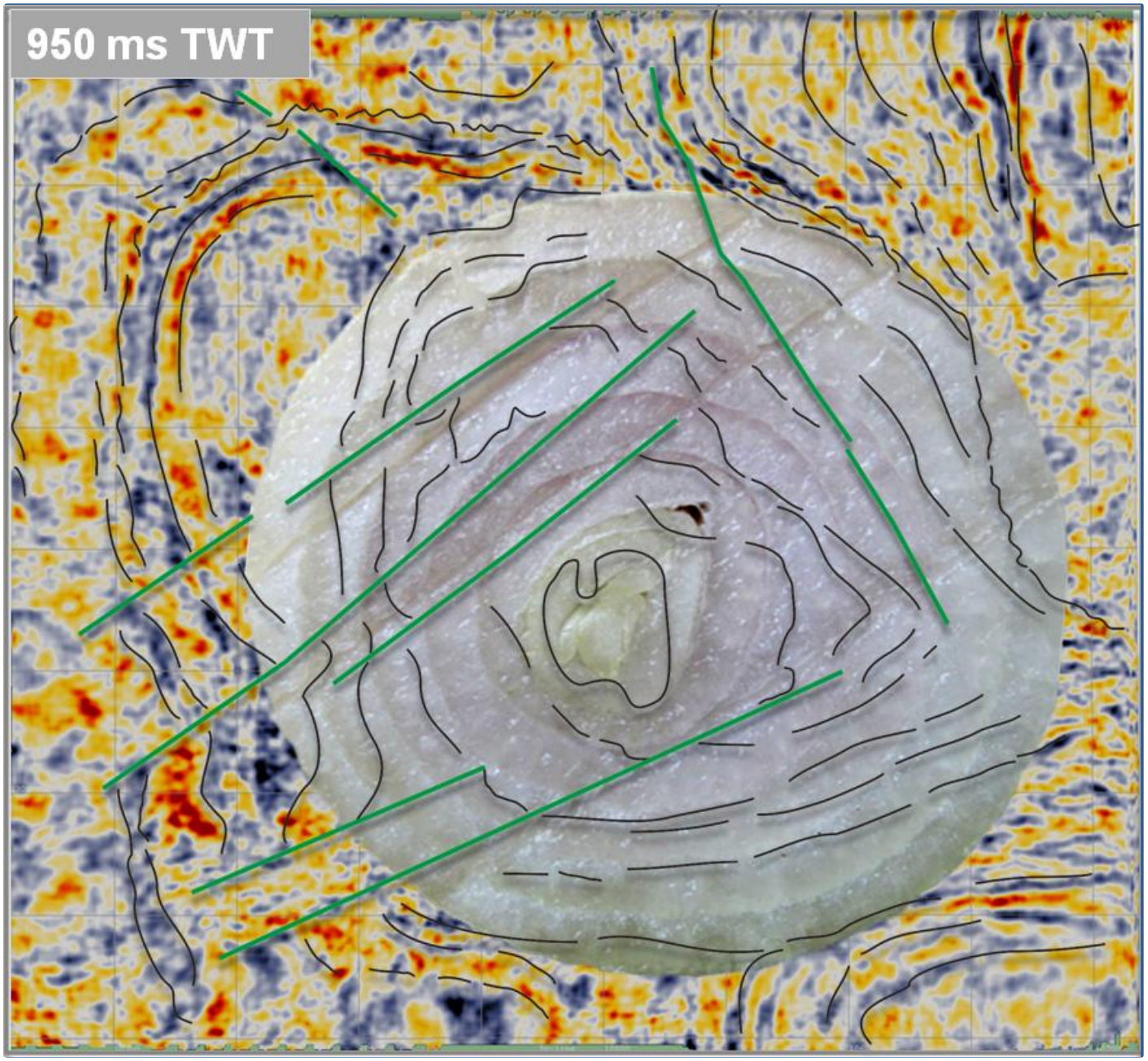
Acquisition area	~35 km^2
Receivers	6 (10 Hz)
Receivers distance	25 m
No. Inlines	463
Inline distance	250 m
No. Crosslines	431
Crosslines distance	275 m
Fold/bin (CDP)	36

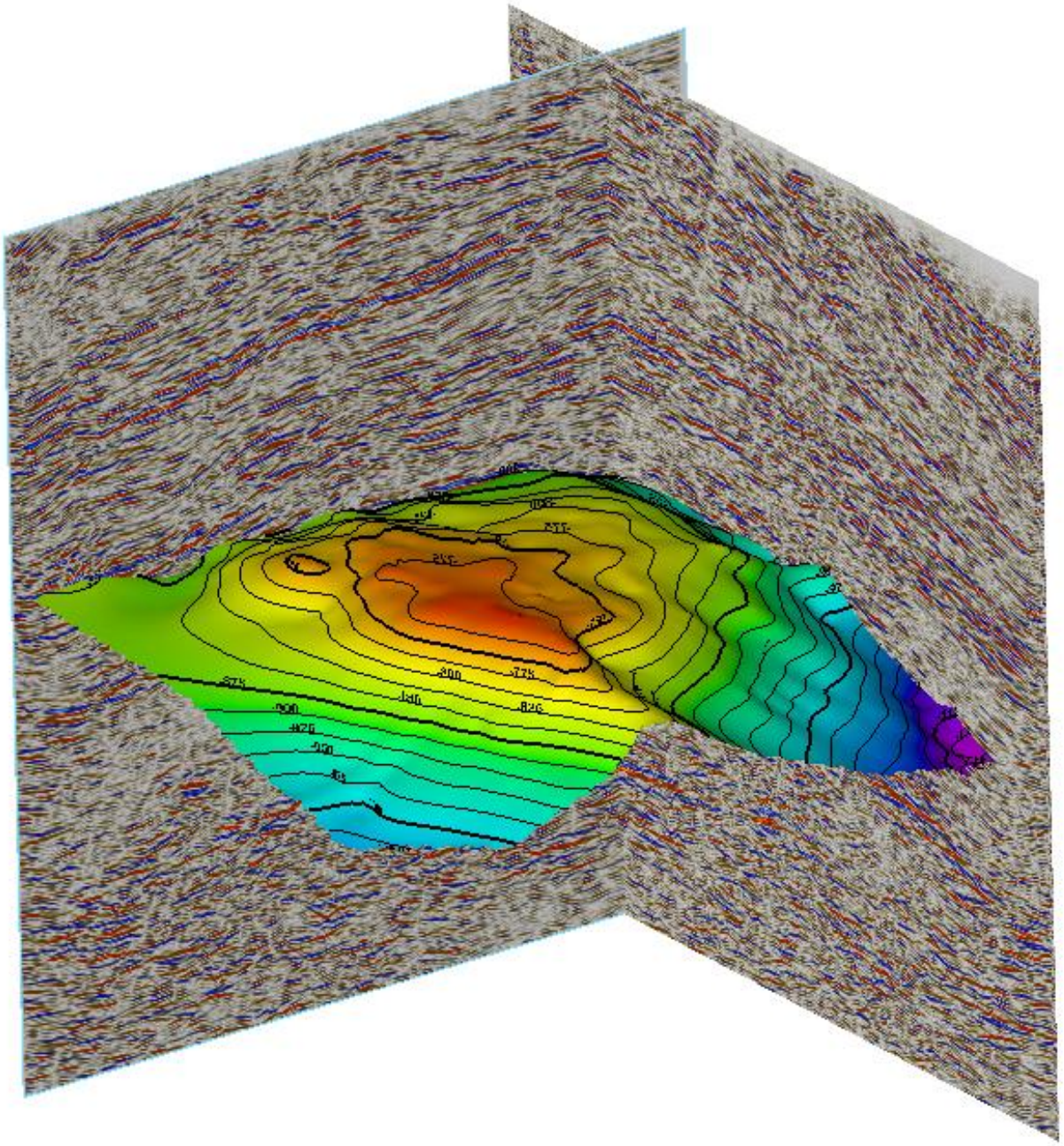
Vibroseis M221	4 * 15 Tn
Sweep	16 seg.
Pop-shot	3 * 1.5 kg
Vibración/shot distance	25 m

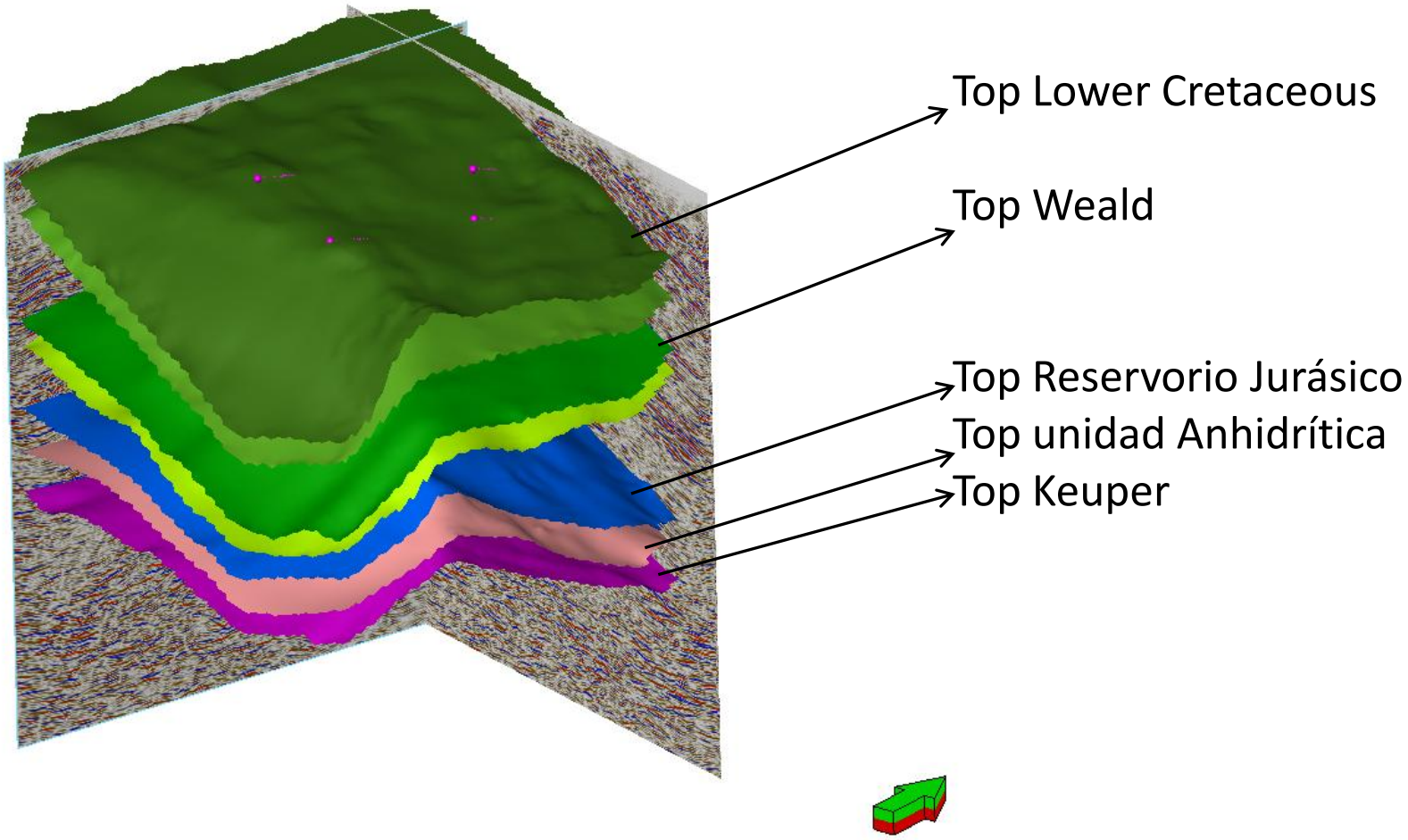


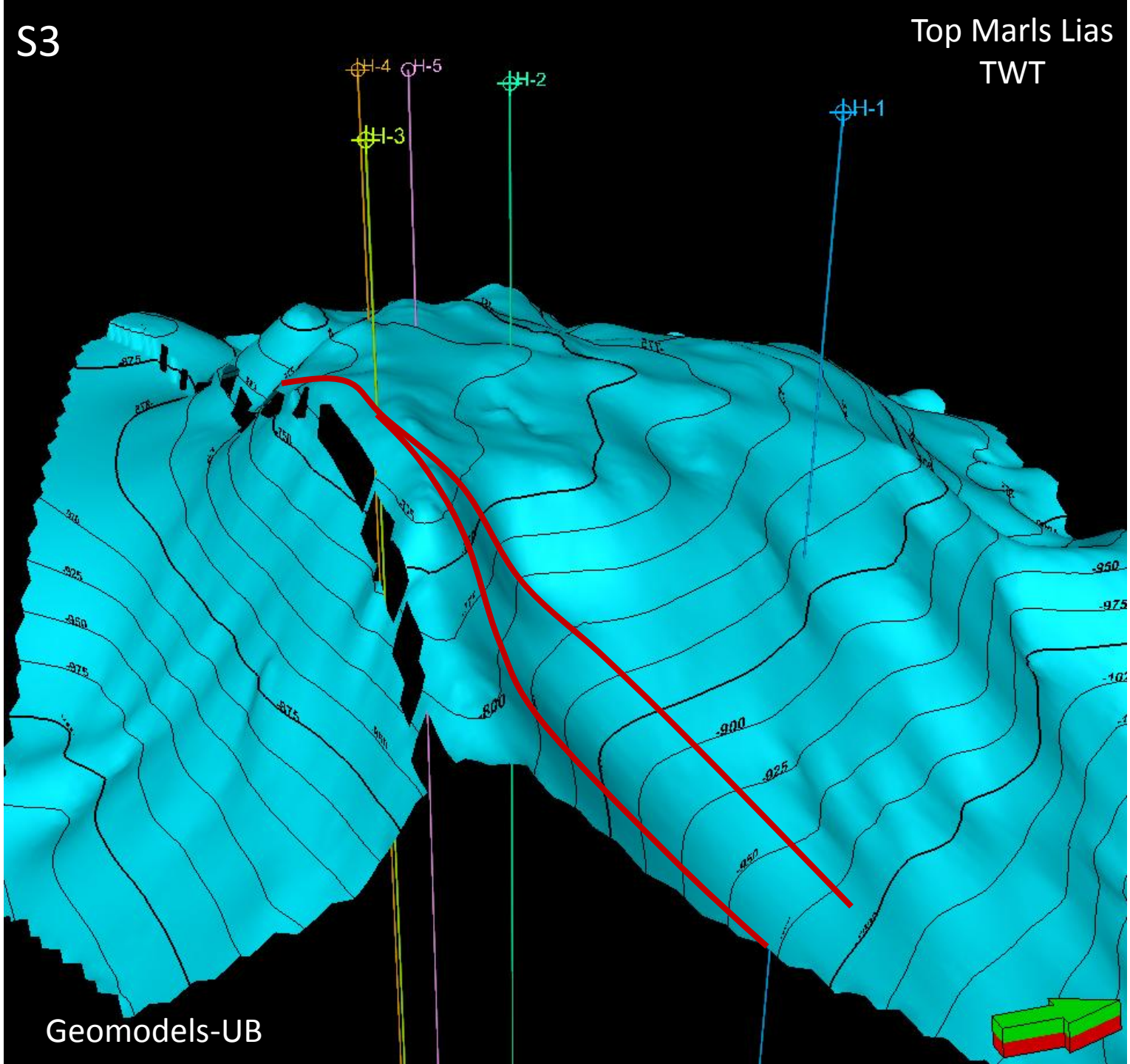

950 ms TWT

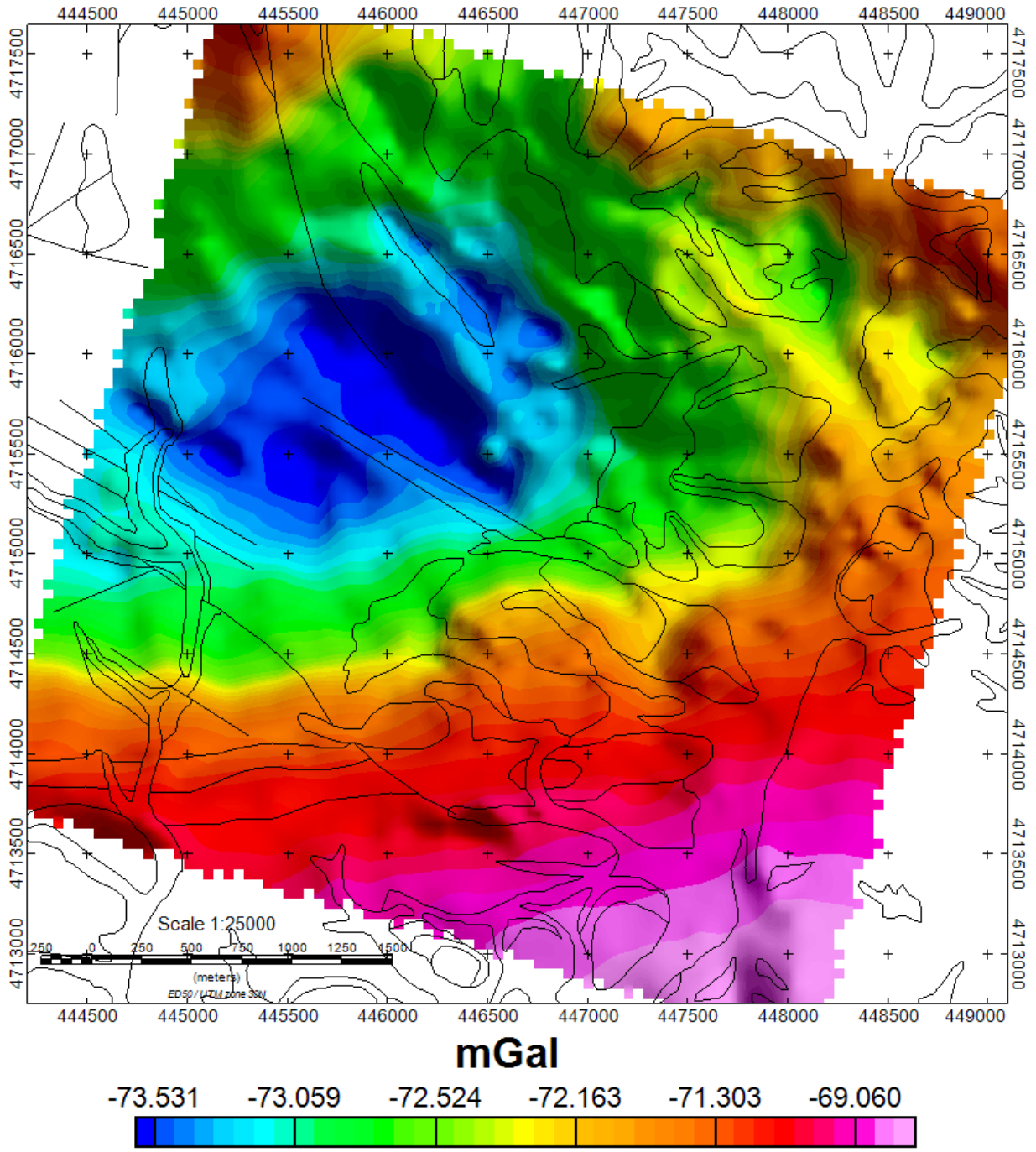

950 ms TWT


950 ms TWT

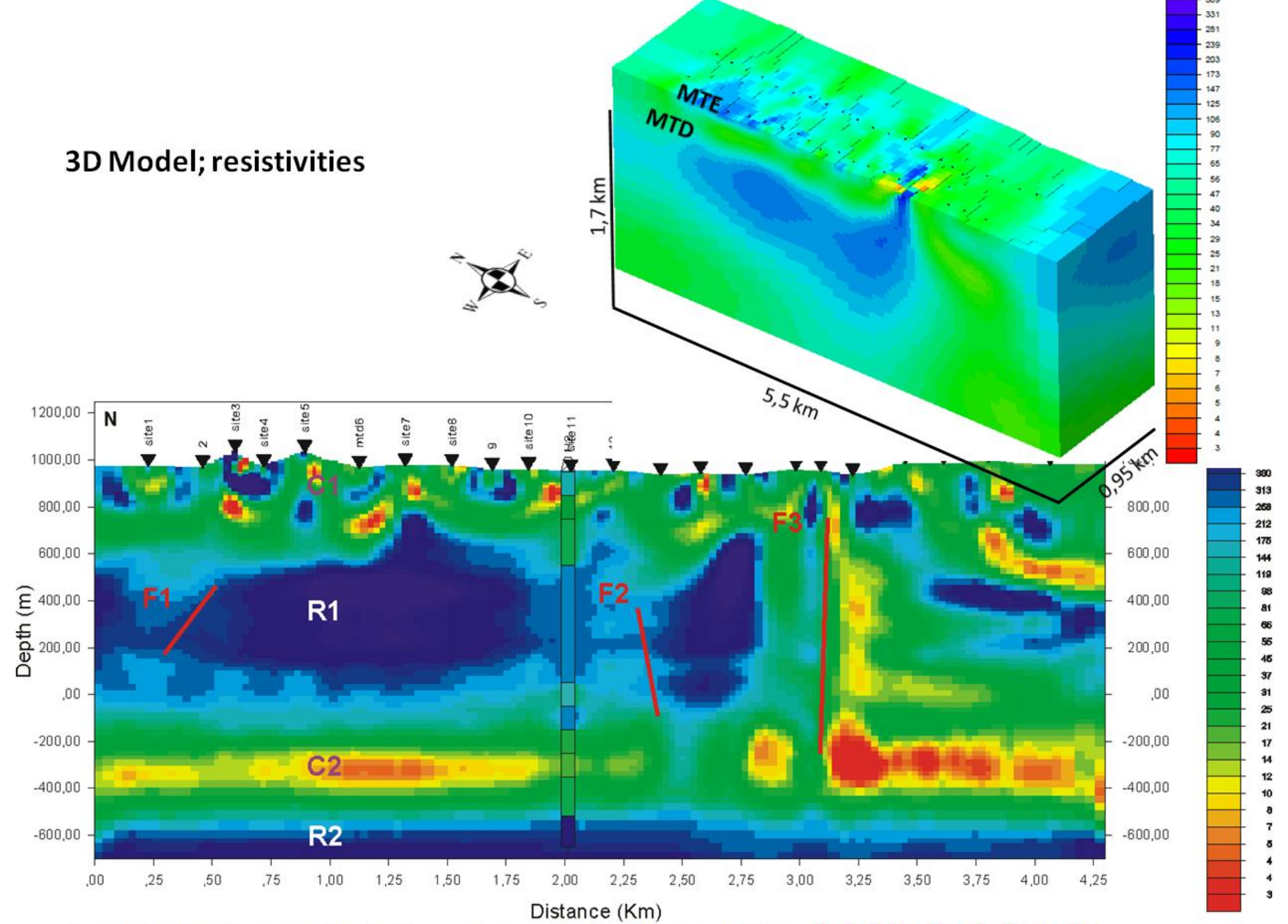



Top Lower Cretaceous
Top Weald
Top Reservorio Jurásico
Top unidad Anhidrítica
Top Keuper


S3
Top Marls Lias
TWT
H-4
H-5
H-2
H-1
H-3
Geomodels-UB


444500
445000
445500
446000
446500
447000
447500
448000
448500
449000
4717500
4717000
4716500
4716000
4715500
4715000
4714500
4714000
4713500
4713000
Scale 1:25000
250 0 250 500 750 1000 1250 1500
(meters)
ED50 / UTM zone 39N
mGal
-73.531
-73.059
-72.524
-72.163
-71.303
-69.060

3D Model; resistivities



- CIUDEN´s public engagement strategy started at the very beginning of its field activities.
- CIUDEN maintains a permanent communication and engagement with the stakeholders.
- These activities will be reinforced with the Visitor´s Centre that will be located next to the TDP.

Thanks for your attention